

**MINISTRY OF HEALTH OF UKRAINE**  
**O.O. BOGOMOLETS NATIONAL MEDICAL UNIVERSITY**

**“Approved”**

at the methodological conference of hygiene  
and ecology department

**Head of the department**

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**GUIDELINES**  
**FOR STUDENTS**

<i>Subject</i>	Hygiene and ecology
<i>Module № 1</i>	Assessment of the environment and its impact on the population health
<i>Submodule № 2</i>	Municipal hygiene
<i>Topic of the lesson</i>	Hygiene of water and water supply in settlements. Sanitary protection of water sources. Sanitary protection of soil and purification of settlements.
<i>Course</i>	6
<i>Faculty</i>	medical
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## **1. Learning objective**

1.1. Master requirements to drinking water quality and hygienic importance of some of its indices.

1.2. Acquire the method of the analysis reading and drinking water quality assessment for local and centralized water supply.

1.3. Understand hygienic, epidemic and endemic importance of soil.

1.4. Master the methods of sanitary examination of the territory and soil sampling for laboratory analysis.

1.5. Master the method of assessment of the soil pollution level and degree of its danger for people's health on the basis of the sanitary examination of the land parcel, and the results of soil samples' laboratory analysis.

## **2. Basics**

2.1. You should know:

2.1.1. Hygienic indices and standards of drinking water quality (physical, organoleptic, chemical composition) and pollution indices (chemical, bacteriological – both direct and indirect), their scientific substantiation.

2.1.2. Concept and characteristics of centralized (domestic and drinking water pipeline) and decentralized (wells, groundwater intake structures, catchments) water supply systems.

2.1.3. Hygienic characteristic of conventional and special methods of water quality improvement, technology of their implementation on main facilities of water pipeline at centralized water supply systems.

2.1.4. Scope of measures during sanitary inspection of exploitation of main facilities of water pipeline (individual components of water pipeline and water supply network) as well as wells and groundwater intake structures (catchments).

2.1.5. Hygienic, epidemic and endemic importance of soil.

2.1.6. Indices and the scale for assessment of sanitary condition of soil.

2.1.7. Importance of soil as the medium for domestic and industrial waste treatment.

2.2. You should have the following skills:

2.2.1. To state a hygienic value of drinking water quality according to results of sanitary inspection of the source of water supply and results of the laboratory analysis of water.

2.2.2. To state a hygienic value of different methods of water quality improvement and exploitation efficiency of individual structures and facilities, used for this purpose.

2.2.3. To elaborate the complex of measures to improve water quality and to prevent diseases caused by poor water quality.

2.2.4. To carry out the sanitary examination of the land parcel considering its function (territory of child institution, hospital, sewage treatment plant etc.).

2.2.5. To determine sampling points and to take soil samples for sanitary-hygienic, bacteriological and helminthological analyses.

2.2.6. To state a hygienic value of sanitary condition of soil on the basis of sanitary examination of land parcel and results of laboratory analysis.

2.2.7. To forecast approximate the population health level according to degree of soil contamination by exogenous chemical substances (ECS).

### **3. Self-training questions**

- 3.1. Influence of drinking water quantity and quality and water supply conditions on the population health level and the sanitary conditions of living.
- 3.2. Water supply rates and their substantiation.
- 3.3. Waterborne infectious diseases. Peculiarities of waterborne epidemics, their prophylaxis.
- 3.4. Diseases of noninfectious origin, which are caused by use of poor quality water and methods of their prevention.
- 3.5. Problem of waterborne macro- and microelementoses of water origin. Hygienic importance of water hardness. Endemic fluorosis and its prevention.
- 3.6. Endemic caries. Fluorine prophylaxis of caries and its importance in practice of centralized water supply.
- 3.7. Contribution made by Ukrainian hygienists in scientific substantiation and practical implementation of water fluorination in centralized water supply systems of Ukraine. Dependence of water fluorination upon climate conditions of locality.
- 3.8. Water-nitrate methemoglobinemia as a hygienic problem, its prevention.
- 3.9. General hygienic regulations on the drinking water quality, their indices – physical, organoleptic, indices of natural chemical composition, their hygienic characteristic. State standard of drinking water.
- 3.10. Sources and criteria of water pollution and epidemiologic safety of water – organoleptic, chemical, bacteriological, their hygienic characteristic.
- 3.11. Comparative characteristic of centralized and decentralized water supply systems.
- 3.12. Components of water pipeline for intake of artesian water and water from open reservoirs. Sanitary protection zones.
- 3.13. Standard methods of water purification for centralized water supply system (coagulation, precipitation, filtration), their essence and facilities that are used for this purpose.
- 3.14. Methods of water disinfection, their classification, hygienic characteristic.
- 3.15. Water chlorination, methods of chlorination and reagents, which are used for this purpose, disadvantages of chlorination.
- 3.16. Water disinfection by ozone treatment and treatment with ultraviolet rays, their hygienic characteristic.
- 3.17. Special methods for water quality improvement, their essence and hygienic characteristic (desalination, deferrization, deodorization, deactivation).
- 3.18. Methods of sanitary inspection of centralized water supply systems (preventive and regular). Types of laboratory analysis of water – bacteriological, sanitary and chemical analysis (short and complete).
- 3.19. Sanitary inspection of local water supply systems. Equipment and exploitation of wells, groundwater intake structures (catchments). “Sanation” of wells.
- 3.20. Methods of analysis “reading” and expert assessment of drinking water quality.
- 3.21. Soil, its definition. Hygienic, epidemic and endemic importance of soil.

3.22. Main physical properties of soil (texture compound, humidity, porosity, permeability, filtration ability, air permeability, capillarity, moisture) and their hygienic importance.

3.23. Main abiotic components of soil (solid substance, soil moisture, soil air), their natural chemical compound and hygienic characteristic.

3.24. Soil biocenoses, their classification and hygienic characteristic.

3.25. Soil as a factor in transmission of infectious pathogens.

3.26. Soil pollution sources, their classification and hygienic characteristic.

3.27. Factors and mechanisms that take part in the natural purification of soil.

3.28. Usage of soil for treatment of domestic and industrial waste.

3.29. Hygienic characteristic of waste collection procedures (door-to-door-based, neighbourhood-based), removal and processing of solid domestic, industrial and building waste.

3.30. "Pickup" system of collection, removal and processing of liquid waste (cesspool fields, sewage irrigation fields).

3.31. The land parcel sanitary examination procedure considering its functionality.

3.32. Rules, methods and devices for soil sampling and preparation for laboratory analysis.

3.33. Criteria of soil sanitary condition, their classification and hygienic importance.

3.34. Procedure of determination of soil physical and mechanical indices.

3.35. Functional diagram for determination of chemical criteria of soil sanitary state.

3.36. Procedure of detecting eggs of geohelminthes in soil.

3.37. Functional diagram for determination of bacteriological criteria of soil sanitary condition and its pollution.

3.38. Approximate assessment scale of soil pollution level and degree of its danger for people's health.

3.39. Hygienic assessment procedure of soil sanitary condition based on the results of sanitary examination of the land parcel and laboratory analysis of the samples.

#### **4. Self-training assignments**

4.1. To solve a following problem: water is taken from the shaft well, which depth from ground surface to water surface is 14 m. Log cabin is made of wood. The well is equipped with an open shed, a cover, a winch with a common dip-bucket. A plot that surrounds the well is clean and there is a fence around it. Sample of water is sent to the laboratory on the 20-th of June of current year, water is sampled into two glass vessels to make sanitary and chemical analysis and bacteriological analysis. Water samples are sealed up; the accompanying letter with information about the state of the well and sampling conditions is attached. The results of laboratory analysis of water samples are the following: transparency – 30 cm according to standard font, colour – 40° according to the scale of potassium dichromate; odour at water temperature equal to 20° and 60°C – is absent (1 point); aftertaste strength – 0 points; sediment – absent; solid residue – 400 mg/l; pH – 7.5; total hardness – 9 CaO mg-equiv/l; total iron – 0.25 mg/l; sulphates – 80 mg/l; fluorine – 1.2 mg/l; chlorides – 82 mg/l; ammonium nitrogen – 0.1 mg/l; nitrite nitrogen – 0.002 mg/l; nitrate nitrogen – 20 mg/l; microbial number – 200 CFU/cm<sup>3</sup>; CBGB index – 4 CFU /cm<sup>3</sup>. Assess the water quality of the well and decide whether water in this well is good for domestic and drinking purposes (see Appendix 4).

4.2. To draw up sanitary certificate of water sample taken from water supply network. The results of the laboratory analysis of water sample are the following: transparency – more than 30 cm according to Snellen scale; colour – 20° according to the standard scale of potassium dichromate; odour and aftertaste – not exceeding 2 points; sediment – absent; turbidity (suspended materials concentration) – 2 mg/l; solid residue – 200 mg/l; iron total – 0.7 mg/l; sulphates – 96 mg/l; chlorides – 34 mg/l; fluorine – 0.8 mg/l; ammonium nitrogen – 0.28 mg/l; nitrate nitrogen – 10 mg/l; nitrite nitrogen – 0.001 mg/l; total hardness 6.3 CaO mg-equiv/l; microbial number – 92 CFU /cm<sup>3</sup>; coli index – 3 CFU/cm<sup>3</sup> (see Appendix 3).

4.3. In the outskirts of a settlement a parcel of 3 ha of former cultivation area is assigned for construction of a new boarding school. During the sanitary examination of the parcel no sources of pollution were discovered. However, the ground could be contaminated by chemical fertilizers and pesticides when it was used for agricultural needs. The relief has a slope in the southern direction. At the distance of 20 m from the northern border of the parcel an unequipped dump of domestic waste was found, which is at the distance of 100-130 m from the people houses. In the center of the parcel soil sample of 40×20 m<sup>2</sup> size was taken by “envelope” technique. 1 kg of soil was taken at each sampling point.

Laboratory analysis data:

Soil physical properties: physical sand (particles of the size bigger than 0.01 mm) – 85%, foreign impurities – up to 9%.

Pollution indices of exogenic chemical substances: dichlorodiphenyltrichloroethane (DDT) (amount of isomers) – 0.05 mg/kg (MAC – 0.1 mg/kg), hexachlorobenzene (HCB) – 0.01 mg/kg (MAC – 0.1 mg/kg).

Sanitary-chemical criteria of epidemic safety: ammonia nitrogen – 45 mg/100 g, organic nitrogen – 0.6 mg/100 g, nitrites – 0.5 mg/100 g, nitrates – 3.3 mg/100 g, chlorides – 75 mg/100 g, Khlebnikoff’s sanitary number – 0.78.

Sanitary microbiological criteria of epidemic safety: microbial number – 5 x 10<sup>5</sup>, when titer is 0.01, titer of anaerobes is 0.001, eggs of helminthes – 7 in 1 kg of soil, number of larvae and chrysalides of flies – 5 on 0.25 m<sup>2</sup>.

Draw up a valid report about sanitary condition of soil and make recommendations concerning the assignment of the parcel for school building

When solving a situational task one should use norms and standards given in Appendices 3 and 5 and recommended literature.

## **5. Structure and content of the lesson** (duration of the lesson 160 min + 10 min break)

5.1. Preamble – 5-10 min.

5.2. Test control for assessment of students’ knowledge datum level – 10-15 min

5.3. Theoretical training – 30-40 min.

5.4. Typical situational tasks “Krok-2” solution – 30-40 min.

5.5. State exams situational tasks solution – 30-40 min.

5.6. Test control for assessment of students’ knowledge final level – 10-15 min.

## Hygienic significance of water

### Water physiological functions:

- flexibility – about 65 % of body mass of adult person consists of water. 70 % of water is the intracellular water, 30 % - extracellular water (in blood), (7%) - lymph and 23 % - intertissue fluid. Water makes up 20 % of the bone mass, 75 %, of the muscle mass, 80% of the connective tissue mass, 20% of blood plasma mass, 99% of vitreous body of an eye. Major part of water is a component of macromolecular complexes of proteins, carbohydrates and fats, forming the jelly-like colloid cells and extracellular structures together with them. The smaller part of it is in a free state;
  - participation in metabolism and interchange of energy – all assimilation and dissimilation processes in organism occur in water solutions;
  - role in support of osmotic pressure and acid-base balance;
  - participation in heat exchange and thermoregulation – at evaporation of 1 g of moisture from lungs' surface, mucous membranes and skin (latent heat of evaporation) organism loses 2.43 kJ (0.6 kcal) of heat;
  - transportation function – delivery of nutrients to cells with blood and lymph, removal of waste products from the organism with urine and sweat;
  - as a component of dietary intake and a source of macro- and microelements supply to organism;
  - there are neuropsychic disorders that are resulted from impossibility to satisfy thirst if water is not available or if it is of bad organoleptic characteristics. According to I.P. Pavlov's doctrine on higher nervous activity, odour, taste, after-taste, water appearance, clarity (transparency) and colour are irritators that influence the whole organism through central nervous system. Worsening of organoleptic characteristics of water causes the reflex effect on water intake schedule and some physiological functions, for example it oppresses the secretory function of stomach. Drinking of such water causes the defence reaction in human organism – the feeling of aversion, which makes a person to refuse such water irrespective of thirst.

### Epidemiological and toxicological role of water

#### Water can participate in spread of infections in the following ways:

- as transfer factor of pathogens with the fecal-oral transfer mechanism: enteric infections of bacterial and viral origin (typhoid, paratyphoid A, B, cholera, dysentery, salmonellosis, coli-entheritis, tularaemia /deep-fly or rabbit fever/, viral and epidemic hepatitis A, or Botkin disease, viral hepatitis E, poliomyelitis and other enterovirus diseases, such as Coxsackie, ECHO etc.); geohelminthosis (ascariasis, trichocephalosis, ankylostomiasis); biohelminthosis (echinococcosis, hymenolepiasis); of protozoal etiology (amebic dysentery (amebiasis), lamblia); zooanthroponosis (tularemia, leptospirosis and brucellosis);
  - as a transfer factor of pathogens of the skin and mucous membrane diseases (when swimming or having another contact with water): trachoma, leprosy, anthrax, contagious molluscum, fungous diseases (i.e., epidermophytosis);
  - as the habitat of disease carriers – anopheles mosquitoes, which transfer malarial haemamoeba and others (open water reservoirs).

#### *Symptoms of water epidemics:*

- simultaneous appearance of big number of enteric infected people, i.e. jump of population morbidity – so-called epidemic outburst;
- people who used the same water source, the same pipeline of water supply network, the same water-pump, shaft well etc. will suffer from diseases;
- morbidity level will stay high for the long period of time to the extent of water contamination and consumption;
- morbidity curve will have one, two, three, or more peaks. First of all those diseases that have short incubation period will be registered (coli-enteritis, salmonellosis - 1-3 days, cholera – 1-5 days, typhoid – 14-21 days and at last - those with the longest period: virus and epidemic hepatitis A and E – 30 days and more);
- after the taking of antiepidemic measures (liquidation of the contamination source, disinfection of water supply network, sanitation of wells) the outburst fades away and morbidity goes down drastically;
- still, for some time morbidity remains above the sporadic level – so-called epidemic tail. This is caused by the appearance of big amount of new potential sources of infection (sick people and infection carriers) during the epidemic outburst and activation of other ways of the pathogenic microorganisms spreading from these sources – domestic contact (through dirty hands, dishes, children toys, personal hygiene articles), through food or by living carriers (flies) etc.

Toxicological role of water consists in it containing chemical agents that may negatively influence people health causing different diseases. They are divided into chemical agents of natural origin, those, which are added to water as reagents and chemical agents, which come into the water as the result of industrial, agricultural and domestic pollution of water supply sources. Insufficient or non-effective treatment of such waters at waterworks procures the continuous toxic effect of small concentrations of chemical agents, or, rarely, in cases of accidents and other emergency situations – acute poisonings.

### Balneal role of water

Water is used in medicinal purpose for rehabilitation of convalescents (drinking of mineral waters, medicinal baths), and also as tempering factor (bathing, swimming, rub-down).

### Domestic and economic role of water

Sanitary-hygienic and domestic functions of water include:

- water usage for cooking and as a part of dietary intake;
- usage of water as means of keeping body, clothes, utensil, residential and public premises and industrial areas, settlements clean;
- watering of the green areas within settlements;
- sanitary-transport and disinfection functions of water – disposal of residential and industrial waste through sewer system, waste processing on plants, self-purification of water reservoirs;
- fire fighting, atmospheric pollution clearing (rain, snow).

Economical functions of water:

- usage in agriculture (irrigation in crop and gardening, greenhouses, poultry and cattle breeding farms);

- industry (food, chemical, metallurgy etc.);
- as the route of passenger and cargo transportation.

### *Classification of water supply sources*

Water supply sources are divided into ground and surface:

- middle waters with pressure (artesian) and without pressure that lie in aquifers (water-bearing horizons,) (sandy, gravelled, cracked) between impermeable to water layers of soil (clay, granites), therefore safely protected from penetration of pollutants from the surface. Middle water replenishes in feeding zones – places, where the auriferous stratum pinches out onto the surface, located considerably far away from the water take point. Middle waters are characterized by not very high, stable temperature (5-12°C), constant physical and chemical composition, steady level and considerable flow; they contain almost no microorganisms, especially pathogenic. Such waters are epidemically safe and don't require disinfection;

- underground waters that are located in aquifers above the first impermeable layer of soil and therefore, in case of them lying not very deep, they are insufficiently protected from penetration of pollutants from the surface. They are characterized by seasonal fluctuations of chemical and bacteriological composition and level, flow that depends on frequency and number of precipitations, availability of open-air water reservoirs, depth and soil type. Getting filtrated through the 5-6 m or bigger layer of clean fine-grained soil ground waters become clear, colourless, contain almost no pathogenic microorganisms. Supplies of ground water are small, therefore, in order to use them as a source of centralized water supply, the artificial recharge (replenishment) of them using special technical facilities is required;

- spring water, flowing out from aquifers that pinch out onto the surface due to descending relief, e. g. on the hill slope, in deep ravine.

- perched groundwater, lying next to the ground surface, is formed as a result of atmospheric precipitates filtration within a small area. Very small supplies and bad water quality do not allow recommending perched groundwater as the source of domestic and drinking water supply.

Surface waters are divided into flowing (running) waters (rivers, waterfalls, glaciers), stagnant (dead-water, still water) (lakes, ponds, artificial open water reservoirs). Their water composition depends much on the soil at the territory of water intake, hydrometeorological conditions, and varies sufficiently during the year depending on the season or even on the weather. Compared to ground waters, surface water sources are characterized by big amount of suspended substances, low clarity, higher colour due to humic substances that are washed away from the soil, higher content of organic compounds, presence of autochthonic microflora and dissolved oxygen. Open-air reservoirs can easily be polluted from outside, therefore, from epidemiological point of view they are potentially unsafe.

In some water-poor or arid areas, the imported and precipitation (atmospheric) water (rain, snow), which is stored in indoor water reservoirs or artificially filled wells, is used.

The best is the situation when quality of water in the source of water supply completely meets the contemporary criteria of the good water quality. Such water doesn't require any treatment and the only concern is not to spoil its quality at the stages of its take from the source and delivery to consumers. But disinfection of such water is the part



of sanitary requirements anyway. Only some underground middle waters are like this, mostly – artesian (pressure) waters. In all other cases water in the source, especially the surface water, requires quality improvement: lowering of suspended materials concentration (clearing) and colour (decolouration), getting rid of pathogenic and conditionally pathogenic microorganisms (disinfection), sometimes chemical composition improvement using special treatment techniques (desalination, softening, defluorination, fluorination, deferrization etc.). Hygienic requirements to water quality in sources of centralized water supply are given in appendix 4.

### **Sources of the surface water reservoirs pollution**

The main source of pollution of surface water reservoirs are sewage waters (especially untreated or insufficiently treated water) that are created as the result of the water use in private life, industry, poultry and cattle factories etc. Partial pollution of water reservoirs occurs in the result of surface drainage of rain, storm waters and waters that appear during snow melting. Sewage waters and surface drainage add a big amount of suspended solids and organic compounds to water of reservoirs that results in more colour and water turbidity increase, clarity (transparency) lowering, oxidation and biochemical oxygen demand (BOD) increase, amount of dissolve oxygen lowers, concentration of nitrogen-containing substances and chlorides increases, bacterial insemination grows. Together with industrial wastewaters and sewage from farmlands, as it was mentioned before, various hazardous toxic chemical substances get into water reservoirs.

Water in open reservoirs may be polluted in the result of its use for transport purposes (passenger, freight shipping, timber floating), when working near river-beds (e.g., extraction of river sand), during watering animals, at sports competitions, recreation of population.

### **Self-purification (natural purification) of open-air water reservoirs**

Self-purification (natural purification) of open air water reservoirs takes place in the result of various factors' effect: a) *hydraulic* (mixing and dilution of pollutants by water of water reservoir); b) *mechanical* (precipitation/sedimentation of suspended solids); c) *physical* (solar radiation and temperature effect); d) *biological* (interaction of water plant organisms and microorganisms with sewage organisms that got into reservoir); e) *chemical* (elimination of contaminants as the result of hydrolysis); f) *biochemical* (conversion of some substances into other due to biological elimination, mineralization of organic substances as the result of biochemical oxidation caused by water autochthonic microflora). Natural purification with pathogenic microorganisms occurs due to their death as the result of antagonistic action of water saprophytic organisms, antibiotic substances, bacteriophages etc. In case of pollution of water reservoirs by domestic and industrial wastewaters, processes of natural purification may be stopped. Water in reservoirs becomes overgrown (vegetation burst of aquatic plants, plankton), putretaction of water.

## Selection of the source of centralized domestic and drinking water-supply

It is based on two theses:

- consumer supply with adequate amount of good quality drinking water (water quality in reservoir must be suitable for conversion using up-to-date water treatment methods into potable water of good quality that would meet all requirements of State Standard (2874-82, SSRandN 136/1940) currently in force);
- control of the highest sanitary reliability of the source (selection of the source is based on assessment and prognosis of its possible pollution).

The source of centralized domestic and drinking water-supply is to be selected as follows: 1) middle water (artesian) aquifers; 2) middle water (not-artesian) aquifer; 3) underground waters, which are refilled artificially; 4) surface waters (rivers, water reservoirs, lakes, canals).

When selecting the source, water amount sufficiency for covering all needs of the built-up area is considered, water supply points (water intakes) are defined and organizational opportunities for sanitary protection zones are assessed.

Hygienic principles are assumed as the basis of selection of water- supply source; water quality requirements of ground and surface sources, selection procedure are represented in SS 2761-84 “Centralized domestic and drinking water supply sources. Hygienic, technical requirements and selection guidelines” (Appendix 4).

Appendix 2

### Technique of sanitary inspection of water-supply sources

Sanitary inspection includes three main stages:

- sanitary-topographic inspection of water source environment;
- sanitary-technical inspection of condition of water source equipment;
- sanitary-epidemiological inspection of area of water source location.

*Main task of sanitary-topographic inspection* of water source is to discover possible sources of water pollution (dumps, refuse pits, lavatories, livestock farms, cemeteries etc.), distances from them to water source, topography of the locality, (drain direction of rain and snow waters towards water source or in another direction, flow direction of ground waters, overflows). On the basis of sanitary-topographic inspection a map – layout of positional relationship of water source and listed objects with marks of distances and direction of locality slope is created.

In most cases relationship between water source and source of pollution may be determined by research. For this purpose a saturated solution of sodium chloride or solution of fluoresceine is poured into the source of pollution (at least one bucket of mixture for every 10 m of distance towards water source), and every 3-4 hours during one or two days chlorides (or fluoresceines) are sampled in the water source.

The *purpose of sanitary-technical inspection* is to give a hygienic assessment of condition of technical equipment of hydraulic works at water source. Thus, in case of decentralized (local) water-supply, accuracy of allocation and exploitation of the mineshaft (availability and condition of log cabin, awning, riprap, devices for water lifting, “loamy key trench”); in case of centralized water-supply from ground middle water source – accuracy of arrangement and condition of artesian well, water lifting pumps; in case of surface water source – of diversion scoop and coastal sink. In case of

centralized water-supply, sanitary-technical condition of main facilities of water-pipe, water supply network and constructions on it (namely, water-pumps).

It is of practical importance to determine the amount of water in the source of water and its discharge (output). E.g. amount of water in the well made of concrete rings with log cabin is determined by the formula:

$$V = \pi \times R^2 \times h,$$

where:  $V$  – amount of water in the well,  $m^3$ ;

$\pi$  - 3.14;

$R$  – radius of log cabin ring, m;

$h$  – water layer height, m.

Water height is determined by cord with weight, which is pulled down till the touch of the bottom and then a wet part of the cord is measured.

To find out discharge (output) of the well, 30-40 buckets of water are pumped out (scooped out) then the change in the level of water is marked and the time during which the previous level of water restores is fixed. Discharge (output) is calculated by formula:

$$D = \frac{V \times 60}{t},$$

where:  $D$  – discharge of the well, l/hour;

$V$  – volume of pumped out water, l;

$t$  – time, during which the level of water restores and time of water pumping, minutes.

*River discharge* is the amount or volume of water that flows through a given cross-section of a river in a given unit of time (m/sec)

Discharge (output) of a brook or a small river is calculated by formula:

$$D = 0.5 \times b \times h \times v,$$

where:  $D$  – output (productivity),  $m^3/\text{sec}$ ;

$b$  – water flow width, m;

$h$  – water flow depth at the deepest point, m;

$v$  – flow velocity, m/sec (is determined using a float and stop-watch).

*Sanitary-epidemiological inspection* is aimed to discover and consider the following:

- presence of intestinal infectious diseases (cholera, typhoid, paratyphoid A, B, dysenteries, virus hepatitis etc.) among population, which uses water from this source or lives close to it;

- presence of epizootic diseases (tularemia, brucellosis, anthrax, murrain, mad cow disease (BSE) etc.) among rodents, domestic animals;

- sanitary condition of the settlement (pollution of the territory, methods of collection and disinfection of liquid and solid domestic and industrial waste etc.).

During sanitary inspection water samples from open water reservoir, well or artesian well for further laboratory analysis are taken.

## Appendix 3

### Technique of water sampling for laboratory analyses

During water sampling from open reservoir or a well the temperature of water is measured by a special thermometer (Fig. 16.1.) or by an ordinary chemical thermometer, the vessel of which is wrapped up with some layers of gauze bandage. Temperature is

taken directly in the water source. Thermometer is put down into the water for 5-8 min., then it is quickly drawn up and temperature is read.

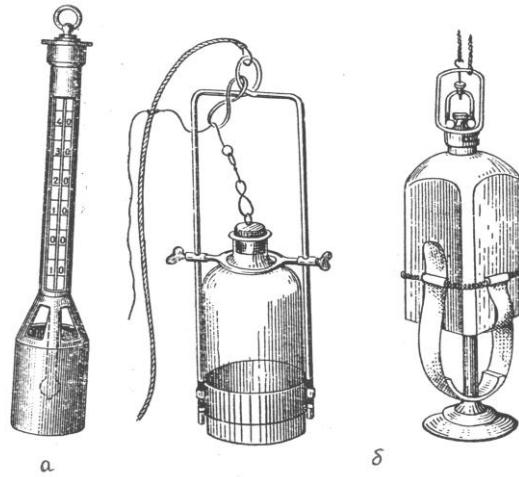


Fig. 16.1 Thermometer for taking temperature of water in reservoirs and wells (a), bathometers for water sampling for analysis (b).

Water sampling from open reservoirs and wells is carried out using bathometers of different design and supplied by double cord for putting the instrument down to specified depth and for opening the cork of the vessel at that depth (Fig. 16.1-b).

For water sampling from flowing water reservoirs (river, brook) there is a design of bathometer with stabilizer that directs a neck of the vessel against the stream.

Water sampling from water tap or equipped catchment is carried out:

- for bacteriological analysis. Sample is put into a sterile bottle of 0.5 l volume, with bulky cork, wrapped with paper cap from above after preliminary singeing of outlet port of the tap or catchment by spirit flame and letting water out from the tap during at least 10 min. In order to avoid bulky cork wetting, only three quarters of the bottle is filled with water to leave at least 5-6 cm of air space under the cork. The bottle with bulky cork is preliminary sterilized in drying box at  $160^{\circ}\text{C}$  during one hour;

- for short sanitary-chemical analysis (organoleptic criteria, main indices of chemical compound and water pollution). About 1 liter of water is taken into a chemically clean glassware, which was preliminary rinsed with water to be sampled (for complete sanitary-chemical analysis 3-5 l of water are taken off).

During sampling a covering letter is written down. This letter indicates: type, name, location, address of the water source (surface water reservoir, artesian well, mineshaft, catchment, water tap, water-pump); its short specification, weather state during sampling and during last 10 days; reason and goal of sampling (regular inspection, adverse epidemic situation, population complaints about deterioration of water organoleptical properties); laboratory, to which the sample is sent; required extent of examinations (short, full sanitary-chemical analysis, bacteriological analysis, determination of pathogenic microorganisms); date and hour of sampling; research result received during sampling (temperature); who tested (surname, position, institution); signature of an official person, who took the sample.

Samples must be delivered to the laboratory as quickly as possible. Bacteriological analyses must be started during 2 hours since taking samples or in case of keeping samples in refrigerator at  $1-8^{\circ}\text{C}$  at the latest 6 hours. Physical and chemical analysis is made during 4 hours after taking a sample or in case of keeping a sample in refrigerator at  $1-8^{\circ}\text{C}$  at the latest 48 hours. In case of inability to perform the analysis during

specified terms, sample must be preserved (except samples for physical-and-organoleptical and bacteriological analyses, and for BOD determination that must be necessarily made during terms specified above). Samples are preserved by 25% of H<sub>2</sub>SO<sub>4</sub> - solution on the basis of 2 ml for 1 l of water or by another method depending on factors to be determined.

Taken sample comes with accompanying form, in which one indicates address details, kind of water source, where samples are directed, aim of the analysis, date and time of taking a sample, signature of an official person, which took this sample.

Appendix 4

Extract from SS 2761-84

**“Centralized domestic and drinking water supply sources. Hygienic, technical requirements and selection guidelines”**

Water composition of fresh water from ground and surface sources must meet the following requirements:

- solid residue – less than 1000 mg/l (by approbation of SES less than 1500 mg/l);
- chlorides – less than 350 mg/l;
- sulphates – less than 500 mg/l;
- total hardness – less than 7 mg-equivalent/l (by approbation of SES less than 10 mg-equivalent/l);
- chemical agents – less than water MAC of reservoirs domestic and drinking and cultural/recreation and domestic use as well as below the norms of radiation safety that are approved by Ministry of Public Health of Ukraine;
- in case of simultaneous presence of toxic chemical agents in water that are able to summarize negative effects at their combined action it is necessary to follow the rule of summational toxicity;

$$\frac{C_1}{MAC_1} + \frac{C_2}{MAC_2} + \dots + \frac{C_n}{MAC_n} \leq 1$$

where: C<sub>1</sub>, C<sub>2</sub>, C<sub>n</sub> – actual concentrations of chemical agents in water, mg/l.

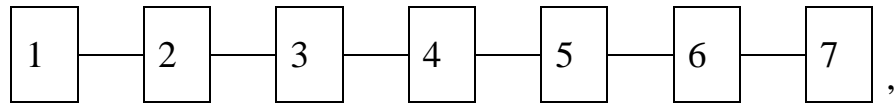
Depending on water quality and water treatment methods, which are necessary for getting good quality drinking water, ground and surface water sources are divided into three classes.

<i>Water quality criteria</i>	<i>Type of water source</i>					
	<i>ground waters</i>			<i>surface waters</i>		
	<i>class</i>					
	<i>I</i>	<i>II</i>	<i>III</i>	<i>I</i>	<i>II</i>	<i>III</i>
<i>Organoleptic:</i>						
Odor at 20 <sup>0</sup> C and 60 <sup>0</sup> C, points	2	2	2	2	3	4
Tastes, points	2	2	2	2	3	4
Turbidity, mg/dm <sup>3</sup>	1.5	1.5	10	20	1500	100000
Colour, degrees	20	20	50	35	120	200
Temperature, °C	8-12	8-12	8-12	8-25	8-25	8-25

Water quality criteria	Type of water source					
	ground waters			surface waters		
	class					
	I	II	III	I	II	III
Hydrogen sulphide, mg/dm <sup>3</sup>	-	3	10	-	-	-
Appearance	without admixtures visible by the naked eye					
<i>Indicators of natural chemical compound (selectively):</i>						
Solid residue, mg/dm <sup>3</sup>	1000-1500			1000-1500		
pH	6-9			6,5-8,5		
Hardness, mg-equiv./dm <sup>3</sup>	7-10			7-10		
Chlorides, mg/dm <sup>3</sup>	350			350		
Sulphates, mg/dm <sup>3</sup>	500			500		
Iron, mg/dm <sup>3</sup>	0,3	10	20	1	3	5
Manganese, mg/dm <sup>3</sup>	0,1	1,0	2,0	0,1	1,0	2,0
Fluorine, mg/dm <sup>3</sup>	1,5	1,5	5,0		0,1-0,5	
Nitrates, mg/dm <sup>3</sup>	45			45		
<i>Indicators that characterize epidemic safety and natural purification of water reservoirs</i>						
a) sanitary-microbiological:						
Number of saprophytic microorganisms in 1 cm <sup>3</sup> of water	100			1000-2000		
Number of colon bacilla group bacteria (CBGB) in 1 dm <sup>3</sup> of water	3	100	1000	1000		
Number of lactose positive colon bacilla (LPCB) in 1dm <sup>3</sup> of water	-	-	-	1000	10000	50000
Number of enterococci, in 1 dm <sup>3</sup> of water		10	10		1000	
Pathogenes of enteric infections (salmonellas, shigellas, enteroviruses)	mustn't contain			salmonellas and enteroviruses may be contained in 10% of samples		
b) sanitary-chemical:						
Permanganate oxidizability, mg/dm <sup>3</sup>	2	5	15	7	15	20
Ammonia salts, mg/dm <sup>3</sup>		0.01-0.1			0.01-0.1	
Nitrite nitrogen, mg/dm <sup>3</sup>		0.005			0.005	
Nitrate nitrogen, mg/dm <sup>3</sup>		0.1			0.1	
Dissolved oxygen, mg/dm <sup>3</sup>		-			4.0	
BOD <sub>20</sub> , mg O <sub>2</sub> /dm <sup>3</sup>		-		3	5	7

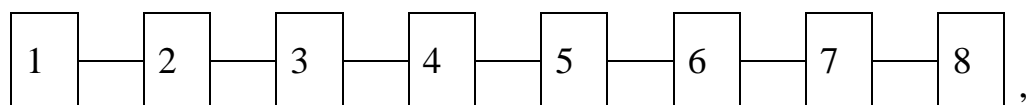
Classes and methods of water treatment. Principal diagrams of water-supplies

Water of I-class ground sources totally meets the concept of the good drinking water quality, it's quality is totally compliant with those for drinking tap water according to SS 2874-82. Therefore it may be directly fed to population without treatment. In this case water-supply diagram looks as follows:



where: 1 – ground source of water–supply (artesian or not-artesian middle waters);  
 2 – artesian well;  
 3 – lifting pump I;  
 4 – disinfection;  
 5 – pure water reservoir;  
 6 – lifting pump station II;  
 7 – water-supply network.

Water of II-class ground sources may contain hydrogen sulphide of mineral origin, much higher content of iron and manganese. This deteriorates its organoleptical properties and causes the need to use special methods of treatment (aeration, deferrization by aeration with further filtration). Besides, ground waters of class II may contain an excessive permanganate oxidability and CBGB index, which is the evidence of water epidemiologic insecurity and requires its disinfection before its supply to consumers. In this case water supply diagram looks as follows:



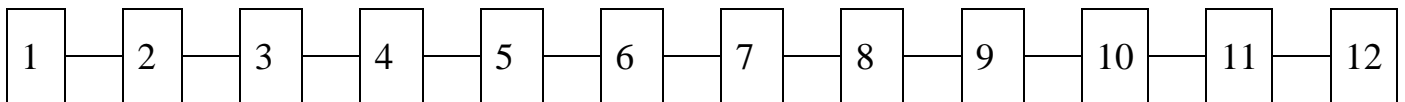
where: 1 – ground source of water–supply;  
 2 – artesian well;  
 3 – lifting pump I;  
 4 – special methods of water treatment;  
 5 – disinfection;  
 6 – pure water reservoir;  
 7 – lifting pump station II;  
 8 – water-supply network.

Water of III-class ground sources may have an excessive concentration of suspended materials, more colour, even higher content of iron, manganese and hydrogen sulphide. Some ground sources contain the excessive amount of fluorine (up to 5 mg/l). CBGB index may run up to 1000. For suspended materials' delution and reduction of colour of such water, it is necessary to clarify and decolourize it by filtration with previous desalination. The removal of hydrogen sulphide, iron and manganese is carried out by aeration and further filtration. In case of excessive content of fluorine such water must be defluoridated. For provision of water epidemiologic safety it must be disinfected.

Surface waters with low concentration of suspended materials and of little colour, without odor, contain little amount of easily oxidized (including organic) substances, has a small excessive content of iron and relatively low level of bacterial contamination compared to class I. Such water may be converted into drinking water of good quality by

filtration, either without coagulation or with the use of small doses of coagulate and by disinfection.

II-class water sources have higher concentration of suspended materials in their water with more colour, natural smell, contain more easily oxidized (including organic) substances, have higher iron content, relatively high level of bacterial contamination and rather big amount of plankton. For purification of such water conventional methods of such treatment are used: microfiltration - to remove plankton, coagulation with water precipitation and further filtration, coagulation with two-stage filtration, contact clarification and obligatory disinfection – to clarify and decolourize water. Principal diagram of such water-supply is:



where: 1 – surface water source;

2 – scoop (water intake facility);

3 – coastal water intake well;

4 – lifting pump station I;

5 – chamber for water head reduction, which simultaneously serves for mixing water with coagulant solution;

6 – reaction chamber;

7 – sediment chamber;

8 – high-rate filter;

9 – disinfection;

10 – pure water reservoir;

11 – lifting pump station II;

12 – water-supply network.

Water of III-class surface sources is of such quality that it cannot be changed according to SS 2874-82 requirements using conventional methods of purification. Water of such reservoirs has too high concentration of suspended materials, has intensive yellow-brown colour due to humic substances, has strong natural odour, contains many easily oxidized (especially organic) substances, contains a lot of iron, high level of bacterial contamination and big amount of plankton (100 000 per cm<sup>3</sup>). Beside conventional methods of treatment for such water purification it is necessary to use additional stages of water clarification, application of oxidative and sorption methods, more efficient disinfection.

Appendix 5

### **Hygienic characteristics of water supply systems of settlements**

There are centralized and decentralized water supply systems.

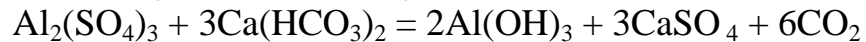
Centralized system (water pipeline) includes: source of water (middle water with or without pressure, open natural water reservoir or artificial storage reservoir), water intake facility (artesian well, artificial flooding with waterside intake well equipped with filter system), water-lifting facility (water-engines or pumps of the first lifting), main facilities of water supply station, where water clearing, discolour, disinfection are executed, and



sometimes there also takes place special water treatment (fluorination, defluorination, deferrization etc.) to improve water quality, reservoirs for water storage (reservoirs of pure water), water-pumping station of the second lifting and water supply network – system of water pipes, which provide consumers with water.

Artesian water (middle water with pressure) often does not need purification, sometimes - only disinfection, rarely – application of special methods of the water quality improvement. In case of use of water from open reservoirs in water pipeline, it should obligatory undergo purification, which is performed at treatment facilities of water supply station and provides for water clearing, discolour and disinfection.

Coagulation is used to purify the water – chemical treatment of water with aluminium sulphate according to the following reaction:



Aluminium hydroxide in form of rather big plates absorbs suspended in water contaminants and humic colloidal particles, as the result of this process water becomes clear and colourless. Dose of coagulant depends upon water alkalinity rate, presence of bicarbonate in it, amount of suspended substance and water temperature. When carbonate hardness is small (less than 4°), we add 0.5-1.0 % solution of soda or slaked lime. To accelerate coagulation the flocculating agents (polyacrylamide) are added into water.

After coagulation water comes to sedimentation tanks, then through filters to reservoirs for pure water and by means of pumps of the second lifting it is pumped into water supply network.

After the filtration water is obligatory disinfected using ozone treatment, UV radiation or chlorination methods.

Chlorination is the simple, effective and cheapest method of water disinfection, but chlorine imparts unpleasant odour to water, and if there is any chemical pollution (due to discharge of industrial sewage water to reservoirs) chlorination facilitates formation of chlorine-organic compounds, for which carcinogenic action, and formation of chlorophenol compounds having unpleasant odour are inherent. As a result of this method of chlorination with pre-ammoniation has been worked out: preliminary introduction of ammonia solution into water binds chlorine in the form of chloramines, which disinfect water, at the same time chlororganic and chlorophenol compounds do not form.

Most often *decentralized (local) water supply* is realised using shaft or tube wells, and more rarely using groundwater intake structures (catchments). Underground (subterranean) water, which accumulates in waterbearing aquifer over the first water-holding horizon, is used in wells. Such water laying depth amounts to some dozens of meters. A well in the conditions of local water supply serves as water intake, water-lifting and water-dispensing facilities simultaneously.

The distance from the well to a water consumer should not exceed 150 m. It is necessary to place wells considering relief, because wells should be placed higher on slope than all sources of pollution (cesspool, underground filtration area, compost pit etc.) at a distance more than 30 – 50 m. In cases when a potential source of pollution is situated higher on slope than a well due to relief, the distance between them should not be less than 80 – 100 m, and in some cases - even not less than 120 – 150 m.

A well is a vertical shaft of square or circular cross-section that reaches the water-bearing aquifer. Sidewalls of the shaft are fortified with impervious material (concrete, iron concrete, bricks, wood and others). Layer of gravel about 30 cm in height is thrown up onto the bottom. Overground part of the well, which is called the log cabin, should not

be less than 1.0 m in height above ground level. When making the well we should build “loamy key trench” of 2 metres deep and 1 metre wide around the well and a riprap within a radius of 2 m with slope directed away from the well. Drainage ditch should be provided for rainwater drain. There should be a fence within a radius of 3-5 metres around the common wells. Water from the well is pumped up or lifted using winch with public dip-bucket. A log cabin should be tightly covered and a shed should be built over the cover and the winch.

“*Sanation*” of shaft well is complex of measures, which includes repair, washing and disinfection of the well as a construction to prevent water pollution in it. For the purpose of prevention, sanation of the well is carried out before putting it into operation, and then depending upon epidemic situation, periodically after washing and remedial maintenance or general overhaul 1 time per year. Prophylactic sanation includes two stages: 1) washing and repair and 2) terminal disinfection. When making terminal disinfection, one treats the log cabin and inner part of the well by means of irrigation method (irrigation with 5% chlorinated lime solution or 3% calcium hypochlorite solution on the basis of 0.5 dm<sup>3</sup> per 1 m<sup>2</sup> of log cabin surface using hydraulic sprayer) first. Then one waits till the well fills up with water to usual level whereupon disinfection of underwater part of the well by means of volumetric method is carried out (necessary amount of chlorinated lime or calcium hypochlorite is dissolved in small volume of water on the basis of 100 — 150 mg of active chlorine per 1 dm<sup>3</sup> of water in the well, cleared by precipitation obtained solution is poured out into the well; water in the well is vigorously stirred during 15-20 minutes, then the well is covered and left for 6-8 hours with prohibition of taking water from it during this period of time).

In case of unfavourable epidemic situation (the well is a factor of spreading enteric infection), if the fact of pollution of water in the well is proved in laboratory or there are scientific evidences of water pollution with faeces, cadavers of animals, other foreign substances, sanitation is performed *according to epidemiologic indications*. At that, the procedure of well cleansing includes three stages: 1) preliminary disinfection of underwater part of the well using volumetric method, 2) washing and repair and 3) terminal disinfection first using irrigation method and then – volumetric method.

In case of insufficient improvement of water quality after performed disinfection (sanation) of the well, sometimes prolonged disinfection of water in the well is performed using dosaging cartridges. Dosaging cartridges are cylindrical pots made of porous ceramics with inner volume equal to 250, 500 or 1000 cm<sup>3</sup>, where chlorinated lime or calcium hypochlorite is put inside. The amount of calcium hypochlorite, which activity is minimum 52 %, is calculated according to the following formula:

$$X_1 = 0.07 \cdot X_2 + 0.08 X_3 + 0.02 X_4 + 0.14 X_5 ,$$

where:  $X_1$  – the amount of agent that is necessary to be loaded inside the cartridge (kg),

$X_2$  – volume of water in the well (m<sup>3</sup>),

$X_3$  – discharge (output) of the well (m<sup>3</sup>/year),

$X_4$  – water pumping (m<sup>3</sup>/day),

$X_5$  – chlorine absorption of water (mg/dm<sup>3</sup>).

Prior to starting the filling up, one should hold the cartridge in water for 3 – 5 hours, and then fill up with chlorinated agent in calculated amount, pour in additional 100 – 300 cm<sup>3</sup> of water, mix thoroughly, close up the cartridge with ceramic or rubber plug, hang it in the well and submerge into the water column at a depth of approximately 0.5 m below upper level of water and 0.2 – 0.5 m above bottom level.

Catchment is a concrete reservoir built near the spring outlet at the bottom of a hill or a mountain; it is equipped with discharge pipe through which water is constantly flowing out. The reservoir is partitioned with wall of proper height into two chambers. The first chamber serves as a sand collector for precipitated sand that is being washed out by spring water, and the other chamber accumulates pure water, which is constantly flowing through the discharge pipe. The place under the pure water outlet is equipped with drainage concrete chute inclined towards a stream, river.

Appendix 6

### **Hygienic characteristics of water quality criteria**

**Organoleptic properties of water** are divided into 2 subgroups: 1) physical and organoleptic – combination of organoleptic characteristics that are perceived by sense organs and are evaluated according to the strength of perception and 2) chemical and organoleptic – content of particular chemical substances, which can irritate receptors of corresponding analyzers and cause one sense or another.

**Odour** – is the ability of chemical substances to evaporate and, producing sensible steam pressure over water surface, to irritate receptors of mucous membranes of nose and paranasal sinuses, and in such a way to cause corresponding sense. There is the following differentiation of odours: natural (aromatic, marshy, putrefactive, fishy, grassy and etc.), specific (pharmaceutical) and indeterminate odours.

**Taste and aftertaste** — is the ability of chemical substances, existing in water, to irritate taste buds, which are placed on the surface of tongue/tongue surface, and to cause corresponding sense. One can differentiate salty, bitter, sour and sweet tastes. The rest are aftertastes: alkaline, marshy, metallic, aftertaste of mineral oil and etc.

To characterize the strength of odours, tastes and aftertastes of water there is a standard five-point scale:

0 — odour (taste, aftertaste) is absent, it can not be detected even by experienced flavourist (taster),

1 — very slight one, consumer can not detect it, but it can be detected by experienced flavourist (taster),

2 — slight one, consumer can detect it only in case of drawing consumer's attention to it,

3 — perceptible one, consumer easily detects it and shows negative reaction,

4 — distinct one, water is unusable,

5 — very intensive one, can be detected at a distance, so water is unusable.

State sanitary norms and rules (SSRandN) 136/1940 represents the assessment of the strength of odour and aftertaste according to dilution indices (DI).

Unpleasant odours, tastes and aftertastes of water restrict consumption of such water and force to search for other sources, as they indicate that water can pose epidemic and chemical hazard. Specific odour, taste and aftertaste are evidence of water pollution in consequence of industrial sewage water ingress or superficial run-off from agricultural land into water body. Natural odour, taste and aftertaste are evidence of presence in water of organic and nonorganic substances that have been generated in consequence of vital functions of water organisms (algae, actinomycete, fungi and etc.) and biochemical transformation processes of organic compounds (humic substances) that get to water from the soil. Odour of ground water sources can depend upon availability of hydrogen sulphide in it, and odour of water from wells can depend upon the log cabin wood. These

substances can be biologically active, not indifferent (neutral) for health, and have allergenic properties. They are efficiency criteria of water purification at water supply stations.

**Colour** — is natural property of water, depends on humic substances, which are washed out from the soil during formation of surface and ground water reservoirs and give water yellow-brown tint. Colour is measured in degrees using spectrophotometers and photocolorimeters by comparison with the colour of scale of chrome and cobalt or platinum and cobalt solutions, which simulate the natural water colour.

Polluted water can have an unnatural colour caused by colouring substances, which can come into water reservoirs together with sewage water of light industry enterprises, certain nonorganic compounds both of natural and man-caused origin. Thus, iron and manganese may cause colour of water from red to black, copper – from faintly azure to blue-green colour. This index is called **colour** of water. To measure it, water is poured into cylindrical vessel with flat bottom, a sheet of white paper is placed 4 cm away from the bottom, then water from cylindrical vessel is poured off until one can see the white colour of the paper through the column of water in the cylindrical vessel i.e. until colour disappears. Height of this water column evaluated in cm characterises water colour.

**Suspended materials concentration (turbidity)** — is natural property of water that depends on the content of suspended substances of organic and nonorganic origin (clay, sludge, organic colloids, plankton and etc.). Suspended materials concentration (turbidity) is measured using nephelometers, spectrophotometers and photocolorimeters by simulation kaolin scale, which is set of suspensions of white clay (kaolin) in distilled water. Suspended materials concentration of water is evaluated in mg/l by comparison of optical water density with the density of standard suspensions of kaolin, according to State standards (SSRandN) 383 – in nephelometric turbidity units (NTU).

Opposite characteristic of water is **transparency** – ability to transmit light rays. Transparency is measured by Snellen method: one pours water into cylindrical vessel with flat bottom, place standard font with the letters of 4 mm height and 0.5 mm thick at a distance 4 cm from the bottom, and then we pour water from the cylindrical vessel off until we can read letters through the column of water in the cylindrical vessel. Height of this water column, evaluated in cm, characterises water transparency.

Colour, tinted, turbid water evokes sense of aversion that restricts consumption of such water and forces searching of new sources of water supply. Increase of colour, suspended materials concentration (turbidity) and decrease of transparency may be the evidence of water pollution with industrial sewage water, which contains organic and nonorganic substances, which can be hazardous to people health or generate harmful substances during water treatment with reagents (for instance, chlorination). Water with high colour index can be biologically active due to humic organic substances. There are efficiency criteria of water purification and decolour at water supply stations. Suspended and humic substances impair water disinfection (prevent mechanical penetration of active chlorine into bacterial cell).

**Temperature** influences greatly on: 1) organoleptic properties of water (odour, taste and aftertastes); water with temperature more than 25°C provokes vomiting reflex; according to the international standard the temperature should not exceed 25°C, cool water with temperature (12–15°C) is considered to be the best water; 2) rate and intensity of water purification and disinfection processes at water supply stations: with temperature increase up to 20–25°C and thanks to better coagulation the processes of water purification and decolour improve, efficiency of water penetration through activated

carbon becomes worse in the result of decrease of activated carbon adsorption capacity, diffusion of molecules of decontaminating chlorinated substances inside bacterial cell intensifies, thus disinfection becomes better.

**Solid residue (total salinity)** — is the quantity of solutes, mainly mineral salts (90 %), in 1 litre of water. Water with solid residue up to 1000 mg/l is called fresh water, one with solid residue from 1000 to 3000 mg/l – saltish water, one with solid residue more than 3000 mg/l – salt water. Salinity of 300—500 mg/l is considered to be optimal. Water with solid residue below 50—100 mg/l is considered as low saline water and it has unpleasant taste; water with solid residue 100—300 mg/l is considered as satisfactorily saline water, and water with solid residue equal to 500—1000 mg/l — is considered as a super saline water but still acceptable.

Saltish and salt water has unpleasant taste. Use of such water is accompanied by increase of hydrophilia of tissues, water retention in body, decrease of diuresis by 30—60 %, in consequence of which, load on cardiovascular system increases, clinical course of ischemic cardiac disease, myocardiodystrophy, morbus hypertonicus becomes more serious and risk of acute attack of these diseases becomes higher; it can cause dyspepsia as a result of alteration in secretory and motor functions of stomach, irritation of mucous membranes of small and large intestines and increase of intestinal peristalsis for persons, who had changed residence; it also causes aggressive clinical behaviour and serious clinical course of nephrolithiasis and cholelithiasis.

Systematic use of low saline water results in water-electrolytic dyscrasia, which is based on the reaction of osmoreceptive field of liver that causes increased release of sodium into blood and is accompanied by water redistribution among extra- and intracellular fluid.

**Hydrogen index (pH value)** — is natural property of water that depends on the presence of free hydrogen ions. Water in most of surface water reservoirs has pH value within the range of 6.5 to 8.5. pH value of ground water varies in the range from 6 to 9. Stagnant water, rich in humic substances (with pH value up to 7), is considered as acidic water. Ground water that contains much hydrocarbonates (with pH value more than 7) is considered as alkaline water.

Change of water active reaction is the evidence of water supply source pollution with acidic or alkaline industrial sewage waters. Active reaction influences the processes of water purification and disinfection: in alkaline water the process of water purification and decolour improves due to better coagulation; in acidic medium the process of water disinfection accelerates.

**Total hardness** — is the natural property of water that depends upon the presence of so-called salts of hardness, namely: calcium and magnesium (of sulphates, chlorides, carbonates, hydrocarbonates and others). We differentiate general, reduced, constant and carbonate hardness. *Reduced or hydrocarbonate hardness* is hardness that depends upon  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  bicarbonates, which during water boiling turn into insoluble carbonates and precipitate according to the following equations:



Hardness that remains after water boiling during 1 hour and depends upon the presence of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  chlorides and sulphates, which do not precipitate, is called *constant hardness*.

Total hardness of water is evaluated in mg-equiv/l. Formerly, for hardness evaluation they used degree of hardness:  $10^\circ = 0.35 \text{ mg-equiv/l}$ ,  $1 \text{ mg-equiv/l} = 28 \text{ mg CaO/l} = 2.8^\circ$ .

Water with total hardness value below 3.5 mg-equiv/l ( $10^\circ$ ) is considered as soft water, from 3.5 to 7 mg-equiv/l ( $10\text{—}20^\circ$ ) — as moderately hard water, from 7 to 10 mg-equiv/l ( $20\text{—}28^\circ$ ) — as hard water and water with total hardness value more than 10 mg-equiv/l ( $28^\circ$ ) is considered as extremely hard water.

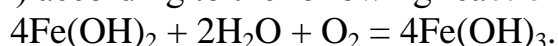
Content of hardness salts of more than 7 mg-equiv/l imparts bitter taste to water. Sudden change from soft water to hard water can cause dyspepsia. In regions with hot climate use of water with high hardness causes deterioration of urolithiasis clinical course. Salts of hardness impair absorption of fats because of their saponification and creation of insoluble calcium-magnesia soaps in bowels. Thus, penetration of polyunsaturated fatty acids (PUFA), liposoluble vitamins, and certain microelements into organism is restricted (water with hardness value more than 10 mg-equiv/l increases endemic goitre risk). High hardness causes dermatitis initiation because of irritant action of calcium-magnesia soaps, which are created at skin oil saponification. The higher is hardness of water, the more complicated is culinary foodstuff processing (meat and legumes are boiled soft much worse, tea is brewed poorly, deposit appears on the walls of pots), consumption of soap increases, hair and skin become coarse after wash; fabrics turn yellow, lose their softness, elasticity and ventilation property because of impregnation of calcium-magnesia soaps.

Long-drawn use of soft water, which has low content of calcium, can cause calcium deficiency in human organism (violet spots appear on enamel of the children, who live in regions with soft water, which are caused by decalcification of dentin; endemic osteoarthritis (Kashin-Bek disease), which is endemic polyhypermicroelementosis of strontium, iron, manganese, zinc, fluorine appears in localities where content of calcium in drinking water is low). Water with low content of electrolytes that cause hardness, promotes development of cardiovascular diseases.

**Chlorides and sulphates** are widely spread in nature and constitute the greater part of solid residue of fresh water. They get into water of water reservoirs both as the result of natural processes of washing out from the soil and pollution of water reservoirs with different sewage water. Natural chloride content in surface water reservoirs is small and varies within the limits of several dozens of mg/l. Water that penetrates through the brackish soil can contain hundreds and even thousands mg of chlorides in 1 litre of water.

They influence organoleptic properties of water – impart it salty (chlorides) or bitter (sulphates) taste. Taking into consideration the great number of chlorides in urine and sweat of people and animals, in domestic sewage water, liquid domestic wastes, sewage water of stock-raising and poultry farms, surface run-off from pastures, chlorides are also used as indirect sanitary and chemical criteria of epidemic safety of water. But chlorides, which get into water reservoirs with industrial sewage waters, for example, of metallurgical works, have nothing common with the probable simultaneous biocontamination and bacterial pollution.

**Iron.** In surface water reservoirs iron is present in the form of persistent humic acid iron (III), in the ground water — as divalent Fe hydrocarbonate (II). After ground water has been lifted on the surface, Fe (II) is oxidized by atmospheric oxygen and forms Fe (III) with Fe hydroxide (III) according to the following reaction:



Fe hydroxide (III) dissolves poorly and forms brown flocks in water that causes colour and concentration of suspended materials in water. When there is a noticeable content of iron in water, in consequence of above mentioned transformations water will obtain yellow-brown tint, become turbid and get viscous metallic aftertaste.

**Manganese.** In concentrations that exceed 0.15 mg/l, manganese causes pink colour of water, imparts unpleasant taste to water, paints linens when washing, makes deposit on pots. If manganese compounds (II) in water can be oxidized, negative effect on the organoleptic properties of water is increased (at water aeration, if concentration of manganese in water is more than 0.1 mg/l, there will be originated brownish black sediment of  $\text{MnO}_2$ , at ozonization for the purpose of water disinfection pink colour of water can occur as a result of formation of  $\text{Mn}^{7+}$  salts (permanganates)).

**Copper.** In concentrations that exceed 5.0 mg/l, copper imparts distinct unpleasant astringent taste to tap water. In concentrations, which are more than 1.0 mg/l, linens are painted when washing; corrosion of aluminium and zinc pots takes place.

**Zinc.** High concentration of zinc in water makes worse organoleptic properties of water. In concentrations that exceed 5.0 mg/l, zinc compounds impart distinct unpleasant astringent taste to water. At that opalescence can appear in water and pellicle can occur on the water during boiling.

**Criteria of safety according to chemical composition** – are indices of maximum allowable concentrations of chemical substances (MAC), which may have negative impact on people health causing progress of different diseases.

**Chemical substances of natural origin** (beryllium, molybdenum, arsenic, lead, nitrates, fluorine, selenium, strontium) cause initiation of endemic diseases. Some of them (molybdenum, selenium, fluorine) are among micro bioelements, which amount in human organism does not exceed 0.01 %, and which are essential for human. They should necessarily be received by human organism in optimal daily doses, which must be strict otherwise hypomicroelementoses or hypermicroelementoses can progress. The rest of them (beryllium, arsenic, lead, nitrates, strontium) being received in excessive amount can have toxic action.

**Chemical substances that come in water as a result of industrial, agricultural and domestic pollution of water supply sources.** They include heavy metals (cadmium, mercury, nickel, bismuth, antimony, tin, chromium etc.), detergents (synthetic cleaning agents or surface-active substances), pesticides (DDT, HCCH (hexachlorocyclohexane), trichlorfon, metaphosphate, 2,4-D, atrazine etc.), synthetic-base polymers and their monomers (phenol, formaldehyde, caprolactam etc.). Their concentration in water must be nonhazardous for the health of people and their descendants when they use such water permanently for the whole life. The concentration of such substances in water must guarantee not only against acute and chronic poisonings, but also against the nonspecific harmful effect connected with the depression of general resistance of human organism. It must provide preservation of reproductive health, guarantee against mutagenic, carcinogenic, embryotoxic, teratogenic, gonadotoxic effect and against other long-term effects. Such concentrations we call maximum allowable concentrations (MAC).

Toxic chemical substances, when they are simultaneously present in water, can have combined effect on human organism, and summation of negative effects i.e. additive action is mostly a consequence of this combined effect. To guarantee preservation of health in conditions of such combined effect, it is necessary to follow the rule of summational toxicity: sum total of ratios of actual concentrations of substances in water to their MAC must not exceed 1:

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

where  $C_1, C_2, C_n$  — actual concentrations of chemical substances in water, mg/l.

**Criteria that characterize epidemic safety of water** are subdivided into 2 subgroups: the sanitary and microbiological criteria and the sanitary and chemical criteria.

**Sanitary and microbiological criteria of epidemic safety of water.** Absence of pathogenic microorganisms – agents of infectious diseases – is a criterion of epidemic safety of water. However, the analysis of water to determine the presence of pathogenic microorganisms is rather long, difficult and labour-intensive process. Thus, the assessment of epidemic safety of water is made using method of indirect indication of possible presence of pathogenic agent, and the following two indirect sanitary and microbiological criteria – total microbial number (TMN) and amount of sanitary-representative microorganisms – are used for this purpose.

**TMN** – is a number of colonies, which have grown when sowing 1 ml of water on 1.5 % beef-extract agar after incubation during 24 hours at temperature equal to 37 °C.

It is very important to discover **colibacillus group bacteria** (CBGB), which are in excrements of people and animals, in water. CBGB include the following bacteria species: Echerihia, Enterobacter, Klebsiella, Citrobacter and other representatives of Enterobacteriaceae, which are gram-negative rod bacteria, do not form spores and capsules, ferment glucose and lactose with formation of acid and gas at temperature equal to 37 °C during 24-48 hours and have no oxidase activity. Endo medium is selective nutrient medium for CBGB, where CBGB grow in the form of dark-red colonies with metallic lustre (E. coli), red lacklustre colonies, pink or transparent colonies with red centre or borders.

Presence of CBGB in water is evidence of previous excrementitious pollution and consequently — of possible contamination of water with pathogenic microorganisms of colibacillus group. Quantitatively, the presence of CBGB is characterized by the two following indices: CBGB index and CBGB titre. Colibacillus index (coli index) — is amount of bacteria of colibacillus group in 1 litre of water, CBGB titre (coli titre) — is the minimal volume of analyzed water in ml, in which one bacterium of colibacillus group is detected.

**Sanitary and chemical criteria of epidemic safety of water** are evidences, first of all, of presence of organic substances and products of their decomposition in water that indirectly indicates the probability of water epidemic danger. This occurs when water of water reservoirs is polluted with domestic sewage water, waste water of stock and poultry farms etc. The most significant of the criteria are given below.

**Permanganate oxidizability** — is quantity of oxygen (in mg) that is necessary for chemical oxidization of easily oxidable organic and nonorganic (Fe (II) salt, H<sub>2</sub>S salt, ammonium salts, nitrites) substances, which are available in 1 litre of water. Here KMnO<sub>4</sub> is oxidizing agent. Artesian water has the least permanganate oxidizability – up to 2 mg O<sub>2</sub> per 1 litre of water. For water from shaft wells this index makes up 2-4 mg O<sub>2</sub> per 1 litre, for surface water reservoirs it can be equal to 5-8 mg O<sub>2</sub> per 1 litre and more.

**Bichromate oxidizability** or **chemical oxygen demand (ChOD)** — is quantity of oxygen (in mg) that is necessary for chemical oxidization of all organic and nonorganic



reducing agents in 1 litre of water. Here  $K_2Cr_2O_7$  is oxidizing agent. Pure ground waters have ChOD index within 3-5 mg/l, surface waters – 10-15 mg/l.

**Biochemical oxygen demand (BOD)** — is quantity of oxygen (in milligrammes) that is necessary for biochemical oxidization (due to activity of microorganisms) of organic substances, which are available in 1 litre of water, at temperature equal to 20 °C during either 5 days ( $BOD_5$ ) or 20 days ( $BOD_{20}$ ).  $BOD_{20}$  is also called complete BOD ( $BOD_{compl.}$ ).

The more polluted with organic substances water is, the higher is BOD criterion of the water.  $BOD_5$  criterion for water from pure reservoirs is less than 2 mg  $O_2/l$  ( $BOD_{20}$  is less than 3 mg  $O_2/l$ ), for water from comparatively pure reservoirs — 2-4 mg  $O_2/l$  ( $BOD_{20}$  3—6 mg  $O_2/l$ ), for water from polluted reservoirs — more than 4 mg  $O_2/l$  ( $BOD_{20}$  is more than 6 mg  $O_2/l$ ).

**Dissolved oxygen** — is quantity of oxygen that is available in 1 litre of water. It is significant for sanitary regime of open water reservoirs. Oxygen of the air diffuses through water and dissolves in it. Some amount of oxygen is created due to vital functions of chlorophyll water-plants. Parallel with the process of water oxygen enrichment, oxygen is spent for biological oxidation of organic substances (processes of natural purification of water reservoir) and for respiration of aerobic aquatic life, fish in particular. To prevent impairment of processes of natural purification and loss of aquatic life, oxygen content in water reservoirs should not be less than 4 mg/l. When sewage waters, which have great amount of organic substances in their content, get into water reservoirs, BOD increases and amount of dissolved oxygen, which is spent for oxidation of organic substances, decreases.

**Nitrogen of ammonium salts, nitrites and nitrates.** Decomposed protein remains, cadavers of animals, urine, and excrements are sources of nitrogen for natural waters. As the result of processes of natural purification of water reservoirs, mineralization of complex nitrogen-containing protein compounds and urea alongside with creation of ammonium salts, which later on are oxidized forming firstly nitrites and finally nitrates, occurs. Exactly the same way the natural purification of water reservoirs from organic nitrogen-containing polluting substances that get into water reservoirs as a constituent of different sewage water and surface run-off occurs.

In pure natural surface and ground water reservoirs content of nitrogen of ammonium salts is within the limits of 0.01-0.1 mg/l. Nitrites, as an intermediate product of further chemical oxidation of ammonium salts, are present in natural water in very small quantities – 0.001-0.002 mg/l. If their concentration exceeds 0.005 mg/l, this fact is the significant indication of the source pollution. Nitrates are the final product of oxidation of ammonium salts. Availability of nitrates in water in the absence of ammonia and nitrites is evidence of comparatively long-term presence in water of nitrogen-containing substances, which have time to complete mineralization. In pure natural water the content of nitrogen of nitrates does not exceed 1-2 mg/l. In ground waters we can observe higher content of nitrates as a result of their migration from the soil in case of organic pollution of the soil or in case of intensive application of nitrogen fertilizers.

**General hygienic requirements to drinking water include the following:**

- good organoleptic properties (transparency, comparatively low temperature, good refreshing taste, absence of odours, unpleasant aftertastes, colour, apparent to the naked eye inclusions and so on);

- optimal natural mineral composition, which guarantees good taste properties of water, the receiving of some necessary for organism macro- and microelements;
- toxicological safety (absence of toxic substances in hazardous to organism concentrations);
- epidemiologic safety (absence of agents of infectious diseases, of helminthiasis etc.);
- water radioactivity – within the limits of set levels.

Sanitary inspection of centralized water supply is subdivided into preventive one and regular. Preventive inspection includes sanitary examination of the design of water pipeline and all the components of water pipeline, supervision of the process of its construction and putting into operation.

Before the constructed water pipeline is put into operation, the following sanitary protection zones are to be designated:

- strict regime zone, which includes the defined part of water area in the place of water intake and upstream, territory around the water-purifying facilities;
- restriction zone – the territory, where any construction and operation of facilities, which can pollute this territory and the water reservoir, is prohibited;
- survey zone, which includes the whole water supply network.

Sanitary regular inspection is exercised using methods of more detailed (during repairs, reconstructions) regular periodical inspection, sporadic one, and sometimes (in case of gross sanitary abnormalities or intestinal infectious diseases) even urgent sanitary inspection. Such inspection is necessarily accompanied by water sampling and by the laboratory analysis of water. Results of this analysis are assessed according to of State Standard 2874-82 “Drinking water (quality requirements)” and State sanitary rules and norms (SSRandN) No.136/1940 „Drinking water. Hygienic requirements to water quality of centralized domestic and drinking water supply” (Appendix 3).

Results of laboratory analysis of water samples taken from local water supply sources are assessed according to “Sanitary regulations on arrangement and maintenance of wells and catchments used for decentralized domestic and drinking water supply” No.1226-75 (Appendix 4).

Appendix 7

**Requirements to drinking water quality of centralized water supply  
(Extract from State Standard 2874-82 “Drinking water. Hygienic requirements and quality control” and State sanitary rules and norms (SSRandN) № 136/1940  
“Drinking water. Hygienic requirements to water quality of centralized domestic and drinking water supply”**

Applies to tap drinking water at centralized domestic and drinking water supply

**Organoleptic criteria of drinking water quality**

<i>Criteria, units of measurement</i>	<i>Standards (maximum)</i>	
	State Standard 2874-82	Sanitary rules and norms (SSRandN)
<i>Physical and organoleptic</i>		

<b>Odour, points</b>	2	2*
<b>Turbidity, mg/l</b>	1.5	0.5 (1.5)**
Spectral colour, degrees	20	20 (35)***
Aftertaste, points	2	2 *
<b>Chemical and organoleptic</b>		
Hydrogen index, pH value, within the range, units.	6.0—9.0	6.5—8.5
Iron, mg/l	0.3 (1.0)	0.3
Total hardness, mg-equiv/l	7.0 (10.0)	7.0 (10.0)
Sulphates, mg/l	500	250 (500)
Solid residue (total mineralization), mg/l	1000 (1500)	1000 (1500)
Polyphosphate residue, mg/l	3.5	—
Chlorides, mg/l	350	250 (350)
Copper, mg/l	1.0	1.0
Manganese, mg/l	0.1	0.1
Zinc, mg/l	5.0	—
Chlorophenols, mg/l	—	0.0003

\* — dilution index, DI (till odour, aftertaste disappear),

\*\* — nephelometric turbidity units NTU.

\*\*\* — values enclosed in brackets can be allowed in consideration of specified situation.

#### Criteria of drinking water epidemic safety

<i>Indices, units of measurement</i>	<i>Standards</i>	
	State Standard 2874-82	Sanitary rules and norms (SSRandN)
<b>Microbiological</b>		
Amount of bacteria in 1 ml of water (total microbial number, TMN), CFU /ml	Maximum 100	Maximum 100*
Amount of colibacillus group bacteria (coliform microorganisms), i.e. CBGB index, CFU /l	Maximum 3	Maximum 3**
Amount of thermostable colibacilli (fecal coliforms), i.e. FC index, CFU /100 ml	—	Absence ***
Amount of pathogenic microorganisms, CFU /l	—	Absence ***
Amount of coli-phages, PFU /l	—	Absence ***
<b>Parasitologic</b>		
Amount of pathogenic intestinal protozoa (cells, cysts) in 25 l of water	—	Absence
Amount of intestinal helminths (cells, roes, larvae) in 25 l of water	—	Absence

\* — For 95% of water samples from water supply network that are analyzed during a year,

\*\* — For 98% of water samples that get into water supply network and are analyzed during a year. In case of excess of CBGB index at the stage of identification of the colonies that have grown, extra analyses are to be made to discover presence of excrementitious coli forms,

\*\*\* — If presence of excrementitious coli forms are discovered in 2 successively taken samples, it is necessary to start making analyses of water within 12 hours to discover presence of agents of infectious diseases of bacterial or viral ethiology (according to epidemiologic situation).

#### Toxicological criteria of drinking water chemical composition safety

<i>Criteria</i>	<i>Standards (maximum), mg/l</i>	
	State Standard 2874-82	Sanitary rules and norms (SSRandN)
<b>Nonorganic components</b>		

Aluminium	0.5	0.2 (0.5)*
Barium	—	0.1
Beryllium	0.0002	—
Molybdenum	0.25	—
Arsenic	0.05	0.01
Polyacrylamide residue	2.0	—
Selenium	0.001	0.01
Lead	0.03	0.01
Strontium	7.0	—
Nickel	—	0.1
Nitrates	45.0	45.0
Fluorine: I—II climatic zone	1.5	1.5
III climatic zone	1.2	
IV climatic zone	0.7	
<b>Organic components</b>		
Trihalogenomethane (THM, sum)	—	0.1
Chloroform	—	0.06
Dibromochloromethane	—	0.01
Carbon tetrachloride	—	0.002
Pesticides (sum)	—	0.0001**
<b>Integral indices</b>		
Permanganate oxidizability	—	4.0
Total organic carbon	—	3.0

\* Value enclosed in brackets can be allowed in case of water treatment with reagents that include aluminium,

\*\* List of controllable pesticides is drawn up in consideration of specified situation.

### Drinking water radiation safety criteria

<i>Criteria</i>	<i>Standards (maximum), Bq/l</i>	
	State Standard 2874-82	Sanitary rules and norms (SSanR&N)
Total activity concentration $\alpha$ -emitters	—	0.1
Total activity concentration $\beta$ -emitters	—	1.0

Note: For special regions the Norms of drinking water radiation safety are to be submitted to chief government sanitary inspector of Ukraine approval

### Criteria of physiologic value of mineral composition

<i>Criteria, units of measurement</i>	<i>Standards</i>	
	State Standard 2874-82	Sanitary rules and norms (SSRandN)
Total mineralization, mg/l	—	from 100.0 to 1000.0
Total hardness, mg-equiv/l	—	from 1.5 to 7.0
Total alkalinity, mg-equiv/l	—	from 0.5 to 6.5
Magnesium, mg/l	—	from 10.0 to 80.0
Fluorine, mg/l	—	from 0.7 to 1.5

**Requirements to drinking water quality of decentralized water supply  
(Extract from “Sanitary regulations on arrangement and maintenance of wells and catchments used for decentralized domestic and drinking water supply”,  
№ 1226-75).**

1. <i>Organoleptic criteria:</i>	
- odour, points,	maximum 2–3
- aftertastes, points	maximum 2–3
- transparency, cm	minimum 30
- turbidity, mg/dm <sup>3</sup>	maximum 1.5
- spectral colour, degrees	maximum 30
- temperature, °C	8-12
- surface appearance	absence of visible impurities
2. <i>Bacteriological criteria of epidemiologic safety:</i>	
- microbial number, CFU /cm <sup>3</sup>	maximum 200-400
- coli index, CFU /dm <sup>3</sup>	maximum 10
3. <i>Sanitary and chemical criteria of epidemic safety:</i>	
- permanganate oxidizability, O <sub>2</sub> mg/dm <sup>3</sup>	maximum 4
- ammonium nitrogen, mg/dm <sup>3</sup>	maximum 0.1
- nitrite nitrogen, mg/dm <sup>3</sup>	maximum 0.005
- nitrate nitrogen, mg/dm <sup>3</sup>	maximum 10.0
- chlorides, mg/dm <sup>3</sup>	maximum 350
4. <i>Chemical and organoleptic criteria:</i>	
- solid residue, mg/dm <sup>3</sup>	1000 (1500)
- hardness, CaO mg-equiv/dm <sup>3</sup>	maximum 10
- iron, mg/dm <sup>3</sup>	0.3 (1.0)
- sulphates, mg/dm <sup>3</sup>	maximum 500
5. <i>Criteria of safety according to chemical composition:</i>	
- fluorine, mg/dm <sup>3</sup>	0.7-1.5
- nitrates, mg/dm <sup>3</sup>	maximum 45.0
- <b>other chemical substances</b>	<b>within the limits of maximum allowable concentrations (MAC) according to (SSRandN) № 4630-88.</b>

## Appendix 9

### **Procedure of water quality hygienic assessment according to results of sanitary inspection and results of laboratory analysis (technique of water analysis “reading”)**

Technique (algorithm) of water analysis reading consists of 7 stages.

At the *first stage* we define the type of requirements to water quality:

The first type includes requirements to drinking tap water quality when having centralized domestic and drinking water supply. This water should be high quality water and satisfy the required criteria of the active standard (State Standard 2874-82 “Drinking water. Hygienic requirements and quality control”, State sanitary rules and norms (SSRandN) № 136/1940 „Drinking water. Hygienic requirements to water quality of centralized domestic and drinking water supply”).

The second type includes requirements to quality of well (spring) water. It should also be high quality water and satisfy the requirements of “Sanitary regulations on arrangement and maintenance of wells and catchments used for decentralized domestic and drinking water supply” № 1226-75.

The third type includes requirements to quality of water from sources (underground and surface) of centralized processing and drinking water supply. It is regulated by the State Standard 2761-84 “Sources of centralized domestic and drinking water supply. Hygienic, technical requirements and selection regulations”.

The fourth type includes requirements to quality of hot water, which should satisfy the requirements of «Sanitary regulations for design and exploitation of centralized hot water supply systems № 2270-80».

At the *second stage* we assign the task: to make up a conclusion about the quality of drinking water from water pipeline or from well, to assess quality and effectiveness of water treatment at the facilities of water supply stations, to define the cause of caries or dental fluorosis initiation among the population, to define the cause of methemoglobinemia progress among children and people of declining years, to ascertain the cause of case of mass infectious disease, to evaluate effect of the new reagents, which are used at water supply stations, or effect of the new polymeric materials, which are used for construction of the facilities of water purification plants or water pipes etc., on drinking water quality.

At the *third stage* we assign the programme and the extent of laboratory analyses. To draw a conclusion about the quality of drinking tap water (from pipes or street water intake standpipe) according to State Standard 2874-82 we must make analyses of the physical and organoleptic (odour, taste and aftertaste, spectral colour, turbidity) and the sanitary and microbiological (microbial number and coli index) indices. To draw a conclusion about the quality of well water according to “Sanitary Regulations...” № 1226-75 we must make analyses of the physical and organoleptic (odour, taste and aftertaste, spectral colour, turbidity), the chemical and organoleptic (solid residue, total hardness, content of iron, active reaction), the sanitary and microbiological (microbial number and coli index), the sanitary and chemical (permanganate oxidizability, content of nitrogen, nitrates, nitrites and ammonia) criteria, and criteria of safety according to chemical composition (fluorides). To define the potential cause of caries or dental fluorosis, it is necessary to assess content of fluorine in drinking water, water-nitrate methemoglobinemia — concentration of nitrates, infectious disease — to make bacteriological or virological analyses, effect of polymeric materials — proper chemical analyses and etc.

At the *fourth stage* we check-up the completeness of entered information and period of carrying out of the analyses.

If water sample was taken at a water supply station, from a water intake standpipe or from a shaft well, there should be presented data of sanitary (sanitary and topographic, sanitary and technical, sanitary and epidemiologic) inspection and the results of the laboratory analysis of water according to the programme of the analyses.

If tap water sample was taken, there should be presented the results of the laboratory analysis of water according to the proper programme of the analyses.

Bacteriological analyses should be made during 2 hours after the sampling or not later than in 6 hours only if the sample is kept in cooler at the temperature range 1—8 °C. The physical and chemical analysis is made during 4 hours after the sampling or not later than in 48 hours only if the sample is kept in cooler at the temperature range 1—8 °C.

At the *fifth stage* we analyze the data of sanitary inspection and make up the following preliminary conclusions: if there are any reasons to suppose that water is polluted, of poor quality, epidemically dangerous, and if there are conditions for water pollution in the source of water supply, in the well, in the water intake standpipe.

At the *sixth stage* we analyze the data of the laboratory analysis of water according to each group of criteria in the following order: 1) physical and organoleptic, 2) chemical and organoleptic, 3) indices of safety according to chemical composition, 4) sanitary and microbiological and 5) sanitary and chemical criteria of epidemic safety. Here we make qualitative and quantitative assessment for each criterion. For example, total hardness of water is 9 mg-equiv/l. We explain in the conclusion: “Water is hard, has total hardness that exceeds the standard of 7 mg-equiv/l”. If solid residue of water amounts 750 mg/l, we record: “Water is sweet, as solid residue is less than 1 000 mg/l, it has high mineralization”. If odour — 2 points, aftertaste — 2 points, transparency— 30 cm, suspended materials concentration — 1.5 mg/l, colour — 20 degrees, the conclusion is: “Water has no odour, no aftertaste, it is transparent, and without colour i.e. it has good organoleptic properties and according to this group of criteria satisfies the requirements of State Standard 2874-82”.

At the *seventh stage* a doctor draws a general conclusion about water quality according to the task and makes recommendations for the improvement of water quality if it is necessary.

## Appendix 10

### Basic physical properties and texture of soil

**Lithosphere (the earth's crust)** – mineral and organic covering of the Earth, which extends from its surface to magma. It consists of lithosphere itself, which is formed from magma rocks destroyed by physical, physicochemical and chemical processes before beginnings of life on Earth, and soil.

**Soil** is a surface layer of lithosphere (from few millimeters in mountains and up to 10 kilometers in lowlands), which was formed after beginnings of life on Earth as the result of climate, flora and life (microorganisms and roots of higher plants) influence. Soil consists of the surface or fertile layer (0-25 cm) or humus layer, which is characterized by fertility and which is cultivated at growing plants, and of soil itself.

Soils are very different depending on conditions of their formation, first of all on climate and flora. In Ukraine most common are chernozem (black earth soils) (54.0% of territory), then — grey forest soils (18.2% of territory) and sod-podsol soils (7.8% of territory).

### Basic physical properties of soil:

- *texture* – percentage of soil particles according to their sizes. It is determined by screening through Knopf sieves. There are 7 types (called “numbers”) of such sieves with apertures of different diameters from 0.25 to 10.0 mm (fig. 18.1). Soil texture consists of the following elements: stones and gravel (size > 3 mm); coarse sand (3-1 mm), medium (1-0.25 mm), fine (0.25-0.05 mm); coarse dust (0.05-0.01 mm), medium (0.01-0.005 mm), fine (0.005-0.001 mm); silt (< 0.001 mm). According to texture, soils are classified based on specific weight of physical sand (particles of size > 0.01 mm) and of physical clays (particles of size < 0.01 mm). (Appendix 3);

- *porosity* – total volume of pores in the unit of soil volume, which is expressed in percents. The bigger is the size of some elements of soil tissue, i.e. its granularity, the bigger is the size of pores in homogeneous soil. The biggest pores are in rocky soil, smaller ones are in sandy soil, very small pores are in clay soil, and the smallest ones – in peat soil. At that total volume of pores, expressed in percents, increases, i.e. soil porosity is as higher as smaller is the size of some elements of soil tissue. Thus, porosity of sandy soil is 40%, and peat soil - 82%;

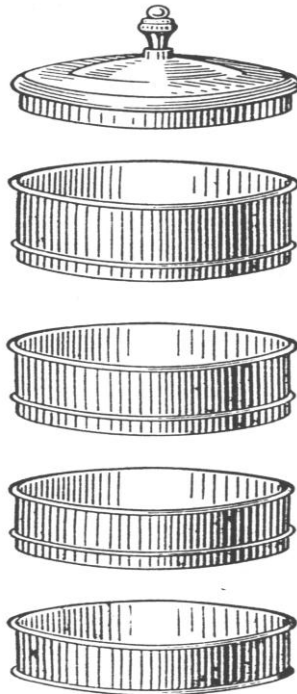


Fig. 18.1 Knopf sieves for soil texture analysis

- *air permeability* – soil ability to let air through its thickness. It increases when size of pores is bigger and doesn't depend on their total volume (porosity);

- *water permeability* – soil ability to absorb surface water and to let it pass through. Permeability consists of two stages: imbibition, when free pores gradually get filled with water till total saturation of soil and filtration, when, in the result of total water saturation of soil, water starts moving in soil pores because of gravity;

- *moisture capacity* – amount of moisture, which soil is capable to retain due to sorptive and capillar powers. The smaller is the size of pores and the bigger is their total volume, i. e. porosity – the bigger is the moisture capacity. The finer is soil texture, the higher is its moisture capacity;

- *soil capillarity* – soil ability to lift water via capillaries from the bottom layers up. The smaller is the size of soil texture particles - the bigger is soil capillarity, but in such soil water goes up higher and slower.



In soils of light texture (sandy, clay sandy, light loamy) compared to heavy soils (clays, heavy loams) physical sand prevails, pores are of the larger size, porosity isn't high, air and water permeability, filtration capacity are considerable, capillarity and moisture capacity are low. On the one hand, processes of soil bio-decontamination run rather quickly in such soils, on the other hand, migration of chemical substances from soil into ground and surface water reservoirs, ambient air and plants is more considerable.

**Soil consists** of biotic (soil microorganisms) and abiotic components. Abiotic components include hard substance of soil (mineral and organic compounds and organomineral complexes), soil moisture and soil air.

60—80% of mineral (non-organic) substances of soil are represented by crystalline silica or quartz. The important place among mineral compounds is occupied by alumina-silicates, i.e. feldspar and mica. Also to alumina-silicates belong secondary clayey minerals, i.e. of montmorillonite group (montmorillonite, notronite, beidelite, saconite, hectorite, stevensite). Their hygienic importance is them being the cause of absorbing capacity and volume of cations' absorption (i.e. heavy metals) by soil.

Beside silica and alumina-silicates, almost all elements of Mendeleev's table appear in mineral compound of soil.

Organic substances of soil are represented both by soil organic (humic acids, fulvic acids etc.) compounds, which are created by soil microorganisms and which are called humus, and by strange for soil organic substances, which came into the soil from outside in the result of natural processes and technogenic (anthropogenic) pollution.

Soil moisture can be both in solid and liquid forms, and in the form of vapour. From hygienic point of view of the most interesting is liquid moisture, which can be in forms of: 1) hygroscopic water, which is condensed on the surface of the soil particles; 2) membranous water, which remains on the surface of soil particles; 3) capillary water, which is kept by capillary forces in thin pores of soil; 4) gravity free water, which is influenced by gravity or hydraulic head and fills in soil big pores.

Soil air is a mixture of gases and vapour, which fills in soil pores. According to its composition it differs from atmosphere air and constantly interacts with it by diffusion and concentration gradient. Soil air and water oppose to each other in respect of space in pores. Natural compound of soil air is controlled by oxygen utilization rate and carbon dioxide generation as the result of microbiological processes of mineralization of organic substances. With growth of depth content of carbon dioxide in soil air increases and oxygen content - decreases.

### **Hygienic significance of soil**

Soil is:

- the medium, where processes of transformation and soil energy accumulation take place;

- leading member of turnover in nature, the medium, in which different complicated processes of destruction and synthesis of organic substances take place continuously;

- main element of biosphere, where processes of migration, transformation and metabolism of all chemical substances both of natural and anthropogenic (technogenic) origin take place. Migration takes place both in short (soil — plant — soil, soil — water — soil, soil — air — soil) and long (soil — plant — animal — soil, soil — water —

plant — soil, soil — water — plant — animal — soil, soil — air — water — plant — animal — soil etc.) migration chains;

- forms the chemical structure of foodstuffs of vegetable and animal origin;
- plays an important role in formation of water quality of surface and ground sources of domestic and drinking water-supply;

- affects qualitative structure of contemporary atmosphere;
- of endemic importance – anomalous natural chemical structure of soil in endemic provinces is a reason of rise and local spreading of endemic diseases (geochemical endemic diseases): endemic fluorosis and caries, endemic goiter, foot-and-mouth disease (FMD), molybdenum gout, endemic osteoarthritis or Kashin-Beck disease, endemic cardiomyopathy (Keshan's disease), selenosis, boric enteritis, endemic nephropathy etc.;

- of epidemic importance – it can be a transmission factor of pathogens of infection diseases and invasions to people: enteric infections of bacterial (typhoid, paratyphoids A and B, bacillary dysentery, cholera, coli-enteritis), viral (virus A hepatitis, enterovirus infections: poliomyelitis, Coxsackie virus infection, ECHO) and protozoa ethiology (amebiasis, lambliaosis); zoonanthroponosis (types of leptospirosis: infectious jaundice or Vasyl'yev – Vail disease, anicteric leptospirosis, brucellosis, tularemia, anthrax); mycobacteria of tuberculosis; spore-forming clostridia – pathogens of tetanus, gas gangrene, botulism; geohelminthosis – ascariidiasis, trichocephalosis, ankylostomiasis.

- the place for liquid and soil domestic and industrial waste disposal due to natural purification processes (soil sanitary significance). Soil natural purification is characterized by presence of saprophytic decomposers, nitrifying and nitroifying bacteria, elemental organisms, larvae, worms, fungi, viruses, coliphages and by its physical-and-chemical properties. It consists in soil capability to transform organic compounds into mineral substances good for plants' assimilation: carbohydrates – into water and carbon dioxide; fats – into glycerin and fatty acids and then – also into water and carbon dioxide; proteins – into amino acids with ammonia and ammonia salts evolvment and their further oxidation to nitrites and nitrates; protein sulfur – into hydrogen sulfide etc.

### **Sanitary purification of settlements**

It is a set of measures that provide for the fulfillment of hygienic requirements during arrangement and exploitation of equipment and facilities that are meant for collecting, temporary keeping, transportation, destruction and utilization of solid and liquid domestic and industrial waste.

**Waste** – these are remains of substances and articles that have been created as the result of domestic, economic and industrial human activity, and cannot be used at the scene of their creation so that their accumulation and keeping make the sanitary condition of the environment worse. They are divided into *liquid*: 1) sewage from cesspool toilets; 2) slops (from cooking and dish and floor washing etc.) and 3) waste waters: domestic, industrial, runoffs, municipal waste water and *solid*: 1) garbage (domestic refuse); 2) rubbish (kitchen waste products); 3) waste from patient care and prophylaxis institutions (including specific ones — used dressing, used disposable autotransfusers and syringes, remains of medicines, remains of organs and tissues after surgical operations, dead bodies of laboratory animals etc.); 4) institutional waste (schools, preschool institutions, high schools and academies, offices, etc); 5) waste of public catering establishments; 6) waste of animal origin (dead bodies of animals, pus, forfeit foodstuff); 7) waste of commercial

facilities; 8) industrial waste; 9) slags from boiler houses; 10) construction waste, urban soil; 11) street sweepings.

There are **three different systems of waste disposal**: “flushing” removal, “pick-up” removal and combined removal.

*Flushing system* is used in the settlements, which are provided with sewerage (pipe) system through which liquid and partially fine solid waste float to waste disposal plants; the rest of solid waste is removed by special motor transport.

*Pick-up system* is used in the settlements without sewerage systems. At that both liquid and solid domestic waste (SDW) is removed to areas of disposal and utilization by special motor transport. Such method of disposal of solid waste is called purification, and of liquid wastes – sanitation.

*Combined system* is used in the settlements that are partially provided with sewerage system. According to combined system liquid waste from the part of settlement, provided with sewerage system, is removed through this system, and from the part of the settlement where there is no sewerage system – with the help of cesspoolage transport. All solid waste is removed by sanitary purification transport.

Sanitary purification of settlement must be systematic (to be performed according to agreed plan and schedule), regular (waste removal in warm season – daily, in cold season – once per 1-3 days), utility (to be performed by utilities and community services, or trusts) and to be independent from wishes of some officials or institutions. It consists of three stages: I — collection and temporary keeping of solid domestic waste; II — removal; III — disposal and treatment.

**Collection, removal (transportation) of solid domestic wastes.** In case of *neighbourhood-based system* SDW is collected into special dustbins that are located at specially arranged plots on the territory near the houses and later on, according to the schedule, it is removed by special motor transport to the place of disposal. In case of *door-to-door-based system* waste is collected in apartments. At the certain time inhabitants take it out to a dust-cart. There are two different methods used in case of *neighbourhood-based system* - method of "fixed" container (waste from dustbins is emptied into dust-carts and dustbins are placed back) and method of "disposeable" container (dustbins together with solid waste are removed by dust-carts to waste disposal places, while empty and clean dustbins are left instead of the used ones).

For garbage and other solid waste removal special motor cars – dust-carts - are used. For method of "fixed" container they use dust-carts 93/M, 53/M, KO-404, KO-413 etc., for method of "disposeable" container – dust-carts M-30. They are mounted on the chassis of the trucks GAZ-93a, GAZ -53, MAZ -500A.

**Solid domestic waste disposal.** All methods of SDW disposal have to meet the following basic hygienic requirements:

- they must provide reliable disposal, transformation of waste into harmless from epidemic and sanitary point of view substrate. From epidemic point of view solid domestic waste is very dangerous: when titer is  $10^{-6}$ - $10^{-7}$ , titer of anaerobes is -  $10^{-5}$ - $10^{-6}$ , microbial number achieves tens and hundreds of billions, contains pathogenic and conditionally pathogenic bacteria, viruses, eggs of helminthes. Especially dangerous is waste from patient care and prophylaxis institutions, which is approximately 10-100 times more contaminated by microorganisms than domestic waste;

- quickness – ideal method is the one that makes possible effective waste disposal during the same period of time in which the waste is formed;

- they must prevent laying eggs and larvae and chrysalides development of flies (*Musca domestica*) both in waste during its disposal and in substrate, which was obtained in the result of the disposal;

- they must prevent access of rodents during waste disposal and to convert waste into unfavourable for their life and development substrate;

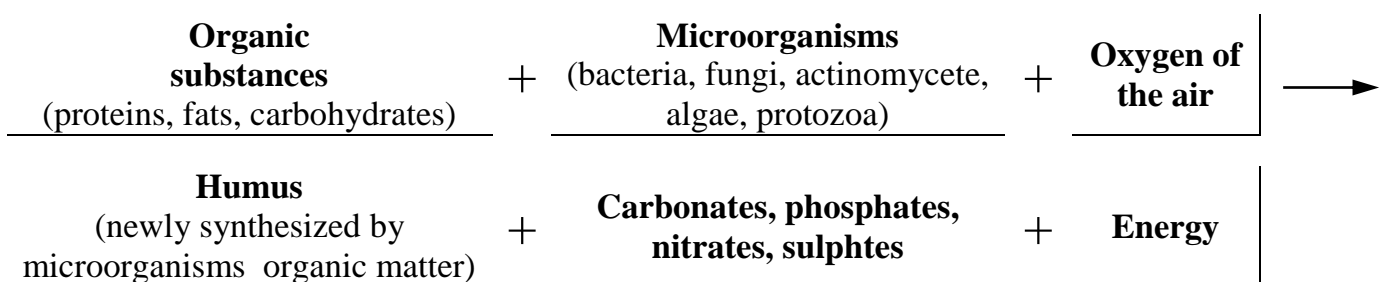
- they must prevent air pollution by volatile products of demolition of organic substances (SDW contain up to 80 % of organic substances, 20-30 % of which easily rot in summer and at the same time evolve stinking gases: hydrogen sulphide, indole, skatole and mercaptans);

- in the process of waste disposal neither surface nor ground waters may be polluted;

- they must provide the best and safe for people's health use of SDW properties, because they contain up to 6% of utilizable waste; by its burn one can receive heat energy, by biothermal treatment — organic fertilizers, and food waste may be used for cattle feeding.

According to the final result methods of SDW disposal are divided into: utilizing (waste processing into organic fertilizers, biological fuel, separation of secondary raw materials, e. g. scrap metal, for industry, use as a power-plant fuel) and liquidation (land disposal, sea disposal, incineration without help of heat). According to technological principle methods of disposal are divided into: 1) biothermal (plough-lands, improved dumps, waste store grounds, waste composting fields, bio-chambers, plants for biothermal treatment; in rural area in farms — compost heaps, hotbeds); 2) thermal (combustion plants without or with utilization of heat energy, which is created in the result of this process; pyrolysis leading to formation of fuel gas and similar to mineral oil - lubricating oil); 3) chemical (hydrolysis); 4) mechanical (waste separation with further utilization, pressing into construction blocks); 5) combined.

Most widely used are biothermal methods. They are based on the complicated processes of soil natural organic purification from pollutants that may be represented in diagram:



*Biothermal disposal* makes it possible to solve two tasks: 1) to decompose complex organic matters of waste and its metabolism products (urea, uric acid etc.) into simpler compounds in order to synthesize by special microorganisms in presence of ambient air a new, stable, safe from sanitary point of view substance, called humus; 2) to destroy vegetative forms of pathogen and conditionally pathogenic bacteria, viruses, protozoa, eggs of helminthes, eggs and larvae of flies, seeds of weeds.

Efficiency of biothermal method of waste disposal depends on:

- aeration of waste (it is necessary to fan 25 air volumes for 1 volume of SDW);
- waste moisture (if moisture < 30 %, SDW must be moistened artificially; if > 70 %, it is necessary to install devices for its lessening);

- content of organic substances in waste that are capable to rot easily (mustn't be < 30 %, in the ration of carbon to nitrogen 30:1), and inorganic compounds (less than 25 %);
- waste particles' size (optimal size is 25-35 mm);
- waste active reaction (pH) (optimal pH is 6.5-7.6);
- degree of output contamination by mesophilic and thermophilic microorganisms (artificial inoculation is carried out for stimulation of purification);
- thermal conditions (more quickly temperature will rise in the thickness of waste, better and more reliable biochemical destruction of organic substances and pathogenic microflora will be).

Sanitary inspection of systems of waste collection, transportation and disposal requires objective assessment of their efficiency, which is impossible without territory sanitary survey, soil sampling and its laboratory analysis.

## Appendix 11

### Methods of land parcel sanitary inspection and soil sampling

Sanitary inspection of the land parcel includes:

- definition of ground assignment (territory of a hospital, preschool institutions, schools, industrial enterprises, objects of waste disposal of domestic, industrial, construction origin, etc);
- visual inspection of the parcel, determination of character and location of sources of soil pollution (distance), relief, drain direction of precipitation waters, flow direction of ground waters;
- determination of soil texture (sand , clay sand, loamy soil, chernozem);
- determination of points for soil sampling for analysis: places near the source of pollution and near test area of known clean soil (at a distance of this source).

Samples are taken by "envelope" technique on rectangular or square areas of 10×20 meters or more. In each of five sampling points of the "envelope" 1 kg of soil is taken from the depth of 20 cm for samples. An average sample of 1 kg mass is prepared from taken samples.

Each taken sample is accompanied by a covering letter, which includes information about place, address and assignment of the parcel, soil type, relief, ditch level of subterranean waters, goal and volume of the analysis, inspection results received at the place, date and time of sampling, weather of previous 4-5 days, who took a sample, his signature. Samples are packed into closed glassware and polyethylene bags.

### Criteria of soil sanitary state

<i>Group of indices</i>	<i>Indices</i>
Sanitary-and-physical	Texture of soil, filtration coefficient, air and water permeability, capillarity, moisture capacity, total hygroscopic moisture
Physical-and-chemical	Active reaction (pH), absorption capacity, total absorbed bases
Chemical safety criteria:	
- chemical agents of natural origin	Background content of total and movable forms of macro- and microelements of non-contaminated soil
- chemical agents of anthropogenic origin (soil pollution indices, ECS)	Amount of pesticide residues, total content of heavy metals and arsenic, content of movable forms of heavy metals, oil and oil products' content, content of sulphides, content of carcinogens (benzpyrene) etc.
Epidemic safety criteria:	
- sanitary-chemical	Total organic nitrogen, Khlebnikoff's sanitary number, ammonia nitrogen,

	nitrite nitrogen, nitrate nitrogen, organic carbon, chlorides, soil oxidation
- sanitary-microbiological	Total number of soil microorganisms, , microbial number, titer of bacteria of colibacillus group (coli-titer), titer of anaerobes (perfingens-titer), pathogenic bacteria and viruses
- sanitary-helminthological	Number of eggs of helminthes
- sanitary-entomological	Number of larvae and chrysalides of flies
Radiation safety indices	Soil activity
Soil natural purification indices	Titer and index of thermophile bacteria

All indices are divided into *direct* (allow to assess the level of soil contamination and level of danger for population health directly from the results of laboratory analysis of taken samples /Appendix 3/) and *indirect* (allow to draw a conclusion of the existence of soil contamination, its prescription and duration by comparison of the results of soil laboratory analysis with test clean soil of the same type, which was taken as a sample from non-contaminated areas).

*Sanitary number of Khlebnikoff* – is a ratio of humus nitrogen (pure soil organic substance) to total organic nitrogen (consists of humus nitrogen and nitrogen of strange for soil organic substances that contaminate it). If soil is pure, sanitary number of Khlebnikoff equals to 0.98-1.

*Soil coli-titer* – is a minimal amount of soil in grammas, in which one bacteria of colibacillus group is found.

*Soil anaerobe titer (perfingens-titer)* – is a minimal amount of wastes in grammas, in which an anaerobic clostridia is found.

*Soil microbial number* – is a number of microorganisms in one gram of soil that grew up on 1.5% beef-extract agar at temperature 37<sup>0</sup>C during 24 hours.

## Appendix 12

### Soil classification according to texture (according to N.A. Kachinskiy)

Names of soils according to texture	Content of particles, %	
	Clay particles of a diameter smaller than 0.01 mm	Sand particles of a diameter larger than 0.01 mm
Heavy clay soils	larger than 80	smaller than 20
Clay soils	from 80 to 50	from 20 to 50
Heavy loamy soil	from 50 to 40	from 50 to 60
Medium loamy soil	from 40 to 30	from 60 to 70
Light loamy soil	from 30 to 20	from 70 to 80
Clay sands	from 20 to 10	from 80 to 90
Sandy	from 10 to 5	from 90 to 95
Light sandy	smaller than 5	larger than 95

### Filtration capability of soils of different texture

<i>Filtration capability</i>	<i>Time of absorption, s*</i>	<i>Type of soil</i>
Large	<18	coarse-grained – and medium size - grained sand
Medium	18—30	fine-grained sand, light clay sand
Small, but sufficient for active realization of processes of organic decontaminations	30—180	Light adobe
Small and insufficient for realization of processes of organic decontaminations	>180	Heavy and medium clay sands and loamy soil, clays

A hole of 0.3×0.3 m in diameter and 0.15 m in depth is dug and quickly filled up with water (12.5 dm<sup>3</sup>). With the help of chronometer the period of absorption is timed.

**Scale for assessment of sanitary state of soil\***

Danger level	Level of pollution	Criteria of epidemic safety					Pollutional index ECS — exceeding factor of MAC	Radiation safety index – soil activity	Natural purification index — thermophile titer
		Coli titer	Anaerobe titer	Number of eggs of helminthes in 1 kg of soil	Number of larvae and chrysalides of flies on 0.25 m <sup>2</sup>	Sanitary number of Khlebnikoff'			
Safe	Pure	1.0 and more	0.1 and more	0	0	0.98-1.0	≤1	Natural level	0.01- 0.001
Relatively safe	Slightly polluted	1.0-0.01	0.1-0.01	less than 10	single specimen	0.86-0.98	1-10	Exceeding natural level by 1.5 times and more	0.001-0.00002
Dangerous	Polluted	0.01-0.001	0.01-0.0001	11-100	10-25	0.70-0.86	11-100	Exceeding natural level by 2 times and more	0.00002 -0.00001
Very dangerous	Heavily polluted	0.001 and less	0.0001 and less	more than 100	25 and more	<0.70	>100	Exceeding of natural level by 3 times and more	<0.00001

\*Under condition of soil sampling in the depth of 0-20 cm.



**Assessment of soil sanitary state according to chemical analysis of soil air**

<i>Soil sanitary state</i>	<i>O<sub>2</sub> and CO<sub>2</sub> content in soil air. %</i>	
	<i>O<sub>2</sub></i>	<i>CO<sub>2</sub></i>
Pure	19.75-20.3	0.38-0.8
Slightly polluted	17.7-19.9	1.2-2.8
Averagely polluted	14.2-16.5	4.1-6.5
Heavily polluted	1.7-5.5	14.5-18

Appendix 15

**Assessment guide scale of the population health state in dependence on soil contamination levels by exogenic chemical substances (ECS)**

Changes in the state of population health	Exceeding factor of MAC of ECS in soil
Minimal physiological disorders	< 4
Significant physiological disorders	4—10
Frequency of morbidity rise by separate nosologic forms and groups of diseases	11—119
Chronic poisonings	120—199
Acute poisonings	200—999
Mortal poisonings	> 1000

Appendix 16

**Technique of hygienic assessment of sanitary state of soil**

When drawing a report on hygienic assessment of sanitary condition of soil it is reasonable to use a scheme (algorithm) that provides for the following 6 stages:

I – goal and task are determined. Thus it is necessary to state a hygienic value of sanitary condition of natural soil at the time of the assignment of the parcel for new settlement construction. During the regular sanitary inspection it is necessary to assess the sanitary condition of artificially created soil on the ground areas for residential and public building, playgrounds for children and sport grounds. When the epidemic situation is unfavorable, it is necessary to find out if soil is a factor in spreading pathogenic microorganisms. Sometimes, when investigating cases of acute and chronic poisonings it's necessary to determine the level of soil contamination by toxic chemical substances (pesticides, heavy metals etc.). Sanitary condition of soil may be studied in order to assess the efficiency of sanitary purification of the settlement territory, during the regular sanitary inspection of sewage disposal plant and facilities of utilization and extermination of SDW in order of assessment of their work efficiency.

II – according to set tasks a required extent of examinations is set. Thus, during the hygienic assessment of natural soil of the ground areas assigned for new settlement construction, complete sanitary analysis of every index of sanitary condition is required. During the hygienic assessment of artificially created soil of settlements, in

case of favorable epidemic situation, it is reasonable to carry out examinations by sanitary analysis reduced scheme: determination of total and hygroscopic moisture, Khlebnikoff's sanitary number, chlorides, soil oxidation, microbial number, titer of coli-group bacteria, anaerobe titer, number of eggs of helminthes, number of larvae and chrysalides of flies. In case of unfavorable epidemic situation it is important to include tests on presence of pathogenic bacteria and viruses into reduced sanitary analysis. When investigating cases of acute and chronic poisonings for the assessment of the level of soil contamination by chemical poisonous substances it is sufficient to determine texture of soil, total and hygroscopic moisture and content of hazardous substances: pesticides, heavy metals, arsenic etc. (Appendices 4, 5).

III – completeness of presented materials and availability of sanitary examination data are controlled, soil sampling schemes, methods of their preliminary analysis, time constraints of analysis, soil samples' keeping are assessed, availability of soil laboratory analysis results in accordance to the required research program are controlled.

IV – sanitary examination results are analyzed: a) sanitary-topographical characteristic of the area; b) sanitary-technical characteristic of the objects that influence condition of the area; c) sanitary-epidemic situation. Preliminary conclusion concerning grounds for suspicion that soil can be contaminated by exogenic chemical substances or being a factor of spreading infections is drawn.

V – laboratory results of soil analysis are assessed according to all data, that are required by examination program. According to indirect indices based on comparing the examined and test (“pure”) soil one, conclusion about the fact of existence, prescription and durability of contamination is drawn. According to direct indices, based on sanitary assessment of the condition of soil (Appendices 4, 5), level of soil contamination and stage of its danger for the population health is assessed.

VI – general conclusion about sanitary condition of soil, stage of its contamination and danger for the population health is drawn, future soil pollution effect on population health depending on its levels is forecasted (Appendix 6), preventive measures of further deterioration of sanitary state of soil and ways of its improvement are offered.

Appendix 17

### **Example of a situational task for training of method of hygienic assessment of soil sanitary state**

For making a decision concerning an opportunity of assignment of the land parcel for construction of multifield hospital in the town N. sanitary analysis was made and soil samples were taken.

**Sanitary analysis data:** Parcel of the total area of 5 hectares is located to the north of the outskirts of the town. This territory formerly belonged to the collective farm “Prometheus” and was used for growing crops and later as a pasture. During last two years this territory was passed to town N. Relief of the area is flat, level of subterranean waters is 2.5 m. At the northern side the parcel borders with forest shelter belt, which separates agricultural areas, at the eastern side – highway, at the southern side – local park, at the western side – residential area. At the distance of 1.5 km to the West from the parcel industrial enterprises are located. Prevailing wind direction is

South-Western. According to the information from local hospital during last 10 years there were no sufficient changes in the general morbidity. Morbidity of first year life infants has slightly increased.

**Sampling report:** Samples have been taken by “envelope” technique from 2 test areas of 5×5 m<sup>2</sup> each, which are arranged on the analyzed land parcel and on the territory of the local park. Samples for chemical and bacteriological analyses were taken layer-by-layer from the depth of 0-5 and 5-20 cm, for helminthological analysis – 0-5 and 5-10 cm. Compound samples for chemical (1.5 kg weight) and helminthological (1.0 kg weight) analyses are put into paper bags, samples for bacteriological analysis are taken with sterility requirements adherence and are placed into sterile glassware. Sampling took place in August 17, 2003, from 10 a. m. till 11 a. m. At the same day at 12 a. m. the samples were delivered to the laboratory.

**Laboratory analysis results:**

Indices	Analyzed area		Test area	
	0-5 cm	5-20 cm	0-5 cm	5-10 cm
<b>Indices that specify physical properties</b>				
Physical clay content, %	15	17	20	18
Physical sand content, %	85	83	80	82
<b>Indices of contamination by exogenic chemical substances</b>				
Lead (bulk forms), mg/kg	30.0	27.0	28.0	26.0
HCB, mg/kg	0.04	0.05	0.03	0.04
DDT, mg/kg	0.1	0.08	0.08	0.09
<b>Epidemic safety criteria</b>				
<i>Sanitary-chemical</i>				
Sanitary number of Khlebnikoff	0.99	0.98	0.98	0.99
Chlorides, mg/100 g	57	53	54	51
Ammonia nitrogen, mg/100 g	3.7	3.5	3.4	3.5
Nitrites nitrogen, mg/100 g	0.2	0.1	0.1	0.2
Nitrates nitrogen, mg/100 g	1.9	1.7	1.8	1.6
<i>Sanitary-microbiological</i>				
Coli-titer	1.0	1.0	1.0	1.0
Titer of anaerobes	0.1	0.1	0.1	0.1
<i>Sanitary-helminthological</i>				
Number of eggs of helminthes in 1 kg of soil	0	0	0	0
<i>Sanitary-entomological</i>				
Number of larvae and chrysalides of flies on 0.25 m <sup>2</sup>	0	0	0	0

MAC in soil (mg/kg): lead (bulk forms) – 30.0, HCB – 0.1, DDT – 0.1.

It is **necessary** to assess the sanitary state of the soil at the land parcel to forecast its possible influence on the population health and to make a decision on possible assignment of the territory for multifield hospital construction.

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6.1.8. Lecture materials.

### 6.2. Additional:

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6.2.2. Даценко І.І., Габович Р.Д. Основи загальної та тропічної гігієни. – К.: Здоров'я, 1995. – С. 176-207.

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5. Гигиена и экология: учебник для студентов высших медицинских учебных заведений. – Винница: НОВА КНИГА, 2008ю – 720 с.

## **7. Equipment required for the lesson**

1. “Drinking water” State Standard, Sanitary Rules and Norms (SRandN) on water of decentralized water supply.
2. Situational task according to results of the laboratory analysis of water and the example of sanitary certificate.
3. Situational tasks on the results of the laboratory analysis of water for students’ self-training.
4. Equipment for soil sampling (scoop, wand).
5. Knopf sieves (7 numbers).
6. Graduated cylinder for 100 ml.
7. Tables: - Soil classification by texture of soil;  
- Soil sanitary state criteria;  
- Soil condition according to Khlebnikoff’s sanitary number.
8. Situational tasks based on the results of soil laboratory analysis.