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ТЕМА:
« HYGIENIC EVALUATION OF THE QUALITY OF DRINKING WATER AND WATER SUPPLY. METHODS OF WATER PURIFICATION (part 1,2)»

Methodical recommendations to the lesson
for students in the specialty 31.05.01 "General Medicine"

г. Волгоград, 2020 г.

Part 1
HYGIENIC EVALUATION OF THE QUALITY OF DRINKING WATER AND WATER SUPPLY

The motivational description of the theme

Water is one of the most important elements of the environment. Water is of great physiological significance as it is the main structural component of the human body.

Nearly 60 – 70% of the body of an adult is water. Pure water is used for washing, cleaning and cooking foods. Water is an important factor contributing to the formation of climate; it is rather essential for agriculture.

Hydrotherapeutic procedures and body conditioning increase the resistance of the human body to the effects of many unfavorable factors. Watching a smooth water surface or listening to rain sounds has a favorable psychotherapeutic effect on the human mind.

The requirements imposed on the quality of water used for drinking, cooking and physical exercise are its sound quality and safety. Thus, the doctor of any specialty should be able to make a hygienic assessment of the quality of water according to the results of laboratory tests.

The objective: to gain knowledge about influence of water quality on persons health; hygienic principles of set norms of water quality; learning how to make hygienic evaluation of the quality of water according to the results of laboratory analyses

Students' classroom activities

1. Case problems of two types.
2. Presentation and discussion of individual students' reports.

Self-study task

1. Physiological, hygienic, epidemiological significance of water.
2. Diseases associated with salinity or microelement composition of water.
3. Comparative estimation of the sources of water supply. Sources of surface and ground water contamination.
4. Hygienic requirements imposed on the quality of drinking water

Plan of students' independent activities

1. Case problem (type 1, type 2). The solution of case problems should be reported in writing.

Reference information

Term descriptions

QUALITY OF WATER – is a characteristic of the composition and properties of water which determine whether the water is fit for specific purposes.

CENTRALIZED WATER SUPPLY is the system which supplies the population with water through water supply systems.

NON-CENTRALIZED WATER SUPPLY is the system which supplies population with water using ground water supply sources to meet the needs of the population in drinking water and agricultural needs. The main source of a noncentralized water supply system is ground water which is obtained by means of special equipment (e.g. water bore wells and tubular wells).

1. Hygienic requirements and standards imposed on the quality of water from centralized water supply

Table 1

Microbiological and parasitological indicators

Indicator	Unit	Norm
Thermoduric coliform bacteria	Amount of bacteria in 100 ml of water	None
Common coliform bacteria	Amount of bacteria in 100 ml of water	None
Microbe value	Number of colony-forming bacteria in 1 ml	No more than 50
Cysts of lamblia	Number of cysts in 50 l of water	None

Table 2

General indicators and pollution rate

Indicator	Unit	Norm (no more than)	Hazard degree indicator	Degree of severity
General indicators				
Hydrogen (H)	PH	6-9	-	-
General mineralization	mg/l	1000 (1500)	-	-
General hardness of water	mole/l	7.0 (10)	-	-
Permanganate water oxidizability	mg/l	5.0	-	-
Inorganic substances				
Nitrates (NO3)	mg/l	45		3
Iron (Fe)	mg/l	0, 3 (1, 0)		3
Sulfates (So4)	mg/l	500		4
Chloride (Cl)	mg/l	350		4
Lead (Pb)	mg/l	0, 03		2
Fluoride (for climatic regions) 1-2 3	 mg/l mg/l	 1,5 1,2		 2

Table 3

Organoleptic properties

Indicator	Unit	Norm
Smell	Points	No more than 2
Taste	Points	No more than 2
Color	Degrees	No more than 20 (35)
Turbidity	mg/l	No more than 1, 5 (2)
Turbidity	mg/l (according to kaolin/china clay)	No more than 2

Table 4

Radiation safety

Hazardous factor	Unit	Norm	Indicator
General α-radioactivity	Bq/l	0, 1	Radiation
General β-radioactivity	Bq/l	1, 0	Radiation

Table 5

Hygienic requirements imposed on the quality of water in a non-centralized water supply system

Indicator	Unit	Norm
Smell	Points	No more than 2-3
Taste	Points	No more than 2-3
Colour	Degrees	No more than 30
Turbidity	mg/l	No more than 2
Nitrates (NO3)	mg/l	No more than 45
Number of colibacilli (coli-index)	Number of colibacilli in 1000 ml of water	No more than 10
Chemical substances	mg/l	No more than MPC (maximum permissible concentration)

1. **Requirements imposed on the location and design of non-centralized water supply systems.**

The location of a non-centralized water supply intake structures is of great significance as it helps preserve the favourable properties of drinking water and prevent it from contamination with bacterial and chemical contaminants.

Noncentralized water supply systems should be located far away from dangerous water contaminants and pollutants, such as landfills for toxic and radioactive substances, places of dumping sewage, burials of the dead, and no less than 50 m upstream the flow of a ground water reservoir.

2. Requirements imposed on the design of water bore wells.

1. Water bore wells are used for obtaining ground water from the closest to the surface free aguifer. The water wells are rounded or square shafts and they consist of three main parts: the aqueduct, the bore and the water-intake portion.
2. The aqueduct is used for preventing water contamination. It should be no less than 0.7 – 0. 8 m in height, above the ground.
3. The aqueduct should have a lid. It should be located under a shed or in a box.
4. There should be a clay retainer along the perimeter of the aqueduct which is made of plastic clay. It should be 2 m in depth and 1 m in width around the bore.
5. A waterproof covering around the water well should be built. It is the so-called "blind area" made of stone, break, concrete or plate asphalt with a radius of 2 m.
6. The water well should be enclosed and there should be a bench for buckets.
7. The bore should prevent water precipitation. For this purpose one should use manhole rings or stone, break or certain timber such as larch, alder-tree, elm-tree, oak, to make the water-intake portion. Fir-tree and pine-tree could be used for the above-water part.
8. Water is obtained from the water well with the help of various devices and mechanisms. The most common devices are hand and electrical pumps. If the pump is not available, one can use a lowering winch with a tub.

PART 2

METHODS OF WATER PURIFICATION

The motivational description of the theme

In their everyday life people use tap water whose quality is supervised by the government or ground water that meets the sanitary requirements. The permission for water use is issued by the Federal Service for Oversight of Consumer Protection and Welfare. In extreme situations like an earthquake or disasters at large industrial plants (chemistry plants or atomic power stations) special requirements are imposed on the organization of water supply to the population. In such cases water is a potential threat; within 3-5 days it can cause outbreaks of infectious diseases or acute poisoning. That is why doctors should master the methods of water purification, decontamination and improvement of its quality. They should educate the population about the hazards associated with unpurified and non-decontaminated water and recommend the means of water processing, and teach the technology of its improvement in extreme situations.

The objective: to develop practical skills for improving water quality, to learn about in-field water disinfection by chlorination.

Students' independent classroom activities

1. Case problems.
2. Laboratory work.
   2.1. Detection of active chlorine in chlorinated lime (%)
   2.2. Estimating chlorine requirement in river water.
   2.3. Detection of residual chlorine in tap drinking water.
   2. Students' oral presentations.

Self-study task

1. Areas of sanitary protection of water supply sources.
2. Methods of improving the quality of water.
3. Methods of water disinfection.
4. Organization of water supply in extreme conditions.

Plan of students' independent activities

1. Case problem. The solution of case problems should be reported in writing.
2. Laboratory work (Appendix).
2.1. Evaluating active chlorine content in chlorinated lime (1%).
2.2. Assessing chlorine requirement in river water.
2.3 Determining residual chlorine content in water (qualitative method).

Reference information

Term descriptions

AREA OF SANITARY CONTROL is a certain area, where specific regime is established which aims to protect centralized water supply and water-treating facilities from contamination.
WATER DISINFECTION is processing the water to remove pathogenic microorganisms.
RESIDUAL ACTIVE CHLORINE is an indicator that the chlorination process is complete. It arises as chlorine is bound by the substances and bacteria found in the water. It guarantees the effectiveness of water disinfection. It is an indirect indicator of water safety when there is a threat of an epidemic; it is necessary to prevent a secondary water contamination in the distribution network.
CHLORINE ABSORPTION OF WATER is the amount of chlorine that can oxidize organic and easily oxidized inorganic substances and disinfect bacteria in 1 L of water within 30 minutes. This value is established experimentally by trial chlorination.
CHLORINE REQUIREMENT OF WATER is the total amount of chlorine necessary to ensure chlorine saturation and the presence of residual active chlorine (0.3—0.5 mg/L).

The primary objective of sanitary control regimen is sanitary protection of water sources and water supply systems as well as the locations they are found in from contamination.
Sanitary control areas are organized as three belts:

1. The first belt (area of strict control) includes the location of water intake systems, water works sites and water supply canal. This is intended for protection of these sites from casual or intended contamination or damage.
2. The second and third belts (restricted area) include the territory used for prevention of contamination of water sources and waterworks as well as the territory they are located on. The second belt is intended for protection from microbial contamination, the third – from chemical contamination.

Factors determining the boundaries of sanitary control area belts:
- type of water source (above ground or underground)
- nature of contamination (microbial or chemical),
- extent of natural protection against surface contamination (for an underground water source).

First belt boundaries for an underground water source: at a distance of 30-50 m or more from the water intake structure; for an above-ground source (rivers, canals)): upstream – 200 m or more from the water intake structure, downstream –100 m or more from the water intake structure, along the adjacent bank –100 m or more.
Second and third belt boundaries are determined with hydrodynamic calculations.

Methods of water purification

General methods:

1.Water clearing & decolorization

- sedimentation

- filtration
- coagulation

2.Disinfection of water(eliminating the infectious agents like bacteria, viruses, etc.).

2.1 Chemical disinfection (Chemical processes for the removal of undesirable elements):

- Chlorination
- Ozonization
- Oligodynamic effect of silver

2.2 Physical non-reagent methods (Physical processes for the removal of undesirable elements):

- Boiling
- Ultraviolet irradiation
- Gamma irradiation (γ-irradiation)
- Water disinfection with ultrasound

Special мethods: (deironing, defluoridation, desalination, softening, fluoridation, mineralization)

Appendix

Laboratory control over water chlorination

1. Determining active chlorine content in chlorinated lime (1%).
2. Chlorination of river water with normal chlorine doses
3. Determination of residual chlorine in tap water.

Water chlorination is one of the main ways of water disinfection nowadays. Gaseous chlorine, chlorinated lime, chloramine, calcium and sodium hypochloride can be used for water chlorination. Chlorine is considered the best choice due to its ability to oxidize bacteria, organic and mineral substances dissolved and suspended in water.

The amount of chlorine which is necessary for oxidizing 1 litre of water containing organic, inorganic and bacterial substances impairing its physical properties within 30 minutes, is called chlorine absorption of water. Chlorine absorptivity of water can be easily established experimentally.

The combination of chlorine with chemical substances gives rise to residual active chlorine in water. It demonstrates that the process of water purification is over and chlorinated water does not contain any bacteria. Tap water should contain small amounts of residual active chlorine (0.3 – 0.5 mg/l) so that water chlorination could be considered an efficient means of water disinfection. Excessive chlorine residue above 0.5 mg/L makes the water unfit for drinking as it entails deterioration of organoleptic properties of water giving rise to an unpleasant taste and odor.

Residual chlorine content is used to control the efficiency of water disinfection. Small doses of chlorine in the amount equal to chlorine requirement of water should be added to water. Chlorine requirement for water is calculated as the sum of values of chlorine absorptivity and residual chlorine (0.3 – 0.5 mg/l).

1. Determination of active chlorine content in chlorinated lime

1% chlorinated lime is commonly used in water chlorination. Chlorinated lime is an unstable compound which releases chlorine so it is necessary to determine active chlorine content in advance.

Droplet technique is used for this purpose. 100 ml of distilled water should be poured into a glass or flask. As little as 0.4 ml of a 1% freshly prepared chlorinated lime, 1 ml of diluted chloric acid (1:5), 1 ml of 5% potassium iodide and 1 ml of 1% freshly prepared starch should be added to the distilled water. The mixture should be shaken thoroughly. Then, it should be titrated using a special drop pipette (i.e. 1 ml corresponds to 25 drops of liquid) and 0.7% sodium thiosulfate until the water is clear.

The percentage of active chlorine is equal to the number of drops of sodium thiosulfate used for titration.

2. Chlorination of river water.

2.1. Determining chlorine requirement of river water.

The disinfecting effect of chlorine-containing agents is due to the ability of chlorine to oxidize bacteria, organic and mineral substances dissolved or suspended in water. A portion of chlorine in this process is absorbed by the suspended substances, which determines the chlorine absorption of water. To ensure a reliable disinfection, we add an amount of chlorine equal to the chlorine absorption value, which is calculated as the sum of values of chlorine absorptivity and residual chlorine. Residual chlorine (the excess of active chlorine remaining in water after oxidation of the dissolved and suspended organic and inorganic substances and demise of microorganisms) in the amount of 0.3—0.5 mg/L does not impair the organoleptic properties of water indicating, at the same time, complete disinfection. However, the worse the contamination, the more active chlorine may be required, which means a greater chlorine requirement. An accurate definition of chlorine requirement prevents using excessive chlorine; it is known that an excess of chlorine above 0.5 mg/L makes the water unfit for drinking as its organoleptic properties are impaired, the water acquires an unpleasant taste and smell.

Chlorine requirement of water is defined by test chlorination of water in three vials. Portions of 0.2 L of water samples are poured into three glasses; 1% chlorinated lime solution is added with a pipette:

- 0.1 ml to the 1st glass (5 mg of chlorinated lime per 1 L of water);
- 0.2 ml to the 2nd glass (10 mg/L)
- 0.3 ml to the 3rd glass (15 mg/L)

The contents of each glass are stirred with a glass rod. The amount of residual chlorine is estimated in 30 minutes. For this purpose, 1 ml of 5% potassium iodide solution and 1 ml of 1% starch solution is added to each glass. In the samples where the water turned blue or pale blue, the amount of residual chlorine is determined by titration of 0.01 mol/L with sodium thiosulfate. Residual chlorine after chlorination is calculated according to the formula:

$$X = \underline{\quad A * K * 0.355 * 1000 \qquad}$$

A – amount of potassium thiosulfate used for titration, ml;
К – adjustment factor (0.95);
V– amount of water in the glass, ml.

2.2. Determining the required amount of dry chlorinated lime.

The amount of dry chlorine-containing agent necessary for chlorination of 1.0 L of river water is calculated on the basis of test chlorination.

Example: let us assume that blue coloration appeared in glass 2 where 2 drops of 0.7% sodium thiosulfate were used for titration to define residual chlorine. In this glass, 2 drops of 1% chlorinated lime were added to 200 ml of water. Hence, 2 by 5 +10 drops are required per 1 L of water or 0.4 ml of 1% chlorinated lime solution as 1 ml contains 25 drops. The amount of dry chlorinated lime contained in 0.4 ml of 1% chlorinated lime solution is a hundred times smaller (as it is a 1% solution) and amounts to 0.4/100 – 0.005 or 4 mg of dry chlorinated lime. That means that the dose of chlorine is 4 mg/L of chlorinated lime.

2.3. Determination of residual chlorine content in tap water (qualitative method).

Some water should be poured into a test-tube. The column of water should be 10 cm high (indicated on the tube). Before taking water for a laboratory analysis, it should be drained for some minutes. As little as 1 ml of 10% potassium iodide and 0.5 ml of 1% freshly prepared starch should be added to it. The mixture should be shaken thoroughly. The tube should be covered with a white sheet of paper and the active chlorine content should be determined.

The amount of residual chlorine is determined according to the colouring of the solution:

Very pale blue – 0.05 mg/L of residual chloride
Light blue – 0.1 mg/L of residual chlorine
Blue – 0.3 mg/L of residual chlorine
Dark blue – 0.5 mg/L of residual chlorine
Bluish-black (the bottom of the flask cannot be seen) – 1 mg/l and even more.