Environmental & Occupational Medicine

Rīgas Stradiņa Universitāte

Jānis Dundurs

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The book includes all of the most important issues of environmental and occupational medicine. As ecological parts of the environment, the air, water, settlements, as well as food toxicology, safety and quality assurance have been discussed. Some chapters are devoted to work environment and assessment of the effect of environmental risk factors on human body.

The textbook has been written for international medical students. Environmental and occupational medicine is closely related to other branches of environmental science and public health, therefore it may be used by many-branched environmental and public health specialists, environmental and work inspectors, ergonomists, ecologists and other interested groups.

Head of the Publishing department: Tenis Nigulis
Senior editor: Aija Lapsa

Editor: Jānis Zeimanis
Proof reader: Regīna Jozauska
Layout design: Ilze Reitere
Cover design: Mikus Čavarts

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PREFACE

For many years, hygiene was a key discipline of preventive medicine with its roots in 2.5-thousand-year long history. In Latvia, Hygiene was one of the courses taught to future doctors since the establishment of the Faculty of Medicine in the early years of our country's independence. During the years of Soviet occupation, teaching was carried out according to unified programmes that were limited only to some theoretical and practical aspects of hygiene recognized in the Soviet Union. After the restoration of independence, teaching of hygiene experienced significant changes.

In the last decades of the previous century, the world's scientific and technical developments with the expansion of the range of eco-environmental factors had led to the loss of balance between human biological characteristics and the ability to timely adapt to the new urban environmental factors. In reality, at certain stages of life, the speed and unpredictability of ecological changes began to overtake the limits and speed of human body's adaptive mechanisms. In our era of globalization, individual health security risk is increasing in the whole society and for each of its members. Health-care tasks have expanded from the medical treatment to maintenance and promotion of health.

The latest knowledge on one of the natural sciences – human ecology – has to be taken into account. Human ecology has ceased to be a purely biological science and has gained medically biological and socially hygienic meaning. Due to the effect of interference with the natural environment, human ecology has been regarded as a multi-disciplinary science, based on the maintenance of the harmony between the human health and the environment, which, in turn, is determined by the social aspects of society.

Under such circumstance, there exists intersection between methodological approaches to the ecological assessment of the environmental factor, its effects on the human organism and hygienic reasons of preventive measures, i.e., education on the role of environmental factors in the life processes of the human body must be regarded as a conceptually unified ecological and hygienic matter. The object of study in both human ecology and hygiene is anthropoecological system "person-environment" with a human, society, and their health in the centre, taking into account all the various environmental and social factors, environmental exposure (impact) on life processes. Both branches of science have a mutually united fundamentals – common goal of finding solution to the crisis in the global ecosystem.

There exists interconnection between health and environmental issues, the concept "environmental health" comprises those aspects of human health, including the quality of life, which are determined by chemical, physical, biological, social and psychosocial environmental factors. Healthy environment is related to the aspects of environmental quality. Environmental Health is a discipline of Environmental science that develops the theoretical and practical foundations to identify, standardize, measure, and control positive and negative environmental parameters (natural, anthropogenic, social), as well as to prevent or reduce their possible harmful effects on the human body. Environmental and Occupational Health should be treated from the position of a structurally systematic approach aimed at multidimensional and objective evaluation of different levels of environmental factors, human health and prediction of public health basing on the significance of the factors, which form lifestyle of a healthy person.

It is very important to provide future medical professionals with the knowledge not only on diagnosing and treatment of diseases and disorders to restore normal functioning of human body, but also about harmful risk factors of domestic and working environments, their impact on health, as well as reduction or even elimination of these factors, thus achieving decrease in mortality and morbidity rates in society.

At present, the courses of preventive medicine include Environmental, Occupational Health and Medicine emphasizing the specifics of students' future work environment. The principle of teaching Environmental and Occupational Health is to identify the relationships between human and medically biological, and socially hygienic factors of environment in system "environment-human-society". The educational process takes place based on the structurally systematic approach, which is aimed at versatile, reasoned and objective assessment of the role of environmental factors, evaluation of human health as well as to predict public health basing on the significance of the factors, which form lifestyle of a healthy person.

The text-book has been written for teaching environmental and occupational medicine and health to international medical and health care students. The manuscript is based on the author's twenty-year-experience in work with international students making use of the latest educational and methodical aids, and brochures in both the Latvian and the English languages written in the recent years.

Seven chapters of the book include definition and outline of the issues related to pollution of air, water, food, and other environmental components, their impact, identification, assessment and selection of decrease measures. The book is an educational material for reducing the risk, or even prevention of various unfavourable factors in domestic as well as any work, including therapeutic and health-care, environment.

I hope that this book will help students to better understand globally increasing environmental pollution problems and health issues related to its maintenance, improvement, and preventive measures in the society as a whole and for each individual's health. I also hope that other readers in English will find the book useful.

I express my sincere thanks to the Rīga Stradiņš University (RSU) administration for support, the reviewer Dr. habil. med. professor Maija Eglīte for valuable remarks and advice, the staff of RSU Publishing House – its head Tenis Nigulis, editor Jānis Zeimanis, proof-reader Regīna Jozauska, layout designer Ilze Reitere and especially senior editor Aija Lapsa.

Dr. chem. Assoc. Professor Jānis Dundurs

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INTRODUCTION

As it is defined by the World Health Organization, health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. However, according to ecologist J. Last [1], health is defined as a balanced state between surroundings and human organism. The concepts of disease, disability, and death tend to be much easier for health professionals to address than this idealistic concept of health.

The environment in which all the inhabitants of the Earth live has an immense influence on their health and on burden of diseases. A clear understanding of the burden of disease and the effectiveness of alternative approaches to reduce this burden provides the basis for the development of effective intervention strategies. Estimating the costs and impacts of policy and technical options provides an objective basis from which to inform decision-making. All diseases in theory can be caused by either genetic factors or environmental factors [4].

The cause of disease is dependant on inheritance and environmental pollution, but these are very complex issues to deal with. Most diseases are to some extent related to inheritance and risk factors in the environment. Inheritance is an important factor in how the body responds to risk factors in the environment. In case of cancer, inheritance is probably the predominant factor in only a few per cent of all cases. Likewise, in only a small fraction of cancer cases one specific environmental risk factor is enough to generate the disease. In most cases, a combination of a number of inherited predispositions and complex exposure to a large variety of environmental risk factors is involved.

The inclusive definitions of environment in the context of health have been proposed. Everything that is external to the individual human host is defined as environment. This definition is based on the notion that a person's health is basically determined by genetics and the environment. Genes, consisting of the DNA in each body cell, come from the parents of an individual. They existed when the embryo was first formed, and do not generally change during the course of one's life. If a gene does change, it may lead to cancer or cell death. An individual's genetic material is one of the major factors that determine how man is affected by environmental exposure. The human environment involves exposure to many different agents. This exposure can be divided into different categories.

Environment can be divided into physical, biological, social, cultural, and different other categories, any or all of which can influence health status in populations (*Figure 1*).

The focus is on how well different environments enhance health rather than on health impacts of bad environments. This effort involves such things as promoting healthy lifestyles, cleaning up industrial pollution, reducing traffic hazards, and reducing tobacco smoking. In developing countries, there may be less concern about these issues than the more immediate goals of decreasing morbidity and mortality. In these areas, the focus is more likely to be on basic sanitation and water supply, improved maternal and child health care, and the control of communicable diseases.

Environmental pollution has a huge impact on people's lives. Basic requirements for a healthy environment are clean air, safe and sufficient water, adequate and safe food, safe and peaceful settlements. The field of environmental health is defined by the problems faced rather than by specific approaches used. These problems include the treatment and disposal of liquid and air-borne wastes, the elimination or reduction of stresses in the workplace, purification of drinking-water supplies, the impacts of over-population and inadequate or unsafe food supplies, and the development and use of measures to protect hospital and other medical workers from being infected with diseases.

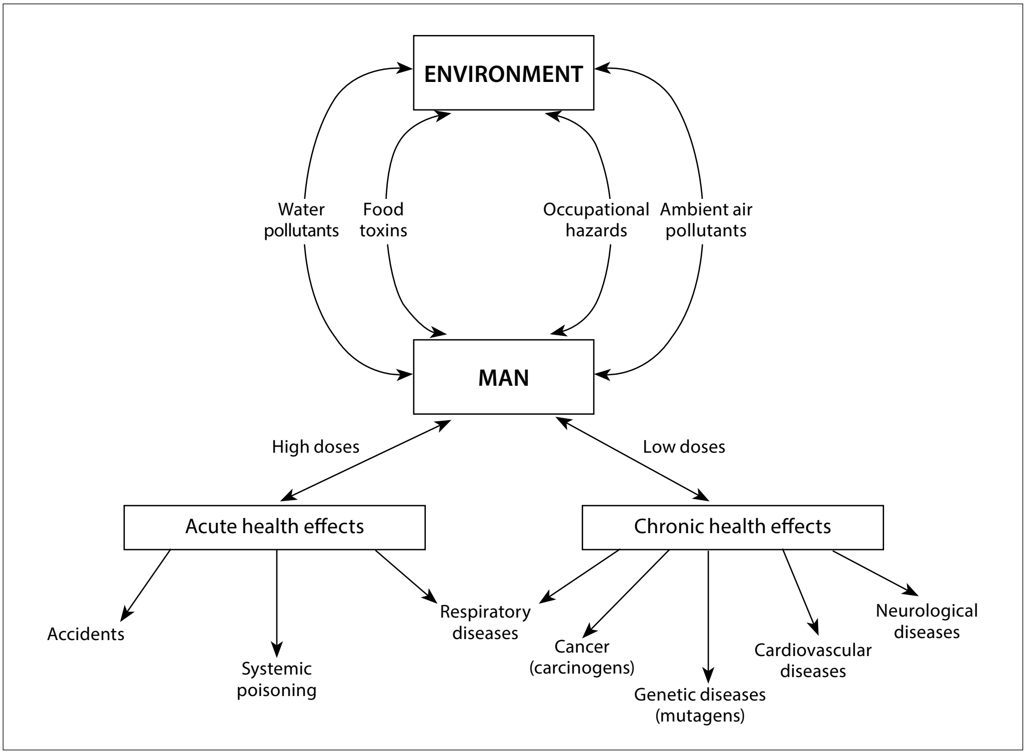

Figure I-1. Interrelationships between man and his environment showing adverse effects on man's health by harmful factors

Within a stable ecosystem (a system of dynamic interdependent relationships among living organisms and their environment) one species does not eliminate another [3]. Ecosystem's capacity to absorb wastes and to replenish soil and fresh water is not limitless. At some point, an external load can overwhelm the ecosystem's resistance, resulting in rapid change of it. Just as the concept of homeostasis (the body system's capability to function in a coordinated way to ensure the constancy of its internal environment) is now generally understood and accepted, this complex, compensating mechanisms seem to apply to ecosystem as well.

Environmental health professionals need to work with all groups in society to promote good health. In addition, they have a special role in environmental health, and one of the major goals of them is to understand the various ways in which humans interact with their environment. Comprehensive and accurate evaluations require integrated, systematic approach, to assess an environmental problem in its entirety.

At least four steps are involved:

1) to determine the source and nature of each environmental contaminant or stress;
2) to assess how and in what form it comes into contact with people;
3) to measure the effects;
4) to apply controls when and where appropriate.

Environmental health is essentially about two things: hazards in the environment, their effects on health, and the development of effective means to protect against hazards in the environment. The aim in environmental health is to improve health by identifying, preventing and reducing environmental hazards and by assessing and managing associated risks.

Environmental medicine is part of broadest discipline – environmental health – the subfield of public health concerned with assessing and controlling the impacts of people on their environment and the impacts of environment on them. It is the interaction between risk agent and human health, which includes a wide variety of risk factors, a wide variety of diseases and a wide variety of genetic predispositions for disease. The aim of environmental medicine is to prevent disease; however, environmental medicine does not focus on how to cure the disease, but rather on explaining the cause of disease in an environmental context [2].

Activities of this field of medicine are focused on investigations, diagnostics, prevention and treatment of health disturbances caused by environmental hazards. The emphasis in the environmental medicine should be on effects that arise in general population in the outdoor and indoor environment through air water, food, consumer products or soil.

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Chapter I

HAZARDS AND RISKS

1. NATURE AND EFFECTS OF ENVIRONMENTAL HAZARDS

Human environment involves exposure to many different physical, biological and chemical agents. This exposure can be divided into different categories. The biological agents and naturally occurring chemical and physical hazards have existed through human history. There is also environmental pollution from human activities.

The first wave of sustained and broad-based environmental concern appeared in the nineteenth century in response to serious public health problems associated with adulterated food and water contamination. The primary threats at the time were agents of infectious disease for public.

The second wave of public environmental concern, which came in the middle of the twentieth century, was dominated by ecology movement. The pure food and drug movement adopted environmental pollutants as a central issue following the massive increase in production.

At the end of twentieth century, the accelerated rate of economic development, combined with a substantial increase in the world's population, have become oriented toward sustainable development, the level of production and activity that can be undertaken in one generation without compromising environmental integrity.

Hazard is an exposure that may adversely affect health. Hazard is a qualitative term expressing the potential of an environmental agent to harm health of certain individuals if the exposure level is high enough [5].

Hazard is defined as an event or situation, which carries a potential for harm. Harm is defined as psychological or physical hurt or damage, and this definition may be expanded to include social harm. However, this simple model should be developed in a number of ways.

It is necessary to introduce two further concepts into the model: the "hazardous situation" and the "hazardous event". A hazardous situation is a set of circumstances in which a person interacts with the hazard but is not necessarily exposed to it.

A hazardous event is the trigger, which exposes the person to the hazard. It initiates the chain of events leading to harm [1]. The hazard is an aspect of the environment; the hazardous situation is effective use of that aspect, while for situations involving acute exposure the hazardous event describes the breakdown of use – the error or accident. The example may serve to illustrate this point:

- hazard (aspect or characteristic of work environment) – HIV;
- hazardous situation (situation with hazard) – nursing HIV-infected patients;
- hazardous event (accident, technical failure) – contact with infected blood;
- harm (disease) – infection by HIV.

The actual hazard or the agent of harm is the human immunodeficiency virus (HIV). The hazardous situation for nurses is nursing patients who are HIV positive, and the hazardous event (error, accident or technical failure) may be the needle stick injury, which results in contact with the patient's infected blood. HIV carries a potential for harm, but it is only when the nurse works with that hazard that such harm may be expressed (hazardous situation) and only then when a breakdown occurs (hazardous event). The person is at risk of harm in a hazardous situation. The sequence of events leading to harm is triggered by the hazardous event.

Hazards can be described in different ways. Exposure of man to any of the hazards may produce an immediate response due to the intensity of the hazard. The response may result from longer exposure at a lower intensity. The second way in which the simple model of hazards needs to be developed relates to the distinction between acute and chronic or more prolonged exposure. Together these define an important dimension of the hazard-harm association. If the example used had been based on chronic rather than acute exposure, there would ave been convergence between the notions of the hazardous situation and the hazardous event. The exposure to the hazard would be on-going, and in a sense the hazardous situation would represent itself as slowly forming.

Acute exposure to the hazard usually occurs because of human error or technical failure in an otherwise safe system, and is subjected to characterization. In the chronic situation, the hazard, whatever its cause, has been present for some time and the person experiences continual exposure in an essentially unhealthy system.

Various environmental factors can cause sickness, impaired health, or significant discomfort in men. Environmental health hazards arise from both natural and anthropogenic source. There are different types of environmental factors that may affect health: chemical factors (heavy metals, pesticides, food additives, etc.); biological factors (bacteria, viruses, parasites, etc.); physical factors (noise, climate, radiation, work load, etc.); psychological factors (lifestyle disruption, stress, effects of social changes, marginalization shift work, payment, human relationships, unemployment, etc.) [4].

Physical hazards are forms of potentially harmful electrical, sound waves, thermal energy, radiations**.** Any activity can include physical hazards. Energy uses, electromagnetic fields, noise sources, physically demanding tasks, and material-handling jobs must all be noted. Hazards that could result in acute traumatic injuries also include vehicles and sources of energy. Vehicles include automobiles, forklift trucks, and overhead cranes. Energy sources could be electrical, pneumatic, hydraulic, and thermal. Temperature extremes, lighting levels, and machine pacing are additional factors to consider in the initial hazard surveillance approach.

Noise, temperature, and radiation are the most common examples of physical hazards. Noise is an unwanted sound. The intensity of a sound is determined by the weight of a sound wave in air. Higher waves produce greater vibrations, which can damage the tiny nerve endings (so-called hair cells) in the inner ear. At lower intensity levels, noise can cause disturbed sleep, and stress. Sound intensity is determined by the changes in the pressure of the sound wave (units – decibels, dB), and depends on the frequency (units – hertz, Hz).

Vibration energy can also be transmitted directly by tight contact with vibration source to the other parts of the human body. These whole body, hand and arm vibrations may damage the musculoskeletal system, and blood vessels.

Hazards associated with extremes of temperature can be divided into exposure to heat and exposure to cold. Extremes of heat and extremes of cold can have local or systemic effects. Local heat can result in burns, but less extreme but prolonged heat results in systemic effects such as heat stress. Local cold damage results in frostbite (local freezing of tissue) while cold affecting whole body results in the condition of low body temperature (hypothermia).

Ionizing radiation emerges when an electron is removed from a neutral atom and pair of ions is produced. Ions are highly reactive and damage critical cell structures. The effects of the ionizing radiation are divided into threshold effects (non-stochastic) and non-threshold effects (stochastic). Exposure to radiation from natural sources (cosmic radiation, from building materials radon exposure) account for more than half of the annual dose man usually receives. People can be directly exposed to ionizing radiation during medical treatments.

All forms non-ionizing radiation are part of the electromagnetic spectrum, which does not have enough energy to cause ionization. Type of non-ionizing radiation is electromagnetic fields, EMF. These develop around electric power lines, electric installations in home, electric machinery, etc. A number of suspected adverse health impacts, including cancer, have been reported, but there is no sufficient scientific evidence to support a definitive statement about whether EMF is an important health concern. Another type of non-ionizing radiation is ultraviolet radiation, UV. The most health effects of UV are skin cancer and cataract of eye. Visible light is not as powerful as UV radiation and mainly causes damage to the eye after overexposure. Physical hazards, which also include barometric pressure alterations, could cause cumulative trauma disorders.

Chemical hazards are toxic chemicals, which arise from excessive air-borne concentrations of mists, vapours, gases, or solids in the form of dusts of fumes. In addition to the hazard of inhalation, some of these materials may act as skin irritants or may be toxic by absorption through skin and ingestion. It is important that those responsible for safety and health be alert to these hazards because of the possible immediate or cumulative effects on the health of humans.

Virtually everyone is potentially exposed to biologic agents on a daily basis. Food, water, air, humans, insects, animals, and inanimate objects (sharp instruments) are a few common vectors capable of spreading pathogenic organisms. In most cases, the human immune system is able to prevent the exposure from causing disease.

Biological hazards are all of the forms of life as well as non-living product they produce. They consist of pathogenic microorganisms and like substance that could pose a risk to the health and physical well-being of humans, animals, or other biological organisms. Biological hazards include infectious agents (bacteria, viruses, parasites, rickettsias and fungi), toxins associated with plants or animals, and pharmacy active substances such as enzymes, hormones, or other biological materials. Infectious agents include tuberculosis in shelters, clinics, hospitals, or offices, bloodborne pathogens for first aid providers, and mould or mildew in a basement office after a flood. In agricultural work areas, one may need to consider other agents. In biotechnology or pharmaceutical companies, exotic, endotoxins or biological materials may be employed. Workers engaging in agricultural, medical and laboratory work have been identified as most at risk to occupational biohazards. However, many varied places present the potential for such exposure.

Other agents considered biohazards include recombinant DNA products, allergens, potentially infected clinical specimens, and bacteria or plant toxins.

A parasitic organism lives on or in a second organism (or host), feeding and multiplying at the host's expense while not contributing to the welfare of the host. Hookworms, *Giardia spp., Cryptosporidia spp.,* and *Schistosoma spp.* are some of the more commonly known parasites of concern when dealing with human exposure.

Fungi are a ubiquitous, diverse group of organisms. Most are non-pathogenic and are either used in their natural form or to produce other useful products (edible mushrooms, the antibiotic, penicillin, yeast for making bread and beer). Fungi are made up of eukaryotic cells (complex cells with true nuclei) similar to those found in higher plants and animals.

Bacteria are small, primitive, one-celled organisms called prokaryotes (cells whose genetic material is not enclosed by a nuclear membrane). Although very small (about 0.1 to 0.5 μm), most bacteria have distinctive cell shapes that affect their behaviour and persistence. Bacteria have been the source of food-borne and water-borne diseases (*Staphylococcus aureus, Clostridium botulinum, Vibrioncholerae, Salmonella spp., Legionella pneumophilia).*

Viruses are small (20 to 300 nm), simple genetic structures unable to change or replace their parts. Viruses are obligate intracellular parasites needing living host cells in order to multiply and transfer the viral genetic material to other cells. Diseases caused by viral agents include influenza, measles, mumps, and yellow fever. Viral agents are also capable of causing human immunodeficiency virus (HIV), hepatitis, polio, and rabies.

Psychological hazards that can cause stress and can result in emotional strain include machine pacing, boring, repetitive tasks, complex, highly demanding requirements, fear of layoffs of physical violence, computer monitoring of performance, and absence of social support.

Ergonomic hazards are workplace factors that include improperly designed tools, work areas, or work procedures. Improper lifting or reaching, poor visual conditions, or repeated motions in an awkward position can result in accidents or illnesses in occupational environment. Designing the tools and the job to fit the worker is of prime importance. Engineering and biomechanical principles must be applied to eliminate hazards of this kind.

2. HEALTH RISKS

The degree of health hazard to an individual arising from exposure to environmental factors or stresses depends on four factors:

1) nature of the environmental factor or stress;
2) intensity of exposure;
3) duration of exposure;
4) human variability or individual differences.

The concept of risk is used in various ways to quantify the relationship between hazards and harm, and to provide some measure of the likely harmful effects of hazards. A risk is the probability that an event will occur, e.g., that an individual will become ill within a stated period. It is the quantitative probability that a health effect will occur after an individual has been exposed to a specified amount of a hazard [3, 6].

Risk is usually defined as the function of the probability of the harm occurring and the magnitude or severity of that harm (Equation 1). The probability of harm occurring is then assumed to be some function of exposure to the hazardous situation (Equation 2) which, in turn, can be defined as the product of frequency of exposure and duration of exposure (Equation 3). An approximation to exposure is often made in terms of the occurrence of the hazardous situation. However, measures of occurrence of hazardous situations and those of exposure to those situations are not identical. Bringing these equations together allows risk to be defined as a function of the product of frequency and duration of exposure, and the magnitude of harm (Equation 4).

Risk = f (probability of harm, magnitude of harm) - Equation 1;

Probability of harm = f (exposure to hazardous situation) - Equation 2;

Exposure to hazardous situation = (frequency and duration of exposure) - Equation 3;

Risk = f (exposure to hazardous situation and magnitude of harm) - Equation 4.

Health effects associated with environmental factors are modified by a number of individual characteristics. It has been argued that objective risk, however calculated, cannot adequately account for man's behaviour in hazardous situations. Human behaviour has a strong bearing on exposure to different risk factors.

Human behaviour is very complex. That behaviour appears more strongly related to subjective or perceived risk. A person's perception of his world is his reality. On the basis of education, cultural behaviour, age, sex and many other factors, we all interpret certain risk very differently [2, 6].

Health effects of environmental factors may be influenced by genetic factors. Physiologic functions, determined by genetic factors, may increase the susceptibility of an individual to environmental hazards. For instance, a person may have a high gastrointestinal absorption of lead because his absorptive capacity is higher than normal. The nature of the risk function may vary in people's perceptions, in genetic properties, and have to be considered with the type of hazard. This also means avoidance of risk factors [7].

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Chapter II

AIR AND HEALTH

1. AIR AS AN ENVIRONMENTAL FACTOR

Air surrounds the environment where man resides. There are three categories of air: atmospheric air, work place air in industry (factories, enterprises, etc.), and indoor air in nonindustrial buildings, such as offices, schools, hospitals, libraries, theatres, cinemas, etc. [2] Air is essential for life itself, without it we could survive only a few minutes. Air is the source of a raw material for many industries, i.e., in order to synthesize chemical substances; for example, chemical industry makes use of oxygen and nitrogen, for production of mineral fertilizers nitrogen is used, etc. Air is the main climate-forming factor. It also serves as a form of information channel (by means of ear, smell or sight).

Air is an enormous reservoir where people drop their waste – everyday life or industrial waste or that from the human body. If there were no these self-clearing processes in the environment, man could not exist.

Exchange of human heat happens thanks to the environment. Air is useful in recon valence processes and in strengthening of man's health. In order to survive, man needs 28 m^3 of air per 24 hours.

Air has the following effects on the human health:

- direct, components cause illnesses or poisoning;
- indirect, functioning as a risk factor, i.e. decreases the activity of human immune system, increases the onset of various diseases;
- distant effect, the cause of the disease can be diagnosed more than a few years later, e.g. cancer.

1.1. Air chemical composition

Air is a mechanical mixture of gases with addition of small, firm and fluid particles. Atmospheric air, when it is liberated from water's vapour, contains $78.08\%_{volume}$ nitrogen, $20.95\%_{volume}$ oxygen, $0.03\%_{volume}$ carbon dioxide, $0.94\%_{volume}$ argon, krypton and trace amounts of other inert gases. This air we breathe on clear days in the mountains. Atmospheric air also contains ozone, radon, drops of water, water vapours, particle of ice, dust and microorganisms.

The chemical composition of air is very important for human organism. Upon aspiration, a part of air's oxygen from the lung's alveoli gets into the blood, but upon expiration carbon dioxide is discharged. Therefore, there is less oxygen in the expired air, but more carbon dioxide than in inhaled air.

Oxygen O_2 is a colourless gas. Life is impossible without it. In the human organism, oxygen maintains the respiration, metabolism and takes part in the processes of oxidation. The consumption of oxygen depends on a man's age, sex and physiological condition. If there is lack of oxygen, toxic substances are created in the organism. Oxygen's admittance in blood and further in the organism depends on its partial pressure – 159 mm Hg. If oxygen's partial pressure is lower than 110 mm Hg, the first signs of hypoxia, the symptoms like mountain disease appear – frequent respiration, fatigue, etc.

The amount of oxygen in the atmosphere is constant. There is little hesitation in the amount of oxygen in the mountains, near the sea and in big cities. However, in a small room, where there are several people, who consume oxygen, its amount decreases by 0.1% within six hours. Green plants are the source of oxygen. Oxygen arises also in water's photochemical reactions in the upper part of atmosphere. In the hermetically closed spaces, for example, in airplanes, in submarines, in mines the amount of oxygen can diminish. If it diminishes to 17–18%, functions of a man's organism are not disturbed, but if the amount of oxygen is 14%, the hypoxemia develops. Diminishing of oxygen's amount down to 9% causes an imminent danger for life. Nevertheless, the inhalation of pure oxygen is dangerous too – toxic symptoms can be caused (toxic rhinopharyngolaryngitis, bronchitis, in more severe cases – pneumonia and toxic lung's oedema).

Carbon dioxide CO_2 is a colourless gas without odour. Its amount in the atmosphere is $0.0357\%_{volume}$. Presence of carbon dioxide in the nature is caused from men and animal expiration, in the processes of organic materials combusting, rotting and fermentation. The constant content of carbon dioxide in the atmosphere may be explained with the non-stop air circulation. The precipitation takes carbon dioxide along from the atmosphere to the soil and water reservoirs. Green plants also take part in the maintenance of constant amount of carbon dioxide in the air. The processes of photosynthesis are part of green plant development.

Nitrogen N_2 is an important element of proteins. In the air, it dilates oxygen and makes it useful for respiration. Human organism is adapted to the existing level of dilution of oxygen and nitrogen. Due to changes in the ratio of these two gases, one can register disorders of oxidation processes in the organism.

1.2. Air physical properties

Physical properties of air are humidity, temperature, air motion, pressure. All these factors together form the microclimate.

The air always contains water particles – vapour, which changes due to the temperature and air motion rates. Temperature is a heat degree in all media in the environment, including a human body itself (air, soil, animals, substances in either aggregative state, etc.).

Atmospheric air motion is the result of irregular atmospheric pressures on the Earth's surface, which is due to unequal warming of air masses. The air has a tendency to move from higher-pressure zones to lower air pressure zones. Such movement of air current which is parallel to the Earth's surface is called the wind.

Atmospheric pressure is the force by means of which atmosphere presses upon the Earth's surface. At the sea level, 1 cm^2 air has a pressure force of 1.033 kg. The influence of atmospheric pressure on the human body is 15 000 kg, but this pressure is neutralized by the inner body pressure.

An extremely important factor seems to be oxygen's partial pressure. At the sea level, at 0 °C the atmospheric pressure is 760 mm Hg or 130.324, 72 Pa (1 mm Hg = 133.322 Pa), but oxygen partial pressure – 159 mm Hg or 21.198 Pa. Rising above the sea level, this atmospheric pressure per each 10 m decreases by 1 mm Hg (133.322 Pa). When the atmospheric pressure decreases, simultaneously there is a decrease of oxygen partial pressure, which approximately amounts to 21% of the common atmospheric pressure.

1.3. Sun radiation

The sun's radiation is known as electromagnetic waves, and it is the main source of energy for all processes, which take place on land and in atmosphere. Only a millionth part of sun's radiation reaches Earth's atmosphere. 1 cm^2 in the upper part of the atmosphere takes 1.94 cal.

There are three parts in the spectrum of sun's radiation:

1) ultra-violet part UV (290–390 nm);
2) infra-red part IR (760–2300 nm);
3) visible part (400–759 nm).

On the surface of the Earth, the sun's radiation spectrum is as follows: infra-red rays – 59%, visible light – 40%, ultra-violet rays – 1%.

Ultra-violet radiation is known to divide into UV-A, UV-B, and UV-C, but only UV-A reaches the Earth's surface. UV-B, UV-C rays are dangerous for life. Yet, they do not reach the surface of the Earth because the ozone layer of the atmosphere absorbs them. In case of damage to the ozone layer, which has currently been shown to occur because of contamination of the atmosphere with chlorofluorocarbon chemicals, there is an increasing intensity of UV-B.

The visible part of the sun's spectrum with the length of waves from 400 nm to 760 nm is perceived by man as the light. The light is necessary for all living organisms, including man.

When the sun's rays reach the surface of the Earth, part of them beam back but another part enter the soil. The last part of sun's rays (IR rays) turn into warmth and warm the soil. The relation of reflected radiation intensity of the surface to the radiation incidence intensity is called albedo. If the surface of the Earth is white, then albedo is 85–90% and the earth warms up very little. The grass albedo is 26%, the rest of 74% of radiation is absorbed by soil and turns it into warmth. Albedo of black, humid earth is only 8%; this is why this soil gets intensively warm. If the temperature of the soil increases, then the surrounding air becomes warm as well.

2. AIR POLLUTION

2.1. Chemicals as pollutants

The rapid growth of industry and motor vehicle traffic has resulted in increased emissions, predominantly in densely populated areas. It has been estimated that about ⅓ of the European population experience air pollutant level exceeding WHO guidelines. The sources of contaminants are from industry, vehicle exhausts, domestic heating, forest fire, solid waste disposal. Pollutants are harmful to plants, animals, and humans. Air pollutants could have significant effects on health but chiefly cause problems in respiratory system.

Ambient air pollution is distributed in the atmosphere without regard to national boundaries. Atmospheric pollutants are transparent to short ware electromagnetic radiation reaching the ground from the sun but they absorb this radiation when it is reflected back from the earth at reduced energy into the atmosphere. Increasing the concentration of these gases in the atmosphere will cause the temperature near the surface of the land to increase much like in a greenhouse. Greenhouse effect is mainly caused by the increasing concentrations of carbon dioxide, methane, nitrogen oxide, and chlorofluorocarbons in the atmosphere.

Carbon dioxide is the most important greenhouse gas and thus a determinant factor for the temperature in the atmosphere. The amount of carbon dioxide in the atmosphere is largely regulated by forests, which cover 33% of global dry land. The use of fossil fuels leads to the accumulation of massive amounts of carbon dioxide in the atmosphere. From a pre-industrial level of about 280 parts per million (ppm) of carbon dioxide concentration in the atmosphere, it has reached 387 ppm nowadays. The mean global atmosphere temperature may increase by 1.5–4.0 °C over the next fifty years.

Polluted air contains sulphur dioxide, oxides of nitrogen, alkane series, polycyclic aromatic hydrocarbons, ozone, and carbon monoxide, among other noxious substances. Chemical pollutants of primary concern to human health include particulate matter and sulphur dioxide. Sulphur dioxide is converted in the air to a particulate, sulphate aerosol. The sulphur dioxide-particulate complex is the result chiefly of the burning of fossil fuels. Exposure can cause irritant and toxic effects on the human airways and result in bronchus constriction.

Particles produced by industry and internal combustion engines are the most hazardous. They remain in the air for long periods, are easily inhaled and are liable to contain toxic chemicals. Each litre of the inspired air may contain several million suspended particles. Highly soluble particles pass into the bloodstream to be metabolized and excreted. Particles may be transported to the lymph and blood circulation, and thus they may cause health problems in other organs.

Nitrogen dioxide is a component of automobile exhaust fumes and consequently a major air pollutant. Although it is not as toxic as ozone and is not present in the environment in concentrations as high as ozone, acute exposure can cause bronchus constriction in persons with respiratory problems.

Hydrocarbons contribute to air pollution as a product of incomplete combustion. Other major sources include gasoline, vehicle exhausts, solvents, paints, and dry-cleaning fluids. Some of hydrocarbons could be carcinogens.

Carbon monoxide, a colourless, odourless, poisonous gas, results from the incomplete combustion of carbon-containing fuels. It is the most widespread air pollutant because of millions of vehicles in use. This gas affects the central nervous system and the cardiovascular system.

The atmosphere is further polluted by a number of other substances, including lead, asbestos, mercury, beryllium, vinyl chloride, arsenic, benzene, cadmium, pesticides, radionuclides, and other toxic chemicals emitted by any number of various sources.

Some of pesticides have estrogenic-like effects on experimental animals, and links have been made to human breast cancer and sperm damage, possibly leading to male infertility. Chlorinated hydrocarbon pesticides DDT is now banned from use in all developed countries, but some developing countries still produce and use this pesticide, as it is the cheapest and most cost-effective means of killing certain important insects, such as malaria bearing mosquitoes and locusts. DDT and other persistent organic pollutants evaporate into the air in tropic countries where they are used, are transported via winds to colder latitudes, and eventually get deposited in these colder countries via rainfall.

Although steps have been taken to reduce emissions from both factories and motor vehicles and to restrict outdoor burning, the problem continues as the population increases, with more cars being in use and more exploitation of home heating fuels. Weather, season and topography play important roles in acute air pollution.

When cooler surface air is trapped under an inversion layer and cannot rise, the effects of air pollution are compounded. When these inversions occur in combination with a high level of air pollution, the results can be life threatening because of high concentrations of sulphur dioxide and various particulates. Weather plays a key role in air pollution effects. Fog and rain can exacerbate the problem, and wind can carry pollutants to cleaner areas.

Rain and fog become acidic only when combined with polluted air. Acid precipitation occurs when rainwater, snow, and other forms of precipitation have a lower than natural pH because of dissolved acidic chemicals that occur from air pollution. This is caused by the increased production of acidifying emissions from industrial sources. In the presence of moisture, the sulphur dioxide in polluted air forms sulphuric acid, a reaction catalyzed by the oxides of nitrogen in the air, which themselves are converted to nitric acid. The resultant sulphuric and nitric acids are carried by the winds and deposited in forests, lakes, and streams. Often, these pollutants are carried for very long distances and fall as acid precipitation hundreds or even thousands of kilometres away from the original site of production. Acid rain is a hazard to natural resources, causing ecological damage, destroying vegetation and fouling lakes and streams, with resultant loss of wild life. It also leaches nutrients from the soil and releases toxic metals to streams and lakes. Both acid rain and fog also deposit toxic metals (lead, cadmium, mercury) and organic pollutants, (alkanes, polycyclic aromatic hydrocarbons), some of which could be carcinogens.

Direct effects of acid precipitation on humans have been difficult to study. Transregional transportation of pollution, as with acid deposition and long-range transport of air toxins, may result in increased airway reactivity and asthma. Asthma has been observed as a result of increased levels of acidic chemicals, such as sulphates, in the air.

As an obvious control, strategy for acid precipitation is to reduce the generation of air pollutants at the source. A particularly important step would be to reduce the consumption of fossil fuels in producing energy. Not every country agrees with the scientific analysis of the problem, nor is every country willing to curtail its own economic development by imposing regulation or decreasing production.

Photochemical smog is formed when hydrocarbons and nitric oxide are photo-oxidized in the air from ozone, nitric acid, and aerosol. A major input occurs during the morning rush-hour traffic, the photo-oxidation occurs in a few hours, and the smog is fully developed in the middle of the day. It diminishes in intensity as the day proceeds because of the rising inversion layer and larger mixing volume in the air basin. Ozone concentration is used as a measure of photochemical smog intensity. It is a respiratory irritant, which damages plants and materials.

2.2. Ionizing radiation and health

The exposure of human beings to ionizing radiation from natural sources is a continuing and inescapable feature of life on earth [7]. For most individuals, this exposure exceeds that from all manufactured sources combined. There are two main contributors to natural radiation exposures: high-energy cosmic ray particles incident in the earth's atmosphere and radioactive nuclides that originated in the earth's crust and are present everywhere in the environment, including the human body itself. Both external and internal exposures to human arise from these sources.

Cosmic rays originate in outer space; they consist primarily of protons and alpha particles. Interactions in upper layers of the earth's atmosphere create secondary components; the more important secondary particles from a dose-assessment view are muons, neutrons, electrons, positrons, and photons. Exposure to cosmic rays is strongly dependent on altitude and weakly dependent on latitude.

The earth is continually bombarded by high-energy particles that originate in outer space. These cosmic rays interact with the nuclei of atmospheric constituents, producing a cascade of interactions and secondary reaction products that contribute to cosmic ray exposures that decrease in intensity with depth in the atmosphere, from aircraft altitudes to ground level. The cosmic ray interactions also produce a number of radioactive nuclei known as cosmological radionuclides.

The magnetic field of the earth partly reduces the intensity of cosmic radiation reaching the top of the atmosphere, the form of the earth's field being such that only particles of higher energies can penetrate at lower geomagnetic latitudes. This produces the geomagnetic latitude effect, with minimum intensities and dose rates at the equator and maximum near the geomagnetic poles.

At ground level, the dominant component of the cosmic-ray field is muons with energies mostly between 1 and 20 GeV. These contribute to about 80% of the absorbed dose rate in free air from the directly ionizing radiation; the remainder comes from electrons produced by the muons or present in the electromagnetic cascade.

Aircraft passengers and crew are subjected to cosmic radiation exposure rates much higher than the rates at ground level. Total exposure on a given flight depends on the particular path taken through the atmosphere in terms of altitude and geomagnetic latitude, as well as on the speed of the aircraft; that is, it depends on the duration of exposure at various altitudes and latitudes.

Radioactive materials, either particles or gases, may be transported great distances by local and large-scale air movements. The periods that the materials remain air-borne depend on the latitude, time of year and height of injection in the atmosphere. The depletion processes include gravitational settlement and dry impaction, incorporation into raindrops and washout by falling precipitation. The physical and chemical characteristics of the materials themselves, such as particle size and chemical and physical forms may influence the removal rates.

Following the release of radionuclides to the atmosphere and before their deposition onto the ground, human beings may receive external exposure. Two situations are usually distinguished: external exposure from the cloud passing overhead (referred to as "cloud shine") and external exposure from radionuclides in air surrounding the human body (referred to as "immersion").The radiation dose from immersion is nearly always much larger than that from cloud shine.

Many exposures to natural radiation sources are modified by human practices. In particular, natural radionuclides are released to the environment in mineral processing and uses, such as phosphate fertilizer production and use and fossil fuel combustion, causing enhanced natural radiation exposures. Very mighty amounts of radioactive materials are emitted when accidents occur at nuclear power plants (*Figure II-1*).

Figure II-1. Nuclear power plant

In a few cases, for example, by paving roads or building houses over water, radiation exposure may be decreased, but these seem to be rather isolated cases.

Naturally, occurring radionuclides of terrestrial origin are present in various degrees in all media in the environment, including the human body itself. Only those radionuclides with half-lives comparable to the age of the earth, and their decay products, exist in significant quantities in these materials. These radionuclides are also present in the body and irradiate the various organs with alpha and beta particles, as well as gamma rays.

There are two main processes, that contribute to internal exposure, the general term used to describe exposures that involve the intake of radionuclides into the body. The two processes are inhalation of contaminated air and ingestion of contaminated foodstuffs.

Many radionuclides occur naturally in terrestrial soil sand rocks and in building materials derived from them. Upon decay, these radionuclides produce an external radiation field to which all human beings are exposed. External exposures outdoors arise from terrestrial radionuclides present at trace levels in all soils. The specific levels are related to the types of rock from which the soils originate. Higher radiation levels are associated with igneous rocks, such as granite, and lower levels with sedimentary rocks.

Radon is the gaseous radioactive product present in rock, groundwater, and soil. Radon and its short-lived decay products in the atmosphere are the most important contributors to human exposure from natural sources. Radon and radon daughters are indoor carcinogens. It can seep into basements of houses, thus being exposed to inhabitants. Residential radon may be contributing to an increased risk of lung cancer.

Solar heating during the daytime tends to induce some turbulence, so that radon is more readily transported upwards and away from the ground. At night and in the early morning hours, atmospheric inversion conditions are often found, which tend to trap radon closer to the ground.

This means outdoor radon concentrations can vary diurnally by the factor of as much as ten. There are also seasonal variations related to the effects of precipitation or to changes in prevailing winds.

2.3. Ozone and ultraviolet radiation

Most ozone (O_3) ~ 90% is contained in the stratosphere about 15–30 km above the Earth's surface where it is present at levels of several parts per million by volume (ppm_{volume}). If all ozone in the atmosphere were compressed to atmospheric pressure, it would form a band ~ 3 mm thick.

In the stratosphere, ozone molecules tend to accumulate through the action of ultraviolet (UV) radiation on oxygen molecules. Ozone has accumulated over time in the stratosphere, where it tends to absorb UV radiation. Natural ozone levels in the atmosphere allow most harmful solar radiation to be absorbed. This serves as a shield, reducing exposure at the Earth's surface below the ozone layer.

Ozone in the stratosphere is a natural filter for UV-B radiation and protects the Earth's surface from high levels of UV-B. Ozone in the lower troposphere is an air pollutant and throughout the troposphere, it is a greenhouse gas.

Any changes in the amount of radiation that penetrates to the Earth's surface as a result of the thinning of the ozone layer can have potentially serious implications for human health and ecological systems. Reduction of the concentration of ozone in the stratosphere reduces the absorption of UV radiation and allows more to get through. Ozone depletion increases exposure to UV radiation at the Earth's surface. Depletion of stratospheric ozone leads to increases in the level of solar UV radiation reaching the surface predominantly at wavelengths ~ 290–320 nm (UV-B radiation). At shorter wavelengths (UV-C, 200–290 nm) atmospheric ozone absorbs essentially all the solar photons, and at longer wavelengths (UV-A, 320–400 nm) the absorption is negligible. Ozone changes have little effect on the higher-energy wavelengths of UV-C, which are fully absorbed by ozone in the stratosphere and are not significantly affected by ozone loss. UV-A carries relatively low energy and is less harmful.

There is strong scientific evidence that the ozone layer is being depleted in recent years well beyond changes due to natural processes. The resultant reduction in ozone concentration reduces the blocking effect on UV radiation of the ozone layer and increases the UV radiation that reaches the surface of the Earth.

The destruction of chlorofluorocarbons (CFC) leads to the release of chlorine atoms, which participate in ozone destruction. CFC release chlorine by photolysis. This free chlorine scavenges ozone and destroys it by the chlorine monoxide catalytic cycle (*Figure II-2*) [6].

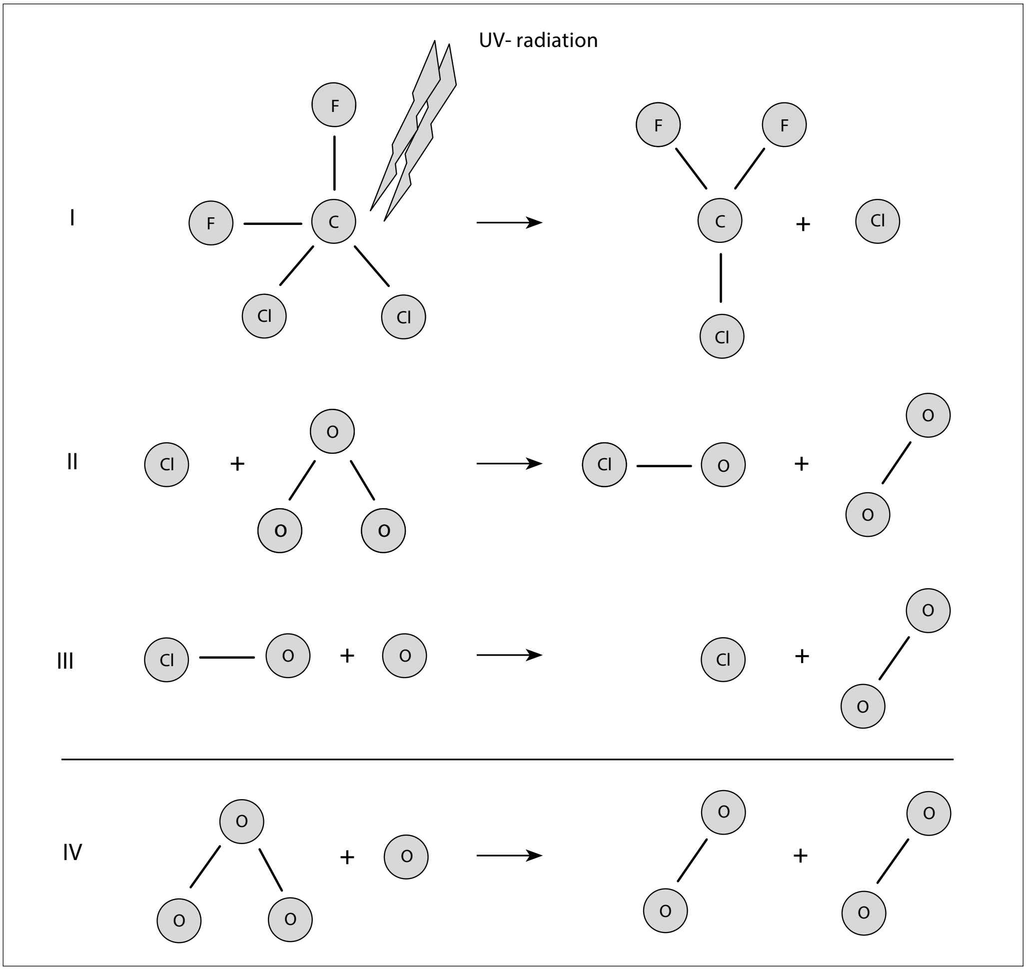

Figure II-2. Chlorine monoxide catalytic cycle for ozone destruction

One CFC molecule may destroy as many as 10 000 ozone molecules. Release of CFC into the atmosphere occurs through industrial activity, leaks, or the decommissioning of old refrigeration and air conditioning units, as well as by use of aerosol cans that use the compounds as propellants. Besides chlorine, bromine also plays an important role in stratospheric chemistry. There are industrial sources of bromine hydrocarbons which are produced industrially and are used as fire extinguishers as an agricultural fumigant.

The increased UV exposure at ground level effects both humans and ecosystems, some of these effects are extremely important for agricultural and fisheries productivity. The human health effects related to ozone depletion are largely centred the increased incidence of skin cancer. The effects include higher risks of squamous cell carcinoma and malignant melanoma, actinic keratosis, cataract, retinal degeneration, and possibly impaired immunological responses [6].

Very high levels of UV index (of 10) based on a scale of 0–15, refer to a maximum risk of harm from unprotected sun exposure. At this level, the average person will get sunburnt in 10 minutes or less. The use of protective clothing, sunscreens, and eyeglasses may reduce the risk of individual exposure to UV radiation, as may change fashions in sunbathing.

Sun protection factor (SPF) of no less than 30 is necessary to prevent immune suppression, and therefore all sunscreens should have an SPF of 29 or above. SPF is a ratio that compares the minimum erythema dose to UV radiation in unprotected and protected skin, and is a concept developed in Europe and adopted worldwide.

2.4. Sick building syndrome and building related diseases

Indoor environment is not always safe and comfortable. Symptoms commonly attributed to indoor air quality problems include headaches, fatigue, being short of breath, sinus congestion, cough, sneezing, dizziness, nausea, eye, nose, throat, and skin irritation [5]. The most common complaint is related to temperature (the air is either too hot or too cold), there is air movement (the air is too draft or too still), humidity (the air is too dry or too humid). Some health related complaints associated with poor air quality mimic those of flu or cold.

Causes of the problem are not recognizable, and successful mitigation is elusive. The problem may be caused by any or all of the following: environmental stressors (overheating, improper lighting, vibration, noise, air-borne chemicals, bacteria, fungi, pollen and dust, as well as new furnishings, poor air circulation), ergonomic stressors, job related psychosocial stressors (overcrowding, uncontrolled renovation activities, labour management problems, personal and work-related stress), or unknown factors.

Potential sources of contaminants in office buildings include tobacco smoke, poor maintenance of heating, ventilation and air-conditioning (HVAC) systems, cleaning supplies, insecticides, fungicides, rodenticide, building materials, occupant metabolic wastes (respiration and perspiration), and cosmetics. Contaminants may also originate outside the building and enter via outdoor air intakes or, when more air is removed by the HVAC system from the building than is supplied, by flowing into the building through any available gap. In addition, lower levels of potentially harmful pollutants might be expected to have a greater effect indoors because of longer exposure times. Both comfort and health can be affected by long-term exposure to pollutants. Virtually all of these are present to some degree in every building. They cause serious indoor air quality problems only when concentrations become excessive.

The World Health Organization estimates that up to 30 per cent of office buildings worldwide may have significant problems, with 30 percent of the occupants of the buildings experiencing health effects, which are, or are perceived to be, related to poor indoor air quality [4]. Complaints by a significant percentage of a building's worker or resident population about acute discomfort, with immediate relief on leaving the building, are suggestive of what has been called the sick building syndrome (SBS). The terminology associated with comfort and health effects of indoor air quality has become confusing. The term SBS is used to describe cases in which building occupants experience acute health and comfort effects that are apparently linked to the time they spend in the building, but in which no specific illness or cause can be identified.

The HVAC system must not only control contaminants, it must provide a comfortable environment. The perception of still or stale air, odour, draught, or errant temperature and humidity leads to discomfort. Three fundamental measures that will greatly reduce the likelihood of SBS problems are good building design, effective building maintenance, and intelligently designed and executed remodelling projects.

Source control is generally the most cost-effective solution to the problem. For example, environmental tobacco smoke-related complaints can be eliminated by prohibiting smoking within the building, or by isolating designated smoking areas and providing them with independent ventilation.

Modification of the ventilation system may also be an effective method, or contaminants such as radon can be isolated or removed by changing air pressure relationships between adjoining areas.

Health-related complaints may be due to allergic reactions [10]. In the presence of an allergen, population may exhibit symptoms including sneezing, swollen airways, and asthma-like attacks. Individuals with a building-related allergy will experience similar symptoms in other environments if the particular allergen is present. Dusty surfaces, stagnant water and damp materials provide an environment ripe for microbial growth. When mould spores and other microbial particles become air-borne, some building occupants may experience allergic reactions. Infectious diseases are more readily transmitted in indoor environments.

The term building related disease (BRD) is used for cases of infectious, allergic, or toxin-induced disease with objective clinical findings related to building occupancy.

Illness allegations can be defined as diseases or infirmities resulting from exposure to indoor air contaminants, usually characterized by clinical signs (blood serology, tissue deterioration, etc.), a low attack rate, and prolonged recovery times after leaving the building. Examples include humidifier fever from fungi and bacteria, legionellosis from, bacteria, and toxicity from carbon monoxide, radon, asbestos, and mycotoxins.

Building-related illnesses as a category refer to illnesses brought on by exposure to the building air, where symptoms of diagnosable illness are identified and can be directly attributed to environmental agents in the air. Diseases that have been clearly related to building occupancy include hypersensitivity diseases (hypersensitivity pneumonitis, lung cancer due to tobacco smoke, allergic alveolitis, humidifier fever, allergic asthma, and allergic rhinitis), and infectious diseases (tuberculosis, influenza, bacterial pneumonia, measles).

Allergic rhinitis could be suspected if the building occupant has nasal symptoms and repetitive sneezing in relation to building occupancy. House dust mites may also produce allergens that may cause bronchus asthma and such allergy is often related to damp housing conditions

Bacterial pneumonia caused by *Legionella pneumophila*, which is occurring in water, and may breed in cooling systems, humidifiers, and showers. One common indoor carcinogen is tobacco smoke.

3. AIR QUALITY CRITERIA

3.1. Air temperature

Biological life can only survive in a narrow range of temperatures. Human body temperature is at constant value. It is possible because the changes of atmospheric temperature, humidity, air motion are the permanent irritants, affecting human thermoregulatory system. If a person is in a relative state of rest, the optimal temperature is from +18 °C up to +20 °C.

High temperatures dehydrate, destroy tissues; very cold temperatures stop essential circulation functioning. The seriousness of exposure depends on time and states of matter contacting the body. Humans have specific safe temperature limits for the environment.

Table II-1. Limits for contact with air and the human being's sensations to various temperatures

Variables	Temperature, °C
16-minute maximum nude exposure	0
1-hour maximum nude exposure	4.4
Stiffness of extremities	10
3-hours maximum nude exposure	15.6
Most comfortable	17.2–23.9
Winter comfort zone	17.2–21.7
Range for light work	18.3–26.7
Summer comfort zone	18.3–23.9
Physically fatiguing	23.9
Maximum for best performance	26.7
Mental activities slow	29.4
Maximum for unprotected long exposure	32.2–34.4
Tolerable for an hour	48.9
Tolerable for ½ hour	71,1
Tolerable for 8 minutes	115.6
Tolerable for 10 seconds abrupt	260

Air temperature is measured with alcohol, mercurial and electric thermometers, which are graduated in scale of Celsius (°C) and of Fahrenheit (°F). The interval between ice thaws and water boils on Celsius scale is divided in 100 points (0–100 °C).

Coherency with Fahrenheit as follows:

$$°F = 32 + \frac{9}{5}\ °C$$

There are thermometers, which show temperature at detected moment and thermometers which fix minimal temperature at detected period. The first thermometers are mercurial and the latter – alcohol. Electric thermometers have thermistors transformed heat to electricity.

To measure air temperature, thermometer is placed where it is not under direct influence of the sun's rays. Exposition time should be 10 minutes.

For characterization, indoor temperature needs to evaluate temperature regime. It allows detecting temperature hesitations which depend on building construction quality, properties of building materials, weather, heat system and ventilation conditions. Measurements usually are made in three levels (0.15 m, 1.0 m, 1.5 m from the floor) at places where people stay.

In spaces with strong heating radiation, the real and the climatic temperatures have to be measured. The climatic temperature characterizes summary air and heating radiation effect on thermometer. The real temperature is the air temperature without heat radiation effect on thermometer. It is measured by thermometer whose reservoir is prevented from radiation.

For continuous observation, the thermograph is used. It contains a bimetallic plate, which is very sensitive to temperature changes, which are fixed by typewriter on paper.

3.2. Air humidity

There are several hydrometric indices. Absolute air humidity A is the water vapour pressure (mm Hg) in the air at a definite moment.

Maximum air humidity M is the water saturated vapour pressure (mm Hg) which the air contains at a definite temperature (*Table II-1*).

The absolute air humidity A is calculated by Regno formula:

$$A = M - \alpha\,(T_d - T_m) \times H,$$

where

M – maximum air humidity according to the moist thermometer;
α – psychrometric coefficient which depends on the rate of air motion (*Table II-2*);
T_d – temperature of dry thermometer;
T_m – temperature of moist thermometer;
H – atmospheric pressure in mm Hg.

Because the amount of water vapour in air is small, relative humidity, the ratio of the partial pressure due to the water vapour to the saturated partial vapour pressure, is much more useful.

Relative air humidity R is the ratio of absolute air humidity and maximum air humidity in percentages (%), and it determines what quantity of maximum air humidity is contained in the absolute air humidity:

$$R = \frac{A}{M} \times 100\ (\%),$$

where

M – maximum air humidity according to the dry thermometer.

Humidity deficit D at a definite moment means the lack of humidity in the air, which would be mandatory for vapour saturated air:

$$D = M - A$$

Table II-2. Maximum air humidity at various temperatures

Air temperature, °C	Water vapour pressure, mmHg
0	4.579
+1	4.926
+2	5.294
+4	6.101
+6	7.103
+8	8.045
+10	9.209
+11	9.844
+12	10.518
+13	11.231
+14	11.987
+15	12.788
+16	13.634
+17	14.530
+18	15.477
+19	16.477
+20	17.735
+21	18.650
+22	19.827
+24	22.377
+25	23.756
+27	26.739
+30	31.842
+32	35.663
+35	42.175
+37	47.067
+40	55.324

Table II-3. Psychrometric coefficient at various air motion velocities

Air motion velocity, m/s	Psychrometric coefficient
0.16	0.00120
0.2	0.00110
0.3	0.00100
0.4	0.00090
0.8	0.00080
2.3	0.00070
3.0	0.00069
4.0	0.00067

Pint of dew P is the air temperature in which the absolute air humidity reaches the saturation level and condenses.

The most hygienic importance is relative air humidity R and air humidity deficit D. The level of humidity is controlled by the intensity of heat release, evaporation of perspiration. Discharge of perspiration and its evaporation are two different processes. Perspiration is a specific reaction of sweat glands to the temperature. Evaporation of perspiration causes lowering of the heat of skin. If humidity is high, perspiration will appear but it will not evaporate. The less humid the air is, the better the evaporation of sweat; we tolerate higher temperatures much better. The optimal relative air humidity is between 30–60%.

Various measuring devices are used: stationary or Augustus psychrometer, aspiration or Assman psychrometer, hygrometer, hygrograph.

Stationary psychrometer consists of two alcohol thermometers. Reservoir of one thermometer is wrapped by gauze, the end of which is dipped in a small vessel containing distilled water. When water evaporates from gauze, temperature lowers and the corresponding thermometer registers the temperature.

When air humidity is lower, water evaporates quicker and, correspondingly, the temperature of the thermometer lower more quickly too. The rate of evaporation of water depends not only on air humidity, but also on the rate of air temperature and motion. To detect humidity it is important to know air temperature and air motion velocity at a definite place and the difference between the temperatures of moist and dry thermometers.

Aspiration psychrometer consists of dry and moist thermometers too. Both thermometers' reservoirs are in metal tubes in which a strong fan pumps air with a permanent velocity. The fan is installed in the upper part of psychrometer and it functions with electricity or clock mechanism.

Before making humidity measurement the gauze is wetted with a special dropper. Exposition lasts for 10 minutes. The reading of both thermometers is done and absolute humidity is calculated as follows:

$$A = M - 0.5 \times (T_d - T_m) \frac{H}{755},$$

where A, M, T_d, T_m, and H, are the same, and relative humidity is calculated as above mentioned.

If the wet and dry thermometers' temperatures are known, relative humidity can be read on the table too, or can be calculated by a much simpler and approximate formula:

$$R = 100 - 10 \times (T_d - T_m)$$

For the evaluation of approximate relative air humidity, hair hygrometer is used. Human hair, which is removed from fat, is applied in device and connected to a pointer. If the air is humid, hair absorbs water and increases in length; however, if the air is dry, it decreases in length. The pointer changes according to the changes of the length of hair. The scale has a graded humidity in percentage.

For permanent control of relative air humidity, a hygrograph is used which functions with the same principles as hygrometer. There is a bush of hairs in hygrograph (about twenty).

3.3. Air motion

Man perceives air motion only in those cases when its speed is 0.1 m/s. Short spell of wind is pleasant, it has a freshening effect, yet the long standing action of the wind makes one tired and slackening.

The motion of the air as well as the air temperature and humidity affect the human heat release. In cases of low or high temperature, the air motion increases heat release. If temperature is low, cool air penetrates the pores of clothes and displaces the warm air therefore heat is given off through the skin, the bare parts of the body. Under such conditions, people catch colds more commonly. High temperature and strong motion of air current intensify heat release because perspiration from the surface of the skin evaporates much quicker.

Feeling of comfort and good mood can be achieved by combining various atmospheric temperatures, humidity and air motion velocity. The optimal factor of this combination at which one feels well is called the comfort zone.

Anemometer is applied for air motion velocity measurement. The principle of anemometer is as follows: under the influence of airflow specially designed spades start rotating which, by means of special device, are connected to a pointer. By rotation of spades the pointer moves on the scale. Air speed is measured per second if the exposition time is known in seconds, and the air speed is calculated according to the curves pointed out in the passport of the device.

Four bowls are used in hand anemometer, which is placed in the upper part of the device. The bowls are heavier than wings therefore this device is used only in those cases when the air speed is more than 1 m/s (usually for meteorological measurements outdoors).

Before air speed measurement is done, the state of scale is fixed. Then the device is switched on and by chronometer the interval of time is checked (exposition time 2–3 minutes). Then the state of scale is fixed again and the difference is calculated. The difference is divided by the exposition time; thus the air speed is detected in meters per second.

The wind is characterized by 2 indices: velocity and streamline (direction) of cardinal point. It is important for medics to know wind influence in that geographic point in which to plan populated areas, project schools, hospitals, factories, stadiums, various polluted by physical, chemical, bacteriological factors objects – fuel filling stations, chemical, pharmaceutical, metal working enterprises.

The graph of wind impact is called rose of wind influence and it is obtained by putting on rhumb line segments the length of which agree to multiplication frequency and velocity of wind expressed in %.

If the air speed is slight (less than 1 m/s), it is detected by thermoanemometer or katathermometer. It is an alcohol thermometer, which has a big reservoir in the lower part and a widening in the upper part of capillary. The katathermometer is heated, and after it is allowed to cool, the cooling rate is rather diverse and dependant on meteoric conditions in the fixed place.

Katathermometer's scale is graded from 35 °C to 38 °C. The amount of heat, that each cm^2 of the surface of katathermometer loses while cooling from 35 °C to 38 °C, is known as a katathermometer factor F. It is stated in the factory and it is written on upper part of the thermometer.

To detect the speed of air motion the alcohol reservoir of a katathermometer is dipped in warm water (80 °C) and heated as long as the alcohol fills up ½ of the capillary widening. Then the katathermometer is dried, installed in the stand

and put in the place where the air speed has to be measured and it is expected to cool down. As soon as the level of alcohol drops down to 38 °C the chronometer is switched on and the cooling time temperature up to 35 °C is fixed. Cooling ability of katathermometer H is calculated according to the formula:

$$H = \frac{F}{t}$$

Katathermometer's cooling ability depends on the air temperature and the air motion velocity.

The next step is to calculate the ratio H/Q, where Q is the difference between katathermometer's working temperature (36.5 °C) and the air temperature in the place of air motion measurement. Air motion velocity is found in *Table II-4*.

3.4. Atmosphere pressure

The man who undergoes changes from the state of normal pressure to low high pressures feels these changes at once. Even when rising above 2 km of the sea level, man experiences heart palpitation, shortness of breath, prostration, dizziness, cyanosis of the face and hands, in some cases bleeding from the nose and gingivitis, i.e., this is the so called "mountain disease". The cause of all these symptoms is due to the lack of oxygen and its insufficiency in blood.

For hygienic purposes, it is essential to know atmosphere pressure hesitations during a definite time. The pressure change depends on different factors in atmosphere and is expected to be weather's messenger. Usually these changes are insignificant and healthy people do not feel those. However, persons with various health disturbances are sensitive.

Patients with rheumatic arthritis, increased nervousness, heart-blood vessels and respiratory tract problems are especially sensitive to the changes in air pressure. It is not so important whether the pressure value increases or decreases, but how quickly it happens. There are medical prognoses in Latvia, which are constructed considering atmospheric pressure hesitations too. For example, there is the fourth expected dangerous prognosis if the pressure change is more than 5 mm Hg within three hours.

There are two types of instruments for measuring pressure: the mercurial and the aneroid barometers. The aneroid barometer is a more commonly used one. Aneroid consists of two metal boxes the upper parts of which are made of glass. There is a small horseshoe-type metal box, which is evacuated from air, inside the instrument. A special mechanism connects the box with a pointer.

The metal box is very sensitive to atmospheric pressure changes. When the pressure increases, it is getting smaller, but when the pressure lowers, the box enlarges. The changes of the box volume are fixed on the scale graded in pascals (Pa) and in mm Hg.

The continuous atmosphere pressure measurement can be done by barograph. It consists of several aneroid boxes connected to an ink pointer. The pressure hesitations are registered on paper, which covers a rotary cylinder.

Table II-4. Air motion velocity, m/s

$\frac{H}{Q}$ *	Air temperature, °C							
	10.0	12.5	15.0	17.5	20.0	22.0	25.0	26.0
0.27	–	–	–	–	0.044	0.047	0.051	0.059
0.28	–	–	–	0.049	0.051	0.061	0.070	0.074
0.29	0.041	0.050	0.051	0.060	0.067	0.076	0.085	0.089
0.30	0.051	0.060	0.065	0.073	0.082	0.091	0.101	0.104
0.31	0.061	0.070	0.079	0.088	0.098	0.107	0.116	0.119
0.32	0.076	0.085	0.094	0.104	0.113	0.124	0.136	0.140
0.33	0.091	0.101	0.110	0.119	0.128	0.140	0.153	0.159
0.34	0.107	0.115	0.129	0.139	0.148	0.160	0.174	0.179
0.35	0.127	0.136	0.145	0.154	0.167	0.180	0.196	0.203
0.36	0.142	0.151	0.165	0.179	0.192	0.206	0.220	0.225
0.37	0.163	0.172	0.185	0.198	0.212	0.226	0.240	0.245
0.38	0.182	0.197	0.210	0.222	0.239	0.249	0.266	0.273
0.39	0.208	0.222	0.232	0.244	0.257	0.274	0.293	0.301
0.40	0.229	0.242	0.256	0.269	0.287	0.305	0.323	0.330
0.41	0.254	0.267	0.282	0.299	0.314	0.330	0.349	0.364
0.42	0.280	0.293	0.311	0.325	0.343	0.361	0.379	0.386
0.43	0.310	0.324	0.342	0.356	0.373	0.392	0.410	0.417
0.44	0.340	0.354	0.368	0.385	0.401	0.417	0.445	0.449
0.45	0.366	0.381	0.398	0.412	0.429	0.449	0.471	0.478
0.46	0.396	0.415	0.429	0.446	0.465	0.483	0.501	0.508
0.47	0.427	0.445	0.464	0.482	0.500	0.518	0.537	0.544
0.48	0.468	0.481	0.499	0.513	0.531	0.551	0.572	0.579
0.49	0.503	0.516	0.535	0.566	0.571	0.590	0.608	0.615
0.50	0.539	0.557	0.571	0.589	0.604	0.622	0.640	0.651
0.51	0.574	0.593	0.607	0.628	0.648	0.666	0.684	0.691
0.52	0.615	0.633	0.644	0.665	0.683	0.701	0.720	0.727
0.53	0.656	0.674	0.688	0.705	0.724	0.742	0.760	0.768
0.54	0.696	0.715	0.729	0.746	0.764	0.783	0.801	0.808
0.55	0.737	0.755	0.770	0.790	0.807	0.825	0.844	0.851
0.56	0.788	0.801	0.815	0.833	0.851	0.867	0.884	0.894
0.57	0.834	0.852	0.867	0.882	0.893	0.915	0.933	0.940
0.58	0.879	0.898	0.902	0.929	0.945	0.959	0.972	0.977
0.59	0.930	0.943	0.957	0.971	0.985	1.001	1.018	1.023
0.60	0.981	0.994	1.008	1.022	1.033	1.044	1.056	1.060

* H – katathermometer's cooling ability.
Q – difference between katathermometer's working temperature (36.5 °C) and the air temperature in the place of air motion measurements.

3.5. Indoor air exchange

The main source of indoor air pollution is man in many cases. The expired air contains less than 21% oxygen and one hundred times more carbon dioxide than the inhaled one (*Table II-5*).

Table II-5. Gases substance in the air

Gas	Inhalation	Expiration
Oxygen O_2, %	21.0	15.4–16.4
Nitrogen N_2, %	78.1	78.3
Carbon dioxide CO_2, %	0.03–0.04	3.4–4.7

The concentration of carbon dioxide in indoor air never reaches the harmful stage for health (more than $3\%_{volume}$). However, besides carbon dioxide man distributes bio-effluents or antropotoxins – products of metabolism. The antropotoxins are a few tens of inorganic and organic compounds mostly with toxic properties.

Besides, the presence of men creates air pollution by microorganisms, viruses, increases concentrations of the dust, of heavy positive ions, temperature and humidity. As a result, as soon as carbon dioxide's concentration surpasses $0.08\%_{volume}$ it is the beginning of various health disturbances: increased blood pressure and skin temperature, fatigue, headache, weakness, reduced mental and physical working ability [1].

It needs ventilation to provide indoors with fresh, good quality air. The ventilation is indoor air exchange – chemically, physically and biologically polluted air is substituted with the clean one. There are natural and artificial air exchanges. The natural air exchange or infiltration happens through chinks, cracks and pores of building materials. It is not constant and depends on the difference of indoor and outdoor air densities: wind direction and velocity. The artificial mechanical air exchange is much more effective.

Older buildings do not have a mechanical ventilation system. While some fresh air may enter through doors, windows and cracks, it is often not enough. And during winter months or when energy conservation measures are implemented, fresh air may be cut off entirely.

New buildings with sealed windows present their own air quality problems, relying solely on mechanical ventilation systems to bring outdoor air into the building and move it to all areas. When the system fails because of contamination, blockage or other problems, air quality may suffer dramatically. To save energy, some buildings use ventilation systems which re-circulate air that has already been heated or cooled. The air is passed through a filter, and sent back out through the building.

But the percentage of fresh air can be as low as 5–10% and in the re-circulated air germs and chemical contaminants multiply, significantly raising both irritation and infection.

To remove fumes and dust from a specific operation, a local exhaust system is used. Examples are the dust control system in a wood shop or ventilation hoods in the chemistry lab. But these systems may create as many problems as they solve. They may be weak, allowing pollutants to escape into the general air supply, or they may pull toxic vapours through an area where people breathe.

Every general ventilation system consists of one or more blowers which collect more air, ducts which carry the air from one place to another, and vents which distribute it. The vents may be either supplying air (income) or removing-exhausting (outcome) it.

To find out what the ventilation effectiveness is, the necessary and the real indoor air exchange frequencies per hour have to be estimated. These are expressed in round numbers.

The necessary air exchange frequency NEF is

$$NEF = \frac{K_n}{K_i},$$

where

K_n – fresh air cubature every hour which needs to keep allowable indoor CO_2 concentration, m^3;

K_i – indoor cubature, m^3.

K_n depends on the number of people and physical load. It is calculated as follows:

$$K_n = a \times \frac{n}{C_{LCO_2} - 0.4},$$

where

a – amount of CO_2 expired by man each hour, h;

n – number of people;

C_{LCO_2} – limited CO_2 concentration, l/m^3;

0.4 – CO_2 concentration in fresh air, l/m^3.

The permissible indoor carbon dioxide concentration is accepted as $0.1\%_{volume}$ or 1 l/cm^3. An adult at comfort conditions with slight physical load expires on average 22.6 l carbon dioxide per hour [1]. A sleeping adult expires 10 l carbon dioxide per hour, but if a man is doing hard physical work, the amount of the expired CO_2 increases to 50–100 l per hour.

Real air exchange frequency REF in case of infiltration is difficult to be estimated. Usually this is calculated by taking into account carbon dioxide amount exchange during an hour.

In case of a mechanical ventilation system, it is naive to estimate the amount of the air passing through the ventilation tubes AA by using the formula:

$$AA = L \times V \times 3600 ,$$

where

L – cross-cut area of tube, m^2;

V – velocity of air flow, m/s.

Real air exchange frequency is calculated as follows:

$$REF = \frac{AA}{K_i} .$$

Flow velocity is measured by anemometer. The living and public building's indoor sufficient air environment is provided if REF = 2–3 times.

3.6. Optical electromagnetic wave band

The optical electromagnetic waves have a great biological meaning. Infra-red rays squeeze in through the man's skin into the tissues and warm them. The skin's blood vessels broaden, and the skin gets red. This property of infra-red rays is used in medicine for treating the inflammations.

Ultra-violet radiation has anti rachitic, bactericidal, erythema forming and pigment creating influence. Rickets, which is still widespread in parts of the globe, is attributable to insufficient exposure to ultra-violet radiation and lack of vitamin D in diet.

Light has a very important role to ensure good health and high working ability. Light activates such physiological processes as growth, circulation of the blood, metabolism, breathing, syntheses of the vitamins, creation of the blood, etc. Light irritates an analyzer of the eyesight and has a strong effect on the head brain crust and on central nervous system tonic. The lighting needed for fine tasks increases significantly with age because of the natural deterioration of eyesight with age. A forty year old man needs twice as much light as a twenty year old man to see an object with the same clarity.

For the characterization of the light, there are used light's stream, light's strength, light's brightness and lighting [3].

Light's stream is a radiation energy which is perceived by human eye as the light. Human eyesight's sensitivity is various to different radiation wave length. It is the most sensitive to yellow-green light (555 nm). Light's stream unit is lumen. 1 lumen = 1.6×10^{-3} W.

In practice light does not spread in all directions regularly. Therefore, for the characterization of a light source it is needed to know the distribution of the light stream density in space. Light stream density in space is defined as light strength, the unit of which is candle-power.

Lighting characterizes the distribution of the light stream density of surface. Lighting is the light stream ratio to a lighted surface area and its unit is lux.

The brightness of light is the only characteristic which a human eye perceives in direct way. Brightness is the power of light which is emitted by a lighted surface area unit into eye.

Of the first magnitude, light's characteristic is lighting. Lighting has to be sufficient and even dispersed. Indoor natural lighting depends on a season, daytime, geographical point, weather, building design, sizes, orientation and clarity of the windows, furniture, etc.

To ensure even dispersion of indoor light, it is necessary to take into consideration a definite ratio between the height and the depth of the space. The distance from a window's till to the inside wall may not be more than double ceiling height in study rooms and in hospital wards. The criterion of the natural lighting sufficiency assessment is the ratio between indoor and outdoor lightings. That ratio could be detected both indirectly and in the direct way.

According to the indirect or geometric method, lighting level of the light coefficient LC is the relationship between a window area WA and floor areas FA:

$$LC = \frac{WA}{FA} .$$

This relationship varies between 1/4 and 1/15 which is dependent on the space's function (kitchen – 1/10; study rooms – 1/5; lodgings – 1/5–1/7; hospital wards – 1/6; operating-rooms – 1/4).

The geometric method is simple and comfortable but the faults are that the method does not take into the consideration indoor constructive sizes, forms of windows, external shade factors and the height of the sun, time of twenty-four hours.

These faults are possible to be minimized by measuring lighting angles in addition. Natural lighting in each point of space is dependent on the light ray's fall and gap angles.

Light's fall angle α (*Figure II-3*) must be no less than 27 degrees. It is detected in the following way: measure the height of the determined place from the floor; mark this height at the window; measure the horizontal distance b as far as the determined place: measure the vertical distance as far as the upper edge of the window pane. The angle value in grades is determined by the help of the table of trigonometric functions.

The gap angle of light γ (*Figure II-4*) must be not less than 5 degrees. It is reduced by increasing the distance from the window and by decreasing the building floor. This angle is detected in the following way: measure the window pane's e upper point projection a_1 of shade element, next detect angle β in the same way as done previously with angle α and the difference between the two is angle γ.

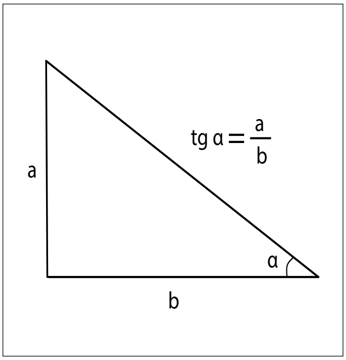

Figure II-3. Light's fall angle α

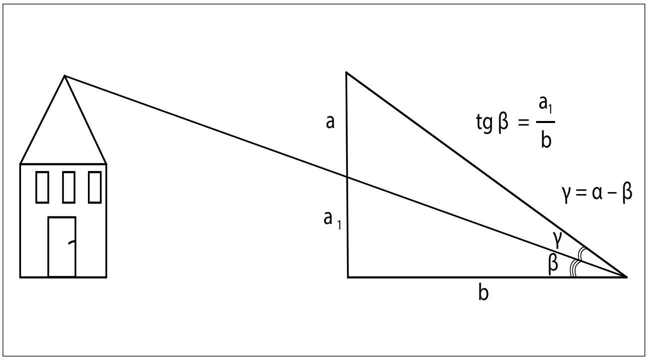

Figure II-4. Light's gap angle γ

The direct technical method is used to calculate natural lighting coefficient NLC:

$$NLC = \frac{L_i}{L_o} \times 100\ (\%)\ ,$$

where

L_i – horizontal lighting in the room's darkest place, in lux;
L_o – outdoor horizontal lighting, in lux.

Natural lighting coefficient must be not less than 0.75% in living rooms, 1.5% in study rooms and in physician, dentist offices, and 2% in operating-rooms.

Lighting is measured by an objective luxmeter, the main components of which are selenium photo element and galvanometer. In the photo element light creates electron stream which is registered on galvanometer.

The orientation of the windows is detected by a compass. By taking into consideration the climate and the altitude of the sun in Latvian geographic situation, it is more favourable if windows are located in the south or south-east.

The window pane's absorbing capacity, in per cent, is calculated by lighting measured outside A_2 and inside A_1 of the glass's surface:

$$GAC = \frac{A_1}{A_2} \times 100\ (\%).$$

Dirty glass absorbs light by 50%, but frozen glass – up to 80% of the visible part of the sun's radiation.

It is necessary to have artificial light if the supply of natural light has been decreased. The indoor artificial light must be sufficient, regularly dispersed, with light spectrum alike emitted by the sun, without an excessive brightness sharp and contrast shadows.

Artificial lighting intensity is measured by luxmeter and it has to be 300 lux at least for reading and writing. The most favourable lighting is 1000 lux in study rooms.

Lighting regularity is determined by the ratio of insufficient lighting place number and all working place number in the space. Lighting of the dark place has to be not less than 3 times weaker than the most common light. It could ensure general indoor lighting at least 10% from the lighting in each working place.

4. HUMAN HEAT EXCHANGE

The organism's thermoregulatory mechanism which provides constant internal body temperature is very complicated. Thermoregulatory abilities are conducted by CNS in combination with heat – regulatory centre, located between two cerebral hemispheres, in hypothalamus area.

Two mutually correlated processes can be determined: heat formation and heat release. There exists a certain balance in the human body between heat formation and heat release (*Figure II-5*) [1].

Heat in the organism originates in two ways. The primary heat originates as a result of respiratory processes of body cells during which the oxidative disintegration of food substances and accumulation of released chemical energy in the way of specific macro energetic combination adenozintriphosphate (ATP) take place. The secondary heat is given off in external working processes. A lot of heat is formed by skeleton muscular system.

Heat release goes side by side with heat formation which is caused by the air physical properties. A naked man exchanges heat with his environment via one or, predominantly, of four physical pathways, conduction K, convection C, radiation R and evaporation E. If body temperature is to remain constant, the net result of his heat exchanges with his environment must be a loss to the environment of an amount of heat equal to his metabolic heat production H. If this balance is not maintained, then the excess heat lost or gained must alter the total body heat content Q and lead to a change in body temperature. Man's conversion of food energy into physical work is not an efficient process and for most activities approximately 80% of metabolic energy production appears as heat. Thus, for a man in heat balance with his environment we may have an equation as follows:

$$H = E + R + C + K + S,$$

where

H – metabolic heat production;

E, R, C, K – rates of heat loss by evaporation, radiation, convection and conduction, respectively;

S – rate of storage of heat in the body.

All quantities may be expressed in watts per square meter of body surface area (W/m^2). A gain of heat by any channel is a negative loss of heat.

Evaporation in humans is the primary means for heat dissipation of sweat. The evaporation of sweat under optimal conditions requires the absorption of about 0.58 kcal/ml [1]. Sustained sweat rates as high as 1 litre/hour have been reported, and thus 580 kcal of heat would be lost, which would be more than adequate for even the most demanding work activities.

With regard to heat balance, it is important to realize that in many industrial situations, the only means for workers to dissipate heat is by evaporation of sweat. Therefore, during heat stress, any time sweat evaporation is hampered, the potential for overheating becomes very serious. Heat loss through sweat evaporation can be hampered in many situations. Sweat evaporation is reduced when the relative humidity level nears 100%, and ambient temperature is near skin temperature.

Convection results in heat by two loss avenues: within the body by blood circulation, and by movement of air across the skin. The transfer of heat by the flow of some liquid or gas is a termed convection and is vital to thermoregulation in the body. This process controls the heat flow between the shell and internal body through the movement of blood.

The role of convective heat transfer by blood flow within the body has been tested as a marker for heat tolerance. It has been hypothesized that when skin temperature was the same as internal body temperature, humans could not continue to act in the heat.

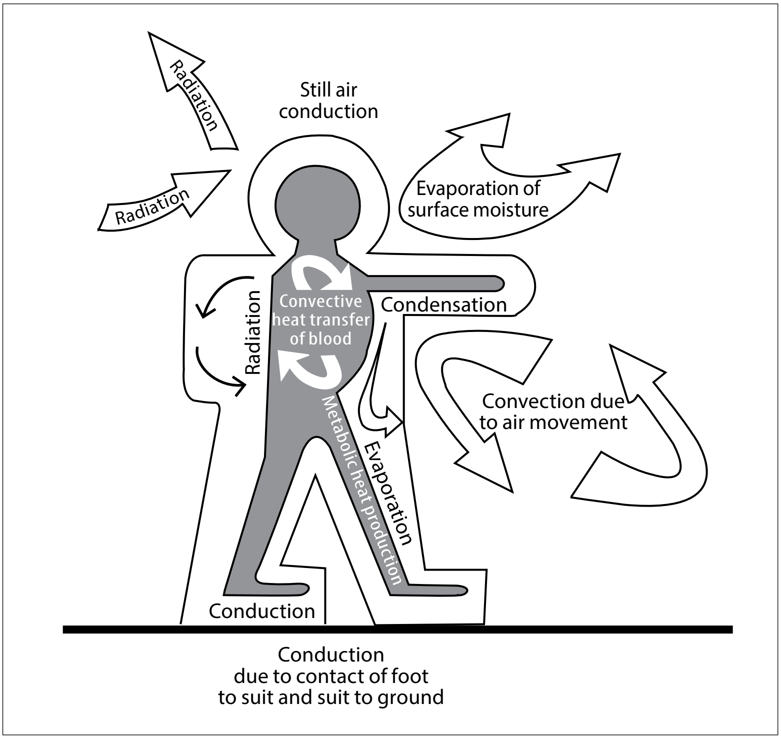

Figure II-5. Thermal factors affecting men in clothing

Heat is produced by the working muscles and metabolic processes; it is carried to the skin through blood flow. From the skin it may be radiated, evaporated, conducted and lost through convection (or in some cases gained) depending on the situation inside the microenvironment. The man plus the suit then reacts with the external environment to gain or lose heat depending on the conditions. The integration of both the micro and macro heat exchanges will determine whether the man´s average body temperature continuously rises or establishes on equilibrium of some higher temperature.

Heat also is transferred by the motion of cooler air across the skin. Convective heat loss can be experienced as the dangerous wind chill in cold environments, or the pleasant cool breeze in warm environments. The importance of convective heat loss is that equilibrium will occur eventually in any situation.

Conductive heat transfer occurs when there is direct contact between a hotter and a colder substance. In most industrial situations conduction of heat to substances other than air is not usually important because there is relatively little contact between the skin and other materials.

Heat radiation is the electromagnetic transfer of heat energy without direct contact. Radiant heating from the sun provides the best illustration. Despite the vacuum of space, sunlight strikes the Earth's surface and is both absorbed and reflected, producing heat. Men in hot environments exposed to high radiant loads will benefit from shielding. This, of course, explains the appeal of shade to those activating in the sun. It is important to recognize that all objects radiate to other object, thus the total thermal radiation to which man is exposed is the sum of all direct and indirect (reflected) radiation, minus the man radiation to cooler objects. For simplicity, when the mean radiant temperature is above about 35 °C, the body will gain heat, whereas below 35 °C, the body loses heat through radiation.

The integration of all the biophysical factors determines the physiological status of the man.

5. TASKS FOR STUDENTS

Seminar: "Air as an environmental factor"

1. Environmental health and medicine – meanings, tasks and methods.
2. Environmental factors, having possible effects on health status. Environmental diseases.
3. Physical properties of air physiological effects, measuring (temperature, humidity).
4. Physical properties of air physiological effects, measuring (motion, pressure).
5. Human heat exchange.
6. Sun's radiation, natural and artificial lighting measuring.
7. The chemical composition of atmospheric air.
8. Ozone and ultraviolet radiation.
9. Ionizing radiation, radon and health.
10. Air pollution. Specific air contaminants.
11. Photochemical smog, acid rain and acid fog.
12. Indoor air exchange measurement.
13. Sick building syndrome and building related diseases.
14. Weather.
15. Climate. Acclimatization.

Solve the situation tasks, or instance:

1. What changes happen in a human body if the air temperature is –30 °C, humidity 30%, air motion 0.5 m/s? Which is the main way of the heat loss?
2. There are 3 patients in ward the windows of which are directed towards the south and its cubature is 60 m^3. The temperature is 18 °C, humidity – 80%, CO_2 concentration in air – 0.15%, air motion – 0.3 m/s.
   What is your conclusion about microclimate's influence on patients? How do patients feel? Give recommendations how to improve living circumstances in the ward.

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Chapter III

WATER AND HEALTH

1. WATER AS AN ENVIRONMENTAL FACTOR

1.1. Significance of water

Water is essential to life. Water has always been an important and life-sustaining drink to humans and is essential to the survival of all known organisms. Universal access to safe drinking water and sanitation is the most fundamental principle necessary to ensure the health and wealth of nations, and there is understandable concern that this could be prejudiced by the unsustainable use and management of water. Many parts of the world are currently well provided with fresh water but it is unevenly distributed between and within countries, and there are shortages in a number of areas.

Water has a very important meaning for mankind ensured that with physiological, hygienic and economic needs. It is a crucial component of metabolic processes and serves as a solvent for many bodily solutes. Water is essential for the growth and maintenance of our bodies, as it is involved in a number of biological processes. Profuse sweating can increase the need for salt replacement. Water intoxication, which results in hyponatremia, the process of consuming too much water too quickly, can be fatal. Water usually makes up 55% to 78% of the human body. We need to drink a minimum of 2 litres per day. After about 4 days without water, a person dies.

The global importance of water, sanitation and hygiene for development, poverty reduction and health is reflected in the United Nations Millennium Declaration. Ensuring poor people's access to safe drinking water and adequate sanitation and encouraging personal, domestic and community hygiene will improve the quality of life of millions of individuals. A better management of water resources to reduce the transmission of vector-borne diseases (such as viral diseases carried by mosquitoes) and to make water bodies safe for recreational and other users can save many lives and has extensive direct and indirect economic benefits, from the micro-level of households to the macro-perspective of national economies.

Almost one tenth of the global disease burden, mainly in the developing countries, could be prevened by water, sanitation and hygiene interventions. Moreover, effective and affordabe interventions have been shown to further reduce this burden significantly. The economic return of investing in improved access to safe drinking water is almost 10-fold. Investing in water management will have dual benefits for health and agriculture.

Approximately 10% of the worldwide annual runoff is used for human necessities. Food and water are two basic human needs. However, global coverage figures indicate that, of every 10 people 5 have a connection to a piped water supply at home, 3 make use of some other sort of improved water supply, such as a protected well or public standpipe, and 2 are not served.

Residents in the towns and cities are generally well supplied with connections to water. In many countries, 100% of the urban population has a home connection to mains drinking water. Because of logistic, political, and cost issues, rural populations are less likely to be connected to mains water supplies.

It is estimated that 8% of worldwide water use is for household purposes [1]. These include drinking water, bathing, cooking, sanitation, and gardening. Recreational water use is usually a very small but growing percentage of total water use. Recreational water use is mostly tied to reservoirs. If a reservoir is kept fuller than it would otherwise be for recreation, then the water retained could be categorized as recreational usage. Release of water from a few reservoirs is also timed to enhance white water boating, which also could be considered a recreational usage. Other examples are anglers, water skiers, nature enthusiasts and swimmers.

It has been found that a fifth of the world's people, more than 1.2 billion, live in areas of physical water scarcity, where there is not enough water to meet all demands [11]. One third of the world's population does not have access to clean drinking water, which affects more than 2.3 billion people. A further 1.6 billion people live in areas experiencing economic water scarcity, where the lack of investment in water or insufficient human capacity makes it impossible for authorities to satisfy the demand for water.

Although some progress has been made over the past decade, coordinated efforts are still needed to ensure that population is supplied with clean drinking water and has access to safe water for recreational activities. The aquatic environment must also be maintained in terms of its access to the chain of information on the monitoring, analysis, and reporting of data that exists in virtually every country is the need to improve the reliability and comparability of data that are being produced to support the assessment and development of water policies.

It is estimated that 69% of worldwide water use is for irrigation, with 15–35% of irrigation withdrawals being unsustainable. It takes around 3000 litres of water, converted from liquid to vapour, to produce enough food to satisfy one person's daily dietary need. This is a considerable amount, when compared to that required for drinking, which is between two and five litres. To produce food for the now over 7 billion people who inhabit the planet today requires the water that would fill a canal ten metres deep, 100 metres wide and 7.1 million kilometres long – that's enough to circle the globe 180 times. As global populations grow, and as demand for food increases in a world with a fixed water supply, there are efforts under the way to learn how to produce more food with less water, through improvements in irrigation methods and technologies, agricultural water management, crop types, and water monitoring. Aquaculture is a small but growing agricultural use of water.

It is estimated that 22% of worldwide water use is industrial. Major industrial users include hydroelectric dams, thermoelectric power plants, which use water for cooling, ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. Water withdrawal can be very high for certain industries, but consumption is generally much lower than that of agriculture.

Water is used in renewable power generation. Hydroelectric power derives energy from the force of water flowing downhill, driving a turbine connected to a generator.

1.2. Water properties

Water is the chemical substance with chemical formula H_2O: one molecule of water has two hydrogenatoms covalently bonded to a single oxygen atom (*Figure III-1*).

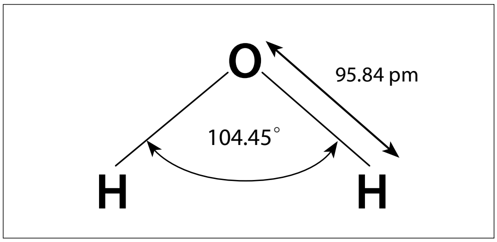

Figure III-1. Chemical formula of water

Like many substances, water can take numerous forms that are broadly categorized by phase of matter. Water is the only common substance found naturally in all three common states of matter and it is essential for all life on Earth. The liquid phase is the most common among all the phases of water. The solid phase of water is known as ice and commonly takes the structure of hard, amalgamated crystals, such as ice cubes, or loosely accumulated granular crystals, like snow. The gaseous phase of water is known as water vapour, and is characterized by water assuming the configuration of a transparent cloud. The fourth state of water that of a supercritical fluid is much less common than the other three and only rarely occurs in nature, in extremely uninhabitable conditions. When water achieves a specific critical temperature and a specific critical pressure, liquid and gas phase merge to one homogeneous fluid phase, with properties of both gas and liquid. Supercritical water is found in the hottest parts of deep water hydrothermal vents, in which water is heated to the critical temperature by scalding volcanic plumes and achieves the critical pressure because of the crushing weight of the ocean at the extreme depths at which the vents are located.

The liquid form at a temperature of 4 °C is denser than the solid form thus water will always accumulate at the bottom of freshwater lakes, irrespective of the temperature in the atmosphere.

Water has a very high specific heat capacity – the second highest among all the hetero atomic species (after ammonia), as well as a high heat of vaporization (40.65 kJ/mol or 2257 kJ/kg at the normal boiling point), both of which are a result of the extensive hydrogen bonding between its molecules. These two unusual properties allow water to moderate Earth's climate by buffering large fluctuations in temperature. The oceans absorb one thousand times more heat than the air and are holding 80% to 90% of the heat of global warming.

The theoretical maximum electrical resistivity for water is approximately 182 kΩ·m at 25 °C. In pure water is a very slight electrical conductivity of 0.055 μS/cm and high static dielectric constant [*Table III-1*].

Table III-1. Water static dielectric constant ε depending on temperature

t °C	0	10	20	30	40	50	60	70	80	90	100
ε	87.9	83.95	80.18	76.58	73.18	69.88	66.76	63.78	60.93	58.2	55.58

Due to the interaction of the forces of adhesion and surface tension, water exhibits capillary action whereby water rises into a narrow tube against the force of gravity. Water adheres to the inside wall of the tube and surface tension tends to straighten the surface causing a surface rise and more water is pulled up through cohesion. The process continues as the water flows up the tube until there is enough water such that gravity balances the adhesive force.

Surface tension and capillary action are important in biology. When water is carried through xylem up stems in plants, the strong intermolecular cohesion holds the water column together and adhesive properties maintain the water attachment to the xylem and prevent tension rupture caused by transpiration pull.

Water is also a good solvent due to its polarity. Many substances dissolve in water and it is commonly referred to as the universal solvent. Because of this, water in nature and in use is rarely pure and some of its properties may vary slightly from those of the pure substance. Substances that will mix well and dissolve in water (e.g. salts) are known as hydrophilic substances, while those that do not mix well with water (e.g. fats and oils), are known as hydrophobic substances. Distilled water has an electrical conductivity of not more than 10 μS/cm and total dissolved solids of less than 10 mg/litre.

1.3. Water resources

Water resources are sources of water that are useful or potentially useful. Uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. 97% of the water on the Earth is salt water (*Figure III-2*). However, only less than three per cent is fresh water. Slightly over two thirds of this is frozen in glaciers and polar caps. Remaining unfrozen fresh water is found mainly as groundwater, with only a small fraction present above ground or in the air. Brazil is the country estimated to have the largest supply of fresh water in the world, followed by Russia and Canada [11].

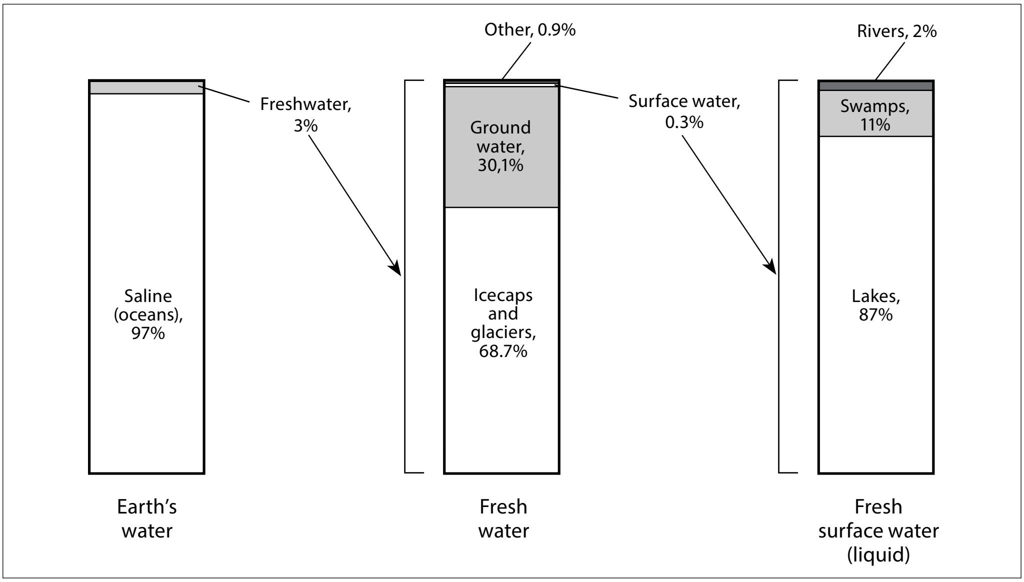

Figure III-2. Distribution of earth's water

In nature, water is constantly circulating. From the surface of the Earth water evaporates in the air, water vapour condenses, returns to the surface as precipitation.

Fresh water is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. Human satisfaction of needs of water for households, irrigation, and its industrial use has increased two times during the few decades. Water demand already exceeds supply in many parts of the world and as the world population continues to rise, so too does the water demand.

Surface water is water in a river, lake, ocean or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, and sub-surface seepage.

Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors also affect the proportions of water loss.

Human activities can have a large and sometimes devastating impact on these factors. The total quantity of water available at any given time is an important consideration. Some human water users have an intermittent need for water. For example, many farms require large quantities of water in the spring, and no water at all in the winter. To supply such a farm with water, a surface water system may require a large storage capacity to collect water throughout the year and release it in a short period. Other users have a continuous need for water, such as a power plant that requires water for cooling. To supply such a power plant with water, a surface water system only needs enough storage capacity to fill in when average stream flow is below the power plant's need.

Nevertheless, over the long term the average rate of precipitation within a watershed is the upper bound for average consumption of natural surface water from that watershed. Humans often increase storage capacity by constructing reservoirs and decrease it by draining wetlands. Humans often increase runoff quantities and velocities by paving areas and channelizing stream flow.

Surface water and groundwater have often been studied and managed as separate resources, although they are interrelated. Surface water seeps through the soil and becomes groundwater. Groundwater can also feed surface water sources.

Most of the groundwater abstracted at the waterworks is used in private households, in institutions or in industry. The supply of healthy and clean drinking water from the waterworks has been a matter of course to the population. Content of inorganic trace elements in groundwater mainly originates from the aquifer material, but also from anthropogenic activity. Due to the increased pollution of the groundwater and the restricted resource, efforts have been made to economize water consumption and hold the population responsible that unnecessary consumption does not occur.

Freshwater resources are continuously replenished by natural processes. About 65% of precipitation on land returns quickly to the atmosphere by evaporation and transpiration [2]. The remainder replenishes surface and underground water as it flows to the sea.

There are many pressures on water resources. They arise from industrialization, the intensification of agriculture, and changes in populations. Surface and underground water sources have a finite capacity for renewal, and societal pressures have an impact on the quality and quantity of the resource. It is essential than both quality and quantity are managed together and that this management is integrated into long term planning and development.

2. WATER POLLUTION

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds. Water pollution affects plants and organisms living in these bodies of water. In almost all cases, the effect is damaging not only to individual species and populations, but also to the natural biological communities.

Water pollution is one of the main concerns of the world today. Sewage, sludge, garbage, and even toxic pollutants are all dumped into the water. Water pollution is the major global problem, which requires on-going evaluation and revision of water resource policy at all levels – international down to individual aquifers and wells. It has been suggested that it is the leading worldwide cause of deaths and diseases and that it accounts for the deaths of more than 14 000 people daily [4]. Approximately 90% of cities in China suffer from some degree of water pollution, and nearly 500 million people lack access to safe drinking water. In addition to the acute problems of water pollution in developing countries, developed countries continue to struggle with pollution problems as well. Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use, such as drinking water, or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish. Natural phenomena such as volcanoes, algae blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water.

Sources of surface water pollution are generally grouped into two categories based on their origin (*Figure III-3*). Point source water pollution refers to contaminants that enter a waterway from a single, identifiable source, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city drainage. Non-point source pollution refers to diffuse contamination that does not originate from a single discrete source. Non-point source pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. A common example is the leaching out of nitrogen compounds from fertilized agricultural lands.

Groundwater contamination is diverse and complex and consists of substances from anthropogenic sources as well as from nature. The natural pollutants largely arise from over-exploitation of groundwater resources. Analysis of groundwater contamination may focus on the soil characteristics and site. Interactions between groundwater and surface water are complex. Consequently, groundwater pollution, sometimes referred to as groundwater contamination, is not as easily classified as surface water pollution. By its very nature, groundwater aquifers are susceptible to contamination from sources that may not directly affect surface water bodies, and the distinction of point vs. non-point source may be irrelevant. A spill or on-going releases of chemical or radionuclide contaminants into soil, located away from a surface water body, may not create point source or non-point source pollution, but can contaminate the aquifer below, defined as a toxin plume.

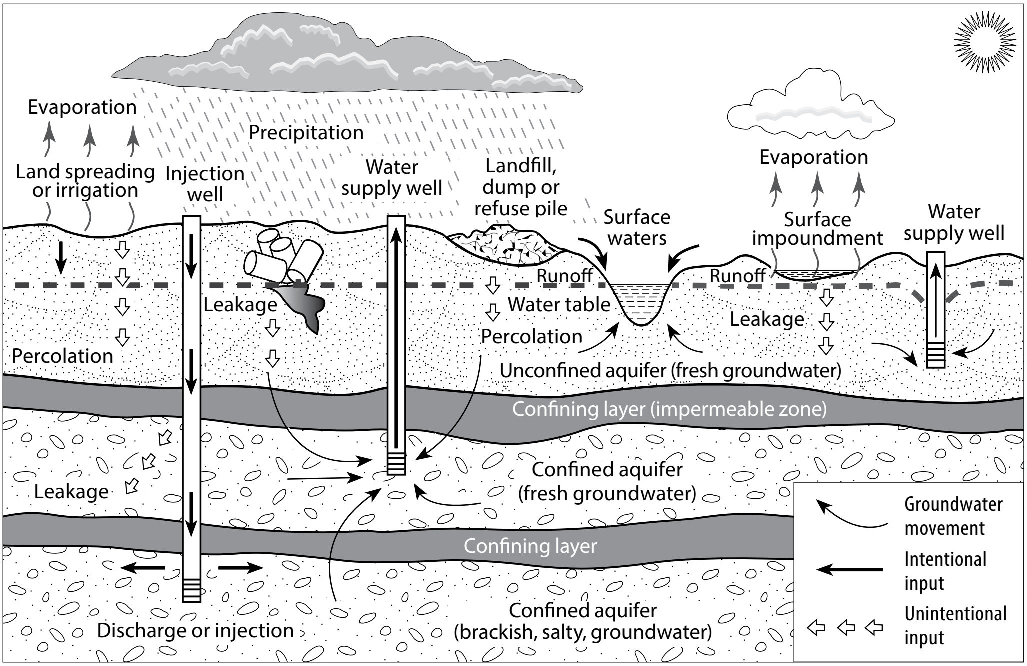

Figure III-3. Sources of water pollution

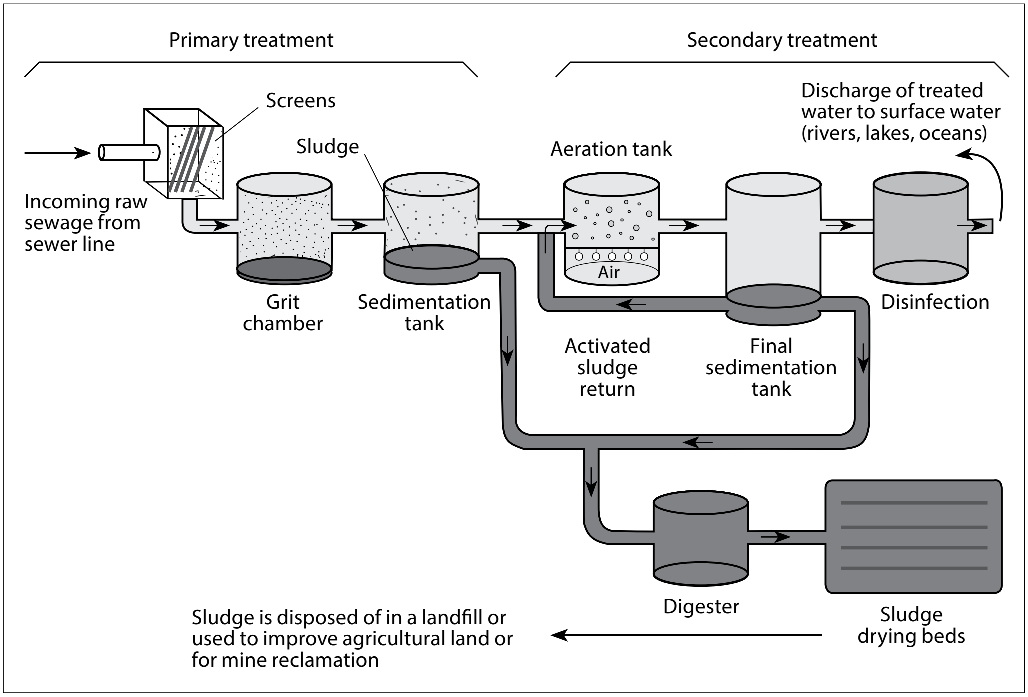

Figure III-4. Sewage treatment plant

The governments of numerous countries have striven to find solutions to reduce this problem. Many pollutants threaten water supplies. There are three levels at sewage treatment plants (*Figure III-4*). In primary treatment (mechanical) sewage is held in settling tanks and solids are allowed to settle out of water and filtrate. In secondary treatment (biological) degradation organics is accomplished by bacteria in anaerobic and aerobic conditions. Tertiary treatment involves chemical separation of nitrates, phosphates and in some cases further action by bacteria ion ponds and filtration.

But the most widespread is the discharge of raw sewage into natural waters. This method of sewage disposal is the most common method in underdeveloped countries, but also is prevalent in quasi-developed countries. Even if sewage is treated, problems still arise. Treated sewage forms sludge, which may be placed in landfills, spread out on land, incinerated or dumped at sea. In addition to sewage, non-point source pollution such as agricultural runoff is a significant source of pollution in some parts of the world, along with urban municipal drainage runoff and chemical wastes dumped by industries and governments.

The specific contaminants leading to pollution in water include a wide spectrum of chemicals, pathogens, and physical or sensory changes such as elevated temperature and discoloration.

2.1. Chemicals as pollutants

A wide range of chemicals has been found in the water but the evidence of their impact on health has often been difficult to identify. Problems of significant chemical contamination are often localized and may arise from natural geological conditions as well as from human activities.

While many of the chemicals and substances that are regulated may be naturally occurring (calcium, sodium, iron, manganese, etc.) the concentration is often the key in determining what a natural component of water is, and what a contaminant is. High concentrations of naturally occurring substances can have negative impacts on aquatic flora and fauna.

Alteration of water's physical chemistry includes acidity, electrical conductivity, temperature, and eutrophication. The latter is an increase in the concentration of chemical nutrients in ecosystem to an extent that increases in the primary productivity of the ecosystem. Depending on the degree of eutrophication, subsequent negative environmental effects such as oxygen depletion and severe reductions in water quality may occur, affecting fish and other animal populations.

Contaminants may include organic and inorganic substances. Inorganic water pollutants include acidity caused by industrial discharges, ammonia from food processing waste, chemical waste as industrial by-products, fertilizers containing nutrients (nitrates and phosphates), heavy metals from motor vehicles.

Concerns about the impact of agriculture on water quality are usually related to issues of the leaching and runoff of chemicals that have been applied to crops and soil. The intensification of agriculture in many areas has resulted in large quantities of inorganic nitrate fertilizers being applied to arable land. These fertilizers compound the problems of excessive plant nutrients, since nitrogen is particularly a problem in coastal waters. The presence of nitrates in surface and groundwater is a problem if the water is to be used as drinking water since limits on the permissible concentrations of nitrates are applied. Countries with a high population density or that use intensive agricultural practices, or both, use greater amounts of nitrate fertilizers compared with countries with low population densities or less intensive agriculture, or both. Although having large numbers of people living together in close proximity simplifies the collection of waste water, disposal of the large amounts of solid and liquid waste generated can compromise the quality of the body of water that receives the waste. Conventional mechanical and biological treatment processes do not remove the plant nutrients (nitrogen and phosphorus) than often cause excessive growth of algae in fresh and coastal waters.

Organic water pollutants include: detergents, disinfection by-products, food processing waste, insecticides and herbicides, petroleum hydrocarbons, including fuels and lubricants and fuel combustion by products, volatile organic compounds, such as industrial solvents, chlorinated solvents, polychlorinated biphenyl, hygiene and cosmetic products.

Oxygen-depleting substances may be natural materials, such as plant matter (e.g. leaves and grass) as well as man-made chemicals. Other natural and anthropogenic substances may cause turbidity which blocks light and disrupts plant growth, and clogs the gills of some fish species.

Many of the chemical substances are toxic. Pathogens can produce water-borne diseases in either human or animal hosts. Many chemicals undergo reactive decay or chemically change especially over long periods of time in groundwater reservoirs. A noteworthy class of such chemicals is the chlorinated hydrocarbons such as trichloroethylene (used in industrial metal degreasing and electronics manufacturing) and tetrachloroethylene used in the dry cleaning industry (note latest advances in liquid carbon dioxide in dry cleaning that avoids all use of chemicals). Both of these chemicals, which are carcinogens themselves, undergo partial decomposition reactions, leading to new hazardous chemicals (including dichloroethylene and vinyl chloride).

Dissolved organic matter in groundwater occurs where organic material is found in the aquifers. A high content of dissolved organic matter excludes the groundwater from being abstracted by the waterworks due to colour and taste.

Contamination of groundwater with pesticides and their metabolites has been an increasing problem. Not only for the general agricultural use of pesticides, but also the use of particularly herbicides for weed control both for domestic purposes and along roads and railways, have been shown to be major sources for pesticide contamination of the groundwater. The major contaminants in groundwater are chlorinated aliphatic hydrocarbons from waste site and industrial areas; aromatic hydrocarbons from oil and gasoline spills and waste sites; pesticides from agricultural and urban areas; nitrate from agricultural areas; unspecific organic matter, i.e. humus substances and fulvid acids from old moors; salt contamination due to over-exploitation of groundwater. Fluoride occurs in old deep and stagnant groundwater, typically in chalk aquifers, but also in more are aquifer types like green sand and sandstone, containing the clay mineral glauconite.

Groundwater pollution is much more difficult to abate than surface pollution because groundwater can move great distances through unseen aquifers. Non-porous aquifers such as clays partially purify water of bacteria by simple filtration (adsorption and absorption), dilution, and, in some cases, chemical reactions and biological activity.

2.2. Microorganisms as pollutants

In many parts of the world the only sources of water are from small streams often directly contaminated by sewage. The most common contamination of raw water sources is from human sewage and in particular human faecal pathogens and parasites. High levels of pathogens may result from inadequately treated sewage discharges. This can be caused by a sewage plant designed with less than secondary treatment (more typical in less-developed countries). In developed countries, older cities with aging infrastructure may have leaky sewage collection systems (pipes, pumps, valves), which can cause sanitary sewer overflows. Some cities also have combined sewers, which may discharge untreated sewage during rain storms. Pathogen discharges may be caused by poorly managed livestock operations. Contamination of water by microbiological pathogens such as enteropathogenic strains of *Escherichia coli* and the protozoan cryptosporidium from farm wastes and animal slurries is also a concern.

The number of micro-organisms discharged (even though 90–99% may be removed) usually renders the receiving water unfit for recreational purposes. Coliform bacteria are a commonly used bacterial indicator of water pollution, although not an actual cause of disease. Other microorganisms sometimes found in surface waters which have caused human health problems include: *Burkholderiapseudomallei*, *Cryptosporidium parvum*, *Giardia lamblia*, *Salmonella*, *Novovirus* and other viruses, parasitic worms (helminth).

2.3. Thermal pollution

Thermal pollution is the rise or fall in the temperature of a natural body of water caused by human influence. Thermal pollution, unlike chemical pollution, results in a change in the physical properties of water. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. Elevated water temperatures decreases oxygen levels which can kill fish and affects ecosystem composition, such as invasion by new thermophilic species. Urban runoff may also elevate temperature in surface waters.

2.4. Radioactive pollution

Radioactive contamination of the aquatic environment may result in ingestion doses by three pathways: drinking of freshwater from both surface and ground sources, consumption of biota living in the water, typically fish, and consumption of terrestrial foods that have been contaminated by the use of freshwater for irrigation, by application of sediments as soil conditioners, or by the application of aquatic plants as fertilizer. Water consumed by animals may also form a pathway for the transfer of radionuclides to the human diet. Shoreline deposits of contaminated sediments can contribute to external exposures. Radioactive material released to the aquatic environment is transported and dispersed by advective and turbulent processes occurring in the water body. Interactions between radionuclides and suspended matter and sediments may remove radionuclides from the solution. It is convenient to consider separate categories of water bodies for modelling the behaviour of radioactive material: lakes, rivers, groundwater, coastal seas, and oceans.

2.5. Water-borne diseases

Over large parts of the world, humans use water sources contaminated with disease vectors, pathogens or unacceptable levels of toxins. Using such water in food preparation leads to widespread acute and chronic illnesses and is a major cause of death and misery in many countries. Reduction of water-borne diseases is a major public health goal in developing countries [10].

Diarrhoea is caused mainly by the ingestion of pathogens, especially in unsafe drinking-water, in contaminated food or from unclean hands. Inadequate sanitation and insufficient hygiene promote the transmission of these pathogens. 88% of cases of diarrhoea worldwide are attributable to unsafe water, inadequate sanitation or insufficient hygiene. These cases result in 1.5 million deaths each year, most being the deaths of children. The category “diarrhoea” includes some more severe diseases, such as cholera, typhoid and dysentery, all of which have related faecal-oral transmission pathways [5].

Childhood underweight causes about 35% of all deaths of children under the age of five years worldwide. An estimated 50% of this underweight or malnutrition is associated with repeated diarrhoea or intestinal nematode infections as a result of unsafe water, inadequate sanitation or insufficient hygiene. Underweight children are also more vulnerable to almost all infectious diseases and have a lower prognosis for full recovery. The disease burden related to this indirect effect on deaths from infectious diseases is an order of magnitude higher than the disease burden related to the direct effects of malnutrition. The total number of deaths caused directly and indirectly by malnutrition induced by unsafe water, inadequate sanitation and insufficient hygiene is therefore 860 000 deaths per year in children under five years of age [9].

Lymphatic filariasis is transmitted by mosquito vectors breeding in water polluted by organic material, and its distribution is therefore linked to urban and per urban areas. In Africa, where *Anopheles* mosquitoes are the main vector, its distribution coincides in part with that of malaria and may be linked to irrigation development.

Trachoma is a contagious eye disease that can result in blindness. In practice, the burden caused by blinding trachoma can be almost fully attributed to unsafe water.

Schistosomiasis is caused by contact with water bodies contaminated with the excreta of infected people. Its distribution is linked to the distribution of the aquatic snails that are the intermediate hosts of the parasitic trematode flatworms.

The transmission of malaria varies widely over space and time [7]. In some places, where mosquito vectors have specific ecological breeding requirements, transmission of malaria can be interrupted by reducing vector habitats, mainly by eliminating stagnant water bodies, modifying the contours of reservoirs, introducing drainage or improving the management of irrigation schemes. Onchocerciasis is a disease caused by a parasitic worm and transmitted through the bites of infected black flies.

Globally, improving water, sanitation and hygiene has the potential to prevent at least 6% of all deaths. It is clear that people in the developing world need to have access to good quality water in sufficient quantity, water purification technology and availability and distribution systems for water. The stabilization in water consumption has enabled the water suppliers to move the focus from water quantity to water quality.

Without effective water treatment, a cooling water system can suffer from scale formation, corrosion and fouling and may become a breeding ground for harmful bacteria such as *Legionella* causing a risk to public health – cause Legionnaires' disease. Water-borne diseases are estimated to have caused 1.8 million deaths each year. These deaths are attributable to inadequate public sanitation systems and in these cases, proper sewerage [8].

In order for the decrease of water-borne diseases to have long term effects, water treatment programmes implemented in developing countries must be sustainable by their citizens. Sewage treatment is the process that removes the majority of the contaminants from wastewater or sewage and produces both a liquid effluent suitable for disposal to the natural environment and sludge. To be effective, sewage must be conveyed to a treatment plant by appropriate pipes and infrastructure and the process itself must be a subject to regulation and controls. Some wastewaters require different and sometimes specialized treatment methods. At the simplest level, treatment of sewage and most wastewaters is carried out through separation of solids from liquids, usually by sedimentation. By progressively converting dissolved material into solids, usually a biological flake, which is then settled out, and an effluent stream of increasing cleanness is produced. Biological processes are employed in the treatment of wastewater and these processes may include, for example, aerated lagoons, activated sludge or slow sand filters.

3. DRINKING WATER

For many years water supply was to the consumer just a matter of turning the tap and drinking the water directly from it. A continuous supply of drinking water of good quality and taste in sufficient quantities is the primary obligation for the water suppliers towards the consumers. The water was very cheap, and the word pollution, in relation to chemical substances, was not invented. The water supply utility was more or less invisible to the consumer.

Drinking water or potable water is water safe enough to be consumed by humans or used with low risk of immediate or long term harm. In most developed countries, the water supplied to households, commerce and industry meets drinking water standards, even though only a very small proportion is actually consumed or used in food preparation. Typical uses for other than potable purposes include toilet flushing, washing and landscape irrigation.

The amount of drinking water varies with the individual, as it depends on the condition of the subject, the amount of physical exercise, and on the environmental temperature and humidity.

3.1. Drinking water quality demands

World Health Organization (WHO) guidelines are generally followed throughout the world for drinking water quality requirements [11]. In addition to the WHO guidelines, each country or territory or water supply body can have their own guidelines in order for consumers to have access to safe drinking water.

Parameters for drinking water quality typically fall under two categories: chemical/physical and microbiological [1].

Chemical parameters tend to pose more of a chronic health risk through build-up of heavy metals although some components like nitrates/nitrites and arsenic can have a more immediate impact. Physical parameters affect the aesthetics and taste of the drinking water and may complicate the removal of microbial pathogens. Good drinking water should have a temperature of 8–10 °C to make it fresh and attractive. Higher temperatures exacerbate taste and odour problems and may deteriorate the microbiological quality. These problems are also caused by long residence times in installations where consumption is low in relation to the dimensions of the installations.

There is increasing concern over the health effects of engineered nanoparticles released into the natural environment. One potential indirect exposure route is through the consumption of contaminated drinking waters. The study explored the potential for engineered nanoparticles contaminate drinking water supplies and to establish the significance of the drinking water exposure route compared to other routes of exposure.

Microbial pathogenic parameters are typically of greatest concern because of their immediate health risk. Faecal contamination was determined with the presence of coliform bacteria, a convenient marker for a class of harmful faecalpathogens.

3.1.1. Microbiological quality

Microbiological parameters include coliform bacteria, specific pathogenic species of bacteria, viruses, and protozoanparasites. The presence of faecal coliforms like *Escherichia coli* serves as an indication of contamination by sewage. Additional contaminants include protozoanoocysts such as *Cryptosporidium sp.*, *Giardia lamblia*, *Legionella*, such as cholera-causing *Vibrio cholerae*, and enteric viruses.

Water intended for drinking must not contain water-borne pathogens. Because the most numerous and the most specific bacterial indicator of faecal pollution from humans and animals is *Escherichia coli*, it follows that *Escherichia coli* or thermo tolerant coliform organisms must not be present in 100-ml samples of any water intended for drinking.

Bacteriological quality of drinking water in Latvia is evaluated by bacteria *Clostridium perfringens, Pseudomonas aeroginosa, Escherichia coli,* total coliform bacteria, and number of microorganisms colonies. There are differences in normative values for central (tap water) and local (well, spring water) drinking water supply systems and for bottled (commerce) water because of various whys and wherefores (*Table III-1*).

3.1.2. Chemical quality

In terms of mineral nutrients intake, it is unclear what the drinking water contribution is. There is a variety of trace elements present in virtually all potable water, some of which play a role in metabolism. For example, sodium, potassium and chloride are common chemicals found in small quantities in most waters, and these elements play a role (not necessarily major) in body metabolism. Other elements such as fluoride, while beneficial in low concentrations, can cause dental problems and other issues when present at high levels.

Magnesium, calcium and other nutrients in water can help to protect against nutritional deficiency. Recommendations for magnesium have been put at a minimum of 10 mg/l with 20–30 mg/l optimum; for calcium a 20 mg/l minimum and a 40–80 mg/l optimum, and total water hardness (adding magnesium and calcium) of 2–4 mmol/l. At water hardness above 5 mmol/l, higher incidence of gallstones, kidney stones, urinary stones, arthrosis, and arthropathies have been observed.

Fluoride is an essential trace mineral that is present in minute amounts in nearly every human tissue but is found primarily in the skeleton and teeth. Fluoride increases the deposition of calcium, thereby strengthening the bones. Fluoride also helps to reduce the formation of acid in the mouth caused by carbohydrates, thereby reducing the likelihood of decayed tooth enamel. Fluoride deficiency increases the incidence of dental caries. Although traces of fluoride are beneficial to the body, excessive amounts are definitely harmful. Excessive fluoride leads to mottling of teeth and in severe cases to bone damage. Fluorine can destroy the enzyme phosphatase, which is vital to many body processes including the metabolism of vitamins.

Toxic levels occur when the content of fluorine in drinking water exceeds 1.5 parts per million. Calcium is an antidote for fluoride poisoning. Dental fluorosis may occur at fluoride concentrations of 2 to 8 ppm, osteosclerosis, at 8 to 20 ppm. Higher levels can depress growth, cause calcification of the ligaments and tendons, and bring about degenerative changes in the kidneys, livers, adrenal glands, heart, central nervous systems, and finally the reproductive organs. The average adult may ingest 1.0 to 1.5 milligrams from drinking and cooking water containing 1 part per million (ppm) of fluoride.

For fluoride the concentration recommended for dental health is 0.5–1.0 mg/l, with a maximum guideline value of 1.5 mg/l to avoid dental fluorosis [3]. The limit level of fluorine ion in the drinking water changes from 1.5 mg/l in north regions to 1.0 mg/l in south regions, but not less than 0.5–0.7 mg/l. However, in Estonia 25–35% of samples of drinking water analysis exceeded this standard. In Sweden, where fluoride occurs naturally, an estimated 2.4% of the population is exposed to concentrations higher than the standard.

The chemical quality of drinking water is evaluated in the same way as bacteriological quality and is different for central and local water supply system. Chemicals may affect organoleptical and toxic properties of water. If there are more the non-toxic chemical substances in drinking water, following consideration have to be taken in mind:

$$\frac{C_1}{MPC_1} + \frac{C_2}{MPC_2} + \ldots + \frac{C_n}{MPC_n} \leq 1 ,$$

where

C_1, C_2, C_n – identified concentrations of chemicals, mg/l;

MPC_1, MPC_2, MPC_n – maximum permissible concentrations for each chemical, mg/l that causes not direct or indirect, harmful or unpleasant effects to human.

An important indicator is the amount of organic compounds in drinking water, because organic substances are a good basis for breeding of microorganisms. The water oxidation number (WON) is the amount of oxygen in mg which is needed to oxidize organic substances in 1 litre water. Destruction products of organic substances are ammonia, nitrite, nitrate, chloride, sulphate. Ammonia significance lies in the fact that in indicates, the presence of decomposing organic polluter matter which may be infected. High ammonia values signify recent pollution, that is, within a period of time which has not allowed oxidation. Nitrites never accumulate to any extent in water because they are soon oxidized to nitrates, the final and stable form of mineralization of organic nitrogen. Nitrites represent a transitional stage of decomposition between ammonia and nitrates. Nitrites, when high, suggest bacterial activity. Nitrites are an index, just as the presence of coliform organisms is an index.

Nitrates represent the final stage in the mineralization or oxidation of nitrogen originally present in organic compounds. Nitrates are used as food by plants for the up-building of new protein.

In some countries large numbers of people drink water that contains higher concentrations of nitrates than are safe. Generally, rural populations are more at risk than urban. Nitrate can be reduced to nitrite in the body and may cause juvenile metahemoglobinemia. Few countries keep records of this disease, and most reported cases are associated with well water, which often comes from shallow wells affected by agricultural activities.

High concentrations of WON and above mentioned destruction productions give evidence about constant organic water pollution process. If there is increase only in WON and ammonia, it means that there is accidental, fresh water pollution, but if there is only nitrate, that means there is very old water pollution.

Chemical parameters also include toxic metals, trace organic compounds, and turbidity, taste, colour, odour. Arsenic is a known human carcinogen, which is associated with skin cancer. It occurs naturally in high concentrations in South Eastern Europe. Chemical precipitation technology is now used to remove arsenic from drinking water in areas where there is no alternative supply.

Concerns about the potential health effects of dissolved lead have resulted in considerable efforts being made to reduce concentrations in drinking water. Raised lead concentrations occur naturally in only a few areas. The usual source of lead contamination is pipes used in plumbing, and replacement of these is the only long term strategy. A reduction in the capacity of water to dissolve lead can be achieved by dosing with orthophosphate or by adjusting the pH from acid to alkaline, or both. Demands of drinking water in Latvia are given in *Table III-2*.

Table III-2. Drinking water quality demands in Latvia

Microbiological indicators	MPN*
For tap water	
Escherichia coli	0/100 ml
Enterococci	0/100 ml
For bottled water	
Escherichia coli	0/250 ml
Enterococci	0/250 ml
Pseudomonas aeroginosa	0/250 ml
22 °C – m. o. colonies	100/ml
37 °C – m. o. colonies	20/ml
For local supply water	
Total coliform bacteria	2/100 ml
Escherichia coli	0/100 ml
22 °C – m. o. colonies	300/ml

(cont. on p. 70)

Table III-2 continued. Drinking water quality demands in Latvia

Chemical indications	MPC**
For tap water	
Vinylchloride	0.5 mkg/l
Arsenic	10.0 mkg/l
Benzene	1.0 mkg/l
Benzopyrene	0.01mkg/l
Mercury	1.0 mkg/l
Cadmium	5.0 mkg/l
Pesticide (summary)	0.5 mkg/l
Selenium	10.0 mkg/l
Lead	10.0 mkg/l
Copper	2.0 mg/l
Fluoride	1.5 mg/l
Nitrate	50.0 mg/l
Nitrite	0.5 mg/l
Control indications	**MPC****
For tap water	
Aluminium	0.2 mg/l
Ammonium	0.5 mg/l
Total coliform bacteria	0/100 ml
Clostridium perfringens	0/100 ml
Turbidity	Without essential changes
Taste	Without essential changes
Colour	Without essential changes
Odour	Without essential changes
Chloride	250 mg/l
Sodium	200 mg/l
Sulphate	250 mg/l
Iron	0.2 mg/l
Manganese	0.05 mg/l
WON	5.0 mg 0_2/l
Hydrogen ion concentration	6.5–9.5 pH units
For local supply water	
Turbidity	Without essential changes
Taste	Without essential changes
Colour	Without essential changes
Odour	Without essential changes
Ammonium	0.5 mg/l
Nitrite	0.5 mg/l
Nitrate	50.0 mg/l
Chloride	30.0 mg/l
Sulphate	80.0 mg/l
WON***	8.0 mg 0_2/l
Iron	0.4 mg/l
Aluminium	0.5 mg/l
Manganese	0.2 mg/l
Fluoride	1.5 mg/l

* MPN – maximum permissible number;
** MPC – maximum permissible concentration;
*** WON – water oxidation number.

3.2. Obtaining drinking water

Today, most consumers get their drinking water from three main sources: central municipal water (tap water), local water (well's water), and bottled water (commerce water).

Tap water, delivered by domestic water systems in developed nations, refers to water piped to homes and delivered to a tap or spigot. For these water sources to be consumed safely they must receive adequate treatment and meet drinking water regulations. Plumbing can require significant capital investment. Some systems suffer high operating costs. Leakage water from pipes reduces access to water. Leakage rates of 50% are not uncommon in urban systems. Local water's wells (well's water) have to be checked annually for harmful bacteria. Drinking water of a variety of qualities is bottled. Bottled water is a safe, refreshing, convenient, and consistently reliable beverage choice. Bottled water is sold for public consumption throughout the world.

Finding and distributing clean drinking water has been a challenge globally for many centuries. People need to have access to good quality water in sufficient quantity, water purification technology and availability, and distribution systems for water.

Water treatment describes those processes used to make water more acceptable for a desired end-use. These can include use as drinking water, industrial processes, medical and many other uses. The goal of all water treatment process is to remove existing contaminants in the water, or reduce the concentration of such contaminants so the water becomes fit for its desired end-use. To produce drinking water purification is the removal of contaminants from untreated water that is pure enough for the most critical of its intended uses, usually for human consumption. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, minerals such as iron, manganese and sulphur, and other chemical pollutants such as fertilisers.

The processes involved in treating water for drinking purpose may be solids' separation using physical processes such as settling and filtration, and chemical processes such as disinfection and coagulation.

The following processes are used for municipal drinking water treatment worldwide:

- pre-chlorination for algae control and arresting any biological growth;
- aeration – along with pre-chlorination for removal of dissolved iron and manganese;
- coagulation for flocculation;
- coagulant aids, also known as polyelectrolytes to improve coagulation and for thicker floc formation;
- sedimentation for solids separation, that is, removal of suspended solids trapped in the floc;
- filtration for removing particles from water;
- desalination for removing salt from the water;
- disinfection for killing bacteria.

Measures taken to ensure water quality not only relate to the treatment of the water, but to its conveyance and distribution after treatment as well. It is therefore a common practice to have residual disinfectants in the treated water in order to kill any bacteriological contamination during distribution.

Drinking water has varying characteristics depending on the water's source. Freshwater for treatment drinking water is available in almost all populated areas of the earth, although it may be expensive and the supply may not always be sustainable. Sources where water may be obtained include: ground sources such as underground water, wells, springs, aquifers; surface water such as lakes, rivers, streams, glaciers; precipitation water which includes rain, hail, snow, fog; the sea water through desalination technology.

Spring water is groundwater that rises to the ground surface. Springs are often used as sources for bottled waters. Additionally, most water contains naturally occurring dissolved minerals and chemicals, which within set limits are safe to consume.

The type and degree of treatment required to make water wholesome differs depending on the quality of the source. Good quality groundwater often requires no treatment other than disinfection, but other sources may be contaminated with nitrates, pesticides, solvents, pathogens, etc.

Distilled water has been the most common form of purified water, but the lack of naturally-occurring minerals in distilled water has raised some concerns. Distillation removes all minerals from water, and the membrane methods of reverse osmosis and nanofiltration remove most, or virtually all, minerals. This results in demineralized water which has not been proven to be healthier than drinking water. The World Health Organization investigated the health effects of demineralized water, and its experiments in humans found that demineralized water increased diuresis and the elimination of electrolytes, with decreased serum potassium concentration. Demineralized water may also increase the risk from toxic metals because it more readily absorbs them, and because the presence of calcium and magnesium in water can prevent absorption of lead and cadmium.

Water filtration devices are becoming increasingly common in households. Most of these devices do not distil water, though there continues to be an increase in consumer-oriented water distillers and reverse osmosis machines being sold and used. Municipal water (tap water) supplies often add or have trace impurities at levels which are regulated to be safe for consumption.

There is the use of ozone, ultra-violet rays, ultra-sound, gamma radiation, chlorine, boiling at 100 °C for water disinfection, but water can also be purified by other processes including reverse osmosis, carbon filtration, microfiltration, ultrafiltration, or electrodialysis. Combination of the above processes has come into use to produce water of such high purity that its trace contaminants are measured in parts per million (ppm) or parts per billion (ppb).

The simplest disinfection method is chlorination. Chlorine, which is an oxidizing agent, is a commonly used water disinfectant. The amount of chlorine necessary to provide adequate protection must satisfy the chlorine demand of organic and other oxidiseable material (microorganisms too) in the water and provide a residual chlorine concentration which ensures proper disinfection. The advantages of disinfection with chlorine – reagents are easily approached and cheap, and the procedure is simple and is not long. The faults – procedure results in toxic substances and has no influence on viruses and spore forms of bacteria. Ozone is a more effective disinfectant than chlorine but it decomposes quite soon. To prevent microbial growth in the water distribution system, light chlorination of water are using. There is universal scheme of drinking water treatment (*Figure III-5*) [2], which many states of European Union is used.

In emergency situations, when conventional treatment systems have been compromised, water borne pathogens may be killed or inactivated by boiling but this requires abundant sources of fuel, and can be very onerous on consumers, especially where it is difficult to store boiled water in sterile conditions and is not a reliable way to kill some encysted parasites such as *Cryptosporidium* or the bacterium *Clostridium*.

In cases, when the drinking water supply in hospitals or in others public places, is interrupted, it is necessary to obtain drinking water of short duration by chemical and bacteriological purification by water personnel themselves. It is a duty, or a task of physicians to manage this enterprise.

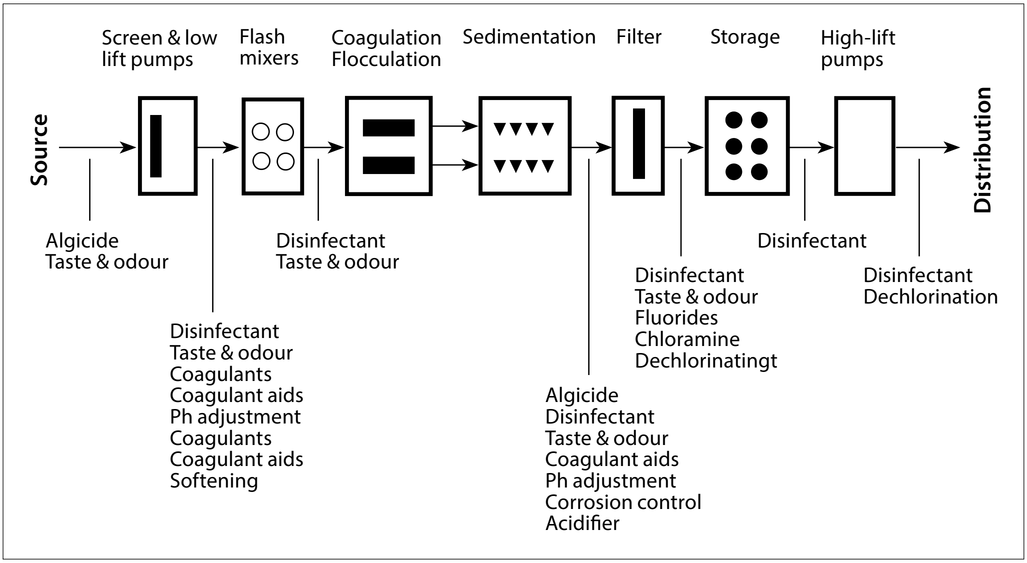

Figure III-5. Scheme of drinking water treatment

Purification is designed to remove turbidity, colour, taste, and odour, as well as to disinfect water. In water purification, coagulation by chemicals, such as aluminium sulphate, ferric chloride, is followed by sedimentation for a period of time during which the flocculent particles are allowed to settle.

Ca and Mg bicarbonates react with $Al_2(SO_4)_3$ and in this reaction are formed hydroxides which settle together with colloid particles and other pollution. The amount of aluminium sulphate is counted after bicarbonate hardness of water.

Determination of bicarbonate hardness

- 100 ml of polluted water + 3 drops methylorange indicator.
- Titrate with 0.1N HCl till colour change (very slight pink).
- Calculate hardness H.

$$H = 2.8 \times {}^\circ T ,$$

where

2.8 – coefficient;

°T – 0.1N HCl in ml.

Experimental coagulation

- In each of three glasses with 200 ml water add 1% $Al_2(SO_4)_3$ in ml as follows:

$$1^{st} \text{ glass: } X \text{ ml} = 0.8 \times H ,$$

where

0.8 – coefficient;

H – hardness;

e.g.: H = 6 °; X ml = 0.8 × 6 = 4.8 ml 1% $Al_2(SO_4)_3$ solution.

$$2^{nd} \text{ glass: } Y \text{ ml} = X \text{ ml} - 0.8 ;$$

e.g.: X ml = 4.8 ml; Y ml = 4.8 – 0.8 = 4.0 ml 1% $Al_2(SO_4)_3$ solution;

$$3^{rd} \text{ glass: } Z \text{ ml} = Y \text{ ml} - 0.8 ;$$

e.g.: Y ml = 4.0 ml; Z = 4.0 ml – 0.8 = 3.2 ml 1% $Al_2(SO_4)_3$ solution.

- Stir contents of the glasses and after 10 minutes observe in which glass greater turbidity white flakes has appeared.

Calculation dose of coagulant need for 1 m³ water purification

$$A = \frac{1000}{0.2} \times B ,$$

where

1000 – l (litres) in 1 m³;

0.2 – amount of water in glass, expressed in l (litres);

B – amount of coagulant need for 0.2 l water;

e.g.: white flakes appeared in 2nd glass, where has been added 4.0 ml 1% $Al_2(SO_4)_3$ solution which contains 40 mg $Al_2(SO_4)_3$ solid:

$$A = \frac{1000}{0.2} \times 40 = 200\ 000 \text{ mg coagulant.}$$

The disinfection is made usually by chlorine lime – $Ca(OH)_2$, $CaCl_2$, $Ca(OCl)_2$ or concentrated active chlorine solution, and the process runs for ~ 50 minutes. The fresh chlorine lime contains 30–34% of active chlorine, but for chlorination it has to be at least 20%. Enough concentrated solution contains 20% active chlorine.

The active part in chlorine lime – calcium hypochlorite – reacts with water very easily and results in hypochloric acid which destructs to atomic oxygen and active chlorine. The latter both participate in process of chlorination and provide for bacteriological effect:

$$Ca\,(OCl)_2 + 2H_2O \rightarrow Ca(OH)_2 + 2HClO$$

$$2HClO \rightarrow Cl_2 + O + H_2O$$

There are two ways of the chlorination: by small or normal chlorine doses, or by large chlorine doses – hyperchlorination.

In case of the hyperchlorination, 10–30 mg active chlorine is added on 1 l water and after the decreasing of active chlorine till to 0.2–0.5 mg/l it has carried out.

Hyperchlorination

- 1 ml of chlorine concentrate solution dissolve in 100 ml distillate water, then take 1 ml this dilute solution ("100 × dil. conc. Cl") and dilute till to 100 ml again.
- 1 ml 0.1N HCl add to all solution (100 ml).
- Add ~ 20 crystals KJ and 1 ml starch solution.
- Blue colour solution titrate with 0.7% Na_2S_2.

1 ml – 1 mg active chlorine;

e.g.: for titration is used 1.5 ml 0.7% $Na_2S_2O_3$ solution,

i.e. $\frac{1.5 \times 1}{1}$ mg active chlorine, or $0.0015 \cdot 100 \cdot 100 = \%$,

i.e. 15% active chlorine in concentrated solution, where 0.0015 – amount of active chlorine in 1 ml 10^4 (100 × 100) dilute chlorine concentrated solution, expressed in g.

If we accept the dose 20 mg active chlorine which is necessary on 1 l water disinfection, then have to weigh $\frac{20 \times 100}{15}$ mg, i.e. 133.3 ml concentrated chlorine solution add to each 1 l water. After contact time 50 min., determine active chlorine in 100 ml water again. The decreasing of active chlorine is carried out with $Na_2S_2O_3$ (sodium hyposulphite):

1 mg active chlorine – 3.5 mg sodium hyposulphite

e.g.: for titration is used 9.9 ml 0.7% $Na_2S_2O_3$,

i.e. $(\frac{9.9 \times 1 \times 1000}{1 \times 100} - 0.5) \times 5.5 = 344.75$ mg sodium hyposulphite / 1 l.

Conclusion: for decreasing active chlorine concentration after disinfection for 1 litre water is needed 344.75 mg sodium hyposulphite.

Chlorination with normal doses

- 200 ml water is poured into each of three glasses;
- Solution “100 × dil. conc. Cl” is added as follows:
  1st glass – 0.1 ml;
  2nd glass – 0.2ml;
  3rd glass –0.3 ml.
- Retain 50 min contact time;
- Evaluate in which glass residual active chlorine concentration is suitable for drinking water (0.2–0.5 mg/l):
  1) 1 ml 0.1N HCl add to all solution (200 ml);
  2) ~ 20 crystals KJ and 1 ml starch solution add;
  3) solution in blue colour titrate with 0.7% $Na_2S_2O_3$ solution:

1 ml 0.7% $Na_2S_2O_3$ – 1 mg active chlorine;

e.g.: for titration in 3rd glass is used 0.1 ml 0.7% $Na_2S_2O_3$,
i.e. residual active chlorine in 200 ml water is

$$\frac{0.1 \text{ ml } 0.7\% \; Na_2S_2O_3 \times 1 \text{ mg active chlorine}}{1 \text{ ml } 0.7\% \; Na_2S_2O_3 \times 0.2} = 0.1 \text{ mg active chlorine;}$$

1000 ml water contains

$$\frac{0.1 \text{ mg active chlorine} \times 1000 \text{ ml water}}{200 \text{ ml water}} = 0.5 \text{ mg active chlorine.}$$

It is agreed to diapason 0.2–0.5 mg/l residual active chlorine.

Calculate how much concentrated chlorine solution is necessary for 1 m^3 (1000 l) water:

200 ml (0.2 l) water contains 0.3 ml chlorine concentrate solution diluted 100 times;

1000 l water contains $\frac{0.3 \times 1000}{100 \times 0.2}$ = 15 ml chlorine concentrated solution.

Conclusion: for disinfection of 1 m^3 water is needed 15 ml chlorine concentrated solution.

Most water requires some type of treatment before use, even water from deep wells or springs. The extent of treatment depends on the source of the water. Appropriate technology options in water treatment include both community-scale and household-scale point-of-use (POU) designs. The ability of POU options to reduce disease is a function of both their ability to remove microbial pathogens if properly applied and such social factors as ease of use and cultural appropriateness. Technologies may generate more or less health benefit than their lab-based microbial removal performance would suggest.

The current priority of the proponents of POU treatment is to reach large numbers of low-income households on a sustainable basis. Few POU measures have reached significant scale thus far, but efforts to promote and commercially distribute these products to the world's poor have only been under way for a few years. Over the past decade, an increasing number of field-based studies have been undertaken to determine the success of POU measures in reducing water-borne disease.

3.3. Protection of drinking water sources

Access to safe drinking water is indicated by proper sanitary sources. These improved drinking water sources include protected dug well, protected spring, household connection, public standpipe, borehole condition, and rain water collection.

In many parts of the world the only sources of water are from small streams often directly contaminated by sewage. Access to sanitary water comes hand in hand with the access to improved sanitation facilities for excreta. Unimproved sanitation facilities are public or shared latrine, open pit latrine, or bucket latrine. Improved sanitation facilities include connection to public sewer, connection to septic system, pour-flush latrine, and ventilated improved pit latrine.

Source protection zones for groundwater sources such as wells, boreholes and springs are used for public drinking water supply. Three main zones (I, II, III) and the fourth zone of special interest show the risk of contamination from any activities that might cause pollution in the area.

Zone I is the protective zone immediately surrounding a well, spring or infiltration gallery; it is required to be a 30–100 m radius, depending on the specific source and aquifer characteristics. Zone I may be determined by a qualified consultant directly calculating the area using site-specific data.

Zone II encompasses the portion of the aquifer through which water is diverted to a well or flows to a spring or infiltration gallery. Zone II must be 1 km radius unless a more detailed delineation is approved.

Zone III lies beyond Zone II and is the area that contributes significant surface water and ground water to Zones I and II. In some settings, Zone III Wellhead protection area may not be required.

For surface water sources with area more than 100 km^2, a three zone approach is used. **Zone I** is an area 300 m wide on either side of the river or stream. It extends from an area 200 m downstream of the intake to an area that is 5-hour time of travel upstream TOT (time of travel based on the 3-year average, using maximum local river velocities).

Zone II is a three km wide area on either side of the river or stream, extending upstream to a 25-hour TOT (based on the 3-year average, using maximum local river velocities.

Zone III is the remainder of the watershed, but can be refined by consideration of river hydraulics to determine flow and critical contributing tributaries. Critical contributing tributaries are tributaries that contribute significant flow to the surface water intake, and therefore, have the potential to contribute significant contaminant loads. For watersheds with an area less than 100 km^2, Zone I is delineated. The remainder of the watershed is inventoried as Zone II.

The well is properly located 30 m from any septic system, from any barnyard, livestock feeding and watering areas, and 10 m from any streams, rivers or impoundments, ponds, and lakes. The well is properly constructed if the casing extends at least 0.4 m above the ground, is properly grouted or concreted, approved materials are used, and installed to the proper depth. The concrete pad have to be intact; it is sloped to drain surface water away from the well casing, it extends 0.5 m in all directions around the well casing, and it is at least 0.1 m thick. The well has to have an intact cap or sanitary seal to prevent contamination, and ensure that the vent faces downward and is screened. Inspection of exposed parts of well is look for cracks, corrosion, or damage to the well casing and cap (sanitary seal), and look for settling or cracking of concrete pad.

For non-point source and microbiological contaminants of concern, a critical area analysis is conducted for each surface water intake, based on existing water quality data and the physical characteristics of the watershed; the analysis include critical areas for nitrate, pathogens, sediment loading and metals. When available, assessments for stream impairment are used to delineate critical areas.

4. EVALUATION OF WATER QUALITY

Water quality may be analyzed through several broad categories of methods: physical, chemical and biological.

4.1. Sampling

Water samples are collected and examined to determine associated physical, chemical, biological and radiological parameters. Sampling of water for physical or chemical testing can be done by several methods, depending on the accuracy needed and the characteristics of the contaminant. Sampling for biological testing involves collection of plants or animals from the surface water body.

The samples collected should be as fully representative as possible of the whole to be characterized, and all precautions should be taken to ensure that, as far as possible, the samples do not undergo any changes in the interval between sampling and analysis. The sampling of multiphase systems such as water containing suspended solids or immiscible organic liquids, can present special problems.

Before any sampling programme is devised, it is very important that the objectives be established since they are the major factors in determining the position of sampling sites, frequency of sampling, duration of sampling, sampling procedures, subsequent treatment of samples and analytical requirements.

When samples of precipitation are collected for chemical analysis, the sampling site should be selected to avoid contamination by extraneous matter, for example, dust, fertilizers, pesticides, etc. The sampling apparatus should preferably be placed in a lawn.

When sampling is carried out to assess the quality of water in an aquifer, the well or borehole should, whenever possible, be pumped prior to sampling to ensure that new water is drawn from the aquifer. The depth below ground level at which the sample is taken should always be recorded.

The drinking water sampling point should be selected so as to permit monitoring of residual disinfection agents before any loss occurs but after all reactions are completed. The usual sampling point is a tap connected directly to the pumping main. The sampling tap should have no attachments and should be suitable for sterilization by flaming. In order to make sure that the sample is drawn directly from the tap into the container, the sample container should be placed immediately below the tap but not connected to it, or in direct contact with it.

Waters, particularly surface waters and, above all, waste waters, are susceptible to being changed to differing extents as a result of physical, chemical or biological reactions which may take place between the time of sampling and the analysis. The nature and rate of these reactions are often such that, if the necessary precautions are not taken before and during transport as well as during the time in which the samples are preserved in the laboratory before being analysed, the concentra tions determined will be different from those existing at the time of sampling.

As the variations which take place in the water samples are due to a large extent to biological processes, it is generally necessary to choose from the various possible methods of preservation a method that does not introduce unacceptable contamination. Even the time for which the preserved sample can be stored before the existing analysis may change.

As a guide, it can be said that methods of preservation tend to be less effective in the case of crude sewage than in the case of purified sewage. On the other hand, surface waters and ground waters can in general be stored more effectively. In the case of potable waters, the problem of storage can be solved more easily because these waters are less susceptible to biological and chemical reactions.

In the case of samples for the determination of physicochemical parameters one simple precaution, which is not, however, adequate in all cases, is to fill the flasks completely and stopper them in such a way that there is no air above the sample.

The sample should be kept at a temperature lower than that during filling. Simple cooling (in melting ice or in a refrigerator between 2 °C and 5 °C) and storage of the sample in the dark are, in most cases, is sufficient to preserve the sample during the transport to the laboratory and for a relatively short period of time before the analysis. Cooling cannot be considered as a means for long term storage, particularly in the case of waste water samples.

Freezing (–20 °C) allows an increase in the period of storage. Nevertheless, it is necessary to master the freezing and thawing technique fully in order to return the sample to its initial equilibrium after thawing. In this case, the use of plastic containers is strongly recommended. Glass containers are not suitable for freezing. Samples for microbiological analysis should not be frozen.

Containers holding the samples shall be marked in a clear and durable manner in order to permit identification without ambiguity in the laboratory. Additionally, it is necessary to note, at the moment of sampling, numerous details which will permit a correct interpretation of the information obtained (date and hour of sampling, nature and amount of preservatives added, etc.).

4.2. Tests

Water samples may be examined using the principles of analytical chemistry. Frequently used methods include pH, biochemical oxygen demand, nitrate and phosphorus compounds, metals oil and grease, total petroleum hydrocarbons (TPH), and pesticides.

Biological testing involves the use of plant, animal, and/or microbial indicators to monitor the health of an aquatic ecosystem.

Common physical tests of water include temperature, solids concentrations (e.g., total suspended solids (TSS)) and turbidity.

There are numerous sources of odours and tastes which occur in potable waters; some of them are as yet imperfectly understood, but most of them can be controlled or at least mitigated. The true tastes, namely, the salty, sour, sweet, and bitter flavours, are comparatively rare in water supplies. Where they occur, they are generally due to excessive amounts of dissolved salts, acid or alkaline substances, iron compounds, and a few others less well identifiable agents. Tastes are sometimes produced as a result of improper or excessive chemical treatment of water. Most of what are called "tastes" in water is in reality odours, they represent the respondent of the old factory centres to substances volatilized from the water in the course of ingestion.

Chemical treatment of water often produced objectionable flavours. The single outstanding defect of chlorine as a disinfecting agent is its tendency to alter the flavour of the water for the worse.

The microorganisms causing bad tastes and odours in water are mostly chlorophyll-bearing forms, which do not depend upon organic matter or the bodies of other organisms for their food supply. They require only sunshine, carbonic acid and the nitrates and minerals always present in the water and in the air. In other words, they have properties comparable to the higher orders of chlorophyll containing vegetation.

Pure water, such as distilled water, when viewed in shallow depths, appears to be perfectly colourless. Most surface waters exhibit a colour varying from green to yellow and brown when examined through a depth of several inches in clear glass tubes.

Colour in surface water is usually of vegetable origin; animal matter contributes but little colour. The colouring matter is extracted from dead leaves, bark, and roots, from soil and from peat. It is similar to the colouring matter of tea. It is certainly harmless, but makes water less pleasing in appearance, and great efforts are made to prevent and remove it.

Ground waters are usually colourless. If the water contains iron it will be perfectly clear on coming from the ground, but will soon turn a rusty yellow colour. This is caused by the oxidation of the soluble ferrous salts to insoluble ferric salts.

The evaluation principle is based in spectrophotometrical comparison with standard solution (0.0875 g $K_2Cr_2O_7$ + 2 g $CoSO_4 \cdot 7\ H_2O$ + 1 ml conc. H_2SO_4 in 1 l water). Pour water sample in volume solute by H_2SO_4 up to 50 ml and carefully mix and at 413 nm in cuvette 50 mm, optical density is measured. Degree of colour will transform from the calibration graphic of the standard scale.

Practically, turbidity is synonymous with muddiness. It is the property when the outline of objects is seen though water. The turbidity of surface waters is usually due to mud, clay or silt, but may also be due to a variety of other substances, such as finely divided organic matter or microscopic organisms. Many industrial waters contribute large amounts of turbidity.

Clean water is clear and sparkling, but brilliancy and clearness do not guarantee freedom from contamination, nor does turbidity necessarily indicate danger. The turbidity problem is practically limited to river water: ground waters should seldom be turbid and, if so, should at once excite suspicion. Some ground waters become more or less turbid through the precipitation of iron or through the failure of supporting strata which allows entrance of clay or rock material to the water.

The concentration of total solids or residue on evaporation is obtained by evaporating a given quantity of water to dryness, where upon a residue, composed of the mineral and organic matter which has been held by the water in suspension and in solution, will be obtained. The amount of this residue varies with the character of the water. If the total residue is ignited, the loss of ignition is a rough index of the total amount of organic substances present. The residue remaining after ignition consists of mineral matter and is an index of the inorganic matter in the water.

Hard water is objectionable because it wastes soap and affects skin unpleasantly. It is less satisfactory than soft water for cooking and washing. However, with the advent of synthetic detergents, some of the objection to hard waters for domestic use has been eliminated. Hardness in water is due to the presence of the soluble salts of the alkaline earths, especially calcium and magnesium. On the base of determination method is colour change in reaction of Ca or Mg and complex III used as indicator Eriochrom black.

Ammonia itself found in drinking water is harmless. The detection method is based on the reaction with Nesler reagent which gives chemical – dimethylammonia iodide the colour solution of which is yellow-brown. The yellow-brown solution optical density is measured at 390 nm in cuvette 10 nm. Concentration of ammonia is detected by calibration graphic.

Amount of nitrites in water is determined by Greass reagent. Pink colour solution is colorimetrated, and by the use of calibration graphic nitrites concentration is detected.

Likewise concentration of nitrates is detected by photocolorimeter. Reagents are phenol and sulphuric acid which react with nitrates and produce picrinic acid. Picrinic acid is transferred to ammonia picrate in yellow colour solution. This solution colour intensity is proportional to the amounts of nitrates.

Test method of fluoride bases on availability ion exchange colour zirconyl-alizarin indicator in acid environment. Intensity of colour is measured by photocolorimeter. For 10 ml of sample add 0.5 ml alizarin solution, then add 0.5 ml zirconyl solution, mix and after one hour colorimetrate at 540 nm in cuvette 20 nm. Concentration of fluoride ion is estimated by the calibration graphic of the standard scale.

Arsenic detection method is based on synthesis of arsenic hydrogen which in the presence of mercury bromide gives characteristic brown colour compound. Concentration of arsenic is determined by colorimetric comparing with standard scale. Detection of lead is based on synthesis of lead sulphide that colours solution into brown at strong alkaline environment.

5. TASKS FOR STUDENTS

Seminar: "Water as an environmental factor"

1. Physiological, hygienic, and economic values of water.
2. Physical and organoleptic characteristics of water pollution.
3. Bacteriological characteristics of water pollution.
4. Chemicals, harmful for health, in water.
5. Chemicals, essential for health, in water.
6. Characterization of water sources.
7. Protection of water sources for drinking supply.
8. Drinking water quality. Water oxidation number.
9. Drinking water obtaining, supply.

Solve the situation task, or instance:

Can this water be used for drinking?
What is the cause of pollution?
What will you do?

Table III-3. Analyses of tap water

Indications	Concentration
Microbiological indications	
Escherchia coli	0/100 ml
Chemical indications	
Copper	1.0 mg/l
Nitrate	45.0 mg/l
Selenium	0.015 mg/l
Copper	1.0 mg/l
Fluoride	1.1 mg/l
Lead	0.03 mg/l
Control indications	
Aluminium	0.5 mg/l
Ammonium	0.5 mg/l
Total coliform bacteria	0/100 ml
Clostridium perfringens	0/100 ml
Colour	Without changes
Odour	Without changes
Taste	Without changes
Taste	Without changes
Turbidity	Without changes
Chloride	100.0 mg/l
Sulphate	200.0 mg/l
Iron	0.6 mg/l
Manganese	0.05 mg/l

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Chapter IV

FOOD AND HEALTH

1. FOOD CONSUMPTION AND SECURITY

Food provides energy for our bodies to function. Food also provides essential vitamins and trace elements, without which people develop deficiency diseases. Without food, most people would die in about 4 weeks.

The most important factors which influence consumption and demand for food are population growth, income distribution and increased urbanization. The concentration of populations in urban settlements, our fast-moving lifestyle and changes in traditional family unit, have all led to revolutionary changes in agricultural methods, food harvesting, processing, packing, storage and distribution.

Considering the numbers of undernourished and malnourished individuals in the world, it is hard to believe that there is enough food being produced to meet the world's needs. However, according to a report by the World Health Organization, that is the case.

Globally, food grain production has been rising faster than the population and current and emerging food production and preservation capabilities provide the potential to produce an adequate supply of safe, nutritious food for all the people of the world, both now and up to the further at projected rates of population growth and beyond. Much of this production capability exists in developing countries where the greatest percentage of malnutrition occurs. In fact, the potential of many developing countries to increase their own food production through increases in yield, arable land and cropping intensity is considerable.

Together with the increased production of food, storage facilities and distribution systems should be improved. Three elements must be in place for the production of food: land, water, and fertilizers.

In spite of the appearance of global sufficiency, the economic climate has changed for the worse; so that for some countries at least, the coming years will bring a deteriorating food situation. In every country, there are communities that are both rich and poor, urban and rural, and industrialized and agrarian, so that even where national food supplies are adequate, large sections of the population may still not have enough food for their needs.

Rapid urbanization in developing countries will also result in changes in patterns of consumption [4]. A move from traditional crops, such as root crops, maize, and millet, to food requiring less preparation time such as wheat, rice, and animal products is already taking place in a number of these countries. As the demand for livestock increases, pressure on agricultural land will become more intense. In addition to having direct environmental effects, intensification of production will increasingly be based on cultivating cereals for animal products that will compete for agricultural resources. The conversion of cereals to animal products will result in large losses of edible energy and corresponding increases in resource requirements.

Asian diets generally contain few animal foods and only small amounts of vegetables and fruits, except in the Middle East and higher-income countries. The bulk of the Asian population consumes low-fat diets, but a marked increase in fat consumption has occurred in the Middle East, and in the more affluent countries, where diets are more diverse. Cereals are the staple food of most Asian countries. Consumption varies inversely with income. Most Asian countries show a decrease in cereal consumption, except for low-income countries where average consumption has been more stable. The most affluent countries show an increase in vegetable and fruit consumption. The consumption of milk and dairy products has increased in only a few countries.

New foods are now processed for convenience, quality control and cost reduction as well as preservation. Consumers want foods that look appetizing, are easy to prepare, retain their freshness until consumed, have acceptable and characteristic colour, odour, taste and texture with a uniform appearance from one package to the next, and have a long shelf life. They must be economical to buy and geographically seasonally available. Substitute foods such as margarine, coffee whiteners and whipped toppings have appeared, while edible oils are now often substituted for dairy products. Complex synthetic foods made out of chemically cross linked corn starch or textured soy proteins combined with the appropriate food colours, flavours, etc., have resulted in artificial cheese and extended meat protein products which have reduced even further the price of major food items. The body may never have been exposed to them before and the long-term effects of consuming such high-tech foods are still not known. It is possible that many of the changes in manufacturing procedures may in themselves pose future problems to human health.

Over the next couple of decades, food production will have to keep pace with an increasing world population. The challenge for governments and food producers will be to ensure food and nutrition security without placing undue pressure on the environment and accordingly perpetuating different types of health problems.

2. FOOD CHEMICALS

Food is made up of many biological molecules, all of which can be called chemicals. All the essential chemical substances, which humans consume daily in their diet, are nutrients. The nutrients account for over 99.9% of food.

There are many other small molecular weight chemicals that are also associated with foods that are far from beneficial. These are the naturally occurring food toxins and drugs which can cause pharmacological or toxic reactions in our bodies (such as alkaloids in potatoes; salicylates in fruits and vegetables; amines in cheeses, sausages; oxalic acid in rhubarb).

In addition to these naturally occurring small molecules present in foods, we also have specific food additives which are put in because of their special properties (such as preservatives, antioxidants, artificial colouring agents, sweeteners, flavours). Many of these are identical to the naturally occurring food toxins and drugs, while others are not found in foods and are added after being synthesized in laboratory.

There is also another group of food chemicals, coming under the heading of contaminants and residues. These environmental chemicals end up in food supply by indirectly entering human food chain (such as herbicides, pesticides, insecticides, toxic metals and other toxic minerals, antibiotics).

2.1. Nutrients

Organic chemicals are very large complex molecules that make up the bulk of our diet and include carbohydrates, proteins and fats, the three major food groups, called macronutrients. We also depend upon the micronutrients that accompany them. These are the minerals, trace elements, vitamins and other essential food factors such as beta-carotene, taurine and choline.

Each nutrient has its own specific function and relationship to the body, but no nutrient acts independently of other nutrients. Protein builds and maintains body cells, and carbohydrates, fats, and some proteins provide calories for energy. It is considered that carbohydrates have to supply human body with 56% fats – 30%, and proteins – 14% of energy in balanced diet [2]. Vitamins and minerals help to regulate the many chemical reactions within the body.

The amounts of the nutrients required by an individual are influenced by age, sex, body size, environment, level of activity, and nutritional status. The total number of essential nutrients required by man is still unknown since new ones are still being discovered and old ones re-evaluated, and there is suggestive evidence that others as yet unidentified also exist.

Protein is of primary importance in the growth and development of all body tissues. It is the major source of building material for muscles, blood, skin, hair, nails, and internal organs, including the heart and the brain.

Protein is needed for the formation of hormones, which control a variety of body functions such as growth, sexual development, and rate of metabolism. Protein also helps to prevent the blood and tissues from becoming either too acid or too alkaline and helps to regulate body's water balance. Enzymes, and antibodies, which help to fight foreign substances in the body, are also formed from protein.

During digestion the large molecules of proteins are decomposed into simpler units called amino acids. Amino acids are necessary for the synthesis of body proteins and many other tissue constituents. They are the units from which proteins are constructed and are the end products of protein digestion.

The body requires approximately twenty two amino acids in a specific pattern to make human protein. All but eight of these amino acids can be produced in the adult body. The eight that cannot be produced are called essential amino acids because they must be supplied in the diet. In order for the body to properly synthesize protein, all the essential amino acids must be present simultaneously and in the proper proportions.

Foods containing protein may or may not contain all the essential amino acids. When food contains all the essential amino acids, it is termed complete protein. Foods that lack or are extremely low in any one of the essential amino acids are called incomplete protein. Most meats and dairy products are complete-protein foods, while most vegetables and fruits are incomplete-protein foods. To obtain a complete-protein meal from incomplete proteins, one must combine foods carefully so that those weak in an essential amino acid will be balanced by those adequate in the same amino acid.

The minimum daily protein requirement, the smallest amino acid intake that can maintain optimum growth and good health in man, is difficult to determine. Protein requirements differ according to the nutritional status, body size, and activity of the individual. As a practical means of calculating a desirable protein intake, a normal adult should receive about 1 g of protein per kg of body weight per day. This should be obtained from a variety of foods, some of animal origin.

Protein deficiency may lead to abnormalities of growth and tissue development. A child whose diet is deficient in protein may not attain his potential physical stature. Extreme protein deficiency in children results in kwashiorkor, a disease characterized by stunted mental and physical growth, loss of hair pigment, and swelling of the joints. It is often fatal. In adults, protein deficiency may result in lack of stamina, mental depression, weakness, poor resistance to infection, impaired healing of wounds, and slow recovery from disease.

Carbohydrates are the most efficient source of fuel for muscular exercise and they constitute more than one half of the usual diet. Carbohydrates also help regulate protein and fat metabolism; fats require carbohydrates for their breakdown within the liver.

The principal carbohydrates present in foods are sugars, starches, and cellulose. Simple sugars, such as those in honey and fruits, are very easily digested. Double sugars, such as table sugar, require some digestive action, but they are not nearly as complex as starches, such as those found in whole grain. Starches require prolonged enzymatic action in order to be broken down into simple sugars (glucose) for digestion. Cellulose, commonly found in the skins of fruits and vegetables, is largely indigestible by humans and contributes little energy value to the diet. It does, however, provide the bulk necessary for intestinal action and aids elimination.

All sugars and starches are converted by the body to a simple sugar such as glucose or fructose. Some of the glucose, or blood sugar, is used as fuel by tissues of the brain, nervous system, and muscles. A small portion of the glucose is converted to glycogen and stored by the liver and muscles; the excess is converted to fat and stored throughout the body as a reserve source of energy. When fat reserves are reconverted to glucose and used for body fuel, weight loss results.

Carbohydrate snacks containing sugars and starches provide the body with almost instant energy because they cause a sudden rise in the blood sugar level. However, the blood sugar level drops again rapidly, creating a craving for sweeter food and possibly fatigue, dizziness, nervousness, and headache.

Overindulgence in starchy and sweet foods may crowd out other essential foods from the diet and can therefore result in nutritional deficiency as well as in obesity and tooth decay. Diets high in refined carbohydrates are usually low in vitamins, minerals, and cellulose. Such foods as white flour, white sugar, and polished rice are lacking in vitamins B and other nutrients. Research continues as to whether or not such problems as diabetes, heart disease, high blood pressure, anaemia, kidney disorders, and cancer can be linked to an overabundance of refined carbohydrate foods in the diet.

Carbohydrates can be manufactured in the body from some amino acids and the glycerol component of fats; therefore, there is no specific requirement for carbohydrates in the diet. However, a total lack of carbohydrates may produce ketosis, loss of energy, depression, and breakdown of essential body protein.

Fats, or lipids, are the most concentrated source of energy in the diet. When oxidized, fats furnish more than twice the number of calories per gram furnished by carbohydrates or proteins. In addition to providing energy, fats act as carries for the fat-soluble vitamins, A, D, E, and K. By aiding in the absorption of vitamin D, fats help make calcium available to body tissues, particularly to the bones and teeth. Fats are also important for the conversion of carotene to vitamin A. Fat deposits surround, protect, and hold in place organs, such as the kidneys, heart, and liver. A layer of fat insulates the body from environmental temperature changes and preserves body heat. This layer also rounds out the contours of the body. Fats prolong the process of digestion by slowing down the stomach's secretions of hydrochloric acid. Thus, fats create a longer-lasting sensation of fullness after a meal.

The substances that give fats their different flavours, textures, and melting points are known as the fatty acids. There are two types of fatty acids, saturated and unsaturated. Saturated fatty acids are those that are usually hard at room temperature and which, except for coconut oils, come primarily from animal sources. Unsaturated fatty acids including polyunsaturates, are usually liquid at room temperature and are derived from vegetable, nut, or seed sources, such as corn, safflowers, sunflowers, and olives. Vegetable shortenings and margarines have undergone a process called "hydrogenation" in which unsaturated oils are converted to a more solid form of fat. Other sources of fat are milk products, eggs, and cheese.

There are three essential fatty acids: linoleic, arachidonic, and linolenic, collectively known as unsaturated fatty acids. Arachidonic and linolenic acids can be synthesized from linoleic acid if it is sufficiently supplied to the body through diet. They are unsaturated fatty acids necessary for normal growth and healthy blood, arteries, and nerves. Also, they keep the skin and other tissues youthful and healthy by preventing dryness. Essential fatty acids may be necessary for the transport and breakdown of cholesterol.

Cholesterol is a lipid or fat-related substance necessary for good health. It is a normal component of most body tissues, especially those of the brain and nervous system, liver, and blood. Although a cholesterol deficiency is unlikely to occur, abnormal amounts of cholesterol may be stored throughout the body if fats are eaten excessively. It results to the development of arteriosclerosis. Lecithin has been found to decrease cholesterol levels in some individuals. Although a fat deficiency rarely occurs in man, such a deficiency would lead to a deficiency in the fat-soluble vitamins. A deficiency of fatty acids may produce eczema or other skin disorders. An extreme deficiency could lead to severely retarded growth.

Excessive amounts of fat in the diet may lead to abnormal weight gain and obesity if more calories are consumed than needed by the body. In addition to obesity, excessive fat intake will cause abnormally slow digestion and absorption, resulting in indigestion. If a lack of carbohydrates is accompanied by a lack of water in the diet, or if there is a kidney malfunction, fats cannot be completely metabolized and may become toxic to the body. There is no recommended dietary allowance (RDA) for fats because of the widely varying fat content of the diet among individuals. Linoleic acid, however, should provide about 2% of the calories in the diet. Vegetable fats, such as corn, safflower, and soybean oils, are high in linoleic acid.

All **natural vitamins** are organic food substances found only in living things, that is, plants and animals. Less than twenty substances have been discovered so far that are believed to be active as vitamins in human nutrition. Each of these vitamins is present in varying quantities in specific foods, and each is absolutely necessary for proper growth and maintenance of health. With a few exceptions, the body cannot synthesize vitamins; they must be supplied in the diet or in dietary supplements. Vitamins taken in excess of the finite amount utilized in the metabolic processes are valueless and will be either excreted in the urine or stored in the body. Excessive ingestion of some nutrients may result in toxicity.

Vitamins are usually distinguished as being water-soluble or fat-soluble. The water-soluble vitamins, B complex vitamins, vitamin C, and the compounds termed bio-flavonoids, are usually measured in milligrams. The fat soluble vitamins, A, D, E, K, are measured in international units IU of activity.

Vitamin A is a fat-soluble nutrient that occurs in nature in two forms: performed vitamin A and provitamin A, or carotene. Performed vitamin A is concentrated only in certain tissues of animal products in which the animal has metabolized the carotene contained in its food into vitamin A. One of the richest natural sources of performed vitamin A is fish-liver oil, which is classified as a food supplement. Some animal products, such as cream and butter, may contain both performed vitamin A and carotene. Carotene is a substance that must be converted into vitamin A before it can be utilized by the body. Carotene is abundant in carrots, but it is present in even higher concentrations in certain green leafy vegetables, such as beet greens, spinach, and broccoli. If, owing to any disorder, the body is unable to use carotene, a vitamin A deficiency may arise. Vitamin A aids in the growth and repair of body tissues, it helps to protect the mucous membranes of the mouth, nose, throat, and lungs, thereby reducing susceptibility to infection. Other important functions of vitamin A include the building of strong bones and teeth, the formation of rich blood, and the maintenance of good eyesight. Recommended dietary allowances RDA of vitamin A are 15000–40000 IU for children and 4000–5000 IU for adults. Excessive daily use of vitamin A may lead to reduced thyroid activity and abnormalities in the skin, eyes, and mucous membranes. Vitamin A deficiency may occur when an inadequate dietary supply exists; when the body is unable to absorb or store the vitamin; when an ailment interferes with the conversion of carotene to vitamin A.

All **vitamins B** are water-soluble substances that can be cultivated from bacteria, yeasts, fungi, or moulds. The known B complex vitamins are B_1 (thiamine), B_2 (riboflavin), B_3 (niacin), B_5 (pantothenic acid), B_6 (pyridoxine), B_{12} (cyanocobalamin), B_{15} (pangamic acid), biotin, choline, folic acid, inositol, and para-aminobenzoic acid (PABA). The grouping of these water-soluble compounds under the term B complex is based upon their common source distribution, their close relationship in vegetable and animal tissues, and their functional relationships. The B complex vitamins are active in providing the body with energy, by converting carbohydrates into glucose, which the body "burns" to produce energy.

All vitamins B are natural constituents of brewer's yeast, liver, and whole-grain cereals. Brewer's yeast is the richest natural source of some of the B complex group. Another important source of some vitamins B is the production by the intestinal bacteria. These bacteria grow best on milk sugar and small amounts of fat in the diet. The most important thing to remember is that all vitamins B should be taken together.

Thiamine or **vitamin B_1** is a component of the germ and bran of wheat, the husk of rice, and that portion of all grains which is commercially milled away to give the grain a lighter colour and finer texture. Known as the "morale vitamin" because of its relation to a healthy nervous system and its beneficial effect on mental attitude, thiamine is also linked with improving individual learning capacity. It is necessary for consistent growth in children and for the improvement of muscle tone in stomach, intestines, and heart. A diet rich in brewer's yeast, wheat germ, black strap molasses, and bran will provide the body with adequate thiamine and will help to prevent undue accumulation of fatty deposits in the artery walls. Individual thiamine needs are determined by body weight, the quantity of the vitamin synthesized in the intestinal tract, and daily calorie intake. As the calorie intake, especially of carbohydrates, increases, the proportion of thiamine ingested increases. It is recommended 0.5 milligram of thiamine per 1000 calories daily for all ages.

Riboflavin or **vitamin B_2** is necessary for cell respiration because it works with enzymes in the utilization of cell oxygen. It also is necessary for the maintenance of good vision, skin, nails, and hair. The amount of B_2 found in most foods is so little that it is normally quite difficult to obtain a sufficient supply without supplementing the diet. Good sources of riboflavin are liver, tongue, and other organ meats, milk, eggs, and brewer's yeast. The recommended dietary allowance is 1.6 mg for an adult male and 1.2 mg for a female. Pregnancy and lactation requirements are 1.5 and 1.7 mg, respectively.

Niacin or **vitamin B_3**, (nicotinic acid, niacinamide, nicotinamide) assists enzymes in the breakdown and utilization of proteins, fats, and carbohydrates. Niacin is effective in improving circulation and reducing the cholesterol level in the blood. It is vital to the proper activity of the nervous system and for formation and maintenance of healthy skin, tongue, and digestive-system tissues. Niacin is necessary for the synthesis of sex hormones.

Relatively small amounts of pure niacin are present in most foods. Lean meats, poultry, fish, and peanuts are daily sources of niacin, as are such dietary supplements as brewer's yeast, wheat germ, and desiccated liver. Niacin is difficult to obtain except from these foods. Daily allowances of niacin have to be based on caloric intake; 6.6 mg of niacin per 1000 calories is recommended. Tryptophan may provide part or all of the daily niacin requirements; 60 mg of tryptophan yield 1 mg of niacin. The recommended dietary allowance is 16 mg for men, 13 mg for women, and 9 to 16 mg for children. During pregnancy, lactation, illness, tissue trauma, and growth periods and after physical exercise, daily requirements are increased.

Pantothenic acid or **vitamin B_5** occurs in all living cells, being widely distributed in yeasts, moulds, bacteria, and individual cells of all animals and plants. Organ meats, brewer's yeast, egg yolks, and whole-grain cereals are the richest sources. Pantothenic acid is synthesized in the body by the bacterial flora of the intestines. Pantothenic acid plays a vital role in cellular metabolism. As a coenzyme it participates in the release of energy from carbohydrates, fats, and proteins and in the utilization of other vitamins, especially riboflavin. Pantothenic acid can improve a body's ability to withstand stressful conditions. Adequate intake of pantothenic acid reduces the toxicity effects of many antibiotics. It aids in the prevention of premature aging and wrinkles. It also protects against cellular damage caused by excessive radiation. Individual needs for pantothenic acid vary according to periods of stress, daily food intake, and urinary excretion levels. Several sources, suggest 5 to 10 mg daily for adults and children, respectively.

Vitamin B_6 or pyridoxine plays an important role as a coenzyme in the breakdown and utilization of carbohydrates, fats, and proteins. It must be present for the production of antibodies and red blood cells. It also aids in the conversion of tryptophan, an essential amino acid, to niacin. The best sources of vitamin B_6 are meats and whole grains. Desiccated liver and brewer's yeast are the recommended supplemental sources. The recommended dietary allowance of vitamin B_6 is 2 mg per day.

Vitamin B_{12}, a water-soluble vitamin, is unique in being the first cobalt-containing substance found to be essential for longevity, and it is the only vitamin that contains essential mineral elements. Animal protein is almost the only source in which B_{12} occurs naturally in foods in substantial amounts. Liver is the best source; kidney, muscle meats, fish, and dairy products are other good sources. Vitamin B_{12} is necessary for normal metabolism of nerve tissue and is involved in protein, fat, and carbohydrate metabolism. Human requirements are minute but essential. The recommended dietary allowance of vitamin B_{12} is 3 mcg for adults and 4 mcg for pregnant and lactating women. Infants require a daily intake of 3 mcg, and growing children need 1–2 mcg. A vegetarian diet frequently is low in vitamin B_{12} and high in folic acid, which may mask a vitamin B_{12} deficiency.

Pangamic acid (vitamin B_{15}) was obtained in crystalline form from rice brain, rice polish, whole-grain cereals, brewer's yeast, steer blood, and horse liver. Pangamic acid is essential in promoting protein metabolism, particularly in the muscles of the heart. It regulates fat and sugar metabolism, which partly accounts for its effects on atherosclerosis and diabetes. Good natural sources of pangamic acid are brewer's yeast, whole brown rice, whole grains, pumpkin seeds, and sesame seeds. The recommended dietary allowance has not been established.

Biotin is a water-soluble B complex vitamin. As a coenzyme, it assists in the making of fatty acids and in the oxidation of fatty acids and carbohydrates. Biotin is an essential nutrient that appears in trace amounts in all animal and plant tissue. Some rich sources of biotin are egg yolk, beef liver, unpolished rice, brewer's yeast, cauliflower and mushrooms. It indicates that 150 to 300 mcg of biotin (the RDA) will meet the body's daily needs.

Choline is considered one of the B complex vitamins. It functions with inositol as a basic constituent of lecithin. It is present in the body of all living cells and widely distributed in animal and plant tissues. The richest source of choline is lecithin, but other rich dietary sources include egg yolk, liver, brewer's yeast, and wheat germ.

Folic acid is part of the water-soluble vitamin B complex and functions as a coenzyme, together with vitamins B_{12} and C, in the breakdown and utilization of proteins. Folic acid is necessary for proper brain function, it is essential for mental and emotional health. In surveys conducted, folic acid was shown to be one of the nutrients most often deficient in our diets. The best sources of folic acid are green leafy vegetables, liver, and brewer's yeast. The recommended dietary allowance of folic acid is 400 mcg for adults, 800 mcg during pregnancy, and 600 mcg during lactation.

Inositol is recognized as part of the vitamin B complex and is closely associated with choline and biotin. Like choline, inositol is found in high concentrations in lecithin. Inositol is found in unprocessed whole grains, citrus fruits, brewer's yeast, crude unrefined molasses, and liver.

Inositol is effective in promoting body's production of lecithin. In combination with choline, it prevents the fatty hardening of arteries and protects the liver, kidneys, and heart. The recommended dietary allowance has not yet been established, but most authorities recommend consuming the same amount of inositol as choline.

Para-aminobenzoic acid, an integral part of the vitamin B complex, is water-soluble and is considered unique in that it is a "vitamin within a vitamin", occurring in combination with folic acid. PABA is found in liver, yeast, wheat germ, and molasses. PABA stimulates the intestinal bacteria, enabling them to produce folic acid, which in turn aids in the production of pantothenic acid. PABA plays an important role in determining skin health, hair pigmentation, and health of the intestines. The need for PABA in human nutrition has not yet been established. PABA is available in supplements in potencies higher than 30 mg, but these higher doses are used for therapeutic purposes.

Vitamin C or ascorbic acid is normally the least stable of vitamins and is very sensitive to oxygen. Its potency can be lost through exposure to light, heat, and air, which stimulate the activity of oxidative enzymes. A primary function of vitamin C is maintaining collagen, a protein necessary for the formation of connective tissue in skin, ligaments, and bones. Vitamin C plays the role in healing wounds and burns because it facilitates the formation of connective tissue in the scar. Vitamin C also aids in forming red blood cells and preventing hemorrhage. In addition, vitamin C fights bacterial infections and reduces the effects on the body of some allergy-producing substances. For these reasons, vitamin C is frequently used in preventing and treating the common cold. The intestinal absorption of iron is greatly increased by adequate vitamin C. Vitamin C is present in most fresh fruits and vegetables.

Because vitamin C is a stress vitamin, it is used up even more rapidly under stressful conditions. Man, apes, and guinea pigs are among the very few animals that need vitamin C in their foodstuffs, because they are unable to meet bodily needs by synthesis and must rely upon a dietary source. Cooking in copper utensils will destroy the vitamin C content of foods. It is recommended 60 mg of vitamin C for adults. The requirement may vary due to differences in weight, amount of activity, rate of metabolism, ailments, and age. Periods of stress, such as anxiety, infection, injury, surgery, burns, or fatigue, increase the body's need for this vitamin.

Vitamin D is fat-soluble vitamin, and it can be acquired either by ingestion or by exposure to sunlight. The action of the sun's ultraviolet rays activates a form of cholesterol, which is present in the skin, converting it to vitamin D. The provitamins D are found in both plant and animal tissue. Vitamin D_2 is known as calciferous, a synthetic; vitamin D_3 is the natural form as it occurs in fish-liver oils. Vitamin D aids in the absorption of calcium from the intestinal tract and the breakdown and assimilation of phosphorus, which is required for bone formation. Vitamin D is necessary for normal growth in children, for without it bones and teeth do not calcify properly. It is valuable in maintaining a stable nervous system, normal heart action, and normal blood clotting. Vitamin D is best utilized when taken with vitamin A. Fish-liver oils are the best natural source of vitamins A and D.

Most of body's needs for vitamin D can be met by sufficient exposure to sunlight and from the ingestion of small amounts of food, but the sun's action on the skin can be inhibited by such factors as air pollution, clouds, window glass, or clothing. The dietary allowance of vitamin D is 400 IU per day to meet the requirements of practically all healthy individuals who have little or no exposure to ultraviolet light.

Vitamin E, a fat-soluble vitamin, is composed of a group of compounds called tocopherol. Tocopherol occurs in highest concentrations in cold-pressed vegetable oils, all whole raw seeds and nuts, and soybeans. Wheat-germ oil is the source from which vitamin E was first obtained. Vitamin E is an antioxidant, which means it opposes oxidation of substances in the body. Vitamin B complex and ascorbic acid are also protected against oxidation when vitamin E is present in the digestive tract. Vitamin E is a highly effective anti thrombin in the bloodstream, inhibiting coagulation of blood by preventing clots from forming. Vitamin E is effective in the prevention of elevated scar formation on the body surface and within the body. As diuretic, vitamin E helps lower elevated blood pressure. It protects against the damaging effects of many environmental poisons in the air, water, and food. It protects the lungs and other tissues from damage by polluted air. Vitamin E has a dramatic effect on the reproductive organs: is helps to prevent miscarriages, increases male and female fertility, and helps to restore male potency.

The daily intake of vitamin E is based upon the metabolic body size and the level of polyunsaturated fatty acids in the diet rather than upon weight or calorie intake. The requirements increase with gains in polyunsaturated fatty acids in the diet.

Air pollution also increases the need for vitamin E. The RDA for infants is 4 to 5 IU daily; for children and adolescents the range is 7 to 12 IU; for adult males, 15 IU; for adult females, 12 IU; in pregnancy and lactation, needs increase to 15 IU daily.

Vitamin K is fat-soluble and can be manufactured in the intestinal tract in the presence of certain intestinal flora (bacteria). If yogurt, kefir, or acidophilus milk is included in the diet, the body may be able to manufacture sufficient amounts of this vitamin. In addition, unsaturated fatty acids and a low-carbohydrate diet increase the amounts of vitamin. Vitamin K is necessary for the formation of prothrombin, a chemical required in blood clotting. It is also vital for normal liver functioning and is an important vitality and longevity factor.

Some natural sources of vitamin K are kelp, alfalfa, green plants, and leafy green vegetables. Cow's milk, yogurt, egg yolks, black strap molasses, safflower oil, fish-liver oils, and other polyunsaturated oils are other good sources. The most dependable supply is the intestinal bacteria. It is estimated that the average daily intake is between 300 and 500 mcg, which is considered an adequate supply of vitamin K.

Bioflavonoids, known as vitamin P, are water-soluble and are composed of a group of brightly coloured substances that often appear in fruits and vegetables as companions to vitamin C. The components of the bioflavonoids are citrin, rutin flavones, and flavonals. Sources of bioflavonoids include lemons, grapes, plums, black currants, grapefruit, apricots, cherries, blackberries, and rose hips. Bioflavonoids are essential for the proper absorption and use of vitamin C. They are vital in their ability to increase the strength of the capillaries and to regulate their permeability. These actions build a protective barrier against infections. There is no RDA for this vitamin.

Minerals are nutrients that exist in the body and in food in organic and inorganic combinations. Approximately seventeen minerals are essential in human nutrition. Although only 4 or 5 per cent of the human body weight is mineral matter, minerals are vital to overall mental and physical well-being. They are important factors in maintaining physiological processes, strengthening skeletal structures, and preserving the vigorous of the heart and brain as well as all muscle and nerve systems. Minerals, just like vitamins, act as catalysts for many biological reactions within the human body, including muscle response, the transmission of messages through the nervous system, digestion, and metabolism or utilization of nutrients in foods.

Calcium, chlorine, phosphorus, potassium, magnesium, sodium, and sulphur are known as the macro minerals because they are present in relatively high amounts in body tissues. They are measured in milligrams. Other minerals, termed trace minerals, are present in the body only in the most minuteness quantities but are essential for proper body functioning. Trace minerals are measured in micrograms.

Calcium is the most abundant mineral in the body. About 99 per cent of the calcium in the body is deposited in the bones and teeth. The major function of calcium is to act in cooperation with phosphorus to build and maintain bones and teeth. It is essential for healthy blood, eases insomnia, and helps regulate the heartbeat. Calcium is present in significant amounts in a very limited number of foods. Milk and dairy products are dependable sources. It is recommended 800 mg as a daily calcium intake.

Chloride is an essential mineral, occurring in the body mainly in compound form with sodium or potassium. Chlorine helps to regulate the correct balance of acid and alkali in the blood and maintains pressure that causes fluids to pass in and out of cell membranes until the concentration of dissolved particles is equalized on both sides. It stimulates production of hydrochloric acid, an enzymatic juice needed in the stomach for digestion. There is no RDA for chloride because the average person's salt intake is high and usually provides between 3 and 9 grams daily.

Magnesium is involved in many essential metabolic processes. By countering the stimulated effect of calcium, magnesium plays an important role in neuromuscular contractions. It also helps to regulate the acid-alkaline balance in the body. Magnesium appears to be widely distributed in foods, being found chiefly in fresh green vegetables, where it is an essential element of chlorophyll. It is recommended a daily intake of 300–350 mg for an adult.

Phosphorus is the second most abundant mineral in the body and is found in every cell. It often functions along with calcium, and the healthy body maintains a specific calcium-phosphorus balance which is needed for these minerals to be effectively used by the body. Good dietary sources of phosphorus are beans, meats, soybeans, and whole grain cereals. As a general rule, if calcium and protein needs are met through usual foods, the phosphorus will be sufficient since foods richest in calcium and protein are usually the best sources of phosphorus. The daily intake of phosphorus should be about one and one and a half times the calcium.

Sulphur has an important relationship with protein. It is contained in the few amino acids, in tough protein substance keratin, necessary for health of the skin, nails, and hair. It also occurs in carbohydrates such as heparin, an anticoagulant found in the liver. The best source of sulphur is eggs. Others are meat, fish, cheese, and milk. It is assumed that a person's sulphur requirement is met when protein intake is adequate.

Sodium functions with potassium to equalize the acid-alkali factor in the blood. Along with potassium, it helps to regulate water balance within the body. Another important function of sodium is keeping the other blood minerals soluble, so that they will not build up as deposits in the bloodstream. Sodium is found in virtually all foods. It is generally observed that the usual intake far exceeds the need.

Potassium is necessary for normal growth, to stimulate nerve impulses for muscle contraction, and to preserve proper alkalinity of the body fluids. Food sources of potassium include all vegetables, oranges, whole grains. Large amounts of potassium are found in potatoes, especially in the peelings, and in bananas. Many authorities suggest that 2 to 2.5 grams have to be included in the diet daily.

The major function of **iron** is in making haemoglobin, the colouring matter of red blood cells. Leafy green vegetables, liver, dried fruits are rich in iron. The average daily intake of iron is 15 mg.

Zinc is an essential trace mineral occurring in body in larger amounts than any other trace element except iron. It is recommended also a daily intake of 15 mg of zinc for adults. Zinc is essential for general growth and proper development of the reproductive organs.

Chromium stimulates the activity of enzymes. In blood it competes with iron in the transport of protein. The chromium-containing foods are brewer's yeast, liver, beef whole-wheat bread, beets, and mushrooms. A daily chromium intake is 80–100 mcg.

Cobalt is considered as an essential mineral and is an integral part of vitamin B_{12}, or cobaltamin. The best sources are liver, kidney, milk, and sea vegetation. The average daily intake of cobalt is 5 to 8 mcg.

Copper is present in many enzymes that break down or build up body tissue. Among the best food sources of copper are liver, whole-grain products, green leafy vegetables. It is recommended a daily dietary intake of 2 mg for adults.

Iodine aids in the development and functioning of the thyroid gland and is an integral part of thyroxine, a principal hormone produced by the thyroid gland. Both types of sea life, plant and animal, are excellent sources of this mineral. It is suggested that an intake of 1 mcg of iodine per kilogram of body weight is adequate for most adults.

Manganese is a trace mineral and plays a role in activating numerous enzymes. The average daily diet contains approximately 4 mg.

Selenium is a natural antioxidant and appears to preserve elasticity of tissue by delaying oxidation of polyunsaturated fatty acids.

Molybdenum is an essential part of two enzymes it is a factor in copper metabolism. The best sources of all trace elements in proper balance are natural unprocessed foods.

2.2. Natural food toxins and drugs

Many compounds in food plants have been chemically characterized, and a number have been found to be toxic. Although it is generally assumed that the natural components of food, even those known to be toxic, do not constitute an acute health hazard, there is very little information about the toxic effects from ingestion of these compounds over long periods. Abnormal and toxic metabolites are frequently produced when plants are subjected to stress. These include protease inhibitors in many legumes, hemagglutinins in indifferent beans, goitrogens in cabbage, turnips, rutabagas, mustard greens, and white mustard, allergens in peanuts, certain fruits, and grains.

Most people probably ingest several grams of these toxins each day, and levels of these natural chemicals are specifically increased or decreased by plant breeders. Many plant toxins may cause indirect problems for humans after food animals consume plants containing these toxins. Certain plants, such as bracken fern, are poisonous to animals, and the toxins may be present in milk from cows that have eaten the plants. Cows and goats foraging on lupine produce offspring with severe teratogenic abnormalities. Significant amounts of these teratogens may be transferred to the milk, so that human babies drinking the milk of such animals may be affected.

The human diet contains a great variety of natural mutagens and carcinogens, as well as many natural anti mutagens and anti carcinogens. Many of these mutagens and carcinogens may act through the generation of oxygen radicals. Dietary intake of natural antioxidants could be an important aspect of body's protection mechanism against these agents. Many antioxidants are being identified as anti carcinogens.

Many foods contain naturally occurring chemicals which act on the body in the same way as drugs to cause what is called a pharmacological effect. The most common naturally occurring drugs in foods are the biologically active amines. These are low molecular weight substances which arise naturally as a consequence of metabolic processes in animals, plants and microorganisms. Most of them are structurally similar to hormones in our body, such as an adrenaline and noradrenaline. These substances are present in vegetables and fruit in fairly small amounts. They predominate in fermented food products including beer, wine, yeast extracts, beef liver, chicken liver, sauerkraut, cheeses, as well as bananas and avocados.

The substance tyramine is the most vasoactive substance. It acts pharmacologically by releasing noradrenaline from tissue stores, and this in turn causes an increase in the blood pressure. Tyramine is found in large amounts in various cheeses, yeast extracts, pickled herring, meat extracts and sausages.

Another biologically active amine found in foods, particularly beverages, is caffeine, a potent pharmacological agent. It is formed in many species of plant including coffee beans, tea leaves and cola nuts. Caffeine is addictive and has widespread pharmacological actions which include the stimulation of the central nervous system and the heart and increased output of gastric acid and urine.

2.3. Food additives

Food additives are substances added to products to perform specific technological functions. It is food additives that provide the qualities that most consumers value in foods. They help to maintain freshness and prevent deterioration; to amplify or promote sensory qualities; to facilitate handling or processing; increase shelf-life or inhibit the growth of pathogens, add colouring and flavouring to food to maintain nutritional quality. Food additives are natural such as extracts from beetroot juice (E162), used as a colouring agent; manmade versions – synthetic identical copies of substances found naturally, such as benzoic acid (E210), used as a preservative; artificial – produced synthetically and not found naturally, such as nisin (E234), used as a preservative in some dairy products [2].

Preservatives are added to foods for two reasons; firstly to inhibit unwanted chemical reactions within it after it has been processed and packaged, and secondly, to inhibit, retard or arrest the growth of microorganisms present in, or gain entry to, the food.

Antioxidants prevent oxygen molecules from attacking the food [1]. These result in a bitter taste, unpleasant flavour and odour, and even more importantly, the production of potentially toxic or carcinogenic substances. The fat-soluble antioxidants are butylatedhydroxyanisole BHA, tocopherols, and phospholipids such as lecithin. Vitamin C, also known as ascorbic acid, or E300, is one of the most widely used antioxidants. Ascorbic acid, erythorbic acid and their salts are used as antioxidants in corned, cured, pickled, salted and cooked manufactured meat, frozen fish and cooked shrimp.

Antimicrobials are a wide variety of chemical agents which are added to foods to control the growth of microorganisms such as yeasts, mould and bacteria. They include common salt, sugar and acid which have been used for thousands of years.

Major chemical preservatives presently in common use are sulphur dioxide and related sulphites; benzoic acid and its salts; parabens (chemically related to benzoic acid, being most active against moulds and yeasts); sorbic acid; nitrates and nitrites; propionic acid and its salts.

Sulphites are used to control micro-organisms in wine and to delay spoilage in many foods. They have also been used to keep vegetables looking fresh in salad bars. Some people can experience asthmatic attacks, hives, diarrhea or other symptoms when exposed to sulphites.

The action of nitrate in meat curing is considered to involve inhibition of toxin formation by *Clostridium botulinum*, an important factor in establishing safety of cure meat products. Major concern about the use of nitrite was generated by the realization that secondary amines in foods may react to form nitrosamines. The nitrosamines are powerful carcinogens, and they may be mutagenic.

The addition of colour agents to foods serves several desirable functions: helps to correct for natural variations in colour; makes the food more visually appealing; assures greater uniformity in appearance, and hence, acceptability, by correcting natural variations; and helps to preserve the identity or character by which foods are recognized.

A great variety of naturally occurring food colours is available to manufacturers, but they are relatively unstable compared with artificial colours. No other group of food additives has undergone such radical changes in the last years as the artificial colouring agents due to toxic and carcinogenic effects. Colouring agents sunset yellow (E110), quinoline yellow (E104), carmoisine (E122), allura red (E129), tartrazine (E102) and ponceau 4R (E124) are used in soft drinks, sweets and ice cream, and have been linked with causing a negative effect on children's health.

Children are most often the ones who have sensitivity to Red 40. Reactions include temper tantrums, hyperactivity, aggressive behaviour, uncontrollable crying and screaming kicking, nervousness, dizziness, inability to concentrate and sit still among other findings. Physically one may get frequent headaches or migraines, upset stomach and feel ill after ingesting this additive. Often when Red 40 is eliminated from the child's diet a remarkable change is noticed immediately. Red 40 is used in many food products including orange and other flavoured sodas, chips, strawberry pop-tarts, any candy with red colouring to it, including skittles, many chewing gums. Also many children's vitamins and pain medicine have Red 40 among the ingredients.

There are over one thousand different flavour modifiers or enhancers which are presently added to food either to enhance or reduce the taste or smell of a food. The permitted artificial sweetening substances are saccharin, cyclamate, aspartame, mannitol and sorbitol. As a flavour enhancer is used MSG. MSG is the sodium salt of glutamic acid, an amino acid abundant in both plant and animal proteins. Most of the MSG is naturally present in foods, not added. Most people have no trouble with MSG, but some experience unpleasant effects such as dizziness, weakness, headaches, chest pain, palpitations, nausea, and vomiting. Artificial flavours were causes of hyperactivity in children.

The most commonly used emulsifiers are the mono and diglycerides, lecithin, glycerol esters and propylene glycol esters. The bulk of the thickening and gelling agents are naturally occurring substances. The anti caking agents, notably carbonates and phosphates, act by preventing lumping, caking and the absorption of moisture. Acids, bases and buffers control the acidity or alkalinity of food, for safety and stability of flavour.

Other phosphates, pyrophosphates, citric acid and food acids are used to bind and remove unwanted minerals which cause undesirable changes in flavour, colour or turbidity and may reduce the shelf life of a product by accelerating rancidity. These agents are called sequestra.

Glazing agents provide a protective coating or sheen on the surface of foods for appearance and shelf-life. Emulsifiers and stabilisers give food a consistent texture, e.g. they can be found in low-fat spreads. Emulsifiers help mix ingredients together that would normally separate. With the exception of lecithin, all emulsifiers used in foods are synthetic derivatives of fatty acids. Stabilisers prevent ingredients from separating again, e.g. locust bean gum (E410). Gelling agents are used to change the consistency of food, e.g. pectin (E440), which is used to make jam. Thickeners help to give food body, e.g. can be found in most sauces. Humectants are agents which are added to confectionery, to help retain moisture. The most commonly used are sorbitol and glycerol.

During food processing products undergo changes that result in loss of micronutrients. To offset the loss of some of these, selected food factors are often put back into the processed foods. Examples include breakfast cereals, bread and milk which may have extra B vitamin complex, vitamin A and D and iron added. Vitamin C is also added to many fruit juice drinks.

While the great majority of people appear to be unaffected by the ingestion of reasonable amounts of food additives, there appears to be a certain proportion of the population that is exquisitely sensitive to very small amounts of food additives.

A simple general rule about additives is to avoid sodium nitrite, saccharin, caffeine, olestra, and artificial colouring. Not only are they among the most questionable additives, but they are used primarily in foods of low nutritional value.

2.4. Contaminants and residues

There are many sources of chemical contaminants in food. It is now well recognized that many components of our foods, whether natural or added, are toxic at certain levels, but harmless or even nutritionally essential at lower levels

Vehicle exhausts and emissions are a common cause of air pollution, and hazardous air-borne elements can be deposited onto and absorbed into various crops. Industrial and mining activities that produce poisonous wastes can contaminate plant and soil alike. Because of the complex interrelationships between air, water, land and plants, the contamination of any one element from, for example, a chemical leak or a nuclear accident will have serious implications for the others. Contaminants are often found in animals, particularly as a result of modern farming methods. Drugs used to prevent disease and promote growth in these animals have to be carefully regulated to ensure that levels in meat are safe for human consumption.

There are presently about 1500 different chemicals in over 60 000 formulations which are available as synthetic organic pesticides [4]. These include insecticides, herbicides, fungicides, nemacides, rodenticides and fumigants. They are systematically and seasonally sprayed, poured or dusted on cereals, fruit and vegetables before, during and after harvest. Many of these chemicals are also used on fallow land, cotton fields, grazing pastures, forests, golf courses and on building timber, woollen carpets, clothes and in kitchens and pantries. Food contamination can arise due to spray drifting onto crops, solvents evaporating from timbers, carpets or clothes and aerosols in the home settling on exposed foods.

It is nearly impossible to avoid the effects of these chemicals in some form or another, though we can try to minimize an exposure to them. Chemicals such as pesticide DDT have now become global contaminants. Traces have been found in the bodies of Antarctic penguins, in the rain, in drinking water, and in just about all commercially produced food. Each human being has in their body fats traces of hundreds or different pesticides. They are in milk and they even find their way into fertilized eggs. There are three major chemical groups of pesticides. These are organochlorines, organophosphates and carbamates.

Chemical contamination can occur during food storage. Coatings containing polychlorinated biphenyls PCBs have been used inside silos and have resulted in high levels of PCBs in milk. Food processing allows another potential period for chemical contamination. Some processing plants have witnessed instances of heat exchangers, transformers, and capacitors containing PCB based fluids leaking and contaminating food. PCBs are rarely detected in vegetables, vegetables oils, fruits, eggs, or cereals although there have been reports of high levels in some breakfast cereals, a result of contamination by packing materials

Many individuals are already sensitive to small quantities of chemicals in environment. Over the next few years it would not be at all surprising to find that the trace quantities of pesticides and herbicides that find their way into daily food supply constitute a major source of adverse food chemical sensitivity reactions.

Another area of concern is the possible contamination of food supply with heavy metals and other toxic minerals [11]. Those posing the greatest threat to human health are presently the minerals mercury, lead, cadmium and aluminium.

A more insidious aspect of mercury has emerged over recent years. Mercury now enters environment as the waste product of several industrial activities, and through mercurial fungicides and from geographical sources, especially as a result of acid rain. Burning fossil fuels are also to blame, as are the refining of ores. It is also used as an integral part of paint, pulp, paper, cosmetics, pharmaceutical products and electrical equipment, all of them leading to the contamination of food supply.

Lead is found in batteries, solder, dyes, and insecticides and can be transferred to food. It may also be found in the enamel used for kitchenware, in the glazes used for pottery and in solder used for cans containing food or drink. Fish and shellfish were generally shown to have a higher concentration of lead than other foodstuffs; however, in regions where there is extensive industry and mining, vegetables show significantly high concentrations. Vegetables, grains and fruit exposed to heavy vehicle exhaust or industrial emissions also contain higher than normal lead concentrations. There is now general agreement that atmospheric lead fallout is the major source of lead in typical food crops and this originates from petrol. Consumption of grass contaminated by aerial fallout of lead gives rise to most of the lead surfacing in the animal's organs.

The main sources of cadmium in foods are industrial emissions and fertilizers. Other potential sources of cadmium in food are cadmium-lined metal equipment used in commercial food processing, kitchen enamel, pottery glazes and some plastics.

Environmental sources of aluminium are aluminium pots, pans, cans, foil; aluminium flocculating agents employed in purification drinking water; baking powders, spices; antiperspirants, deodorants; air-borne contamination from air conditioner corrosion, clay dust. In high acid rain fallout areas mobilization of aluminium in high concentrations results in both surface and ground water. Again, the acid rain can be lethal to fish, not because of the acidification process but because of the increased content of aluminium.

A few highly toxic and persistent inorganic insecticides are also presently marketed in the world and these include arsenic, boron, sodium fluoride and sodium cyanide.

Nitrates and nitrites are common ingredients of nitrogen fertilizers and thus can be taken up by vegetables [13].

The concentrations in vegetables vary widely, depending primarily on the species, the concentration of nitrate in the soil light intensity, and drought conditions.

For many years now food producers have come to rely heavily on antibiotics to increase the growth rate of their food animals, thereby leading to a reduction in costs and also in the possible spread of disease in, for example, battery chickens. The concept of producing bigger, fatter animals much faster and cheaper, and with less disease, is very attractive to food producers. However, the use of subtherapeutic amounts of antibiotics in animal feed is not without its problems.

Bacteria and other microorganisms in animals have a remarkable ability to develop resistance to antibiotics and pass on this resistance genetically. Although there is no direct evidence that these antibiotic-resistant bacteria are transmitted to people who eat meat or eggs from these animals, there is evidence that the genetic material contained in these plasmids may certainly be transferred from animals that are eaten to humans. There is also evidence that people who handle raw meat, or feed laced with antibiotics, have a large number of resistant bacteria in their gut.

The transmission of antibiotics through milk and dairy products could affect people who have adverse reactions to certain drugs and, of course, children. Such practices may also lead to the development of microorganisms that are more resistant to antibiotics. This resistance can lead in turn to the ineffectiveness of antibiotics currently used in medical treatment and the need for newer, often costlier, antibiotics. Presently, half of the antibiotics produced in the world are used in animal feed. There is much pressure all over the world on the medical profession at the moment to reduce the prescription rate of antibiotics.

2.5. Genetically modified food

Genetically modified foods are foods derived from genetically modified organisms. Genetically modified organisms have had specific changes introduced into their DNA by genetic engineering techniques. These techniques are much more precise than mutagenesis where an organism is exposed to radiation or chemicals to create a non-specific but stable change.

Typically, genetically modified foods are transgenic plant products: soybean, corn, canola, rice, and cotton seed oil. These may have been engineered for faster growth, resistance to pathogens, production of extra nutrients, or any other beneficial purpose. The world population has topped 7 billion people and is predicted to double in the next 50 years. Ensuring an adequate food supply for this booming population is going to be a major challenge in the years to come. GM foods promise to meet this need. Critics, sometimes referring to genetically modified foods as frankenfood, have objected to GM foods on several grounds, including safety issues, ecological concerns, and economic concerns raised by the fact these organisms are subject to intellectual property law. Genetic modification involves the insertion or deletion of genes. In nature this occurs when exogenous DNA penetrates the cell membrane for any reason. To do this artificially may require transferring genes as part of an attenuated virus genome or physically inserting the extra DNA into the nucleus of the intended host using a microsyringe, or as a coating on gold nanoparticles fired from a gene gun.

The first genetically modified plant was produced in 1983, using an antibiotic resistant tobacco plant. The first commercially grown genetically modified whole food crop was a tomato which was modified to ripen without softening. The process of genetically engineering animals is a slow, tedious, and expensive process. However, new technologies are making genetic modifications easier and more precise (*Figure IV-1*).

The first genetically modified animal was produced by injecting DNA into mouse embryos then implanting the embryos in female mice. In 2011, Chinese scientists bred cows genetically engineered with genes for human beings to produce milk that would be the same as human breast milk. This would possibly be beneficial for the mothers who cannot produce breast milk.

Figure IV-1. Genetically modified fowl

There is a growing concern that introducing foreign genes into food plants may have an unexpected and negative impact on human health (*Figure IV-2*). On the whole, with the exception of possible allergic most scientists believe that GM foods do not present a risk to human health. Labelling of GM foods and food products is also a contentious issue.

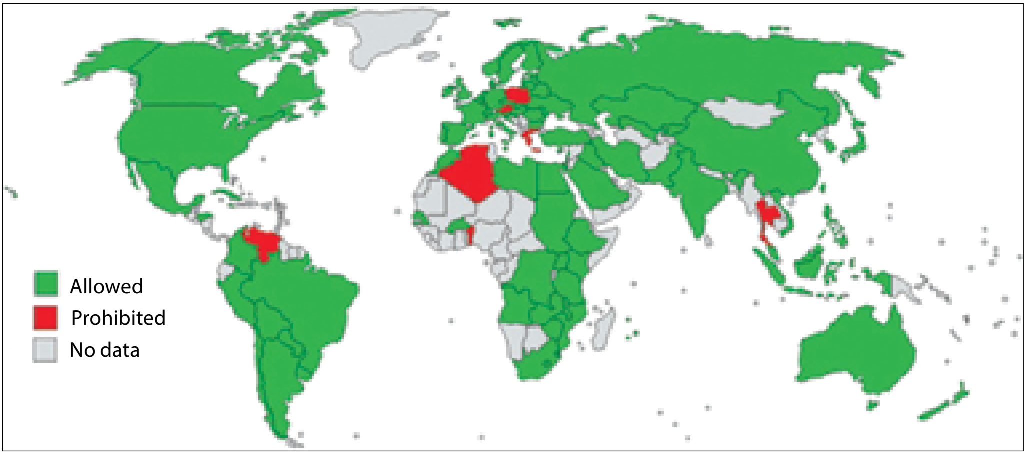

Figure IV-2. Distribution of genetically modified plants

People have the right to know what they eat, argue the interest groups, and historically industry has proven itself to be unreliable at self-compliance with existing safety regulations (*Figure IV-3*). Genetically-modified foods have the potential to solve many of the world's hunger and malnutrition problems, and to help to protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides. Yet there are many challenges ahead for governments, especially in the areas of safety testing, regulation, international policy and food labelling. Many people feel that genetic engineering is the inevitable wave of the future. However, it must proceed with caution to avoid causing unintended harm to human health and the environment.

Figure IV-3. Demonstration against genetically modified food

3. FOOD TOXICOLOGY

While malnutrition continues to be a pervasive health problem worldwide, food-borne illnesses are an equally worrisome public health problem. Statistics often underestimate the number of cases of food-borne illness because not everyone affected visits a doctor, and doctors may not report all cases to public health authorities. Some cases of food-borne illness may not be documented because they are not recognized as such. In various developed countries up to 60% of cases may be caused by poor food handling techniques and by contaminated food served in food service establishments. Similar problems exist in the developing world.

No normal person wants to consume dirty or decomposed food, even though there may be no threat to health. Food must be sanitary. It must also be safe in that it is not a vehicle for the transmission of disease. The distinction should be made between the food that is itself poisonous and one that merely serves as a vehicle for the transmission of pathogens to man. Food can be a source of disease by four different means – inherently harmful characteristics, ptomaine poisoning, toxin transfer, and infection transfer.

Hazards of food by nature may be divided into biological, chemical, and radioactive.

3.1. Biological agents

Biological hazards of concern to public health include pathogenic strains of bacteria, viruses, parasites, helminths, protozoa, algae and certain toxic products they may produce. They also include a phenomenon to gain significant attention – the presence of prions.

Of all of the biological hazards, the presence of pathogenic bacteria in foods currently presents the most significant problems internationally. Biological hazards may act through two general mechanisms in causing human illness. One mode of action is to produce toxins that may cause effects ranging from mild symptoms of short duration to severe intoxication that can even be life-threatening or induce long-term health consequences. These toxins are complex enzymes that can destroy protein and tissues. The second mode of action is to produce pathological responses that result from ingestion of viable organisms capable of infecting the cost.

Bacterial food illness is commonly due to a member of the genus of microorganism known as *Salmonellae,* the disease is called salmonellosis. Salmonellosis is characterized by an incubation period of approximately 12 hours. It is produced as the result of infection of food by human carries or by the infection already being present in the food at the time it is prepared. The most commonly infected foods are fowl and eggs. Other incriminated foods include dairy products, shellfish and vegetables. Prevention of salmonellosis involves education of food handlers in methods of cooking and refrigerating food. Cooking at approximately 75 °C for at least 2 minutes will destroy *Salmonellae.*

It should also be pointed out that there are organisms undoubtedly capable of producing bacterial food illnesses. However, it has been difficult to prove conclusively that these other organisms have been actually responsible. Among those incriminated are *Streptococcus faecalis, Clostridium welchii, Bacillus cereus.* There is, however, one important etiologic agent. These are the dysentery bacilli *Shigella.* They produce a more severe type of illness, sometimes fatal.

Viral food-borne diseases are believed to be more prevalent than they are documented. Even if a microbiological examination of food and water does not reveal a high number of bacteria, the food may still contain pathogenic viruses. Among the most notable viral food-borne diseases is hepatitis A. Epidemiological evidence shows that the hepatitis A virus is spread primarily through food. However, because the incubation period is quite long (usually to 30 days), outbreaks are difficult to investigate. Symptoms include fever, malaise, nausea and abdominal discomfort followed by jaundice. Shellfish from polluted areas, water, fruits and vegetables contaminated by faeces, and various types of salad prepared under unhygienic conditions have all been involved in outbreaks. While the causes of many food-borne diseases, as well as the means for their prevention are widely known, this knowledge is often not applied. Large sections of the public remain ignorant of the fact that symptoms such as diarrhoea and diseases such as hepatitis A are often food-borne.

Parasitic infections of food are difficult to investigate as little is known about the infectious dose required, or the exact method of transfer to an individual. Contamination may occur from hand to food or directly from polluted water. Problems arise in many parts of the world where meat and/or fish are eaten raw or undercooked, and where people drink untreated water or use it in food preparation. The best protection from parasitic diseases is a safe water supply and adequate cooking and refrigeration temperatures. Two of the most widespread parasitic food-borne diseases are giardiasis and trichinosis.

Giardiasis generally characterized by flatulence, belching, nausea, vomiting, fatigue, and cramps, caused by *Giardia* cysts penetrating the intestinal walls. *Giardia* is often spread by faeces entering water which is later used for washing food. The disease occurs most often in areas where there is poor sanitation and lack of clean drinking water. The main preventive measure is the sanitary disposal of faeces and the protection of public water supplies.

Trichinosis characterized by fever, retinal haemorrhage, diarrhoea, muscle soreness and pain, skin lesions, and prostration is caused by the migration through the body of the worm *Trichinellaspiralis.* In the small intestine, larvae develop into mature adults and mate. Female worms produce larvae which penetrate the intestinal wall and enter the bloodstream. The larvae encyst themselves in skeletal muscle. Infection occurs through the consumption of raw or undercooked meat, particularly pork. Preventative measures are inspection of meat in the slaughterhouse and adequate cooking of pork.

Prion disease bovine spongiform encephalopathy (BSE) or mad-cow disease first came to the attention with the appearance in cattle of a newly recognized form of neurological disease in the United Kingdom. Epidemiological studies suggested that the source of disease was cattle feed prepared from carcasses of dead cattle. BSE is associated with a transmissible agent called a prion, which stands for proteinaceous infectious particle, and is yet to be fully characterized. The prions multiply in a very exceptional way, by converting normal protein molecules into dangerous ones by changing their shape. The prions affect the brain and spinal cords of cattle. It is a highly stable agent, resisting normal cooking temperatures and even higher temperatures such as those used for sterilization, freezing and drying. The disease is fatal to cattle within weeks to months of its onset.

3.2. Chemical agents

Organic compounds can produce pathological changes in the body, including stimulation of certain metabolizing enzymes. Such stimulation may have important implications for human health, particularly if the affected enzymes activate or deactivate certain environmental chemicals.

Organochlorines such as chlordane, DDT, lindane, and aldrin are highly toxic, and are not biodegradable. They last for decades in the soil and being fat soluble, can be stored in human fat tissues, liver and the central nervous system to produce suspected chronic and delayed effects. Polychlorinated dibenzodioxins PCDDs, polychlorinated dibenzofurans PCDFs and polychlorinated biphenyls PCBs constitute a group of persistent environmental chemicals [12]. A number of dioxin or furan congeners, have been shown to exert a number of toxic responses similar to those of 2,3,7,8-tetrachlorodibenzo-p-dioxin TCDD, the most toxic dioxin. These effects include dermal toxicity, immune toxicity, reproductive effects, endocrine disruption and carcinogenicity. Human background exposure to PCDDs, PCDFs and PCBs predominantly occurs through the diet, with food from animal origin being the major source. High levels of dioxins have been found in poultry, eggs and pork meat.

Organophosphates are another major group of pesticides which act by blocking nerve transmission in the insect by inhibiting a vital enzyme called cholinesterase. These substances are often highly toxic and, being volatile, can be easily inhaled. They are more biodegradable than the organochlorines. Carbamates have the same mode of action as the organophosphates, but their toxicities are variable.

It is disconcerting to discover that chemical pesticides that are still freely available in one country have been banned in another because of fears of carcinogenicity and teratogenicity, quite apart from potential problems with chemical hypersensitivity arising from residues in food.

Both commercial and domestic cooking utensils have been detected as sources of lead and cadmium in foods. Lead produces a series of effects on blood forming tissues, the digestive and nervous systems, and the kidneys.

Cadmium is a cumulative poison that affects the kidneys even at relatively low levels of exposure. It also affects the placental function, liver function, testes and the formation of bone tissue. There was a sharp increase in cadmium concentration in molluscs and crustaceans and in animal kidneys, the contamination of rice with cadmium (Itai-itai disease).

Mercury has toxic effects on animals and on people. Pregnant women, nursing mothers and children are particularly susceptible to mercury poisoning. The most toxic form of mercury is methyl mercury, which causes damage to the central nervous system. Symptoms of methyl mercury toxicity start with numbness and parasthesia around mouth, fingers and toes, slurred speech, loss of peripheral vision, awkward gait and incoordination.

Methyl mercury is often found in fish because of the industrial effluents containing mercury that are discharged into rivers or seas and converted by bacteria into methyl mercury. The disease, which is known as Minamata disease, was traced to the discharge of methyl mercury into the bay from a vinyl chloride factory. Mercury was biomagnified up the food chain and became concentrated in fish. The symptoms and findings were similar to the toxicity of consumption of seeds contaminated with mercury. There is always the problem of a slow accumulation of mercury in the liver and brain cells. Even though it has a biological half-life of seventy-four days, it is still known that the removal of heavy metals from the nervous system occurs much more slowly than for other tissues.

Aluminium has been implicated as an important factor in some neurological disorders, particularly in patients on chronic renal dialysis.

High concentration of nitrate in baby food, much of which is converted into nitrites, is a cause of methemoglobinemia in infants [13]. Nitrite modifies hemoglobin compounds in the blood so that they cannot transport oxygen from the lung to the tissues.

3.3. Radioactive agents

Radioactive agents may be present in foods in very low levels; however, the levels of radioactivity in foods may be important. They may present carcinogenic, mutagenic and teratogenic hazards, and as a consequence of long half-lives, several radionuclides may persist throughout life.

Ingestion exposure occurs when radionuclides in the environment enter food chains. This component and that of external exposure are usually the significant and continuing sources of exposure following releases of radionuclides to the environment. Radionuclides released to the atmosphere may deposit onto both terrestrial and aquatic surfaces.

Plants are the primary recipients of radioactive contamination to the food chain following atmospheric releases of radionuclides. Vegetation may be subject to direct and indirect contamination. The direct contamination of terrestrial vegetation refers to the deposition of radioactive materials from the atmosphere onto the above-ground parts of plants. Indirect contamination refers to the sorption of radionuclides from the soil by the root system of plants. Secondary recipients of food chain contamination are animals that consume plants or other animals. Both plant and animal products enter the diet of humans.

The radionuclides that are of interest in food toxicology are the so-called internal emitters that enter the body by ingestion. Naturally occurring internal emitters that contribute to the total radioactive dose in the diet are potassium-40, radium-226, uranium-228, carbon-14, rubidium-87, lead-210, and polonium-210. In addition to this natural radioactivity, the environment and therefore also food can be contaminated with a number of human-made radioactive elements. Small amounts of these elements may be released in the environment by emission from nuclear reactors.

3.4. Food poisoning

Illnesses that relate to consumption of foods that are contaminated in high level with bacteria, toxin, or chemical, are referenced to as food poisoning [4, 10]. These illnesses have the acute form and require bacterial growth and toxin production in the food and not in the individual. Food poisoning is a term so generally used that it encompasses a spectrum of digestive disorders, acute onset of nausea, vomiting, diarrhoea, abdominal cramps and fever of varying degree. Food poisoning may be divided into three general groups: toxic, bacterial, chemical.

Food-borne toxins can originate from two sources: either they are a naturally occurring constituent of the food, or they are produced by microorganisms present in or on the food. In the course of evolution, humans have learned to select foods that do not cause acute adverse health effects. A number of poisonous plants occasionally produce food poisoning; among the most common of these is the mushroom. Symptoms usually appear soon after eating. Liver damage and death may occur if sufficient mushroom toxin has been ingested. Another poisoning which is not uncommon is mussel poisoning. This again, is the result of a toxin present in mussels. It is characterized by early onset of illness, followed by muscle weakness and respiratory paralysis.

Usually, natural toxins are not acutely toxic, except in a few cases in animals. Some species of fungi are capable of producing mycotoxins, toxic metabolic by-products [7]. Plant-related toxins include ergotic alkaloids, aflatoxin, and hydrogen cyanide. Ergotism is caused by toxins from the fungus *Clavicepspurpurea*. This fungus infects grain of all kinds with toxins which contain several alkaloids that are related chemically to the hallucinogenic compound LSD. Victims suffer such symptoms as burning in the extremities, convulsions, and hallucinations. Aflatoxin poisoning, unlike ergotism, is subtle. Aflatoxins are powerful liver carcinogens produced mainly by *Aspergillusflavus,* a mould that grows on grains and seeds. Corn and peanuts are especially vulnerable to mould. Aflatoxins are easy controllable in stored grains by treating the grains with very dilute solutions of certain fatty acids.

Food-borne poisoning due to bacteria *Staphylococci* depends on sufficient toxin in the food. Symptoms include nausea, vomiting, abdominal pain, prostration, dehydration, and subnormal temperature, which usually occur in 2 to 4 hours after the ingestion of contaminated food. The patient usually feels much better after 24 hours. Outbreaks of staphylococcal food poisoning are usually due to the contamination of food from infections existing on the body of the food handler, typically boils on the hands or other body surfaces. The staphylococcus produces enterotoxin, which is the factor involved in producing the symptoms. The most common kinds of food implicated in this poisoning are milk and milk products and custard or cream-filled pastries. Incriminated foods include ham, poultry, egg salads. Prevention of staphylococcal food poisoning involves education of food handlers, restriction of workers from handling food if they have obvious sores on their hands or other exposed surfaces, and ensuring that food is maintained hot (above 60 °C) or under refrigeration (below 4 °C) and not left to stand at atmospheric temperatures for a long time.

Other microorganism is *Clostridium botulinum,* which secretes the toxin that causes the botulism. This poisoning occurs much less frequently than does staphylococcal poisoning, but is a highly fatal food intoxication produced as a result of ingestion of food in which the toxin of *Clostridium botulinum* has been produced. The incubation period is usually from 12 to 36 hours and is followed by muscular weakness and visual disturbance. There is difficulty in talking and swallowing, followed by incoordination, respiratory paralysis and death. The microorganism and its spores are widely distributed in nature. They occur in soil, bottom sediments of streams, lakes, and coastal waters, and in the intestinal tracts of fish and mammals, and in the other shellfish.

Almost any type of food that is not very acidic (pH above 4.6) can support growth and toxin production by *Clostridium botulinum*. Toxin has been demonstrated in a considerable variety of foods, such as canned corn, peppers, green beans, soups, mushrooms, ripe olives, tuna fish, chicken, ham, sausage, and smoked and salted fish. The risk of botulism is much greater with home-canned foods than with commercially canned foods. There is a specific antitoxin available for use in the treatment of botulism. However, once the disease occurs, the mortality rate is high. Prevention is therefore all important and consists of proper education of householders in safe methods of home canning.

Microorganism *Escherichia coli*, one of the common cause of diarrhoea, are present in the lower intestinal tract of most warm-blood animals and are the most prevalent oxygen-tolerant bacteria in the large intestine of humans. They are transferred from faeces and intestinal contents to carcasses and meat during processing. Shellfish and watercress can be contaminated if drown in sewage-contaminated waters. The enterotoxigenic strains cause poisoning within 8–48 hours after infection. Diarrhoea usually ceases within 30 hours. Contamination with *Escherichia coli* can be minimized or prevented by good personal hygiene during food handling. Outbreaks can be prevented by heating food long enough and at temperatures high enough to destroy the bacteria, and then cooling the food at temperatures sufficiently low (below 4 °C) to prevent their proliferation.

There is food poisoning classification in Latvia, as well. Food poisoning is divided into microbe and non-microbe origin. The first contains toxicoinfections and toxicoses.

Toxicoinfections can be created by *Proteus mirabilis et vulgaris, Escherichia coli, Salmonella*, or others microbes which have multiplied in meat and fish products or salads. Symptoms include acute gastroenteritis, diarrhoea, vomit with increased temperature till to 38.5 °C; incubation period about 12 hours (*Figure IV-4*).

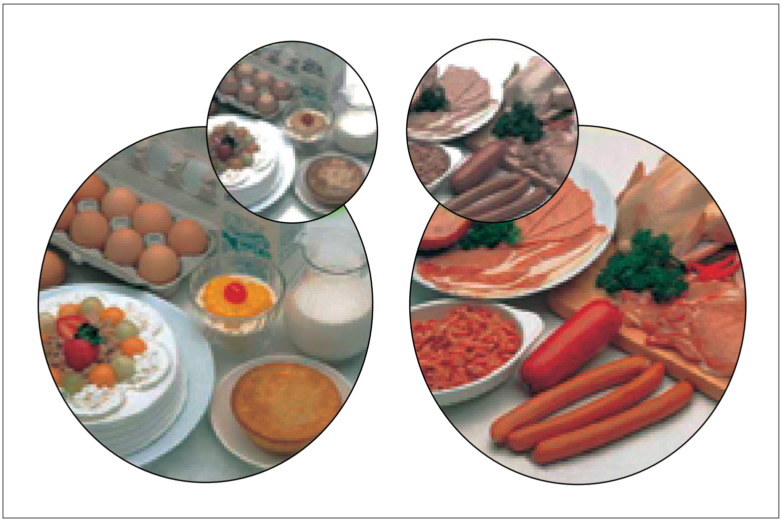

Figure IV-4. Food products potentially poisoned by bacteria *Salmonella*

Toxicoses are divided into bacterial (staphylococcal, botulism), and myco or fungus (toxins of *Clavicepspurpurea, Fusariumsporotrichiodes, Asperigillus).*

The non-microbe food poisoning is chemical food poisoning which is classified into poisonous of plants and animals tissues (alkoloids in mushrooms, fazine in beans, solanine in potatoes, etc.) and chemicals which are in food additives or in packing material (nitrite, pesticides, lead, zinc, etc.). The main preventive measures are the right treatment and storage conditions of foods and beverages.

4. FOOD SAFETY AND QUALITY ASSURANCE

Access to safe, healthy food is a human right [4]. Food is also a commodity that contributes to a country's national economy, with enormous economic interests at stake in food production, processing marketing and distribution. Each year around 130 million Europeans are affected by episodes of food-borne diseases.

Production and consumption of food should reduce the risk of both food-borne and non-communicable diseases, and prevent micro-nutrient deficiency. A healthy diet can also be environmentally sound. Growing the right kinds of food for health can reduce fuel consumption, pollution, transport and packaging cost and promote biodiversity, especially if grown near to where it is consumed. This can improve food security, promote a sustainable environment and create local jobs.

The quality and safety of the food supply is a topic of continual interest to the media and the general public. The word quality has many different meanings and interpretations. The average consumer associates quality with personal preferences, and may therefore subjectively interpret the term as indicating whether the food is liked or disliked, good or poor. Food quality from a scientific point of view includes a number of safety aspects such as the presence of environmental contaminants, pesticide residues, use of food additives, microbial contamination and nutritional quality.

Thus, food quality is determined by four main categories of qualitative properties:

1) organoleptic aspects (how it influences the senses);
2) nutritional value;
3) functional properties;
4) hygienic properties.

Any critical appraisal of adverse reactions arising from the ingestion of chemicals must examine all sources of chemicals in all foods. We cannot separate the chemicals that are naturally occurring in food from those that are directly added or exist as contaminants, particularly when many of the chemicals are identical in structure. Most people ingest several grams of chemicals each day, and many of them cause adverse symptoms in the unsuspecting. These can range from acute toxicity to hypersensitivity or pharmacological reactions. Some individuals may have been suffering from the adverse effects of these foods for most of their lives, but are still unaware of the problem.

It is not possible to eliminate our chemical environment overnight. But it is possible to minimize exposure to chemicals in food, using improved knowledge of the sources of these and their potential toxicity. By the choice of selective diets and supplementary antioxidant nutrients men can also support body's defensive system, thus aiding the chemical detoxification process and reducing the incidence of adverse food reactions to chemicals.

Safe food can be defined as food that causes no adverse health effects. However, it is clear that absolute safety is an unattainable goal, and safety must therefore be defined in relative terms such that any health risk associated with food consumption is limited to an acceptable level. It is necessary to discriminate between the various kinds of toxicological risks. Natural toxins and contaminants are undesirable and unintentionally present in food. The setting of acceptable intakes is based on the toxicological profile of the component. In case of food contaminants, usually the terms tolerable daily intake TDI is used to reflect the levels permissible in food to maintain a safe supply. In case of genotypic carcinogens, human exposure should be reduced to the lowest practically achievable level.

Ideally, all toxic contaminants should be removed from food, but usually the factors leading to their presence are difficult or impossible to control. Therefore, the unavoidable intake of contaminants should be limited to safe levels. The concept of irreducible level is defined as the concentration of a substance which cannot be eliminated from food without involving the discarding of the food altogether and thereby compromising the ultimate availability of major food supplies.

When new food is produced, it is necessary to have detailed information about its nutrient content that can be label on the package. New foods may also contain natural toxins as well as contaminants Presence of both will have to be considered. In the event that new contaminants or toxins are detected, it is necessary to assess the risk involved.

There are three criteria that are considered before a new chemical is introduced into food system. First, acute toxicity of the substance; second, mutagenic properties of the substance; third, the substance is carcinogenic, or cancer producing. It is fairly easy to test whether a substance is going to be toxic in one of the organs such as liver, kidney or bone marrow, but such tests do not screen agents for potential long-term hazardous effects due to cumulative low-dose administration, or subtle changes are not looked for in normal toxicological testing, such as behavioural effects.

Processing, storage, and preparation of food may influence the nutritional value of food. Proper understanding of the nutrients and the means of balancing a diet of the foods that contain them will result in optimum health for the body and mind.

The flow of raw food materials to the actual consumption is presented by hazards as follows:

1) production of raw material: environmental contaminants, natural toxins, microbial toxins;
2) food handling: reaction products, chemical contamination, additives, microbial contamination;
3) food preservation, storage: chemical contamination, microbial contamination;
4) food consumption: food poisoning, food-borne infections.

4.1. Production of raw materials

To ensure safe food production, it is important to look at the agricultural level and improve the hygienic quality of raw foods. By improving the conditions under which animals are raised, the hygienic quality of raw food products can be significantly improved. Furthermore, use of both pesticides and fertilizers should be reduced. Residue levels of toxic chemicals used to improve crop production should be systematically monitored. Food safety at this stage can be improved by regulatory measures aimed at reduction of industrial and vehicle emissions and disposal of hazardous waste materials that can enter the food chain.

4.2. Food processing

Substantial losses of food by contamination and spoilage can be prevented both through carefully controlled technology and through the development of a strong associated infrastructure. Equipment used should be designed to facilitate cleaning. Vehicles used to transport food products must be clean and should not be used to transport any other products. Refrigerated vehicles must be available for the transport of perishable food. Modern technologies can prevent or reduce the formation or use of chemicals in food. For example, crops can be dried to prevent mould growth and thus also diminish the production of mycotoxins during storage. Biotechnological methods can be used to develop crops that are more resistant to pests and thereby decrease the need for pesticide use.

Facilities should be designed so that all food, particularly vegetables, can be stored above the floor where they will remain dry and will not come into contact with powders and sprays applied to control insects and rodents.

In the processing and preparation of food products, personal hygiene is indispensable. Food handlers must wash their hands after toilet use and before and after work; avoid contact between open wounds and foodstuffs; wear clean outer garments, including a cap over the hair; and avoid using tobacco products while working. Food handlers should also be trained in appropriate methods of food storage, garbage disposal, and insect and rodent control.

4.3. Food preservation

Many bacterial pathogens are able to multiply in food because of the temperature at which the food is stored. There is a variety of safe methods for preserving wholesome food, preventing contamination, and destroying organisms or toxins that may have gained access to or been produced within it.

Effective use of these methods requires an understanding of the factors that affect bacterial growth:

1) acidity and alkalinity: most bacteria grow best in a neutral medium; highly acid or alkaline media inhibit growth; most bacteria that contaminates food require oxygen for growth;
2) moisture: most bacteria will grow on moist surfaces or in water; each kind has an upper and a lower limit of growth activity in solution, depending on whether salt, sugars, or other materials are present;
3) temperature: each kind of bacteria has maximum, optimum, and minimum temperatures at which growth proceeds; most disease organisms grow best at the normal temperature of the human body; temperatures above 71 °C will kill most organisms, but temperatures below 4 °C will retard their growth.

Most bacteria, then, will grow rapidly under warm and moist conditions, contaminating any food in which they are present. However, certain bacteria are very useful, particularly in the fermentation of food. Examples include bread, yogurt, and wine. In these cases, their growth and the changes they produce are essential to their beneficial effects. Fermentation is a gradual chemical change caused by the enzymes of some bacteria, moulds, and yeasts.

The process of canning consists in heating food to a sufficient degree to kill any microorganisms present and then sealing it in a container to keep it sterile. The combination of time and temperature required to preserve food by canning varies with the product and its likely contaminants. Acid foods, such as tomatoes and some fruits, need to be heated to the boiling point for only a few minutes. Non-acid foods, such as corn and beans, must be heated to higher temperatures for a longer time to prevent undesirable changes in appearance and flavour.

Air drying is one of the most effective ways of preserving food. Methods of drying include spray drying, freeze drying, vacuum drying, and hot-air drying. However, once the food is reconstituted by the addition of water, bacterial activity resumes, and sanitary control is essential.

Certain preservatives can be used to inhibit the growth of microorganisms or to kill them. Salt, sugar, sodium nitrate, and nitrites, salicylic acid and sodium benzoate are commonly used for curing and pickling meats and vegetables. Propionates and sorbic acid are commonly used to prevent mould formation in breads.

Storing food at temperatures lower than (5 °C) will retard the growth of pathogenic organisms and more important spoilage organisms. Although bacteria that cause food spoilage do not multiply at freezing temperatures, once thawing begins, frozen food becomes vulnerable to bacteria and the associated toxins they may produce. One variation of freezing is dehydrofreezing, in which the food is partially dehydrated and then frozen. This process provides the space and weight savings of dehydration without depriving food of its fresh colour, flavour, and palatability.

Pasteurization is an excellent method for preserving food for a short time. Combined with refrigeration, it extends the useful shelf life of dairy product. Milk is generally heated to 63 °C for 30 minutes or to 72 °C for 15 seconds to kill pathogenic organisms.

Food irradiation is one method of improving the keeping properties of certain high-value perishable foods and thereby facilitating international trade. It consists of exposing food to gamma rays, X-rays, or electrons over a limited period of time, which kills the present pathogens. No radioactive material is permitted to come onto contact with the food, and the final product is not radioactive.

Micronutrients, especially vitamins, may be sensitive to any food processing method, including irradiation. This sensitivity depends upon the conditions under which food is irradiated. Vitamins A, E, C, K, and thiamine (B_1) in foods are relatively sensitive to radiation, while some other B vitamins such as riboflavin, niacin, and vitamin D are much more stable. Losses are generally less if oxygen is excluded and if temperature during irradiation is low. Under optimal conditions, vitamin losses in foods irradiated at doses up to 1 Gy are considered to be insignificant. At higher doses, the effect of irradiation will depend on the specific vitamin, temperature, dose, food, and packaging.

4.4. Eating establishment regulations

Perhaps no valid proof exists that if dust or other dirt gets on food, the person who eats the food will have his health impaired. Likewise, there may be no overwhelming evidence that a person coughing on food will produce illness in a person who eats the food. Yet, public is entitled to sanitary and safe food when it eats in a public eating establishment.

The consequences of improper food preparation in food preparation in food services such as canteens and restaurants can be much bigger than that in the household simply because a larger number of individuals may be simultaneously exposed to unsafe products. It is essential to have a quality control programme that will ensure the maintenance of specifications; it must also be applied to all areas and equipment that come into contact with food and beverages.

Licensing of public eating places is the instrument of control. In order to qualify for a license, the establishment must satisfy the equipment and operating requirements of the health department. Health department sanitarians make periodic inspections. Each item checked in an inspection contributes to the overall image of good construction, good maintenance, and good operating practices. Equipment and the interior of the food establishment itself need to be of the types which can be easily cleaned. Insect and rodent control programmes are important in food preparation areas. Care should be taken in the storage of insecticides, cleaning compounds and other non-food items so as to avoid the accidental contamination of food by these products. Covering of food to prevent contamination is also important. Water-proof containers with tight-fitting covers should be used in storing garbage at the food establishment.

Clinical examinations of new employees, even accompanied by laboratory tests, are of limited value as a means for preventing spread of disease. The second key factor in the protection of the public is a safe water supply. A third factor is proper toilet and lavatory facilities, with approved methods of waste disposal. Proper refrigeration and storage of food are highly important. Corrosion-proof utensils and equipment should be properly sanitized with detergents, decontaminants, and hot water.

4.5. Food sanitary control

The foods constitute the chief potential hazards to health, and the infections and food poisoning which may result from them. Against most of these hazards the individual must provide his own protection rather than rely on society to do so. There is control of food products sold in interstate commerce or for export, as well as inspection.

Considerable losses of nutrients, especially the B complex, vitamin C, and bioflavonoid complex, occur during storage and cooking. It is essential to select, store, and prepare foods wisely in order to obtain these nutrients. Precautions should also be taken to avoid food-borne illnesses caused by the growth harmful bacteria.

Some basic rules for storing and preparing foods in order to retain their nutrient content and to prevent food poisoning are as follows:

- cook meats thoroughly in order to kill harmful bacteria;
- keep perishable foods in the refrigerator to avoid bacterial contamination;
- destroy cans that bulge in order to avoid food poisoning;
- avoid soaking fruits, vegetables, or meats in water, to protect against the loss of water-soluble vitamins;
- reduce the store fresh foods as soon as possible to minimize nutrients loss.

4.5.1. Milk analysis

Milk and dairy products are commodities which are so susceptible to contamination and adulteration that the only way to obtain protection against fraud and against the diseases which may be transmitted through milk is by community action. The first step in achieving such protection is education, followed by the passage of a satisfactory milk ordinance. The next step is to make sure that this ordinance is enforced. For milk to be clean and also safe from disease is the aim of programmes for milk sanitation.

These objectives can be attained by observing the essentials listed below:

- healthy cows. This implies freedom from tuberculosis, contagious abortion (bang's disease, or brucellosis), and specific diseases and also infections of the udder;
- clean and healthy workmen. The freedom of dairymen from communicable disease is of vital importance;
- clean, airy, dustless barn with sanitary cow yard and surroundings;
- separate milk room, well constructed, properly screened, and supplied with pure water;
- utensils and equipment of proper design;
- effective sterilization and scrupulous cleanliness of pails, cans, coolers, bottles, and other equipment with which milk comes into contact;
- prompt cooling and proper handling of milk, including the milking, bottling, capping, and delivery;
- pasteurization is essential to safe milk, for experience has shown that with all other possible precautions infections may still enter, and pasteurization is the most practicable method of overcoming such danger. Pasteurization does not impair the nutritional value of milk.

Complete analysis requires about 2500 ml of milk. If milk is packed up, pick up 1–3 packs of chosen ones.

The colour, smell and taste of milk have to be evaluated. Milk has its own peculiar smell which is estimated without warming.

Milk's reactions is being evaluated by dipping litmus paper into the milk and by comparing them with ones dipped into distilled water. The reaction of just milked milk is amphoteric for the phosphates. The reaction of fresh milk is neutral and of aging one – acid or even alkaline.

The temperature of milk is being evaluated by mercury thermometer in the 15 cm depth in the centre of the vessel if the product is packed. Milk's temperature must be 10 °C.

The cleanliness of milk is being estimated by special apparatus. Put in an apparatus a filter from cotton and pour 250 ml of milk. After filtering the surface of the filter is being compared with standards. The contamination of non-packed milk has to be not higher than 2 °C, and packed one – 1 °C. When estimating by weight method, the allowed amount of mechanical admixtures is 10 mg per 1 litre.

Density of milk is being estimated by lactodensimeter. Milk is being well mixed and 250–500 ml of milk is being carefully poured into a cylinder. Put the lactodensimeter inside, leave everything for 5 min. The lactodensimeter has not to contact with walls, bottom, the scum has to be removed. The readings of scale are being made to the highest brim of meniscus. The temperature correction to density is being calculated by counting the density of investigative milk for the temperature of 20 °C. If temperature of milk is higher than 15 °C, then the number 0.0002 has to be added to the density for every degree of difference; and if lower than 15 °C – 0.0002 has to be subtracted for every degree. The density of milk must be 1.029–1.034. The density of skim milk is higher and it is lower when milk is diluted with water, but it can be normal if milk is skim and diluted.

The level of fat in milk is being detected by butirometer. 10 ml of sulphuric acid (d = 1.81–1.82) is being poured into it and 11 ml of milk is added with a dropper very carefully, not mixing liquids. Then add amyl alcohol. Cork up tightly with dry rubber cork and mix carefully while milk clots will fuse. The butirometer is being held in 65–70 °C water bath for 5 minutes when number of revolutions is 800–1000 per minute. While taken from the centrifuge, the butirometer is being put into 65–70 °C water bath for 5 minutes with the cork first again. After this regulate the fat column with the cork holding the butirometer vertically. The biggest section corresponds to 1%; the smallest one – 0.1%.

The level of fat in milk can be evaluated approximately by lactoscope. Pour 4 ml of milk into it and add distilled water gradually while the black dashes in the apparatus become distinct. The height of diluted milk's surface will indicate the level of fat in per cent. The level of fat in milk has to be not lower than 3.2%.

The acidity of milk is being evaluated by Turner's degrees. The amount of 0.1N NaOH ml, which is needed for titration of 100 ml of the product, indicates the acidity by Turner's degrees. 10 ml of milk, 20 ml of distilled water and 3 drops of phenolphtalene solution are being poured with a dropper into a cone flash. Continue with mixing titrates 0.1N NaOH till the very weak pink colour, which does not disappear during 1 minute appears.

$$A = a \times 10\ (°T),$$

where

A – acidity in Turner's degrees, °T;

a – 0.1N NaOH solution has been used for titration, ml.

The acidity of milk has to be 21–22 °T. When milk is going off the level of acidity is increasing. Boil the milk in the test-tube. Milk will coagulate when acidity is higher than 25–27 °T.

While trying to decrease milk's acidity, it can be falsified by various preserves such as soda, hydrogen peroxide, etc. These substances protect milk from souring or can lower the acidity. But there cannot be any preserves in milk which is used for food. Soda is detected by pouring 2–3 ml of milk and the same quantity of 0.2% spirituous rozalies acid solution into the test-tube and mixing all this well. The mixture becomes pink-white when soda is available, and pink-yellow, when there is no soda.

Fluor is being added into the skin or diluted milk for falsifying, trying to make milk's appearance better. Pour few ml of milk into a test-tube and boil it up for starch coagulation. Drop some of spirituous iodine solution after cooling. When flour is available the blue colour appears.

4.5.2. Bread analysis

The appearance, colour, smell, and taste of bread have to be evaluated. Bread has its own peculiar smell which is estimated without warming. Bread has to be without any visible admixture (flour, paper, rope, bone, etc.). A crust thick may be 2–3 mm and a crumb – even.

The porosity favours bread digestion in stomach. For rye-bread it is recommended not less than 45% but for wheat-bread more than 55%. The porosity is being estimated as follows: from crumb cut out cube in sizes 3 × 3 × 3 cm (volume 27 cm^3). The crumb cube (CC) carefully is being pressed to remove all air and it forms a round bead. Few beads are being put in cylinder with 25–30 cm^3 of distilled water. Remark the highest brim of meniscus and calculate bead volume BV = volume after putting beads – volume before putting beads, in ml.

The porosity P is calculated by formula:

$$P = \frac{CC - BV}{CC} \times 100\ (\%)$$

The acidity of bread is being evaluated likewise milk. First, organic acids are being extracted from bread by distilled water. Weigh 10 g crumb and mix it accurately with 50 ml water till even mass is formed. Retain mixture for one hour and then determine acidity in extract. Pour 10 ml extract by pipette into a cone flask, add 3 drops of phenolphtalene and titrate by 0.1N NaOH.

$$A = \frac{a \cdot b}{c},$$

where

A – acidity in Turner's degrees, °T;

a – 0.1N NaOH solution has been used for titration, ml;

b – volume of all extract, ml;

c – weight bread is taken for extraction.

The acidity of a rye-bread has to be not more than 12 °T and wheat-bread – not more than 6 °T.

4.5.3. Vegetable and fruit analysis

A piece from the surface to the centre of fruits or vegetables is cut off, while dishes are mixed up to get the average (medium) sample. 5 g of chopped fine and mixed stuff are poured into a pestle where it is pounded, at the same time adding in parts 15 ml of 2% HCl solution. The substance is swelled till united mass and left for 10 minutes to stay and extract. Then it is strained off through gauze. 1 ml of extract is taken by a pipette. Distilled water up to 10 ml is added. If the extract is coloured, distilled water must be added up to 30 ml. Titration is carried out with a pipette filled with 0.001 N Tilmanss' reagent (2.6-dichlorphenol-indophenolsodium solution) up to light pink colour which remains constant for 1 minute. Oxidation-reduction reaction between Tilmanss' reagent and ascorbic acid takes place. Titration must be done during two minutes and using only from 1 to 2 ml of Tilmanss' reagent – this is very important, because the reagent firstly reacts to ascorbic acid and after that with all other reduction substances. Correction test is used by 9 ml of distilled and 1 ml of 2% HCl solution and is poured in a flask. Titration with Tilmanss' reagent must be up to light pink colour. Calculation of concentration of ascorbic acid indicates freshness and wholesomeness of food product.

$$A = \frac{(a - b) \times d \times 0.088 \times 100}{c},$$

where

A – ascorbic acid in a tested product, mg%;

a – Tilmanss' reagent used in the test, ml;

b – Tilmanss' reagent used in correction test, ml;

c – weight of product, g;

d – amount of 2% HCl which is used for preparation of extract;

0.088 – 1 ml of Tilmanss' reagent corresponds to 0.088 mg of ascorbic acid.

5. NUTRITION AND HEALTH

Nutrition is a fundamental human need, a basic right, and a prerequisite to health. Nutrition is essential for normal organ development and function, for normal reproduction, growth, and maintenance, for optimum activity level and working efficiency; for resistance to infection and disease. The foods and beverages people consume should provide their bodies with the nutrients necessary for good health. Good health is a product of heredity, environment, and nutrition. Good nutrition is essential for good health.

Health depends upon nutrition more than any other single factor in environment. Without adequate nutrition, there can be no sound social and economic development in a community. Healthy nutritional status is best understood as the complex interaction between health, the food, and surrounding environment.

5.1. Physiological requirements

The foods and beverages people consume should provide human body with the nutrients necessary for good health. They must be broken down by the body into simpler chemical forms so that they can be taken in through the intestinal walls and transported by the blood to the cells. There they provide energy and the correct building materials to maintain human life. Protein builds and maintains body cells, and carbohydrates, fats, and some proteins provide calories for energy. Vitamins and minerals help to regulate many chemical reactions within the body. These are the processes of digestion, absorption, and metabolism.

Digestion is a series of physical and chemical changes by which food, taken into the body, is broken down in preparation for absorption from the intestinal tract into the bloodstream. Absorption is the process by which nutrients in the form of glucose from carbohydrates, amino acids from protein, and fatty acids and glycerol from fats are taken up by the intestines and passed into the bloodstream to facilitate cell metabolism. The process of metabolism involves all the chemical changes that nutrients undergo from the time they are absorbed until they become a part of the body or are excreted from the body. Metabolism is the conversion of the digested nutrients into building material for living tissue or energy to meet the body's needs.

Metabolism occurs in two general phases that occur simultaneously, anabolism and catabolism. Anabolism involves all the chemical reactions that the nutrients undergo in the construction or building up of body chemicals and tissues, such as blood, enzymes, hormones, glycogen, and others. Catabolism involves the reaction in which various compounds of the tissues are broken down to supply energy. Energy for the cells is derived from the metabolism of glucose, which combines with oxygen in a series of chemical reactions to form carbon dioxide, water, and cellular energy. The carbon dioxide and water are waste products, carried away from the cells by the bloodstream. Energy can also be derived from the metabolism of essential fatty acids and amino acids, although the primary effect of the metabolism of amino acids is to provide material for growth and the maintenance and repair of tissues. The waste products of essential fatty acid and amino acid metabolism are also carried away from the cells by the bloodstream.

The fuel potential of nutrients is expressed in calories, a term that signifies the amount of chemical energy that may be released as heat when food is metabolized. Therefore, foods that are high in energy value are high in calories, while foods that are low in energy value are low in calories. By disintegration of 1 g of protein, 17.8 kJ (4.1 kcal) are released, 1 g of fats – 39.0 kJ (8.3 kcal), and 1 g of carbohydrates – 17.2 kJ (4.1 kcal).

Many factors influence eating patterns and therefore affect nutrition. For example, taste preferences, states of health, and various social and cultural customs all determine what foods a person eats. Poor nutrition may be the result of consuming too little, too much, or the wrong kinds of food, because of any number of reasons. Fresh, raw fruits and vegetables are generally more nutritious than prepared ones, although many kinds of foods are more palatable when cooked.

Malnutrition remains the major cause of mortality and morbidity and significant percentage of the word's population remain undernourished. While the word's most profound nutritional emergency is visibly exhibited in only 1 or 2% of the world's children, an estimated 190 million children under the age of five are chronically malnourished. The causes of malnutrition are complex; many households run short of food between harvests, or amid drought and war. Many malnourished children, however, live in homes with adequate food supplies and need only a very small proportion of a family's intake to remain adequately fed. Often low birth weight and specific practices such as bottle feeding contribute to malnutrition in these cases. Malnutrition amplifies all other illnesses and the risk of dying from some other disease is doubled for mildly malnourished children and tripled for moderately malnourished children.

Nutritional deficiency, resulting in disease, is one of the major problems in modern society despite adequate food supply, primarily because of ignorance of good nutrition. Most diseases caused by such deficiencies can be corrected when all essential nutrients are supplied. However, in some instances of severe deficiency, irreparable damage may be done. The World Health Organization outlined a number of specific nutritional deficiencies, many of which are a direct result of the local environment.

Iodine deficiency disorders are a serious affliction in many parts of the world. The Alps, Great Lakes, the Andes, and the Himalayas are particularly deficient. The most clinically obvious effects of iodine deficiency are goitre and cretinism, even mild iodine deficiency can lead to less obvious conditions such as delayed mental development, and diminished work capacity.

Traditionally, health risks related to vitamins are associated with deficiencies. However, the relation between health and the intake of vitamins shows an optimum. Excessive vitamin intake may result in toxic effects. The margin between physiological need and toxic dose is different for two distinct groups of vitamins: lipophilic vitamins (A, D, E and K) and hydrophilic vitamins (B and C, biotin, niacin, patothenic acid and folate). For the lipophilic vitamins this margin may be relatively narrow as compared to that of the water soluble vitamins.

Vitamin A deficiency leads to xerophthalmia and sometimes to blindness. It also decreases resistance to disease and infection and increases mortality. Anaemia is a widespread and persistent problem. Most iron deficiency anaemia in developed countries is the result of iron loss from the body because of internal bleeding. Women are at much greater risk because they lose iron due to blood loss during normal menstrual cycles. Africa and Southern Asia have particularly high levels of iron deficiency anaemia due to a combination of both low intake and poor absorption. Ascorbic acid and animal foods are known to promote iron absorption. When either of these constituents is missing, a diet based on cereals and legumes may provide a low level of available iron, even though the plant foods are themselves rich in iron.

The importance of calcium deficiency as a cause of osteoporosis has been stressed many times. In general, the etiology of osteoporosis is related to disturbances of the hormonal regulatory systems involved in the maintenance of bone mass as well as extracellular calcium concentration.

Fluoride deficiencies can lead to dental caries. Rickets is attributable to a combination of insufficient exposure to sunlight and lack of vitamin D in the diet. Ascorbic acid deficiency still occurs in some drought affected areas, particularly Africa. Vitamin B_{12} deficiency can cause anaemia and even neurological disorders – this may occur in people consuming vegetarian diets containing no food of animal origin.

A balanced diet could be guaranteed if a plentiful and varied supply of different foods could be eaten. A variety of nutrients is required by humans to maintain healthy metabolic function. The number of calories required varies greatly between individuals, depending on size, and age and the level of physical activity the individual maintains, but it is based on balancing intake with output. If energy intake and expenditure are not in balance, this results in changes in body mass. Being underweight and overweight both have negative effects on human health. Obesity defined as a state characterized by excess body fat, is a common cause of severe morbidity and diminished longevity. Nutrition has to have sufficiency, variety, and balance (*Figure V-5*). Proper nutrition means that the essential nutrients are supplied and utilized in adequate balance to maintain optimal health and well-being.

5.2. Foods

Eggs are an excellent source of complete protein; they contain all essential amino acids. Also found in eggs are vitamins A, B_2, D, and E, niacin, copper, iron, sulphur, phosphorus, and unsaturated fatty acids. The egg yolk contains the richest known source of choline, found in lecithin and necessary for keeping the cholesterol within the egg emulsified and keeping cholesterol moving in the bloodstream. The yolk also contains lecithin itself and biotin, one of the B-complex vitamins. Eggs should be kept refrigerated at all times (at 5 °C to 10 °C) because temperature variations will cause the whites to become thin.

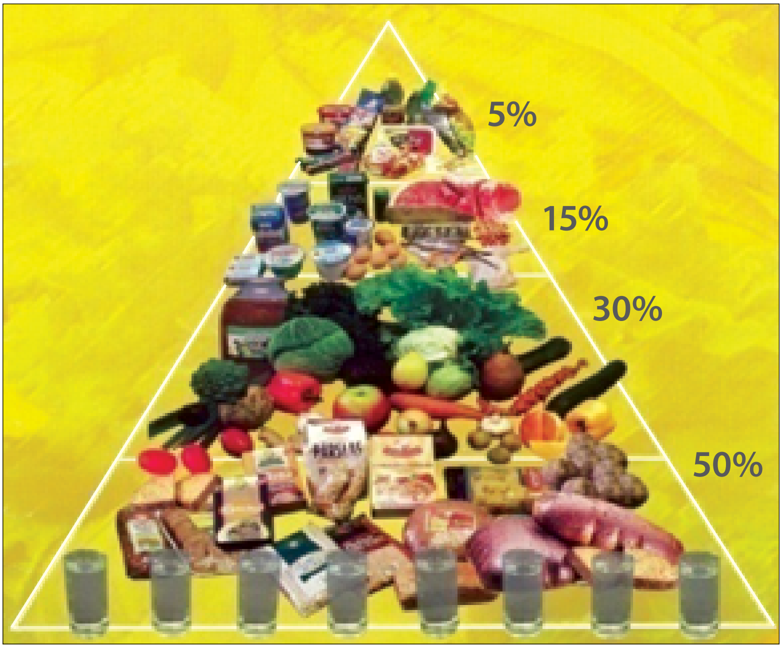

Figure IV-5. Pyramid of rational diet

Fibre is the part of food that is not digested by the human body, such as the skin of an apple and the husk of a wheat kernel. The normal functioning of the intestinal tract depends upon the presence of adequate fibre.

Fish are excellent source of high-grade protein, polyunsaturated fatty acids, and minerals, especially iodine and potassium. Freshwater fish provide magnesium, phosphorus, iron, and copper. Saltwater fish and shellfish are rich in iodine, fluorine, and cobalt. The unsaturated fat content of fish and shellfish varies with the species and season of year. Fatty fish, such as halibut, mackerel, and salmon, are good sources of vitamins A and D. Herring, oysters and sardines contain zinc. Shellfish are low in fatty acids but are relatively high in cholesterol. Because of the possibility of bacterial infection, fresh fish and shellfish should not remain at room temperature for more than two hours.

Fresh fruits are good sources of vitamins and minerals, especially vitamins A and C, carbohydrates in the form of cellulose and natural sugars, and water. They are good substitutes of such high-carbohydrate foods as candy, cookies, and cakes, which contain few nutrients.

Yellow fruits, such as apricots, cantaloupe, and persimmons, are good sources of carotene, which is converted to vitamin A. Aside from acid red cherries and rose hips, the best natural sources of vitamin C are citrus fruits, such as oranges, grapefruit, and lemon. Apples and bananas contain valuable bulk fibre in the form of indigestible cellulose, which is needed for regular bowel movement. Bananas are high in magnesium and may be useful for treatment of diarrhoea, colitis, ulcers. Fruits may be fresh, frozen, dried, or canned, but nutrient values decreases if fruits are not properly stored or if they are refrigerated for extended periods of time.

The main constituent of bread is flour. Cereals can be made from a variety of grains, such as corn, barley, oats, wheat, rice, and rye. Nutritious pastas can be made from a variety of whole grains. Whole-grain flour contains the germ of the grain, which possesses the most nutrients, and must be refrigerated to prevent rancidity. Whole-grain breads should be stored at room temperature or frozen until used. Enriched flour has the nutrients thiamine, riboflavin, and niacin of the vitamin B complex, and sometimes iron, returned to it.

Whole brown rice contains a generous supply of B vitamins, plus calcium, phosphorus, and iron. Wild rice contains twice as much protein, fourth times as much phosphorus, eight times as much thiamine, and twentieth times as much riboflavin as white rice. White rice, polished rice has no significant amount of B vitamins.

Vegetables are composed primarily of carbohydrates and water and contain very little protein. Vegetables also provide vitamins, minerals, and bulk to the diet. In general, light-green vegetables provide vitamins, minerals, and a large amount of the carbohydrate cellulose, necessary to provide bulk in the diet. Yellow and dark-green vegetables are excellent sources of vitamin A. Vegetable leaves are usually rich in minerals and vitamins C, and many of the B vitamins.

Legumes are plants that have edible seeds within a pod they include peas, beans, lentils, and peanuts. Legumes are a rich source of incomplete protein, iron, thiamine, riboflavin, and nician. Because of their high incomplete protein content, legumes can be used as a meat substitute when used with other complementary protein foods. Dried legumes should be stored in tightly covered containers in a cool, dry place.

Generous supplies of soybean products may serve as the major protein source in a meatless diet. However, the balance of essential amino acids in soybeans is not the same as that in meats. Therefore, more grams of this protein are required to supply the essential amino acids adequately. In addition, soybeans contain vitamins and minerals in a natural relationship that is similar to the human body's needs.

Meat commonly refers to the flesh of animals. It is the most important source of first-class protein in the modern diet. In addition to protein, beef, lamb, and pork are good sources of B complex vitamins, phosphorous, iron, sulphur, potassium, and copper. Poultry, also a good source of protein, contains B complex vitamins, iron, and phosphorus. Both raw and cooked meat should be refrigerated at a temperature of –1 °C to 0 °C.

Milk and dairy products are excellent sources of calcium, complete protein, and riboflavin. Milk also contains phosphorus, thiamine, and vitamins B_6 and B_{12}, but it contains little iron or vitamin C. Butter is made from milk, contains vitamins A and D, and is high in fat content. It is a concentrated saturated fat that can cause the development of cholesterol in the arteries. Margarine made from unsaturated oils is a preferable substitute. Milk that has been fermented by a mixture of bacteria and yeasts forms custard like product called yogurt. Yogurt aids digestion and controls the action of the intestine in favourably stimulating the kidneys.

Vegetable oils, such as corn, cottonseed, safflower, soybean, olive, and sunflower, are widely used in cooking. These oils are important in diet because of their content of unsaturated fatty acids, especially, linoleic acid, which is necessary for growth and maintenance of the cells. Margarine is a popular butter substitute made from solidified vegetable oils. Oils, margarine, and all other fats should be kept refrigerated. Some protection from rancidity is provided by vitamin E, a fat-soluble vitamin that is a natural antioxidant and is present in most fat-containing foods.

The most important nutritive elements of seeds are B complex vitamins, vitamins A, D, and E, unsaturated fats, proteins, phosphorus, calcium, and a trace of fluorine. Edible seeds such as pumpkin seeds, sesame seeds, and sunflower seeds are rich in iron, iodine, potassium, magnesium, and zinc.

Cane and beet sugars, jellies, jams, candy, syrup, and honey are concentrated sources of sugar. Fruits are a natural source of sugar and furnish bulk in the diet. Sugar is a major carbohydrate source but is completely devoid of protein, vitamins, and minerals and is not considered nutritious. Honey, barley malt date sugar, unrefined granulated sugar cane juice, and concentrated fruit juices are preferable sweeteners because they are not refined and contain vitamins, minerals, and enzymes to aid in their digestion.

5.3. Beverages

Beverages such as alcohol, coffee, cola, and tea add little nutritive value to the diet, except for water. However, milk drinks and fruit and vegetable juices contribute fair amounts of protein, fat vitamins, and minerals in the diet.

Fresh vegetable juices are an excellent source of minerals and vitamins. Juices from dark-green and yellow vegetables are especially high in vitamin A. Vegetable juices may be the preferred form for persons suffering from disorders of the digestive system.

Carbonated beverages are high in sugar content and have no nutritional value. In order to hold the sugar in suspension and keep it from crystallization, all soft drinks contain acid, usually orthophosphoric or citric, which eats away tooth enamel and can impair the appetite and the stomach. Cola contain large amounts of caffeine, which stimulates the metabolism and leads to depletion of valuable nutrients in the body.

Vegetable juices are excellent sources of vitamins and minerals. Juice should not be allowed to stand for a long period of time after extraction, because vitamin C will be lost.

Coffee is produced from the coffee bean. It contains no nutrients but does contain caffeine. Coffee quickens the respiration process, raises the blood pressure, excites the functions of the brain, and temporarily relieves fatigue.

Tea is similar to coffee in that it contains caffeine. It contains tannin, or tannic acid, and essential oils as well. The tannin gives it colour and body; the oils give it flavour and aroma. Tea actually has little nutritive value with the exception of its fluoride content.

5.4. Supplementary foods

Supplementary foods may be useful for further increasing the nutritional value of meal. Supplementary foods must also be stored and prepared properly in order to prevent nutrient loss. Supplements may be in the form of tablets, liquids, powders, syrups, capsules, granules, or bars; various forms may have differing nutrient characteristics.

Brewer's yeast is non-leavening yeast that can be added to all foods to increase their nutritional value. It contains sixteen amino acids, fourteen minerals, and seventeen vitamins. The recommended supplemental allowance is 1 tablespoon daily.

Lecithin is a natural constituent of every cell of the human body and helps to emulsify cholesterol in the body and allows it to pass through arterial walls, helping to prevent atherosclerosis. Lecithin is available both naturally in egg yolk, liver, nuts, whole wheat, unrefined vegetable oils and as a supplement in capsule, liquid, and granule forms. Two tablespoons daily are recommended.

Seaweed is a vegetable from the ocean which is rich in all necessary minerals and is one of the best natural sources of iodine. It is also rich in B complex vitamins, vitamins D, E and K.

Wheat germ is the heart of the kernel of wheat. Wheat germ contains a vegetable oil and therefore should be tightly covered and refrigerated. Wheat-germ oil is a supplemental food high in unsaturated fatty acids and is one of the richest known sources of vitamin E.

5.5. Nutrient allowance chart

For individual recommended dietary allowances of nutrients the nutrient allowance chart (*Table IV-1*) has been used. The following chart is designed to give a better understanding of the calories and nutrients body requires daily. The figures are based on the recommended dietary allowances RDA. The chart is divided into four categories: girls, women, boys, and men. The sections are further divided into different ages and weights. The carbohydrate, fat, and protein allowances given apply to only those persons with light activity patterns.

Level of activity is divided into five categories: resting metabolic rate (represents the minimum energy needs for day and night with no exercise or exposure to cold), sedentary (includes occupations that involve sitting most of the day, such as secretarial work and studying), light (includes activities that involve standing most of the day, such as teaching or laboratory work), moderate (include walking, gardening, and housework), active (include dancing, skating, and manual labour such as farm or construction work).

Table IV-1. Nutrient allowance chart [8]

Gender	Boys		Men		Girls		Women	
Age, years	**15–18**	**19–22**	**23–50**	**> 50**	**15–18**	**19–22**	**23–50**	**> 50**
Weight, kg	**61**	**67**	**70**	**70**	**54**	**58**	**58**	**58**
Calories required for light activity	3000	3000	2600	2600	2300	2000	2000	1850
Carbohydrates, g	—	—	390	390	345	346	300	277
Fats, g			87	87	78	79	66	59
Protein, g	56	56	56	56	46	44	44	44
MINERALS								
Calcium, mg	1200	800	800	800	1200	800	800	800
Iodine, mcg	150	150	150	150	150	150	150	150
Iron, mg	18	10	10	10	18	18	18	10
Magnesium, mg	400	350	350	350	300	300	300	300
Phosphorus, mg	1200	800	800	800	1200	800	800	800
VITAMINS								
Vitamin A, IU	5000	5000	5000	5000	4000	4000	4000	4000
Vitamin B complex								
Thiamine (B_1), mg	1.4	1.5	1.4	1.2	1.1	1.1	1.0	1.0
Riboflavin (B_2), mg	1.7	1.7	1.6	1.4	1.3	1.3	1.2	1.2
Pyridoxine (B_6), mg	2.0	2.2	2.2	2.2	2.0	2.0	2.0	2.0
Cyanocobalamin (B_{12}), mcg	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin C, mg	60	60	60	60	60	60	60	60
Vitamin D, IU	400	300	200	200	400	300	200	200
Vitamin E, IU	15	15	15	15	12	12	12	12
Vitamin K, mcg	70–140	70–140	70–140	70–140	70–140	70–140	70–140	70–140
TRACE MINERALS								
Chromium, mg	Adequate daily intake 0.0–0.2 mg							
Copper, mg	Adequate daily intake 2–3 mg							
Fluoride, mg	Adequate daily intake 1.5–4 mg							
Manganese, mg	Adequate daily intake 2.5–5 mg							
Molybdenum, mg	Adequate daily intake 0.15–0.5 mg							
Selenium, mg	Adequate daily intake 0.05–0.2 mg							
Zinc, mg	Adequate daily intake 15 mg							

The chart below is included to allow calculation of calories for the requirements for sedentary, moderate, and active levels. Although calories' requirements vary with the level of activity, nutrient requirements, as stated under an individual's desirable weight (*Table IV-2*) remain the same [5].

Table IV-2. Daily calorie requirements for levels of activity

Metabolic rate	Men	Women
Sedentary	40 cal/kg body weight	35 cal/kg body weight
Moderate	50 cal/kg body weight	45 cal/kg body weight
Active	65 cal/kg body weight	55 cal/kg body weight

It can be seen from the above chart that a moderately active man of 70 kg requires approximately 3500 calories per day. This figure is obtained by multiplying 70 kg by 50 calories. These estimates do not take into account body build and height, which also affect calories' requirements.

5.6. Tables of food composition [9] (Appendices 1–12)

The foods in these tables have been divided according to food groups and similar types of foods that do not belong to any one group. Food values have been calculated so as to permit easy computation. All figures are, of necessity, averages of different food samples. The dash (–) does not indicate an absence of a particular nutrient, but rather that meaningful analysis of the food for that nutrient is lacking. Only the zero confirms the absence of a nutrient. There are three major factors that influence the nutrient content of foods: first, the inherent characteristics of the plant or animal; second, environmental conditions affecting the plant or animal; and third, the method of handling, processing, and cooking the plant or animal material. The content of trace minerals such as selenium, copper, and zinc depends on the soil in which they are grown, and therefore varies significantly in foods from area to area.

One of the most important aspects of obtaining a good diet is the balancing of amino acids. There are approximately twenty-two amino acids that are the primarily components of protein. Eight of these amino acids, tryptophan, leucine, lysine, methionine, phenilalanine, isoleucine, valine, and threonine, are known to be essential, because they cannot be manufactured by the body itself and must be supplied in the diet. Histidine and arginine are necessary for growth in children.

Amino acid content of every food differs. Amino acids in foods must be consumed in amounts and proportions that closely approximate the pattern required by the body. If one essential amino acid EAA is missing or present in a low amount, protein synthesis in the body will fall to a very low level or stop altogether. In most foods containing, protein, all the EAA are present, but in some foods one or more of the EAA may be present in a substantially lower amount than the others, placing it out of proportion and deviating from the EAA pattern required by the body. The EAA that is absent or provides the lowest percentage of the daily estimated amino acid requirements EAAR is known as the limiting amino acid LAA and is the factor determining the amount and quality of protein utilized by the body. For example, a food containing 100 per cent of a person's lysine requirement but only 20 per cent of his methionine requirement results in only 20 per cent of the protein in that food being used as protein by the body. The rest is used as fuel rather than for replenishing or building of tissue.

Foods such as meat, fish, poultry, and dairy products are high in protein content and have a good proportion of EAAs. Many vegetables and fruits are low in or missing some amino acids, thus rendering the amino acids present relatively useless. Foods low in or missing a particular amino acid will have increased protein quality when combined in a meal with foods high in this same particular amino acid. Macaroni and cheese, vegetable stew, and chicken chow mein are examples of how foods high in certain amino acids can be balanced with foods low or missing one or more EAA. Supplements may be used to increase the protein quality of foods.

Body's protein requirements can be easily met if the foods eaten are properly combined in order to provide usable protein. This means that smaller quantities of food can be consumed and the body's nutritional needs still are taken care of. The importance of balancing the amino acids to obtain the best possible protein from foods cannot be overstressed. To find exact individual amino acid requirements multiply this figure times the requirement for each amino acid listed under "infant", "child", or "adult" (*Table IV-3*). The results will appear as total milligrams of each amino acid required to carry on the daily bodybuilding functions of protein.

Table IV-3. Daily amino acid requirements (per kg of body wt), mg/day

Amino acid	Infant (4–6 months)	Child (10–12 yrs)	Adult	Amino acid pattern for high quality proteins, mg/g
Histidine	33	?	?	17
Isoleucine	83	28	12	42
Leucine	135	42	16	70
Lysine	99	44	12	51
Total S-containing amino acids	49	22	10	26
Total aromatic amino acids	141	22	16	73
Threonine	68	28	8	35
Tryptophan	21	4	3	11
Valine	92	25	14	48

5.7. Diet and cancer

Global and national trends in diet and in cancer rates are generally unfavourable, with specific important exceptions, such as stomach cancer. Urban-industrial diets and their associated lifestyles increase the incidence of many cancers. Furthermore, the burden of cancer is increasing because the population of the world is both increasing and ageing rapidly. Successful programmes of cancer prevention may therefore have the effect of slowing an upward trend or even reducing rates of cancer, but they may still not decrease the total number of cancer cases.

Evidence on the relationship between dietary constituents and cancer risk is, with the exception of alcohol, less strong than that on relevant foods and drinks. As already stated, diets high in fibre possibly decrease the risk of cancer of the colon, rectum, breast and pancreas; diets high in starch possibly decrease the risk of cancer of the colon and rectum. Diets high in carotenoids probably decrease the risk of cancer of the lung, and possibly of cancers of the stomach. Diets high in selenium possibly decrease the risk of cancer of the lung, and diets high in vitamin E possibly decrease the risk of cancer of the lung and cervix. Evidence of dietary protection against cancer is the strongest and most consistent for diets high in vegetables and fruits. Evidence that refrigeration of food protects against stomach cancer is convincing.

On the other hand, diets high in saturated animal fat possibly increase the risk of cancers of the lung, breast, colon and rectum, endometrium and prostate, those high in cholesterol possibly increase the risk of cancer of the lung, and pancreas. As stated, epidemiological evidence that diets high in starch possibly increase the risk of cancer of the stomach is likely to apply only when such diets are monotonous and very high in processed carbohydrates.

In the higher-income countries of Asia, cancer patterns in urban areas are now approximating to those of established industrial economies in the West. For example, in India, cancers associated with Western diets and lifestyles are becoming more common. There are indications of rising incidence of cancer of the lung, colon and rectum, previously relatively low in comparison to western countries. The sharp increase in rates of cancer particularly in the economically developing world amounts, in the view of the panel, to a global public-health emergency.

With respect to diet-related diseases, the only feasible public health policy for many countries is to ensure that population preserve appropriate food patterns (primordial prevention) or to encourage people to change their diets before disease occurs (primary prevention).

These strategies require national programme using appropriate agriculture and food policies, combining the benefits of traditional diets and lifestyles with the benefits of current science and technology.

6. TASKS FOR STUDENTS

Seminar: "Food as an environmental factor"

1. Nutrition. Food chemicals. Nutrients.
2. Proteins and amino acids.
3. Carbohydrates.
4. Fats and oils.
5. Minerals and microelements.
6. Fat soluble vitamins.
7. Water soluble vitamins.
8. Food additives, contaminants, toxins.
9. Hazards of food (chemical, biological, radioactive).
10. Food poisoning.
11. Food safety and quality assurance.

Solve the situation tasks, for instance:

1. It was stated by a physician that three schoolchildren had necrotic process on tonsils and bloody blades on tongue and in mouth. Victims complained of general weakness, number of leucocytes – 1500/mm^3, erythrocytes – 2 000 000/mm^3. It was found out the boys had eaten grains which had survived in the field from the previous year.

   What poisoning group relate to this disease?
   What is the cause?
   What are preventive measures?

2. There are 7 cases of illness in one family. All seven were hospitalized by diagnosis gastroenteritis. Victims complained about the headache and dizziness, disturbances of eyesight and "double", disturbances to speak and to swallow. Everybody of them had eaten preserved mushroom yesterday.

   What poisoning group relate to this disease?
   What is the cause?
   What are preventive measures?

3. In the morning after celebrating a birthday students ate abundant with cream cake. After 3 hours during the lecture eight students suddenly fell ill. Victims vomited, they had diarrhoea, stomach ache, temperature 36.6–37.5 °C, symptoms of intoxication.

   What poisoning group relate to this disease?

   What is the cause?
   What are preventive measures?

Calculate nutrients sufficiency and balancing:

1. Make up your daily menu.
2. Calculate calories from table of food composition.
3. Calculate protein, carbohydrate and total lipid (fat). Calculate relation between them.
4. Calculate minerals calcium, magnesium and phosphorus. Calculate relation between them.
5 Compare with nutrient allowance chart.
6. Is your menu sufficient?
7. Is your diet balanced?
8. Give recommendations how to improve your diet.

Inspect public eating establishment using Model for inspection checklist-evaluation form

1 **Address** – Where is this establishment located?
2. **Callers** – What category of people visit it regularly?
3. **Hall, cloak-room, washroom** – Are there places for cloak hanger, for washing hands? Is there cleanliness, good ventilation, good lighting?
4. **Dining hall** – What microclimate is there? Are there specific unpleasant odours? Is there enough lighting? Are there clean plates, delicious dishes, fine furniture?
5. **Kitchen** – What do you understand with working conditions (lighting, humidity, temperature, ventilation, draught, mechanization of works, noise)?
6. **Vessel, plates and dish washing and drying** – Is there adequate mechanization? Is there not too moist air?
7. **Storage of foods** – Are there separate spaces for various and different foodstuff? Is there not too high temperature?
8. **Meal preparation** – Are there adequate spaces and tables for treatment food raw-materials? Is it clean there?
9. **Keeping of dishes** – How long are meals kept? Where are they kept?
10. **Food qualitative control** – How frequently does it take place?
11. **Abolition the scraps of foods** – How frequent, and when scraps are removed?
    Facilities for employees – Are there rest-rooms, toilets, showers, etc.?
12. **Medical health control** – How many people work there? How frequently are health control for different category workers are carried out?
13. **Conclusion** – Do you like this dining establishment? Are you not afraid of food poisoning there? Give your covered impression – is it satisfactory or not?
14. **Recommendations** – Give your propositions how to improve the action of this dining establishment?

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Chapter V

HUMAN HABITAT ENVIRONMENT AND HEALTH

1. HOUSING

Habitat environment, ecosystem created by and inhabited by humans, consists of both the built and human-modified physical environment. Thus, they include the processes of social aggregation, migration, modernization and industrialization, and the circumstances of human living.

Human habitat environment is a nexus of dynamic conditions among inhabitants and activities within ambient areas. In a stable, sustainable habitat environment ecosystem, one group of persons or activities does not destroy or harm the natural or human-made environment that supports and enhances the living conditions of other groups or systems of plants, animals, or humans within that operating environment.

Both rural and populated areas must meet many requirements to provide adequate circumstances for the needs of economic, physical, and psychological health. Universal principles for sustainable human habitat environment include the following:

1) provide clean, safe physical environment of high quality including housing quality;
2) ensure adequate water supply. In order to be sustainable, each habitat environment should use only its fair share of regional freshwater;
3) maintain vegetation cover. It is important to maintain and enhance the natural environment, including trees and watered areas;
4) preserve quality soils. As far as possible, the best soils should be preserved for agriculture uses and lesser soils should be used for buildings and infrastructure;
5) maintain regional food production potential. To ensure that human habitat environment can be self-sustaining with respect to at least certain aspect of their fresh food needs;

6) create habitat environment on a human scale. Adapt the transportation system, land use patterns, architecture, and governance of cities so that they are convenient and energy efficient;
7) support an optimum level of appropriate public health and sick care services accessible to all.

1.1. Dwelling

A safe and peaceful place in which to live is necessary for good health. Indoor air quality can be affected by both the pollutants found in the ambient air and from those that originate within the structure (furnishings, operations conducted inside, and the structure itself). Conditions that can exacerbate problems with pollutant levels range from poor ventilation rates to tight buildings.

The family dwelling not only serves as a shelter but is usually the focus of people's emotional state life. Housings furnish a larger dimension of shelter, including basic communal services such as water supply, waste disposal, communications, roads and public transportation, and the production and distribution of consumer goods like food and clothing. They also enable the provision of services such as education, health, and law enforcement, as well as provide infrastructure and support for cultural, religious, and recreational activities. Settlements also give assistance to vulnerable groups, such as elderly people.

Family dwelling is not just a place in which to eat and sleep but it is also where people store their possessions, relax, study, procreate, nurture and educate their children. Housing provides the union of support for families and individuals. Shelter requirements are to a large degree dependent on climate. For example, in extreme northern and southern latitudes, shelter from cold is of central importance, while in hotter regions protection from heat is essential. People require access to a safe and permanent supply of water and food as well as to appropriate household energy for cooking, heating, lighting, etc.

A dwelling should also protect its inhabitants against physical hazards and toxic exposures; this depends on both the structure of the facility and the behaviour of the people using it. In the planning of housing, many factors must be taken into consideration to protect residents against these hazards, including structural features and furnishings. Poorly designed or inadequately built homes increase the risk of accidents and injuries, particularly for children. Elderly people often stumble on thresholds, carpets, or other flooring hazards, causing hip fractures, one of the more common and costly injuries among elderly people.

Shelter's conditions play a crucial role in the control of many diseases, especially in the transmission of communicable diseases. A house can either protect from disease or facilitate disease. Water supply and sanitation facilities often appear to be the most important in determining a community's health.

Pollutants from the environment surrounding dwellings can also become a problem. Air pollution builds up in populated areas from the concentration of population and industry. If there are not sufficient rooms in the house to allow for separation of sick people from healthy inhabitants, contagious diseases are more readily transmitted. Additionally, a dwelling house with no adequate sunlight and ventilation facilitates spread a disease by increasing available breeding sites of vectors.

Poor psychological health makes people generally more susceptible to many communicable and chronic diseases and there are numerous other health problems that accompany poor psychological health.

Overcrowding is an important factor in the spread of a number of communicable diseases [8]. Tuberculosis is a contagious disease that flourishes in crowded, unhygienic environments. Meningitis is a communicable disease that kills many people worldwide. Like TB, it is spread by air-borne transmission and is linked to overcrowding and poor-quality housing. Other diseases, such as influenza, may also be transmitted more readily if housing is inadequate.

The quality of housing from health perspective can be assessed using a number of indicators categorized according to the:

1) driving force: migration, urbanization, land use, population growth, poverty, settlement planning;
2) pressure: lack of housing, lack of surface water drainage, overcrowding, use of home as a workplace, lack of safe water supply or adequate sanitation facilities, lack of adequate excreta and solid waste disposal, lack of personal, domestic, and environmental hygiene, lack of lighting, ventilation, and insulation;
3) exposure: microbiological and chemical contamination of water supplies, contamination of food supplies, refuse and wastes, dampness, odours, indoor air pollution, pest, rodents, vermin, pathogenic organisms, fires, explosions;
4) effect: eczema, dermatitis, lice, violence, crime, abuse, drugs, alcoholism, injuries, and burns in the home, or traffic accidents, gastrointestinal diseases, parasitic diseases, tuberculosis, measles, neurobehavioral disorders, conditions, stress-related, anxiety, depression, environment-related respiratory conditions;
5) action: land-use planning and zoning measures, conservation measures, housing legislation, standards, and enforcement measures, low-cost housing provision, housing upgrading, community participation and action programme support, education measures for housing and health.

1.2. Urbanization

Urbanization, the process by which an increasing proportion of the population comes to live in urban areas, has become a worldwide problem [2, 8]. Urbanization is a reflection of population growth and opportunities in cities. A population can grow, only through increase in births, decrease in deaths; or increased immigration.

Decreased emigration may reduce the loss of population if the rate of immigration does not also fall. Urban areas of the world are now experiencing both a natural increase and an increase in net migration to the cities.

People migrate from rural to urban areas for a variety of reasons. As life expectancy increases and the birth rate rises, single farms may not be able to support all family members. In addition, rural customs and discriminatory inheritance laws can encourage or force migration from rural areas. Improved survival of children has created a rapid growth in the number of young people without sufficient land to support them.

Economic and political factors greatly influence migration patterns. An increased economy means more industry. Jobs follow industries, and people often follow jobs. Additionally, wars, natural disasters, and ecological crises can have a large impact on urbanization trends of specific regions.

The process of urbanization has often been haphazard and chaotic. Most of the urban poor live in low-quality, overcrowded, self-made forms of shelter that are only marginally served by the public utilities taken for granted by others. In many cities, a majority of people live in shantytowns, or informal settlements, which in turn account for more than half the built-up areas.

2. SURROUNDINGS

Green areas have an important role in betterment microclimate of populated areas. Buildings and pavement warm up in the summer and overly warm the air, but greenery absorbs pollutants, dust, produce oxygen and damp the refined air [7].

The major sources of noise in urban environment are road and air traffic, construction, industry, and people [3, 5]. These types of noises are generally on the rise as urban centres become dense, industry expands, and the need for transportation increases. Noise is of most direct concern in the workplace, where hearing loss most commonly occurs. However, rates of urbanization all over the globe exceed the ability of city planners to protect residents from noise.

Noise may cause physical, physiological, and psychological effects in humans [1]. The physical effect of sound waves against the ear drum resulting in hearing loss is sometimes referred to as a direct effect. The physiological changes that may register cognitively include sleep disturbance and psychological damage, and are considered indirect effects.

Exposure to noise can induce disturbance of sleep through causing difficulty in falling asleep, alterations of sleep rhythm or depth, and being awakened. Noise can also give rise to headaches, fatigue, and irritability. Annoyance with noise is widespread in urban centres and around airports.

In developed countries, the mortality rate for motor vehicle accidents has been dropping over the last 70 years, even as the rate of vehicle ownership has dramatically increased. This has been attributed to the gradual improvement of road conditions, the establishment of higher vehicle safety standards, and increased driver training.

Globally, two-thirds of motor vehicle related fatalities involved pedestrians, predominantly children and the elderly. Children are often unable to identify the source of a sound and they have difficulty making simple distinctions in direction. They are also greatly disadvantaged by their lack of experience with motor vehicle traffic. The elderly frequently suffer from a decreased ability to see and hear and walk slower.

The loose upper layer of the earth – soil is one of a habitat environment factor. The formation of soil happens by participation microorganisms, plants and animals. They put out substances that chemically interact with ground to ameliorate it. In the formation of soil, a significant role is played by the climate. The soluble substances are washed deeper down into groundwater in wet climate. In arid climate a soil is dry, groundwater percolates capillaries lifting the dissolved substances on the surface of soil. Worms and insects manure soil and favour the growth of organisms that decompose organic matter.

Radionuclide released to the atmosphere undergos decay in transit or are deposited on the earth's surface by wet or dry deposition within relatively short periods. There follows a generally longer period in which the radionuclide on the terrestrial surface will eventually decay and produce external radiation exposure and dose to the population living in the settlements. Radionuclide is initially deposited on the upper surface of the soil, but it quickly weathers into the first centimetre of soil, especially if it is deposited via rainfall. This weathering effect and also the fact that the soil surface is not a smooth plane reduce the radiation field at the generally used reference height of 1 m above the soil surface.

Soil has an important role in ecotoxicology because nearly all waste products and toxic substances are washed to soil. Soil has self cleaning abilities, it is a nature's cleaning system, but if too many toxic substances are washed in it as a result of human activities, soil is not capable of its cleaning function. Toxic substances from soil can reach human organism by eating plant and consuming animal products. Soil contamination makes the quality of air, water and food worse and causes damage of human health.

3. WASTE MANAGEMENT

The objective of the waste management is to prevent the environment from contamination, and to reduce waste formation [6]. Waste is households, municipal and production remains created as a result of human activities, and is divided according to its features and impacts on humans and the environment.

Hazardous waste is defined as any waste or combination of waste which because of its quantity, quality, concentration, physical, chemical, or infectious characteristics could cause or significantly contribute to adverse effects in the health and safety of humans or the environment if improperly managed. This includes any waste exhibiting a general characteristic of ignitability, reactivity, or toxicity. Plastic, cloth protective covers, and glass can become contaminated during experiments or medical treatment. Wider use of disposable personal protective equipment and a higher level of awareness to medical hygiene as a result of AIDS have led to an increased amount of medical waste. Health-care institutions produce a great volume of medical waste, including large quantities of infectious waste. If regulations were based on epidemiological and microbiological information, the only two types of medical waste that would be regulated are sharps (syringes) and microbiological waste.

Academic and medical institutions generate also low-level radiological waste in research, teaching, and medical treatment [4]. The environmental professional should have a radiation safety programme in place and know at any given time the location and quantity of the radioactive material that is located at determined institutions. Nonhazardous solid waste streams include paper and paperboard, yard wastes, glass, metals, plastics, and food wastes.

Appropriate waste disposal and storage can discourage insect and rodent vectors of disease and reduce population exposure to habitat environment conditions likely to cause problems. Solid waste management is even more crucial when excreta are among waste products. Waste disposal problems tend to exist predominantly in urban settings, where there are space constrictions, crowding, and greater consumption.

In some cases, waste is simply dumped where it may pollute groundwater, the oceans, or land (*Figure V-1*).

Figure V-1. Illegal dump

Waste disposal is the collection, sorting, scavenging, discharge, deposit, injection, or placing of waste into or on any land or water so that waste or any constituents may not enter the air or be discharged into any waters, including groundwater (*Figure VI-2* and *Figure VI-3*).

Figure V-2. Waste sorting in waste-bins

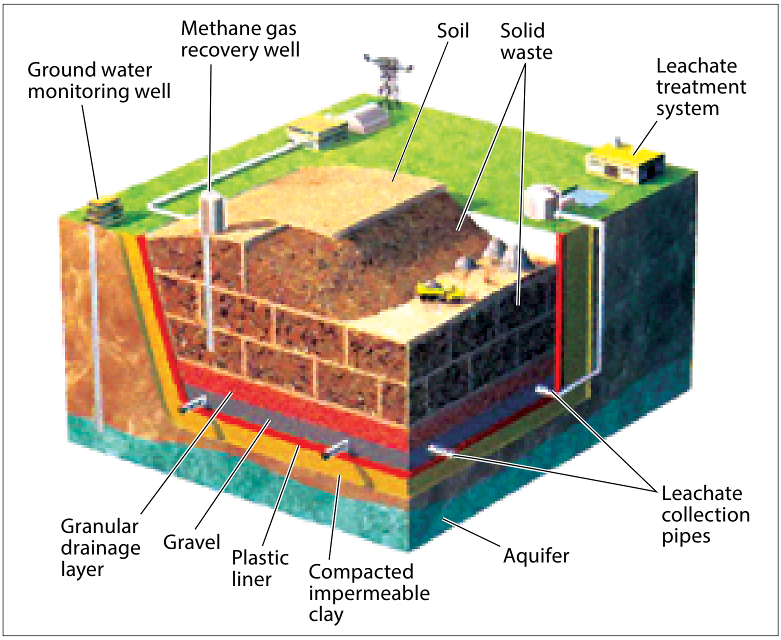

Figure V-3. Well organized waste disposal landfill

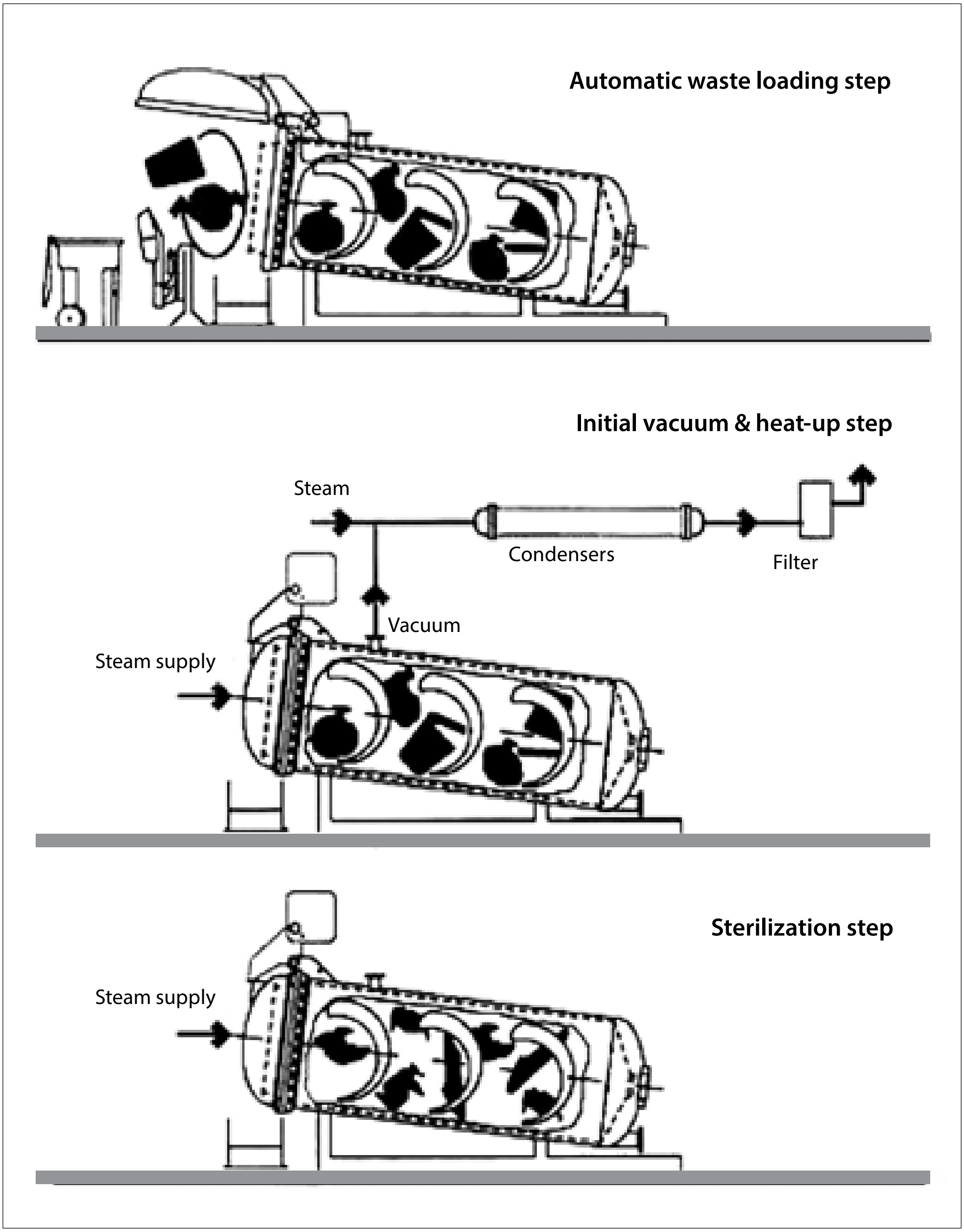

Figure V-4. Sterilization method of the infected biomaterial

Toxic and hazardous chemicals are increasingly mobile in today's world. Not only are they being shipped around the world as commodities for various purposes in production but also chemical and radioactive wastes are being moved about as the concern grows about proper storage and handling. In the developed world, it is becoming increasingly unacceptable to local residents to permit the storage or disposal of hazardous waste. In many developed countries, the options for getting rid of such wastes are disappearing. Hazardous waste disposal sites are being closed because of community's opposition, and chemical treatment facilities are becoming increasingly costly because of ever more stringent measures to protect the environment. It has been estimated that approximately 400 million tons per year of hazardous waste cross international boundaries, much of it being illegally moved to unauthorized disposal sites.

Any treatment method, technique, or process that changes the physical, chemical, or biological character of any hazardous waste so as to neutralize such waste, to recover energy or material resources from the waste, to render such waste non-hazardous, less hazardous, safer to manage, amenable for recovery, amenable for storage, or reduced in volume. Wastewater treatment has three stages. First, both solid and liquid insoluble substances are divided from water. In the secondary treatment the remaining organic substances in water are exposed to destructive activity by special microorganisms.

Recycling (waste recovery, utilization) applies to any practice that processes a previously used material for reuse. It includes the reclamation of useful constituent fractions within a waste material or the removal of contaminants from a waste to allow it to be reused. Each ton of recycled paper saves 17 trees. Recycling old paper instead of using new timber to produce paper uses 60% less energy and 60% less water, and creates 75% less air pollution and 35% less water pollution.

In the past, most medical waste was sent to landfills untreated. Highly infectious material from microbiology departments tended to be sterilized (*Figure V-4*). Sterilization may not be acceptable for this purpose if the temperature of the waste, not only the temperature in the drain, is not high enough to penetrate the core load and kill all organisms present. Many hospitals have incinerators. Now, many states require that regulated medical waste be rendered non-infectious and destroyed.

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Chapter VI

WORK AND HEALTH

1. HUMAN HEALTH AND WORK

Individual activities of spending time can be divided into those aspects which are work related and those which are non-work related. Much time of their lifetime men spend working. At work both material and mental products necessary for human being are created. Certainly, qualitative and quantitative characteristics of these products, i.e. efficiencies of the production, are connected close by the nature of the work. Besides, the nature of the work that people do, and of the environments in which it is done, can determine work safety, health and the general quality of life. Therefore, it is very important to provide for the suitable working conditions, which avert not only any disturbance on human health but quite on the contrary – increase worker's psychoemocional elation.

The nature of work is rapidly changing as is its technological and political context [8]. As a result, the profile of hazards to which workers are exposed is also changing. Hazards are those aspects of characteristics of the work situation which have the potential for causing harm to the individual worker.

The traditional approach to occupational health is concerned with the two-way relationship of work and health:

Health ⟷ Work

It is as much related to the effects of the working environment on the health of the worker, as it is to the influence of the worker's state of health on his ability to perform the tasks for which he was employed. The term work implies the broad notion of planned physical or mental activity, with the associated expenditure of energy or mental effort. Occupational health should logically refer to the dynamic interaction between work and work-related processes, on the one hand, and physical, psychological and social health on the other.

Occupational medicine is part of environmental medicine dealing with recognition of working environment hazards and their impact on worker's health. It is also interdisciplinary field making use of broad range of scientific knowledge –

toxicology, epidemiology, sociology, hygiene, environmental sciences, etc. Based on preventive medicine, the broad purpose of occupational medicine is the promotion and maintenance of the physical and mental health of persons at work. The World Health Organization defined occupational health as "the promotion and maintenance of the highest degree of physical, mental and social wellbeing of workers in all occupations".

There are two main activities' pathways on this field:

1) to forecast, to recognize, to evaluate, and to control occupational health hazards;
2) to investigate influence, effect on worker's health, to diagnose, and to treat health disturbances, diseases caused by these hazards.

The provision of such a service to the workforce requires managerial and union involvement. A large number of professionals are also involved, including physicians, nurses, lawyers, epidemiologists, ergonomists, safety engineers, occupational hygienists.

Occupational hygienists work out norms, standards for occupational environment chemical, physical, biological, ergonomic stresses. In addition to the occupational environmental stresses, occupational health now includes psychological and physiologic adaptations of man to work. This shift in emphasis calls for methods devised to improve relationships with workers, labour groups, management and government at all levels.

The new and broader approach to health concerns at work focuses attention on the psychosocial and organizational hazards of work as well as on the more tangible ones. It should develop a more comprehensive understanding of the complex relationship between work hazards and worker's health. The three-factor model of work, health and organization suggest that an organization can be healthy in two different ways at the same time: healthy in terms of its function and effectiveness, and healthy in terms of its impact on its workers.

This new approach has been described as "organizational health" in order to stress the role of organizational factors and processes in occupational health issues, and introduce the concept of "organizational healthiness".

Questions about the relationship between individual health and organizational healthiness can be framed in two ways, first, in what ways and to what extent the healthiness of the organization determines worker stress and health, or affects the relationship between the two, and second, in what ways and to what extent the healthiness of its workers determines the structure, function and culture of their organization and its effectiveness, or affects the relationships among these.

Occupational hazards are listed in *Table VI-1*. Exposure to hazards may threaten psychological health, physical health and social wellbeing. The evidence suggests that such effects on health may be mediated by, at least, two pathways, first, a direct physicochemical mechanism, for example, as in the effects of dust inhalation as a contributory factor in pneumoconiosis, and, second, a psychophysiological stress-mediated mechanism, for example, as in the effects of the perceived loss of control as a possible contributory factor in coronary heart disease (*Figure VI-1*).

Table VI-1. Factors which can affect worker's health

Physical	Chemical	Biological	Ergonomic	Psychosocial
Noise	Dusts	Insects	Posture	Worry
Vibration	Fumes	Mites	Movement	Work pressure
Ionizing radiation	Fibres	Moulds	Repetitive actions	Monotony
Non-ionizing radiation	Liquids	Yeasts	Illumination and visibility	Unsocial hours
Heat	Mists	Fungi		
Cold	Gases	Bacteria		
Extremes of pressure	Vapours	Viruses		

These two mechanisms do not offer alternative explanations of the hazard-health relationship. In most hazardous situations both operate and interact to varying extents and in various ways.

The outcome of the effects which interact additively is simply the sum of the separate effects. However, the outcome of the effects which interact synergistically may be different from the sum of the separate effects. It may be greater, where one set of effects facilitates or enhances another, or it may be smaller, where one set attenuates or weakens another. Examples of such interactions may exist in relation to work-related upper limb disorders of the alleged reproductive health effects of exposure to visual display units.

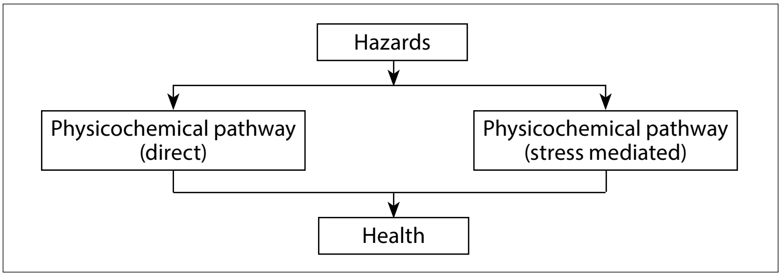

Figure VI-1. Pathways from occupational hazards to employee health

Many of the effects of psychosocial and organizational hazards are undoubtedly mediated by psychophysiological – stress related – processes, while many of the direct physicochemical effects of work on health are accounted for by more tangible physical environment hazards. Despite this, latter hazards clearly can affect health through psychophysiological pathways, while certain psychosocial hazards may have direct effects. For example, exposure to organic solvents may have a psychological effect on the person through their direct effects on the brain, through the unpleasantness of their smell and through fear that such exposure might be harmful. The latter can give rise to the experience of stress. Violence, as a psychosocial hazard, may somewhat similarly have a direct physical effect on its victim in addition to any psychological trauma or social distress that it causes.

2. PHYSICAL OCCUPATIONAL HEALTH HAZARDS

Physical hazards are hazards that result from energy and matter, and the interrelationships between the two. Conceptually, physical hazards in the workplace can be subdivided into worker-material interfaces, the physical work environment and energy and electromagnetic radiation. The consequences of exposure to these hazards can be modified by worker protection and a variety of human factors.

Physics is the science of energy and matter and of the interrelationships between the two, grouped in traditional fields such as acoustics, optics, mechanics, thermodynamic, and electromagnetism. Quantum physics deals with very small energy forces; relativity deals with objects travelling at very high speeds (which causes time effects). Thus, physical hazards can be thought of as primarily hazards of energy, temperature, pressure, or time. This broad definition allows for investigation of many hazards that are otherwise hard to classify, but, nevertheless, represent important issues in workplaces. An understanding of these physical hazards requires familiarity with the two basic concepts of physics-classical mechanics, with its derivatives of thermodynamics and fluid dynamics, and electromagnetic radiation. For measurements there are used Standard International (SI) units, but there are included conversions to other units where they are in common usage.

Mechanics deals with the effects of forces on bodies or fluids at rest. From mechanics, we can get to the study of sound, which is a result of the mechanical vibration of air molecules. The behaviour of heat arises from the vibration of molecules. Temperature is proportional to the average random vibratory or translational kinetic energy. The physics of pressure arises from the laws of motion and temperature. The laws that can govern electricity can be derived from special cases of mechanics, and electromagnetic energy and waves are a direct result of the laws that govern electricity.

Mechanics has been central to the advancement of physics. Two mechanical concepts are central to understanding what strategies to adopt in order to prevent injury and illness from physical hazards – kinetic energy and potential energy. In order for physical hazards to affect humans, they must possess energy to impart to the biological system. Energy is commonly described in terms of either force F or work W. Force equals mass times the acceleration, and the result is a vector. The work done on an object equals the amount of displacement times the force component acting along that displacement. In the special case of the force acting parallel to the displacement, work equals force times displacement.

Kinetic energy KE is the energy of a mass that is in motion relative to some fixed frame. Potential energy PE is stored energy that can do work when it is released as kinetic energy. Since mass and energy are conserved in all interactions, the sums of potential and kinetic energy from before and after an encounter are equal. The equation for kinetic energy is also important for electromagnetic radiation.

An electrical system can store electrical energy in a magnetic field in an induction coil. The kinetic energy of the electrical charges equals the amount of work done to set up the field in the coil, which is stored as potential energy. Potential energy is potential to do work, and theoretically all this work can be turned into kinetic energy. The expressions for kinetic energy in the mechanical system and potential energy in the electrical system have identical form. This form shows the similarity between kinetic and potential energy in mechanics and electromagnetic radiation and lays the groundwork for examining the electromagnetic wave.

2.1. Thermal stresses

Man, has the ability to maintain his body temperature within narrow limits. This characteristic is known as homeothermic and conveys important evolutionary advantages by permitting high levels of body activity which are substantially independent of environmental temperatures over a wide range. A disadvantage, however, is that where environmental or other circumstances are such as to exceed the capacity of man's thermoregulatory processes to control his body temperature within a degree or two of 37 °C, the consequences may be serious. Such consequences range from the mere loss of comfort and contentment to the impairment of physical or mental performance or even to thermal illnesses.

The evaluation and control of occupational thermal stress requires knowledge of its origins and of the way in which the physical components of the environment (humidity or air motion, for example) influence the exchange of heat between man and his surroundings [22].

A comfortable person has a deep body temperature close to 37 °C and a mean skin temperature of 33 °C. Heat generated by metabolic processes in the organs and muscles is transferred to skin surface via blood supply. In comfortable conditions the metabolic heat load is lost at skin surface primarily by convection and radiation. In hot conditions heat loss is increased first by vasodilatation which increases the flow of blood to skin and raises skin temperature. If this is insufficient, body temperature rises further and sweating commences, thus increasing heat loss by evaporation. In cold conditions heat loss is restricted by vasoconstriction which reduces blood flow to skin and lowers skin temperature.

There are three main sources of thermal stress in occupational environment. First, there is exposure to hot or cold environmental extremes which may either be those that occur naturally such as in the desert, the jungle or the arctic, or those that are man-made such as in steel, glass and mining industries or in cold stores. Essentially, hot and cold environments may reduce both safety and productivity. Besides, the obvious dangers from frostbite or heatstroke, even a milder thermal strain can be problematic. Environments do not have to be life-threatening to cause problems. A cold environment, for example, may increase the risk of cumulative trauma disorders. Likewise, a warm environment can compromise the concentration, steadiness, or vigilance of workers. Even moderately warm environments may require interruption of work with extensive rest breaks, especially when protective clothing is worn. In many other places in the world, the outdoor environment can pose problems for workers. For example, the average wet bulb globe temperature in July in many regions of America, Europe, and Asia, is above 29 °C. Some potential hot areas are easily anticipated, such as foundry operations. Many occupational and protective clothing environments result in temperature as high as 43 °C [24].

Second, there is the level of physical work involved in the task. An environment which may not be stressful to an individual undertaking sedentary or light work may be highly stressful to an individual undertaking heavy physical work. The converse may be equally true in that the performance of workers in sedentary tasks may be adversely affected if environmental conditions are too cool.

Third, there is clothing. Normally individuals will adjust the clothing they wear to suit the environmental conditions, but sometimes this is not possible. In many industries workers are required to wear specific protective clothing to guard against hazards or injuries from chemicals, radiation or other physical dangers in the environment. Welders, for example, may suffer from heat in warm environments and from cold in cool environments because their protective clothing retains heat in the summer, but the design of welding masks and gloves hampers adding adequate insulation in winter. Such clothing is frequently made from materials impermeable to water vapour which inhibits the evaporation of sweat and thus causes thermal stress as a side-effect. In practice, of course, all three of these courses of thermal stress may exist together.

The most common thermo-physiological treats to worker safety and productivity in industry are heat stress disorders. Heat stress is the external heat load placed on the body due to the characteristics of the environment, and heat strain is body's response. Workers show a large variation in heat strain, even though all may be working at the same work rate in the same environment. This is because many controllable and uncontrollable factors affect heat strain, as summarized in *Table VI-2* [5]. Of these, the most serious risk is heatstroke. If heatstroke continues unchecked, it will result in blood clots, tissue death, cerebral hypoxia, general central nervous system dysfunction, and finally death. Death from heat strain occurs when internal body temperature approaches 43 °C.

Cold strain injuries are also potentially dangerous. The most dangerous cold threat is hypothermia, which fortunately is rare in industry. Similar to the way in which high temperatures can cause heat strain, extremely low temperatures can interfere with vital biochemical processes. The best data suggests that humans with internal body temperatures of 25 °C or below would be expected to die. Symptoms of hypothermia include uncontrollable shivering and intense feelings of cold, falling blood pressure, and irregular heartbeat.

Table VI-2. Variables that may influence work in thermally stressful environments [5]

Variables	Impact
1	2
Controllable variables: Work task Rate Type	 Metabolic rate influences heat storage rate Mobility influences ability and type of cooling, possible, psychomotor function may by affected
Workers (may be controlled through selection/training)	
Physical fitness	Improved fitness increases thermal tolerance
Training	Increases safety
Acclimatization	Increases tolerance; with impermeable clothing, sweat effects may be mitigated
Size	Both mass/area and absolute mass may influence tolerance
Body fat content	Theoretically may influence heat loss
Hydration	Dehydration increases heat injury risk; repeated workdays may affect pre-work hydration and electrolytes
Electrolyte levels	Will influence rehydration and physiological function
Health	Fever, other illness, or medications may affect tolerance
Genetics	Large inter individual variability
Gender	Generally unstudied; thermoregulation shows a sex difference, but not in overall response, except that females may be less cold-tolerant
Age	Does not affect thermal tolerance except to the degree it affects physical fitness
Clothing (including protective clothing) required	
Insulating value	As insulation increases, potential heat loss decreases
Permeability	As permeability decreases, less opportunity for sweat evaporation; this may eliminate cooling or increase clothing wellness
Weight	Increases in weight increase metabolic requirements
Stillness	Increases in stillness raise metabolic costs of movement
Glove/mitten	Effects dexterity and hand/arm type fatigue
Gas mask	Reduces field of vision, may fog, impedes communication, raises metabolic costs
Uncontrollable factors: Work task Type	 Mobility will influence ability and type of cooling possible, psychomotor function may be affected

(cont. on p. 154)

Table VI-2 (continued).

1	2
Workers size	Both mass/area and absolute mass may influence tolerance
Body fat content	Theoretically may influence heat loss
Genetics	Large inter individual variability
Gender	Thermoregulation shows particular sex differences, but not in overall response
Age	Does not affect thermal tolerance except to the degree it affects physical fitness
Environment temperature	Increases in temperature increase heat storage
Humidity	Major impact on heat tolerance, but in protective clothing the role of humidity is less
Radiant load	Can be a major heat source
Wind velocity	Can play a major rate in heat loss, in both hot and cold environments

There are several ways of controlling the physical strains of hot and cold environments. Administrative controls can be used to certain advantage. Worker training is always a good idea. Teaching workers to recognize potential hot/cold problems and training them to deal with these should improve both safety and productivity. Most industries do not have a great degree of scheduling flexibility, but annual planning and careful scheduling to minimize stressful exposure to heat or cold when possible would improve safety and increase productivity. Factors to be considered in scheduling include time of day, season, and locale. Work-rest intervals are means used to set controls for the environmental exposure of workers. The balance between work and rest must consider both safety and the thermal physiology. Engineering controls can also be employed to improve safety and productivity in hot and cold environments. Several steps that can be taken to minimize thermal stress in hot environments have been listed, such as cooling general work environment; reduction of ambient humidity; increase in air velocity. For cold environments, reduced air velocity is recommended; minimization of drafts; balancing of work rate so that periods of intense work are not followed by low work rates; increasing radiant heat with micro heaters.

2.2. Barometric stresses

From an occupation hygiene perspective barometric stresses can be categorized as hypobaric (low pressure) stresses, hyperbaric (high pressure) hazards and stresses from changes in pressure, predominantly, but not exclusively, decreases in pressure [8].

Hypobaric conditions produce adverse health effects due to the lack of oxygen, specifically the low absolute partial pressure of oxygen. In normal air (20.9% oxygen) these effects do not begin to be detectable until at least 2000 m above the sea level. Occupational examples of hypobaric conditions include high-altitude construction, mining, and aviation, especially aircrews or passengers under rapid loss of pressurization conditions.

Effects of hypobaric health hazards include hypoxia due to insufficient oxygen; benign acute mountain sickness is a constellation of symptoms (highlighted by frontal headaches); acute mountain sickness without the above benign qualifier refers to high altitude pulmonary edema and high altitude cerebral edema.

If total pressure decreases but the gases mixture stays the same, the partial pressures of oxygen and nitrogen will decrease in parallel with the total pressure. In other words, as long as there are no local sources of emission, absorption or consumption of either gas, the molar ratio of nitrogen to oxygen in ambient air will always be about 3.73 to 1. One of the physiological symptoms of hypoxia is shortness of breath on exertion. The body acclimatizes to altitude in 2–5 days, facilitating hyperventilation.

Personal protective equipment, similar to supplied air respirators, is available to increase O_2 in the breathing air. The maximum option of providing 100% oxygen will extend the no-effect zone to about 1000 m. Acclimatization is a remarkably effective long-term control for habitable high altitudes. Acclimatization changes the balance between two respiratory control mechanisms. The first adaptation over 2–5 days at altitude is a reduction in blood's bicarbonate ion concentration, decreasing the negative sensitivity of the respiratory centre to increased ventilation. After the period of 2–3 weeks, physiological changes further benefits one's working capacity.

The most common occupation associated with hyperbaric conditions is underwater diving. Occupational diving is expanding into new frontiers like fish farming. Compressed air work in construction is a less common occupation. Pressure supplied to an airtight caisson used to be a common technique to reduce the flow of water or mud while digging bridge pilings. As workers removed the under-surface mud and sand, the caisson would settle until reaching a stratum where a stable structural foundation could be formed. Similar air pressure has also been applied to tunnels and mines to control water intrusion during construction.

The array of hazards associated with hyperbaric conditions includes:

1) gas narcosis caused by nitrogen in normal air during dives of more than 35 m. Helium, substituted for nitrogen in "mixed gas diving", can cause an effect called high pressure nervous syndrome;
2) gas toxicities caused by oxygen and carbon dioxide. The damage of oxygen to the lung and brain will vary with time of exposure and depth.

The first of these hazards is simply the result of the narcotic effect of any gas absorbed into neural tissues. The simplest prevention of oxygen toxicity can be achieved by administratively limiting the time of exposure above one atmosphere.

The recognized adverse health effects of changing pressure can occur in either hypobaric or hyperbaric conditions:

1) pain due to expanding or contracting trapped gases, potentially leading to barotraumas;
2) decompression sickness (DCS) due to the evaluation of inert gas bubbles in the body;
3) dysbaric osteonecrosis causing detectable lesions most commonly on body's long bones.

The most common sites of pain from trapped gases are teeth, the GI tract, sinuses, middle ear, and lungs.

Divers and flyers should anticipate and not attempt to suppress the release of natural gases of digestion that expand during ascent. DSC is the most commonly know of the many dysbarism. Dysbaric osteonecrosis manifests itself as regions of bone and marrow necrosis. The lesions are indistinguishable histologically from necrosis from other causes. Most of these lesions are in the head, neck, or shaft of the long bones where they are generally benign.

2.3. Noise

For hundreds of years, many people have been paying a high price for industrial noise, in permanent loss of hearing and others disorders. Levels of noise well below those which produce hearing loss can cause annoyance, and interfere with concentration and communications in workplace. Noise induced hearing loss poses the highest incidence of all occupational diseases in many industrial countries and some 20–30% of all employees are exposed to excessive noise levels [15].

Noise is unique among health hazards as it would be undesirable to eliminate it altogether, since man relies on sounds to control his actions. If a machine suddenly changes its normal noise pattern, this is a warning that something is wrong and evokes a quick response to avert serious damage to machine or man.

Sound may be defined as any pressure variation in air, water or other medium that the human ear can detect. Sound is a form of energy, generated when a surface vibrates and sets the adjacent air molecules into sympathetic vibration, creating pressure fluctuations above and below atmospheric pressure. The smallest pressure change detectable by the human ear is 20 μPa, used as a baseline for comparative measurements and as the standard hearing threshold at 1000 Hz [8].

Sound is measured in terms of the logarithmic increase in intensity relative to that at the threshold of hearing, and this value is known as the sound intensity level or the sound level and is measured in decibels (dB). The hearing threshold value is 0 dB, and at the pain threshold it is 130 dB. Although an increase of 6 dB represents a doubling of the sound pressure, an increase of about 10 dB is required before the sound subjectively appears to be twice as loud. The smallest change we can hear is about 3 dB.

The number of pressure variations per second is called the frequency of the sound, and is measured in Hertz (Hz). The frequency of a sound produces its distinctive tone. Thus, the rumble of distant thunder has a low frequency, while a whistle has a high frequency. The normal range of hearing for a healthy young person extends from approximately 20 Hz up to 20 000 Hz (20 kHz) while the range from the lowest to highest note of a piano is 27.5 Hz to 4 186 Hz.

There are factors which can influence the effect of noise exposure on workers:

1) the variation in individual susceptibility;
2) the total energy of the sound;
3) such characteristics of noise exposure as whether it is continuous, intermittent or made up of a series of impacts;
4) the total daily time of exposure;
5) the length of employment in the noise environment.

The subjective or perceived loudness of a sound is determined by several complex factors. One such factor is that human ear is not equally sensitive at all frequencies. It is most sensitive to sounds between 2 kHz and 5 kHz, and less sensitive at higher and lower frequencies.

Most sound level meters provide the option of quantifying the combined sound at all frequencies with several different "weighting" filters: the "A weighted" response, the "C weighted" response, and the "flat" response.

The most common single-number measure is the A weighted sound level, often denoted dB (A). The A weighted response simulates the sensitivity of the human ear at moderate sound levels. Low-frequency sounds are significantly reduced in level (–26.2 dB at 63Hz), and high-frequency sounds are slightly increased (+1.2 dB at 2000 Hz). After this weighting, the levels at all frequencies are summed logarithmically to determine the A weighted sound level. In addition to being a good estimate of the perceived loudness at moderate levels, there is also a good correlation between the A weighted sound level and the potential loss of hearing from prolonged noise exposure. Because of this, the A weighted sound level is used for many applications from community noise ordinances to occupational noise exposure regulations.

Noise is considered to be a steady state when its variation is less than 6 dB (A), as measured by a time constant "Slow" 1 second. "Fast" has a time constant of 125 milliseconds and provides a fast reacting display response if the sound level fluctuates more rapidly and with peak levels 15 dB (A) higher than background noise. The "Impulse" characteristic has a time of 35 milliseconds and the risk of damage to hearing is increased. Impulses are typically exemplified by gas explosion, hammer blows and welding sparks.

When measurements have shown that the sound levels are too high, steps must be taken to reduce them.

There are three general guidelines to possible solutions:

1) eliminate or reduce the noise at its source (Figure VI-2). This may be done by acoustic treatment of machine surfaces, redesign of the machine, or purchasing a new quieter machine;
2) block the sound transmission path, for example, by placing an enclosure or acoustic screens around the machine and mounting it on vibration isolators to prevent transmission through the floor. Noise is further reduced by coating walls, ceiling and floor with absorbent materials to reduce reflections from their surfaces;
3) provide the exposed person with hearing protection. However, this should not generally be regarded as a permanent solution (Figure VI-3).

The two main types of hearing protectors are earmuffs and earplugs (*Figure VI-4*), collectively known as hearing protection devices. Earmuffs are designed completely to cover the external ear and foam filled or fluid filled cushion seal ensures a close fit to the head. The ear seals and the headband tension must be regularly checked, since their efficiency diminishes rapidly with constant use. Earplugs are of more varied design than earmuffs. The main types are soft, solid plastic or silicone rubber inserts and plastic foam plugs.

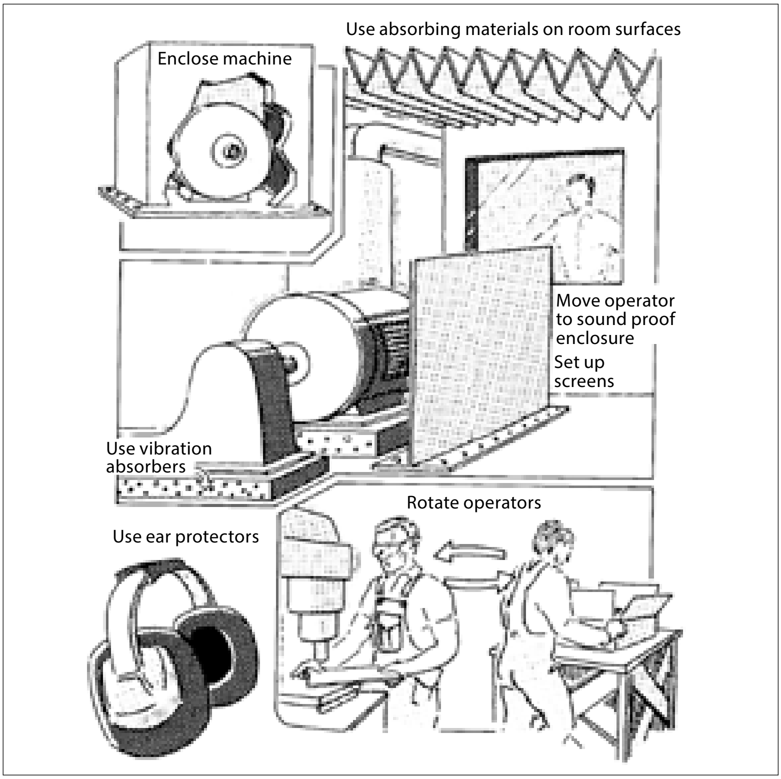

Figure VI-2. Noise reduction measures

Figure VI-3. Hearing protection

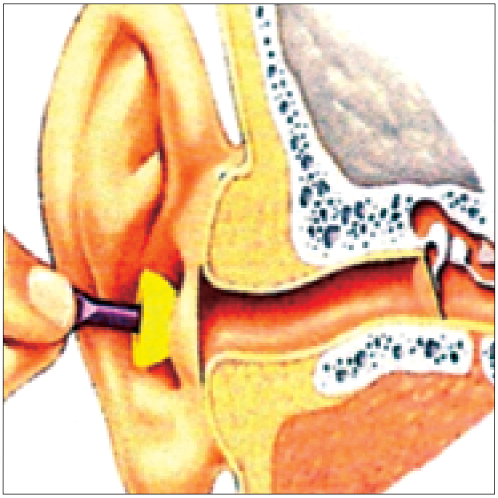

Figure VI-4. Earplugs

2.4. Infra and ultra sound

Although unpleasant physiological and psychological effects, such as headaches, dizziness and nausea, are said to be associated with exposure to high levels of infrasound and ultrasound, there has been no evidence of hearing loss.

Vibration at frequencies below 20 Hz (infrasound diapason) are not perceived as sound in air, but can be felt through any part of the body which is in contact with a solid or liquid vibrating at these frequencies. Infrasound can be generated in ship's engine rooms, compressor rooms, and some motor vehicles.

Ultrasound is commonly defined as the sound with frequencies above the range audible to the human ear. Although the audible range varies from person to person, the division between audible sound and ultrasound is often placed at 20 kHz. The upper frequency limit for ultrasound ranges from 50 kHz to above 100 kHz, but most effects on hearing are the lower ultrasonic frequencies. In addition to ultrasonic waves in the air, ultrasonic energy in liquids can also be a hazard.

Over the past several decades, uses of ultrasound have increased rapidly in industry, the military, and home. Both commercial and industrial uses may produce potentially harmful levels of air-borne ultrasound, and both also use liquid propagation media. Ultrasonic cleaning baths, mixers and welders are commonly used in industry. Commercial uses of air-borne ultrasound include automatic door openers, automatic photographic and video devices, dog whistles, security systems, sirens, etc. Commercial uses of liquid-borne ultrasound include cleaning (e.g., humidifiers and cleaners), and medical applications. Ultrasound is also used in both destructive and non-destructive testing of materials.

The adverse effects of air-borne ultrasound include headaches, sore throats, dizziness, and nausea. These responses, sometimes called ultrasonic sickness, are highly variable among individuals. Exposed individuals may experience these symptoms while the sound levels are low or inaudible. High-level ultrasound may cause changes in vestibular functions, which may explain the dizziness.

Because acoustic impedances are better matched between liquids and the body than between air and the body human body can absorb a much higher percentage of incident ultrasound when in direct contact with a transducer or a liquid medium than in air. Such exposure results in localized tissue heating; therefore, workers must be prohibited from touching transducers or immersing any part of their body in a liquid while an immersed transducer is operating.

It is sometimes possible to reduce employee exposure to ultrasound by relocating work areas or ultrasound equipment to another room. Because of the high directivity of ultrasound, it is possible to reduce exposure significantly by changing locations even within a room.

Engineering controls for ultrasound are often effective because of its high directivity and the high transmission loss characteristics of most materials at ultrasound frequencies [14]. High-frequency sounds are blocked more effectively by barriers than are lower frequencies. Barriers can be used to isolate either the noise source or the worker. When simple barriers are insufficient due to very high levels of ultrasound, complete enclosures can be built around the ultrasound source or the worker.

2.5. Vibration

Man in today's occupational environment commonly encounters mechanical vibration of some form. The most common source perhaps is his contact with vehicles of all types: forklift trucks and other industrial movers, transportation vehicles, such as trains, airplanes and trucks, and farming and earth-moving equipment to mention a few [2, 10]. The general increase in mechanization within industries also provides vibratory environments for many factory workers who are near large mechanical machinery, such as forges, presses, compressors, etc. Another category of vibration is that generated from the use of hand tools. These include pneumatic jackhammers, chain saws, grinder, chipping hammers and a wide variety of hand-held reciprocating, rotary or oscillatory devices [6].

Vibration is an oscillating motion about a central fixed position. However, in the context of occupational health practice, vibration implies the motion of a solid object, and the concern is centred on vibration frequencies and amplitudes which are likely to affect the comfort and wellbeing of a person exposed to them. Vibrations at frequencies outside the audible range may also be of interest where they give rise to audible harmonics, or where they can be eliminated from investigation.

Frequency is expressed in cycles per second or hertz (Hz), where each cycle represents motion from a mean position to one extreme and then a return to the mean. Frequencies below 30 Hz are of primary concern for man under whole-body vibration from a vibrating medium. When vibration is transferred through the arms and hands, frequencies of higher magnitude (30–1000 Hz) may also have determinable effects on man.

Intensity, in the case of simple harmonic motion, may be expressed in terms of amplitude, which is the measure of travel from the mean position to either extreme, in terms of displacement or excursion, which is the distance from one extreme to another, or in terms of successive derivatives of amplitude measurement, which are velocity, acceleration and jerk or jolt, respectively.

Figure VI-5. Whole-body vibration

Human exposure to vibration is normally divided into whole-body vibration (*Figure VI-5*) and hand-arm vibration (*Figure VI-6*). Although these two different types of vibration exposures usually result in different effects and responses, workers can be exposed to both types simultaneously. For example, when a jack-hammer operator holds the tool away from his body, supporting and guiding it only by his limbs, he is exposed to hand-arm vibration; however, if he leans against the jack-hammer with his abdomen, he is exposed to whole-body vibration as well.

Majority of workers exposed to whole-body vibration are truck and bus drivers, heavy equipment operators, and aircraft pilots. Whole-body vibration is transmitted to the body as a whole, generally through the supporting surface (that is, feet, buttocks, back, etc.). A person driving a vehicle, for example, is subjected to whole-body vibration through buttocks, and if there is back support, through back as well.

Figure VI-6. Hand-arm vibration

Hand-arm vibration is transmitted to hands and arms. It is mainly experienced by operators of hand-held power tools (gasoline-powered chain saws, string trimmers, and pneumatic tools.

The Instantaneous Root Mean Square (RMS) value of vibration acceleration is obtained by taking an exponential aver-age of values measure during short time intervals (e.g. 1 second). When vibration signal has been averaged over a longer period of time (1 minute or 1 hour, for example), we have obtained the equivalent acceleration value, a_{eq} (m/s^2) which is related to the energy content of the vibration, and the signal can be much more reliably assessed.

It is essential that human vibration is accurately measured. The accuracy of measurements is dependent on the quality of the vibration transducers and the analysis and recording equipment used. The transducer is the piezoelectric accelerometer. It is extremely important that the vibration is measured as close as possible to the point or area through which the vibration is transmitted to the body.

Hazardous health effects are quite unspecific for whole-body vibration. There are two different mechanisms. Low-frequency vibration of the vehicle or its sway together with blows may cause stresses to the spine, especially when the driver is sitting in a rotated position. Other effects on performance decrement can occur in the resonance phenomenon of sections of the body (*Figure VI-7*). Whole-body vibration can cause both physiological and physiological effects ranging from fatigue and irritation to motion sickness (kinetosis) and to tissue damage. Some work has taken place in the occupational setting, principally in transportation and with on- and off-road vehicles [18].

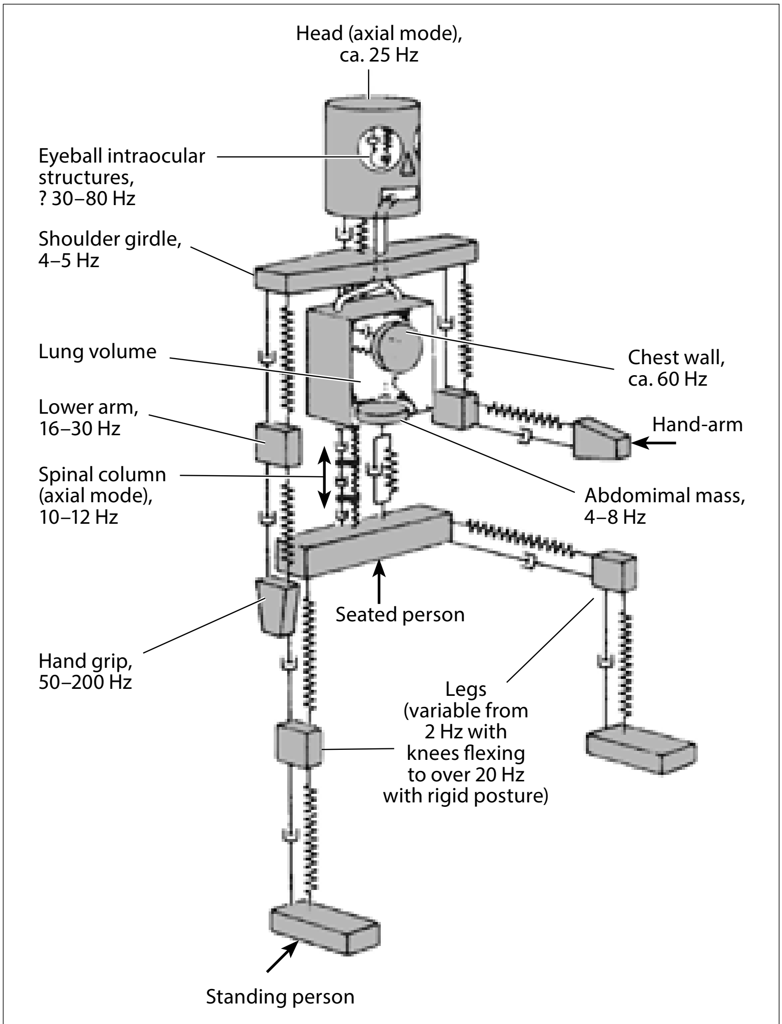

Figure VI-7. Resonance frequencies of body

Daily exposure to whole-body vibration over a number of years can result in serious physical damage, for example, ischemic lumbago [9]. This is a condition affecting the lower spinal region. Exposure can also affect the exposed person's circulatory and urological systems. Workers suffering from the effect of long-term exposure to whole-body vibration have usually been exposed to this damaging vibration in association with some particular task at work. Exposure to whole-body vibration can disturb the central nervous system. Prolonged whole-body vibration has been reported to cause giddiness, headaches, nausea, varicose veins, blurred vision, lung damage, rectal bleeding, haemorrhage, weight loss, and heart failure in extreme cases. Each of these effects is associated with vibration at a particular (resonant) frequency, for example at 60–70 Hz, the eyeballs resonate, affecting vision; 10–20 Hz is the frequency of the α-wave of the brain; at < 1 Hz, motion sickness is induced. Most effects are reversible when exposure ceases, and are frequently experienced by shipboard personnel, lorry-drivers and tractor-drivers [8].

Daily exposure to hand-arm vibration over a number of years can cause permanent physical damage usually resulting in what is commonly known as "white-finger syndrome", or it can damage the joints and muscles of the wrist and elbow. White-finger syndrome, in its advanced stages, is characterized by a blanching of the extremities of the fingers which is caused by damage to the arteries and nerves in the soft tissue of the hand (*Figure VI-8*). The syndrome usually affects one finger first but will affect the other fingers also if exposure to hand-arm vibration continues. In the most severe cases both hands are affected. In the early stages of "white finger syndrome" the symptoms are tingling, numbness, and loss of feeling and control in those fingers which are affected.

Figure VI-8. White-finger syndrome

Table VI-3. Degrees of vibration injury to blood circulation in the fingers

Stage	Degree	Symptoms
0	Mild	No attacks
1	Moderate	Sporadic attacks affecting only the tips of one or more fingers
2	Moderate	Sporadic attacks affecting terminal joint or two terminal joints of one or more fingers
3	Severe	Frequent attacks that can affect all the joints of most fingers
4	Very severe	Like stage 3, but with atrophy of the skin on the fingers

Damage to the wrist or elbow joints is often caused by long-term exposure to the vibrations produced by low-blow rate percussive tools (e.g. asphalt hammers and rock drills). This damage causes pain in the joints and muscles of the forearm and is accompanied by reduction of control and muscular strength in the forearm.

There are several basic approaches that can be utilized to help protect worker in a vibratory environment, including means for reducing the mechanical vibration itself through engineering controls, isolation of man from the vibratory force, increasing man's mechanical resistance to the vibration, reduction of the exposure time during which man is experiencing the vibration.

Vibration often can be reduced at its source by various engineering means, such as:

- use of vibration isolators (springs or compression pads) on which machinery can be mounted;
- proper machine maintenance, balancing and replacement of worn parts;
- substitution of equipment and processes that involve high levels of vibration for those that generate less vibration;
- modification of speed, feed or motion characteristics of the equipment generating the vibration.

Administrative controls, such as removing man from the vibration, are not always possible, but they do represent another alternative for minimizing exposure to vibration. This is the only solution left when all the other damping methods have failed.

There are four principle ways in which a hand-tool operator's exposure to harmful vibrations can be decreased:

1) by damping the tool internally. Therefore, when new hand-tools are selected care should be taken to check that the tool's does not produce harmful not-dampened vibrations;
2) by inserting damping between the tool housing and the hand. This damping could be introduced coating the handles with rubber, and using rubber gloves to hold the tool (*Figure VI-9*);
3) by operating the tool remotely. This is the most effective, but unfortunately the most expensive, method of damping;
4) by decreasing the operator's daily exposure time, e.g. by introducing job rotation (*Figure VI-10*). This method also applies to whole-body vibration and is the ultimate method. This is the only solution left when all the other damping methods have either failed, or not been considered feasible.

Figure VI-9. Protective rubber gloves

Figure VI-10. Job rotation

If the maximum continual period of exposure for a frequency-weighted RMS acceleration of $a_{limited}$, is set at $T_{limited}$, it has been concluded that the allowed exposure time $T_{allowed}$, for frequently-weighted acceleration of a_{eq} could be found using the equation which follows:

$$a_{eq}^2 \cdot T_{allowed} < a_{limited}^2 \cdot T_{limited},$$

thus

$$T_{allowed} < \frac{a_{limited}^2 \cdot T_{limited} / a_{eq}^2}{a_{eq}^2}.$$

This method of reducing exposure involves a great deal of planning and is not always easy to implement.

2.6. Radiation

Electromagnetic radiation (EMR) is the propagation, or transfer, or energy through space and matter. EMR has a dual, particle-wave nature. Its energy transfer is best described by a particle, but the behaviour of the radiation is best described as a wave. All EMR travels at a constant speed $c = 3{\cdot}10^8$m/s. Each particle of energy, called a photon, is accompanied by an electric field and a magnetic field. These fields are perpendicular to each other and perpendicular to the direction of travel of the wave.

Electric fields are produced by electric charges, while magnetic fields are produced by moving charges, or a current. Electric and magnetic fields in turn exert force on electric charges, and this is the basis for interactions with matter. Electric fields will act on a charge regardless of its motion, while the charge must be in motion relative to the magnetic field, or vice versa, before an interaction occurs between the magnetic field and the charge.

EMR is a continuum of energies with different wavelengths and frequencies. Two similarities of all EMR are that they all move at the same speed, and they are all produced by the acceleration or deceleration of electrical charge. Wavelength λ is the distance between the ends of one complete cycle of a wave. The wavelength range of the whole spectrum is enormous: 10^{-12} cm to 1 km or more. Frequency f and wavelength are related by the speed of light c:

$$c = f \cdot \lambda$$

Photon energy describes the energy possessed by electromagnetic energy when characterized as discrete bundles, as described by quantum theory. The unit of photon energy is the electron volt (eV).

The electromagnetic spectrum is a continuum that spans high-energy gamma radiation to non-time-varying fields (*Figure VI-11*). Any location on the spectrum may be characterized by wavelength, frequency, and photon energy. The effect of such radiation on living tissue is variable but the ability of this energy to ionize the target tissue distinguishes two main regions of the electromagnetic spectrum: ionizing radiation and non-ionizing radiation. The boundary between these regions is photon energy of 12.4 eV.

Photons with energies less than 12.4 eV are considered to have insufficient energy to ionize matter, and are non-ionizing in nature. The non-ionizing spectral region includes the ultraviolet (UV), visible, infrared (IR), radio-frequency (RF), and extremely low-frequency (ELF) (*Figure VI-12*) spectral regions. Wavelength is the descriptor used for UV, visible, and IR radiation and frequency is used for RF and ELF.

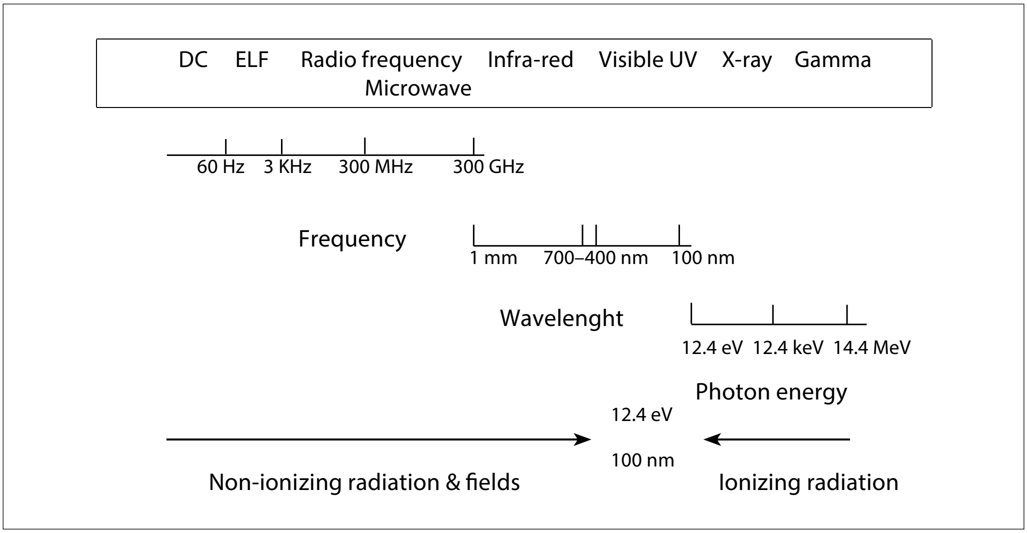

Figure VI-11. Electromagnetic spectrum

Figure VI-12. ELF electromagnetic radiation

2.6.1. Non-ionizing radiation

UV, visible, and IR radiation are called optical radiation because they behave according to the laws and principles of geometric optics. The optical wavelengths can be divided into spectral bands. The boundaries between the bands have no physical basis and serve only as a framework for addressing biological effects.

Occupationals potentially associated with ultraviolet radiation exposures, modified here, include aircraft workers, barbers, brick masons, burners, cattlemen, construction workers, cutters, drug makers, electricians, farmers, fishermen, food irradiators, foundry workers, furnace workers, gardeners, gas mantle makers, glass blowers, glass furnace workers, hairdressers, herders, iron workers, lifeguards, lithographers, miners, nurses, oil field workers, pipeline workers, plasma torch operators, railroad track workers, ranchers, road workers, seamen, glass skimmers, steel mill workers, stockmen, stokers, vitamin D preparation makers and especially welders.

The ultraviolet spectrum is divided into three different wavelength bands, 315–400 nm (UV-A), 280–315 nm (UV-B) and 200–280 nm (UV-C), for convenience in classification. These ranges, with slight variations, are also referred to as near, midrange and far ultraviolet, respectively. Wavelengths below 200 nm are of little biologic significance, since radiation in this region (vacuum ultraviolet) is absorbed in very short pathlengths in the air, with associated production of ozone.

The target organs for UV radiation are the skin, eyes, and immune system. Skin effects that may be of importance from occupational exposures include erythema, photosensitivity, aging, and cancer. The most common adverse response of the skin to UV is erythema or sunburn. The maximum effect is at 260 nm, with a secondary peak at 300 nm. The cancerogenic action spectrum for humans is known to include the UV-B region but may extend throughout the UV-A region. Ocular effects are photo keratoconjunctivitis, cataracts, and retinal effects. Photokeratitis and photo conjunctivitis result from acute, high-intensity exposure to UV-B and UV-C. Commonly referred to as welder's flash by workers this injury results from the exposure of unprotected eye to welding arc or other artificial sources rich in UV-B and UV-C. Sunlight exposure produces these sequelae only in environments where highly reflective materials are present such as snow (snow blindness) or sand.

UV-A, UV-B, and UV-C have been found from fluorescent lamps used in open fixtures, but UV-B and UV-C were not found when an acrylic diffuser was used with the fixture. The highest UV-B and UV-C irradiances were associated with high-output and super high-output lamps.

Medical uses include phototherapy, photo-chemotherapy, tanning, and disinfection and sterilization. Phototherapy workers have a greater risk of dying from skin cancer than medical workers who do not work with UV, but their risk is much less than medical workers who use ionizing radiation. Dentist may use UV and blue-light-curable materials. Generally, handheld applicators that are properly designed, maintained, and used will minimize exposure to the dentist.

Limited test data of UV-protective eyewear are available on prescription: eyewear, contact lenses, and sunglasses. If sunglasses with UV transmission windows reduce visible light levels to comfortable levels of illumination, the eyewear may view potentially hazardous UV-A sources for relatively lengthy periods of time, which would increase the ocular dose of UV-A. UV leakage as high as 25% has been found for poorly fitting eyewear.

Above 400 nm high-intensity exposure to visible wavelengths can lead to thermo coagulation of skin similar to that produced by electrical or thermal burns. Exposure to intense light, such as the sun, carbon arc, or welder's arc, without proper protection may produce temporary or permanent retinal blind spots. Glare may produce visual discomfort, often due to squinting in an effort to screen light. If glare is substantial or frequently induced, it may result in tiredness, irritability, possibly headache, and a decrease in work efficiency. The lack of sufficient lighting is a big problem. Poor lighting can increase eye strain, which can lead to headaches, various psychosomatic symptoms and to the risk of injuries in the working environment.

Most of the sources discussed under visible radiation also emit IR radiation (the region between 0.75 μ and 1.5 μ). Exposures to IR radiation can occur from any surface that is at a higher temperature than the receiver.

Industrial applications include drying and baking of paints, varnishes, enamels, adhesives, printer's ink and other protective coating; heating of metal parts for shrink tin assembly, forming, thermal aging, brazing, radiation testing and conditioning of surfaces for application of adhesives and welding; dehydrating of textiles, paper, leather, meat, vegetables, pottery ware and sand moulds; spot and localized heating for any desired objective. Infrared radiation may be used for any heating application where the principal product surfaces can be arranged for exposure to the heat sources.

Infrared radiation is perceptible as a sensation of warmth on the skin. The increase in tissue temperature on exposure to IR radiation depends on the wavelength, the total amount of energy delivered to the tissue and the length of exposure. IR radiation in the far wavelength region is completely absorbed in the surface layers of the skin. Exposure to IR radiation can cause acute skin burn and increased persistent skin pigmentation. The short wavelength region of the infrared is capable of causing injuries to the cornea, iris, retina and lens of the eye. Excessive exposure of the eyes to luminous radiation, mainly visible and IR radiation, from furnaces and similar hot bodies has been said for many years to produce "glass blower's cataract" or "heat cataract".

Light amplification by stimulated emission of radiation (laser) is optical radiation that propagates in the form of a beam and has some special properties. Most lasers emit light in a very narrow band width, which is described as monochromatic. Laser radiation also propagates in a highly directional manner and is characterized by a low level of divergence, or beam spread. Coherence means that the wavelengths of laser radiation are in phase both in space and time.

Laser applications areas are medicine, dentistry, science, industry, communications, construction, commerce, education, entertainment, criminal justice, and military applications.

Laser light of high energy can be extremely damaging to the eye and can even burn the skin or other materials. Generally, due to the larger surface area of the skin, it may be at greater risk of exposure than the eye. However, the eye is more vulnerable to laser radiation. Laser induced biological effects depend primarily on wavelength, irradiance, and exposure duration. The penetration depth into the skin and eyes is wavelength dependent.

Individuals who work with lasers must have medical approval. Medical approval includes an evaluation of visual acuity, colour vision, the skin and the possibility of photosensitization.

The eyewear must be marked with optical density and wavelength so users can select the proper eyewear. It should be inspected routinely to determine if there is pitting, crazing, or solarization of the lenses and if goggle straps or spectacle side shields are in good condition.

The radio-frequency and microwave radiation (RF) spectral region is 300 GHz to 3 kHz. Usually, microwave radiation is considered a subset of RF radiation, although an alternative convention treats radiowaves and microwaves as two spectral regions. In the latter context, microwaves occupy the spectral region between 300 GHz and 300 MHz, while radiowaves include 300 MHz to 3 kHz. Major sources of RF include power lines, video display units, telecommunications and broadcasting facilities, mobile telephones and their base stations, and radars. Most industrial microwave equipment operates between 915 MHz and 2450 MHz. Applications employing microwave energy are: drying purposes, including match heads, veneers, paper, plastic ceiling and pharmaceutical drying, and in the food industries for fish drying.

EMR interacts with biological tissues in one of the following three ways:

1) transmission, where the radiation passes through tissue without any interaction;
2) reflection, where the radiation is unable to pass through air/tissue interface (the boundary layer) and is reflected back into space;
3) absorption, where the radiation is able to pass the boundary layer and deposit its energy in a tissue.

The frequency of the EMR determines what energy is released in the tissues (heat, electrical potential, bond breaking, etc.). These interactions are summarized in *Figure VI-13*.

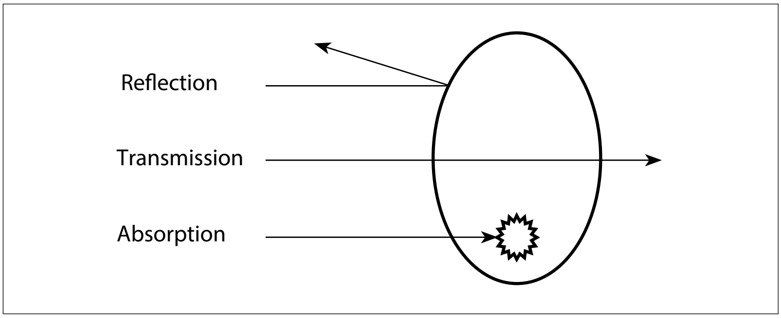

Figure VI-13. Interactions of EMR and biological tissue

In general, short-wavelength RF has a relatively shallow penetration depth into tissues. Longer wavelengths may penetrate more deeply, and the body is relatively transparent to long-wavelength magnetic fields. Obviously, penetration depth may affect what organs or systems are at risk. At 3000 MHz the microwave penetration produces heat within the tissue; in the eye will be damaged, as may cause iris. Shorter wavelength penetration and heat to the tissue are greatest and damage can result to the internal organs.

Administrative controls include footwear, protective clothing and gloves, pre-purchase review of sources, controlling the duration of exposure, increasing the distance between the source and workers, restricting access, and placing warning signs. RF protective suits are made of a base material that is impregnated with a highly conductive metal, such as silver, or is woven with metallic stainless steel tread. Protective gloves may provide protection from RF induced contact currents and spark discharge. Rubber insulated gloves can be effective in reducing low-frequency contact currents.

In occupational settings high exposures sometimes occur, and information about the sources and various factors that may influence the exposure levels is needed for the individual to be able to act prudently. This information should be included in the instructions at each workplace.

2.6.2. Ionizing radiation

Ionizing radiation (IR) is electromagnetic radiation that has sufficient energy (more than 12.4 eV) to separate electron from their atomic orbits. Ionizing radiation is a general term applied to both electromagnetic waves and/or particulate radiation capable of producing ions by interaction with matter. The energy in ionizing radiation (IR) is carried in packets by either EMR (X-rays, γrays) or moving particles (α and β particles, neutrons and protons).

The background IR comes from several sources. Cosmic rays are a complex mixture of high energy radiations originating in outer space but producing a wide variety of secondary radiations when the primary radiation meets the Earth's atmosphere. The Earth's crust is mostly due to the presence of the components of the uranium and thorium decay series. Radioactivity in the air is mainly due to radon and thoron which diffuses from the ground and buildings. Ingested potassium-40 is the major component of dose from diet apart from radon decay products.

There is a wide variety of situations in which people at work are exposed to IR. These situations range from handling small amounts of radioactive material, such as for tracer studies, to operating IR generating or gauging equipment, to working in installations of the nuclear fuel cycle. There are also situations where the exposure of workers to natural sources of radiation is sufficiently high to warrant its management and control as an occupational hazard.

Human activity raises IR exposure due to discharge from coal fired and nuclear plants. Most important non-medical sources of IR exist in the power industry in the areas of mining, milling fuel fabrication, reactors, reprocessing and waste disposal. Doses vary greatly in different professions. Typically, the largest exposures in nuclear power plants are received in maintenance jobs. Most applications use radioactive properties in measurement and testing. X-ray and γ radiography use ionizing radiation in the testing of welding joints, pressure vessels, ships, bridge structures and other metallic structures.

Medical facilities can discharge low level, non-biologically contaminated medical radionuclides into the sewer system. Patient excreta with radionuclides exempt from regulation. The largest IR from medical causes is due to diagnostic X-rays, including dental X-rays, that contribute about 10% of the total annual dose to the average man. Radioactive chemicals as pharmaceuticals have a wide variety of uses: diagnostic (determination of body composition); and therapeutic (the radioactive material in the desired organ or tissue).

An ionizing event in tissue has typically an energy of about 100 eV and since the average chemical bond only requires about 3 eV to break, it is clear that ionizing radiation can exert a powerful molecular action resulting in effects such as cell death, mutation, chromosome breaks, inhibition of cell division, formation of giant cells, action on macromolecules, and reduction of metabolism and protein synthesis. The health effects of ionizing radiation can be divided into non-stochastic and stochastic ones, that is, respectively, effects for which there is a threshold and no threshold. These are acute radiation syndrome (gut, blood, CNS delayed, cataracts, dermatitis – non-stochastic) and usually, chronic radiation syndrome (cancer, genetic damage – stochastic). IR can be detected, and is more effective at ionization than others, a second measure Sv (sievert) is used to quantify the biological dose equivalent. The biological dose equivalent is obtained by multiplying the radiation exposure by a quality factor.

Diagnostic and therapeutic machines are calibrated with dose rate exposures at a given distance and field size. Focal sizes are known and the formula applied. In general, high Z material is used to shield against photons, e.g., lead, concrete. Shielding for beta emission and neutrons requires low Z material to reduce the initial energy by inelastic scattering and prevent X-ray production.

IR protection principles cover the concepts of time, distance, and shielding. Radiation exposure increases linearly with an increase in the amount of time spent. The rule is to reduce the time of exposure to a minimum period. The standard rule for radiation protection regarding distance from a source is that the dose, or more appropriately dose rate, is inversely proportional to the distance squared from the source. In order to prevent acute effects (non-stochastic effects) of IR exposure, and to limit the occurrence of late effects (stochastic effects) to an acceptable level there are recommendations of dose limits for occupational exposures (*Table VI-4*).

Table VI-4. Ionizing radiation dose limits [7]

Application	Occupational dose limit
Effective dose	20 mSv per year averaged over defined periods of 5 years with single year max of 50 mSv
Annual equivalent dose in:	
the lens of the eye	150 mSv
the skin	500 mSv
the hands and feet	500 mSv

Personnel protection for contamination requires use of latex gloves, eye shields, and protective clothing. Radiation monitors for the whole body are required as well as finger badges for those materials that involve hand transfer techniques. The use of shield layers such as eye shields and gloves not only prevent the particles from reaching the body but also shield by absorption.

3. CHEMICAL OCCUPATIONAL HEALTH HAZARDS

Basic to the chemical occupational environment vocabulary are states of matter. Dusts are solid particles generated by handling, crushing, grinding, rapid impact, detonating of organic or inorganic materials, such as rock, ore, metal, coal, wood, and grain. Dust is a term used in industry to describe air-borne solid particles that range in size from 0.1–25 μm. Evaluating dust exposure properly requires knowledge of the chemical composition, particle size, dusts concentration in air, how it is dispersed, and many other factors. Large particles, more than 10 μm aerodynamic diameter, can be deposited through gravity and impaction in large ducts before they reach the very small alveoli. Except for some fibrous materials, dust particles must usually be smaller than 5 μm in order to penetrate to the alveoli or inner recess of the lungs.

Fumes are formed when the material from a volatilized solid condenses in cool air. The solid particles that are formed make up a fume that is extremely fine, usually less than 1.0 μm in diameter. In most cases, the hot vapour reacts with the air to form an oxide. Gases and vapours are not fumes, although the terms are often mistakenly used interchangeably. Welding, metalizing, and other operations involving vapours from molten metal's may produce fumes. Arc welding volatilizes metal vapour that condenses as the metal or its oxide in the air around the arc. These fumes, because they are extremely fine, are readily inhaled.

Other toxic fumes, such as those formed when welding structures that have been painted with lead-based paints or when welding galvanized metal, can produce severe symptoms of toxicity rather rapidly unless fumes are controlled with effective local exhaust ventilation or the welder is protected by respiratory protective equipment.

Smoke consists of carbon or soot particles less than 0.1 μm in size, and results from the incomplete combustion of carbonaceous materials such as coal or oil. Smoke generally contains droplets as well as dry particles.

Aerosols are liquid droplets or solid particles of fine enough particle size to remain dispersed in air for a prolonged period of time. Mists are suspended liquid droplets generated by condensation of liquids from the vapour back to the liquid state or by breaking up a liquid into a dispersed state, such as by splashing, foaming, or atomizing. Examples are the oil mist produced during cutting and grinding operations, acid mists from electroplating, acid or alkali mists from pickling operations, paint spray mist in painting operations, and the condensation of water vapour to from fog or rain.

Vapours are the volatile form of substances that are normally in the solid or liquid state at room temperature and pressure. Solvents with low boiling points volatilize readily at room temperature.

Gases are formless fluids that expand to occupy the space or enclosure in which they are confined. Gases are a state of matter in which the molecules are unrestricted by cohesive forces.

A potential threat to the health, productivity, and efficiency of workers in most occupations and industries is their exposure to gases and vapours from solvents, chemical products, by-products of chemical use, and chemical processes. There are very many different chemicals which pollute workplace environment in various occupations. Common industrial chemicals can damage various parts of the body (*Figure VI-14*) [7].

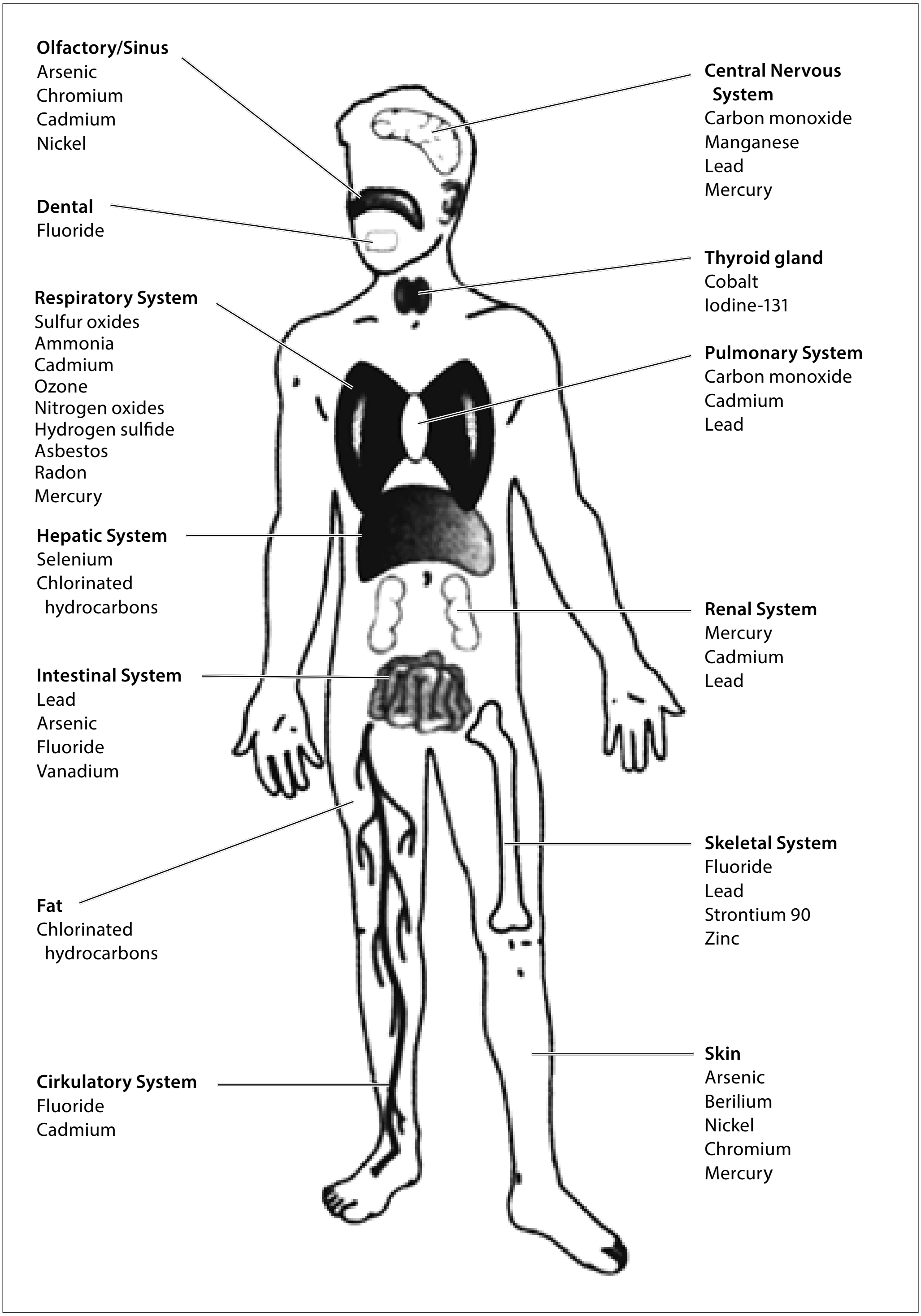

Figure VI-14. Human occupational exposure to chemicals [7]

Chemical compounds in the form of liquids, gases, mists, dusts, fumes, and vapours can cause problems by inhalation, absorption, or ingestion. Inhalation involves air-borne contaminants that can be inhaled directly into the lungs and can be physically classified as gases, vapour, and particulate matter including dusts, fumes, smokes, aerosols, and mists. Inhalation, as a route of entry, is particularly important because of the rapidity with which a toxic material can be absorbed in the lungs, pass into the bloodstream, and reach the brain. Inhalation is the major route of entry for hazardous chemicals in the work environment.

Respiratory hazards can be broken down into two main groups:

1) oxygen deficiency, in which the oxygen concentration is below the level considered safe for human exposure;
2) air that contains harmful or toxic contaminants.

Oxygen-deficient atmospheres may exist in confined spaces as oxygen is consumed by chemical reactions such as oxidation (rust, fermentation), replaced by inert gases such as argon, nitrogen, and carbon dioxide, or absorbed by porous surface such as activated charcoal.

The first physiological signs of oxygen deficiency (*anoxia*) are increased rate and depth of breathing. Oxygen concentrations of less than 16% by volume cause dizziness, rapid heartbeat and headache. Oxygen-deficient atmospheres may cause inability to move and a semiconscious lack of concern about the imminence of death.

Inhaled contaminants that adversely affect the lungs fall into three general categories:

1) aerosols, which, when deposited in the lungs, can produce either rapid local tissue damage, some slower tissue reactions, eventual disease, or physical plugging: an example of an aerosol is silica dust, which causes fibrotic growth in lungs;
2) toxic vapours and gases that produce adverse reaction in the tissue of lungs: an example of the second type of inhaled contaminant is hydrogen fluoride, a gas that directly affects lung tissue;
3) some toxic aerosols or gases that do not affect lung tissue locally but pass from the lungs into the bloodstream, where they are carried to other body organs: an example of the third type of inhaled contaminant is carbon monoxide, a toxic gas passed into the bloodstream without harming the lung.

Absorption through skin can occur quite rapidly if the skin is cut or abraded. Many organic compounds, such as cyanides, most aromatic amines, amides, and phenols can produce systemic poisoning by direct contact with the skin. Chemical agents are the predominant causes of dermatitis in manufacturing industries. Cutting oils and similar substances are significant because the oil dermatitis they cause is probably of greater interest to industrial concerns than is any other type of dermatitis. Detergents and solvents remove the natural oils from skin or react with the oils of the skin to increase susceptibility to reactions from chemicals that ordinarily do not affect the skin. Materials that remove the natural oils include alkalis, soap, and turpentine.

Desiccators, hygroscopic agents, and anhydrides take water out the skin and generate heat. Examples are sulphur dioxide and trioxide, and strong alkalis such as potash.

Protein precipitants tend to coagulate the outer layers of the skin. They include all the heavy metallic salts and those that form alkaline albumins on combining with skin.

Oxidizers unite with hydrogen and liberate nascent oxygen on skin. Such materials include nitrates, chlorine, hydrogen peroxide, permanganates, and ozone. Solvents extract essential skin constituents. Examples are ketone, aliphatic and aromatic hydrocarbons. Allergic or anaphylactic proteins stimulate the production of antibodies that cause skin reactions in sensitive people. The sources of these antigens are usually cereals and flour.

In workplace, people can unknowingly eat or drink harmful chemicals. Toxic compounds can be absorbed from gastrointestinal tract into blood. Thorough washing is required both before eating and at the end of every shift. Inhaled toxic dusts can also be ingested in hazardous amounts. If the toxic dust swallowed with food or saliva is not soluble in digestive fluids, it is eliminated directly through the intestinal tract. Toxic materials that are readily soluble in digestive fluids can be absorbed into the blood from the digestive system. It is important to study all routes of entry when evaluating the work environment – candy bars or lunches in the work area, solvents being to clean work clothing and hands, in addition to airborne contaminants in working areas.

To recognize occupational factors, a health and safety professional must first know about chemicals used as raw materials and the nature of the products and by-products manufactured.

The toxicity of a material is not synonymous with its hazard. Toxicity is the capacity of a material to produce injury or harm when the chemical has reached a sufficient concentration at a certain site in the body. Hazard is the probability that this concentration in the body will occur.

The effects of exposure to a substance depend on dose, rate, physical state of the substance, temperature, site of absorption, diet, and general state of a person's health. In evaluating the degree of exposure, the measured concentration of the air contaminant is compared to the limits or exposure guidelines that appear in the published standards on levels of exposure.

Threshold Limit Values (TLVs) are exposure guidelines established for air-borne concentrations of many chemical compounds. TLVs are air-borne concentrations of substances that are believed to represent conditions under which nearly all workers may be repeatedly exposed, day after day, without adverse effect. TLVs are based on available information from industrial and agriculture experience; from experimental human and animal studies; and, when possible, from a combination of the three.

Application of TLVs to workers on work schedules markedly different from the conventional 8-hour day, 40-hour week requires particular judgement in order to provide, for such workers, protection equal to that provided to workers on conventional workshops. Since adjusted TLVs do not have the benefit of historical use and long-time observation, medical supervision during initial use of adjusted TLV is advised.

TLVs for gases and vapours are usually established in terms of parts per million of substance in air by volume (ppm).

The criteria for effective evaluation of workplace exposure to hazardous substances normally involve:

1) development of a sampling strategy for assessment workplace exposures;
2) selection of the most appropriate measurement equipment;
3) interpretation of the results and deciding on the basis of the results and observations whether a health hazard exists.

Some pollutants to look for, even without exact measurements, are the following:

1) carbon monoxide is a chemical asphyxiant which can cause headaches, nausea and dizziness;
2) carbon dioxide can also cause headaches, nausea and dizziness at concentration exceeds $3\%_{volume}$;
3) ozone can be a respiratory irritant;
4) smoke and dusts can cause eye and throat irritation, coughing, if particularly heavy, lung disease;
5) oxides of nitrogen can cause watery eyes and irritations of the respiratory system.

There is no simple one-to-one relationship between the concentration of an atmospheric particulate contaminant and duration of exposure and the rate of dosage by the hazardous agent to the critical site in the body. For a given magnitude of atmospheric exposure to a potentially toxic particulate contaminant, the resulting hazard can range from an insignificant level to one of great danger, depending on the toxicity of the material, the size of the inhaled particles, and other factors that determine their fate in the respiratory system.

Synergistic action or potentiality may occur with some combinations of air contaminants. Such cases at present must be determined individually. Potentiating or synergistic agents are not necessarily harmful themselves. Potentiating effects of exposure to such agents by routes other than that of inhalation are also possible, e.g., imbibed alcohol and inhaled narcotic.

When a given operation or process characteristically emits a number of harmful dusts, fumes, vapours or gases, it will frequently be only feasible to attempt to evaluate the hazard by measurement of a single substance. In such cases, the threshold limit used for this substance should be reduced by a suitable factor, the magnitude of which depends on the number, toxicity, and relative quantity of the other contaminants ordinarily present.

Before different chemicals are introduced in an established process, possible health hazards should be carefully considered. Once these hazards are anticipated, suitable engineering controls should be devised and built into the processes to avoid them.

Respirators can be used as emergency or backup protection. Respiratory protective equipment, especially the air-purifying type, is limited by leakage around the mask edges, surface contamination, impaired efficiency with use, and need for adequate oxygen. Unless it is correctly used and properly cared for, a respirator may present a greater danger to an employee than no protection at all.

Another major route of entry for hazardous chemicals is through skin. The most effective way and often the only way to prevent harm is to keep the chemical from the skin. This can be done by using mechanical handling devices, such as tongs and baskets, and by using impermeable protective clothing, such as aprons, face shields, and gloves. The use of gloves requires caution. Many solvents can quickly penetrate latex rubber or neoprene gloves and come in contact with skin.

Workers at risk for a splash of chemicals in the eyes must wear appropriate protective eyewear. It must be noted that protective eyewear should not be used as the sole protection, but in conjunction with engineering controls, guards, and good manufacturing practice.

For chemical splash or irritating mists, eye protection should be selected from unvented chemical goggles, indirect-vented chemical goggles, or indirect-vented eyecup goggles. For severe exposure, a face shield should be used in conjunction with goggles. Where both an inhalation and splash hazard exists, full-face respiratory protection is preferable over a half-mask and goggles.

4. BIOLOGICAL OCCUPATIONAL HEALTH HAZARDS

Some two hundred biological agents are known to produce infectious, allergenic, toxic, and carcinogenic reactions in workers. Biologically derived air-borne contaminants include bioaerosols and volatile organic compounds released from living organisms. Bioaerosols are air-borne particulates composed of or derived from living organisms which include microorganisms, dead microorganisms and fragments, toxins, and particulate waste products from all varieties of living things. Biologically derived air-borne contaminant mixtures are ubiquitous in nature and may be modified by human activity.

Most of the identified biohazardous agents are:

1) microorganisms and their toxins (viruses, bacteria, fungi, and their products) – infection, exposure, or allergic reaction;
2) arthropods (crustaceans, arachnids, and insects) – skin inflammation, systemic intoxication, transmission of infectious agents, or allergic reaction;

3) allergens and toxins from higher plants – dermatitis from skin contact or rhinitis or asthma as a result of inhalation;
4) protein allergens from vertebrate animals (urine, excrement, hair, saliva, and dander) – allergic reaction;
5) invertebrate animals other than arthropods (parasites such as protozoa, flatworms such as *Scbistosoma*, and roundworms such as *Ascaris*).

Work-related illnesses due to biological agents such as infectious micro-organisms, biological allergens, and toxins have been widely reported. Exposure to biological hazards in the workplace results in a significant amount of occupationally associated disease. Many varied workplaces have a potential for such exposure. Individuals who are at a higher risk from exposure to biohazards include health-care workers, patients, veterinarians, animal handlers, farmers, dairymen, sanitation workers, emergency-response personnel, laboratory personnel involved in biotechnological research. It has been estimated that the population at risk from occupational biohazards may be several hundred million workers worldwide.

Most manual workers are prone to cuts and abrasions which may be infected. In the main, these are the zoonosis and contact with animals or animal products is, thus, a common thread connecting many of the diseases.

Brucellosis

Properties: gram-negative bacteria *Br. abortus, Br. melitensis, Br. Suis.*

Exposures: slaughter houses, veterinary surgeons, farmers, laboratory workers.

Health effects: fever, headaches, low-back pain, liver and splenic disorders.

Glanders

Properties: gram-negative organism *Actino bacillus mallei.*

Exposures: working with horses, mules and donkeys.

Health effects: severe lymphangitis with suppuration and fever.

Serum hepatitis

Properties: a virus.

Exposures: medical and paramedical staff, blood transfusion centres, venereal disease clinics.

Health effects: malaise, myalgia, headache, fever. Can be fatal and it is usually more severe than infective hepatitis.

Leptospirosis

Properties: motile spirochaete-like organisms including *Leptospira interrogans, Leptospira canicola,* and *Leptospira hebdomadis.*

Exposures: sewer canal workers, farmers, paddy field workers, slaughterhouse men, veterinarians.

Health effects: fever, headache, malaise, vomiting, myalgia; head tic or renal complications.

Tuberculosis

Properties: fungous bacteria, usually *Mycobacterium tuberculosis.*

Exposures: medical and paramedical staff, agricultural workers and veterinarians.

Health effects: reactivation of latent focus with variable course of pulmonary infiltration, fibrosis, cough, weight loss, chest pain frequently.

In food processing there is a risk of contact with infection from the food. Diseases develop due to the content of infectious matter in the food, e.g. *campylobacter, salmonella* and *listeria,* but also tapeworm *taenia.*

Biological materials typically have no threshold level of exposure. A single pathogenic organism is capable of replication and in some cases, given the right conditions, can infect a host and cause disease. They are ubiquitous in the environment and are affected by biological competition. Biological agents compete among each other for dominance in the environment, and after entering the host, they may be biologically inactivated by the immune system or other normal or innate metabolic processes.

To assess risk one must understand and consider the nature of organisms and their products, the nature of the host, and environmental conditions. These interrelationships must be considered within the context of external forces affecting them. There are three main pathways to prevent from biohazards: decontamination, disinfection, sterilization.

Decontamination is the use of physical or chemical means to render materials safe for further handling by reducing the number of organisms present to an acceptable level. Decontamination is used not only to protect personnel and the environment, but also to protect the work area. Decontamination may be accomplished by physical means such as heat, steam, and radiation or by chemicals.

Sterilization is complete killing of all organisms including bacterial spores. Boiling and pasteurization kills vegetative cells but not bacterial spores. Used at 121 °C under pressure in an autoclave, steam is the most widely used and convenient method of sterilization. Ionizing radiation is used for the sterilization of pre-packaged medical devices, including operating room supplies such as syringes and catheters. UV radiation usefulness is limited by its low penetrating power, and shadows and dust on the lamps can also reduce the effectiveness.

Disinfection kills infectious agents, except bacterial spores, below the level necessary to cause infection. Chemical disinfectants inactivate microorganisms by chemical reaction. The effectiveness of the disinfectant against an infectious agent varies with the nature of the chemical, the concentration, contact duration, temperature, humidity, pH, and the presence of organic matter. Chemical agents such as ethylene oxide, formaldehyde, glutaraldehyde, and strong acids and bases require special handling techniques.

5. PSYCHOSOCIAL AND ORGANIZATIONAL HEALTH HAZARDS

Psychosocial and organizational hazards are those which relate to the interaction among job content, work organization, management systems, environmental and organizational conditions, on the one hand, and worker's competencies and needs on the other. To declare that the mental or emotional state of employees has enormous consequences in occupational environment is a vast understatement. The fact that emotional problems account for the largest single source of time lost in industry is well known and is becoming a major concern.

The new approach to occupational health provides an appropriate conceptual framework for thinking about the nature, control and monitoring of the psychosocial and organizational hazards of work. Certain psychological and organizational characteristics of work are associated with the experience of stress, job dissatisfaction and ill health.

Exposure to many psychosocial and most organizational hazards of work are chronic rather than acute. The most obvious exception is exposure to traumatic events, such as violent incidents. The problems associated with assembly line work, for example, quantitative work overload, qualitative work underload and lack or control over the pacing of work, are chronic in nature and offer a contrast to those associated with violent incidents. Working on the assembly line can represent both the hazardous situation as well as the hazardous event.

The various psychosocial and organizational hazards at work are grouped into four categories:

1) quantitative overload;
2) qualitative underload;
3) lack of control over work;
4) lack of social support.

Different characteristics of jobs, work environments and organizations can create hazardous conditions: organizational function and culture (poor communications, poor problem-solving environment, poor development environment); participation (low participation in decision making); career development and job status (career uncertainty, work of low social value, poor pay, job insecurity); role in organization (role conflict, continual contact with other people); job content (high uncertainty, lack of variety, meaningless work, physical constraint); workload and work pace (qualitative and quantitative work overload or underload, lack of control over pacing, time pressure); work organization (inflexible work schedule, unpredictable hours, unsocial hours, shift working); interpersonal relationships at work (social isolation, lack of social support, interpersonal conflict and violence); home-work interface (conflicting demands of work and home, low social or practical support from home). Work characteristics may not be linearly associated with health, but they might combine interactively in relation to their health effects. Workers in jobs perceived to have both low working individual's potential control over his tasks and high psychological stressors involved in accomplishing the workload were particularly likely to report poor health and low satisfaction. The lowest probabilities for illness and death are found among work groups with moderate workloads combined with high control over work conditions.

5.1. Harm and the effects of stress

It has been argued that many effects of psychosocial and organizational hazards on health are mediated by psycho-physiological processes.

The experience of stress may be considered to be one outcome of exposure to the hazards of work and to hazardous situations [23]. A classically stressful situation would involve work demands which are not well matched to the knowledge and skills of workers or their needs, especially where those workers have little control over work and receive little support at work. Each aspect of such a situation could be said to carry the potential for harm under certain conditions and thus each represents a hazard.

The individual and organizational effects of stress are briefly summarized under four headings:

1) possible physical effects – allergies, backaches, cancers, chest pain, colds and flu, colitis, diarrhoea, dermatitis, digestive problems, dizziness, headaches, heart disease, impaired sleep, injuries, obesity, respiratory problems, sexual problems, skeleton muscular problems;
2) possible psychological effects – addictions and dependencies, boredom, depression, inability to concentrate, insomnia, irritability, low self-esteem, mental breakdown, nervousness, phobias, suicide, tiredness;
3) possible social effects – apathy, family breakdown, interpersonal aggression, social isolation;
4) possible work-related effects – absenteeism, poor time-keeping, high rate of client/customer complaints, poor quality of work.

The experience of stress can detrimentally affect the way a person feels, thinks and behaves. The effects of stress may be expressed in various ways: through increased irritability, poor decision-making, excessive smoking and drinking, poor diet, impaired sleep and sexual behaviour.

Individual differences are obvious both in exposure to psychosocial and organizational hazards, and in worker's response to them. However, these individual differences may be secondary to or, at least, combine with different sets of circumstance to create vulnerable groups of workers.

5.2. Control of psychosocial and organizational hazards

A particular account of the control cycle can be elaborated:
1) the acceptance that workers may be experiencing problems at work, or are being injured, made ill or distressed through work;
2) the analysis of work situation, with the identification of psychosocial, organizational and other hazards involved, and the nature of the harm;
3) the assessment of the risk to health associated with relevant hazards;
4) the design of practicable control strategies.

Three levels of control strategy have been adopted to deal with psychosocial and organizational hazards, stress and their health effects:
1) preventive strategies, often controlled by design or through worker training;
2) reactive strategies, often based on management and group problem solving;
3) rehabilitative strategies, often involving enchained employee support to help workers cope with problems.

The control strategies for work stress can be divided according to three dimensions. The first dimension refers to the target (the worker or the organization). The second dimension refers to the type of strategy used, and the third dimension refers to the agency by which the intervention will be accomplished (the organization, external consultants or the workers).

6. HAZARDS IN MEDICAL ENVIRONMENT

Medical office environment is not only patient's treatment surroundings but also medical staff's working surroundings. Within health care, there are many different professional groups working to prevent and treat diseases and injuries. Work within health care is characterized by high tempo, big workload and different tasks, which has to be done under time pressure. The world demands for increased quality and reduced waiting lists, which has lead to increased workload.

Recently, very little attention has been paid to the problem of environment, because it was considered that work in hospitals is easy and intellectual. Later morbidity has been analysed, including morbidity of medical employees and the following conclusion has been drawn –medical employee's morbidity is the same as that of other working people.

The two biggest causes of problems among the staff is high physical and mental workload. Violence and threats are also common, especially in psychiatry and emergency departments.

Heavy lifting and moving of patients in health care is a common reason that many suffer from discomfort in neck, shoulders, arm and lower back. Narrow spaces in hospital rooms and toilets contribute to extra load on the neck, shoulders and back. The knowledge of appropriate posture and moving techniques are often absent.

Different aids are not always available or not used properly. Heavy lifting and stressful work posture are examples on musculoskeletal disorders that should be prevented.

Musculoskeletal disorders are among the most common reasons why people are sick. Physical load in combination with stress increases the risk of musculoskeletal disorders. Mental stress leads to increased muscle tone, which often remains after the work. Working in shifts, high workload and reorganizations increase the risk of physical and mental stress. The tasks are often demanding but can also be stressful, and in combination with high work tempo, it can lead to illness in the form of stress.

The most frequent diagnosis for physicians is infectious diseases, while frequent diagnoses for nurses are chronic back pain, eczemas, and occupational infections. Among the nurses, the most common is musculoskeletal disorders. Nursing assistants suffer the same illnesses as nurses. The most frequent illnesses are chronic lower back pain, tendon inflammation, myalgia, contact dermatitis, and occupational infections. For dentists the most frequent diagnoses are tendonitis and chronic back pain syndrome, and the same applies to dental nurses, who also have a high rate of contact dermatitis.

Medical employees in their work are subjected to the effect of various harmful factors: biological hazards (human immunodeficiency virus (HIV), hepatitis B virus, tuberculosis); chemical hazards (antineoplastic drugs, waste anaesthetic gases, cytotoxic agents, methyl methacrylate); physical hazards (radiation, ultrasound, lasers, noise); psychological hazards (stress, shiftwork); ergonomic hazards (lifting, standing for long periods of time, poor lighting).

6.1. Chemical hazards

During the course of treating their patients, medical employees may inadvertently exposure themselves to hazardous substances.

Medical staff and employees of drug stores are daily in contact with drugs. These drugs – foreign antigens – can cause disbalance in the immune system. A great number of cancer diseases among nurses working with chemotherapy can be explained by the immune status deficiency. Allergy is spread among paramedical staff and employees of drug stores. This above mentioned illness depends on individual sensitivity and length of work experience.

Cytotoxic drugs are preparations which are used mainly in the treatment of malignant growing cells. They may damage growth and reproduction of normal cells as well. The potential for harmful effects developing over the longer term is, however, well known.

All antineoplastic agents cause adverse effects of a kind when therapeutically administered to patients. These effects range from nausea to the induction of secondary cancers. Mutagenic, carcinogenic, and teratogenic properties are also documented for many of these substances through studies *in vitro* and *in vivo*.

Antineoplastic drugs are usually dissolved in a liquid for intravenous administration to the patient. It is the preparation of these solutions that possesses the greatest hazard to health care personnel.

The first report that indicated that health professionals could fall ill as a consequence of exposure to anaesthetic gases in operating rooms came at the end of the 19th century. However, it was the physical properties of anaesthetic agents that attracted the most interest. Through the introduction of halogenated anaesthetic agents the anaesthetic compounds have become less explosive and flammable, and the interest has been focused on the hazards for health professionals with regard to pregnancy outcome, cancer risk, and impaired central nervous system function.

Anaesthetic halothane gives trifluoroacetic acid as a metabolite, which is easily accumulated in the body. This metabolite interferes possibly with trichloroacetic acid in binding to plasma proteins.

Nitrous oxide (N_2O) is another substance commonly used for anaesthetic purposes. The critical effect of irreversible nature seems to be the teratogenic effect and the critical effect of reversible nature is the disturbance of mental function.

When no scavenging is used, the levels of anaesthetic gases in operation rooms are very variable and might be rather high. The highest levels are found in older operating rooms with poor general ventilation or when performing paediatric anaesthesia. However, scavenging systems have been in use for a long time and better systems for close or local scavenging have been introduced as well as a system with double mask. The double mask can in comparison with a conventional mask reduce the amount of escaped anaesthetic gases by 90%. In most cases in the practical situation, exposure levels less than the exposure limit values for anaesthetic gases are attainable. This does not mean that the risk is negligible for adverse effects among health professionals working with anaesthetic gases in hospitals, dental offices, or elsewhere.

Methyl methacrylate is an ester of methacrylic acid and methanol and is used for repairing dental prostheses [11]. The following groups of health care personnel may come in contact with methyl methacrylate: technicians and technical aides making and mending acrylic dentures and hearing aid apparatus, orthopaedic operation personnel using methyl methacrylate bone cement for fixation of metallic and plastic prostheses, and employees at pathology laboratories where methyl methacrylate may be used for embedding of histological preparations.

Methyl methacrylate can cause both allergic and irritative contact dermatitis. Surgical gloves are often used for protection when handling methyl methacrylate.

High standards of hygiene necessitate frequent hand washing, hand disinfection, and the use of gloves for large groups of hospital workers. This inevitably involves a cumulative irritant exposure of the hands among ward orderlies, nurses, assistants, nursing assistants, physicians, and dental personnel. The use of rubber gloves involves the risk of contact allergy and contact urticaria and should thus be restricted as much as possible.

Before new chemicals are introduced into the hospital environment, predictive tests for irritant, urticariogenic, and sensitizing properties should be carried out. If alternatives exist, the least hazardous agents should be chosen.

6.2. Biological hazards

More than ⅔ of physicians inquired – surgeons, gynaecologists, dentists, doctors of first aid, therapists, infectionists, psychiatrists, otolaryngologists and dermato-venerologists have a contact with pathogenic microorganisms [1, 17].

There are biological hazards to medical employees which can be a cause of parasitic, fungal, viral or bacterial infections:

1) skin diseases caused by fungi;
2) excretions of patients;
3) materials of post-mortal;
4) insects.

Classification of microorganisms according to their levels of hazard is used to establish safe, practical, and economic ways of dealing with the pathogens. The purpose is to reduce the risk for spread of the organisms, both within hospitals and laboratories and in the community at large. Usually, lists of pathogens with the same levels of hazards have been generated, and the laboratory conditions under which the microorganisms should be handled have also been specified.

The WHO classification can be summarized as follows:

1) risk group I – agents of low risk. The general public may enter the laboratory;
2) risk group II – agents of moderate individual and low community risk. Accesses are the same as for risk group I;
3) risk group III – agents of high individual but low community risk. Authorized personnel should have access to the laboratory;
4) risk group IV – agents of high individual and community risk. Entry should be restricted to only a very few authorized staff.

Tuberculosis (TB) which is spread in Latvia is regarded as an occupational disease for medical employees, if:

1) suffering from this disease is due to contact with TB patients;
2) no contact with TB patients in their families.

Medical employees suffer from virus hepatitis 6 times more often than representatives of other professions. Surgeons, otolaryngologists, dentists, employees of blood transfusion office suffer more often from serum hepatitis contact with patient's blood and saliva. One cannot exclude the possibility to become infected by air droplets with virus hepatitis. Infection of measles, mumps and toxoplasmosis is possible.

A new problem has dawned with the emergence of the acquired immune deficiency syndrome (AIDS) epidemic, posing a significant potential risk to health care workers. AIDS is a serious clinical condition of different manifestations. When the viral origin of the disease became clear the potential risk of contracting HIV caused great concern both among the general public and medical personnel [4].

6.3. Physical hazards

Radiation is used in medicine for both diagnostic and therapeutic purposes [21]. The physicians, technicians, nurses, and others involved constitute the largest group of workers occupationally exposed to man-made sources of radiation.

There are several medical specialities such as X-ray diagnosis, radiation therapy, and nuclear medicine which are entirely based on the use of ionizing radiation. X-ray examinations remain the most frequent use of ionizing radiation in medicine. Occupational exposure in medicine depends on a number of factors, the most important of which is the X-ray procedure.

Although doses to patients from computed tomography (CT) may be high, the exposure of staff is usually low, because the primary X-ray beam is highly collimated, and scattered radiation levels are low. In all such CT units, leakage of radiation has been reduced to near zero. For staff in the control room of a properly designed facility, computed tomography does not represent a significant source of exposure.

During fluoroscopy, the X-ray tube maybe energized for considerable periods of time. Fluoroscopic procedures require the operator to be present in the examination room, usually close to the patient. In fact, the patient is the main source of exposure because of scattered radiation. In special examinations, fluoroscopic times may belong and the accompanying radiographic exposures can be numerous. Medical personnel are nearly always present in the room close to the patient, and it is difficult to shield against scattered radiation.

In almost every dental office or clinic, a diagnostic X-ray machine is available and frequently used. The number of X-ray devices used in dentistry is thus extremely large. Occupational exposure in dentistry is from scattered radiation from the patient and leakage from the tube head, although the latter should be insignificant with modern equipment.

Whereas the broad aim in diagnostic radiology is the imaging of anatomy, that in nuclear medicine is more the investigation of physiological processes, with most procedures involving some form of measurement to quantify organ function.

The magnitude of the exposures when performing clinical nuclear medicine procedures depends on the precautions taken, including the use of syringe shields when performing the injections. Personnel must be close to the patient when giving him injections and while positioning the patient and camera. Usually, the imaging process makes the greatest contribution to the exposure of staff. Internal exposures of personnel are usually much less than external exposures. They are controlled by monitoring work surfaces and air-borne concentrations.

Radiotherapy is an important treatment modality for malignant disease. There are three main categories of the activity in radiation oncology: brachytherapy, external beam treatment, and therapy simulation. Brachytherapy, where there is manual loading of the radioactive sources, is usually the most significant source of personnel exposure. Exposures may occur during receipt and preparation of the sources, during loading and unloading, and during treatment. Personnel should not normally be present in the treatment room when external beam therapy is being used, with the possible exception of low-energy X-ray contact therapy units, which are sometimes used for intra cavity treatments**.**

There are three principles which can be applied to prevent or control the exposure of personnel to ionizing radiation hazards: remove the hazard, guard the hazard, and guard the worker. These principles imply that working places are properly designed and that appropriate equipment and shielding are provided to ensure the maximum amount of protection.

All personnel working with radiotherapy must be issued a radiation monitor or personal dosimeter to assess general body dose.

There are also several new technologies in medicine based on non-ionizing radiation such as nuclear magnetic resonance (NMR) examinations, hyperthermia cancer treatment, diagnosis and physical therapy with ultrasound, light amplification by stimulated emission of radiation (LASER) surgery, ultrasound crushing of kidney stones, psoriasis treatment, etc. It is therefore important for hospital workers to be well informed in the safety of all kinds of radiation, both ionizing and non-ionizing.

There is a golden rule of radiation protection which is always applicable: as many exposures may involve some degree of risk, any unnecessary exposure must be avoided, and all doses must be kept as low as is readily achievable [14, 16].

Ultraviolet (UV) radiation in the form of phototherapy is at present expanding. In the phototherapy of infants with neonatal jaundice (hyperbilirubinemia), incorrectly selected fluorescent tubes have given rise to erythema. The use of certain photodynamic dyes and of light for the treatment of herpes, and UV-A for other skin diseases, such as psoriasis, expose the patient to a number of risks. If adequate safety precautions are not taken, the treatment personnel may also be at risk.

The extremely collimated character and generally high degree of monochromatic of the LASER beam make this device as a potential value in the treatment of the eye and skin, in various diagnostic techniques, in surgery of the skin and internal organs and in dentistry.

Measures to prevent damage by LASER exposure can be summarized as follows:

1) never look into a LASER beam;
2) protection measures must be made, which to as large extent as possible, protect human exposure to laser radiation;
3) special protection glasses with side protection must be used;
4) no unprotected areas of the body are allowed to be exposed to direct LASER irradiation;
5) personnel who are operating LASER instruments should undergo an eye examination at least once a year.

ELF electric and magnetic fields are generated by 50 Hz power lines as well as by electronic equipment of various kinds. Electric and magnetic fields are also generated whenever electric energy is used.

In the interest of health protection, the question has been raised as to the effects, if any, that these fields may have on man.

In standard whole-body chemical NMR – scanning equipment, the static magnetic field is generated on high intensity. When a NMR imaging unit is to be installed in a hospital area, two major problems arise: the environment must be protected from the machine and the machine must be protected from the environment. Therefore, all demands of safety must be observed very strictly during the work-time (shielding, ventilation, etc.).

Ultrasound is used in a wide range of power levels in applications from mechanical industry to medical examinations. In medical ultrasound therapy, equipment is operated at frequencies from about 0.8 to 3 MHz, with a spatial average output not exceeding 3 W/cm^2. This power level is in the range where undesirable bioeffects have been reported at an exposure time above 10 s.

In order to protect the medical personnel from unnecessary exposure to ultrasound, one can apply the following measures:

1) use the lowest power level and the shortest time possible for the operation;
2) avoid unnecessary contact between ultrasound equipment and the user, use protective gloves;
3) remember the possible damage due to air-borne ultrasound that can give auditory effects, use hearing protection;
4) undergo annual medical examination.

6.4. Psychosocial and organizational hazards

Medical employees are subjected to very different psychosocial and organizational hazards (very compact schedule, frequent overwork, sleeplessness, ever crowded wards, a lot of "paper" work, incorrectly functioning equipment, severe incurable patients, capricious patients and malingerers, acute cases, death of patients, etc.), which may cause psychological reactions.

Of psychological reactions, "burnout" has been the most common concept during recent years. Burnout has three main components, namely, emotional exhaustion, depersonalization, and lack of personal accomplishment. Of these, emotional exhaustion has been the most extensively studied one. Emotional exhaustion relates to a state of emotional emptiness. In general, female physicians are more burnout than male physicians. The reason could be, for instance, that female caregivers demand more emotional involvement from themselves than a male caregiver does and also that patients expect more emotional care giving from women than they expect from men.

Women doctors work in the same conditions as men, at the same time women are more occupied with household work and upbringing of children. Therefore, women are exposed to sickness more often. Besides, the organism of a woman is more sensitive to the effect of chemical substances, such as toxic, allergic and embryotropic substances.

Long exposure to a caring job and a high degree of emotional devotion to patients are predisposing factors in relation to emotional exhaustion.

Personnel in various kinds of care are frequently exposed to violence from patients. This is particularly true in mental hospitals and emergency units. Injuries due to assaults have their highest rate among mental health personnel. One third of the assaults occur during the evening or night, when the working staff is usually reduced.

6.5. Ergonomic hazards

The musculoskeletal injuries and diseases constitute the dominating safety risk in health services [3, 12]. Most of the occupational musculoskeletal injuries are acute and they usually occur when the injured person is lifting without help. Very often this occurs when applying inappropriate work postures, such as twisting and lifting at the same time. Among the nurses and nursing assistants, the highest risk for these kinds of injuries is found among the youngest age group. Injuries due to falls, contact with tools and handled objects are also frequent among health professionals. Compulsory body poses of surgeons, otolaryngologists, dentists, etc. can cause osteochondrosis. Permanent work on feet causes the development of varicose veins. Lifting of heavy patients may cause different illnesses of backbone: lumbago, osteochondrosis and hernia of disks.

The individual susceptibility to musculoskeletal disorders plays a role in the outcome. The importance of muscle strength and other physical characteristics has been emphasized and muscle strength has been demonstrated as a predictor for occupational cervical-brachial disorders. Thus, muscle strength has to be considered when young women enter the occupation. Training in lifting techniques is another important item to reduce the musculoskeletal disorders.

Effort of sight (poor or wrong lighting), especially for analysts (virusologists, immunologists, etc.) develop short sight quickly; it can be considered as an occupational disease. Dentist's eyesight becomes worse after a 10-year long work experience. Besides they begin to squint with the right eye.

6.6. Other problems associated with hospital

At the temperatures recommended for hospitals (21–22 °C), patients are satisfied with the low humidity, but not below 30%. Many hospital activities such as bed-making, cleaning, physiotherapy, etc. imply a much higher rate of heat production. Hospital clothing should therefore have a lower vapour diffusion resistance than normal clothing. High humidity becomes a cause for complaint during sedentary, slight activities above 70%, when clothing fibres are noticeably damp.

Thermal problems in operating theatres stem from fact that there are different categories of staff present in the same room and that while their activities differ, and therefore their rate of heat make, they are all expected to wear the same clothing. Such differences – the extra gowns, aprons, and gloves of the scrubbed staff at the table – are in the wrong direction, as is the thermal effect of the operating lamp. The surgeon and his assistants are in the upright position and therefore produce about 10% more heat than the anaesthetist, who remains seated. One of the table staff, usually the surgeon, may be using his muscles more, either to perform some operation or to maintain an awkward posture. The operating lamp contributes radiant heat to the upper part of the bodies of those at the table. Extra gowns and aprons constitute extra thermal insulation and an increased barrier to vapour diffusion from the skin. Sweating becomes ineffective. Surgeons sweat profusely from the forehead under conditions that are not felt by anaesthetists. Anaesthetics have a passive, supervisory function for a large part of the time during an operation. They sit still for long periods.

The situation of the nurses is somewhat different. They stand, go in and out but must often be passive for long periods. They are not at the table. They tend to be too cold rather than too hot and should also have extra items of clothing under the gown. They can, like the anaesthetist, lose heat by sweating, if necessary, much more easily than the table staff can.

The situation in a delivery theatre is quite different from that of an operating theatre. Both patient and staff work physically hard, at times, and are passive, waiting, for long periods, but there are no systematic differences in thermal requirements. The main problems are the intermittent activity, the fact that both patient and staff may become very wet and may therefore lose too much heat, and the intermittently recurring crises that occur unpredictably in a delivery suite, so that staff may have to leave one patient, unclothed, exhausted, wet, and cold, untended for a considerable time while they cope with the next. Some form of supplementary radiant heat under patient's control, within reach of the delivery table, would solve all of these special problems. It is more important to ensure that a patient knows how to switch it on and off than to attempt to automate its use.

The patient in a dental surgery is usually normally clothed and has no abnormal heat loss from wet clothing or a large incision. The modern practice of reclining patients fully has had two adaptive thermal consequences: though still nervous in many cases, the patient tends to relax more and to produce rather less heat, and the dentist, by being able to work in a more natural posture, also produces less heat than formerly. Modern dental spotlights generate very little heat, and the beam needs not impinge on more than a negligible area of either patient or dentist. Provided that the dentist and assistant dress in very light clothing, normal room temperatures are now appropriate. A low noise level and a comfortably cool temperature, together with appropriately light clothing, are necessary for efficient dentistry.

It is more important in a hospital than in other categories of buildings to ensure that the personnel have the knowledge and the means to optimize their indoor climate. They should have access to simple instrumentation for measuring the parameters of the indoor climate, so that feedback learning can take place. Without feedback, learning is impossible. There should be instrumentation to show whether the installed systems for climatic control are working as designed, mounted where they can be seen and checked every day.

A large number of quite different demands are placed on clothing function in hospitals: low bacteriological dissemination, washability, durability, cost, appearance, convention, convenience, and status denotation. These must be seen as additional to the thermal function of clothing, and no one set of considerations should be paramount.

Floors in hospitals must be antistatic, electrically conducting, easy to clean, nonslip, and pleasant to walk or stand on. They should not emit air pollutants. Some of these requirements are difficult to reconcile It appears to be difficult to make plastic flooring soft to walk on, without polluting the air with the softening agents. Plastic floors are often made conducting by letting in metal grids, thus making them harder clean, and so on.

Footwear in hospitals should be chosen in conjunction with the floor to compensate for its shortcomings, e.g., to make electrical contact, to provide good friction, to cushion the feet on hard floors, etc. Almost any footwear is thermally satisfactory if floor temperatures are maintained between 20–26 °C.

Noise in hospitals is a major problem for the patients rather than for the staff. Patients who are trying to rest and sleep are more easily disturbed than if they were alert and actively engaged in some normal work activity. Pain and apprehension lowers the threshold for subjective tolerance of unwanted sounds. Many sounds in hospitals are intrinsically frightening and disturbing for patients, but this is not the case for the staff.

Hospital wards should have windows that fulfil the specified functions. It is perhaps more important than they provide a view out, however, limited than that they provide useful amounts of daylight. If their size must be limited, it is then better to have low sills than to place them near the ceiling to increase the daylight. It should be possible to open them (emergency fresh air, escape). They should have clear glass, not frosted glass. The thermal asymmetry introduced by a window (downdraft in winter or radiation gain or loss) may be a positive quality in a homogenous thermal environment, provided that it does not result in a direct feeling of draft.

Potable water should be provided in place when needed for drinking and personnel and patients washing, cooking, washing of foods or utensils, washing of food preparation premises, and personal service rooms. Drinking fountain surfaces must be constructed of materials impervious to water and not subject to oxidation.

The nozzle of the fountain must be located to prevent the return of water in the jet or bowl to the nozzle orifice. A guard over the nozzle prevents contact with the nozzle by the mount or nose of people using the drinking fountain.

Potable drinking water dispensers must be capable of being closed and equipped with a tap. Ice that comes in contact with drinking water must be made of potable water and maintained in a sanitary condition. Standing water in cooling towers and other air moving systems should be monitored for *Legionella bacteria*.

When hospitals are extremely well ventilated to reduce the risk of cross-infection and to remove odours, chemicals, and anaesthetic gases, the health risks due to radon, obviously, are not present in the hospital environment.

7. EMPLOYEE PROTECTION IN WORKPLACE

7.1. Principles of evaluating employee exposure

Evaluation can be defined as the decision-making process resulting in an opinion on the degree of health hazard posed by stresses in work places [13]. The risk estimation is a careful examination of what, in work, could cause harm to people, to have taken enough precautions or should do more to prevent harm. Risk is the probability, high or low, that somebody will be harmed by the hazard. To assess the risks in workplace, look for the hazards, decide who might be harmed and how, evaluate the hazards and decide whether the existing precautions are adequate, and record findings.

From the information developed in preparing a job description and the measurements made of the magnitude of the environmental factor, a daily 8-hour and peak exposure can be calculated and a decision can be made as to the degree of exposure of an individual or a group of individuals.

Anticipating and recognizing occupational health hazards involve knowledge and understanding of the several types of workplace or factors and the effects of these factors on the health of the worker. Control involves the reduction of stresses to values that the worker can tolerate without impairment of health or productivity. Measuring and quantitative analysis of stress are the essential ingredients, and instrumental in conserving the health and wellbeing of workers.

Assuming a hazard is anticipated effectively, it becomes recognized and its magnitude is determined. The hazard is then evaluated and, when the level of hazard is unacceptable, necessary control is implemented.

Anticipation depends on and extends the ability to recognize, coupled with a broad and current awareness of developments in the organization and its business, in scientific developments in the organization and its business, in scientific developments and new technologies, in regulatory areas bearing on the organization's activities, and in other activities that have an impact on the health of workers.

Recognition of possible factors affecting health and comfort is achieved by studying work processes to ascertain the:

- nature of the materials used;
- products and by-products involved;
- possible points of release or emission of hazardous agents;
- posture and movements of the operatives;
- hours and duration of rest periods at work;
- nature of protective equipment provided.

Anticipation of hazards can and does occur with existing facilities, and recognition of hazards can take place when the facility is in a planning stage. Whether it occurs in anticipation or recognition of hazards, the process commonly referred to as risk assessment is appropriate at this point because of the potential impact of health considerations on project, process, and product viability.

Evaluation of the degree of hazard is gauged by:

- measuring the intensity or concentration of the hazardous agent;
- comparing the results against known standards or researched toxicological data;
- ascertaining the human physiological effects upon workers from tests provided by medical sources, e.g. blood, urine analysis, lung function tests, nerve conduction velocities, etc.;
- forming a judgment as to the degree of hazard and the possible remedies to the workplace environmental conditions.

7.2. Prevention and control of hazards

It is required that all employees be provided with a safe and healthful place of employment. The key to avoiding injuries and illnesses is to prevent the individuals in the workplace from being overexposed to the kinetic energy or toxicity in the hazards. In order to prevent exposure, the first step is to educate the workforce. A good training programme includes education about the potential hazards; the safest procedures to follow for each manufacturing or maintenance operation; correct tool selection and use for each task; use and care of personal protective equipment, and procedures to follow in emergency situations, including fire and loss control, shut-down, rescue, and evacuation.

The human body can endure considerable discomfort and stress and can perform many awkward and unnatural movements for a limited period of time. However, when awkward conditions or motions are continued for prolonged period, they can exceed the worker's physiological limitations. To ensure a continued high level of performance, work systems must be tailored to human capacities and limitations.

According to the International Labour Office (ILO) ergonomics is defined as the application of the human biological science in conjunction with the engineering sciences to achieve the optimum mutual adjustment of man and his work, the benefits being measured in terms of human efficiency and well being.

Ergonomics attempts to fit the job to the worker instead of the traditional method of fitting the worker to the job. It is the study of human characteristics, both behavioural and biological, for the appropriate design of the living and working environment.

The modern concept is that man is to be considered the monitoring link of man-machine environment system. The components of a system can cover a wide range, including machines, tools, materials, environmental factors, people, operating instructions, training manuals or computer programmes, etc. Ergonomics principles are based on the physical and psychological capabilities of people to the design or modification of tasks, equipment, products, and workplaces.

The goals of ergonomics are:

1) to decrease risk of injuries and illnesses, especially those related to musculoskeletal system;
2) to improve worker performance;
3) to decrease worker discomfort;
4) to improve the quality of work life.

To accomplish these goals, the disciplines applied to solve ergonomic issues include psychologists, cognitive scientists, physiologists, biomechanists, applied physical anthropologists, occupational hygienists, safety specialists, occupational and systems engineers.

In many apparently routine and mundane working systems, there are elements of uncertainty. There are three main variables that contribute to the uncertainties of work for health professionals: physical dependence of a patient, medical constraints, and patient's behaviour. None of them are static and the behaviour, in particular, is often unpredictable. For this reason, every working system in a hospital or in community health care must be adaptable. Not only may the individual patient present problems of uncertainty, so may the medical or health care needs of a community.

An ergonomic intervention at workplace should be fast. It proves beneficial not only in terms of increased productivity, but also with respect to minimizing work related morbidity, job turnover, need for recruiting and training new workers.

The advice on ergonomics is one of the functions of an occupational health service. Wherever the prevalence and incidence rates are high or show signs of increasing, ergonomic investigation may be a necessity. This is abundantly true for back pain which is one of the most common sources of work related morbidity in health professionals. Recognition, therefore, depends on a comprehensive and reliable information system.

Relating the physical characteristics and capabilities of the worker to the design of equipment and to the layout of the workplace is important key ergonomic concept. When this is done, the result is an increase in efficiency, a decrease in human error, and a consequent reduction in accident frequency.

There are many major contributory factors than must be recognized concerning work situations. External factors are geographic location, community or sociological, type of industry, occupation (weight of equipment or tools, shape and size of material worked, machined, etc., type and location of machine, methods and processes, time of day, illumination, air temperature and humidity; temperature of walls, machines, materials; air velocity, type of clothing worn, time exposed to the tasks assigned, and atmospheric contaminants). Some of the important human factors are muscular activity, age, sex, size, health status of the man, individual physical working capacity, psychological adaptations, and management attitudes.

Work methods study is a systematic recording and critical examination of existing, as well as proposed ways of doing work. It is a means of developing and applying safe, easy, and effective solutions and reducing overall job costs.

Checklists provide an alternative approach to methods study. On the plus side, checklists are easy to use because they are a qualitative method that quickly evaluates job risk factors. On the negative side, checklists are not quantitative, and in some instances may not tell the evaluator what the real risk factors are.

In general, equipment and users can be defined easily. The systematic measurement of physical properties of the human body is the application of anthropometry. Anthropometric data consist of various heights, lengths, and breaths used to establish the minimum clearances and spatial accommodations, and the functional arm, leg, and body movements that are made by the worker during the performance of the task. In the majority of jobs, the demands of work can be defined in reasonably precise terms with regard to the physical and mental workload.

The aim of ergonomic assessment is to teach people how to modify their working environment to make it ergonomically more satisfactory and this is more comfortable for the workers as well as more efficient in operation. It could well be applied to the work of many different health professionals.

Techniques to assess risk factors associated with musculoskeletal injuries and illnesses are broadly classified as biomechanical, physiological, and psychophysical. Biomechanics means the mechanics of biological organisms. It deals with the functioning of the structural elements of the body and the effects of external and internal forces on the various parts of the body. Physiological techniques are useful for repetitive and whole body work, such as manual materials handling. Psychophysical techniques are suitable for repetitive as well as non-repetitive or infrequently performed tasks. These techniques are also inexpensive since little or no equipment is needed.

Ergonomics considers physiological and psychological stresses of the task. The process of design begins with a clear definition of the aims and purposes to be served. The process encompasses the design of the building itself, the equipment to be used, and all the furniture and fittings as well as taking account of the environmental factors. It must include the design of every working procedure together with the selection and training of the operators. In hospitals and in the community where patients are cared for, their needs should dominate the aims and purposes to be served. The starting point for the design models is set by the requirements of the user, i.e., the patient in a hospital or the disabled person in the community. It would be wrong, however, to focus solely on user requirements. For example, in an otherwise valuable study of the design requirements for seating elderly and disabled people, there was little written about associated ergonomic problems for nurses or care assistants: although mention was made of access to the seated person, there was no analysis of the effect of chair design on the techniques of transferring dependent patients to and from chairs. Ideally, a care plan is drawn up for a patient, taking into account every medical and nursing consideration for the initial programme of therapeutic management and rehabilitation. The question of patient handling is central to this care plan. As the patient makes progress, the need for patient handling by the nursing staff recedes and their physical burdens are reduced. The care plan provides a framework in which ergonomic problems can be foreseen and action can be taken. Ergonomics is essential to the education of an occupational therapist. It should become so for all administrators and planners in the health services, including community health.

Principles of the hazard control in the work environment are divided into three basic categories.

First, engineering controls that engineer out the hazard, either by initial design specifications or by applying methods:

- substitution of a less harmful material for one that is dangerous to health. The risk of injury or illness may be reduced by the replacement of an existing process, material, or equipment with a similar item having more limited hazard potential. Some examples include brush painting instead of spray painting to reduce inhalation hazards, welding instead of riveting to reduce noise levels;
- change or alteration of a process to minimize worker contact;
- isolation or enclosure of a process or work operation to reduce the number of persons exposed. Hazards are controlled whenever an appropriate barrier or limit is placed between the hazard and an individual who may be affected by the hazard. This isolation can be in the form of physical barrier, time separation, removing, or distance. Examples include motor guards, electrical insulation, glove boxes, ventilation of polluted air, and remote controlled equipment.
- wet methods to reduce generation of dust in such operations as mining and quarrying;
- local exhaust at the point of generation of contaminants;
- general ventilation with clean air to provide a safe atmosphere.

Engineering controls should be used as the first line of protection against workplace hazards wherever feasible.

Second, personal protective equipment the employees wear to protect themselves from their environment. This method of hazard control is least preferred because personal protective devices may reduce a worker's productivity, while affording less effective protection against the recognized hazard than other methods of control. Nevertheless, there are instances where adequate levels of risk reduction cannot be achieved through other methods, and personal protective devices must be used, either alone or in conjunction with other protective measures.

Personal protective equipment includes anything from gloves to full body suits with self-contained breathing apparatus, and can be used in conjunction with engineering and administrative controls.

Third, administrative controls are the final strategy for hazard controls. These controls are implemented when exposures cannot be controlled to acceptable levels with substitution, engineering controls, or personal protective equipment. Administrative measures can be instituted to either rotate a worker through different jobs to prevent repetitive motion injuries, or to remove workers from hazard exposure once a predetermined exposure level is reached.

Measures to reduce employee exposures:

- scheduling reduced work times in contaminant areas (or during cooler times of the day for heat stress exposure, for example);
- employee training that includes hazard recognition and specific work practices;
- special control methods for specific hazards, such as film badges and similar monitoring devices, continuous sampling with preset alarms and medical programmes to detect intake of toxic materials;
- medical controls;
- good housekeeping, including cleanliness of the work place, waste disposal, adequate washing, toilet and eating facilities, healthy drinking water and control of insects and rodents.

7.3. Inspection of the working object

The best way to determine what hazards are present in a specific workplace is to go to the site and walk through the manufacturing or service process [7]. An additional point that will become obvious is that there are some significant measurement issues that need to be addressed by an appropriate health professional.

Successful improvement of a workplace requires collaboration between designers, occupational health personnel and workers [13]. Superficial application of rules of thumb by designers or control activities of occupational health professionals fall short of the goal to design safe, healthy and productive workplaces and tasks.

The basis of workplace analysis is a systematic and careful description of the task or workplace. Observations and interviews are used to provide the necessary information. In a few cases measuring devices are needed. Before allowing entry into a permit space, the employer must, pursuant to the permit space entry programme: identify and evaluate the hazards of the space; develop and implement appropriate entry, monitoring, and rescue procedures; train and equip affected employees; and inform contactors of the hazards identified and any procedures developed for dealing with them.

In a workplace the analysis proceeds according to the following three steps:

1) the analyst defines and outlines the task to be analysed. The analysis may concern a work task or a work site;
2) the task is described. For this purpose, the analyst makes a list of operations and draws a sketch of the workplace;
3) with a clear picture in mind, the analyst can proceed with the ergonomic analysis item by item using the guidelines.

The analyst rates the various factors on a scale, usually from 1 to 5. The primary basis for rating is the deviation of work conditions and work arrangements from the optimum level or generally accepted recommendations. A rating of 4 to 5 indicates that the work condition or environment could even be harmful to a worker's health. Special attention should be then given to the work environment or work condition in question.

The ratings are gathered on the evaluation form, and together they comprise the overall evaluation of the work task in question. In the evaluation the analyst can list suggestions for improvement based on the results of the analysis.

The analyst interviews the worker and marks his/her subjective assessment as good (++), fair (+), poor (-), or very poor (- -). If the worker's assessment and the analyst's rating differ considerably, the work situation must be further analyzed.

There is given a sample rating and a worker's subjective assessment of the workplace which can be used as a guide showing how the observations and measurements are used to reach a rating and evaluation of the particular work task.

Work space. For the analysis, work site refers to the immediate, physical surroundings of the worker. The evaluation considers the equipment, furniture and other work aids and their arrangement and dimensions. The effect of these factors on the work load is important, especially when the work is stationary and done in either a sitting or standing position.

A confined space means a space that is large enough and so configured that an individual can make a full body entry and perform assigned work, has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits), and is not designed for continuous employee occupancy. A confined space is a space with one or more of the following characteristics: contains or has a potential to contain a hazardous atmosphere, contains material that may engulf an entrant, has an internal configuration likely to trap or asphyxiated an entrant, or contains any other recognized serious safety or health hazard (e.g., extreme temperatures).

A confined space is an enclosed space that has limited openings for entry and exit, poor ventilation, and is not designed for continuous worker occupancy. A confined-space atmosphere can become extremely hazardous due to the lack of air movements. These hazardous atmospheres are classified as oxygen deficient/enriched, flammable/explosive, and/or toxic. The oxygen level in a confined space can decrease because of work such as welding, cutting, or brazing; or, it can decrease by certain chemical reactions or through bacterial action. The oxygen level also decreases if oxygen is displaced by another gas, such as carbon dioxide or nitrogen. This is known as an oxygen deficient atmosphere. An acceptable limit of oxygen is between 19.5% and 23.5%.

Another atmospheric hazard is an oxygen-enriched atmosphere. This occurs when the oxygen level exceeds 23% by volume. This condition represents a serious fire hazard. Flammable atmospheres are the product of gas, vapour, or dust in the proper mixture. Different gases have different flammable ranges.

Toxic atmospheres in a confined space can be the product of chemical products stored in the area, the work being performed in a confined space, and/or areas adjacent to the confined space. The two most common gases found in confined spaces are hydrogen sulphide (H_2S) and carbon monoxide (CO).

Hydrogen sulphide is a toxic, colourless, combustible gas that is heavier than air. It is formed by the decomposition of organic plant and animal life by bacteria. Hydrogen sulphide poisons a person by building up in the bloodstream. This toxic gas paralyzes the nerve centres in the brain which control breathing. Hydrogen sulphide can be found in oil and gas refining and production, sewers, pulp mills, and a variety of industrial processes. Hydrogen sulphide is easily detected by a strong rotten egg odour in low concentration.

Carbon monoxide is a toxic, colourless, odourless, combustible gas that is slightly lighter than air. A by-product of combustion, it can be found in almost every industry. Carbon monoxide enters our bloodstream through lungs. CO has extreme affinity for hemoglobin in our bloodstream at about 200–300 times that of oxygen. As a result, carbon monoxide quickly replaces oxygen in our bloodstream and causes asphyxiation.

General physical activity. It is determined according to the extent that the work, the work methods and the equipment require a particular physical activity. These requirements can be optimal, but may also be too great or too little. The quality is determined by whether the worker is able to regulate the work load or whether it is regulated by the production method or the situation in which the work is done.

Lifting. Stress caused by lifting is assessed from the weight of the load, the horizontal distance between the load and the body, and the lifting height.

Weight lifting capabilities depend on many factors: age, set, body build, health, one or two hands, team work, of load, shape of load, height lifted, distance carried, time carried, and frequency of lifting, The left hand and arm are generally 10%

weaker than the right hand and arm. Two hands carry twice the weights as one hand. Team work is not proportional to the number of members: 2 are 95% efficient, 3 are 85% efficient and 8 are 50% efficient.

Male strength increases during the first 20 years, holds for 5 or 10, gradually declines through the rest of the life. Maximum strength on an average occurs at 15–25 years, 5–10% less at the age 40, 15% less at 50, 20% less at 60, and 25% less at 65. Older persons do not grow weaker uniformly: hands are 16% less, and arms and legs are 50% less strong at the age 60. Back strength of older persons becomes relatively weaker, but physical exercise can delay the decrease.

Females reach their peak strength at 30. Women are generally 30–35% weaker than men. Females should not be required to lift heavy weights above their shoulder heights. To minimize strain, reduce maximum strength 33.3%. If force must be sustained without discomfort, reduce maximum strength 50%. If force is used frequently, reduce maximum strength 66.6%. Strength is also affected by altitude: 15% loss at 3 km, 40% loss at 8 km.

Many values are available for lifting weights: some are maximum values some are safe, some are based on static lifting (standing in one position) and some on dynamic lifting (carrying loads for a distance). The average strength value is a poor choice as 50% of people concerned would be unable to meet the strength requirements. Designing for adults would include the weakest woman.

Work postures and movements. Work postures refer to the position of the neck, arms, back, hips and legs during work. Work movements are the body movements required by the work.

Accident risk. Accident risk refers to the possibility of sudden injury and the risk of sudden poisoning caused by occupational exposure of not more than one day. It is determined by assessing the possibility of an accident occur and its severity. Accident risk is classified as small, considerable, great, and very great. Slips and falls can occur on a wet surface, causing injury or death to employees. Also, a wet surface increases the likelihood and effect of electric shock in areas where electrical circuits, equipment, and tools are used.

Job content. Job content is determined by the number and quality of the individual tasks included in the work.

Job restrictiveness. In restricted work the performance conditions limit the worker's freedom to move and the freedom to choose when and how the work is to be done. The worker can be restricted, for example, by the way a conveyer is used or by the need for continuity required by the process. He can also be restricted by the fact that within the particular work phase other workers determine the time of execution or the work tempo.

Worker communication. Worker communication and personal contacts refer to the worker's opportunities for communicating with superiors or fellow workers.

Decision making. Difficulty in making decisions is influenced by the adequacy of available information and the risk involved in the decision. The connection between the worker's available guiding information and his action may be simple and clear as when information received is comprised of only one indicator. For example, the lighting of a signal is information which leads to the decision to stop a machine. The connection can also be complicated, and the decision can require the formation of an activity model and the comparison of alternative actions.

Repetitiveness of the work. It is determined by the average length of a repeated work cycle and is measured from the start to the end of the cycle. Repetitiveness can be evaluated only for those jobs in which a task is repeated more or less in the same manner continually. This kind of work is found in advanced serial production or, for example, in packing tasks.

Attentiveness. Attentiveness comprises all the attention and observation that a worker must give to his work, instruments, machines, displays, controls, process, etc. The demand for attention is evaluated from the relation between the length of the observation and the degree of the attention needed.

Lighting. The lighting conditions of a workplace are evaluated according to the type of work. For tasks that require normal visual accuracy, the illumination is measured and the degree of glare is assessed by observation. For tasks that require high visual accuracy, the differences in luminance are measured if possible.

Thermal environment. Temperature extremes heat or cold could create health hazards and affect the amount of work that people can do and the manner in which they do it. Thermal factors are assessed for all indoor workplaces. In work with thermal radiation or in prolonged work in temperature which continually exceeds 28 °C. The heat strain and hazard caused by the thermal conditions depend on the combined effect of the microclimate (air temperature, air humidity, air velocity, heating radiation), the work load and the clothing use. Humidity makes a cold room feel colder and a hot room feel hotter.

Noise. The noise rating is assessed according to the type of work done. A risk for hearing damage is present if the noise level is greater than 80 dB(A). The hearing protectors is then used. Excessive noise can damage hearing, and can also affect communication between the authorized entrants and the worker. In work requiring verbal communication, people need to be able to speak to each other to manage or execute the work. In work requiring concentration, the worker must reason, make decisions, applied his memory and concentrate. Approximate value of noise intensity are given in *Table VI-4*.

Forced-air ventilation may also be used to maintain the 19.5% oxygen requirement. To eliminate workplace air pollution, there must be a good source of fresh air as well as sufficient air movement. Blowers (fresh air supply) are necessary if the confined space or a portion of the confined space to be occupied is not naturally ventilated. The focus is on whether the workplace has a ventilation system; whether the system is continuous or it goes on and off during the working day. Check of air flow during the working day. Are the vents supplying or removing air? In each space there should always be a supply and an exhaust vent. One must determine which vents bring air in and which remove it by holding a tissue at the face of the vent. Are the vents for supply and exhaust right next to each other? When supply and exhaust vents are too close, the clean, fresh air gets sucked out of the space before it has adequately circulated. This is called short-circuiting. It is a result of poor engineering design. Does it have a control over the ventilation system? It may be able to turn the blower or fan supplying the air up and down. Is there a smoke detector in the workplace ventilation system? There should be one. It is essential for early signalizing of a fire. The detector should be located in the duct taking the air out of the space.

Table VI-4. Intensity of various noise sources and sites

Intensity, dB(A)	Source or site
130	Jet plane
110	Rock drilling machines
100	Heavy metal workshop
85	Offset press, lathe
75	Typing, truck cabin
65	Conversation in offices
55	Control room
35	Queit small office
30	Library
20	Sound isolated room
0	Hearing threshold

Based on the hazard evaluation, a qualified person shall consider for the following:

1) gloves to protect against sharp edges, abrasion, punctures, chemicals, heat, cold, electricity;
2) hard hat to protect against falling objects and structural configurations within the space, i.e. low ceilings or passageways;
3) eye and face protection to protect against irritation dusts, vapours, mists, abrasive particles, and flying objects;
4) hearing protection to protect against excessive noise within the space. Be sure that alarms are audible and communication with the qualified person is possible while using the hearing protection;
5) clothing to protect against temperature extremes, moisture, chemicals, vapours, and toxic materials.

Personal protective equipment does not eliminate the hazard. It provides protection from the hazard. To be effective, it must fit properly and be used in the manner for which it is designed.

8. TASKS FOR STUDENTS

Seminar: "Working environment"

1. Occupational medicine. Occupational health. Occupational hygiene.
2. Hazard and harm at work. Classification. Anticipation, recognition, evaluation, control.
3. Physical hazards. Engineering and administrative controls.
4. Thermal stresses. Human heat exchange.
5. Barometric stresses. Prevention measures.
6. Noise. Prevention measures.
7. Ultra and infrasound. Prevention measures.
8. Vibration. Prevention measures.
9. Ionizing radiation. Prevention measures.
10. Non-ionizing radiation. Prevention measures.
11. Chemical hazards. Effect, evaluation, and protection.
12. Biological hazards. Affection and prevention.
13. Ergonomics.
14. Psychosocial and organizational hazards. Physical and psychological effects. Control.
15. Chemical hazards in medicine environment.
16. Microbes and other biological hazards in medicine environment.
17. Physical hazards in medicine environment.
18. Ergonomic hazards in medicine environment.
19. Psychosocial and organizational problems in health care occupations.
20. Other different problems in medical offices.

Answer the questions, for instance:

1. What is a hazardous situation?
2. What temperature can many occupational clothing environments result in?
3. What are physical pathways of human body to exchange heat with his environment?
4. On what does the degree of the health hazard depend to human?
5. At what internal body temperature does death of heat strain occur?
6. Due to what can improperly used heaters be dangerous?
7. What are the main sources of thermal stress in occupational environment?
8. What is relative humidity of the working environment when the sweat evaporation is at its most?
9. Into how many basic categories are control methods divided for health hazards in work environment?
10. With what internal body temperature of or below would workers be expected to die?
11. What heat loss of worker's body can be hampered mostly in industry of South Asia?

12. How are barometric stresses classified in work environment?
13. What is the smallest pressure change detectable by a worker's ear?
14. Which weighted sound level is used for the regulation of occupational noise exposure?
15. What daily exposure over number of years can cause white finger syndrome?
16. What is the level of the ear pain threshold?
17. What do the adverse effects of air-borne ultrasound and infrasound include?
18. What speed has electromagnetic radiation got?
19. How are different wave bands of UV spectrum divided?
20. What medical uses does UV radiation include?
21. What occupations are associated with UV exposure include especially?
22. What UV leakage is determined for poorly fitting eyewear?
23. What is laser radiation?
24. What radiation produces glass blower's cataract?
25. Into how many groups is health effects of ionizing radiation divided?
26. What concept do ionizing radiation protection principles cover?
27. How many categories of TLV are specified for air-borne concentrations of chemical components?
28. Are or are not contact lenses perfect personal protective equipment in eye chemical hazard areas?
29. What size of dusts can cause inhalation problems?
30. What are the main pathways to prevent from biological occupational hazards?
31. What does ergonomics attempt to fit?
32. What are the important goals of ergonomics?
33. Is exposure to occupational psychosocial and organizational hazards rather chronic or acute?
34. How are psychosocial and organizational hazards grouped?

Inspect working object using Model for inspection checklist-evaluation form:

1. Name of the object. Geographical situation in the inhabited place.
2. Process of technology used in entity.
3. Condition of floor, walls, ceilings, tools, equipment, machinery (colour, smooth, clean).
4. Microclimate (temperature, relative humidity, air motion, radiant heat) in the different workshops and workplaces.
5. Dust (concentration, cause for).
6. Gases, vapours, fumes, smoke, aerosols (concentration, cause for).
7. Noise (intensity, frequency, sources).
8. Vibration (whole-body, hand-arm, source, intensity).
9. Lighting (intensity, contrast, blaze) in different places.
10. Supply and quality of drinking water.

11. Preventive measures (supply ventilation, isolation, personal protective equipment, administrative).
12. Accidents, spread and risk (possibility of occurrence, severity).
13. Duties of a doctor of occupational medicine.
14. Recommendations how to improve working conditions.

Inspect department of hospital using Model for inspection checklist-evaluation form:

1. Name of the hospital. Address.
2. Characteristic of the concrete department:
   - ✓ the profile;
   - ✓ what floor it is situated;
   - ✓ the age of the building;
   - ✓ design.
3. Characteristic of the microclimate:
   - ✓ temperature of air;
   - ✓ humidity of air;
   - ✓ air motion;
   - ✓ characteristic of air exchange;
   - ✓ type of ventilation.
4. Objective characteristic of microclimate produced from thermal condition of patients (colour of skin, availability of perspiration on forehead, palpable overheating or cooling of skin).
5. Natural lighting:
   - ✓ orientation of windows;
   - ✓ cleanliness of windows;
   - ✓ colour of walls, floor, and furniture.
6. Artificial lighting:
   - ✓ universal: bulb or fluorescent bulb;
   - ✓ local and night-rest lighting;
   - ✓ patient's opinion about lighting.
7. Signalization from wards.
8. Daily regimen.
9. Sanitary conditions.
10. Facilities for personnel and patients (eating, washing, rest, etc.).
11. Patient's subjective opinion about:
    - ✓ microclimate;
    - ✓ treatment;
    - ✓ care.
12. Risks of occupational hazards of personnel.
13 Recommendations how to improve treatment and working conditions.

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APPENDICES 1–12. Tables of food composition

Appendix 1. Table of food composition: Weights and measures. Abbreviations and symbols*

WEIGHTS AND MEASURES

Weights
1 microgram = 1/1 000 000 gram
1000 micrograms = 1 milligram
1 milligram = 1/1000 gram
1000 milligrams = 1 gram
1.00 ounce = 28.35 grams
3.57 ounces = 100.00 grams
0.25 pound = 113.00 grams
0.50 pound = 227.00 grams
1.00 pound = 16.00 ounces
1.00 pound = 453.00 grams

Capacity measurements
1 quart = 4 cups
1 pint = 2 cups
1 cup = ½ pint
1 cup = 8 fluid ounces
1 cup = 16 tablespoons
2 tablespoons = 1 fluid ounce
1 tablespoon = ½ fluid ounce
1 tablespoon = 3 teaspoons

Approximate equivalents
1 average serving = about 4 ounces
1 ounce fluid = about 28 grams
1 cup fluid
cooking oil = 200 grams
water = 220 grams
milk, soups = 240 grams
syrup, honey = 325 grams
1 cup dry foods
cereal flakes = 50 grams
fluor = 100 grams
sugar = 200 grams
1 tablespoon fluid
cooking oil = 14 grams
milk, water = 15 grams
syrup, honey = 20 grams
1 tablespoon dry foods = 1/6 ounce
flour = 8 grams
sugar = 12 grams
1 pat butter = ½ tablespoon
1 teaspoon fluid = about 5 grams
1 grain = about 65 milligrams
1 minim = about 1 drop of water

ABBREVIATIONS AND SYMBOLS USED IN THE TABLES

avg – average
cal – calorie
C – cup
ckd – cooked
diam – diameter
enr – enriched
g – gram
IU – International Unit
lb – pound
lge – large
mcg – microgram
med – medium
mg – milligram
oz – ounce
reg – regular
sm – small
sg – square
svg – serving
t – trace
T – tablespoon
tsp – teaspoon
unsw – unsweetened
w – with
w/o – without
whl grd – whole ground
– reliable data lacking
/ – of, with, per
" – inches

* Nutrition almanac / Nutrition search, Inc., John D. Kirschmann, Lavon J. Dunne. – 3rd ed. – 1990. – Pp. 267–307.

Appendix 2. Table of food composition: Beverages

Variables	Measure	Alcoholic		Common				
		Beer	Wine, dessert	Coffee	Cola drink	Fruit-flavoured drink	Diet drink	Tea
Measure		12 oz	3.5 oz	6 oz	12 oz	12 oz	12 oz	8 oz
Weight	g	360	103	180	369	372	355	240
Calories		148	153	3	159	179	0	0
Protein	g	0.94	0.09	–	0	0	0	–
Carbohydrate	g	13.2	11.4	0.54	40	45.8	0.43	0.06
Fiber	g	–	–	–	0	0	0	–
VITAMINS								
Vitamin A	IU	–	–	0	0	0	0	–
Vitamin B_1	mg	0	0.02	0	0	0	0	0
Vitamin B_2	mg	0.07	0.02	0.02	0	0	0	–
Vitamin B_6	mg	0.18	0.05	–	0	0	0	–
Vitamin B_{12}	mcg	–	–	–	–	–	–	–
Vitamin C	mg	0	0	0	0	0	0	–
Vitamin E	IU	–	–	–	–	–	–	–
MINERALS								
Calcium	mg	14	9	13	11	15	14	5
Copper	mg	0.292	0.06	0.007	0.103	0.074	0.057	0.026
Iron	mg	0.11	1.61	0.02	0.18	0.26	0.46	0.1
Magnesium	mg	36	4	13	4	4	4	5
Manganese	mg	0.032	0.102	0.022	–	–	–	1.19
Phosphorus	mg	50	–	4	62	13	15	10
Potassium	mg	115	102	117	7	37	6	58
Selenium	mcg	0.47	–	–	–	–	–	0.1
Sodium	mg	18	7	2	20	52	76	19
Zinc	mg	0.18	0.06	0.05	0.15	0.26	0.78	0.07
LIPIDS								
Total lipid (fat)	g	0	0	0.01	0	0	0	0.01
Total saturated	g	–	–	–	–	–	–	–
Total unsaturated	g	–	–	–	–	–	–	–

Appendix 3. Table of food composition: Bakery and grains

Variables	Measure	Breads				Cereals		
		Cracked wheat, enr	Rye	Wheat	Zwieback	Corn flakes, Kellogg's	Oat flakes, fortified	Rice, puffed
Measure		1 slice	1 slice		1	1 ¼ C	1 C	1 C
Weight	g	23	23	100	7	28	48	14
Calories		60	56	255	31	110	177	56
Protein	g	2	2.1	9.55	0.9	2.3	5.3	0.9
Carbohydrate	g	12	12	47	5.4	24.4	20.5	12.6
Fiber	g	0.1	0.1	0.64	0.02	0.3	1.2	0.1
VITAMINS								
Vitamin A	IU	t	–	t	3	1250	2116	–
Vitamin B_1	mg	0.03	0.04	0.46	0.004	0.4	0.6	0.02
Vitamin B_2	mg	0.02	0.02	0.32	0.005	0.4	0.7	0.01
Vitamin B_6	mg	0.02	0.02	0.109	–	0.5	0.9	0.011
Vitamin B_{12}	mcg	0	0	0	–	–	2.5	–
Vitamin C	mg	t	–	t	–	15	–	–
Vitamin E	IU	–	–	–	–	–	–	–
MINERALS								
Calcium	mg	20	17	126	0.95	1	68	1
Copper	mg	–	0.06	0.24	–	0.019	0.255	0.024
Iron	mg	0.3	0.4	3.49	0.04	1.8	13.7	0.15
Magnesium	mg	8	10	46	–	3	58	3
Manganese	mg	–	0.3	–	–	0.023	–	0.21
Phosphorus	mg	29	34	184	5.04	18	176	14
Potassium	mg	31	33	138	11	26	343	16
Selenium	mcg	–	–	–	–	–	–	–
Sodium	mg	122	128	539	18.2	351	429	0
Zinc	mg	–	0.4	1.05	–	0.08	1.5	0.14
LIPIDS								
Total lipid (fat)	g	0.6	0.3	4.1	0.6	0.1	0.4	0.1
Total saturated	g	0.1	–	–	0.2	–	–	–
Total unsaturated	g	0.4	–	–	0.4	–	–	–

(cont. on p. 214)

Appendix 3 (continued). Table of food composition: Bakery and grains

Variables	Measure	Desserts and sweets					Grains		
		Chocolate, baking	Honey	Jams	Pie, apple, 9"	Sugar, cane	Macaroni, enr, ckd	Popcorn	Spaghetti, enr, ckd
Measure		1 oz	1 T	1 T	1/6	1 T	1 C	1 C	1 C
Weight	g	28	21	20	160	12	140	14	140
Calories		143	64	54	410	46	151	54	155
Protein	g	3	0.1	0.1	3.4	0	4.8	1.8	4.8
Carbohydrate	g	8.2	17.8	14	61	11.9	32.2	10.7	32.2
Fiber	g	0.7	0	0.1	0.6	0	0.1	0.3	0.2
VITAMINS									
Vitamin A	IU	20	0	t	48	0	0	–	0
Vitamin B_1	mg	0.01	0.002	t	0.03	0	0.2	0.055	0.2
Vitamin B_2	mg	0.07	0.014	0.01	0.03	0	0.11	0.02	0.11
Vitamin B_6	mg	–	0.004	0.005	–	–	0.029	0.03	–
Vitamin B_{12}	mcg	–	0	0	0	–	0	0	0
Vitamin C	mg	0	t	0	2	0	0	0	0
Vitamin E	IU	3.12	–	–	0.32	–	–	–	–
MINERALS									
Calcium	mg	22	1	4	1	0	11	2	11
Copper	mg	0.748	0.008	0.062	0.096	0.002	0.028	0.04	–
Iron	mg	1.9	0.1	0.2	0.5	t	1.2	0.4	1.3
Magnesium	mg	81.8	0.6	1	–	–	25	–	27
Manganese	mg	–	0.006	–	–	–	–	–	–
Phosphorus	mg	109	1	2	35	0	70	39	70
Potassium	mg	235	11	18	128	t	85	33.6	85
Selenium	mcg	–	–	–	–	–	–	–	–
Sodium	mg	1	1	2	482	t	1	t	1
Zinc	mg	–	0.016	0.006	0.143	0.006	0.7	0.574	–
LIPIDS									
Total lipid (fat)	g	15	0	t	17.8	0	1	0.7	0.6
Total saturated	g	8	–	–	4.74	–	–	t	–
Total unsaturated	g	6	–	–	11.8	–	–	0.6	–

Appendix 4. Table of food composition: Dairy products

Variables	Measure	Cheese					Cream	
		Bleu	Camembert	Cheddar	Cottage, dry	Swiss	Coffee	Whipped, light
Measure		1 oz	1 oz	1 oz	1 C	1 oz	1 T	1 C
Weight	g	28	28	28	145	28	15	239
Calories		100	85	114	123	107	29	699
Protein	g	6.07	5.61	7.06	25	8.06	0.4	5.19
Carbohydrate	g	0.66	0.13	0.36	2.68	0.96	0.55	7.07
Fiber	g	0	0	0	0	0	0	0
VITAMINS								
Vitamin A	IU	204	262	300	44	240	108	2694
Vitamin B_1	mg	0.008	0.008	0.008	0.036	0.006	0.005	0.057
Vitamin B_2	mg	0.108	0.138	0.106	0.206	0.103	0.022	0.299
Vitamin B_6	mg	0.047	0.064	0.021	0.119	0.024	0.005	0.067
Vitamin B_{12}	mcg	0.345	0.367	0.234	1.19	0.475	0.033	0.466
Vitamin C	mg	0	0	0	0	0	0.11	1.46
Vitamin E	IU	–	–	–	–	0.098	–	1.4
MINERALS								
Calcium	mg	150	110	204	46	272	14	166
Copper	mg	0.011	0.022	0.031	–	0.036	0.033	–
Iron	mg	0.09	0.09	0.19	0.33	0.05	0.01	0.07
Magnesium	mg	7	6	8	6	10	1	17
Manganese	mg	0.003	0.011	0.003	–	0.005	–	–
Phosphorus	mg	110	98	145	151	171	12	146
Potassium	mg	73	53	28	47	31	18	231
Selenium	mcg	–	–	–	–	2.83	0.075	–
Sodium	mg	396	239	176	19	74	6	82
Zinc	mg	0.75	0.68	0.88	0.68	1.11	0.04	0.6
LIPIDS								
Total lipid (fat)	g	8.15	6.88	9.4	0.61	7.78	2.9	73.8
Total saturated	g	5.3	4.33	5.98	0.396	5.04	1.8	46.2
Total unsaturated	g	2.44	2.19	2.93	0.182	2.34	0.95	23.8

Appendix 5. Table of food composition: Dairy products and eggs

Variables	Measure	Cream		Milk		Yogurt			Eggs
		Whipped, heavy	Sour cream	Whole	Condensed sweetened	Plain	Plain, lowfat	Fruit, lowfat	Whole
Measure		1 C	1 C	1 C	1 C	1 C	1 C	1 C	1 lge
Weight	g	238	230	244	306	227	227	227	50
Calories		821	493	150	982	139	144	225	79
Protein	g	4.88	7.27	8.03	24.2	7.88	11.9	9.04	6.07
Carbohydrate	g	6.64	9.82	11.37	166	10.5	16	42.3	0.6
Fiber	g	0	0	0	0	0	0	0.27	0
VITAMINS									
Vitamin A	IU	3499	1817	307	1004	279	150	111	260
Vitamin B_1	mg	0.052	0.081	0.093	0.275	0.066	0.1	0.077	0.044
Vitamin B_2	mg	0.262	0.343	0.395	1.27	0.322	0.486	0.368	0.15
Vitamin B_6	mg	0.062	0.037	0.102	0.156	0.073	0.111	0.084	0.06
Vitamin B_{12}	mcg	0.428	0.69	0.871	1.36	0.844	1.27	0.967	0.773
Vitamin C	mg	1.38	1.98	2.29	7.96	1.2	1.82	1.36	0
Vitamin E	IU	3	–	0.293	–	–	–	–	0.57
MINERALS									
Calcium	mg	154	268	291	868	274	415	314	28
Copper	mg	–	–	0.5	0.66	–	–	–	0.1
Iron	mg	0.07	0.14	0.12	0.58	0.11	0.18	0.14	1.04
Magnesium	mg	17	26	33	78	26	40	30	6
Manganese	mg	–	–	0.005	–	–	–	–	0.029
Phosphorus	mg	149	195	228	775	215	326	247	90
Potassium	mg	179	331	370	1136	351	531	402	65
Selenium	mcg	–	–	3.17	–	–	–	–	3.2
Sodium	mg	89	123	120	389	105	159	121	69
Zinc	mg	0.55	0.62	0.93	2.88	1.34	2.02	1.52	0.72
LIPIDS									
Total lipid (fat)	g	88	48.2	8.15	26.6	7.38	3.52	2.61	5.58
Total saturated	g	54.8	30	5.07	16.8	4.76	2.27	1.68	1.67
Total unsaturated	g	28.7	15.7	2.65	8.46	2.24	1.07	0.79	2.95

Appendix 6. Table of food composition: Fats and oils

Variables	Measure	Fats			Oils			
		Beef tallow	Butter	Margarine	Corn	Olive	Soybean	Sunflower
Measure		1 T	1 T	1 T	1 T	1 T	1 T	1 T
Weight	g	12.8	14.1	14.1	13.6	13.5	13.6	13.6
Calories		115	101	101	120	119	120	120
Protein	g	0	0.12	0	0	0	0	0
Carbohydrate	g	0	0.008	0	0	0	0	0
Fiber	g	0	0	0	0	0	0	0
VITAMINS								
Vitamin A	IU	–	433	465	–	–	–	–
Vitamin B_1	mg	–	t	0	–	–	–	–
Vitamin B_2	mg	–	0.004	0.006	–	–	–	–
Vitamin B_6	mg	–	t	0	–	–	–	–
Vitamin B_{12}	mcg	–	–	0.012	–	–	–	–
Vitamin C	mg	–	0	0.024	–	–	–	–
Vitamin E	IU	0.3	0.223	1.25	11.3	1.7	12.7	1.3
MINERALS								
Calcium	mg	–	3.37	4.23	–	0.02	0.01	0.03
Copper	mg	–	0.004	0.006	–	0.01	0.056	–
Iron	mg	–	0.022	–	–	0.05	0	0
Magnesium	mg	–	0.25	0.36	–	0	0	0.03
Manganese	mg	–	0.006	–	–	–	–	–
Phosphorus	mg	–	3.25	3.24	–	0.16	0.03	–
Potassium	mg	0	3.62	5.97	–	–	–	–
Selenium	mcg	–	–	–	–	–	–	–
Sodium	mg	0	117	133	–	0	0	0.01
Zinc	mg	–	0.007	–	–	0.01	0	–
LIPIDS								
Total lipid (fat)	g	12.8	11.5	11.4	13.6	13.5	13.6	13.6
Total saturated	g	6.4	7.15	1.8	1.7	1.8	2	1.4
Total unsaturated	g	5.8	3.74	9	11.3	11	11	11.7

Appendix 7. Table of food composition: Fruits and juices

Variables	Measure	Apple	Apple juice	Apricot	Apricot, dried	Avocado	Banana	Blackberries	Cherries
Measure		1	1 C	3	10 halves	1	1	1 C	1 C
Weight	g	150*	248	114*	35	272*	175*	144	145
Calories		81	116	51	83	324	105	74	104
Protein	g	0.27	0.15	1.48	1.28	3.99	1.18	1.04	1.74
Carbohydrate	g	21	29	11.7	21.6	14.8	26.7	18.3	24
Fiber	g	1.06	0.52	0.64	1.03	4.24	0.57	5.9	0.58
VITAMINS									
Vitamin A	IU	74	2	2769	2534	1230	92	237	310
Vitamin B_1	mg	0.023	0.052	0.032	0.003	0.217	0.051	0.043	0.073
Vitamin B_2	mg	0.019	0.042	0.042	0.053	0.245	0.114	0.058	0.087
Vitamin B_6	mg	0.066	0.074	0.057	0.055	0.563	0.659	0.084	0.052
Vitamin B_{12}	mcg	0	0	0	0	0	0	0	0
Vitamin C	mg	7.8	2.3	10.6	0.8	15.9	10.3	30.2	10.2
Vitamin E	IU	1	–	–	–	–	0.6	–	–
MINERALS									
Calcium	mg	10	16	15	16	22	7	46	21
Copper	mg	0.057	0.055	0.094	0.15	0.527	0.119	0.202	0.138
Iron	mg	0.25	0.92	0.58	1.65	2.05	0.35	0.83	0.56
Magnesium	mg	6	8	8	16	79	33	29	16
Manganese	mg	0.062	0.28	0.084	0.096	0.454	0.173	1.86	0.133
Phosphorus	mg	10	18	21	41	83	22	30	28
Potassium	mg	159	296	313	482	1204	451	282	325
Selenium	mcg	0.7	–	–	–	–	1.5	–	–
Sodium	mg	1	7	1	3	21	1	0	1
Zinc	mg	0.05	0.07	0.28	0.26	0.84	0.19	0.39	0.09
LIPIDS									
Total lipid (fat)	g	0.49	0.28	0.41	0.16	30.8	0.55	0.56	1.39
Total saturated	g	0.08	0.047	0.029	0.011	4.9	0.21	–	0.313
Total unsaturated	g	0.166	0.094	0.262	0.102	23.2	0.148	–	0.577

* With refuse.

(cont. on p. 219)

Appendix 7 (continued). Table of food composition: Fruits and juices

Variables	Measure	Kiwi fruit	Grapefruit	Grapefruit juice	Grapes, slip skin	Grape juice	Orange	Orange juice	Pear
Measure		1	1/2	1 C	1 C	1 C	1	1 C	1
Weight	g	88*	241*	247	153*	253	180*	248	180*
Calories		46	38	96	58	155	62	111	98
Protein	g	0.75	0.75	1.24	0.58	1.41	1.23	1.74	0.65
Carbohydrate	g	11.3	9.7	22.7	15.7	37.8	15.4	25.8	25
Fiber	g	0.84	0.24	–	0.7	–	0.56	0.25	2.32
VITAMINS									
Vitamin A	IU	133	149	–	92	20	269	496	33
Vitamin B_1	mg	0.015	0.043	0.099	0.085	0.066	0.114	0.223	0.033
Vitamin B_2	mg	0.038	0.024	0.049	0.052	0.094	0.052	0.074	0.066
Vitamin B_6	mg	–	0.05	–	0.1	0.164	0.079	0.099	0.03
Vitamin B_{12}	mcg	0	0	0	0	0	0	0	0
Vitamin C	mg	74.5	41.3	93.9	3.7	0.2	69.7	124	6.6
Vitamin E	IU	–	0.26	0.1	–	–	0.43	–	–
MINERALS									
Calcium	mg	20	14	22	13	22	52	27	19
Copper	mg	–	0.056	0.082	0.037	0.071	0.059	0.109	0.188
Iron	mg	0.31	0.1	0.49	0.27	0.6	0.13	0.5	0.41
Magnesium	mg	23	10	30	5	24	13	27	9
Manganese	mg	–	0.014	0.049	0.661	0.911	0.033	0.035	0.126
Phosphorus	mg	31	10	37	9	27	18	42	18
Potassium	mg	252	167	400	176	334	237	496	208
Selenium	mcg	–	–	–	–	10	2.5	14.9	1.2
Sodium	mg	4	0	2	2	7	0	2	1
Zinc	mg	–	0.09	0.13	0.04	0.13	0.09	0.13	0.2
LIPIDS									
Total lipid (fat)	g	0.34	0.12	0.25	0.32	0.19	0.16	0.5	0.66
Total saturated	g	–	0.017	0.035	0.105	0.063	0.02	0.06	0.037
Total unsaturated	g	–	0.045	0.09	0.107	0.064	0.063	0.188	0.295

* With refuse.

(cont. on p. 220)

Appendix 7 (continued). Table of food composition: Fruits and juices

Variables	Measure	Pineapple	Pineapple juice	Plum	Raisins, packed	Raspberries	Strawberries	Tangerine	Tangerine juice
Measure		1 C	1 C	1	1 C	1 C	1 C	1	1 C
Weight	g	155	250	70*	165	123	149	116*	247
Calories		77	139	36	488	61	45	37	106
Protein	g	0.6	0.8	0.52	4.16	1.11	0.91	0.53	1.24
Carbohydrate	g	19.2	34.4	8.59	12.9	14.2	10.4	9.4	25
Fiber	g	0.84	0.25	0.4	1.11	3.69	0.79	0.28	0.25
VITAMINS									
Vitamin A	IU	35	12	213	0	160	41	773	1037
Vitamin B_1	mg	0.143	0.138	0.028	0.185	0.037	0.03	0.088	0.148
Vitamin B_2	mg	0.056	0.055	0.063	0.3	0.111	0.098	0.018	0.049
Vitamin B_6	mg	0.135	0.24	0.053	0.31	0.07	0.088	0.056	–
Vitamin B_{12}	mcg	0	0	0	0	0	0	0	0
Vitamin C	mg	23.9	26.7	6.3	9	30.8	84.5	26	76.6
Vitamin E	IU	–	–	–	–	–	–	–	–
MINERALS									
Calcium	mg	11	42	2	46	27	21	12	44
Copper	mg	0.171	0.225	0.028	0.498	0.091	0.073	0.024	0.062
Iron	mg	0.57	0.65	0.07	4.27	0.7	0.57	0.09	0.49
Magnesium	mg	21	34	4	49	22	16	10	20
Manganese	mg	2.55	2.47	0.032	0.441	1.24	0.432	0.027	0.091
Phosphorus	mg	11	20	7	124	15	28	8	35
Potassium	mg	175	334	113	1362	187	247	132	440
Selenium	mcg	0.93	–	–	–	–	–	–	–
Sodium	mg	1	2	0.06	47	0	2	1	2
Zinc	mg	0.12	0.29		0.3	0.57	0.19	–	0.06
LIPIDS									
Total lipid (fat)	g	0.66	0.2	0.41	0.9	0.68	0.55	0.16	0.49
Total saturated	g	0.05	0.013	0.032	0.294	0.023	0.03	0.018	0.059
Total unsaturated	g	0.3	0.093	0.356	0.298	0.45	0.354	0.06	0.188

* With refuse.

Appendix 8. Table of food composition: Meats

Variables	Measure	Beef				Lamb		
		Dried	Flank steak	Ground beef, regular	Liver	Leg	Chops	Liver
Measure		1 oz	1 lb	4 oz	4 oz	1 lb	1 lb	1 lb
Weight	g	28	454	113	113	454	454	454
Calories		47	888	351	161	845	1146	617
Protein	g	8.25	87.4	18.8	22.6	67.7	63.7	95.3
Carbohydrate	g	0.44	0	0	6.58	0	0	13.2
Fiber	g	0	0	0	0	0	0	0
VITAMINS								
Vitamin A	IU	–	50	40	39941	–	–	229070
Vitamin B_1	mg	0.02	0.499	0.043	0.292	0.59	0.57	1.81
Vitamin B_2	mg	0.09	0.680	0.171	3.14	0.82	0.79	14.9
Vitamin B_6	mg	–	1.87	0.27	1.06	1.05	1.05	1.36
Vitamin B_{12}	mcg	0.52	13.4	2.99	78.2	8.2	8.2	472
Vitamin C	mg	–	0	0	25.3	–	–	152
Vitamin E	IU	–	–	–	1.59	3.6	3.5	–
MINERALS								
Calcium	mg	2	22	10	6	0.39	35	45
Copper	mg	0.045	0.327	0.07	3.12	0.27	0.73	25
Iron	mg	1.28	8.9	1.96	7.71	5.1	4.7	49.4
Magnesium	mg	9	93	18	22	61	55	64
Manganese	mg	–	0.064	0.019	0.298	–	–	1.04
Phosphorus	mg	49	864	146	360	593	567	1583
Potassium	mg	126	1585	258	365	1083	1019	916
Selenium	mcg	–	–	23.5	51.5	–	78	–
Sodium	mg	984	321	77	82	237	223	236
Zinc	mg	1.49	15.7	4.01	4.43	–	–	–
LIPIDS								
Total lipid (fat)	g	1.11	57	30	4.34	61.7	97	19.6
Total saturated	g	0.45	25.6	12.18	1.69	35	54.3	6.9
Total unsaturated	g	0.52	28.36	14.37	1.53	24	37.8	6.63

(cont. on p. 222)

Appendix 8 (continued). Table of food composition: Meats

Variables	Measure	Pork					Veal		
		Bacon	Ham, boneless	Pork and beef sausage	Pork sausage	Salami, hard	Breast	Cutlet	Liver
Measure		1 lb	1 lb	1 link	1 link	1slice	1 lb	1 lb	1 lb
Weight	g	454	454	13	28	10	454	454	454
Calories		2523	827	52	118	42	828	681	635
Protein	g	39	79.6	1.79	3.31	2.29	65.6	72.3	87.1
Carbohydrate	g	0.42	14.1	0.35	0.29	0.26	0	0	18.6
Fiber	g	0	0	0	0	0	0	0	0
VITAMINS									
Vitamin A	IU	0	0	–	–	–	–	–	102060
Vitamin B_1	mg	1.67	3.9	0.096	0.155	0.06	0.48	0.53	0.9
Vitamin B_2	mg	0.472	1.14	0.019	0.046	0.029	0.87	0.96	12.3
Vitamin B_6	mg	0.64	1.52	0.01	0.07	0.05	1.22	1.22	3.04
Vitamin B_{12}	mcg	4.2	3.75	0.06	0.32	0.19	5.7	5.7	272
Vitamin C	mg	0	–	–	0	t	–	–	161
Vitamin E	IU	1.82	–	–	–	–	–	–	–
MINERALS									
Calcium	mg	34	0.32	–	5	1	39	41	36
Copper	mg	0.29	0.449	0	0.02	0.01	–	1.14	36
Iron	mg	2.7	4.5	0.15	0.26	0.15	9.7	10.9	39.9
Magnesium	mg	39	85	1	3	2	–	73	73
Manganese	mg	0.032	0.141	–	–	0.004	–	–	–
Phosphorus	mg	646	1122	14	34	14	652	734	1510
Potassium	mg	631	1508	–	58	38	1050	1157	1275
Selenium	mcg	–	–	–	–	–	–	–	–
Sodium	mg	3107	5974	105	228	186	230	253	331
Zinc	mg	5.23	9.69	0.24	0.45	0.32	–	–	17
LIPIDS									
Total lipid (fat)	g	261	47.9	4.71	11.4	3.44	61	41	21.3
Total saturated	g	96.4	15.4	1.68	4.1	1.22	29.3	19.7	–
Total unsaturated	g	150	27.9	2.74	6.73	2.03	28	18.8	–

Appendix 9. Table of food composition: Nuts and seeds. Poultry

Variables	Measure	Nuts and seeds				Poultry				
								Chicken		
		Hazelnuts	Sunflower seeds	Tahini	Walnuts	Dark meat	Light meat, w/o skin	Leg	Wing	Liver
Measure		1 C	1 C	1 T	1 C	5.6 oz	3 oz	1	1	1
Weight	g	135	145	15	100	160	88	231	90	32
Calories		856	812	89	651	379	100	312	109	40
Protein	g	17	34.8	2.55	14.8	26.7	20.4	30.3	8.98	5.75
Carbohydrate	g	22.5	28.9	3.18	15.8	0	0	0	0	1.09
Fiber	g	1.05	5.5	0.75	2.1	0	0	0	0	0
VITAMINS										
Vitamin A	IU	144	70	–	30	273	25	206	72	6576
Vitamin B_1	mg	0.62	2.84	0.183	0.33	0.098	0.06	0.112	0.024	0.044
Vitamin B_2	mg	0.738	0.33	0.071	0.13	0.234	0.081	0.274	0.043	0.628
Vitamin B_6	mg	0.735	1.8	–	0.73	0.39	0.48	0.48	0.17	0.24
Vitamin B_{12}	mcg	0	0	0	0	0.47	0.34	0.54	0.15	7.35
Vitamin C	mg	t	–	0	2	3.4	1.1	4.1	0.3	10.8
Vitamin E	IU	28	–	–	1.5	–	–	–	–	–
MINERALS										
Calcium	mg	282	174	64	99	18	10	17	6	3
Copper	mg	1.72	2.57	0.242	1.39	0.086	0.035	0.097	0.02	0.126
Iron	mg	4.6	10.3	1.34	3.1	1.57	0.64	1.68	0.47	2.74
Magnesium	mg	313	57	14	131	30	24	34	9	6
Manganese	mg	5.67	2.9	–	1.8	0.03	0.016	0.033	0.009	0.083
Phosphorus	mg	455	1214	110	380	217	164	249	65	87
Potassium	mg	950	1334	62	450	285	210	331	76	73
Selenium	mcg	2.7	–	–	–	–	–	–	–	–
Sodium	mg	3	4	17	2	117	60	132	36	25
Zinc	mg	4	7.3	0.69	2.26	2.53	0.85	2.96	0.65	0.98
LIPIDS										
Total lipid (fat)	g	84.2	68.6	8.06	64	29.3	1.45	20.2	7.82	1.23
Total saturated	g	4.2	8.2	1.13	4.5	8.41	0.38	5.7	2.19	0.42
Total unsaturated	g	59	56.9	6.57	49.5	18.5	0.68	12.6	4.77	0.5

Appendix 10. Table of food composition: Salad dressings and sauces

Variables	Measure	Salad Dressings			Sauces				
		French	Mayonnaise	Russian	Catsup	Soy	Tartar	Umeboshi	Vinegar
Measure		1 T	1 T	1 T	1 T	1 T	1 T		1 T
Weight	g	15.6	13.8	15.3	15	18	14	100	15
Calories		67	99	76	16	11	31	17	2
Protein	g	0.1	0.2	0.2	0.3	1.56	0.1	0.3	t
Carbohydrate	g	2.7	0.4	1.6	3.8	1.5	0.9	3.4	0.9
Fiber	g	0.1	0	0	0.075	–	0.042	0.3	0
VITAMINS									
Vitamin A	IU	–	39	106	210	0	30	0	–
Vitamin B_1	mg	–	0	0.01	0.01	0.009	t	0.06	–
Vitamin B_2	mg	–	–	0.01	0.01	0.023	t	0.09	–
Vitamin B_6	mg	–	–	–	0.016	0.031	–	–	t
Vitamin B_{12}	mcg	–	–	–	0	0	–	–	0
Vitamin C	mg	–	0	1	2	0	t	0	–
Vitamin E	IU	1.3	–	1.34	–	–	–	–	–
MINERALS									
Calcium	mg	1.7	2	3	3	3	3	6.1	1
Copper	mg	–	0.034	–	0.089	0.018	–	–	0.014
Iron	mg	0.1	0.1	0.1	0.1	0.49	0.1	2	0.1
Magnesium	mg	–	–	–	–	8	–	–	0.2
Manganese	mg	–	–	–	–	0	–	–	–
Phosphorus	mg	2.2	4	6	8	38	4	26	1
Potassium	mg	12.3	5	24	54	64	11	–	15
Selenium	mcg	–	–	–	–	–	–	–	13.3
Sodium	mg	213	78.4	133	156	1029	99	9400	t
Zinc	mg	0.01	0.02	0.07	0.039	0.036	–	–	0.015
LIPIDS									
Total lipid (fat)	g	6.4	11	7.8	0.1	0	3.1	0.8	0
Total saturated	g	1.5	1.2	1.1	–	0	–	–	0
Total unsaturated	g	4.6	9.4	6.3	–	0	–	–	0

Appendix 11. Table of food composition: Seafood and seaweed

Variables	Measure	Carp	Cod	Crab	Frog legs	Herring	Mackerel	Oysters	Perch	Pike
Measure		3 oz	3 oz	3 oz	4 lge	3 oz	3 oz	6 med	3 oz	3 oz
Weight	g	85	85	85	100	85	85	84	85	85
Calories		108	70	71	73	134	174	58	80	75
Protein	g	15	15	15.6	16.4	15	15.8	5.9	15.8	16.4
Carbohydrate	g	0	0	0	0	0	0	3.29	0	0
Fiber	g	0	0	0	0	0	0	0	0	0
VITAMINS										
Vitamin A	IU	25	34	20	0	80	140	282	34	60
Vitamin B_1	mg	0.008	0.065	0.037	0.14	0.078	0.15	0.128	0.08	0.049
Vitamin B_2	mg	0.036	0.055	0.037	0.25	0.198	0.265	0.139	0.094	0.054
Vitamin B_6	mg	0.162	0.208	0.272	0.12	0.257	0.339	0.042	0.2	0.099
Vitamin B_{12}	mcg	1.3	0.772	9.08	–	11.6	7.4	16	0.85	–
Vitamin C	mg	1.4	0.9	1.8	–	0.6	0.3	–	2.72	3.2
Vitamin E	IU	–	–	–	–	1.8	1.45	–	–	0.18
MINERALS										
Calcium	mg	35	13	39	18	49	10	38	91	48
Copper	mg	0.048	0.024	0.784	–	0.078	0.062	3.74	0.022	0.043
Iron	mg	1.05	0.32	0.5	1.5	0.94	1.38	5.63	0.78	0.47
Magnesium	mg	25	27	30.8	–	27	64	46	26	27.2
Manganese	mg	–	0.013	0.03	–	0.03	0.013	0.378	0.013	0.018
Phosphorus	mg	352	173	186	147	201	184	117	184	187
Potassium	mg	283	351	173	308	278	267	192	232	220
Selenium	mcg	–	37.2	–	–	–	–	44.4	–	–
Sodium	mg	42	46	711	55	76	76	94	64	33
Zinc	mg	1.26	0.38	5.05	–	0.84	0.53	76.4	0.41	0.57
LIPIDS										
Total lipid (fat)	g	4.76	0.57	0.51	0.3	7.68	11.8	2.08	1.39	0.58
Total saturated	g	0.921	0.111	–	–	1.73	2.77	0.53	0.207	0.1
Total unsaturated	g	3.17	0.276	–	–	4.98	7.48	0.83	0.894	0.305

Appendix 12. Table of food composition: Vegetables and vegetable juices

Variables	Measure	Beets	Broccoli	Cabbage, common	Cabbage, Chinese	Carrots	Carrot juice	Cauliflower	Celery
Measure		1 C	1 C	1 C	1 C	1 C	1 C	1 C	1 C
Weight	g	136	88	70	70	110	227	100	120
Calories		60	24	16	9	48	96	24	18
Protein	g	2	2.6	0.84	1.05	1	2.47	1.98	0.8
Carbohydrate	g	13.6	4.6	2.76	1.53	11	22	4.9	4.36
Fiber	g	1	0.9	0.56	0.42	1	2.34	0.82	0.82
VITAMINS									
Vitamin A	IU	28	1356	88	2100	30942	24750	16	152
Vitamin B_1	mg	0.068	0.058	0.03	0.028	0.1	0.13	0.076	0.036
Vitamin B_2	mg	0.028	0.1	0.02	0.049	0.064	0.12	0.058	0.036
Vitamin B_6	mg	0.06	0.14	0.066	–	0.16	0.534	0.23	0.036
Vitamin B_{12}	mcg	0	0	0	0	0	0	0	0
Vitamin C	mg	15	82	33	31.5	10	20	71	7.6
Vitamin E	IU	–	–	0.2	–	–	–	0.15	0.57
MINERALS									
Calcium	mg	22	42	32	74	30	8.3	28	44
Copper	mg	0.1	0.04	0.016	–	0.05	–	0.032	0.042
Iron	mg	1.24	0.78	0.4	0.56	0.54	1.5	0.58	0.58
Magnesium	mg	28	22	10	13	16	51	14	14
Manganese	mg	0.47	0.2	0.11	–	0.156	–	0.2	0.164
Phosphorus	mg	66	58	16	26	48	81	46	32
Potassium	mg	440	286	172	176	356	767	356	340
Selenium	mcg	–	–	1.54	–	2.2	–	0.7	–
Sodium	mg	98	24	12	45	38	105	14	106
Zinc	mg	0.5	0.36	0.12	–	0.22	–	0.18	0.2
LIPIDS									
Total lipid (fat)	g	0.2	0.3	0.12	0.14	0.2	–	0.18	0.14
Total saturated	g	0.02	0.048	0.016	0.018	0.034	0.066	0.028	0.038
Total unsaturated	g	0.1	0.17	0.07	0.078	0.09	0.192	0.096	0.1

(cont. on p. 227)

Appendix 12 (continued). Table of food composition: Vegetables and vegetable juices

Variables	Measure	Onions, green	Onions, nature	Parsley	Peas, green	Peppers, sweet	Potato	Sauerkraut	Tomato	Tomato juice
Measure		1 C	1 C	1 C	1 C	1 C	1 C	1 C	1	1 C
Weight	g	100	160	60	146	100	150	235	123	243
Calories		26	54	26	118	24	114	42	24	46
Protein	g	1.7	1.88	2.2	7.9	0.86	3.2	2.4	1.1	2.2
Carbohydrate	g	5.5	11.7	5.1	21	5.3	25.7	9.4	5.3	10.4
Fiber	g	0.84	0.7	0.9	3.2	1.2	0.66	1.6	0.57	0.4
VITAMINS										
Vitamin A	IU	5000	0	5100	934	530	t	120	1394	1940
Vitamin B_1	mg	0.07	0.096	0.07	0.387	0.086	0.15	0.07	0.074	0.12
Vitamin B_2	mg	0.14	0.016	0.16	0.193	0.05	0.06	0.09	0.062	0.07
Vitamin B_6	mg	–	0.25	0.098	0.247	0.164	–	0.31	0.059	0.366
Vitamin B_{12}	mcg	0	0	0	0	0	0	0	0	0
Vitamin C	mg	45	13.4	103	58.4	128	30	33	21.6	39
Vitamin E	IU	–	0.4	–	3.1	–	–	–	0.55	–
MINERALS										
Calcium	mg	60	40	122	36	6	11	85	8	17
Copper	mg	0.06	0.064	0.293	0.257	0.1	0.388	0.235	0.095	0.246
Iron	mg	1.88	0.58	3.7	2.14	1.2	0.9	1.2	0.59	2.2
Magnesium	mg	20	16	24.5	48	14	51	31	14	20
Manganese	mg	–	0.2	0.563	0.599	0.14	0.394	–	0.15	0.188
Phosphorus	mg	32	46	38	157	22	80	42	29	44
Potassium	mg	256	248	436	357	196	611	329	254	552
Selenium	mcg	–	2.5	–	–	0.48	–	–	0.8	–
Sodium	mg	4	4	27	7	4	5	1755	10	486
Zinc	mg	0.44	0.28	0.44	1.8	0.18	0.58	1.88	0.13	0.1
LIPIDS										
Total lipid (fat)	g	0.14	0.42	0.4	0.58	0.46	0.2	0.33	0.26	0.2
Total saturated	g	0.024	0.07	–	0.1	0.068	0.04	0.083	0.037	0.02
Total unsaturated	g	0.074	0.144	–	0.323	0.272	0.068	0.17	0.146	0.08

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