Ministry of Education and Science of Ukraine
V. N. Karazin Kharkiv National University

METHOD OF HYGIENIC ASSESSMENT OF SOIL

Methodical recommendations
to prepare 3rd year students for practical classes
for the discipline of "Hygiene and ecology"

Electronic resource

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М 61 **Method** of hygienic assessment of soil : methodical recommendations to prepare 3rd year students for practical classes for the discipline of "Hygiene and ecology" [Electronic resource] / compil.: Iryna V. Redka. – Kharkiv : V. N. Karazin KhNU, 2024. – (PDF 47 c.)

The methodical recommendations set out the basic physical and chemical properties of soils and methods of their assessment. The rules of soil sampling for further laboratory research, depending on its purpose, are disclosed. Schemes for determining helminthological, entomological and bacteriological indicators of sanitary conditions and soil contamination are given. Legislatively approved regulations and standards regarding acceptable levels of soil pollution are given. For 3rd year students to prepare for practical classes in the discipline "Hygiene and ecology".

УДК 614.76(072)

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PLANNED LEARNING OUTCOMES

According to the requirements of the educational and professional program, students must

know:

- hygienic, epidemic and endemic value of soil;
- the concept of soil helath;
- physical and chemical properties of the soil;
- indicators of sanitary and epidemiological safety of the soil;
- techniques for soil sampling;
- stags of sanitary inspection of the land plot;

be able to:

- carry out a sanitary inspection of the land plot and the soil sampling for laboratory analysis;
- assess the level of soil pollution and the degree of its danger to the population health based on the data of the sanitary inspection of the land plot and the results of the laboratory examination of soil samples;
- plan and carry out preventive measures for the sanitary protection of the soil to prevent diseases.

Studying this topic will ensure that students acquire the following **program learning outcomes (PLO):**

- PLO 1. Have thorough knowledge of professional activity structure. To be able to carry out professional activities that require updating and integration of knowledge. To be responsible for professional development, the ability for further professional training with a high level of autonomy.
- PLO 2. Understanding and knowledge of fundamental and clinical biomedical sciences at a level sufficient for solving professional tasks in the health care area.
- PLO 3. Specialized conceptual knowledge, which includes scientific achievements in the field of health care and is the basis for conducting research, critical understanding of problems in the medicine field and related interdisciplinary problems.

- PLO 4. Determinate and identify leading clinical symptoms and syndromes; according to standard methods, using preliminary data of the patient's history, data of the patient's examination, knowledge about the person, his/her organs and systems, establish a preliminary clinical diagnosis of the disease.
- PLO 19. Plan and implement a system of anti-epidemic and preventive measures regarding the occurrence and spread of diseases among the population.
- PLO 21. Search for the necessary information in the professional literature and databases of other sources, analyze, evaluate and apply this information.
- PLO 25. It is clear and unambiguous to convey one's own knowledge, conclusions and arguments on health care problems and related issues to specialists and non-specialists.
- PLO 27. Communicate freely in the official language and in English, both orally and in writing to discuss professional activities, research and projects.

1. Introduction

Soil is a vital natural resource and its health is fundamental for sustainable agricultural production. However, soils can also become a risk factor for human health and ecosystems. The soil of the area where an industrial enterprise is located, as well as beyond its borders, is usually contaminated with emissions and waste containing various chemical compounds of the organic and inorganic series, many of which have toxic properties. As a result of exposure to industrial emissions and waste, the physical and chemical properties of the soil deteriorate, soil absorption complex and structure are destroyed, acidity increases, and buffer capacity decreases. All this leads to disruption of the normal functioning of soil microorganisms, and sometimes to its complete suppression, increases the soil contamination with pathogens, a decrease in the yield of cultivated plants, and a decrease in the nutritional value of food. Soil contaminated with pathogens, chemicals, industrial and agricultural waste can be a source of groundwater contamination, and surface runoff can become a source of contamination of open water bodies. This can have serious consequences for human health through consumption of contaminated food or contact with contaminated soil.

Therefore, preservation and protection of soils from pollution and degradation are extremely important tasks for preserving human health, biodiversity and ensuring food security.

Soil health referred to as soil quality, is defined as the capacity of soil to function within ecosystem boundaries to sustain biological activity, maintain environmental quality, and promote plant, animal and human health. Soils function to provide ecosystem services that include increased soil water retention and availability, soil aggregation, nutrient cycling and storage, and microbial diversity and function.

Healthy soil should possess the following characteristics:

- High organic matter
- Good soil tilth and structure
- High water infiltration and retention
- Resistance to compaction

- High soil biological activity
- Plant nutrient recycling and availability
- Resistance to erosion
- Devoid of toxic chemicals
- Low in weed and disease pressures

Soil health indicators generally describe specific soil properties. Soil properties can be generally categorized as stable or dynamic. *Stable soil properties* are influenced by soil-forming factors such as climate, organisms, parent material, and topography, which change little with management practices. Examples of stable properties include soil texture, soil type, and soil depth. *Dynamic properties* can change with land-use and management practices over the course of a short time, generally within a human lifespan, and include soil organic matter, bulk density, and pH. Accordingly, soil health assessment programs that include measurement of various physical, chemical, and biological properties of soil that respond to management changes provide clues on soil processes.

Some of the commonly used soil properties to assess soil health are listed below:

Physical	Chemical	Biological
✓ Soil color ✓ Aggregate stability ✓ Water infiltration ✓ Bulk density ✓ Penetration resistance ✓ Water holding capacity ✓ Runoff and erosion ✓ Rooting depth	✓ Organic C and N ✓ Particulate organic matter ✓ Active carbon ✓ pH ✓ Cation exchange capacity and base saturation ✓ Electric conductivity ✓ Heavy metals	✓ Soil respiration ✓ Potential mineralizable nitrogen ✓ Microbial biomass ✓ Soil enzymes ✓ Earthworms ✓ Crop condition, root growth ✓ Weed and disease pressure

The sanitary state of the soil is a combination of physico-chemical, biological properties of the soil that determine the quality and degree of its safety in an epidemic and hygienic sense.

3. Physical properties of the soil

The soil is a heterogeneous, polyphasic, particulate, disperse, and porous system, with a large interfacial area per unit volume. A handful of clay, for instance, may have an internal surface area of several hectares. The disperse nature of soil and its consequent interfacial activity give rise to such phenomena as adsorption of water and chemicals, capillarity, ion exchange, swelling and shrinking, dispersion and flocculation.

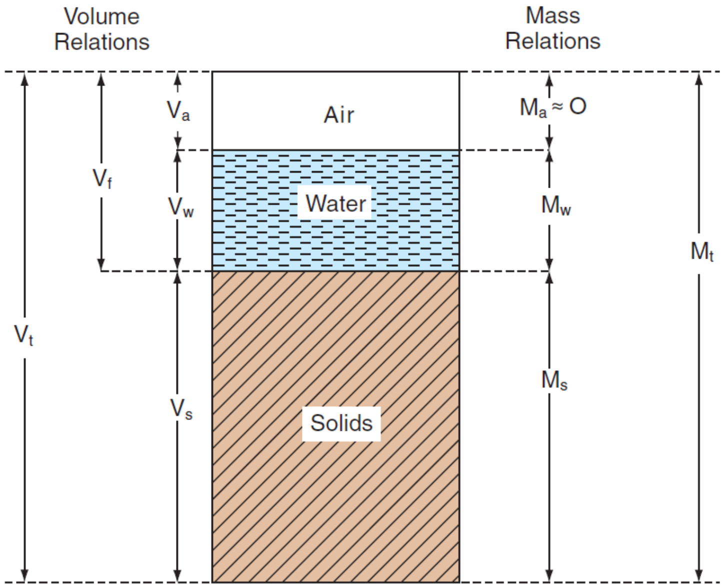


Fig. 2. Schematic diagram of the soil as a three-phase system.

The three phases of ordinary nature are represented in the soil as follows: the solid phase forms the *soil matrix*; the liquid phase is the water in the soil, which always contains dissolved substances, so it should properly be called the *soil solution*; and the gaseous phase is the *soil atmosphere*.

The solid matrix of the soil consists of particles that vary in chemical and mineralogical composition as well as in size, shape, and orientation. It also contains amorphous substances, particularly organic matter, which is attached to the mineral grains.

Soil texture refers to the composition of the soil in terms of the amounts of small (clays), medium (silts), and large (sands) size particles.

Soil texture is determined by screening through *Knopf sieves*. There are 7 types sieves with openings range from 10 to 0.25 mm (0.25, 0.5, 1.0, 2.0, 3.0, 5.0, 10.0 mm).

Thechnique by sieve analysis (fig. 3)

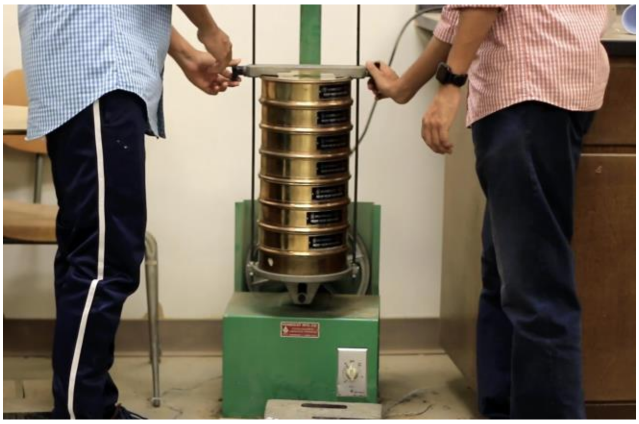
1. Pulverize the soil sample as finely as possible, using a mortar and pestle or a mechanical soil pulverizer.
2. Obtain a representative air-dried soil sample (200-300 g, W_0).
3. Make sure the sieves are clean, If soil particles are stuck in the openings, use a brush to poke them out.
4. Stack the sieves so that those with larger openings (lower numbers) are placed above those with smaller openings (higher numbers). Place a pan under the last sieve) to collect the portion of soil passing through it.
5. Weigh the pan and all of the sieves separately.
6. Pour the soil from above into the stack of sieves and place the cover on it. Put the stack in the sieve shaker, affix the clamps, set a timer for 10 to 15 minutes, and start the shaker. The soil particles are distributed in different sieves according to their size.
7. Stop the sieve shaker and measure the mass of each sieve and retained soil. Calculate the ratio of soil weight in each sieve to total soil sample weight (W_0).

1. Weighing some representative air-dried samples

2. Washing the sieves before the test

3. Stack of sieve in order

4. Pouring the soil sample at the top of the sieves



5. Sieve shaker

6. Weighing of each sieve after shaking

Fig. 3. Soil texture determination by sieve analysis

Soil texture consists of the following elements: stones and gravel (size > 3 mm); coarse sand (3-1 mm), medium sand (1-0.25 mm), fine sand (0.25-0.05 mm); coarse dust (0.05-0.01 mm), medium dust (0.01-0.005 mm), fine dust (0.005-0.001 mm); silt (< 0.001 mm).

The primary particles of sand, silt, and clay make up the inorganic solid phase of the soil. These particles often become aggregated together with each other and other parts of the soil, most importantly soil organic matter.

In general, the size of soil particles and their spacing determine how much water can flow through the soil. The larger the spacing, or pore size, the greater the infiltration rate. Thus, sandy soils will have high infiltration rates because pore sizes are large and there are no finer materials to block the pores.

According to texture, soils can be classified based on specific weight of physical sand (particles of size > 0.01 mm) and of physical clays (particles of size < 0.01 mm).

Table 1 – Soil classification according to its texture (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

The overall textural designation of a soil, called textural class, is conventionally based on the mass ratios of the three fractions. Soils with different proportions of sand, silt, and clay are assigned to different classes, as shown in the triangular diagram of Fig. 4.

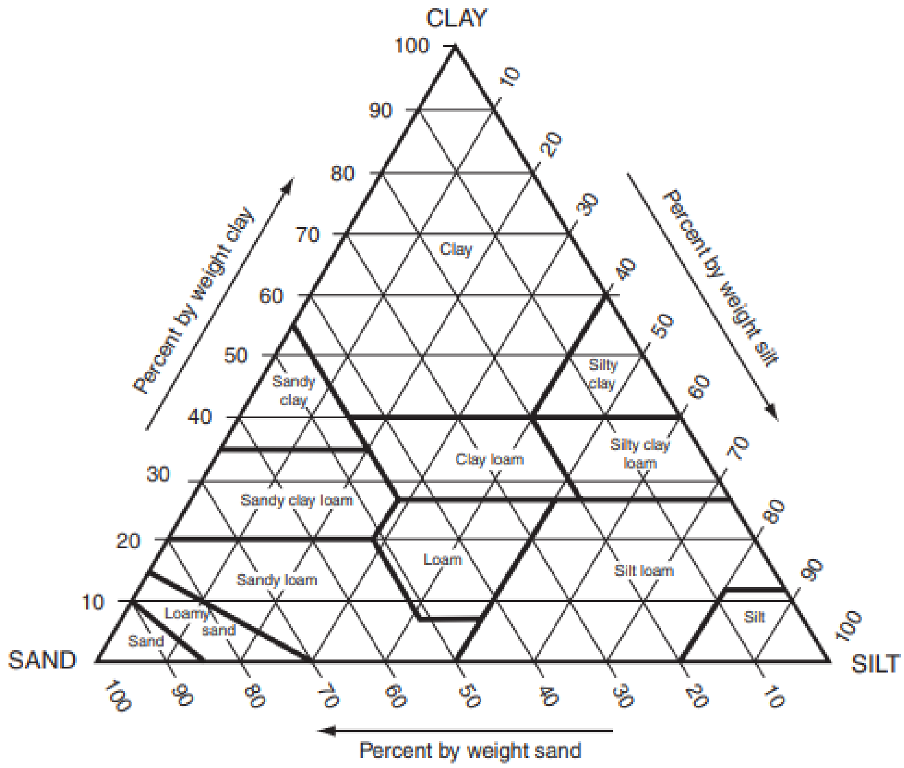


Fig. 4. Textural triangle, showing the percentages of clay (below 0.002 mm), silt (0.002–0.05 mm), and sand (0.05–2.0 mm) in the conventional soil textural classes.

Soil porosity refers to the fraction of the total soil volume that is taken up by the pore space.

$$\text{POROSITY } (Pt) = \frac{\text{PORE VOLUME } (Vp)}{\text{TOTAL VOLUME } (Vt)} = \frac{\text{PORE VOLUME } (Vp)}{\text{SOLID VOLUME } (Vs) + \text{PORE VOLUME } (Vp)}$$

Mainly, pore spaces facilitate the availability and movement of air or water within the soil environment. Four hierarchical pore structures have been characterized as macropores, pore space between macro-aggregates, pores between micro-aggregates but within macro-aggregates, and pores within micro-aggregates in the soil environment. These pores influence soil biodiversity (i.e., soil microorganisms) by facilitating space for their survival. For instance, protozoa, small nematodes, and fungi inhabit the pore space between micro-aggregates while bacteria colonize within the pores of micro-aggregates for their habitat.

Porosity is an index of the relative pore space in a soil. Its value generally ranges from 0.3 to 0.6 (30–60%). Coarse-textured soils tend to be less porous than fine-textured soils, though the mean size of individual pores is greater in the former. In clayey soils, the porosity is highly variable because the soil alternately swells, shrinks, aggregates, disperses, compacts, and cracks.

Several methods can be employed to directly measure soil porosity but in hygiene the *saturation (imbibitions) method* (**Fig. 5**) is prevalent.

Fill one 1000 ml beaker to 500 ml with clean dry soil (V_{soil}). Then fill a graduated cylinder to 500 ml with water (V_{water}). Slowly and carefully pour the water into the beaker and wait for the soil/water mixture to reach equilibrum, leading to a water-saturated soil phase and a layer of water on top of the soil ($V_{mixture}$).

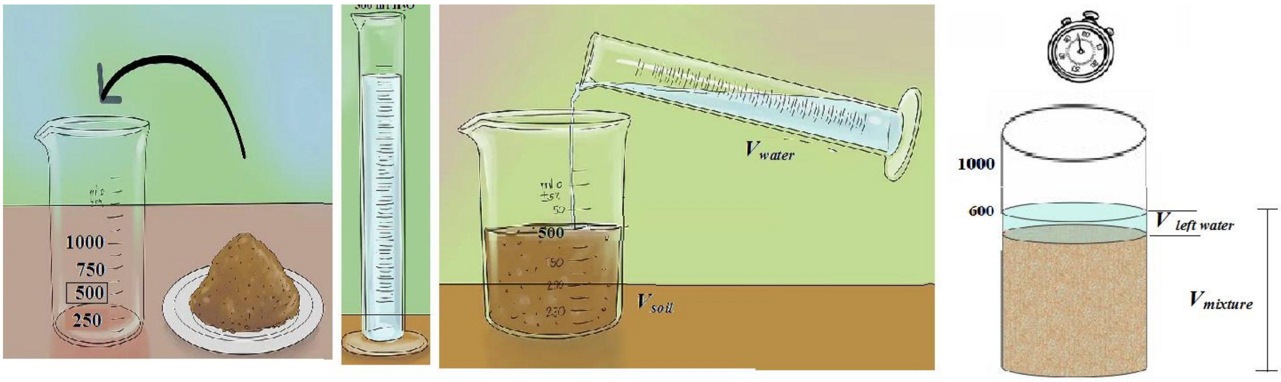


Fig. 5. Measuring soil porosity by saturation (imbibitions) method

Measure the volume of water/soil mixture (it must be less than 1000 ml) and calculate the soil porosity based on the following formula:

$$Pt = \frac{(V_{water} + V_{soil}) - V_{mixture}}{V_{soil}} \times 100\%$$

Also porosity can be calculated directly measuring the volume of water left after soil saturation ($V_{left\ water}$) based on the following formula:

$$Pt = \frac{V_{left\,water}}{V_{soil}} \times 100\%$$

Soil porosity is as higher as smaller is the soil texture. It is known that with porosity 60–65% correspond to the best conditions for soil self-purification processes.

Air permeability of soil is the coefficient, governing convective transmission of air through soil under an applied total pressure gradient. It depends on the size of the soil pores and increases with increasing atmospheric pressure and decreases with increasing thickness of the soil layer and its moisture content. Air permeability is very sensitive to differences in soil structure and has been widely used to characterize the changes in structure that result from different soil management practices. It has even been used to predict other important soil physical properties such as the saturated *hydraulic conductivity* (= *water permeability*). High air permeability is a favorable hygienic property, as it promotes soil aeration, i.e. oxygen saturation necessary for the oxidation of organic substances.

Water permeability or *hydraulic conductivity* is defined as a capacity of soil to allow water passes through it i.e. quantity of flowing for a unit of soil surface under a pressure of 1 unit hydraulic gradient.

Water permeability includes two stages: 1) *absorption*, when free pores gradually get filled with water till total saturation of soil; 2) *filtration*, when, in the result of total water saturation of soil, water starts moving in soil pores because of gravity.

Factors affecting permeability of soils:

- Particle size: the permeability varies approximately as the square of grain size. It depends on the effective diameter of the grain size.
- Void ratio: increase in the void ratio increases the area available for flow hence permeability increases for critical conditions.
- Properties of pore fluid: pore fluids are fluids that occupy pore spaces in a soil or rock. Permeability is directly proportional to the unit weight of pore fluid and inversely proportional to viscosity of pore fluid.

- Shape of particles: permeability is inversely proportional to specific surface e.g. As angular soil have more specific surface area compared to the round soil therefore, the soil with angular particles is less permeable than soil of rounded particles.
- Structure of soil mass: for same void ratio the permeability is more for flocculent structure as compared to the dispended structure.
- Degree of saturation: the permeability of partially saturated soil is less than that of fully saturated soil.
- Adsorbed Water: adsorbed water means a thin microscopic film of water surrounding individual soil grains. This water is not free to move and hence reduces the effective pore space an thus decreases coefficient of permeability.
- Entrapped air and organic impurities: the organic impurities and entrapped air obstruct the flow and coefficient of permeability is reducing due to their presence.
- Temperature: as the viscosity of the pore fluid decrease with the temperature, permeability increases with temperature, as unit weight of pore fluid does not change much with change in temperature.
- Stratification of soil: stratified soils are those soils which are formed by layer upon layer of the earth or dust deposited on each other. If the flow is parallel to the layers of stratification, the permeability is max while the flow in perpendicular direction occurs with minimum permeability.

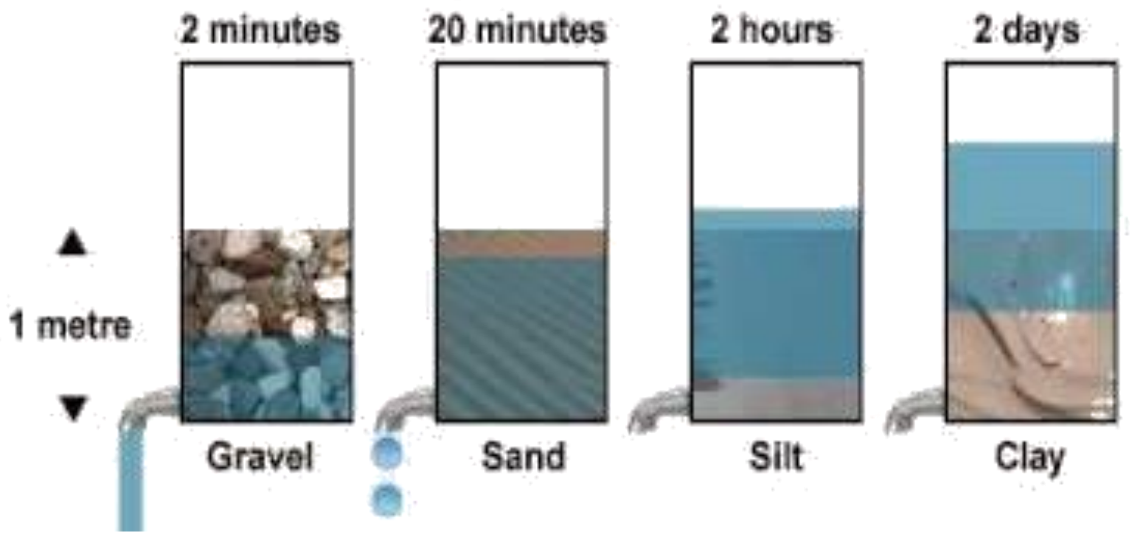


Fig. 6. Permeability of different soils

Permeability is measured in terms of permeability rate or coefficient of permeability (cm per hour, cm per day, cm per sec.).

There are two general types of permeability test methods that are routinely performed in the laboratory:

1) the constant head test method that is used for permeable soils ($k>10^{-4}$ cm/s);
2) the falling head test method that is mainly used for less permeable soils ($k<10^{-4}$ cm/s).

Test procedure of Standard Test Method for Permeability of Granular Soils (Constant Head):

1) Measure the initial mass of the pan along with the dry soil (**M_1**).
2) Remove the cap and upper chamber of the ***permeameter*** by unscrewing the knurled cap nuts and lifting them off the tie rods. Measure the inside diameter of upper and lower chambers. Calculate the average inside diameter of the permeameter (**D**).
3) Place one porous stone on the inner support ring in the base of the chamber then place a filter paper on top of the porous stone (*see Photo C*).
4) Using a scoop, pour the prepared soil into the lower chamber using a circular motion to fill it to a depth of 1.5 cm. A uniform layer should be formed.
5) Use the tamping device to compact the layer of soil. Use approximately ten rams of the tamper per layer and provide uniform coverage of the soil surface. Repeat the compaction procedure until the soil is within 2 cm. of the top of the lower chamber section (*see Photo D*).

6) Replace the upper chamber section, and don't forget the rubber gasket that goes between the chamber sections. Be careful not to disturb the soil that has already been compacted. Continue the placement operation until the level of the soil is about 2 cm below the rim of the upper chamber. Level the top surface of the soil and place a filter paper and then the upper porous stone on it (*see Photo E*).

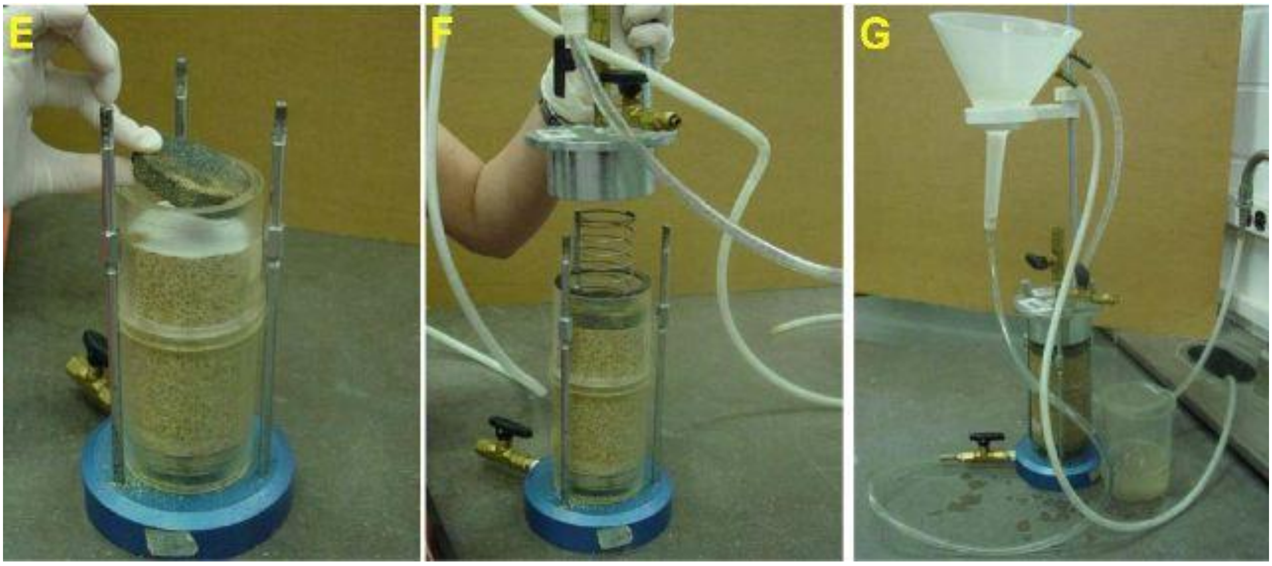
7) Place the compression spring on the porous stone and replace the chamber cap and its sealing gasket. Secure the cap firmly with the cap nuts (*see Photo F*).

8) Measure the sample length at four locations around the circumference of the permeameter and compute the average length **(L)**.

9) Keep the pan with remaining soil in the drying oven.

10) Adjust the level of the funnel to allow the constant water level in it to remain a few inches above the top of the soil.

11) Connect the flexible tube from the tail of the funnel to the bottom outlet of the permeameter and keep the valves on the top of the permeameter open (*see Photo G*).



12) Place tubing from the top outlet to the sink to collect any water that may come out (*see Photo G*).

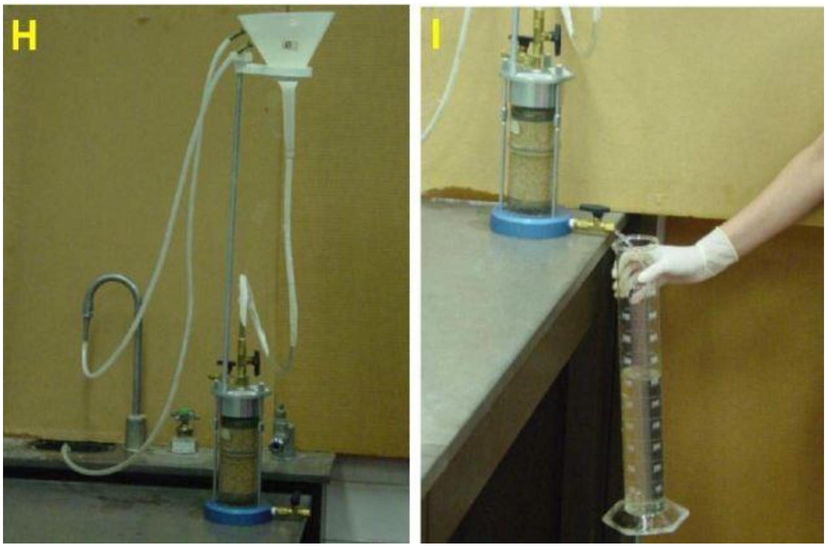
13) Open the bottom valve and allow the water to flow into the permeameter.

14) As soon as the water begins to flow out of the top control (de-airing) valve, close the control valve, letting water flow out of the outlet for some time.

15) Close the bottom outlet valve and disconnect the tubing at the bottom. Connect the funnel tubing to the top side port (*see Photo H*).

16) Open the bottom outlet valve and raise the funnel to a convenient height to get a reasonable steady flow of water.

17) Allow adequate time for the flow pattern to stabilize.



18) Measure the time it takes to fill a volume of 750 – 1000 ml using the graduated cylinder, and then measure the temperature of the water. Repeat this process three times and compute the average time (**t**), average volume (**Q**), and average temperature (**T**) (*see Photo I*).

19) Measure the vertical distance between the funnel head level and the chamber outflow level, and record the distance as **h**.

20) Repeat step 16 and 17 with different vertical distances.

21) Remove the pan from the drying oven and measure the final mass of the pan along with the dry soil (**M_2**).

22) Calculate the permeability, using the following equation:

$$K_T = \frac{Q \cdot L}{A \cdot t \cdot h}$$, where:

K_T = coefficient of permeability at temperature T, cm/sec.

L = length of specimen in centimeters

t = time for discharge in seconds

Q = volume of discharge in cm^3 (assume 1 mL = 1 cm^3)

A = cross-sectional area of permeameter (**A= [(π D^2)/4]** , D= inside diameter of the permeameter)

h = hydraulic head difference across length L, in cm of water; or it is equal to the vertical distance between the constant funnel head level and the chamber overflow level.

23) Standardize the coefficient of permeability at 20°C

The viscosity of the water changes with temperature: as temperature increases viscosity decreases and the permeability increases. The coefficient of permeability is standardized at 20°C, and the permeability at any temperature T is related to K20 by the following ratio:

$$K_{20} = K_T \frac{\eta_T}{\eta_{20}}$$, where:

η_T and **η_{20}** are the viscosities at the temperature T of the test and at 20°C, respectively.

Table 2 – Properties of Distilled Water (η = absolute)

Temperature (^0C)	Density (g/cm^3)	Viscosity (Poise*)	Temperature (^0C)	Density (g/cm^3)	Viscosity (Poise*)
4	1.00000	0.01567	**23**	0.99757	0.00936
16	0.99897	0.01111	**24**	0.99733	0.00914
17	0.99880	0.01083	**25**	0.99708	0.00894
18	0.99862	0.01056	**26**	0.99682	0.00874
19	0.99844	0.01030	**27**	0.99655	0.00855
20	0.99823	0.01005	**28**	0.99627	0.00836
21	0.99802	0.00981	**29**	0. 99598	0.00818
22	0.99780	0.00958	**30**	0. 99568	0.00801

***1 Poise = dyne*s/ cm^2 = 8/cm*s**

To compare different soil samples it is important to compute:

- the volume of soil used from: $\mathbf{V = LA}$;
- the mass of dry soil used in permeameter: $\mathbf{M = M_1\text{-}M_2}$;
- the dry density (ρ_d) of soil: $\boldsymbol{\rho_d} \mathbf{= M/V}$

In the field, it is possible to use the express method to test water permeability: 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^3). The period of absorption is timed by stopwatch. The result is compared with table 3.

Table 3 – Water permeability of the soil

Permiability	*Time of absorption, s**	*Type of soil*
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

Soils with sandy textures have large pore spaces that allow water to drain very quickly through the soil. Sandy soils are known to have high permeability, which results in high infiltration rates and good drainage. Clay textured soils have small pore spaces that cause water to drain slowly through the soil. Clay soils are known to have low permeability, which results in low infiltration rates and poor drainage.

Soil moisture is amount of water, which soil is capable to retain due to sorptive and capillar powers. The smaller is the pores size and the bigger is their total volume, i.

e. porosity, the bigger is the soil moisture. The finer is soil texture, the higher is its moisture.

The moisture being derived from the rainfall on one side, and the ground-water on the other, will vary with the amount of these. Some soils are practically impermeable to water, such as trap or metamorphic rocks, unweathered granite, hard limestone, and dense clay; while others, such as chalk, sand, sandstone, vegetable soils are permeable. Commonly the metamorphic rocks and hard limestones present fissures, which render them pervious.

Measurement of soil moisture is carried out by gravimetry after drying at a maximum temperature of 105°C. This increase in temperature maintained for a controlled period of time, is sufficiently high to eliminate “free” forms of water and sufficiently low not to cause a significant loss of organic matter and unstable salts by volatilization. The measuring procedure include the following activities:

- dry tared weighing bottles (50 × 30 mm borosilicate glass low) for 2 h at 105°C, let them cool in the desiccator and weigh the tare with the lid placed underneath ***(m_0)***
- place about 5 g of air-dried soil (fine earth sieved through a 2 mm mesh) in the tare box and note the new weight ***(m_1)***
- place the weighing bottles with their flat caps placed underneath in a ventilated drying oven for 4 h at 105°C (the air exit must be open and the drying oven should not be overloaded)
- cool in the desiccator and weigh: all the lids of the series contained in the desiccator should be closed to avoid moisture input **(m_2)**
- again place the opened weighing bottles in the drying oven for 1 h at 105°C and weigh under the same conditions; the weight should be constant; if not, continue drying the weighing bottles until their weight is constant.

$$\%\ \text{water content at } 105°\text{C} = 100 \times \frac{m_1 - m_2}{m_1 - m_0}$$

The results can also be expressed in pedological terms of ***water holding capacity (HC)*** by the soil:

$$HC = 100 \times \frac{m_1 - m_2}{m_2 - m_0}$$

The moisture in the soil varies in amount. Open gravel will absorb from 9 to 13 % by weight of water; gravelly surface soil 48 per cent.; light sandy soils from 23 to 36 %; loamy soil 43 %; stiff land and clay soils from 43.3 to 57.6 %.; sandy and peaty soils from 61.5 to 80 %; peat 103%.

Capillary rise is a well known unsaturated soil phenomenon that describes the movement of pore water from lower elevation to higher elevation driven by the hydraulic head gradient acting across the curved pore air/pore water interface. Capillary rise occurs when the adhesive intermolecular forces between a water and soil particles are stronger than the cohesive intermolecular forces between water molecules.

The height of the capillary rise depends primarily on the mechanical composition: the heavier and denser the soil, the thinner the capillaries and the higher the capillary rise, to a certain limit, but its speed is lower. In sandy soils, the capillary rise is usually less than 0.6 m, in loamy soils – 0.6-1 m, in light loamy – 1-1.5 m, in heavy loamy – 3-5 m. The higher the soil structure, the weaker the capillary properties of the soil. The higher the soil moisture, the greater the rate of water movement through the capillaries. The higher the temperature of the water, the lower the height of the capillary rise, because the surface tension decreases.

Three fundamental physical characteristics related to capillary rise are of primary practical concern: the maximum height of capillary rise, the fluid storage capacity of capillary rise, and the rate of capillary rise.

Testing the capillarity rise of soil:

1. Take a glass tube with a diameter of 2-3 cm and height of 15 cm. One end of tube is covered with filter paper and gauze.
2. Pour air-dry soil, passed through a sieve with holes of 2 mm, into the tube. The soil is compacted by gently tapping the bottom of the tube against the hand palm.

3. Immerse one end of the tube in a graduated cylinder with water to a depth of 5-10 mm.
2. Every 3-5 to 10 min measure the height of the capillary rise in the tube (**H**) for 30 min.
3. The speed of the capillary rise is calculated by the formula:

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

The temperature of the soil varies greatly with its geological character, as well as with the temperature of the atmosphere. The daily changes in the temperature of the atmosphere do not affect the soil beyond a depth of about three feet.

Although the average temperature of any soil depends on the climate, soils conduct heat in a very varying degree, and therefore absorb unequal quantities.

Schübler's experiments give the absorbing power of the chief kinds of soil, 100 being taken as the standard:

Sand, with some lime	100·0
Pure sand	95·6
Light clay	76·9
Gypsum	73·2
Heavy clay	71·1
Clayey earth	68·4
Pure clay	66·7
Fine chalk	61·8
Humus	49·0

It is evident from this table that sand is very retentive of heat, while clays and humus are very cold. Green vegetation lessens the absorbing power of the soil, and radiation of heat is more rapid, evaporation occurring constantly from the herbage.

Soil colour gives an indication of the various processes going-on in the soil as well as the type of minerals in the soil. For example the red colour in the soil is due to the abundance of iron oxide under oxidised conditions (well-drainage) in the soil; dark colour is generally due to the accumulation of highly decayed organic matter; yellow colour is due to hydrated iron oxides and hydroxide; black nodules are due to manganese oxides; mottling and gleying are associated with poor drainage and/or high water table. Abundant pale yellow mottles coupled with very low pH are indicative of possible acid sulphate soils.

To sum up, 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.

Table 4 – Properties of soil particle size

Properties	Sand	Silt	Clay
Porosity	mostly large pores	small pores predominate	small pores predominate
Permeability	rapid	low to moderate	slow
Water holding capacity	limited	medium	very large
Soil particle surface	small	medium	very large

4. Chemical properties of soil

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.

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.

The water contained in the soil is divided into moisture and ground or subsoil-water. When air is present in the soil as well as water, the soil is merely moist. Pettenkofer defines the ground-water as that condition in which all the interstices are filled with water, so that, except in so far as its particles are separated by solid portions of soil, there is a continuous sheet of water.

The moisture being derived from the rainfall on one side, and the ground-water on the other, will vary with the amount of these. Some soils are practically impermeable to water, such as trap or metamorphic rocks, unweathered granite, hard limestone, and dense clay; while others, such as chalk, sand, sandstone, vegetable soils are permeable. Commonly the metamorphic rocks and hard limestones present fissures, which render them pervious.

A sudden rising of ground-water expels the air in the soil, together possibly with particles which may comprise infectious material; it also washes similar impurities out of the subsoil, and carries them into neighbouring wells. Numerous epidemics have been traced to this source.

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. The air contained in the soil varies greatly in amount with the character of the soil, and with the level of the ground-water. As the ground-water rises, the ground-air is driven out. Thus, after a heavy rainfall a large proportion of this air will be displaced. Variations in barometric pressure, and a rise or fall of temperature, cause movements in ground-air.

The air in the soil is similar in composition to that in the atmosphere with the exception of oxygen, carbon dioxide, and water vapor. In soil air as in the atmosphere, nitrogen gas (dinitrogen) comprises about 78%. In the atmosphere, oxygen comprises about 21% and carbon dioxide comprises about 0.36%. However, in the soil air, oxygen usually is replaced by carbon dioxide, so both range from about 0.4% to 21%.Oxygen is used by plant roots and soil microbes during respiration, and carbon dioxide is released. Thus, in the soil, the oxygen levels are generally less than atmospheric levels and the carbon dioxide levels are generally greater than atmospheric levels. Some factors that determine the extent of the difference between atmospheric and soil air constituents include depth in the soil profile, soil pore size distribution, and soil water content

The amount of ground-air varies greatly. Loose sands often contain 40 to 50 %, soft sandstone 20 to 40 %, and loose surface-soil many times its own volume.

The nature of the air is not accurately known. 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. It is, however, extremely rich in carbonic acid, of which it contains from 1 to 10 % or even more. The carbonic acid is derived from the organic matter in the soil, by the action of bacteria, in a manner analogous to nitrification.

The soil consists of mineral and organic matters. 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 montmorilonite group (montmorilonite, 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 Mendeleyev'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.

The content of humus in mineral soils varies from as high as 10% or even more in the top layer of chernozem (the typically black soil that occurs in the American prairie and in the plains of Ukraine) down to nil in desert soils and is of the order of 1–3% in many intermediate soils. The humus content generally diminishes in depth through the B horizon and becomes negligible at the bottom of the normal root zone, unless the soil is a deposit of alluvial material with a high original content of humus. Organic soils such as peat and muck may contain well over 50% organic matter, though not all of that would fit the accepted definition of humus.

Soil organic matter comprises organic materials in various states of decomposition, such as tissues of living soil organisms, plant and animal residues, and excretions from plant roots and soil microbes.

On the amount and character of the animal and vegetable matters (along with the condition of moisture and aeration), the healthiness of a given soil depends. The presence of vegetable matter, subject to alternate wettings and dryings, and to heat, has until recently been regarded as the condition on which malaria depends; but it is now known that malarial places owe their character to their being favourable to the growth of the larvæ of certain mosquitoes; and that drainage of the soil cures malaria by removing the ponds in which these develop.

The two chief agencies at work to rid the soil of organic impurities are nitrification and the influence of growing plants. The organic matters become oxidised into ammonia, nitrites, and nitrates, and these are eagerly assimilated by vegetation.

Nitrification is effected by micro-organisms in the soil. Ordinary garden mould and agricultural humus contain large numbers of micro-organisms. Their number diminishes with the depth of the soil, and below 12 to 15 feet there are few. Apart from the occasional presence of pathogenic (disease-producing) micro-organisms, the most important are those producing oxidation of organic matter, especially nitrification. This occurs at a less depth than 4 feet from the surface of the ground. The operation of these micro-organisms is necessary to convert sewage and other impurities into harmless nitrites and nitrates, and it is regularly going on in all normal soils. That the power of purification of sewage by soil is due to the micro-organisms in the latter, can be proved by the fact that when the soil is baked, it loses for a time its purifying power.

So, the nitrogen cycle is the most complex processes are responsible for recycling the chemicals necessary for life on Earth.

Soil organic matter is a key indicator of soil health due to its influences on soil structure, aggregate stability, water storage and availability, water infiltration, nutrient storage and availability, soil biological activity, adsorption of metals and agrochemicals, and pH buffering and amelioration.

Soil pH is a measure of hydrogen ion (H^+) activity in a soil solution and indicates acidity or alkalinity of the soil. The soil pH scale ranges from 0 to 14, where a pH value of 7 is neutral, pH values above 7 are basic or alkaline, and pH values below 7 are acidic. Soil pH influences many physical, chemical, and biological processes in soil that control plant nutrient availability, cation exchange capacity (CEC), element toxicity, and agronomic yields. Availability of most macronutrients (nitrogen, potassium, calcium, magnesium, and sulfur) is optimal within a pH range of 6 to 7 and decreases outside this range. Typically, low soil pH (acidity) can lead to significant yield reductions due to nutrient deficiencies in crops. Soil acidity, particularly at pH levels below 5.5, increases solubility of aluminum and manganese in soils, causing toxicity to roots and thereby interfering with root growth and plant development.

The most important effect of pH in the soil is on ion solubility, which in turn affects microbial and plant growth. A pH range of 6.0 to 6.8 is ideal for most crops because it coincides with optimum solubility of the most important plant nutrients. Some minor elements (e.g., iron) and most heavy metals are more soluble at lower pH. This makes pH management important in controlling movement of heavy metals (and potential groundwater contamination) in soil.

Some chemical indicators of soil health

The examination the nitrogen content in soil includes the following steps:

1. Preparation of a water extract by Khlebnikoff's method.

Weigh 50-100 g of a freshly prepared soil and carry into 500-700 ml capacity flask which is immediately flow 250-500 ml of distilled water. The content is shaken for 3 min. Then 1 ml of 13% solution aluminium sulphate is added and the content is being shaken again during for 30 sec. If the solution hasn't bleached and suspension coagulation hasn't come about, 0.5ml of 7% solution of caustic potassium is added and the content of the flask is shaken again. If neither bleaching nor coagulation is observed at this stage, we add both aluminium sulphate and caustic potassium into mixture. After the extract has bleached it's filtered through a dense paper filter previously washed with water. The first portions of filtrate rejected. It's preferable to run the procedure over and over.

2. Ammonia identification techniques

Ammonia in combination with Nessler agent formed of iodine mercury ammonium – the solution of yellow colour (if the content of the ammonia is low) land if the content of the ammonia is high solution as has a reddish-brown colour.

Testing procedure:

1. 50 ml of the water extract is poured into a test tube. Then seignette's salt and Nessler agent solution are added, each in 1 ml portions. The contents is stirred. As a result the change in colour of the solution is marked.
2. Prepare the colour scale. The solution of chloride ammonium (in 1 ml - 1 mg NH_3) is used as a standard solution. 0.1; 0.3; 0.5; 1.0 and 2.0 ml of the solution of chloride ammonium are poured respectively into 5 colour test rubes. The rest of the volume of the tubes (as much as 50 ml) is filled with distilled water. The contents of the tubes are stirred carefully as soon as 1 ml of Nessler agent have been added.
3. Compare intensity of painting of a water extract of soil to painting of test tubes of a standard scale.
4. Calculation spend by the formula:

$$x = \frac{a \cdot 100}{y}$$, where

a **-** the amount of the ammonia in the colour scale test tube;

y **-** the volume of the soil (10 mg) under study, with allowance mode for dilution;

x **-** the amount of the ammonia in the soil (per l00 g of soil).

5. *Evaluate the soil purity.*

If the ammonia content is more than 50mg/100g, the soil is named severe contamination; 25 – 50 mg/100g - moderately clean, less tnan 25 mg/100 g - relatively clean.

The identification and determination of the salts of both nitric and nitrous acids, chlorides, hydrogen sulphides as well as oxidability follows the same order as in the base of the water analysis: nitrites are determined with the use of Griss agent; nitrates with disulphophenol agent; chlorides – by the titration with silver nitrate; hydrogen sulphide – in the course of the quantitative reaction with lead paper and, at last, oxidability – by the titration of the solution of potassium permanganate.

Humic content (organic fraction) is the decomposing part of the naturally occurring organic content of the soil. High humic content will act to bind the soil, decreasing the mobility of organics and decreasing the threat to ground water; however, high humic content can inhibit soil vapor extraction (SVE), steam extraction, soil washing, and soil flushing as a result of strong adsorption of the contaminant by the organic material. Reaction times for chemical dehalogenation processes can be increased by the presence of large amounts of humic materials. High organic content may also exert an excessive oxygen demand, adversely affecting bioremediation and chemical oxidation.

Total organic carbon (TOC) provides an indication of the total organic material present. It is often used as an indicator (but not a measure) of the amount of waste available for biodegradation. TOC includes the carbon both from naturally-occurring organic material and organic chemical contaminants; however, all of it competes in reduction/oxidation reactions leading to the need for larger amounts of chemical reagents than would be required by the contaminants alone.

Measurement of *volatile hydrocarbons, oxygen (O_2), and carbon dioxide (CO_2)* at sites containing biodegradable contaminants like petroleum hydrocarbons or sites with high TOC is useful in further delineating and confirming areas contaminated, as well as identifying the strong potential for bioremediation by bioventing. In addition, if the use of thermal combustion or certain oxidation systems is planned for off-gas treatment of extracted vapors, then adequate supply of air or oxygen will have to be provided to efficiently operate these systems.

Table 5 – Assessment of soil sanitary state according to chemical analysis of soil air

Soil sanitary state	*O_2 and CO_2 content in soil air. %*	
	O_2	CO_2
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

Biochemical oxygen demand (BOD) provides an estimate of the aerobic biological decomposition of the soil organics by measuring the oxygen consumption of the organic material that can be readily or eventually biodegraded. *Chemical oxygen demand (COD)* is a measure of the oxygen equivalent of the organic content in a sample that can be oxidized by a strong chemical oxidant such as dichromate or permanganate. Sometimes COD and BOD can be correlated, and the COD/BOD ratio can give another indication of biological treatability or treatability by chemical oxidation. COD is also useful in assessing the applicability of wet air oxidation.

5. 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.

III – completeness of presented material**s** 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.

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) 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).

The main epidemic safety indicators of soil are the following:

Khlebnikoff's sanitary number – 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-titter – is a minimal amount of soil in grammas, in which one bacteria of colibacillus group is found.

Soil anaerobe titter (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 37^0C during 24 hours.

Table 6 – Criteria of soil sanitary state

Group of indices	*Indices*
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-enthomological	Number of larvae and chrysalides of flies
Radiation safety indices	Soil activity
Soil natural purification indices	Titer and index of thermophile bacteria

Examination content of helminth eggs by the Vasilkovn's method. 5-10 g of soil is weighted from the sample taken with the use of the method outlined above. It is carefully comminute and poured into the sterile glosses which then are filled with 20ml of 5% solution of caustic potassium. Pound a sterile stick for the best determination of helminth eggs.

After upholding a mix within 1 hour surplus of alkali rack. To increase the rate of the detection of helminth eggs pour 20ml of the solution of sodium nitrate added into the mixture and again to stir it carefully.

The eggs which come to the surface, after I hour possess, are skimmed from the surface with a sterile metal loop (not fewer than 7-10 loops) and transferred into the microscopic slide, and then are examined in the microscopic at low magnification. The result of the investigation is the number of eggs and larvae having been found to occur in soil. The calculation is performed for a definite weight (1, 10, 100, 1000 g) of soil depending on the degree of contamination. According to the degree of contamination (per 100 g by weight) soil is conventionally classified into four groups:

1. Clean - helminth eggs are not found.
2. Slightly contaminated - 1-3 eggs found for each sample.
3. Moderately contamination - as much as 10 eggs found for each sample,
4. Severely contaminated - 10 and more eggs found for each sample.

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, level of soil contamination and stage of its danger for the population health is assessed.

Table – 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

VI – general conclusion about sanitary state of the 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, preventive measures of further deterioration of sanitary state of soil and ways of its improvement are offered.

6. Methods of land plot sanitary inspection and soil sampling

Sanitary inspection of the land plot includes:

- determination 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 (fig. 7) on rectangular or square areas of 10×20 meters or more.

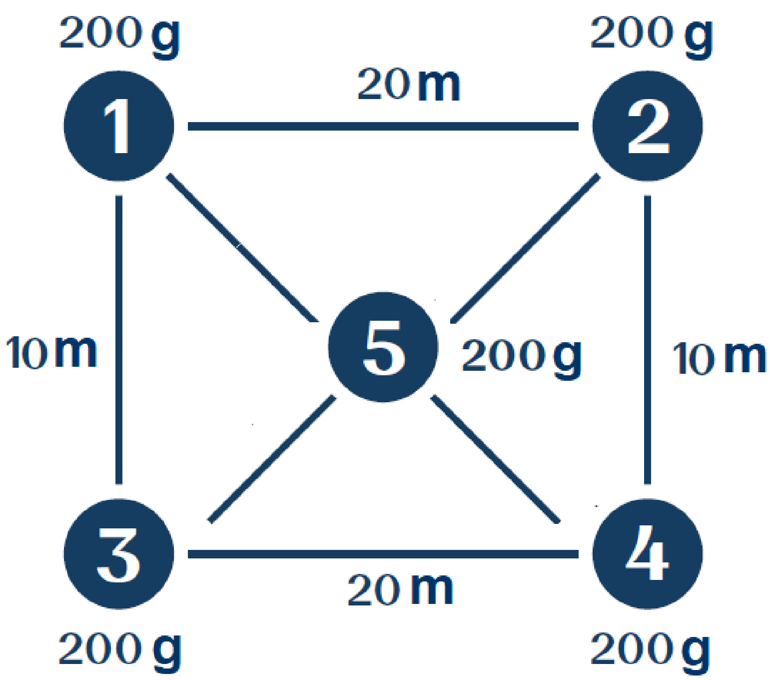


Fig. 7. “Envelope” technique of soil sampling

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^2	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.

The methods and procedures for obtaining soil samples vary according to the purpose of the sampling:

1. *Physico-chemical analysis.* Samples are taken in 3-5 points from the area of 25 m^2 at a depth of 0.25 m or if it's necessary of 0.75 and l.75-2 m. Samples are taken the aid of an auger or a spade are carefully stirred. An average sample by weight 1 kg is made by stirring the samples taken from this or that very level.
2. *Bacteriological analysis.* Samples are also taken in 3-5 points from the area of 25 m^2 at a depth depending on the soil character and occurrence of the layer. It is necessary to use sterile tools and sterile banks. The layers occurring at the depth not over 0.25 m are the most interesting.
3. *Helminthologic investigation*. Samples are taken from the surface layer and at a depth not over 2-3 cm. The reason is that the life-time of helminth eggs depends on the depth. Not a few then ten samples are taken bias from the every area of 50 m^2, each sample must be about 100 g by weight. An average sample 1 kg by weight is mode for separately.

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.

TEST QUESTIONS FOR SELF-CONTROL

1. Hygienic value of physical properties of soil:

A - affect the effectiveness of self-cleaning in the soil;

B - affect the chemical composition of atmospheric air;

C - affect the occurrence of epidemics;

D - play a role in the occurrence of geochemical endemics;

E - play a role in the emergence of endemic diseases.

2. The basic physical properties of the soil are:

A - capillarity, moisture capacity;

B - fertility, density;

C - oxidizability, solubility;

D - conductivity, capillarity;

E - stiffness, alkalinity.

3. The main types of soil, depending on the mechanical composition:

A - clay, loam, sandy loam;

B- sandy-quartz soils, shale, basalt;

C - alumina, gravel, granite;

D - silt-sandy, silty, quartz;

E - easily podzolic, peaty, gravel.

4. The porosity of the soil is:

A - the total volume of pores in the soil (in%), determined when the air is displaced by water;

B - the maximum number of pores when water is absorbed by the soil;

C - time, the passage of water through a layer of soil height of 20 cm;

D - the percentage of moisture in the soil in relation to absolutely dry soil;

E - the height of the water rise along the capillaries of the porous soil for a certain time.

5. The maximum moisture capacity of the soil is:

A - the greatest amount of water (in %) absorbed by the soil;

B - the percentage of moisture in the soil in relation to absolutely dry soil;

C - the maximum volume of pores in the soil (in %), when the air is displaced by water;

D - the maximum time, the passage of water through a layer of soil height of 20 cm;

E - maximum amount of water in the sample of soil 300g.

6. Soil moisture is:

A - the percentage of moisture in the soil in relation to absolutely dry soil;

B - the total volume of pores in the soil (in %), determined when the air is displaced by water;

C - time of water moistening of soil in a cylinder 20 cm high;

D - the maximum amount of water (in %) absorbed by the soil;

E - the height of the water rise on the capillaries of the soil for a certain time.

7. Water permeability of soil is:

A - the time of passage of water through a layer of soil 20 cm high;

B - the time of passage of water through a layer of soil 24 cm high;

C - the maximum amount of water absorbed by the soil;

D - the total volume of water that has passed through a layer of soil of 20 cm;

E - the height of the water rise on the capillaries of the soil for a certain time.

8. Capillarity of the soil is:

A - the height of the water rise on the capillaries of the soil for a certain time;

B - the maximum volume of water absorbed by the soil;

C - the volume of water that passed through the capillaries through a layer of soil of 20 cm;

D - the volume of water needed to wet 20 g of soil;

E - the time of passage of water through a layer of soil 24 cm high

9. The indicators of sanitary assessment of soil include:

A - sanitary-bacteriological, sanitary-helminthological, radiation;

B - sanitary-statistical, statistical, toxic-chemical;

C - sanitary-bacterioscopic, invasive, radiochemical;

D - sanitary-epidemic, sanitary-parasitological, sanitary-physical;

E - toxic-technological, physical, chemical.

10. The sanitary number of the soil is:

A - the ratio of humus nitrogen to all inorganic nitrogen;

B - the number of pathogenic microorganisms in 1 mg soil;

C - the minimum amount of soil in which at least 1 anaerobic clostridium is found;

D - the amount of E. coli in 1 mg of soil;

E - the ratio of soil humus to total organic soil nitrogen.

11. The indicator of the content of exogenous chemicals in the soil:

A - toxicological;

B - geochemical;

C - man-caused soil load;

D - entomological;

E - endemic.

12. According to the results of laboratory examination, the soil of the land plot of the hospital is assessed as contaminated. The sanitary number of Khlebnikoff was:

A - 0.70-0.86;

B - 0.98-1.00;

C - 0.86-0.97;

D - 0.60-0.69;

E - 0.50-0.59.

13. At laboratory examination of soil of the ground area which has been taken away for the building of hospital, it is established: coli-titre - 1; titre anaerobes – 0.1;

sanitary number of Khlebnikoff – 0.99; eggs helminthes are not present in 1 kg of soil; larvae and chrysalides of flies are not present on the area 0.25 m^2. To estimate degree of epidemic safety of soil:

A - safe;

B - extremely dangerous;

C - dangerous;

D - moderately safe;

E - relatively safe.

14. According to the laboratory monitoring of the sanitary condition of the soil, the soil is poorly contaminated in terms of sanitary indexes, the titre of E. coli is contaminated, and the titer of anaerobes (Cl. Perfringens) is slightly contaminated. This indicates:

A - receipt of fresh fecal contamination;

B - old fecal contamination;

C - insufficient intensity of humification processes in the soil;

D - constant intake of organic protein contamination;

E - insufficient insolation and aeration of the soil.

15. In the laboratory examination of the soil of the land plot allocated for the construction of the city dispensary, it was established: colitre - 0.01; the titer of anaerobes is 0.001; the sanitary number of Khlebnikoff is 0.86; eggs of helminths in 1 kg of soil - 100; larvae and pupae of flies on an area of 0.25 m^2 - 25. Degree of epidemic safety of soil:

A - dangerous;

B - low-risk;

C - safe;

D - moderately safe;

E - relatively safe.

Keys: option A is correct answers in all questions

SITUATIONAL TASK

To resolve the issue of the possibility of allocating a land plot for the hospital building in the city K., a sanitary survey was conducted and soil samples were taken.

The land plot with a total area of 5 hectares is located on the northern outskirts of the city. Previously, it belonged to the farm and was used for growing agricultural plants, and later as a pasture. In the last 2 years, the specified territory has moved to the city K. The topography of the area is calm, the groundwater level is 2.5 m. On the north side, the plot borders a forest strip that separates agricultural land, on the east – with a highway, on the south – with a city park. from the west – with residential buildings. Industrial enterprises are located at a distance of 1.5 km to the east of the land plot. The predominant wind is south-west. According to the data of the city hospital, no significant changes in the general morbidity of the adult population were observed during the last 10 years. The morbidity of children in the first year of life has slightly increased.

Soil samples were taken by the "envelope" method from 2 sampling sites each measuring 5x5 m^2 , which were laid out on the investigated plot of land and the area of the city park. Samples for chemical and bacteriological analyzes were taken in layers from a depth of 0-5 and 5-20 cm, for helminthological – 0-5 and 5-10 cm. Combined samples for chemical (weighing 1.5 kg) and helminthological (weighing 1.0 kg) examination were placed in paper bags, for bacteriological analysis – selected in compliance with the requirements of sterility and placed in sterile glasses. Sampling was carried out from 10:00 to 11:00. On the same day at 12:00 the samples were delivered to the laboratory.

Results of laboratory analysis				
	Tested area		***Control area***	
Depth of soil sampling	0 – 5 cm	5 – 20 cm	0 – 5 cm	5 – 20 cm
Indicators characterizing physical properties				
Physical clay content, %	15	17	20	18
Physical sand content, %	85	83	80	82
Indicators of pollution by exogenous chemical substances				

Lead (gross forms), mg/kg	30.0	27.0	28.0	26.0
HCG, mg/kg	0.04	0.05	0.03	0.04
DDT, mg/kg	0.1	0.08	0.08	0.09
Indicators of epidemic safety:				
Sanitary and chemical indicators				
Khlebnikoff's sanitary number	0.99	0.98	0.98	0.99
Chlorides, mg/100 g	57	53	54	51
Ammonium nitrogen, mg/100 g	3.7	3.5	3.4	3.5
Nitrite nitrogen, mg/100 g	0.2	0.1	0.1	0.2
Nitrate nitrogen, mg/100 g	1.9	1.7	1.8	1.6
Sanitary and microbiological indicators				
Coli titer	1.0	1.0	1.0	1.0
Titer of anaerobes	0.1	0.1	0.1	0.1
Sanitary and helminthological indicators				
The number of eggs of helminths in 1 kg of soil	0	0	0	0
Sanitary and entomological indicators				
The number of fly larvae and pupae per 0.25 m^2	0	0	0	0

MAC in soil (mg/kg): lead (gross form) – 30.0, hexachlorocyclohexane (HCCG) – 0.1, dichloro-diphenyl-trichloroethane (DDT) – 0.1.

It is necessary to assess the sanitary state of the soil of the land plot, to predict its possible impact on the public health, and to resolve the issue of the possibility of allocating the area for the hospital building.

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Електронне навчальне видання комбінованого використання
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Редька Ірина Василівна

МЕТОДИКА ГІГІЄНІЧНОЇ ОЦІНКИ ҐРУНТУ

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для здобувачів вищої медичної освіти 3-го року навчання
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(Англ. мовою)

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