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Lecture notes

Standardization of anthropogenic load on the environment

(Regulatory Actions Anthropogenic Load upon Environment)

Kyiv
2020

УДК 504

Наведено лекційний матеріал англійською мовою із дисципліни «Нормування антропогенного навантаження на природне середовище». Лекції спрямовані на засвоєння теоретичного матеріалу з дисципліни, що допомагає при визначенні ступеня забруднення навколишнього природного середовища відповідно до нормативних документів студентами спеціальності 101 «Екологія».

Ухвалено навчально-методичною радою факультету захисту рослин, біотехнологій та екології розвитку НУБіП України протокол №_ від 2020 р.

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1. Classification of the environment pollutions and its standardization

In the international practice of the beginning of 70th years has been created strategy of practically full protection of human person from influence of pollutants.

Pollution is

- an emission into the environment or sudden increase into it of concentration of chemical, physical, biological, information or any other traditional and new agents and factors leaded to negative results (Rheimers, 1990).

The act or process of polluting or the state of being polluted, especially thecont amination of soil, water, or the atmosphere by the discharge of harmful substances.

Pollution can affect air, water, or land andcan threaten the health of humans, wildlife and plants.

Pollution usually is divided into *natural* and *anthropogenic.* Examples of the first group are dust, volcanogenic gases, influenza virus, grasshopper plague ctr. Then we shall consider anthropogenic pollution. The *anthropogenic pollutants* are danger to all humanity, his health and the Nature. With development of a mechanical production the person changes into significant geological intensity and influences on all nature circulations. The person synthesizes further and further new substances

which are used in manufacture and agriculture. But these substances never *existed in nature.* Therefore, they are accumulated in biosphere (like first insecticide –DDT (dichlorodiphenyltrichloroethane)). So, all polluting agents can de divide into *steady* and *unsteady* ones. *Unsteady pollutants* are substances which are destroyed or modified to a safe condition under influence of biosphere or physical conditions on a surface of the Earth. *Steady pollutants* are substances which cannot be destroyed for short time and have negative influence for biosphere.

The most part of *steady pollutants are called* xenobiotics (from Greek xenos - strange, alien). The xenobiotics are all dangerous substances for human health (carbon substances, high molecular substances, ctr.), irritants, pesticides, nitrates, nitrites, amine, alcohol, tannic substances, drugs, cosmetics and others.

It is known that pollutants are divide into *industrial and nonindustrial (agricultural)*. This classification is based on an origin of agents of pollution. All pollutants are divided into *energy* and *material* ones depending on the nature of pollution.

Also, there is also other classification of polluting substances which can be used for classification of industrial wastes:

- Mechanical (mainly firm waste),
- Chemical (gases, liquid and artificial substances),
- Physical (all kinds of physical fields, wave radiations),
- Biological (plants, animal which are created or modified by the person).

Depending on the size of «beaten zone» (the area and distance of diffusion or transference) pollutions are divides into *pollution of habitation, local, regional, global ones.* For an example, *local* pollution of soil is pollution of soil by one or several sources of pollution.

Regional pollution is a land pollution which arises is formed as a result of transfer of pollutants on distance over 40 km from anthropogenic and more than 10 km from agricultural sources.

Global pollution is transfer of pollutants on distance more than 1000 km from any sources of pollution.

The pollutants are divided into some groups depending on the specification of action and a level of harmfulness for human. There are most harmful pollutants which influence on the person in the lowest concentration or amounts (an example is radionuclide).

2. Our state has begun creation of hygienic standards in 1922 when first three standards of occupational are have been established. In 1925 the quantity of standards has already achieved ten ones. In 40th years development of maximum allowable concentration of chemical compounds of atmospheric air of city has begun. Then have been established the maximum allowable concentration for water, soil and food stuffs. Also, the question of action of chemical pollution on an organism of the person was developed.

Accordingly, standards of specifications of industrial zones have been established. That had been incorporated the beginning of work in the field of sanitary and hygienic normalization. A basis of sanitary and hygienic normalization is the concept *of maximum allowable concentrations.* Comprehensive regulation of air pollution in the Soviet Union was established in the late 1970's. *Standards of MAC which are approved Ministry of health protection, for 600 substances of air, 200 substances of water and 100 substances of soil have been establish.* Maximum allowable concentrations (MACs) for 540 air pollutants and about 4,000 water pollutants have been one of the main bases for establishing permit conditions based on ambient standards in Ukraine.

For substances which action is not the enough information, *temporarily allowable concentration (TPC)* have been establish for the period of 2-3 years.

But the person is not the most sensitive to pollution among biological species. Ecological normalization connects with *allowable load on ecosystem*. *Allowable load* is such load, which leads to a deviation from a normal condition of system, does not

exceed natural changes, does not cause undesirable consequences on organisms and does not lead to deterioration of an environment. Both ecological, and sanitary and hygienic normalization is based on knowledge of effects which appear different factors of influence on organisms. Some people are now known ecological standards developed in the different countries.

Intervention of the person in biosphere processes (undesirable for ecosystem) can be grouped by types of pollution:

- Ingredient pollution is the aggregate of substances, which quantitatively or qualitatively have influence on natural biocenoses (ingredient is a component of a substances or mix);

-parametric pollution is change of qualitative parameters of environment (for example, noise level, radiation, illumination, ctr.);

- pollution influences on composition and structure of population of organisms;

-Staci destructive pollution (стация - a place of existence of populations) is charges of landscape and ecological systems during nature management.

The influence of harmful chemical, physical, biological factors on biocoenosis have 4 levels:

1 level - pollution of an environment does not cause changes in biocenosis;

2 level - pollution of an environment is cause of loading on biocenosis within the limits;

3 level - pollution of an environment is cause of irreversible changes in biocoenosis, its species are sick, term of their life is reduced;

4 level - pollution of an environment is cause of destruction and disappearance of separate species of biocenosis.

Ecological standardization is an activity of the specially authorized state bodies which development and approval of ecological standard and guarantee of their observance with different subjects.

The main goal of ecological standardization is to identify all potential contaminants of environment and find exposure standards for them.

Ecological standards are scientifically proved and obligatory measures for performance of maximum allowable negative influence of the person on natural environment. Negative effect is the activity of the person bringing physical, chemical, biological changes in the environment which threatens a health and human life, a status vegetative kingdom and fauna.

3. Excess of ecological standard is an ecological breaking and involve the stopping, abeyance or restriction of ecologically harmful activity (Laws of the Ukraine" About protection of the environment "), and also application of measures of the legal accountability.

Ecological standard is determined on the basis of three indicators:

а) Medical indicator is a indicator level of threat to health of the person, his gene pool;

б) Technological indicator is ability of available technologies to provide performance of the determined standard;

в) Scientific and technical indicator is ability of scientific and technical means to control maximum allowable impact and its parameters. However, it should be noted that definitions used in Ukrainian legislation do not always correspond with the terms used in the EU legislation. According to the Law of Ukraine “On Standardization”, standards arc the regulatory documents which establish rules, define basic principles or requirements for the different types of activities or their results (energy, oil and gas, environmental protection, construction, transportation, telecommunications, mining, food processing, and other industries).

In the sense of the sustainable usage of natural resources, standards define the terminology and the methods used for the monitoring and protection of the environmental components (e.g. air, water, soil, ecological systems). GOST 17.2.3.02- 78 “Environmental protection, Atmosphere. Rules for setting allowable

pollutant emissions by industrial enterprises" (Gosstandard USSR 1979) is an example of environmental standards. Standards serve as a basis for developing environmental norms (e.g. norms of environmental safety of the atmospheric air, norms for maximum allowable concentrations). According to Art. 33 of the Law of Ukraine "On environmental protection", environmental norms set the maximum allowable emissions and discharges of pollutants into the environment, and permissible levels for the prevention of adverse effects from physical and biological factors (i.e. acoustic, electromagnetic, radiation, ionizing etc.). Ukrainian legislation divides environmental norms into the following groups (sec Fig. 1.1):

- norms of environmental safety;
- norms for impacts of pollution sources.

Norms of the first group are often referred as the norms of environmental quality.

They are the indicators for the state of the environmental components.

For instance, norms provided by the Law of Ukraine "On protection of the atmospheric air" (Art. 5) are used in the assessment of impacts on the atmospheric environment, while norms used in water protection are set out in the Water Code of Ukraine (Art. 36, 38-40), and the Land Code of Ukraine defines norms used in assessment of soil pollution levels (Art. 165).

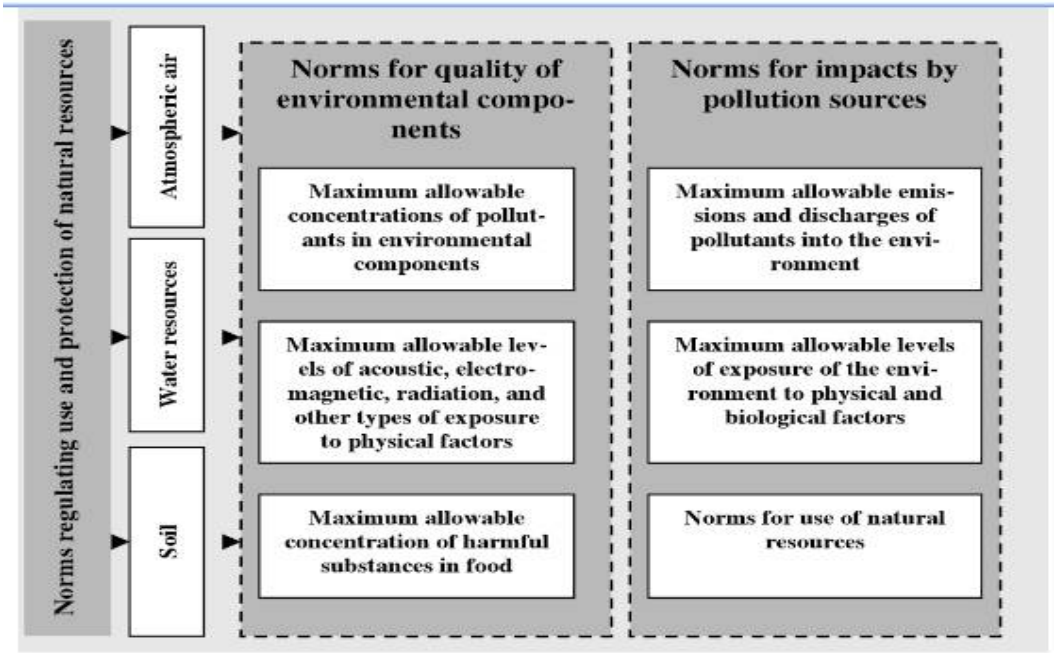


Fig. 1.1. System of environmental norms under Ukrainian legislation

3.1. Standards of quality are criteria of a favorable status of the environment. In the practical relation it is important to mean in case of need protection of the ecological rights of citizens (Fig1.1). Standard of quality of the environment are also considered a rating of influence of planned economic activities on an environment, at development of cities and other settlements.

The standards are:

a) Standards of maximum allowable concentration (MAC) of chemical and biological substances are quantity of harmful substance in the environment, what practically not influence on health of the person, and also on status of wild animals, plants, microorganisms, natural communities as a whole. Their parameters are determined for atmospheric air, economic – palatable and domestic water objects, soils;

b) Standards of maximum allowable levels (MAL) of harmful physical impacts-noise, vibration, electromagnetic radiation and thermal influence Ukrainian approach to the application of standards and thresholds in environmental assessment practice implies setting limit values (norms in Ukrainian) both for impacts and for state of the

environment. Therefore, environmental standards and norms are the criteria for environmental quality and are the tool for environmental management and legal regulation.

3.2 Standards of maximum allowable harmful impact on the environment regulate activity of sources of such influence - the industrial and agricultural enterprises, separate technological processes, the equipment, transport and others.

This group of standards includes:

а) Standard of maximum allowable emission (MAE) – quantity of harmful substances which are authorized to emit in air for a time unit;

These standards, officially called “Norms for pollutants emission limits from stationary sources” were approved by the MEP Order No. 309 of 27 June 2006 and came into force in August 2006. Emission limits are specified for particulate matter, solid toxic and carcinogenic pollutants, gaseous inorganic pollutants, and organic pollutants. The norms list emission limits for over a hundred air pollutants.

б) Standard of maximum allowable discharges of substances into water body (MAD) - quantity pollutants in the sewage discharging in water objects for a time unit.

Standards of MAE and MAD are determined for each source of harmful impact proceeding from conditions of inadmissibility of excess of standard of maximum concentration limit in the given region. In case of impossibility of observance of MAE and MAD by the legal persons temporarily coordinated standard can be determined. Thus, corresponding legal persons are obliged to develop and present for the statement to the state bodies plans of stage-by-stage reduction of pollution;

в) Standards of waste formation are the determined quantity of waste products of one kind by manufacture of a unit of production;

с) Limits of waste placing are maximum allowable quantity of waste products of a one kind which are authorized to be placed in the certain way on a fixed date in objects of placing of waste products (polygons, slag storages, heaps of rocks and etc.).

Standard of formation of waste products and limits of accommodation of waste products are determined for all enterprises, while in service which waste products are formed.

d) Maximum allowable norms of application agrarian chemicals in an agriculture - fertilizers, weed and pest killers, growth factors and others agrarian chemicals. It is known that agrarian chemicals can accumulate and remain in soil. As a result, it is pollution of soil and agricultural production that can represent health hazard of the person. Therefore, the basic requirement of the legislation - agrarian chemicals should be used in the dozes providing observance of determined standard of residual quantities of chemical substances in food stuffs, health protection, and preservation of genetic fund of the human, vegetable kingdom and fauna. The Ministry of Agriculture of the Ukraine authorizes the List of chemical and biological means of pest control, by plant diseases, weeds and regulators of plant growth allowed for use in agriculture. The norm of the consumption, a method and time of processing, limitations, deadline and the maximal rate of processing are provided this document.

e) Standard MPL of a radioactive irradiation of the population as a result of use of sources ionizing irradiation. There are determined an average annual effective dose and an effective dose for the period of a life. It equal accordingly:

- For the population - 0,001 sievert (Sv) and 0,07 Sv;
- For workers, namely for persons, which constant or temporarily working directly with sources of ionizing radiations, - 0,02 Sv and 1 Sv.

The effective doze is value of impact of ionizing emission used as a measure of risk of becoming of the late radiation effect of an organism of the person and his separate organs subject to their radio sensitivity.

3.3. Standards (limits) of use of natural resources are determined by the prevention of their exhaustion and disbalance of the environment subject to their ability to self-reproduction. They are the volumes of maximum use (removal) of the

natural resources, determined by the state bodies for the certain term. To them can be related:

a) Norms of allotment of land for construction of the automobile and rail ways, airports, main pipelines, land reclamation systems, ctr.;

b) Limits of water consumption are maximum allowable volumes of water removal of resources or discharge of sewage of normative quality which are determined to the water consumption for the certain term;

c) Prescribed cut is the standard used in forestry. There is a standard of deforestation of the wood, corresponding to its annual gain which is determined on each forestry enterprise, forestry and the woods transmitted to using;

d) Limits of use of objects of fauna are determined for hunting, fishery, and killing of the animals which have been not related to objects of hunting and fishery.

3.4 Ecological standards are determined on new technical equipment, technologies, materials, substances, products of consumption and other production, which capable of harmful influence on environment and health of the human. These standards are a part of state standards. They affirm the State committee on standardization of the Ukraine and are single in territory of all country.

The standards of maximum allowable residual quantities of chemical substances are determined for foodstuffs. There are minimally allowable dozes harmless to health of the person for each used chemical and their total influence. Now Ministry of Health of Ukraine determines standard of residual quantities of nitrates, pesticides, mercury, lead, arsenic and other harmful substances in agricultural production.

3.5 Standards of sanitary and protective zones are the size of territory within the limits of which the special mode of economic and other activity is determined. So, around of industrial, municipal and warehouse objects are determined sanitary protection zones in which accommodation of dwelling, kindergartens, schools, establishments of public health services, rest, sports and health objects, gardening,

cottage and market gardening cooperatives are not admitted, and also manufacture of agricultural production.

With the purpose of protection of water objects around of them water protection zones can determined. In their territories accommodation of warehouses of weed and pest-killer chemicals, cemeteries, burial ground for animal refuses, dumps of waste products, ploughing up the soils, cutting of trees and some other kinds of economic activities are forbidden. Around of the water bodies of drinking and household water supply, zones of sanitary protection are determined.

For prevention of unfavorable anthropogenic impact on the reserves, national and natural parks, other especially protected natural territories, on border upon them area security zones can be created. The economic activity on this zones are limited or forbidden.

Control questions

1. What is understood as ecological standardization?
2. What are criteria of an establishment of ecological standard?
3. What role are discharge standards of maximum allowable concentration?
4. Who develops standard of maximum allowable emissions and discharges of pollutants? Where are fixed it?
5. What are conditions of an establishment of temporarily coordinated standard of emissions and discharges of pollutants?
6. What are the basic hygienic standard of an irradiation of the population?
7. In case of absence of ecological standards on production who realizes their development and statement?
8. What is essence of an establishment of sanitary and protective zones?

Lecture 2. Standardization of quality of air

1. Definition of air pollution and maximum allowable concentration (MAC)
2. Classification of MAC
3. Definition approximate safe exposure level
4. Effects of several pollutants in air

The problem of air pollution is very important because any pollution of an atmosphere necessarily influences a condition of water and ground. Therefore, actions on protection of air ensure conservation of flora and fauna. This problem requires the team approach to determination of problem of the prevention of air and water pollution by emissions of the industrial enterprises.

The air pollution is increase of concentration of physical, chemical and biological components more than a natural level which results natural systems in a status of disbalance. The main sources of air pollution are transport, power system, the industry, especially chemical and oil refining ones.

MAC of air is the maximum concentration in air of a toxic material that the facility and the public authorities having jurisdiction are willing to tolerate at a populated downwind location in the event of a major accident.

The maximum allowable concentrations of toxic substances used in toxicology and industrial hygiene are not sufficiently stringent for general use, and control standards are therefore based on the results of tests carried out on animals and human subjects.

Tests on animals show that certain concentrations of toxic substances cause functional changes (e.g., in higher nervous activity, cholinesterase activity, and excretion of coproporphyrin) as well as several protective adaptational reactions. The results are used to establish maximum allowable concentrations of pollutants within a 24-hour period.

2. By the standardization of air pollution is discriminated the maximum single and daily average concentration of pollutants. For substances which have immediate, but temporarily irritating action, establish MAC one -time (MAC_{ot}). The $MACs_{ot}$ are determined for 20 minutes or 30 minutes. That is, samples take sometimes for this term. MAC_{ot} are necessary for the prevention of reflex reactions at the person (sensation of a smell, change of bioelectric activity of the brain, light sensitivity of eyes, etc.).

Tests on human volunteers provide a basis for determining the maximum average concentrations at a given time. Reactions to odorous substances give the olfactory threshold and the level of concentration causing respiratory and visual reflexes, as well as subsensory effects such as changes in light sensitivity and in the activity of the cerebral cortex.

For substances, which have harmful effect on an organism by accumulation, are established MAC daily average (MAC_{da}).

Daily average concentration is determined during day with a view to the prevention of resorption influences of pollutant (general toxic, carcinogenic, mutagenic and others). For determination of MAC_{da} the samples take four times and day or each hour.

For air pollution MACs of city air (MAC_a) are established. It is the maximal concentration of pollutants related by the averaging time which at periodic influence or influence during all human life does not have harmful action on him, allowing for the action remote in time.

Industrial emissions in air have significant distance, pollute of air not only on industrial platforms, and in the nearby occupied territories.

For occupational air is established MAC of occupational air (MAC_{oa}). A working zone is an area in two meters from a floor where workers are constant or temporarily. MAC_{oa} is a concentration of pollutants which cannot cause disease or any changes in health status of the person and the following generation now

or in the future at job every day (except weekend) during 8 hours or at the other working day, but it is no more 41 hours per week, during all work. There are determined for modern research actions.

The existing specifications and technical documentation admit to maximum air pollution in territory of the enterprise. It is equaled to 0,3 MAC_{oa}. That is, in territory of the enterprise quality of air should be higher beside occupational air. Air pollution by emissions from ventilating systems should not exceed 1MACap. However, at many enterprises the mentioned requirements are not carried out, and air pollution is higher in sometimes than MAC.

3. In the case that the MAC norms do not establish, the approximate safe exposure level (ASEL) of chemical substance, including chemical mixtures of constant composition, is used for environmental assessment. ASEL are the maximum dose or concentration which, based on current knowledge, is likely to be tolerated by an organism without producing any adverse effect.

ASELs are established based on short-term research studies according to the appropriate procedure, they are adopted as temporary sanitary norms, and are approved by the Chief state sanitary inspector of Ukraine.

ASEL must be revised two years following their adoption or replaced by MAC considering the accumulated data on the impact of the chemical substances (or their mixtures) on health.

4. Degree of air pollution is established subject to multiplication factor of MAC, a hazard class of substances, quantity of substances, simultaneous presence in air and coefficient of combined action.
At presence of several pollutants in air we have such effects:

•independent effects on recipients;

•additivity or arithmetic summation;

•potentiation is gain by one substance of effect of another one;

•antagonism is decrease one substance of effect of another one.

In zone of impact of the designed object Fcd should be performed a condition (State sanitary regulations (ДСП) 201-97):

$\sum C_i / MAC_i \leq Fcd$

• C_i - concentration of air pollutant, mg / m3;

•MAC_i - maximum allowable concentration of air pollutant, mg / m3;

•F_{cd} - factor of the combined action of air pollutants.

Additive effect of air pollutants takes place during 20...30 minutes. Additive effect is the combined effect produced by the action of two or more pollutants and equal to the sum of their separate effects. By long absorption by organism of harmful substances, even in small concentration, the combined influence is mostly unknown.

$C_1 / MPC_1 + C_2 / MPC_2 + C_3 / MPC_3 \leq F_{cd}$ where C — concentration of the revealed substances, MPC_1, MPC_2, MPC_3 — their standards, Fcd>1

The toxic effect of separate pollutant intensifies in combination with a heat, ultraviolet radiation and other factors.

In case of independent effect, the estimation of environment (water, air, etc.) is carried out by comparison of concentration of each revealed substance with its MPC separately. Estimation of the object is given by formula:

$C / MPC < 1$,

where C — concentration of revealed substance, MPC — its maximal permissible concentration in the given object of the environment.

At summarizing the combined effect, the estimation of the environment is carried out according to the formula of summation toxicity:

$C_1 / MPC_1 + C_2 / MPC_2 + C_3 / MPC_3 \leq 1$

where C — concentration of the revealed substances, MPC_1, MPC_2, MPC_3 — their standards.

Factor of combined action (Fcd) represents the character of combined effect of air pollutants.

Control questions

1. What is maximum allowable concentration?
2. Name classification of MAC of air
3. What effects have air pollutants by synchronous presence?
4. What is Factor of combined action?

Lecture 3. Standardization of impact on air quality

1. Legal framework
2. Classification of sources of air pollution
3. Dispersion of pollutant in air
4. Self-monitoring and reporting of emissions
4.1. Air pollution index (API)
4.2. The total air pollution index
4.3. Hazard category of enterprises

1. The Law on Air Protection (revised in 2001)

The procedure for approving investment programmers and construction projects and performing complex state environmental impact assessments (2002; Cabinet of Ministers Resolution No. 483)

The State Construction Norms DBN A.2.2-1- 2003 "Structure and content of the documentation for environmental impact assessment (EIA) in designing and building industrial enterprises, buildings and structures. Main regulations for design" (2003),

"Norms for pollutants emission limits from stationary sources" (2006). Emission limits are specified for particulate matter, solid toxic and carcinogenic pollutants, gaseous inorganic pollutants, and organic pollutants.

2. The sources of air pollution are divided into stationary (all enterprises) and mobile (transport).

Stationary sources are *not shaded* and *shaded*, hot and cold ones

- *Not shaded* or high sources are the chimneys and other sources. The air pollution emission has the height which is equaled to 2,5 heights of the near located buildings and other objects.
- *The shaded* sources are in a zone of wind shadow of the building or other objects.
- Sources of air pollution subdivided into *organized and unorganized.* The air pollution of *the organized source* is pollution airlines, chimneys, etc.
- *The unorganized source* of air pollutants is formed as a result of damages of air hermiticity of same equipment, in places of loading, unloading or storage of raw materials.

3. The pollutants are diluted in air and are transported by airflows at different distances.

The nature of the dispersion of pollutants in the atmosphere are affected by:

- meteorological conditions (horizontal and horizontal)
- vertical movement of air masses, wind speed and direction,
- air temperature, intensity of solar radiation, humidity, quantity and rainfall, fog, etc.),
- higher of chimney,
- relief, the presence of forests, ponds, mountains.
- Contamination of cities are affected by their planning and landscaping.

By construction of the enterprises, which have the source of air pollutions, is necessary to take account of emissions of already existing natural and anthropogenic sources of air pollution i.e. background concentration.

The concentration (or level) of a substance characteristic of a medium (e.g. soil, water, rock etc.) in an area or region arising from both natural sources and non-

natural diffuse sources such as atmospheric deposition. (after definition for background concentration soil, ISO 11074-1:1996)

Levels of chemical or physical agents that are normally found in the environment.

Two types of background levels may exist for chemical substances or physical agents:

(*a) Naturally occurring levels:* ambient concentrations of substances or agents present in the environment, without human influence;

*(b) Anthropogenic level*s: Concentrations of substances or agents present in the environment due to human-made, non-site sources (e.g., automobiles, industries).

The document ("Procedure of determination of background concentrations of pollutants in atmospheric air ") makes:

- the method of determining the background concentrations according to data of stationary posts,
- technique of determination of background concentrations according to torch data (when the enterprise is the only one or the major source of atmospheric pollution by a substance on territory),
- determining the background concentrations by the calculated method (according to formulas OND - 86 with using a computer).

The regulation of air emissions by enterprise is carried out based on establishment of maximum permissible emission (MPE) (State Standard 17.2.1.04.-77). MPE is a scientific and technical norm which ensures, that concentration of pollutants in a ground air layer from a source or their sum does not exceed normative concentration of these substances in the air (MAC).

Unit of MPE is quantity of substance, which are discharged in unit of time (gram per second, (g/s). MPE for each stationary source is established subject to that emissions of harmful substances from such source of pollution with the background

pollution will not create concentration in the ground layer of the atmosphere, exceeding the MAC, that is, the condition is necessary

$$C + Cb \leq MAC,$$

where C – concentration of pollutant, Cb - background concentration of this pollutant.

In a case when concentration of harmful substance exceeds the allowable concentration and it is reduced phased, the temporarily agreed emission (TAEs) are established. In this case for each phase are established TAE. They are revised once every five years.

MPE for heated emissions from a single source with a round hole or

Groups of sources closed to each other when the background concentration of mixtures is established as independent from velocity and direction of the wind and is the constant in the area, are determined by formula

$$MPE = \frac{(MAC - C_b) \cdot H^2 \cdot \sqrt[3]{V_1 \cdot \Delta T}}{A \cdot F \cdot n \cdot m \cdot \eta}$$

where H is height of chimney, meters; V_1 – volume of polluted air, g per second,

ΔT - alteration between temperature of emission and temperature of the environment, Celsius degree; *AFmnη* – coefficients

4. As part of the permitting process, emissions are to be regularly monitored by the industries themselves and sporadically checked by independent accredited laboratories. The industry labs that perform the regular monitoring need to be accredited too. The industries also have the option of using independent laboratories for regular monitoring.

Quarterly and annual reports are a normal mechanism for reporting of emissions to the authorities by enterprises. These reports are the basis for payment of emission charges within the established limits.

Smaller industries are normally not required to monitor their emissions. Their emissions reporting is based on the use of emission factors calculations.

In Ukraine, only a limited number of industries monitor environmental quality in their surroundings. Ambient environmental monitoring by industries is voluntary and is often linked to ISO 14000 certification.

4.1. Accordingly, the level of atmospheric pollution by a single pollutant is expressed in general terms through a single (partial) pollution index

$$I_i = \left(\frac{C_{avg}}{MAC_i} \right)^{a_i},$$

where *Cavg* -is the average concentration of the substance*; MACi* - is the daily average MAC of the substance, *at* - is the dimensionless constant of revaluation of the level of harmfulness of a substance to the harmfulness of sulfur dioxide.

Table 3.1 Classes of potential danger of standardized substances

Hazard class	Level of danger	MAC, mg/m^3	API
I	Extremely dangerous	≥0,1	1.7
II	Highly dangerous	0,1 –1,0	1.3
III	Moderately dangerous	1,0 –10,0	1.0
IV	Low risk	>10.0	0.9

The obtained API indicates how many times the total level of atmospheric pollution by several substances exceeds the MAC of sulfur dioxide (Tab. 3.1).

For each city a specific list of five priority air pollutants has been determined, which is used to calculate the atmospheric pollution index API_5.

For Kyiv the total pollution index (API_5) is determined by such substances as nitric oxide (IV), carbon monoxide (II), sulfur oxide (IV), dust, hydrogen chloride.

According obtained score there are 4 classes of air pollution

$API_5 \leq 5$ - low;

$5 < API_5 < 7$ – increased;

$7 \leq API_5 < 14$ - high;

$API_5 \geq 14$ - very high.

4.2. The level of atmospheric pollution by several substances is expressed through the total (integrated) air pollution index I_{TAPI}.

$$I_{TAPI} = \sum_{i=1}^{n} I_i = \sum_{i=1}^{n} \left(\frac{C_{avg}}{MAC_i} \right)^{a_i},$$

where n - is the number of harmful substances.

4.3. For the development of environmental protection measures, the focus is to determine the hazard category of the enterprise and the distribution of harmful substances (Tab. 3.2).

The enterprise hazard category (CNP) depending on the pollutants emitted into the atmosphere, can be calculated by the formula:

$$\text{CNP} = \sum_{i=1}^{n} \left(\frac{M_i}{MAC_{ad}^{i}} \right)^{a_i},$$

M_i - emission mass of j substance, ton per year

MAC_i -daily average maximum allowable concentration of j substance, mg per m^3

J - constant defined according hazard class of substance.

Table 3.2 Hazard category of the enterprise

Hazard category of the enterprise	Value of hazard category of the enterprise	Size of sanitary protection zone, meter
I	**$\geq 10^8$**	**1000**
II	**$10^8 \leq CNP \geq 10^4$**	**500**
III	**$10^4 \leq CNP \geq 10^3$**	**300**
IV	**$\leq 10^3$**	**100**

Depending on hazard category of the enterprise, the pollutant emissions into the atmosphere are considered and the periodicity of the control of emissions of the enterprises, as well as the sanitary protection zone from sources of pollution to residential areas (SPAs) is designed.

Control questions

1. What is the index of air pollution?
2. How do you read the air pollution index?
3. What are the six levels of air quality?
4. How can you tell if air pollution is affecting you?
5. Where is the best air quality in the world?

Lecture 4. Norms of anthropogenic load on the water objects

1. Pollution Factors Affecting Water
2. Norm of water quality
    2.1 Organoleptic properties
    2.2. Colored water
    2.3. Taste and odor problems
3. Physical Indicators
    3.1 Water temperature
    3.2. Turbidity
    3.3. Water Clarity
4. Chemical indicators
    4.1 pH and total mineralization
    4.2. Dissolved Oxygen
    4.3. Chemical oxygen demand (COD)
    4.4. Biochemical oxygen demand (BOD)
5. Biological Indicators
    5.1. Macroinvertebrates
    5.2. Bacterial indicators
6. Maximum permissible discharge

1. Pollutants can be released into the environment as gases, liquids, dissolved substances, or particulates, and can enter aquatic ecosystems by atmospheric deposition, soil erosion, seepage, runoff, or direct discharge. Pollution that can be attributed to a single source, such as a sewage outfall, is known as point source pollution. Pollution that originates from diffuse sources rather than from one discrete location—for example, runoff that carries pesticides into the water from agricultural fields—is known as non-point source pollution.

Pollution can be released into the environment with different frequencies. Some sources of pollution may discharge continuously, while others may release pollution only occasionally. Sources of pollution can also vary periodically or cyclically—for example, in the spring when ice begins to melt, pollutants deposited on land during the winter months can be flushed into the river system. Still other sources of pollution—including accidental releases of contaminants, and pollution associated with disasters such as fires and floods—occur infrequently.

The effect of pollution on aquatic environments depends on pollution patterns as well as environmental conditions. For example, pollution during periods of high river flow may result in lower concentrations of contaminants than the same discharge released during periods of low river flow. Pollution prevention and management strategies must consider the amount and timing of pollution as well as its interaction with variable natural conditions.

The effect of pollution also depends on the type of pollutant. Pollutants in the water column can undergo chemical transformation, be taken up by aquatic animals or plants, flushed downstream, or adsorb (attach) to aquatic sediments. Some pollutants can persist for years in sediments and can be re-released into the water column depending on environmental conditions (e.g. pH, dissolved oxygen levels).

2. Norm of water quality

1. Sanitary and hygienic norms (for population)

2. Fish breeding norms

BASIS:

1.MAC of pollutants in water or ASL

2.Physical properties

3.Chemical properties

4.Radioactive properties

5.Biological properties: bacteriological (microbiological) and hydrobiological

The Maximum Allowable Concentrations (MAC) is a level that has been established for certain substances that are known or suspected to cause adverse health effects.

The approximate safe level (ASL) in water of water bodies for drinking and domestic water use is a temporary hygienic standard developed based on calculation and express experimental methods for predicting toxicity and applied only at the stage of preventive sanitary supervision of designed or projects under construction, reconstructed treatment plants.

2.1The organoleptic properties is established for parameters that may impair the taste, smell, or color of water; or which may interfere with the supply of good quality water. They do not cause adverse health effects.

- Odor in water may be defined as that sensation that is due to the presence of substances that have an appreciable vapour pressure and that stimulate the human sensory organs in the nasal and sinus cavities.

- Perhaps the most common cause of watercolor is the presence minerals. Red and brown colors are due to iron; black to manganese or organic matter; and yellow to dissolved organic matter such as tannins. Iron and manganese are common, at least in small amounts, in most rocks and sediments.

- Not sweet or salty, just tasteless. Pure water is colorless, odorless and tasteless. *No taste + No aroma = No flavor*. Mineral water- what we drink everyday- has chlorine added to the supply to destroy bacteria and other microbes.

- Transparency is how easily light can pass through a substance. In lakes this means how deep sunlight penetrates through the water.

Organoleptic properties of water, temperature and floatable substance are physical characteristic of natural water.

2.2. *Green or blue water*: Usually caused by corrosion of copper plumbing. If corrosion is occurring, dripping water will leave a bluish-green stain on porcelain fixtures. Certain metals that can get into drinking water from corrosion, such as

copper or lead, may pose a health concern. Overly corrosive water may cause a problem with the home's piping. If you suspect corrosion, contact your water utility or a licensed plumber.

Black or dark brown water: Often caused by manganese in the water or pipe sediment. If the water doesn't clear after a few minutes of flushing all your cold-water faucets and toilets, wait about an hour and try again. If it still isn't clear, contact your water utility. If you have your own well, you may need a licensed plumber to evaluate and correct the problem. Check with your local health agency for advice.

Brown, red, orange or yellow water: Usually caused by iron rust. Galvanized iron, steel, or cast-iron pipes in a home or business, or the water main can cause rusty water. While unpleasant and potentially damaging to clothes and fixtures, iron in drinking water is not a human health concern.

Milky white or cloudy water: Usually caused by tiny air bubbles. If your water is white, fill a clear glass with water and set it on the counter. If the water starts to clear at the bottom of the glass first, the cloudy or white appearance is trapped air. It is not a health threat and should clear in a few minutes. If you have your own well, the pumping system may be causing this issue. You may need a qualified contractor to determine how it to correct it.

2.3. *Petroleum, gasoline, turpentine, fuel, or solvent odors*: These odors are rare, but potentially serious. Do not use the water. A leaking underground storage tank may be contaminating your water supply. Immediately contact your water utility or local health agency.

Metallic taste: Iron or copper, may leach into the water from the pipes. Less common metals, such as zinc and manganese, could also be a problem. If you are concerned, have your water analyzed by a certified lab, or contact your water utility. Ask your local health agency for a list of qualified labs.

Chlorine, chemical, or medicinal taste or odors: Adding chlorine to the water or the interaction of chlorine with a build-up of organic matter in your plumbing

system may cause the taste or odor to be strong. This is not usually an immediate health threat. If the taste or odor seems strong to you, contact your local health agency or water utility for advice.

Sulfur or rotten egg odor: Bacteria growing in your sink drain or hot water heater may cause odor. Naturally occurring hydrogen sulfide in your water supply may also cause this odor. To evaluate the cause, put a small amount of water in a narrow glass, step away from the sink, swirl the water around inside the glass, and smell it. If the water has no odor, the likely problem is bacteria in the sink drain. If the water does have an odor, it could be from your hot water heater. There is an element in your hot water heater designed to protect it from corrosion. Sometimes the element causes sulfide smell as it deteriorates over time. A licensed plumber may be able to evaluate this problem. If you rule out the drain and the water heater, and the odor is coming from the tap water, do not use it. Contact your water utility or local health agency.

Moldy, musty, earthy, grassy, or fishy odor: Bacteria growing in a sink drain or from organic matter such as plants, animals, or bacteria that are naturally present in lakes and reservoirs during certain times of the year may cause odor. You can evaluate the source of this problem by putting a small amount of water in a narrow glass, stepping away from the sink, swirling the water around inside the glass, and smelling it. If the water has no odor, the likely source is the sink drain. If it does have an odor, the source could be organic matter in water. Although harmless, this material can affect the taste and smell of your drinking water even at very low concentrations.

Salty taste: High levels of naturally occurring sodium, magnesium, or potassium may cause a salty taste. If you live in a coastal area, seawater may be seeping into the fresh water supply. This could be a health threat. Contact your water system or local health agency.

3. Physical properties of water quality include temperature and turbidity.

3.1. *Water temperature* is one of the most important characteristics of an aquatic system, affecting:

Dissolved oxygen levels. The solubility of oxygen decreases as water temperature increases.

Chemical processes. Temperature affects the solubility and reaction rates of chemicals. In general, the rate of chemical reactions increases with increasing water temperature.

Biological processes. Temperature affects metabolism, growth, and reproduction.

Water temperature fluctuates between day and night (diurnal temperature changes) and over longer time periods (e.g., seasonally). In the spring, snowmelt running into rivers reduces the water temperature to below the ambient air temperature. Permafrost also contributes to cold water runoff when it begins to thaw in June or July, and its meltwater seeps into the river.

Water temperature varies along the length of a river with latitude and elevation but can also vary between small sections only meters apart, depending on local conditions. For example, a deep, shaded pool is cooler than a shallow, sunny area. In lakes, temperature can vary with depth, according to the level of solar radiation penetration and mixing characteristics. The temperature of surface water is usually between 0ºC and 30ºC, although the temperature of hot springs may exceed 40ºC.

Human activities affecting water temperature can include the discharge of cooling water or heated industrial effluents, agriculture and forest harvesting (due to effects on shading), urban development that alters the characteristics and path of stormwater runoff, and climate change.

3.2. *Turbidity* is an optical determination of water clarity.

1. Turbid water will appear cloudy, murky, or otherwise colored, affecting the physical look of the water. Suspended solids and dissolved colored material reduce water clarity by creating an opaque, hazy or muddy appearance. Turbidity

measurements are often used as an indicator of water quality based on clarity and estimated total suspended solids in water.

The turbidity of water is based on the amount of light scattered by particles in the water column

2. The more particles that are present, the more light that will be scattered. As such, turbidity and total suspended solids are related. However, turbidity is not a direct measurement of the total suspended materials in water. Instead, as a measure of relative clarity, turbidity is often used to indicate changes in the total suspended solids concentration in water without providing an exact measurement of solids (Fig.4.1).

Figure 4.1 Tannins from decomposing vegetation have colored this river red.

Turbidity can come from suspended sediment such as silt or clay, inorganic materials, or organic matter such as algae, plankton and decaying material. In addition to these suspended solids, turbidity can also include colored dissolved organic matter (CDOM), fluorescent dissolved organic matter (FDOM) and other dyes. CDOM is also known as humic stain. Humic stain refers to the tea color produced from decaying plants and leaves underwater due to the release of tannins and other molecules.

This discoloration is often found in bogs, wetlands or other water bodies with high amounts of decaying vegetation in the water. CDOM can cause water to appear

red or brown, depending on the type of plants or leaves present. These dissolved substances may be too small to be counted in a suspended solids concentration, but they are still part of a turbidity measurement as they affect water clarity.

3.3. *Water clarity* is a physical characteristic defined by how clear or transparent water is. Clarity is determined by the depth that sunlight penetrates in water. The further sunlight can reach, the higher the water clarity. The depth sunlight reaches are also known as the photic zone. The clearer the water, the deeper the photic zone and the greater the potential for photosynthetic production 10. The photic zone (and thus water clarity) has a maximum depth of 200 m based on the light absorption properties of water.

Water clarity is directly related to turbidity, as turbidity is a measure of water clarity. The transparency of water is affected by the amount of sunlight available, suspended particles in the water column and dissolved solids such as colored dissolved organic material (CDOM) present in the water.

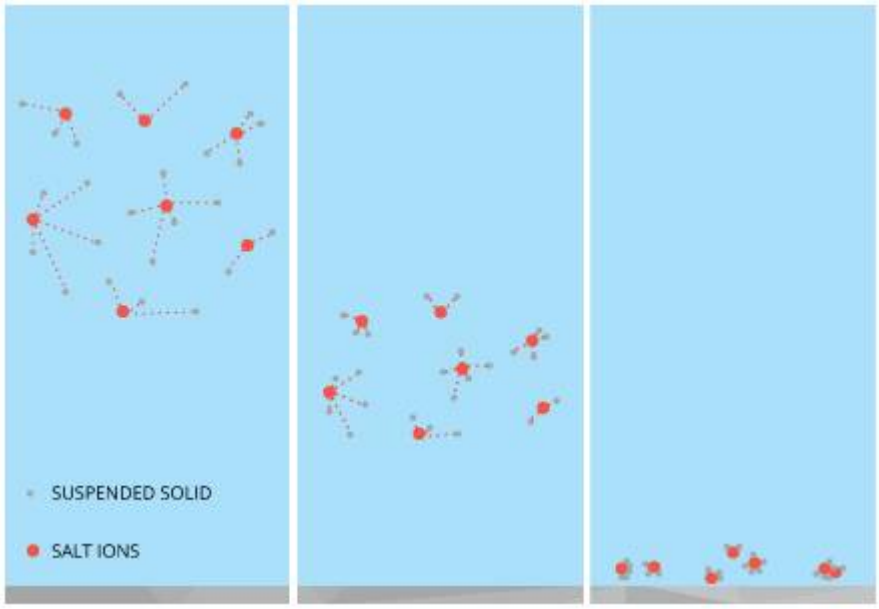


Figure 4.2 Salt ions can cause suspended particle to aggregate and settle at the bottom of a body of water (https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/#:~:text=Water%20clarity%20is%20directly%20related,CDOM)%20present%20in%20the%20water.)

Salinity also affects water clarity. This is because of salt on the aggregation and settling velocity of suspended particles. In other words, salt ions collect suspended particles and bind them together, increasing their weights and thus their likelihood of settling to the bottom. Due to this mechanism, oceans and estuaries tend to have a higher clarity (and lower average turbidity) than lakes and rivers. These marine environments also have a higher rate of sedimentation as solids are pulled out of the water column to the seafloor.

Turbidity vs Suspended Solids – What is the difference?

Turbidity and total *suspended solids* refer to particles present in the water column. Turbidity and water clarity are both visual properties of water based on light scattering and attenuation. All three parameters are related to particles in the water column, whether directly or indirectly.

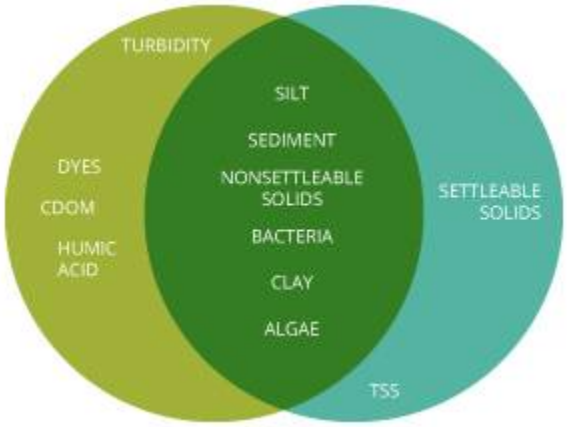


Figure 4.3 While turbidity and total suspended solids often overlap, there are a few outlying factors that only contribute to one or the other
(https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/#:~:text=Water%20clarity%20is%20directly%20related,CDOM)%20present%20in%20the%20water)

Turbidity is determined by the amount of light scattered off these particles. While this measurement can then be used to estimate the total dissolved solids concentration, it will not be exact. Turbidity does not include any settled solids or bedload (sediment that "rolls" along the riverbed). In addition, turbidity measurements may be affected by colored dissolved organic matter. While this dissolved matter is not included in TSS measurements, it can cause artificially low turbidity readings as it absorbs light instead of scattering it.

Total suspended solids, on the other hand, are a total quantity measurement of solid material per volume of water. This means that TSS is a specific measurement of all suspended solids, organic and inorganic, by mass. TSS includes settleable solids and is the direct measurement of the total solids present in a water body. As such, TSS can be used to calculate sedimentation rates, while turbidity cannot.

Water clarity is strictly relative to sunlight penetration. While this is usually determined by the amount of suspended solids in water, it can also be affected by CDOM and other dissolved solids 10. Water clarity is the most subjective measurement of these three parameters, as it is usually determined by human observation.

4. Chemical characteristics involve parameters such as pH, heavy metals, nitrate, orthophosphates, pesticides , surfactants and dissolved oxygen.

4.1. *pH* is a measurement of the hydrogen ion (H+) concentration in water and is commonly used to describe the acid/base balance of water. Water pH affects both biological and chemical processes. Values of pH below 4.5 and above 9.5 are usually lethal to aquatic organisms.

pH affects the solubility of organic compounds, metals, and salts. *For instance, ammonia is a common toxic chemical in water, and takes two forms: ammonia, NH_3, and the ammonium ion, NH^{4+}. The relative proportion of the two forms depends on pH and temperature. Unionized ammonia (NH_3) is more toxic to aquatic organisms because it can cross biological membranes such as gills.

Generally, natural waters have a pH of between 5 and 9 and most aquatic organisms survive in waters within this range. Except for some bacteria and microbes, if pH goes higher or lower than this range, aquatic life is likely to perish.

Dry residue (total mineralization) *includes solutes such as sodium, calcium, magnesium, bicarbonate, chloride and others that remain as a solid residue after evaporation of water from the sample. Fresh water usually has TDS levels between 0 and 1000 mg/L, depending on the geology of the region, climate and weathering, and

other geographical features that affect sources of dissolved material and its transport to a water system.

4.2. The *amount of oxygen* that dissolves in water can vary in daily and seasonal patterns, and decreases with higher temperature, salinity, and elevation. The maximum solubility of oxygen in water at 1 atm pressure (standard air pressure at sea level) ranges from about 15 mg/L at 0ºC to 8 mg/L at 30ºC—that is, ice-cold water can hold twice as much dissolved oxygen as warm water. Dissolved oxygen comes from the atmosphere and from photosynthesis by aquatic plants, and is depleted through chemical oxidation and respiration by aquatic animals and microorganisms, especially during the decomposition of plant biomass and other organic material.

Surface water, near the water-atmosphere interface and with enough light for photosynthesis, is generally saturated or even supersaturated with oxygen. Deeper water receives oxygen through mixing by wind, currents, and inflows. Mixing and aeration also occur at waterfalls and rapids. Dissolved oxygen can be reduced to very low levels during the winter months when water is trapped under ice.

Dissolved oxygen is essential for a healthy aquatic ecosystem. Fish and aquatic animals need the oxygen dissolved in the water to survive. The need for oxygen depends on the species and life stage; some organisms are adapted to lower oxygen conditions, while others require higher concentrations. Dissolved oxygen can affect the solubility and availability of nutrients, which can be released from sediments under conditions of low dissolved oxygen.

4.3. In environmental chemistry, the *chemical oxygen demand (COD*) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is commonly expressed in mass of oxygen consumed over volume of solution which in SI units is milligrams per liter (mg/L). A COD test can be used to easily quantify the amount of organics in water. The most common application of COD is in quantifying the amount of oxidizable pollutants found in surface water (e.g. lakes and rivers) or wastewater. COD is useful in terms of water

quality by providing a metric to determine the effect an effluent will have on the receiving body, much like biochemical oxygen demand (BOD).

4.4. *Biochemical oxygen demand (BOD*) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water.

BOD reduction is used as a gauge of the effectiveness of wastewater treatment plants. BOD of wastewater effluents is used to indicate the short-term impact on the oxygen levels of the receiving water.

BOD analysis is similar in function to chemical oxygen demand (COD) analysis, in that both measure the amount of organic compounds in water. However, COD analysis is less specific, since it measures everything that can be chemically oxidized, rather than just levels of biologically oxidized organic matter.

5. One important way to determine the status of water's living systems is through biological assessment (bioassessment), which is the use of biological surveys and other direct measurements of living systems within a watershed. Aquatic macroinvertebrates (animals without backbones that live in aquatic environments and are large enough to be seen without the aid of a microscope or other magnification) are commonly monitored and are the basis of Part I of this activity.

5.1. *Macroinvertebrates* are valuable indicators of the health of aquatic environments in part because they are benthic, meaning they are typically found on the bottom of a stream or lake and do not move over large distances. Therefore, they cannot easily or quickly migrate away from pollution or environmental stress. Because different species of macroinvertebrates react differently to environmental stressors like pollution, sediment loading and habitat changes, quantifying the

diversity and density of different macroinvertebrates at a given site can create a picture of the environmental conditions of that body of water.

If exposed to an environmental stressor (e.g., pollution, warming due to low flows, low dissolved oxygen due to algal blooms, etc.), those macroinvertebrates that are intolerant to that stress may perish. Tolerant macroinvertebrates often inhabit the spaces left by the intolerant organisms, creating an entirely different population of organisms. For example, an unimpacted body of water will typically contain most macroinvertebrates that are intolerant of environmental stressors, such as *Mayflies* (*Ephemeroptera*), *Stoneflies (Plecoptera*) and *Caddisflies (Trichoptera*). A body of water that has undergone environmental stress may contain most macroinvertebrates that are tolerant of these conditions such as leeches (*Hirudinea*), *Tubifex worms* (*Tubifex* sp.), and *Pouch Snails (Gastropoda*).

5.2. The coliform index is a rating of the purity of water based on a count of fecal bacteria. It is one of many tests done to assure enough water quality. Coliform bacteria are microorganisms that primarily originate in the intestines of warm-blooded animals. By testing for coliforms, especially the well-known *Escherichia coli* (*E. coli*), which is a thermotolerant coliform, can determine if the water has possibly been exposed to fecal contamination. That is, whether it has meet human or animal feces. It is important to know this because many disease-causing organisms are transferred from human and animal feces to water, from where they can be ingested by people and infect them. Water that has been contaminated by feces usually contains pathogenic bacteria, which can cause disease.

*Coli titer is a quantity of *Esherichia colli* (bacteria) per 0,333 liter of water

*Coli index is a quantity of *Esherichia colli* (bacteria) per 1 liter of water.

6. In case of wastewater discharge into water objects, entrepreneur is obligated to approval the *maximum permissible discharges (MPD)* in accordance to «Sanitary rules and norms of surface water protection from pollution» (SRN №4630-88) and to «Water Code of Ukraine».

The maximum permissible discharges are maximum permissible mass of substances of wastewater that discharge due to the established order and regime at object of discharge for certain period for guaranty quality of water.

Maximum permissible discharge (MPD) is a limit of permissible mass of pollutant in waste waters in unit time. It is established to provide legally permissible water quality on control points.

For right calculation of MPD it is necessary to consider the maximum allowable concentrations (MAC) at places of water use, ability of water object for assimilation and for distribution mass of substances, which come into wastewater, between water users. The norms of MPD are defined as to operating sources of pollution and to objects are in project stage. It worth to note that enterprises in the discharges which are substances with undefined MAC, putting into operation is prohibited. If during activity entrepreneur exceeds norms of water abstraction, or uses ineffective treatment equipment which leads to water objects pollution, or does not comply other norms and rules in the sphere of water use and water objects protection, so local power bodies will send a prescript for corrective actions with a defined term.

Information about maximum permissible discharges must be noted in permission for special water use according to the Act of Cabinet of Ministers of Ukraine «On order for design and approval norms of maximum permissible discharges (MPD) of wastewater substances into water objects», approved by the Order of Ministry of ecology №116 from 15th of December 1994.

Control questions

2. What is the odor of water?
3. What causes smelly water?
4. Is it safe to drink smelly water?
5. What causes color water?
6. What is the taste of the water?

7. What is water transparency?
8. Why is the water transparent?
9. How do you measure water transparency?

Lecture 5. Evaluation methods of water quality

1. Water quality
2. Maximum allowable concentration of water chemical
3. The limiting sign of hazard of chemicals of fish breeding
4. Integral estimation of water quality by hydrochemical characteristics
5. Hydrochemical Water Pollution Index
6. Water Pollution Index
7. Saprobiont Index

1. Water pollution is any chemical, physical or biological change in the quality of water that has a harmful effect on any living thing that drinks or uses or lives (in) it. When humans drink polluted water it often has serious effects on their health.

There are several classes of water pollutants. The first are disease-causing agents. These are bacteria, viruses, protozoa and parasitic worms that enter sewage systems and untreated waste.

A second category of water pollutants is oxygen-demanding waste; waste that can be decomposed by oxygen-requiring bacteria. When large populations of decomposing bacteria are converting this waste, it can deplete oxygen levels in the water. This causes other organisms in the water, such as fish, to die. A third class of water pollutants is water-soluble inorganic pollutants, such as acids, salts and toxic metals. Large quantities of these compounds will make water unfit to drink and will cause the death of aquatic life.

Another class of water pollutant is nutrients. They are water-soluble nitrates and phosphates that cause excessive growth of algae and other water plants, which deplete the water's oxygen supply. This process kills fish and, when found in drinking water, can kill young children.

Water can also be polluted by a number of organic compounds such as oil, plastics and pesticides, which are harmful to humans and all plants and animals in the water.

A very dangerous category is suspended sediment, because it causes depletion in the water's light absorption and the particles spread dangerous compounds such as pesticides through the water.

According to the Water code of Ukraine, the estimation of water quality is determined on the basis of standards of environmental safety of water consumption and ecological standards of water quality.

The limiting sign of hazard (LSH) is a sign characterized by the smallest harmless concentration in water. It is a sign that determines the earliest and most likely nature of the adverse effect in the event of the appearance in water of a chemical substance in a concentration exceeding the maximum permissible concentration.

For water of domestic and drinking purposes there are three types of LSH – sanitary and toxicological, general sanitary and organoleptic. Sanitary and toxicological means concentration, when exceeding which the substance becomes toxic to humans. The general sanitary normalizes the effect of this substance on the natural properties of the reservoir and its ability to neutralize organic substances. Organoleptic threshold concentrations changing organoleptic properties of water, which water changes taste, color, smell, and is also characterized by the formation of foam or film.

The MAC is established based on the definition of LSH - the smallest of three. Example: Copper is toxic to humans at 10 mg/l, breaks the processes of self-

purification of the hydro ecosystem at 5 mg/l, gives water a taste at 1 mg/L. The last value is the smallest of three, so here LSH is organoleptic, and economic and drinking MPC - 1 mg / L.

2. Maximum allowable concentration of water chemical

Maximum allowable concentration for water is a concentration of a harmful substance in the water, which should not produce direct or indirect effect on the human being throughout life or on health of the next generations, and which should not worsen hygienic conditions of the water use.

Maximum allowable concentration of water used for fish breeding (MAC_f) is a concentration of harmful substances in water, which should produce no harmful effect on fish stock, and, notably, commercial fish stock.

MAC_f is often considered as an environmental standard, which is not correct. Practically, MAC*f* is the concentration of a harmful substance in water, which effect on the environment is accompanied with the following conditions:

•No fish or organisms die;

•No species of fish, which earlier inhabited the water, disappear;

• no fish or organisms, valuable as a food, are replaced with species, inappropriate for food;

•No damage of commercial properties of the fish is observed,

•No changes, which may potentially result in death of fish, replacement of fodder or loss of commercial properties of the species, occur.

3. For water for fish breeding purposes there are five types of LSH

•sanitary and toxicological,

• general sanitary,

• organoleptic,

• toxicological: presence chemicals in water with toxic effect for fish

•fish breeding: characteristic of food base of fish.

$MACs_f$ are usually more stringent, than MPC_{sw}.

It should be emphasized, that it is fishery and consumer protection in the first place, although certain principles of environmental water protection, have been considered within the standards.

However, since they are established, they are not based upon the characteristics of geographical zones, biogeochemical provinces, hydrological conditions, which speaks for commerce being the priority (Tab.5.1).

Table 5.1 Ratio between MACs of some substances in water

Substance	MAC_f, mg/l	MACw, mg/l
Mercury and other non-organic compounds (Hg)	0,0001	0,0005
Ammonium fluoride	0,05	0,7

4. The grade of excess MAC_f is calculated for each ingredient based on actual concentration (Ki) and frequency of occurrence (Hi), as well as the general assessment grade (Bi).

$Ki = C_i / MAC_i$

$Hi = (N_{MACi}/N_i)\cdot 100\%$

$Bi = Ki * H_i$,

where Ci — is the concentration of i ingredient,

MACi — maximum allowable concentration of i ingredient for waters of one limiting sign of hazard used for commercial fishery;

N_{MACi} — number of frequencies of MAC excess (i ingredient);

N_i — total number of measurements of the i ingredient

5. As it is with the atmospheric air, various indices are used to ensure comparative analysis of water pollution. These indices allow analysis of several polluting substances. The most used index is the complex hydrochemical water pollution index (referred to as wpi in formulas). It is obtained through the following formula:

$$WPI = \frac{\sum_{i=1}^{n} \frac{C_n}{MAC_n}}{N} \text{ WHERE}$$

C_n — concentration of the component (or parameter value);

MAC_n — the established value for the relevant type of water hazard n — number of properties, used to calculate the index

6. Normally, *water pollution indices* are calculated upon six or seven hydrochemical properties, including content of dissolved oxygen [O_2], pH, BOD_5.

Depending on *water pollution index*, areas of water are divided in classes (Tabl.5.2).

Table 5.2 Water quality classes

Waters	Water pollution index	Water quality classes
Very clean	Up to 0,2	1
Clean	0,2–1,0	2
Moderately polluted	1,0–2,0	3
Contaminated	2,0–4,0	4
Polluted	4,0–6,0	5
Very polluted	6,0–10,0	6
Exceptionally polluted	>10,0	7

7. Integral characteristics of the quality also include the *saprobiont index*, which is calculated based on individual properties of the species of saprobiont, present in various aquatic communities (phytoplankton, periphyton):

$$S = \sum S_i \cdot h_i / N,$$

where S_i – is the value of the individual saprobiont index of the i-th aquatic organism, which is established through special reference tables;

h_i – relative frequency of occurrence of indicative organisms (when under the microscope);

N – number of indicative organisms selected (usually, N>30).

The S_i value represents the sum of the physiological and biochemical properties of an aquatic organism, which can inhabit in water containing a certain amount of organic substances.

Therefore, the index characterizes the nutritive status of the water body. Water quality is regulated according to the value of S_i (Tabl.5.3).

Table 5.3 Saprobiont Index

Rate of pollution	Zones	Saprobiont indices, S	Water quality classes
Unpolluted	Xenosaprobic	Up to 0,50	1
Little polluted	Oligosaprobic	0,50–1,50	2
Moderately polluted	β-mesosaprobic	1,51–2,50	3
Strongly polluted	α-mesosaprobic	2,51–3,50	4
Excessively polluted	Polysaprobic	3,51–4,00	5
Ecologically destroyed	Hyperpolysaprobic	>4,00	6

Control questions

1. What is permissible limit?
2. What is the limiting sign of hazard of water?
3. What are hydrochemical characteristics of water?
4. What is saprobiont index?

Lecture 6. Microflora and indicative bacteria of water. The methods of studying

1. Microbiota water
2. Main sources of biological pollution
3. The sanitary and bacteriological analysis
4. Determination of the total number of microorganisms in the water
4.1. Identification of bacteria of E. coli group

1. In the seas, rivers, lakes and other bodies of water as well as groundwater contains many species of microorganisms. The combination of all the microorganisms of water body is called "microbiol plankton." Microbiota of natural waters largely depends on their origin. There are fresh and sea water. Fresh waters are divided into superficial, including flow (rivers, streams) and standing (lakes, ponds, reservoirs), groundwater (soil, groundwater, artesian) and atmospheric (rain, snow). All these groups are studied Water Hydrobiology. The growing shortage of fresh water on Earth makes pay serious attention on the development of the ecosystem in the pond and processing of water contamination. Water - the natural habitat of microbes, the bulk of which comes from soil, dust settling from the air, waste, sewage and industrial livestock facilities and others. A lot of microorganisms in open ponds and rivers, they are often found in muddy sediments of oceans, seas, swamps, mineral waters. Quantity of living microorganisms in water depends mainly on the properties of wastewater and industrial waste. By constantly living microorganisms in water include Azotobacter, Nitrobacter, Micrococcus, Pseudomonas, Proteus, Spirillum and others. Deep groundwater, artesian water is almost free of microorganisms.

Microbiota of water forms two groups: autochthonous (water) and allochthonous (come outside as pollution) microorganisms. Autochthonous microbiota it is microorganisms that permanently live in water. Microbial

composition of water is depended of soil microflora, which faces water (bottom and coastal soil). Allochthonous microbiota is microorganisms that was added to water by accident and live in it relatively short time. The proportion of microorganisms in open water verities widely depending on the type of reservoir, the degree of pollution, changing weather conditions, seasons.

2. The sources of river water pollution are domestic and industrial wastewater often. In open water most of the bacteria comes from the soil. Therefore, in lakes, ponds and rivers the highest content of microbiota noted in the coastal zone. In the water live all known groups of microorganisms, but the most significant component of population water - bacteria. As you know, cytoplasmic membrane of bacteria can actively transfer through the cell wall the nutrients. This bacterium can consume nutrient substrate present in minute concentrations (1-5 mg per day).

Therefore, any water source must expose sanitary microbiological assessment. Self-cleaning water is caused by several factors:

- fast current of water, leading to decrease of concentration of organic substances;
- bactericidal action insolation;
- mineralization of organic compounds by microbes;
- existence food chain: bacteria - simple - insects – fish - animals - man;
- adsorption of solid particles of sludge;
- adsorption of the plants;
- effect of volatile chemicals.

Water is a factor of transmission of many infectious disease pathogens. In open water it is detected intestinal pathogens and natural fecal infections. In the sediments of ponds and lakes often live pathogens of botulism. Pathogenic microorganisms of reservoirs can enter the food chain and transfer them to different groups of animals, birds and fish. It was shown that waterway is contributory cause of typhoid fever,

bacterial and amebic dysentery, cholera, leptospirosis, polio, hepatitis A and E and other diseases.

3. The sanitary and bacteriological analysis

- the total microbial count (total number of microorganisms in 1 ml);
- pathogenic microorganisms;
- number of bacteria groups of *E. coli* as an indicator of the degree of fecal contamination.

Secondary analysis includes titer *CI. perfringens*, index bacteriophage and *Giardia cysts*. The presence of pathogens is determined by epidemiological indicators. Among the facilities of microbiological controls, the most important place is water quality control.

In accordance with the existing regulations subject of control is:

- Drinking water (central and local supply);
- Water of swimming pools; water of open reserves;
- Wastewater;
- Purified water to prepare drugs;
- Water for injection and eye drops.

The warning of surveillance exercises:

1. Water of sewage areas;

2. Control of water pollution of the sanitary pools, beaches, places of collective recreation.

Current sanitary inspection is:

1. Assessment of the quality of rotatable water supply of settlements;

2. Assessment of status of surface water of biological contamination and the ability of water to clear itself;

3. Control of the disinfection of wastewater;

4. Epidemic control of the possible transmission of infectious diseases.

4. Determination of the total number of microorganisms in the water

4.1. Detection indicates fecal contamination of fresh water. *E. coli* bacteria are detected by different methods. The most common method is membrane filters. To determine bacteria of *E. coli* group, use this Zeitz method. In Bunsen flask after sterilization is placed acetate cellulose membrane. The volume of water is passed through the filter with the vacuum pump. Before new tests filtration apparatus are sterilized. Then the filters are placed on the surface of Endo medium in petri dishes and incubated in thermostat during 24 hours at 37ºC. In the structure of medium Endo is lactose as indicator. Therefore, bacteria of E. coli group have red colonies with a metallic sheen. Count of the number of colonies, prepare them smears and Gram stain and check oxidase activity. Oxidase negative bacteria decompose lactose to acid and gas discovered in the filter. In the analysis of drinking water, quantity of bacteria of E. coli group is calculated in 100 ml. For differentiation of bacteria of E. coli group and thermotolerant bacteria of E. coli group each colony is grown on the filter in two test tubes with lactose medium. One of the tubes is heated to 44ºC for inactivation of bacteria. Then this tube incubated at the same temperature for 24 hours. The second tube is cultivated in thermostat at 37ºC for 48 hours to verify the presence of bacteria of E. coli group. The polluted water of open water object is filtrated in volume not less than 10 ml. Further research is carried out as described above. For detection of bacteria in water samples is used two-phase fermentation method.

The first phase (first day) – growth on the Eijkman lactose medium for gas collection and incubation in thermostat at 43oC for 24 hours. For growth of small volumes of water used Eijkman diluted medium (1% peptone; 0,4% NaCl, 0,5% glucose). For cultivation of large volumes Eijkman concentrated medium is added 10 multiple concentration of the main components. It is prepared two water samples in 100 ml flasks with 10 ml of medium and ten samples of 10 ml of water in tubes with 1 mL of medium. Therefore, the amount of water is 300 ml: 2 flask of 100 ml and 10 tubes of 10 ml.

The second phase (2nd day) - full-grown bacterial colonies is transferred on Endo medium in the flasks and tubes. Colonies of *E. coli* growth in the Eijkman medium and liberate gas from lactose at 37^{O}C for 24 hours.

The third stage (3rd day). Signs of growth of *E. coli* on Endo medium are formation of colonies of red color with metallic luster. Carry out biochemical identification of *E. coli* - cytochrome oxidase test. The oxidase test is a test used in microbiology to determine if a bacterium produces certain cytochrome c oxidases. It uses disks impregnated with a reagent such as N,N,N′,N′-tetramethyl-p-phenylenediamine (TMPD) or N,N-dimethyl-p-phenylenediamine (DMPD), which is also a redox indicator. The oxidase test is a key test to differentiate between the families of *Pseudomonadaceae* (ox +) and *Enterobacteriaceae* (ox -) and is useful for speciation and identification of many other bacteria, those that must use oxygen as the final electron acceptor in aerobic respiration.

Procedure of Oxidase test:

1. Take a filter paper soaked with the substrate tetramethyl-p-phenylenediamine dihydrochloride
2. Moisten the paper with a sterile distilled water
3. Pick the colony to be tested with wooden or platinum loop and smear in the filter paper
4. Observe inoculated area of paper for a color change to deep blue or purple within 10-30 secondsю

Control questions

1. What does total viable count mean?
2. What is viable titer?
3. Is sulfate reducing bacteria harmful?
4. How are sulfate reducing bacteria treated?
5. What does oxidase positive mean?
6. Is *E. coli* oxidase positive or negative?

Lecture 7. Standardization of soil contamination

1. General conception

2. Soil chemical pollution in residential areas

2.1. Sanitary estimation of soil contamination of urban territory

3. Standardizations of agricultural soil

4. Accumulation of toxic substances on territories of the enterprises

4.1. maximum quantity of toxic industrial waste on territory of the enterprise

4.2. Maximum allowable concentration of chemical substances on soil from waste

1. Soil contamination or soil pollution as part of land degradation is caused by the presence of xenobiotics (human-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals or improper disposal of waste. The most common chemicals involved are petroleum hydrocarbons, polynuclear aromatic hydrocarbons (such as naphthalene and benzo(a)pyrene), solvents, pesticides, lead, and other heavy metals. Contamination is correlated with the degree of industrialization and intensity of chemical substance. The concern over soil contamination stems primarily from health risks, from direct contact with the contaminated soil, vapors from the contaminants, or from secondary contamination of water supplies within and underlying the soil.

The pollution of soils takes place on territory a city, which can be divided into mechanical, chemical and biological pollutions.

Mechanical pollution is determined for the contamination of soils by a build wastes, beaten glass, ceramics and other inert wastes. It has as a result the influences on the mechanical properties of soils.

Chemical pollution of soils relates to a coming of substances, which change the natural concentration of chemical elements exceeding a norm. As a result, it has a change of physical and chemical properties of soils. This type of pollution is most widespread, long-term and dangerous.

Biological pollution relates to coming in the ground environment of dangerous for people organisms and their reproduction. The bacteriological, helminthological and entomological indexes of the soil of city territories determine the level of their epidemiology danger.

The basic signs of harmful action at normalization of pollutants in the ground:

Organoleptic — change of organoleptic properties of air, subsoil waters, vegetable foods contacting with ground, containing various concentrations of normalized substance.

Common sanitary — effect on the ground microflora and processes of its autopurification.

Phytoaccumulative (translocative) — accumulation of normalized substance in vegetable foods (not higher than maximal permissible concentration for foodstuffs).

Air-migratory — evaporation of substance in atmospheric air above the ground (not higher than MPC for air)

Water-migratory — accumulation of substance in subsoil waters (not higher than MPC for water).

Toxicological — by toxic, specific and remote effects on laboratory animals at skin or inhalation action together with a soil dust.

2. The estimate of pollution level is got with using of the maximum allowable concentrations of substances. It was fixed that the level of chemical contamination of soils can use as an indicator of pollution of atmosphere and the health of people. In this case a base for the estimate of pollution level of soils is a value of background concentration of substance in soils of region. Usually such approaches are used for an analysis of pollution of territory by heavy metals and other toxic elements.

By hazard evaluation the land pollutants are subdivided into three classes:

· 1 class is highly hazardous substances;

· 2 class is moderately hazardous substances;

· 3 class is hazardous substances.

On degree of pollution the soils are subdivided into strongly, moderately and week polluted.

In strongly polluted soil the quantity of pollutants exceeds the maximum permissible concentration many times.

In moderately polluted soils the excess of maximum allowable concentration is insignificant but have the appreciable changes of its properties.

In week polluted soils the contents of chemical substances do not exceed maximum allowable concentration but exceed a background one (Tabl.7.1).

Table 7.1 The hazardous classes

Indicator	Norm of concentration		
	I class	II class	III class
Toxicity, LD50 (mkg)	200	200-1000	>1000
Persistence of soil, month	>12	6-12	<6
MAC of soil, mg/kg	>0.2	0.2-0.5	>0.5
Persistence of plant, month	> 8	1-3	<1
Influence on food value of agricultural produce	highly	moderately	no
Migration	migrate	insignificant migrate	not migrate

The level of the pollution is characterized by the coefficient of the concentration of elements Kc which is determinate by the ration:

$$Kc = Cc/Cg ,$$

Where Cc - concentration of pollutant in the soil;

Cg - geochemical background of pollutant; mg/l.

The contamination usually can be made by no one element. The total index of the pollution is determined as the sum of thus for every element:

$$Z = \sum Kc \quad — (п — 1), \text{ where}$$

Kc — the coefficient of the concentration of elements;

п — quantity of the elements on Kc > 1.

The total index of the pollution less to 16 corresponds to admit level of dangerous for the population health, from 16 to 32 – to middle dangerous, from 32 to 128 – to dangerous, more of 128 - to very dangerous.

2.1. Sanitary estimation of soil contamination of urban territory

· Indicator of bacterial pollution of soil is coli titer.

· Sanitary and helminthological indicator of land pollution is the number of eggs of the helminths in 1 kg of a soil.

· The entomological indicator of soils is quantity of larvae and pupae of flies in 0, 25 $м^2$ of a soil.

The sanitary condition of ground is supervised also on following indicators: sanitary number, acidity, biological oxygen demand, oxidation, contained of sulphates, chlorides, ctr.

Sanitary number is the indicator of biological pollution of soil which equal to a quotient from division of quantity of soil protein nitrogen (mg per 100 gram of dry soil) into total quantity of organic nitrogen in soil.

4. The ecological assessment of agricultural soil is established with using of dates of pesticide application on it. Soil polluted level and pollution of vegetable matter by pesticides is determined by comparison of pesticide content in soli or vegetable production with MAC.

5. The permissible residual quantity (PRQ) of chemical is a maximum quantity of substance which getting to human organism during all life does not cause heavy health insurance of the children and adults (Tabl.7.2).

Table 7.2 Norms of assessment of soil pesticide contamination

Type of ecological situation	Residual quantity of pesticides, kg/ha	Soil	Plants
Normal	<3	No present	No present
Satisfactory	3 – 4	< MAC	<MAC
Before critical	4 – 5	< MAC	< MAC
Critical	5 – 6	1, 1-1,5 MAC	1,1-1,5 MAC
Catastrophic	>6	1, 6-10 MAC	1, 6-10 MAC

4. Accumulation of toxic substances on enterprise territory is detected by two indicators:

´ maximum quantity of toxic industrial waste on territory of the enterprise and

´ maximum contents of toxic substances in industrial waste.

4.1. Maximum quantity of toxic industrial waste on territory of the enterprise

The maximum quantity of waste on enterprise territory is such quantity which can be placed provided that in air of a working zone the possible accumulation of harmful substances does not exceed 30 % maximum allowable concentration of these substances i.e. MACoa.

If this relation is more than1,

C/0,3 MACoa>1 this quantity of a waste is maximum, and this waste should be very quickly removed.

4.2. Maximum allowable concentration of chemical substances on soil from waste. For topsoil, in which is formed the plant roots, is established the maximum allowable concentration (MACr):

· Allowable concentration of substance in soil transferring in food and food chains does not exceed permissible residual quantity (PRQ) or maximum allowable concentration in foodstuff (MAC food);

· Allowable (volatile substance) concentration which concentration in air does not exceed established MAC of this substance in air (MAC air);

· Allowable concentration of substances which presence in subsoil waters does not exceed maximum allowable concentration of the water objects;

· Allowable concentration of substances which does not affect the microorganisms and processes of self-cleaning of a soil.

Control questions

1. What is meant by soil pollution?
2. What are the causes for soil pollution?
3. What is coli titer of soil?
4. What is a helminthological index of urban soil?
5. What is an entomological index of urban soil?
6. To enumerate indicators of pollution by chemical substances on soil from waste
7. To define the total index of the pollution of soil

Lecture 8. Microflora and sanitary-indicative bacteria of the soil. The methods of studying

1. Soil microbiota
2. Pollution and soil purification
3. Soil health assessment for microbiological parameters
4. Methods for determining the composition and activity of soil microorganisms

1. The soil consists of inorganic chemicals and organic compounds that result from the death and decomposition of living organisms. Soil living organisms in the soil together constitute biocenosis. Contained in the soil living organisms (including bacteria) are living a phase of soil. It includes microorganism and microorganisms, both animal and vegetable origin. Microorganisms that live in the soil are divided into two types: - autochthonous microorganisms (bacteria resident, resident microbiota), ie

germs that are unique to a particular type of soil; - allochthonous microbes (transient microbiota), ie microorganisms which under normal conditions do not occur in the soil. Microorganisms in the soil and water in developing colloidal films covering solid particles, especially in the capillary and gravitational water that fills the pores between the mineral particles of the soil and contains dissolved organic and inorganic materials. In the living soil:

1. *Algae* (green, blue-green and diatoms). They are ubiquitous, especially in the surface layers of soil. The most important environmental factor governing the spread of algae is moisture, although they can withstand long periods of drought. Morphological diversity of algae is very large, but they are microscopic in size, thread-like form and are composed of a single cell. The most numerous blue-green and green algae. Their number in 1 g soil can reach 100 thousand.

2. *Mushrooms*. They can be divided into three groups: yeasts and yeast, mold, including filamentous fungi, basidiomycetes. Yeast and yeast-like fungi was common in ordinary soil, so their role and importance in the life of the soil are small. Mold and basidiomycetes more numerous in the soil, especially in basidiomycetes forest soils, where they cause the formation of mycorrhizae. Fungi can live in conditions of partial anaerobiosis, but aerobioses stimulates their development. The number of fungi in the soil surface layer of 8 thousand. 1 million. 1 g, and biomass - from 1000 to 1500 kg / ha. The most favorable reaction medium for mushrooms - acidic (pH 4.0).

3. *The bacteria* (spore-forming bacteria, spirochetes, mycobacteria, pseudomonads, nitrogen-fixing bacteria and nitrifying bacteria, archaea). At the bacteria cultivated soils surpass all other groups of microorganisms, both in number and in their diversity. In the fertile soil total biomass of bacteria reaches 500 kg / ha and more.

Bacteria are divided into heterotrophs and autotrophs. In relation to oxygen soil microorganisms are divided into aerobic (requiring for their existence free oxygen) and anaerobic (not requiring for its existence oxygen free). The greatest value in soil

with nitrogen-fixing bacteria able to 10 assimilate molecular nitrogen (*Azotobacter*, *Nitrobacter, Mycobacterium* and others), and spore-forming bacillus genera *Bacillus* and *Clostridium*.

2. Soil populated areas contaminated solid and liquid garbage, human and animal secretions, their dead bodies, the remains of plants, domestic and industrial wastewater. Together with organic contamination in the soil gets a lot of microorganisms. Especially dangerous in epidemiological sewage slaughterhouses, meat processing plants, companies in processing leather, wool, which may contain pathogenic bacteria. In this connection, the soil may be a factor of transmission of infectious agents. Because the soil contamination can occur saprophytic and pathogenic microbe raw food, feed. Therefore, scum entering the soil shall be subjected to purification and disposal. The duration of survival of pathogenic bacteria in the soil depends on biological characteristics and habitat conditions. The longest living spore-forming bacteria - pathogens tetanus, botulism; bacilli of anthrax spores may persist for decades. Under favorable conditions micro-organisms in the soil not only survive, but for a long time (weeks, months or even years) retain virulence properties.

Classification of soil pathogens:

- Pathogenic microorganisms live permanently in the soil (e.g., the agent of botulism). The bacteria into the soil with feces of humans and animals, their spores stored in it indefinitely.

- Pathogenic spore-forming microorganisms for which the soil is secondary reservoir (e.g., anthrax). The bacteria into the soil with feces and other secretions of sick animals, and with the corpses of dead animals.

- Pathogenic microorganisms into the soil with secretions of humans and animals and are kept for weeks or months. In this group are not different microorganisms form spores.

The main factors that lead to rapid death of microorganisms - inability to sporogony and antagonistic properties of soil microbiota (competition for energy and food). The duration of survival of pathogens in soil depends on the biology of the pathogen, moisture content and appropriate nutrients, pH, temperature, presence of microbes-antagonists, bacteriophages. In wet soils survival 2-4 times longer than dry. Asporogenic bacteria killed rather than sporogenic. Pathogenic microbes asporogenic survive in the soil little time dysentery pathogens - from 10 days to 9 months; vibrio cholerae - from 10 days to 4 months; typhoid bacteria - from 14 days to 10 months; tularemia bacteria - from 10 days to 2.5 months; *Mycobacterium tuberculosis* - from 3 to 7 months or more; *Brucella* - 2 to 3 months. Nonspore-forming bacterium survival in the soil promotes microbial agent, along with getting enough nutrients (faeces, sputum, pus). The favorable physical and chemical environmental conditions, lack of microbes-antagonists. The most dangerous is soil contaminated with feces of patients with intestinal infections. Pathogens dysentery, cholera, typhoid fever, salmonellosis, enterovirus diseases enter the body with contaminated ground vegetables, fruits and other foodstuffs.

A direct correlation between the level of morbidity with intestinal infections and poor sanitary conditions of the soil caused by its poor clearance. We describe a few water outbreaks of intestinal infections caused by contaminated soil had runoff and sewage. In the soil home is to many fungi. Some of them, such as fungi of the genus Fusarium, falling on crops and other plants in its development process, produce toxic substances. When used bread baked from grain threshing and later affected the fungus *Fusarium sporotrichiella*, there toxicosis in humans, known poisoning "drunk bread". Mushrooms of the genus *Aspergillus* (*A. flavus, A. fumigatus*), parasitic on ground nuts, cereals and fodder, may also form toxic substances - aflatoxin. When eating foods contaminated aflatoxins there is severe poisoning, characterized by necrotic liver, kidney, hemorrhagic inflammation of the digestive tract.

3. In assessing the sanitary soil into account, the results of chemical, microbiological and helminthologic research. Microbiological studies conducted for the health assessment of soil characteristics purification processes, assessment methods biothermal soil and waste disposal, in determining the suitability of land for construction, as well as epidemiological and epizootic surveys to determine ways of soil contamination, duration of survival of pathogenic microbes in it.

Depending on the task using short or full sanitary-bacteriological analysis of soil. Short sanitary and microbiological analysis involves determining GMC, titles bacteria of *Escherichia coli*, *Enterococci*, *Cl. perfringens*, thermophilic bacteria, nitrifying bacteria. The results indicate the presence and extent of fecal contamination. A brief analysis of the soil carried out during the current sanitary surveillance of soil. Full sanitary-microbiological analysis includes identification of all parameters of a short analysis and total saprophytes, OMCH and percentage of spore microorganisms, aerobic bacteria that destroy tissue, bacteria of ammonification. Also, examine the toxicity to soil microorganisms. Full analysis carried out in the implementation of preventive sanitary inspection, initial inspection when choosing a site for the placement of individual objects. Sanitary value of soil microbial number cannot be considered without considering the features of different types of soil. For example, black soil microorganisms contain much more than podzol. Therefore, when determining the total number of bacteria in the soil is necessary to compare the results of unpolluted soil microbial count of the same type. Research on the direct detection of pathogenic microbes in soil is carried out only in the investigation of outbreaks of infectious diseases. As indirect indicators of possible soil contamination by pathogenic bacteria use sanitary indicative microorganisms: bacteria of *Escherichia coli*, *CI. perfringens*, bacteria of the genus *Proteus*, thermophilic bacteria. The presence of soil bacteria of *E. coli* indicates fecal contamination.

Detecting *CI. perfringens* in the soil as it indicates fecal contamination. The soil layer once enriched bacteria of *E. coli* and *CI. perfringens*. After 4-5 months marked dying *E. coli*, *CI. perfringens* is found in titer of 0.01. Consequently, *CI. perfringens* has sanitary indicative value only if the titer is determined in conjunction with the circle captions and other indicators. Fresh or old fecal contamination of the soil can be determined by the ratio of vegetative forms of *CI. perfringens* and spore forms. Detection of soil bacteria of the genus Proteus indicates contamination of organic substances or animal feces. Thermophilic bacteria are indicators of contamination of soil with manure, compost. In pure soil thermophiles are not detected.

4. The biological activity of the soil is determined in the following ways:

- Estimates of the total number of soil microorganisms. Due to imperfect methods, this method gives conditional determination, rough characterization of the biological activity of the soil.

- Determination of the number of individual physiological groups of microorganisms, such as nitrifying bacteria.

- Determination of soil carbon dioxide is released - the main biochemical method for determining the biological activity of the soil. The more intense carbon dioxide from the soil, the more place it biological processes, better conditions for the cultivation of crops and their potential yields above. Of carbon dioxide from the soil surface layer of the atmosphere called soil respiration. The intensity of soil respiration depends on the properties of hydrothermal conditions, nature of vegetation farming practices. Bold carbon dioxide in the soil increases its cultivated due to the activation of biological processes and improving the conditions of aeration. Reduction of carbon dioxide ground (reduced biological activity) may impair the flow of oxygen into the soil, which in turn promotes the formation of toxic substances.

The adequately assess soil has special significance selection indicator microorganisms. Evaluation of fecal contamination of soil and its limitations is held on the following parameters:

- bacteria group *E. coli* index (number of bacteria of *E. coli* in 1 g soil);

- perfringens captions (least amount of soil, which turns *CI. perfringens*);

- a titer enterococci. *E. coli* shows the presence in the soil of other Enterobacteriaceae. Thermophilic bacteria into the soil connect with rotted manure or compost, so they should exercise to ascertain the nature and limitations of organic soil contamination. Fresh manure, sewage usually contain many bacteria group *E. coli* and few thermophilic bacteria. The decomposition of organic matter increases the number of thermophiles. The appearance of nitrifying bacteria indicates the development of self-cleaning process, as they complete the cycle decomposition of nitrogen-containing compounds, converting ammonia into nitrogen. In fresh fecal contamination nitrifying bacteria will not, as a substrate for their development is missing. During the microorganisms that decompose organic matter, ammonia is formed, which stimulates the development nitrifying bacteria. In fresh fecal contamination of soil indicating high titers bacteria group *E. coli* and relatively high content of vegetative forms of *CI. perfringens*. Identification of enterococci always indicates fresh fecal contamination, whatever the other indicators.

The purpose of the sanitary and microbiological study of soil:

- sanitary evaluation of urban soil and placement of buildings;
- issues of water supply and wastewater settlements;
- sanitary evaluation of soil contaminated with chemicals;
- control processes of self-purification of soil.

Sampling was carried out with a square section (at least 5x5 m^2) with 5 points - from every angle and center square ("envelope method"). Sample number 1 kg taken in aseptic conditions with a depth of 20-30 cm. The frequency of monitoring 16 depends on controlled objects, but at least 1 time per year. In the study of the

dynamics of self-purification of soil in contaminated areas taking samples during the first month after the contamination week, in the coming months - 1 once a month during the growing season to the active phase of self-purification.

Control questions

1. What disease does Fusarium cause?
2. Describe basic microflora of soil
3. Can Fusarium affect humans?
4. What pathogenic bacteria live in soil?
5. Where is Fusarium found?
6. Describe process of microbial investigation of soil simples?

Lecture 9. Noise pollution

1. Introduction
2. Noise sources and measurement
3. Normalization of noise pollution
3.1. Reduction of sanitary-hygienic zone
3.2. Impact of noise on human health

1. Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic; industries; construction and public work; and the neighborhood. The main indoor noise sources are ventilation systems, office machines, home appliances and neighbors. Noise protection is an important part of population health protection, especially in conditions of close proximity to sources of negative impact to residential buildings.

What is noise? Acoustic noise is an oscillatory movement of particles of elastic medium, which has negative impact on sound-sensing apparatus of organisms and perceived as undesirable. Originally, noise can be mechanic (as a result from operation of machines and equipment), aerodynamic (occurs in gas environment), hydrodynamic (occurs in liquid environment), and electromagnetic (occurs among electromechanical devices under the influence of magnetic forces. Therefore, mechanic noise is occurred because of operation of machines and production equipment. The main indicators of value or force, noise are oscillation frequency, which measured in Hertz (Hz). *According to the oscillation frequency, noise is divided on high frequency (more 1000 Hz), mid-frequency (400-1000 Hz) and low frequency (less than 400 Hz).* At ranges, which are not tangible by human sound-sensing system for high *frequencies noise with frequency more 20 kHz*, is used definition – ultrasonic, for ultralow frequencies noise with frequency less than 20 Hz – infrasonic. For determining noise level, it is necessary to conduct laboratory researches by authorized organizations with special equipment. MCL, LLC proposes conduction of laboratory researches for determining frequency of noise.

In contrast to many other environmental problems, noise pollution continues to grow and it is accompanied by an increasing number of complaints from people exposed to the noise. The growth in noise pollution is unsustainable because it involves direct, as well as cumulative, adverse health effects. It also adversely affects future generations, and has socio-cultural, esthetic and economic effects.

2. Physically, there is no distinction between sound and noise. Sound is a sensory perception and the complex pattern of sound waves is labeled noise, music, speech etc. Noise is thus defined as unwanted sound.

Most environmental noises can be approximately described by several simple measures. All measures consider the frequency content of the sounds, the overall sound pressure levels and the variation of these levels with time. Sound pressure is a basic measure of the vibrations of air that make up sound. Because the range of sound

pressures that human listeners can detect is very wide, these levels are measured on a logarithmic scale with units of decibels. Consequently, sound pressure levels cannot be added or averaged arithmetically. Also, the sound levels of most noises vary with time, and when sound pressure levels are calculated, the instantaneous pressure fluctuations must be integrated over some time interval.

Most environmental sounds are made up of a complex mix of many different frequencies. Frequency refers to the number of vibrations per second of the air in which the sound is propagating and it is measured in Hertz (Hz). The audible frequency range is normally considered to be 20–20 000 Hz for younger listeners with unimpaired hearing. However, our hearing systems are not equally sensitive to all sound frequencies, and to compensate for these various types of filters or frequency weighting have been used to determine the relative strengths of frequency components making up the environmental noise. The A-weighting is most used and weights lower frequencies as less important than mid- and higher-frequencies. It is intended to approximate the frequency response of our hearing system.

The effect of a combination of noise events is related to the combined sound energy of those events (the equal energy principle). The sum of the total energy over some time period gives a level equivalent to the average sound energy over that period. Thus, LAeq,T is the energy average equivalent level of the A-weighted sound over a period T. LAeq,T should be used to measure continuing sounds, such as road traffic noise or types of more-or-less continuous industrial noises. However, when there are distinct events to the noise, as with aircraft or railway noise, measures of individual events such as the maximum noise level (LAmax), or the weighted sound exposure level (SEL), should also be obtained in addition to LAeq,T. Time-varying environmental sound levels have also been described in terms of percentile levels.

Currently, the recommended practice is to assume that the equal energy principle is approximately valid for most types of noise and that a simple LAeq,T measure will indicate the expected effects of the noise reasonably well. When the

noise consists of a small number of discrete events, the A-weighted maximum level (LAmax) is a better indicator of the disturbance to sleep and other activities. In most cases, however, the A-weighted sound exposure level (SEL) provides a more consistent measure of single-noise events because it is based on integration over the complete noise event. In combining day and night LAeq,T values, night-time weightings are often added. Night-time weightings are intended to reflect the expected increased sensitivity to annoyance at night, but they do not protect people from sleep disturbance.

Where there are no clear reasons for using other measures, it is recommended that LAeq,T be used to evaluate more-or-less continuous environmental noises. Where the noise is principally composed of a small number of discrete events, the additional use of LAmax or SEL is recommended. There are definite limitations to these simple measures, but there are also many practical advantages, including economy and the benefits of a standardized approach.

3. There are 2 kinds of noise pollution.

A. *Community Noise/ Environmental Noise* (nonindustrial noise pollution).

• Aircraft noise
• Roadway noise pollution
• Under water noise pollution

Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources, except at the industrial workplace. Main sources of community noise include road, rail and air traffic, construction and public work, and the neighborhood. Typical neighborhood noise comes from live or recorded music; from sporting events including motor sports; from playgrounds and car parks; and from domestic animals such as barking dogs.

B. *Occupational Noise* (industrial noise pollution)

The many and varied sources of noise is industrial machinery and processes include rotors, gears, turbulent fluid flow, impact processes, electrical machines, internal combustion engines, pneumatic equipment, drilling, crushing, blasting, pumps and compressors. Furthermore, the emitted sounds are reflected from floors, ceiling and equipment.

Acoustic noise is capable to provoke increasing of human arterial tension, nervous breakdowns and diseases of sound-sensing apparatus. Ukrainian legislation («Protection of territories, buildings and constructions from noise» SCN B.1.1-31:2013, «Residential housings and constructions» SCN B.2.2-9-2009) clearly determines maximum permissible limits of noise oscillations. The maximum permissible limit of noise must not be over 85 dB. For residential housing was approved a norm of noise limit, which must not exceed 55 dB at day and 45 dB at night.

Sanitary-hygienic zone (SHZ) which established for enterprises also includes noise and vibration which can cause after their activity. If enterprise achieves constant noise and vibration limit through installing specific equipment which allows construction and operation of residential and similar housings in sanitary-hygienic zone, enterprise has to organize and justify possible allocation of residential housings within sanitary-hygienic zone and to conduct certain legal actions for reducing SHZ.

For reducing noise load from mechanic equipment or other objects of infrastructure, specialized equipment or materials with absorbing and shielding (reflecting) capabilities are used. In protecting of noise which caused by production equipment, this equipment is covered by noise absorbing materials.

If using of local measures is insufficient and general noise limit is over maximum permissible limits, business entity can order determination and implementation of specific project decision and measures for compliance of hygienic

standards of noise and vibration. Such services are provided by MCL, LLC which has the biggest experience in conducting similar works in Ukraine.

3.1. Reduction of sanitary-hygienic zone

Sanitary-hygienic zone (SHZ) is a territory around production objects aimed for protection of residential and public buildings, recreation zones, health resorts from possible harmful impact on human health. Establishing of sanitary-hygienic zone is compulsory for all objects of economic activity, which can be the source of negative impact on environment and human health. Although, SHZ refers as a territory of special order for usage (limits in operation for reducing impact of chemical and physical factors on atmospheric air).

While working on a project of SHZ and organization of sanitary and epidemiological expertise for establishing sizes of SHZ objects, we use terms and notions approved by legislative acts, sanitary norms and rules. The sizes of sanitary-hygienic zone are defined and regulated by project documents, technological guidelines of equipment and state normative acts and State Sanitary Rules 173-96. Design of project of SHZ can be required for boiler stations. The SHZ for objects in operation can adjusted due to articles of SSR 173-96.

The main objects of impact on population are vibration, hazardous substances emissions into atmospheric air and other biological, chemical, radioactive potentially hazardous objects of impact. The correcting and defining of sizes of sanitary-hygienic zone are conducted in such way as the concentration of harmful substances or noise levels, vibration does not exceed maximum permissible concentration. Therefore, sanitary-hygienic zone refers as protective barrier, providing maintaining of human health and required safety level during permanent activity of object of impact. For protection from harmful impact and for more effective stumble of hazardous substances, sanitary-hygienic zone is wooded; in addition, there are recommendations for implementation of planting trees and shrubs in single line of double-level and also, planting of evergreen trees.

It is forbidden to allocate in sanitary-hygienic zone residential buildings, recreation zones, gardens, sanatoriums and cottage complexes, individual or collective summer cottage, children`s playgrounds and sports playgrounds, recreational and treatment establishments, educational institutions. Although, in SHZ is prohibited allocation of enterprises of production medical preparations and agents, storages for saving substances and materials of pharmaceutical production, objects of food industry, storages for saving food staples and food products, objects of water-retaining constructions for potable water.

There is no prohibition to allocate within sanitary-hygienic zone industrial objects: premises for shift workers (but duration no more than two weeks), non-residential premises for breakdown staff, administrative and municipal buildings, research laboratories and designing bureau, medical centers, laundries and saunas, hotels, motels, garages and premises for individual and public transport, depot, communications, gas- and oil-pipe lines, power lines, wells, constructions for preparation and storage of process water, service stations, gas filling stations and canalization stations. In modern conditions of development of tools and methods for noise prevention and in case of insufficient area for residential buildings near objects that located in SHZ.

Particularly, the specialists of MCL, LLC and architectural bureau designed the complex of measures and special engineering decisions for allocation of residential complex within sanitary-hygienic zone of railway station. As one example of necessary reduction of sanitary-hygienic zone, there was a situation: for years of dead time of piggery activity, near it has been constructed residential buildings, and in premises of abounded piggery has been appeared manufactory for baking bread and flour products. New owner has launched abandoned piggery and thanking implementation of modern European equipment and usage of biologically active probiotics, which have helped to reduce the volume of pollutants emissions into the

atmospheric air and regarding to teamwork with specialists of MCL, LLC, we have achieved the reduction of SHZ.

The specialists of MCL, LLC, guided by years of experience in development of individual project decisions directed on leveling of impact of hazardous factors on human health, and due to objective justification of opportunity to reduce sanitary-hygienic zone, provide qualified services for reduction of sanitary-hygienic zone or for justification of possible allocation of residential buildings within sanitary-hygienic zone.

3.2. Impact of noise on human health

Noise pollution makes men more irritable. The effect of noise pollution is multifaceted and interrelated.

The effects of noise pollution on human being, follows:

• Hearing Impairment
• It Decreases the Efficiency of A Man
• Lack of concentration
• Abortion is caused
• Pupil Dilation
• Mental Illness
• It Causes Heart Attack
• Digestive problems

Animal and property are as

• Temporary or pennant deafness
• Aggressive Behavior
• Effect on Vegetation Poor Quality of Crops
• Effect on Animal
• Effect on Property
• Sleep interference
• Speech interference

Control questions

1. What is dB in sound?
2. What is dB unit?
3. How is noise measured in decibel dB unit?
4. How much louder is 20 dB compared to 10 db?
5. What is noise pollution and its effects?
6. What is noise pollution examples?
7. What are the causes of noise?

Lecture 10. Ultrasound pollution of the environment

1. Introduction
2. Characteristics of ultrasound
3. Normalization of ultrasound pollution
4. Effect of ultrasound on human health

1. Ultrasound is acoustic (sound) energy in the form of waves having a frequency above the human hearing range. The highest frequency that the human ear can detect is approximately 20 thousand cycles per second (20,000 Hz).

Ultrasound is used in electronic, navigational, industrial, and security applications. It is also used in medicine to view internal organs of the body.

2. Ultrasound characteristics are oscillation frequency and intensity. The unit of measure of ultrasound intensity is Watt (W) on square centimeter, but more is used dB (decibel). A decibel is tenth part of bel.

Ultrasonic oscillation has the next characteristic:

1. In air at atmospheric pressure, ultrasonic waves have wavelengths of 1.9 cm or less. Ultrasonic waves have a little wavelength (maximal 1.5 cm). They generate the high-energy beam.

2. Ultrasonic waves on the interface of two mediums are refracted, have interface diffraction and adsorption.

3. In hard and liquid medium an ultrasound causes mechanical and chemical effects (Fig.10.1).

Acoustic energy may be transformed into several other forms of energy, which may exist at the same time within any given medium. The mechanisms of transformation into these other forms of energy are conventionally subdivided into three major categories compering a thermal mechanism, a cavitation mechanism, and other mechanisms including streaming motions.

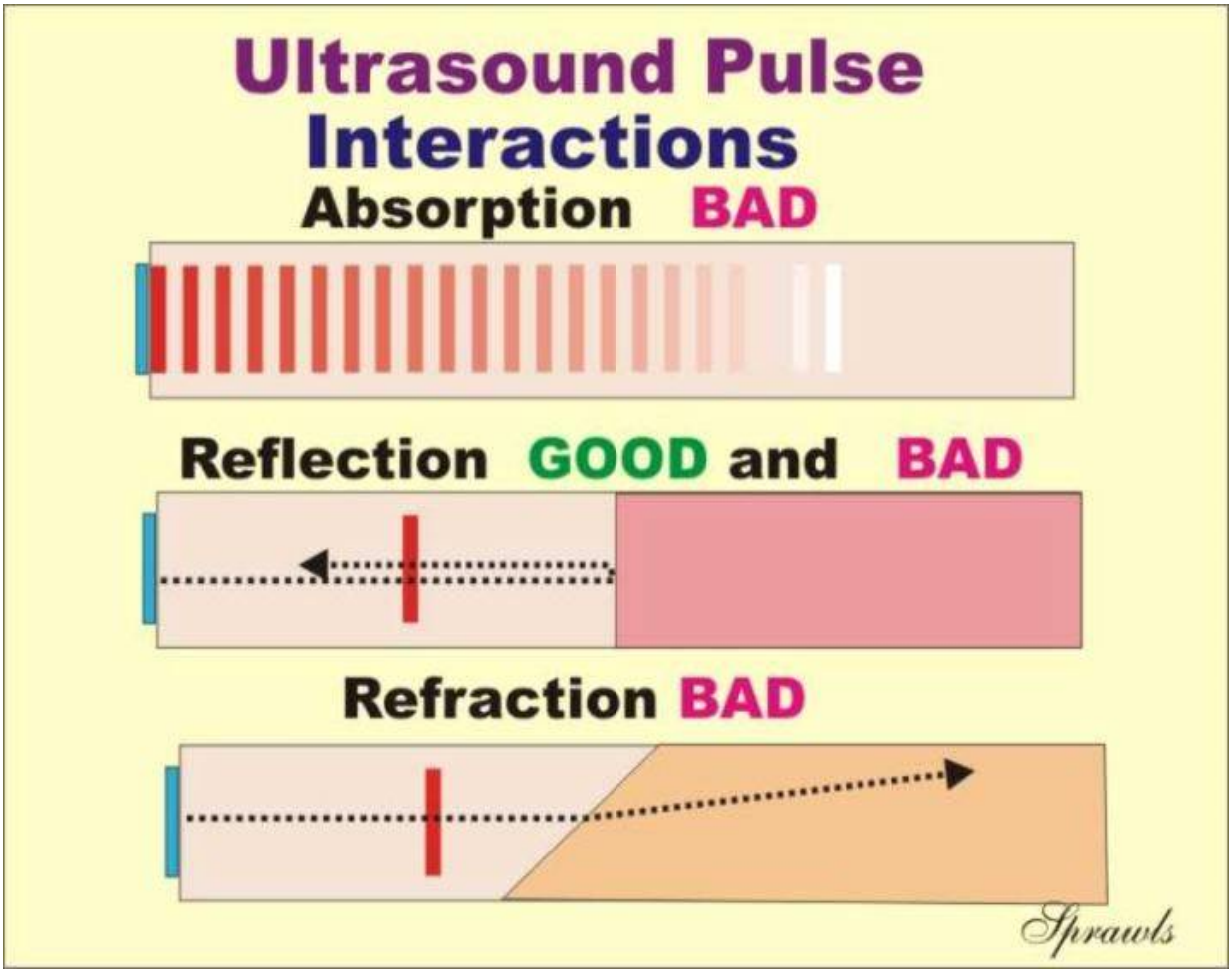


Figure 10.1 Properties of ultrasound

When ultrasound is absorbed by matter, it is converted into heat producing a temperature rise in the exposed subject.

An ultrasound wave produces alternate areas of compression and rare fact ion in the medium and the pressure changes produced can result in cavitation. Cavitation effect is appeared in the mixed medium as a liquid – gas. Ultrasonic waves of high intensity ultrasound generate cavitation in liquids. Cavitation causes extreme effects locally, such as liquid jets of up to 1000 km per hour, pressures of up to 2000atm and temperatures of up to 5000 Kelvin. During the low-pressure cycle, high-intensity ultrasonic waves create small vacuum bubbles or voids in the liquid. When the bubbles attain a volume at which they can no longer absorb energy, they collapse violently during a high-pressure cycle. This phenomenon is termed cavitation. During the implosion very high temperatures (approx. 5,000K) and pressures (approx. 2,000 atm.) are reached locally. The implosion of the cavitation bubble also results in liquid jets of up to 280m/s velocity

Streaming motions and shearing stresses can occur within the exposed system through stable cavitation; twisting motions (radiation torque) have also been observed in biological systems exposed to ultrasound.

Exposure to ultrasound can be divided into two distinct categories: airborne and liquid borne. Exposure to airborne ultrasound occurs in many industrial applications such as cleaning, emulsifying, welding, and flaw detection and using consumer devices such as dog whistles, bird and rodent controllers, and camera rangefinders, and commercial devices such as intrusion alarms. Liquid-borne exposure occurs predominantly through medical exposure in diagnosis, therapy, and surgery.

3. According to sanitary and hygienic norms an airborne ultrasound on the method of transmission from a source to the object is divided into:

- Aerial ultrasound, which is passed through air;
- Contact ultrasound, which is passed on the hands of man through liquid and hard medium.

According to spectrum ultrasound is divided into:

- Low-frequency, which ultrasound is passed to the man through air or by a contact (frequency from 1, 2· 104 to 1·105 Hz).
- High frequency, which ultrasound is passed only by the contact way (frequency from 105 to 109 Hz).

Parameters of air or *low-frequency ultrasound* are levels of voice pressure in dB in tertiary - octave strips with frequencies: 12.5, 16, 20, 25, and 31.5, 50, 63, 80, and 100 kilocycle (kHz).

Parameters of *high frequency ultrasound* are a vibration velocity (m\s) in a frequency range from 0.1 megahertz to 10 megahertz or its logarithmic level (dB), which is calculated by a formula:

$$L_б = 20 \lg \frac{V}{V_0},$$

When V – maximum peak of vibration velocity; m/s;

V_0 – reference value of vibration velocity (5·10-8 m/s).

The maximum allowable levels (MAL) of ultrasound in center frequencies of octave bands should not increase next levels (Tab. 10.1):

Table 10.1. The maximum allowable levels of ultrasound

Center frequencies of octave bands, kHz	Sound pressure level, dB
12.5	80
16.0	90
20.0	100
25.0	100
31.5-100.0	110

The maximum allowable level (MAL) of contact ultrasound during 8 – hour pressure is not more than 110 dB.

4. An action of ultrasound on a man, at temporal influence of airborne ultrasound causes changes in cardiovascular system, nervous, endocrine and influences on a hearing and vestibular apparatus and the hormonal disbalance.

For airborne ultrasound exposure, at least one of the critical organs is the ear. Effects reported in human subjects exposed to airborne ultrasound include; temporary threshold shifts in sound perception, altered blood sugar levels, electrolyte imbalance, fatigue, headaches, nausea, tinnitus, and irritability. However, in many instances, it has been difficult to state that the observed effects were caused by airborne ultrasound because they were subjective and there was often simultaneous exposure to high levels of audible sound.

Character of morbidity depends of ultrasound dose.

Little doses (80-90 dB) have a stimulate affect and use for the therapeutic massage and stimulation of metabolic processes.

Large doses from 120 dB result the damage of internal organs.

The use of experimental animals to study the effects of airborne ultrasound has serious drawbacks because they have a greater hearing acuity, wider audible frequency range, and a greater surface-area-to-mass than man and most have fur covered bodies.

The ultrasound is used in systems of air cleaning from a dust and chemical substances, for treatment of very hard specific materials (diamond), etc. Also, ultrasound is used in agriculture for treatment of seed and struggle with destructive insect.

Doctors commonly use ultrasound for procedures such as: abdominal scans – may be used to investigate abdominal pain, nausea, vomiting, abnormal sounds and lumps. Structures to be examined may include the gallbladder, bile ducts, liver, pancreas, spleen, kidneys and large blood vessels.

The depth of ultrasound penetration is usually described in terms of the half-value depth for the specific ultrasound frequency. Therefore, 1-MHz continuous ultrasound, with a half-value depth of approximately 2.3 cm, is frequently used to treat deep tissues that are approximately 2.3 to 5 cm deep.

It produces pictures of the inside of the body using sound waves. Ultrasound imaging is also called ultrasound scanning or sonography. It uses a small probe called a transducer and gel placed directly on the skin. ... A computer uses those sound waves to create an image.

Control questions

1. What are three uses of ultrasound?
2. What is the production of ultrasound?
3. How does ultrasound produce an image?
4. What is ultrasound depth?
5. What are the dangers of ultrasound?
6. What are the disadvantages of ultrasound?

Lecture 11. Infrasound and its impact on the environment

1. Introduction
2. Sources of infrasound
3. Main characteristics of infrasound
4. Normalization of infrasound pollution
5. Effect on human health

1. Infrasound can be defined as the low-frequency sound that is below 16-20 Hertz.

For this reason, it cannot be heard by the human ear. Animals, on the other hand, are sensitive to such sounds. Research has proved that some of them can

sense infrasonic sounds from natural events like earthquakes and volcanoes, and act accordingly. They can also use it for communication between each other.

There are many uses of infrasonic sound. Primarily, it can be used to detect volcanic eruptions. Scientists use infrasound to track the passage of meteors through the atmosphere (Fig.11.1)

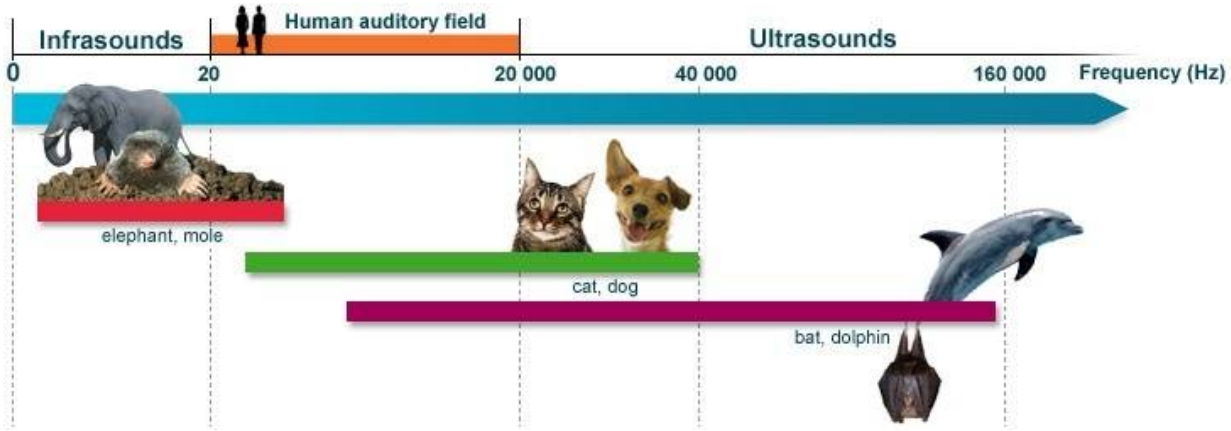


Figure 11.1 Properties of different waves

2. Infrasound is sound below 16 Hz, lower than humans can perceive. Infrasound can result from both natural and human sources.

For example, some animals, such as whales, elephants and giraffes communicate using infrasound over long distances. Avalanches, volcanoes, earthquakes, ocean waves, waterfalls and meteors generate infrasonic waves.

In addition, man-made events such as explosions, wind turbines, aircraft breaking the sound barrier, and certain speakers too, produce it. Some sources of man-made infrasound are nuclear and chemical explosions, engines, machinery and airplanes (Figure 1). Infrasonic waves propagate with very little attenuation and hence are capable of propagating over great distances.

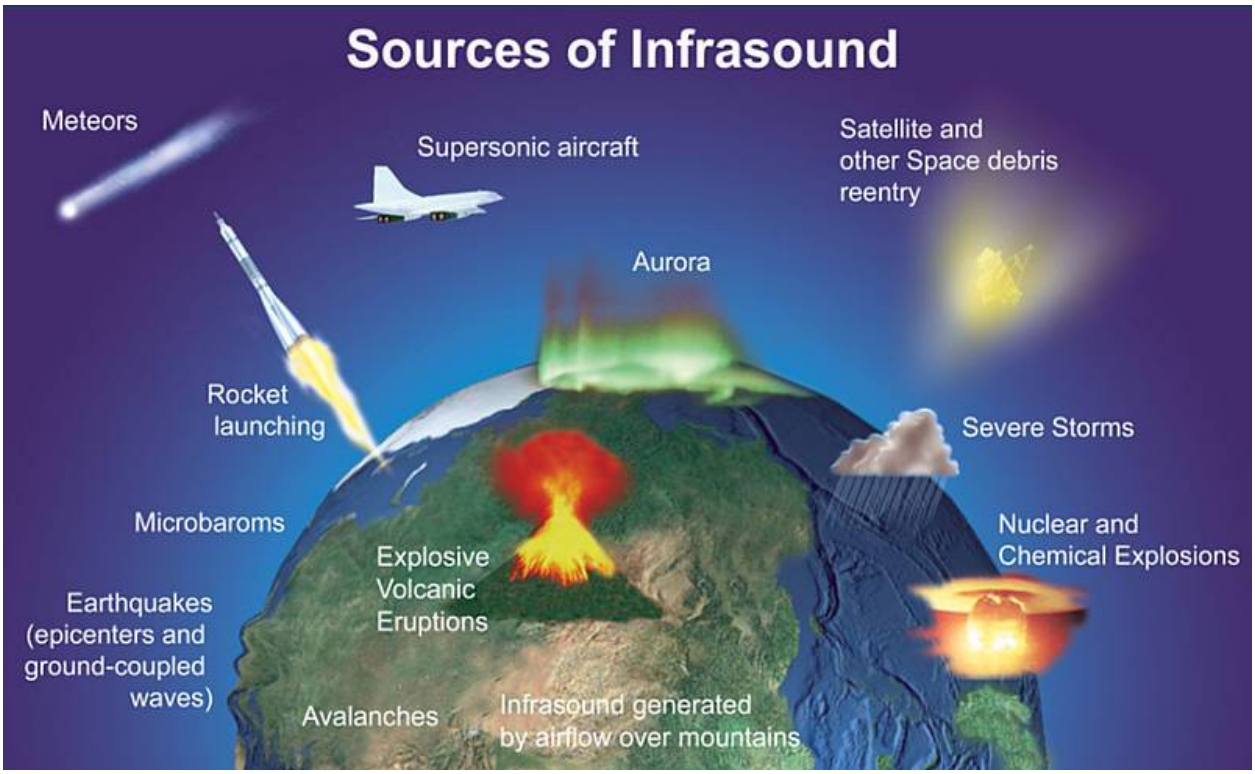


Figure 10.2 Sources of infrasound
(http://aquarid.physics.uwo.ca/images/new/source%20of%20infrasound.jpg)

3. Infrasound is characterized such properties:

- Infrasound has the greater amplitude of oscillation;
- Infrasound waves propagate the large distances from source since and weak absorb by atmosphere;
- Infrasound waves penetrate the apartment and round any protective screens (phenomenon of diffraction).

4. According to time response the infrasound (State Sanitary Norms on industrial noise, ultrasound and infrasound, 1999, State norms) can divided into:

- permanent (when voice pressure changes no more than 10 dB after 1 minute)
- inconstant - (when voice pressure changes on 10 dB after 1 minute). The maximum allowable level of infrasound pressure must not exceed 105 dB measured in octave bands with frequency: 2, 4, 8, 16 Hz and MAL equal to 102 dB in octave bands with frequency 31,5 Hz.

5. Infrasound is especially dangerous, due to its strong vibrations, or oscillations They hug the ground, travel for long distances without losing strength, and are unstoppable.

Furthermore, not much amplitude is needed to produce negative effects in the human body. Therefore, even mild infrasound exposure requires several hours, or even days, to reverse the resulting symptoms.

Waves of infrasound are invisible, but they slam into living tissues and physical structures with great force.

The infrasound affects the cardiovascular system, nervous and respiratory systems, vestibular apparatus.

It is identified that some low-frequency sounds or infrasound are of negative action: sound at the frequency of 37 Hz causes cardiac, pulmonary and stomach disorders; due to frequently heard 16 Hz frequency the activity of the stomach gets disturbed. It is notable that we can feel very low and high sounds, beyond the limit of hearing, with all the body, like mechanical vibrations, heat and the like. Sounds, with the frequency lower than 16 Hz, are harmful to the individual, causing the unjustified fear, anxiety, fatigue, “sea” disease symptoms, and may be harmful to eyesight and become the cause of the serious health disorders. Especially dangerous is infrasound at the frequency of 7 Hz, since this sound, generating frequencies, close to characteristic frequencies of the organs of our body, may disturb the heart or brain activity.

Due to the above-mentioned properties of infrasound, many animals sense the approaching storm earlier than the storm itself approaches. Animals feel the manifestations of infrasound in advance, approximately 10-15 hours before the storm.

It is possible to judge about this from the following observation of scientists:

- jelly-fish hurries to hide deeper;
- dolphins sail behind the rocks;
- whales put out to the open sea;

• penguins lie down on the snow, flattened to the earth.

The infrasound affects the cardiovascular system, nervous and respiratory systems, vestibular apparatus.

Infrasound, is sound that is lower in frequency than 20 Hz or cycles per second. That's the "normal" limit of human hearing. infrasound is the primary issue for those concerned about wind-turbine syndrome. They also say that audible sound and vibrations coming from wind turbines contribute to the health problems reported by some people who live close to wind farms. Symptoms of wind-turbine syndrome might include:

- Headaches
- Sleep problems
- Night terrors
- Ringing in the ears (tinnitus)
- Mood problems (irritability, anxiety)
- Concentration and memory problems
- Issues with equilibrium, dizziness and nausea

These symptoms have been observed and documented by a limited number of scientists studying small groups of people, and the scientific community hasn't concluded whether wind-turbine syndrome exists. There are also mixed opinions on whether wind turbines emit infrasound and if the amount is any more than that emitted by diesel engines or waves crashing on the beach. But we do know that at high speeds, wind turbines can produce an audible hum and vibration that can be carried through the air.

- **Medical: (therapeutic devices)**
- - Several studies conducted in Russia and Europe reported that infrasound has therapeutic effects.
- - Infrasound peumomassage: At 4 Hz, the progression of myopia in school children can be stabilized.

- Infrasound phonophersis in antibacterial drugs: In treatment of patients with bacterial keratitis, it is as effective as local instillations of the same drugs.

Control questions

1. Can infrasonic sound be dangerous?
2. Can infrasound kill you?
3. What can hear infrasound?
4. What is the frequency of infrasound?
5. What frequency can kill you?
6. What is an example of infrasound?
7. What frequencies are harmful to humans?
8. What frequency do humans vibrate?
9. Do humans emit infrasound?

Lecture 12. Electromagnetic pollution of the environment

1. What Is Electromagnetic Radiation?

1.1. Waves and fields

1.2. The EM spectrum

1.3. Calculation of MPL of electromagnetic field

2. Sources of electromagnetic pollution

3. Negative effect

4. Sanitary protective zone of radio-technical objects

1. Electromagnetic (EM) radiation is a form of energy that is all around us and takes many forms, such as radio waves, microwaves, X-rays and gamma rays. Sunlight is also a form of EM energy, but visible light is only a small portion of the EM spectrum, which contains a broad range of electromagnetic wavelengths.

Electricity and magnetism were once thought to be separate forces. However, in 1873, Scottish physicist James Clerk Maxwell developed a unified theory of

electromagnetism. The study of electromagnetism deals with how electrically charged particles interact with each other and with magnetic fields.

There are four main electromagnetic interactions:

- The force of attraction or repulsion between electric charges is inversely proportional to the square of the distance between them.
- Magnetic poles come in pairs that attract and repel each other, much as electric charges do.
- An electric current in a wire produces a magnetic field whose direction depends on the direction of the current.
- A moving electric field produces a magnetic field, and vice versa.

Maxwell also developed a set of formulas, called Maxwell's equations, to describe these phenomena.

1.1. EM radiation is created when an atomic particle, such as an electron, is accelerated by an electric field, causing it to move. The movement produces oscillating electric and magnetic fields, which travel at right angles to each other in a bundle of light energy called a photon. Photons travel in harmonic waves at the fastest speed possible in the universe: 186,282 miles per second (299,792,458 meters per second) in a vacuum, also known as the speed of light. The waves have certain characteristics, given as frequency, wavelength or energy.

A wavelength is the distance between two consecutive peaks of a wave. This distance is given in meters (m) or fractions thereof. Frequency is the number of waves that form in each length of time. It is usually measured as the number of wave cycles per second, or hertz (Hz). A short wavelength means that the frequency will be higher because one cycle can pass in a shorter amount of time, according to the University of Wisconsin. Similarly, a longer wavelength has a lower frequency (Fig12.1).

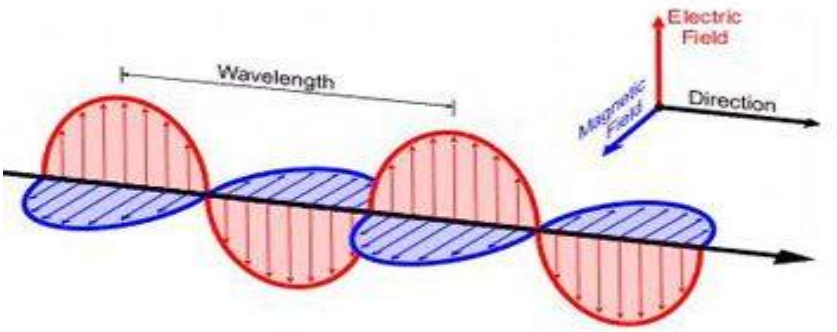


Figure 12.1 Characteristics of wave (https://www.toyo-chem.com/en/products/electronics/column/emishield.html)

1.2. EM radiation spans an enormous range of wavelengths and frequencies. This range is known as the electromagnetic spectrum. The EM spectrum is generally divided into seven regions, in order of decreasing wavelength and increasing energy and frequency. The common designations are

- radio waves,
- microwaves,
- infrared (IR),
- visible light,
- ultraviolet (UV),
- X-rays and
- gamma rays.

Typically, lower-energy radiation, such as radio waves, is expressed as frequency; microwaves, infrared, visible and UV light are usually expressed as wavelength; and higher-energy radiation, such as X-rays and gamma rays, is expressed in terms of energy per photon (Fig.12.2).

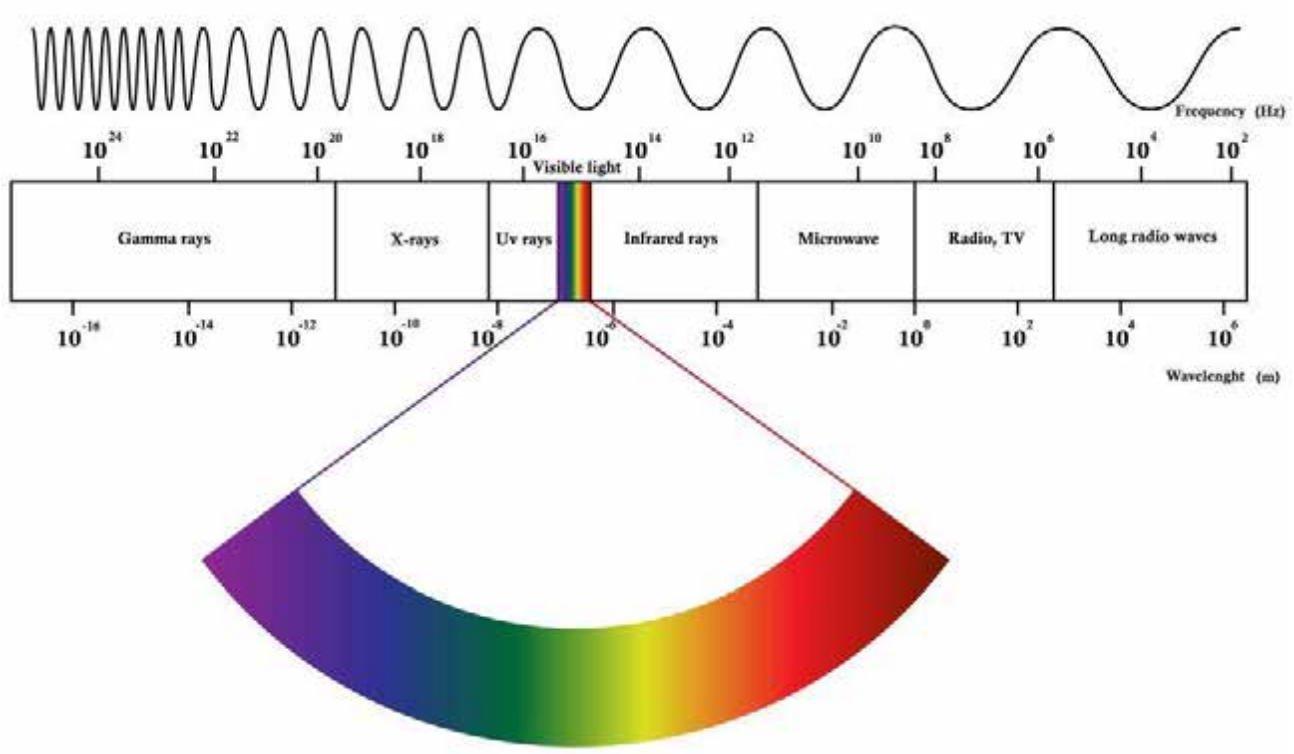


Figure 12.2 Electromagnetic spectrum (https://socratic.org/questions/what-are-some-examples-of-electromagnetic-waves)

Radio waves are at the lowest range of the EM spectrum, with frequencies of up to about 30 billion hertz, or 30 gigahertz (GHz), and wavelengths greater than about 10 millimeters (0.4 inches). Radio is used primarily for communications including voice, data and entertainment media.

2. The sources of electromagnetic radiation in settlements include radio, television and radar stations of various functions operating in the band of radio frequencies, as well as a network of transmission lines, which consists of high-voltage transmission lines and electrical substations.

Table 12.1 Sources of electromagnetic fields and radiation influencing living organisms

Type	Frequency	Source
Static*	—	Natural, video screens, magnetic resonance imaging, and other diagnostic/scientific equipment, electrolysis, and welding devices
ELF	Below 300 Hz	Power transmission lines, home wiring, car electric engines, electric trains and trams, and welding devices

Type	Frequency	Source
IM	300 Hz 100 kHz	Video screens, antitheft devices used in cars, homes, and shops, card readers, metal detectors, magnetic resonance imaging, and welding devices
RF	100 kHz 300 GHz	Radio, television, smartphones, tablets, microwave ovens, radar and radio transmitters, and magnetic resonance imaging

*Static electromagnetic fields do not exist and should be understood as either static electric or magnetic fields.

3. EMF of radiofrequencies negatively affect human health. These fields cause

■ damage primarily to the nervous system,

■cause headaches,

■severe fatigue,

■ neuroses and insomnia,

■visual impairment.

The negative influence of EMF on the endocrine, cardiac and immune systems has also been noticed. In order to protect the population from the influence of EMF, created by radio-technical objects, sanitary protection zones and zones of building constraints are established.

A wide range of environmental influences causes biological effects. 'Biological effect' does not equal 'health hazard'. Special research is needed to identify and measure health hazards. At low frequencies, external electric and magnetic fields induce small circulating currents within the body. In virtually all ordinary environments, the levels of induced currents inside the body are too small to produce obvious effects. The main effect of radiofrequency electromagnetic fields is heating of body tissues.

There is no doubt that short-term exposure to very high levels of electromagnetic fields can be harmful to health. Current public concern focuses on possible long-term health effects caused by exposure to electromagnetic fields at levels below those required to trigger acute biological responses.

Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health. The focus of international research is the investigation of possible links between cancer and electromagnetic fields, at power line and radiofrequencies.

4. The sanitary protection zone (SPZ) is created to protect the population against the effects of adverse production factors (dust, gases, noise, vibration, etc.). SZZ establishes the lines of city-planning regulation and protects the enterprise from unreasonable claims from people living nearby from local state environmental and sanitary control; (from attempts to build a new home or other objects with normalized environmental quality indicators within the established SPZ size).

According to Article 114 of the Land Code of Ukraine, sanitary-protective zones (SPZs) are created around objects that are sources of harmful substances, odors, elevated levels of noise, vibration, ultrasonic and electromagnetic waves, electronic fields, ionizing radiation, etc., in order to separate those objects from the territories of residential development.

Within the sanitary protection zones, construction of residential objects, social infrastructure objects and other objects related to permanent residence of people is prohibited. The legal regime of lands of sanitary protection zones is determined by the legislation of Ukraine.

In accordance with clause 5.5 of the DSP 173-96 “The dimensions of the sanitary protection zones for industrial enterprises and other objects that are sources

of industrial hazards should be established in accordance with the current sanitary norms of their placement in confirming the adequacy of the sizes of these zones in accordance with “The Methodology for calculating concentrations in atmospheric air of harmful substances contained in the emissions of enterprises “OND-86, calculations of noise and electromagnetic radiation levels taking into account the actual sanitary situation (background pollution, features of relief, weather conditions, etc.) As well as data on laboratory studies of similar existing businesses and facilities.

The sanitary protection zone is an area where the maximum permissible levels of EMF are exceeded at height up to 2 meters from the surface of the earth. It is usually adjoined to the mechanical territory of the RTO. The outer boundary of the sanitary protection zone is determined at height up to 2 m from the surface of the earth at the maximum permissible levels of EMF.

Each RTO, which emits electromagnetic energy into the environment, must have a sanitary passport with relevant data. The passport is valid for 5 years. After reconstruction of the RTO and with other changes, that may affect the electromagnetic fields, the sanitary passport is re-issued ahead of schedule.

Control questions

1. Is EMF harmful to humans?
2. How does electromagnetism affect the environment?
3. What causes electromagnetic?
4. What material can block EMF?
5. Does electromagnetism affect the environment?
6. How harmful is electromagnetic radiation?
7. What are the effects of electromagnetic radiation in our environment?
8. Is RF exposure cumulative?

Lecture 13. Electric pollution

1. Introduction
2. Difference between electric and magnetic fields
3. Standardization of electric fields
4. Effect of electric field
5. Sanitary and protective zones
6. Effect of human health and biota

1. An electric field is an invisible force field created by the attraction and repulsion of electrical charges (the cause of electric flow), and is measured in Volts per meter (V/m).

The intensity of the electric field decreases with distance from the field source.

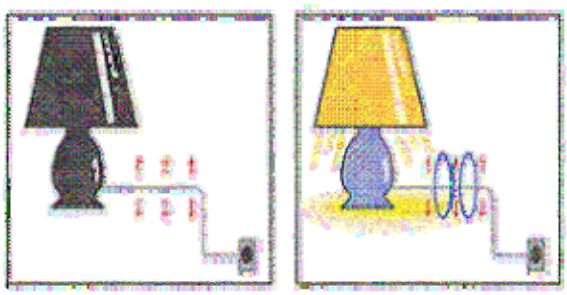
A static electric field (also referred to as electrostatic field) is an electric field that does not vary with time (frequency of 0 Hz). Static electric fields are created by electrical charges that are fixed in space. They are different from fields that change over time, such as electromagnetic fields generated by appliances using alternating current (AC) or by cell phones etc. When a bedside lamp is plugged in, i.e. connected to the electricity network through the socket, there is only an electric field. The electric field can be compared to the pressure inside a hosepipe when it is connected to the water supply system and the tap is closed. The electric field is linked to the tension whose unit is the Volt. It is generated by the presence of electric charges and is measured in Volts per meter (V/m). The greater the power supply of the appliance, the greater the intensity of the resulting electric field.

When the lamp is switched on, i.e. when the current goes through the alimentation cable, there are both an electric and a magnetic field. The magnetic field results from the passage of current (i.e. the movement of electrons) through the electric wire. In the example with the hosepipe, the magnetic field would correspond to the passage of water through the pipe. The unit of the magnetic induction field is

the Tesla (T). However, the magnetic fields that are commonly measured are within the range of the microtesla (μT) that is to say one millionth of a Tesla. Another unit sometimes used is the Gauss (G). One Gauss is the equivalent of 100 microtesla.

When switched off (left): electric field

When switched on (right): electric and magnetic field



Source: GreenFacts

2. Electric Fields Electric fields are produced by voltage. Voltage is the pressure behind the flow of electricity. It can be likened to the pressure of water in a hose. Electricity in UK homes is at a voltage of 230 volts (V), but outside homes it is distributed at higher voltages, from 11,000 volts (usually written 11kV) up to 400,000 volts (400 kV). Generally, the higher the voltage, the higher the electric field. Electric fields are measured in volts per meter (V/m). Magnetic Fields Magnetic fields are produced by current, which is the flow of electricity. Current, which is measured in amperes or amps, can be likened to the flow of water in a hose when the nozzle is open. Generally, the higher the current, the higher the magnetic field. Magnetic fields are measured in microteslas (μT). Other Differences One difference between electric and magnetic fields is that electric fields are very easily screened - by buildings, hedges, fences and trees. So, inside a house there will be very little electric field from a power line outside. By contrast, magnetic fields pass readily through most buildings. Another difference is that a mains appliance such as a radio or lamp does not have to be operating to produce an electric field - as long as it is plugged into a main supply it will produce an electric field. However, it produces a magnetic field only when it is turned on and drawing a current.

3. The permissible levels of electric field strength are indicated in the "State Sanitary Norms and Rules for Protecting the Population from the Influence of the Electric Field Generated by the Devices of Electric Power Transmissions of Industrial Frequency" (1996), GOST 12.1002-84 "Electrical Fields of Industrial Frequency. Permissible levels of electric field strength and workplace control requirements". The rules are intended to ensure the protection of the population and their health from the harmful effects of electric fields, which are formed by electrical networks and their elements. Elements of electric fields include alternating current electric transmission lines (ETL) of industrial frequency (50 Hz), electrical substations, switchgear, current cables, underground and underwater cable lines of power transmission, etc.

4. Effect of electric field

An electric field, depending on its level, can have a harmful effect on a person.

There are such types of effects:

- direct effect, which appears during the presence in the electric field, and the effect of the impact increases the higher the field intensity and the time of exposure is;
- the impact of electrical charges (impulse current) that happens when a person touches ungrounded constructions, machinery casings and conductors, or with the touch of a person isolated from the ground, to plants, grounded constructions and other grounded objects;
- the electric field impact on a person, when the current passes through the body, which is in contact with the objects isolated from the earth (machines and mechanisms, extended conductors, etc.) – drainage current.

In addition, the electric fields can cause the ignition or explosion of flammable substances as a result of the occurrence of electrical discharges during the contact of objects and people with machines and mechanisms. The degree of danger of each of these factors increases with increasing strength of the electric field.

The following values are used for the MPL of the electric field strength:

-inside residential buildings – 0,5 kV/m;

-on the territory of the residential development zone – 1 kV/m;

-in the populated area, outside the area of residential development, as well as in the territory of towns and gardens – 5 kV/m;

-at places of transmission lines and highways of the I-IV categories intersections – 10 kV/m;

-in unpopulated areas (not accessible for transport and agricultural machines) and in specially fenced areas – 20 kV/m.

Electric field strength is measured on the level of 1.8 m from the earth surface, the same goes for rooms form the floor level.
GOST establishes the MPL of the electronic field strength with a frequency of 50 Hz for staff, serving electrical appliances and being in the zone of influence of the electric field, depending on time of exposure.
MPL of the strength of a functioning electric field equals 25 kV/m. Protective equipment must be used in such conditions. Exposure to an electric field with a strength of 5 kV/m is allowed during the whole working day, but with the strength in range from 20 to 25 kV/m the time should not exceed 10 minutes.

Allowed exposure time in an electric field with a strength from 5 to 20 kV/m is calculated by the formula:

$$\mathbf{T= 50/E - 2,}$$

where T – allowable exposure time, hours; E – strength of the electric field in the examined area, kV/m.

5. In order to protect the population from the influence of electric fields, one should establish sanitary and protective zones. These are areas where the strength of the electric field exceeds 1 kV/m. The sanitary and protection zone for electric transmission lines is placed in the form of a land area at 20 to 55 m depending on the voltage (from 300 to 1150 kV). If the strength of the field exceeds the MPL,

residential buildings should be removed farther from the ETL or vice versa. Also, the use of screening devices and other electric field strength reducing devices are needed.

In addition, in the territory of sanitary and protection zones of transmission lines with a voltage of 750 kV and above, it is prohibited to carry out agricultural and other works by persons under the age of 18 years.

6. EM fields have a negative impact on citizens. The nervous system is the most vulnerable to EMF: its impulses pass through the nervous system, reach internal organs and affect them.

The reproductive system is also sensitive to EM fields: reproductive glands can be severely damaged. Influence of fields on the mother's body causes the birth of a defective offspring. EMF (UHF, SHF, EHF) affect the cardiovascular system: decreased pulse, muffled heart sounds, etc. EMF of low intensity stimulate an increase in the mass of animals, while the high ones suppress it.

Usually, stationary and portable security screens and personal protective equipment (protective suit, headgear, etc.) are used in order to protect workers from electric fields.

With long-term chronic EP effects, deviations in human health are observed.

A volume of field strength of 1000 V/m causes headache and severe fatigue. Higher yields can develop neuroses, insomnia, and severe diseases. These may be the first signs of occupational pathology.

The use of electricity in cities is often accompanied by an outflow of electric current in the soil, which leads to the occurrence of wandering currents. This phenomenon is called electro corrosion pollution. It relates to corrosion damage of metal and concrete structures. Flooding of soils (bacterial and chemical), pollution of groundwater and reservoirs can happen in case of water supply and sewage-fecal drainage failures

At the wandering currents field strength of 0.8-3.6 kV/m, the corrosion rate of the metal is 0.2-2 mm per year, while the damage to the sustaining capability of metal and concrete structures is 10-15 and 5-8%, respectively.

Control questions

1. Does making electricity cause pollution?
2. How does electricity harm the environment?
3. How does electricity pollute the air?
4. What is the main cause of pollution?

Lecture 14. Food contamination. Part I

1. Introduction
2. Food contamination
3. Types of food contamination
3.1. Biological contamination
3.2. Chemical contamination
3.3. Physical contamination
3.4. Cross-contamination
4. Classification of food poisonings
4.1. Food poisonings microbe aetiology
4.2. Bacterial toxicosis
4.3. Food poisonings not microbe aetiology

1. Food is any substance consumed to provide nutritional support for an organism. Food is usually of plant or animal origin, and contains essential nutrients, such as carbohydrates, fats, proteins, vitamins, or minerals. The

substance is ingested by an organism and assimilated by the organism's cells to provide energy, maintain life, or stimulate growth.

The died substances in an optimum ratio contain all necessary nutrients. It provides the best absorption and high-grade using of food substances.

Examples of balance:

Protein ratio: fats: carbohydrates (P:F:C) = 1:1:4 (for adult person), 1:1:5 (heavy physical work), 1:0,8:3 (older persons), 1:1:3 (children).

Ratio between proteins: animal 60 %, plant 40 %,

Ratio between fats: animal 70-80 %, plant 20-30 %

Ratio between carbohydrates: the unprotected 10-15 %, protected 85-90 %.

Ca: P ratio= 1:1,5 etc.

Absence in products chemical substances or microbes is higher than allowable levels - an opportunity food poisoning. Now it is very important principle in view of global pollution of biosphere by heavy metals, pesticides etc. Ways of the control: chemical and bacteriological analyses.

Structure of foodstuff: 1) Nutrients are proteins, fats, carbohydrates, vitamins, mineral substances and water. 2) Not alimentary substances are the substances giving to products organoleptic property (color, smell etc.) 3) Antialimentary substances are antitrypsin (protein of wet eggs), antivitamins (ascorbinase, thiaminase), antimineral substances (phytates, oxalates). 4) Toxic substances: a) Inherent in products is toxins of poisonous mushrooms, solanine in a potato etc. b) Casually got pollutants from environment are pesticides, heavy metals, dioxines etc.

2. Food contamination refers to the presence of harmful chemicals and microorganisms in food, which can cause consumer illness. This article addresses the chemical contamination of foods, as opposed to microbiological contamination, which can be found under foodborne illness.

Food poisoning can be caused by eating food contaminated with bacteria, viruses, chemicals or poisonous metals such as lead or cadmium.

Environmental contaminants are chemicals that are present in the environment in which the food is grown, harvested, transported, stored, packaged, processed, and consumed. The physical contact of the food with its environment results in its contamination. Possible sources of contamination and contaminants common to that vector include:

•Air: radionuclides (caesium-137, strontium90), polycyclic aromatic hydrocarbons (PAH)

•Water: arsenic, mercury

•Soil: cadmium, nitrates, perchlorates

•Packaging materials: antimony, tin, lead, perfluorooctanoic acid (PFOA), semicarbazide, benzophenone, isopropylthioxanthone (ITX), bisphenol A

•Processing/cooking equipment: copper or other metal chips, lubricants, cleaning and sanitizing agents

•Naturally occurring toxins: mycotoxins, phytohemagglutinin, pyrrolizidine alkaloids, grayanotoxin, scombrotoxin (histamine), ciguatera, shellfish toxins (shellfish poisoning), tetrodotoxin, among many others.

3. There are three types of food contamination: biological, chemical and physical. Food contamination can easily occur in a commercial kitchen.

Food contamination happens when something gets into food that shouldn't be there. There are three types of food contamination: physical, biological and chemical contamination.

Contaminated food can have dire consequences for the person who eats it, and for the business who sold it.

3.1. Biological contamination

Biological contamination is when bacteria or other harmful microorganisms contaminate food; it is a common cause of food poisoning and food spoilage.

Food poisoning can happen when disease-causing bacteria or other germs, also called 'pathogens', spread to food and are consumed. Bacteria are small microorganisms that split and multiply very quickly. In conditions ideal for bacterial growth, one single-cell bacteria can become two million in just seven hours.

Certain types of bacteria also produce bacterial toxins in the process of multiplying and producing waste. Bacterial toxins can be very dangerous — in fact, botulinum, the bacterial toxin that causes botulism, is the most potent natural poison known.

Certain foods are more vulnerable to biological contamination than others because they provide everything bacteria need to survive and multiply — food, water and neutral acidity (pH). These are called high-risk foods.

3.2. Chemical contamination

Food contamination happens when something gets into food that shouldn’t be there. There are three types of food contamination: physical, biological and chemical contamination.

Contaminated food can have dire consequences for the person who eats it, and for the business who sold it.

Food Handlers must be trained to handle food safely, practise good personal hygiene and prevent cross-contamination to protect customers — and their employers — from the consequences of food-borne illness, allergic reactions to food or injuries from contaminated food.

Chemical contamination occurs when chemicals get into food. Common sources of chemical contamination in a commercial kitchen include:

Kitchen cleaning agents: Never keep food stored in the same place as your cleaning chemicals, and always use cleaning products designed especially for kitchen use.

Unwashed fruits and vegetables: Pesticides and fungicides on fruits and vegetables can be harmful if ingested, so it's important to properly wash all fruits and vegetables before preparing them.

Food containers made from non-safe plastics: Single-use items like plastic containers are not designed to be reused again and again. Always store food in containers that are specially designed for reuse.

Pest control products: Pest control products are extremely hazardous. Always store these products away from food items and never use these products in areas where food is being prepared.

Kitchen equipment: Equipment with moving parts, such as slicers and mixers, may need regular oiling. Always use food-safe oil to prevent chemical residues from contaminating food.

3.3. Physical contamination

Physical contamination happens when physical objects enter food. Common sources of physical contamination include:

- Hair: Always wear hair neatly tied back and wear a hairnet if possible.
- Glass or metal: Cracked or broken crockery and utensils should be thrown away, as well as any food that might have come into contact with it.
- Pests: Pests — such as mice, rats and cockroaches — leave droppings (urine, saliva, fur, faeces) that can contaminate food. Pests themselves can also make their way into food.
- Jewelers: It is not recommended to wear jewelers when handling food. In some regions, it may be restricted by local laws or regulations.
- Dirt: Because dirt is so small, it's easy not to notice it. Dirt often gets into food via unwashed food and vegetables.
- Fingernails: Always keep nails short and clean to prevent contamination. Avoid wearing fake nails as these can easily fall off and contaminate food.

3.4. Cross-contamination

In a food setting, cross-contamination refers to the transfer of contaminants from a surface, object or person to food. This can happen in many ways. Common causes of cross-contamination include:

Clothing: Dirty clothes can transport bacteria from one place to another. If possible, clothing should be replaced when moving from one work area to another. You should also thoroughly wash your face and hands. This is especially important when working with high-risk foods or when preparing allergen-free meals.

Utensils: Different utensils should be used to prepare different types of foods. For example, you should never use the same chopping board or knife to prepare raw meat and ready-to-eat foods.

Food Handlers: Coughing, sneezing or even touching your face or hair before handling food can cause cross-contamination. Washing hands regularly when handling food is essential.

Pests: Flies, cockroaches, mice and rats carry harmful bacteria, which they can transport from one place to another. Pest control is vitally important in the workplace when it comes to preventing cross-contamination.

Raw food storage: Cross-contamination frequently occurs when raw food encounters cooked or ready-to-eat food. If this happens, it's fair to assume the cooked or ready-to-eat food has become contaminated. Raw food should always be covered and stored below ready-to-eat food in the refrigerator to prevent this type of contamination.

Waste control: Garbage should be stored and sealed correctly to prevent cross-contamination. It should always be stored away from other items in the kitchen to ensure it never comes into contact with food during preparation. Regular cleaning and sanitizing of waste bins should also be carried out to minimize the risk of pest infestation.

4.

1. Microbe aetiology.

2. Not microbe aetiology.

3. Mycotoxicosis.

4. Food poisonings not investigated aetiology

4.1.

- Microorganisms making in organism toxins. Specific activators are salmonellas, potentially pathogenic microbes such as intestinal stick (*E. coli*), Proteus, etc.

- Bacterial toxicosis (the old name - food intoxications) arise at hit in organism products, containing bacterial toxins. Representatives are staphylococcal toxicosis, botulism.

- Mixed aetiology diseases when in food are both alive microbes and bacterial toxins - for example, salmonellas + staphylococcal toxin.

Toxic infections. Product sources: meat products, especially forcemeat, eggs, fish, lactic products. Conditions when products become dangerous for *toxic infections*: 1) The reasons of hit activators in products: a) Using ill and tired animals, wrong cutting animal carcass, b) Wrong storage and transportation products, processing of crude and ready products on one board, one knife etc., c) Non-observance by the personnel food objects rules of personal hygiene, absence regular physical examinations of the personnel, attraction to work casual people, 2) The reasons of duplication and preservation activators in products: a) Wrong storage - non-observance temperature and terms of realization, b) Insufficient thermal processing.

The main causes of *toxicoinfections.* Sources of infectivity of food products

1. Sick animal

2. Polluted water

3. Polluted utensils

4. Polluted equipment

5. Polluted apparatus

6. Polluted transport

7. Polluted rooms of food department

8. Infected food products

9. Carriers of bacilli: -man, cast, dogs, poultry

10. Carriers of microbes - flies, etc.

11. Non-observance of the rules of personal hygiene.

Disturbances of technological processes in food cooking

1. Insufficient thermal treatment of food products (meat, fish and so on).

2. Insufficient sterilization of tinned food.

3. Insufficient pasteurization.

4. A small quantity of preservative (antiseptics, sugar, vinegar, salt and others).

4.2. Group of food poisonings microbe aetiology caused by the microbe toxins, which have collected in products.

1) *Staphylococcal toxicosis*. The reason is golden staphylococcus it is capable to produce exotoxin in feed. Products are as sources: dairy products, creams, pies, cakes, dairy, fish and meat products. Conditions of hit staphylococcus and forming by its toxin in products: a) Staphylococcal diseases of the personnel of eating establishments -quinsy, pustular diseases of a skin of hands, b) Wrong storage - at room temperature, non-observance terms of realization.

Clinic: gastroenteritis at high temperature, diarrhea seldom, in heavy cases - infringement cardiac system, dehydration of organism. Prevention: physical examinations the personnel correct storage products, it is especial for cakes and pies in a hot season.

2) *Botulism*. The reason is formation in food product exotoxin of botulinum stick - *Clostridium botulinum*. Features of the activator: a) Spore-making - spores maintain boiling 4-5 hours, (in the vegetative form - only 15 minutes), maintain action preservatives - salts, vinegar, sugar long time, b) Obligate anaerobe microbe -

develops without access of oxygen (canned food), c) Under certain conditions (+ 10 - + 30° C without oxygen) is formed the strongest neurotropic exotoxin - a fatal doze for person 35 micrograms. Products are as sources: earlier in Germany in 19 century - cooked and blood sausages ("sausage poison"), dry-cured and cold smoked fish, now it is especial frequently - canned food (mushroom, vegetable domestic preparation - it is difficult to destroy spores in domestic conditions), sometimes - dry-cured and smoked meat, a canned meat.

4.3. *Poisonings with poisonous mushrooms*. Between many mushrooms, which people can collect in forests, some kinds are very poisonous and can give heavy intoxication. Poisoning by *Amanita phalloides*. Contains amanitotoxin and ammonitohemolysin. Block all kinds of metabolism, first of all carbohydrate and water. Sharp gastroenteritis is cholera-liked diarrhea - dehydration of organism - infringements of central nervous system and cardiac system (sharp falling the blood pressure). Hemolysis of erythrocytes is displayed pallor of skin and sharp hepatic insufficiency - jaundice of skin. Death is from collapse.

Poisoning by fly agaric (*Amanita muscaria*). Atypical appearance - sometimes mask under edible mushrooms. It contains muscarine what causes changes of nervous system. There are in clinic: gastroenteritis, perspiration, tearing and salivation, expansion of pupils. Defeat central nervous system as alcoholic poisoning. Death is from paralysis of the respiratory center.

Poisonings by poisonous wild growing plants are most typical at children's age.

Reason is usage of plants with m-cholinolytics such as atropine, scopolamine - belladonna, and dope. On background of gastroenteritis - expansion of pupils (belladonna - the beautiful woman), spasm of accommodation (infringement of sight on close distance), dryness and reddening skin and mucous, hoarse voice, lock. At poisoning dope human is arisen hallucinations and oppression central nervous system

(CNS). After recovery human may have the remote effects on CNS such as amnesia etc.

Poisonings with products sometimes or in part poisonous.

Solanine in potato. It is in growing and become green potatoes. It has irritating and hemolytic action. Gastroenteritis may be easy and average degree of weight. Phasin in string beans. Its toxin gives irritation and hemagglutination action. Destruction toxin may be at long thermal processing. In case of this food poisoning gastroenteritis are easy and average degree of weight.

Amygdalin in stone fruits. Most of all are in bitter almonds, in stones of apricots, peaches, cherries etc. In an organism breaks up with allocation prussic acid - blockade of fabric breath. In heavy cases it may be loss of consciousness, short wind, plentiful vomiting, diarrhea, spasms, death in 2-9 hours from paralysis of the respiratory center.

Control questions

1. Which foods contain amygdalin?
2. How much amygdalin is lethal?
3. What are the three main causes of food contamination?
4. What is the major cause of foodborne illness?
5. What are the 6 food borne diseases?
6. What are the two main ways pathogenic bacteria can cause foodborne illness?

Lecture 15. Food contamination. Part II

1. Alimentary poisonings not microbe aetiology

1.1. Heavy metals

1.2. Food contamination by agrochemicals

1.3. Food contamination by food additives

2. Mycotoxicosis

3. Standardization of food contamination

1. Alimentary poisonings not microbe aetiology by chemical materials:

a) Heavy metals - lead, copper, zinc, hydrargyrum etc.

b) Pesticides

c) Nitrates and nitrites

d) Alimentary additives

1.1. Heavy metals

Contamination of foods by heavy metals has several different sources. The most significant ones are:

•contamination of the soil from which foods are produced;

• residual muds;

•chemical fertilizers and pesticides used in agriculture;

• the use of other materials; etc.

Since this contamination has so many different sources, there is a wide range of foods contaminated by heavy metals, including products of plant origin (cereals, rice, wheat, edible roots, mushrooms, etc.) as well as foods of animal origin (fish, crustaceans, mollusks).

•Utensils and equipment that contain toxic metals such as Lead, Copper, Brass, Zinc, can cause a toxic poisoning. If acidic food is stored in or prepared using these types of utensils or equipment it can leach toxins into the food.

•Among the most significant heavy metals from the point of view of health are mercury, lead, cadmium, nickel, and zinc.

– Mercury (Hg). Mercury is a highly toxic heavy metal. Mercury can also enter our bodies through plant and animal products, given that it travels and accumulates in the soil. Such mercury is generated by human activities, for instance: mining,

foundries, agricultural fertilizers, wastewater discharge, and the burning of solid waste.

– Lead (Pb). Lead is a metal often used in residential installations and in metal alloys or chemicals, such as pipes, the manufacturing of paints, putties, and pesticides. It is one of the heavy metals that can most easily contaminate us. Lead enters the body through vegetables, meat, fruits, seafood, and wine (among many other foods contaminated with heavy metals). Tobacco smoke is another pollutant with a high concentration of lead.

– Cadmium (Cd). Cadmium (in its majority) comes from zinc refining processes. It is a residual or a by-product of zinc. The foods that are potentially most susceptible to cadmium contamination are mushrooms, shellfish, freshwater fish, dried algae, and potable water, among others.

– Copper (Cu). Copper is a mineral of great importance for the development of human life. Care should be taken to include this element in one's diet, but in its rightful measure. In high doses, copper is considered a heavy metal and provokes severe health disorders, such as anemia, stomach problems, and harm to the kidneys and the liver. Copper is prevalent in our homes in pipes and cookware. From there, it passes into water and cooked foods. Copper is massively used in industry.

1.2. Food contamination by agrochemicals

1 Food contamination by pesticides

Pesticides are widely used in producing food to control pests such as insects, rodents, weeds, bacteria, mold and fungus.

Sometimes it is possible accumulation it in products above maximal permissible concentration and development poisonings.

The reasons accumulation of pesticides in products:

a) Application non-authorized preparations (very proof or toxic),

b) Excess the established norms of the charge or frequency rate of processing,

c) Non-observance term of expectation - time between last processing plants and harvesting.

The clinic poisonings depend on group of pesticides - chlorine-organic, phosphor organic, carbamates, etc. They blockade enzymes such as cytochrome oxidase, cholinesterase.

2 Fertilizers are the substances for increase productivity of plants. Nitrogen fertilizers are most of all applied. Thus, in plants can accumulate nitrates which are transformed in nitrites in organism. Nitrates connect with haemoglobinates and form disease methemoglobinemia – hemoglobin cannot transport oxygen and a results hypoxia. Are especially dangerous to children first 3 months.

At high levels nitrates in products can created nitroso-combinations (NS) - cancerogenic effects.

1.3. Food contamination by food additives

Substances that are added to food to maintain or improve the safety, freshness, taste, texture, or appearance of food are known as food additives.

WHO, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), is responsible for assessing the risks to human health from food additives. The Codex Alimentarius Commission is established levels for maximum use of additives in food and drinks. Codex standards are the reference for national standards for consumer protection, and for the international trade in food, so that consumers everywhere can be confident that the food they eat meets the agreed standards for safety and quality, no matter where it was produced.

Classification food additives allowed to application in the countries of European Union

- E100s are generally colors.
- E200 to E282 are mainly preservatives and acids.
- E300 to E341 are mainly antioxidants and acid regulators.

- E400s include emulsifiers, stabilizers, thickeners, anti-caking agents, release agents and bulking agents.
- E500 – E599 Emulsifiers
- E600 – E699 Flavor enhancers
- E700 – E899 Don’t exist (codes are reserved)
- E900 – E999 Glazing agents and miscellaneous

2. The food contamination caused by toxins of micromycetes on bakeries (on grain, on flour) when stored in humid conditions. In poultry, this usually results when toxin-producing fungi grow in grain and feed. Hundreds of mycotoxins are known and of mild to severe toxicity.

Ergotism. *Claviceps purpurea* is a fungus of many grasses and several cereal grains, especially rye, oats and wheat.

Ergot Alkaloids are compounds produced as a toxic mixture of alkaloids in the sclerotia of species of *Claviceps*, which are common pathogens of various grass species. The ingestion of ergot sclerotia from infected cereals, commonly in the form of bread produced from contaminated flour, causes ergotism, the human disease historically known as St. Anthony's Fire. There are two forms of ergotism: gangrenous, affecting blood supply to extremities, and convulsive, affecting the central nervous system.

In food can products toxins as ergotoxine, ergotamine, ergometrine. Cause a spasm of smooth, then - other muscles.

Fusariosis A poisoning with "drunk bread". Species *Fusarium graminearum*. In clinic is gastroenteritis and defeat CNS as alcohol intoxication. Endemic disease on the Far East.

Alimentary toxic aleukia Up to 1944 year named "septic quinsy". Species *Fusarium* develop in the grain, which has wintered under snow. Deep violations of blood-forming, leuco- and thrombocytopenia. Heavy necrotic quinsy and a sepsis. Mortality is 50-80.

Aflatoxocoses Aflatoxins occur in nuts, cereals and rice under conditions of high humidity and temperature and present a risk to human health that is insufficiently recognized. The two major *Aspergillus* species that produce aflatoxins are *A. flavus*, which produces only B aflatoxins, and *A. parasiticus*, which produces both B and G aflatoxins. The clinical picture includes enlarged, pale, fatty liver and kidneys and severe cerebral oedema.

3. Standardization of food contamination

Base is the Law of Ukraine "On Quality and Security of Food Products and Food Raw Materials".

Maximum residue limit (maximum permitted residue level, maximum allowable concentration) – maximum permitted content in food products or animal feed of a specific substance, including pesticides, veterinary preparations, feed additives, residues of processing aids, and other chemical or biological substances, intentionally used and/or required for the technology of growing, storing, transporting, or producing food products and the residues of which, including any derivatives of such substance, such as conversion products, metabolites, and reaction products of toxicological significance are unsafe for humans when their maximum permitted content in food products consumed by humans is exceeded.

Acceptable daily intake (ADI) is a very import concept in chemical risk assessment. It is defined as the maximum amount of a chemical that can be ingested daily over a lifetime with no appreciable health risk.

Food additives. All food additives are subject to in-country registration by the National Competent Authority for Healthcare (Ministry of Healthcare of Ukraine - MHCU). As of November 2018, the Ukrainian competent authority has yet to publish the new official list of approved additives, as required by law. However, Ukraine officially accepted, and allowed for use, all EU-registered food additives.

Pesticides and Other Contaminants. The Catalogue of Pesticides and Agricultural Chemicals Allowed for Use in Ukraine (2018 list in Ukrainian) lists all registered pesticides by brand name, group, applicant, country of origin, active ingredients, and duration of registration. Agricultural chemicals not listed in the catalogue cannot be used domestically, and no residues in agricultural products are allowed.

Ukraine implemented a single food safety authority model for its food and animal safety control, as well as consumer protection. The single regulatory agency is called the State Service of Ukraine on Safety of Foodstuffs and Consumer Protection (SSUFSCP). SSUFSCP establishes its own maximum residue limits (MRLs) for chemical and biological contaminants in food products. The MRLs and detection methods for pesticides and other agricultural chemicals are established during the state pre-registration (tests and trials). The use of officially registered pesticides and their application procedures are controlled by the SSUFSCP. The SSUFSCP inspectors control these MRLs in agricultural products, food and feed, including imported products.

Microbiological indicators. Current microbiological indicators were adopted by the Ministry of Healthcare of Ukraine (MHCU) in 2012, by Order 548 (in Ukrainian), and empowered on August 10, 2015. The Ministry claims that the new list is harmonized with EU norms. The first chapter of the law established Maximum Residue Level (MRLs) for the presence of the following pathogens, toxins and substances in food products:

- *Listeria monocytogenes*,
- *Salmonella* (no strains specified),
- *Staphylococcal enterotoxins*,
- *Cronobacter* spp. (*Enterobacter sakazaki*),
- *E. coli* (as fecal masses contamination indicator),

- Histamine (for selected fish products)
- *Salmonella typhimurium* (for poultry).

Some MRLs establish zero tolerance for pathogens. Safety parameters for poultry meat established by the MHCU Oder 695 (in Ukrainian) became valid on September 6, 2016. The new norms are harmonized with EU requirements. It establishes MRLs for the following contaminants: toxic elements including lead, arsenic, cadmium, tin, chrome, mercury, benzpyrene and aflatoxin B1; antibiotics including levomycetin, tetracycline group, Bacitracin, nitrosamines; pesticides including DDT and hexachlorocyclohexane; dioxins; and a number of pharmacological substances.

Control questions

1. What happens if you eat food with pesticides?
2. What foods are sprayed with pesticides?
3. Is pesticide harmful to humans?
4. Why are additives used in foods?
5. What do mycotoxins do to humans?
6. What is Maximum Residue Level of contaminants in food production?

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