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DEPARTMENT OF GENERAL HYGIENE
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Drinking Water Quality improvement methods

educational and methodological guide for 3rd year students studying in the specialty "Medicine" (educational program partially implemented in English)

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Drinking Water Quality improvement methods: educational and methodological guide for 3rd year students studying in the specialty "Medicine" (educational program partially implemented in English)

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This training manual presents a modern classification of methods for improving the quality of drinking water, the basic scheme of their use, a comparative assessment of fast and slow filtration, chlorination and ozonation methods, their advantages and disadvantages, side effects, as well as a brief description and scope of special methods. At the end of the manual, a description of laboratory practical work on this topic is provided.

The manual contains situational tasks, test questions and self-control questions, and a list of recommended literature.

The training manual " Drinking Water Quality improvement methods "is prepared in the discipline" Hygiene "in accordance with the Federal state educational standard of higher professional education for students studying in the specialty" Medical care " (31.05.01), an educational program partially implemented in English.

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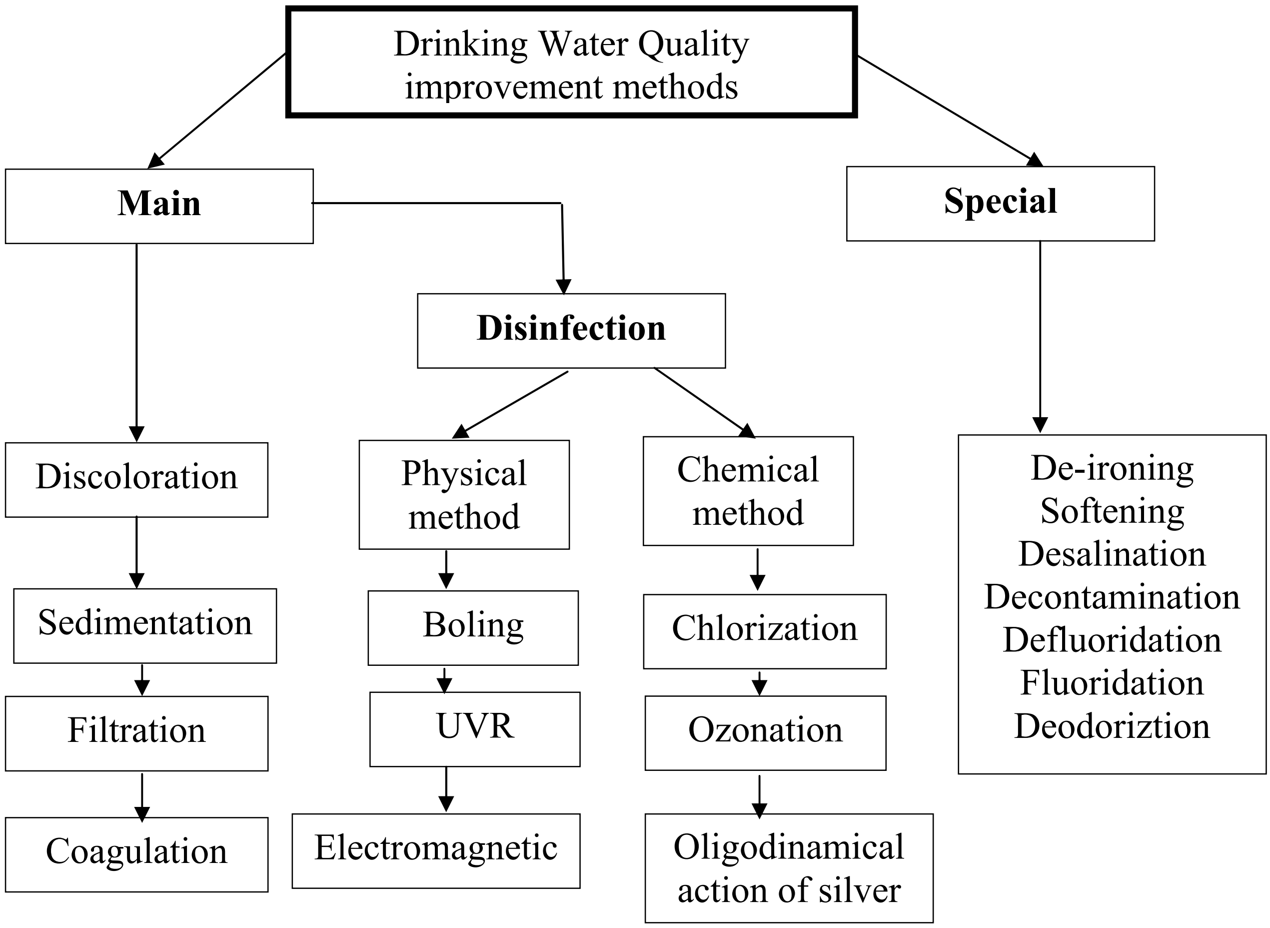
The main goal of these methods: Safety drinking water for health of the users. Water has to be treated before use and it must be confirmed to be official sanitary standard in the country.

Methods of improvement of water quality allow to exempt water from dangerous microorganisms, suspended particles, excess of salts, toxic and radioactive substances evil-smelling gases.

Methods of processing of water are subdivided into the main and additional. (special).

At the initial stage water purification from mechanical, including microscopic impurity is made. At the same time acceptable organoleptic properties are reached, water becomes somewhat colorless and deodorized. For the purpose of epidemic safety use various methods of disinfecting. If use of the main ways is not enough, use special.

Picture N1. Drinking Water Quality improvement methods



The basic scheme of water treatment

The basic scheme of water treatment includes the following steps:

1. Pretreatment. Pretreatment includes processes such as roughing filters, micro strainers, off-stream storage and bankside filtration. Pretreatment options may be compatible with variety of treatment processes ranging in complexity from simple disinfection to membrane processes. Pretreatment can reduce and/or stabilize the microbial, natural organic matter and particulate load.

2. Coagulation, flocculation, sedimentation (or flotation) remove colloids, suspended solids, and some macro-organisms, improve color and turbidity. This step has indirect impacts on the efficiency of the disinfection process.

3. Pre-ozonation kills microorganisms, removes odor and unpleasant taste, color, prevents the formation of by products in the subsequent disinfection.

4. Filtration removes remaining suspended solids, bacteria and organic compounds that can support the growth of biofilms (mucus). Various filtration processes are used in drinking-water treatment, including granular, slow sand, precoat and membrane (microfiltration, ultrafiltration, nanofiltration and reverse osmosis) filtration. With proper design and operation, filtration can act as a consistent and effective barrier for microbial pathogens and may be the only treatment barrier in some cases (e.g., for removing Cryptosporidium oocysts by direct filtration when chlorine is used as the sole disinfectant).

5. Disinfection kills microorganisms and reduces the possibility of formation of biofilms.

Methods of cleaning choose taking into account quality and character of a source of water supply.

Use of underground interbedded water sources for the centralized water supply has a number of advantages before use of superficial sources: security of water from external pollution, safety in the epidemiological relation, constancy of quality of water.

Usually underground waters do not need clarification, decolouration and disinfecting. The most important of these sources include the protection of water from external contamination.

Underground water sources use more often for settlements with small population. In villages use different types of wells more often (mine, tubular).

Water of open reservoirs is subject to pollution therefore all open water sources are potentially dangerous. Besides, this water often contains suspended matters from various chemical therefore it needs more careful cleaning and disinfecting.

Table N1. Class and methods of purification

Type of source	Class of the source	Quality of the water	Methods of purification
Undeground water	*1*	*Safety water without pollution*	*No need*
	2	*There are some signs higher than recommended standard*	*Aeration, Filtration and disinfecting*
	3	*The level of Most elements in the water higher than safety level*	*Aeration, sedimentation, Filtration, and disinfecting*
Surface water	*1*	*Low level of pollution by bacteris and organic elements*	*Filtration, with or without coagulation and disinfecting*
	2	*Meddle level of pollution*	*Coagulation, sedimentation, Filtration and disinfecting*
	3	*High level of pollution, need for complementary methods of purification*	*As in second class, plus complementary method of purification and more effective methods of disinfecting*

Purification of drinking water

Main objective of water purification – protection of the person against pathogenic organisms and contaminants that may be cause hazardous to his health.

Purification is done to make the water safe and to remove any trace of contamination that may give rise to disease.

The aim of water purification - completely to exempt it from a suspension (turbidity), to make transparent (to clarify) and reduce chromaticity.

The water supply system consists of constructions for a fence and improvement of quality of water, a tank for clear water, pumps and a water tower. The conduit and the parting network of the pipelines manufactured of steel or with a corrosion-resistant coating departs from it.

The first stage of water purification of an open water source is a clarification and decolouration. In the nature it is reached by long upholding. But the natural sediment proceeds slowly and efficiency of decolouration low. Therefore at waterworks apply the chemical treatment coagulants accelerating sedimentation of suspended particles.

The most effective is the method of sorption cleaning on absorbent carbon.

1. Plain sedimentation: it is a process of gravity settling and deposition of compatively heavy suspended material in water. Period ranging from hours to few days.

Upholding. Water is pumped in horizontal or vertical settlers. In horizontal settlers the speed of the movement of water of 2-4 mm/s, in vertical - 1 mm/sec., passing time through a settler of 4-8 hours. To accelerate and increase efficiency of loss of a suspension and removal of colloid substances in settlers, before upholding coagulation is made.

2. Coagulation: it is the process of forming flocculent in raw water by the addition of chemical coagulant as aluminum surfaces. The processes of coagulation takes place in the three successive tanks:

- flash Mixing tank where coagulant is added
- flocculation tank

- the setting tank, period: 1-3 hours.

As coagulants apply surface aluminum - $Al_2(SO_4)_3$; chloric iron – $FeCl_3$; sulfate iron – $FeSO_4$, etc. coagulant solution addition to water there is its interaction to bicarbonate salts of Sa and Mg with formation of flakes. Flakes of a coagulant possess a huge active surface and positive electric charge. They adsorb a suspension of microorganisms and colloid substances which are fond on a settler bottom. It leads to effective clarification of water and promotes its decolouration.

Coagulation of water improves at addition of the flocculants promoting fast formation of large flakes. Treat high-molecular flocculants the activated silicon acid, alkaline starch, sodium alginate, polyacrylamide.

The working dose of a coagulant is established by practical consideration. The coagulant is brought in water in the special *cameras of reaction* located before settlers. Dissolution of a coagulant and process of flocculation lasts 20-45 minutes. Speed of the movement of water - 0,2-0,6 m/s. The "ripened" solution moves in settlers where large flakes settle and clarify water.

3. Filtration: is the process of removing suspended matter from water, the result of the filtration depends on the characters and size of the filter media, the thickness of the bed, and the size and quantity of the suspended solids (the Filter beds are made of fine sand and gravel). Types of filters. Slow sand filters. The size of sand particles in filter is 1-2 mm, the speed of water: 0,3 – 0,5 m3/h, efficiency: 99%.

The slow filter well purifies water only after maturing: in an upper layer of sand there are biological processes – reproduction of microorganisms, aquatic organisms, flagellates, their death, a mineralization of organic matters and formation of a biological film to very small time capable to detain even the most fine particles, eggs of helmints and to 99% bacteria. It remove the bacteria better than offers filters because of zoogleal layer, which formed on the surface of the filter.

Slow-acting filters apply on small water supply systems to water supply in rural areas (villages and settlements of city type)/ Time in 30-60 days a blanket of the contained sand is removed together with a biological film.

Shortcomings: small productivity, large volume of constructions. Slow filters are used on small, is more often than rural water supply systems.

Rapid sand filters: are used for sity water supply. Their productivity is 50 times higher, however ability to detain a bacterium – is 4% lower. Speed of water: 5-7 m^3/h, efficiency 85%. It is less efficient than slow sand filter, after filtration water need disinfection.

Double filters: Speed of water: 15 m3/h, efficiency 75%, usually used in the cities. After double filters, water need for disinfection.

Constraction of the filter

Filter is reservoir from cement or brick, with drainage on the bottom for water after filtration. In the bottom of the filter, there is bed from gravel, thickness of this layer about 0,7 v, as a filter usually used a layer of sand on the bed, the size of sand 0,25-0,5 mm, and it is thickness about 1 m in slow sand filter, and about 0,8 m in rapid filter.

Every times filters cleaned by reverse flow of water, the speed of water, 5 times higher than the speed of water at the time of filtration. The time of cleaning, about 10-15 min.

Water disinfecting

Disinfecting has to be the final stage of processing of water on a water supply system from a superficial.

A problem of disinfecting – destruction of pathogenic microorganisms, i.e. ensuring epidemic safety of water. The effect of disinfecting depends on biological microbes, their stability, from activity and time of action, quality of the water.

Disinfecting of water can be carried out by chemical and physical (reagentless) methods.

Application of an adequate level of disinfection is an essential for most treatment systems to achieve the necessary level of microbial risk reduction. Taking account of the level of microbial inactivation required for the more resistant microbial pathogens through the application of the C-T concept (product of disinfectant concentration and contact time) for a particular pH and temperature ensures that other more sensitive microbes are also effectively controlled.

Where disinfection is used, measures to minimize disinfection by-products formation should be taken into consideration.

The most commonly used disinfection process is chlorination. Ozonation, UV radiation, chloramination and application of chlorine dioxide are also used. These methods are very effective in killing bacteria and can be reasonably effective in inactivating viruses (depending on type) and many protozoa, Including Giardia and Cryptosporidium. For effective removal or inactivation of protozoal cysts and oocysts, filtration with the aid of coagulation/flocculation (to reduce particles and turbidity) followed by disinfection (by one or a combination of disinfectants) is the most practical method.

6. Secondary filtration removes remaining of disinfection by-products.

Disinfection of drinking water

Physical method's:

The most important after treatment process, to destroy all pathogenic bacteria or other harmful organisms present in the drinking water is disinfecting.

Boiling, uviolizing, influence by ultrasonic waves, currents of high frequency, gamma-rays, etc. belong to physical methods.

Advantage of physical methods of disinfecting before chemical consists that they do not change chemical composition of water, do not worsen its organoleptic properties.

UV-rays (200 – 275 nm): with high bactericidal effect, UV-rays, cause disruption (violate) the intercellular metabolism and death of bacteria.

We get a good result, specially after coagulation and filtration the water.

Ultrasonic fluctuations promote mechanical destruction of bacteria in the ultrasonic field.

Ultra-sound: with high bactericidal effect all types of microorganisms and spores but its action depend upon the level of the waters turbidity. This method may used for sewages disinfection.

Ionizing radiation. Gamma radiation possesses the expressed bactericidal action. The dose 25 000 - 50 000 P causes death, practically of all species of microorganisms, and the dose 100 000 P exempts water from viruses.

Thermal ways of disinfecting: open flame (high-temperature plasma), hot air, superheated steam, boiling. Boiling is used for disinfecting of individual or group reserves of drinking water in house conditions, on autonomous objects and transport, at a difficult epidemiological situation.

Boiling: It is a simple and safe, method, the vegetative bacteria dead in 80 C (temperature of the wa.er) after 20 - 40 s. In boiling water (100'C) all types of bacteria dead after 3-5 min.

Ultraviolet radiation the most effective and widespread way of physical disinfecting. Method advantages: speed of action, efficiency of influence not only on vegetative, but also on sporous forms of bacteria, eggs of helminths and viruses.

a) UV-rays: short specter (280-200 nm), has a bactericidal action against the cell of microorganisms, causing disturbance of metabolism in the cell and its death. Ultraviolet rays have a bactericidal effect. The maximum effective area of the ultraviolet part of the optical spectrum within the wavelength range from 200 to 270 nm. The maximum bactericidal action falls on rays with the wave length of 260 nm. The mechanism of antibacterial action of ultraviolet irradiation now explain the breathes in enzyme systems bacterial cells, causing violation of microstructure and cell metabolism, leading to cells death. Dynamics of dying microflora depends on the dose and the original contents of microorganisms. On the efficiency of disinfection is influenced by the degree of turbidity, chromaticity of water and salt composition.

The Ultraviolet Water Disinfection System

Ultraviolet light in the wavelength range 240 to 280 nm has been known to germicidal for almost a century. The germicidal effect occurs because the UV light causes severe damage to the DMA of the micro-organisms. The germicidal effect is most potent at a wavelength of 260 nm. Since a low-pressure mercury arc (same at that used inside ordinary household fluorescent lamps) puts out 95% of its energy 254 nm, it can provide an extremely effective germicidal effect. UV dose is measured in microwatt seconds of UV energy (at or close to 260 nm) per cm^2 of water surface.

b) The dose to inactivate 90% of E. coli is 3000 W/cm^2. Other pathogenic bacteria and viruses have doses of similar magnitude (rotavirus at 8000 W/cm^2 is the highest among these). On the other hand, UV doses of very much larger magnitudes at needed to inactivate the cysts of protozoa, such as Giardia and Cryptosporidium. UV is not a treatment of choice for removal of cysts. Appropriate filtration or sedimentation can remove these larger pathogens and also reduce turbidity (which improves UV transmittance and reduces shielding of microbial pathogens by particulate matter) before UV treatment.

In contrast to many of the chemical disinfectants, UV disinfection imparts no taste d odor to the water, and presents no risks from overdosing or formation of carcinogenic disinfection by-products.

The very high sensitivity of DMA to UV light allows very short treatment time for the water. In contrast to chlorine (which requires contact times of 30-60 minutes), disinfects water in a few seconds.

Most UV system designs comprise a linear UV lamp, enclosed within a cylindrical coaxial UV-transparent sleeve (made of quartz or teflon), submerged in water in the UV-exposure chamber. Water flows axially on the outside of the sleeve and receive; the UV dose.

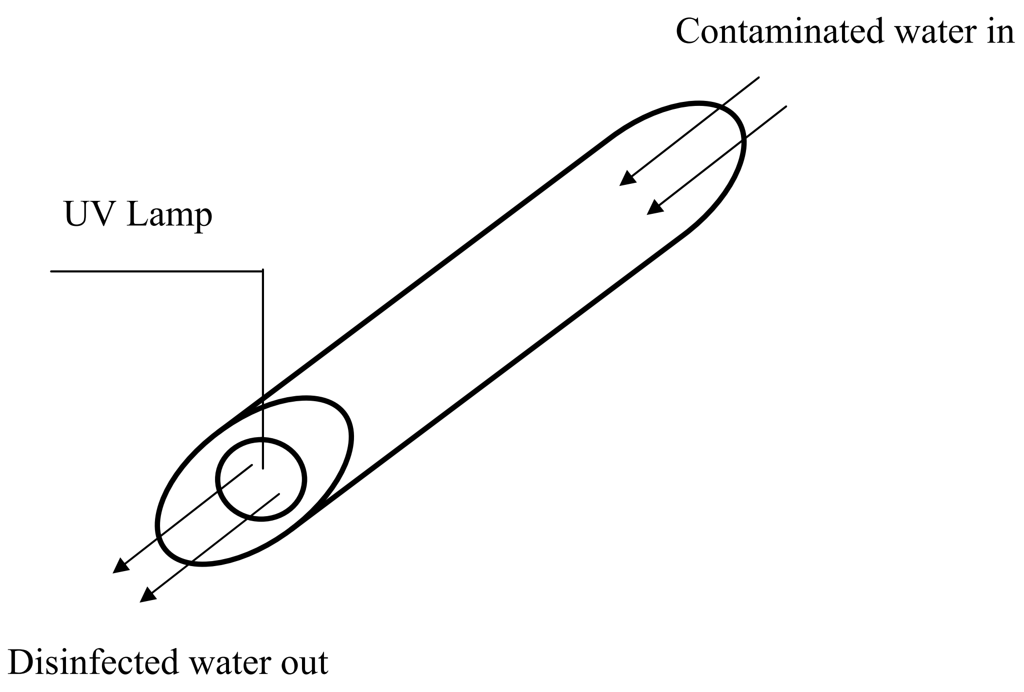
The glass tubes of the fluorescent lamps that light our offices, and sometimes homes, are coated with a phosphor that absorbs ultraviolet light and gives off visible light. The lamp that is used in the UV disinfection system is similar to a standard fluorescent lamp, but the lamp tube is not coated with phosphor and is made of a special glass that is transparent to UV light. This "germicidal" variety of lamp is already manufactured by many large companies that make standard fluorescent lamps. Conseqently, lamps, ballasts, and starters for the UV disinfection system can be bought “off the shelf”, with the full benefits of mature volume production.

Before contaminated water enters the UV, disinfection chamber, the water must be filtered to reduce turbidity. If water is pumped into the chamber directly from a ground water source (e.g., a shallow tube well), filtering is often unnecessary because the turbidity of ground water is low. The turbidity in surface water can be reduced by using an appropriate sand filter.

In the disinfection chamber, water is disinfected by exposure to UV light. In the present design, the UV chamber is constructed from sheet metal and contains a UV lamp under a reflector. A shallow' stream of water flows under the UV lamp through channels in a metal tray.

The figure shows a 36-inch (91 cm) long, 1-inch (2,5 cm) diameter, 36-watt UV lamp located under a curved aluminum reflector. The water depth is 12,5 cm (about 4 inches). At the rated flow of 30 liters per minute through the UV device, the energy density of the UV light shining on the water is 20 mW - more than enough to kill 99% of the waterborne pathogens. The chamber has an electrical interlock so that the lamp cannot operate unless the lid to the chamber is shut tightly. The interlock system eliminates the risk to system operators of exposure to the harmful UV light. From the disinfection chamber, the water is delivered through a spigot to the user or can be channeled into a small storage tank for potable water. Gravity is used to move water through the system. Consuming a total of 40 watts, the system disinfects approximately 30 liters of water per minute.

Picture N2. UV Lamp



Chemical methods

Chlorinazation:

Ozonization (O_3) - gas with specific odour, in water ozone formed H_2O and OH will high oxidation power (Bactericidal).

Oligadynamic silver (silveration): With high Bactericidal effect (for individual using).

Refer chlorination and ozonization to chemical methods of disinfecting of water.

Now on treatment facilities of water supply systems the basic is the chlorination method. The increasing implementation receives an ozonization method, including in a combination with chlorination.

Chlorinization is the most common method, which easy to control, and low cost in addition to its effectiveness.

Chlorination is characterized wide antimicrobic action concerning vegetative forms of microorganisms, profitability, simplicity of technology, a possibility of operating control behind disinfecting process.

So, chlorination is a cheap and reliable method of disinfecting of water.

Chlorine for disinfecting can be entered or before a settler, or at once into the filtered water. A water processing time at waterworks from 3 to 6 hours.

The principle of chlorination is based on water processing by the chlorine or chemical compounds containing chlorine in the active form possessing oxidizing and bactericidal action.

At addition of chlorine to water there is its hydrolysis, i.e. arc formed hydrochloric and hypochlorous acid. The mechanism of bactericidal effect of chlorine is connected with hypochlorous acid. Hypochlorous acid quickly passes through a cover of a bacterial cell and influences cellular enzymes (SH groups) important for a metabolism and processes of reproduction of a cell. Chlorine destroys enzymes of a respiratory chain of bacteria – dehydrogenases blocking SH groups.

Use chlorine-containing reagents: chloroarnines, calcium hypochlorites and sodium, chloric lime, gaseous chlorine, chlorine dioxide. Most often at waterworks use gaseous chlorine.

On large water supply systems apply the gaseous chlorine arriving in steel cylinders or tanks in the liquefied look to chlorination.

Types of chlorine

1. Plain chlorine (under pressure gas).
2. Chloramine: ammonia may be added to react with chlorine, forming a new oxidizing agent named chloramine, it is more effective in controlling taste and odour, more effective in control of organic matter, more stable during long periods of time.
3. Bleaching powder: 25% or 36% of active chlorine (it is loose and unstable compound), mainly used for water sterilization, in the same time, as powder it is prinkled over latrines and drains, especially in rural areas.
4. Tablet as. Aquasepte and Panthocide.

The efficiency of disinfecting power of chlorine demand depend on:

- pH of water (high PH of the water decrease the action of chlorine in water)
- Temperature of water (time of reaction in summer 30 min In winter 60 min)
- Level of turbidity (more turbidity, less action)

Methods of chlorinization

Chlorination helps in killing pathogenic bacteria, as salmonella and shigella, but has weak effect on spores, virus, and helmenthic ova.

a) Normal chlorinization (usual chlorination – chlorination by normal doses of chlorine 1-5 mg/l).

Chlorine Dose: It is the amount of chlorine added to cover all purposes of water.

Chlorine absorptivity of water – amount of chlorine which at chlorination of 1 L of water is spent for oxidation of the organic, easily oxidized inorganic matters and disinfecting of bacteria within 30 minutes.

Chlorine requirement of waters – the total quantity of chlorine necessary amount of residual chlorine.

Residual chlorine: is the amount of free chlorine remained from the chlorine dose afte) covering the chlorine demand (0,3-0,5 mg/1) for one hour. The disinfecting action oi chlorine due to hypochlorous acid, which effect the cells protoplasm of the bacteria.

Control definitions of residual chlorine in water are made each 30-60 minutes. In large water supply systems automatic control is carried out. Once a day the bacteriological research is conducted.

b) Chlorination with a preammonization.
c) Hyperchlorinazation: more than 10 mg/l (time 10-15 min), the high dosage is used in following situations: (unknown source of water and in epidemic situation).

Dechlorination: This method usually used when the residual chlorine more than 0,6 mg/l (After Hyperchlorinazation) which is not allowed for domestic use, this is accomplished by use of sulfur dioxide and sodium thiosulfate, or activated carbon filters.

Side effects of high doses of chlorine:

- disfunction of intestinal tract;
- change of taste and odour of water;
- irritation of the mucus membrane.

Chlorination short comings. Chlorine and its drugs are toxic connections, work with them demands strict observance of safety measures. Chlorine affects, generally vegetative forms of microorganisms. Gram-positive forms of bacteria are steadier against its action, than gram-negative. After chlorination in water halogen containing connections can be formed. Their sources are the humic acids derivative of phenol, aniline, products of metabolism of seaweed. Accumulation in the GCC drinking water is hazardous to health of the population in connection with their biological activity. GCC have the expressed all-toxic properties, give the remote effects - embriotohic, mutagen, cancerogenic.

Most of the physical and chemical methods are better than chlorinating, because they don't change the physical quality (taste and the odour) of drinking water.

Other reagent ways of disinfecting of drinking water (use of peroxide of hydrogen oligodynamic effect of silver and copper, iodine drugs) did not find broad application and are used for processing of an individual or small group deposit of moisture on navy, spaceships, in field conditions and extreme situations.

Oligodynamic effect of silver is used for disinfecting of preferential individual deposit of moisture. Silver possesses the expressed bacteriostatic action. Even at introduction to water of insignificant quantity of ions microorganisms stop reproduction. The concentration of silver capable to cause death of the majority of microorganisms, at the long use and waters are toxic also for the person. Therefore silver, is generally applied to conservation of water at long storage of water in swimming, in astronautics, etc.

The tableted forms containing chlorine are applied to disinfecting of an individual deposit of moisture.

Ozonation

Now the method of ozonization of water is one of the most perspective and already finds application in many countries of the world - France, the USA.

Ozone is currently the next most widely used drinking water disinfectant after chlorine (there are some 1100 water treatment plants using ozone worldwide), its use is almost exclusively limited to the industrial countries with high-integrity piped water networks.

Ozone (03) - gas of pale violet color with a characteristic smell.

Ozone is produced electrically by passing oxygen from ambient air between electrodes with a high voltages (tens of thousands of volts) applied across them. Care is needed in operating and maintaining the generators, and in destroying excess ozone so it is not released into ambient air.

Ozone (O_3) is a potent oxidant since it readily decomposes into oxygen and nascent oxygen atom. At decomposition of ozone in water as intermediate products short-lived free radicals are formed. Elemental oxygen and free radicals, being strong oxidizers, cause bactericidal properties of ozone.

Strong oxidizing properties provide the expressed bactericidal effect of ozone. Ozonization is deprived of the shortcomings inherent in chlorination.

The disinfecting effect of ozone by 15-20 times, and on sporous forms of bacteria is 300-600 times stronger than effect of chlorine. Ozone is highly effective at destruction in water of pathogenic protozoa.

Indicator of efficiency of ozonization is residual ozone at the level of 0,1-0,3 mg/1.

Success of ozonization depends on change of temperature, pH, organoleptic properties of water a little;

at ozonization mineral composition, pH of water do not change;

excess of ozone, unlike chlorine, does not denature water, ozone in large numbers in water is non-toxical since within several seconds it turns into oxygen;

Along with bactericidal effect of ozone in processing of water there is a decolouration and elimination of smacks and smells.

Ozone is used not only for disinfecting, but also for deodorization of drinking water, removal of toxic organic matters.

Advantages of ozonization:

- ozone works quicker than chlorine, reliable disinfecting is reached in several minutes;
- ozone has no taste and a smell in itself, at connection with the substances which are contained in water;
- in addition to disinfecting, ozone decolours water, eliminates smells and smacks ozone does not form in water of toxic connections (organochiorine compounds, dioxine, chlorphenols, etc.), improves organoleptic indicators of water and provides bactericidal effect at smaller time of contact - up to 10 minutes. It is more effective in relation to pathogenic protozoa - a dysenteric amoeba, lyambliya, etc.

Ozonization shortcomings. Ozone is explosive and toxic reagent. When processing water collateral toxic products can be formed by ozone: bromates, aldehydes, ketones, carboxylic acids, etc. connections. These products can cause mutagen, etc. adverse effects.

Ozone does not provide residual protection against recontamination in the distribution system. Therefore, its common use is to pre-treat the water source before chlorination in a municipal system.

Quick decomposition in the fulfilled water (in 20-30 minutes) limits its use, after ozonization significant growth in microflora owing to reactivation of bacteria and secondary pollution is quite often observed. Even high doses of ozone and long exposure do not provide completely effective disinfecting concerning bacterial spores.

So that a smaller chlorine dose is required. Although ozonation can effectively disinfect water, it is more expensive way in comparison with chlorination.

The combine chemical ways: use of chlorine and ozone, chlorine drugs with hydrogen peroxide, ions of silver and copper, hydrogen peroxide with ozone, some other combinations.

The combined physical ways: combination of ultraviolet radiation and ultrasonic fluctuation and heat treatment to ultrasonic fluctuation or gamma radiation, complex of electric influences.

Now the possibility of use of the pulse electric discharges for disinfecting of drinking water (so-called "electrohydraulic effect") is considered.

Physical and chemical ways: ultraviolet radiation combination to ions of silver and copper, ultraviolet radiation to chlorine and peroxide of hydrogen, ultrasonic fluctuation and chlorine. The high antimicrobic effect existence of an after-effect are characteristic of them.

The special methods of water treatment.

If it needs, the special methods of water treatment are used to improve indicators that do not correspond to the water quality requirements (Table 2).

Table 2. The special methods of water treatment

Method of water treatment	Method assignment.
Deferrization (deironing)	Decrease iron concentration in water
Defluorination	Decrease fluorides concentration.in water
Desalination	Decrease the mineral composition concentration in water (decrease the total mineralization, sulfates, chlorides,
Softening	Decrease the water hardness
Deodorization	Elimination of unpleasant odors
Deactivation	Decrease of water radioactiveness

Degasification	Remove of toxic gases, include chemical warfare gas
Adding .of salts	Organoleptic properties improving, increasing the content of trace elements
Fluorination	Increase fluorine concentration in water

- Deodorization - elimination of smells. It is reached by aeration, processing by oxidizers.

Deferrization — at the increased content in iron water (more than 0,3 mg/l).

Water softening is carried out at high hardness of water (more than 7 mg/l).

Desalting - the thermal method of desalting distillation, evaporation with the subsequent condensation. Winterizing. Electrodialysis desalting with use of the selection membranes

Decontajminationt (deactivation) — decrease in content of radioactive materials in water.

Defluoridation – carry out by filtering.

Fluoridation - artificial addition of fluorine carry out at the content in water less than 0,7 mg/1 for the purpose of prevention of caries of teeth.

From additional methods softening, deferrization, fluoration are necessary.

Practical work

Definition of a necessary dose of a coagulant

The working dose of a coagulant depends on water temperature, pH. a turbidity coloring, the size oi removable rigidity. The more rigidity, the more is required a coagulant. However at surplus of a coagulant a part it remains native water becomes muddy, develops an acid taste. In very soft water coagulation proceeds badly since there is no sufficient formation of the flakes of hydroxide of aluminum settling on a bottom. In such cases add hydropotassium carbonate or lime to water to increase removable rigidity and to provide flocculation.

Definition course:

In three glasses pour 200 ml of the contaminated water. In the first glass flow 2 ml of 1 % of solution of sulfate aluminum, in the second - 3 ml, in the third - 4 ml.

Contents of glasses are mixed a glass stick within 1-1.5 minutes and left for 20-30 minutes, watching the coagulation course. For calculation choose togas a glass where reaction is expressed better at the smallest quantity of a coagulant. If coagulation proceeds inertly, with insignificant formation of small flakes, water alkalinize by addition in each glass 1% of solution of soda in quantities, half smaller, than is taken a coagulant.

Situational task. Water analysis

1. Transparency	- 26 cm
2. Color	- slightly yellowish
3. Smell	- 3 points
4. Turbidity	- 2,0 mg/l
5. Rigidity the general	-11,5 mg/1
6. Ammonium salts	- 0,1 mg/1
7. Nitrites	- 0,004 mg/1
8. Nitrates	- 50,6 mg/1
9. Oxidability	- 7,3 mg/1
10. Chlorides	- 54,7 mg/1
11. Sulfates	- 20,0 mg/1
12. Iron salts	- 0,5 mg/1
13. Fluorine	- 0,4 mg/1
14. Coli-index	- 4
15. Quantity of bacteria in 1 ml	- 450
16. Flora and fauna	- β - mesosaprobes

Questions:

1. Evaluate water quality indicators and determine whether the water is suitable for drinking
2. What indicators characterize chemical pollution of water?
3. To estimate prescription of pollution of water.
4. What is saprobity?
5. Offer methods of improvement of quality of dunking water.

Answer standard

1. Water is not suitable for drink on all organoleptic indicators, on physical and chemical (high general rigidity, the content of salts of ammonium, nitrates, high oxidability is increased, the content of iron, insufficient content of fluorine is increased) and to bacteriological indicators. Existence of mesosaprobes says that it is a reservoir of average pollution where the content of organic matters rather small and their disintegration reaches a foil mineralization.
2. Nitrogen - containing substances. oxidability.
3. Pollution is older since the content of salts of ammonium and nitrites is normal.
4. Saprobity - ability of water organisms to develop at a certain content in water of organic matters and products of their disintegration.
5. Water needs to be subjected to cleaning, disinfecting (normal doses of chlorine).

Control question

1. Classification of methods for improving the quality of drinking water.
2. Methods of purification of drinking water.
3. Advantages and disadvantages of fast and slow filters.
4. Coagulation of water. What chemicals are used as coagulants?
5. Methods of disinfection of drinking water, their classification.
6. Types of chlorination, the scope of their application. What is a" normal " chlorine dose?
7. Adverse effects of water chlorination products on the body.
8. Ozonation of water. Adverse health effects.
9. Comparative characteristics of water chlorination and ozonation methods, their advantages and disadvantages.
10. Special methods of improving quality of drinking.

Test task

1. To compare indicators of quality of water to hygienic standards.
2. What sanitarno - chemical indicators demonstrate water pollution by organic compounds?

Direct - microbiological and parasitological indicators.

Indirect - oxidability, a nitrogen triad, sulfates and chlorides.

3. Presumably, from what source water is taken?

From a superficial source subject to continuous anthropogenous pollution.

The control training tests

1. Detection at the same time of ammonia, nitrites and nitrates in water is an indicator:

a) blossomings;
b) rigidity;
c) continuous and long fecal pollution;
d) old fecal pollution;
e) fresh fecal pollution.

2. Water has to be drinking quality in water supply system points:

a) before receipt in distribution network;
b) before receipt in distribution network and in places of water analysis;
c) before receipt in distribution network, in places of water analysis and in places of a water intake
d) in places of a water intake

3. When rationing content of chemicals in drinking water the account the climatic area it is carried out:

a) for fluorine
b) for fluorine and arsenic
c) for fluorine, arsenic, lead
d) for all chemicals normalized in drinking water

4. The infection caused by protozoa and extending water in the way:

a) lambliasis

b) cholera
c) hepatitis A
d) typhoid
e) epidemic parotitis
5. Hygienic requirements to chemical composition of drinking water extend to substances:
a) natural origin
b) a natural origin and the reagents applied to water processing
c) anthropogenous origin
d) a natural origin, the reagents applied to water processing anthropogenous pollutants of water of a source
6. Treat organoleptic properties of water:
a) smell, smack
b) smell, smack, chromaticity
c) smell, smack, chromaticity, turbidity
d) smell, smack, chromaticity, turbidity, rigidity
7. The size 1 of a zone water supply belt of an underground source of water supply depends.
a) from degree of security of a source
b) from degree of security and a water profuseness
c) from degree of security and size of water selection
d) from degree of security, a water profuseness and size of water selection
8. Mineral composition of water can be the main reason:
a) water fever
b) convulsive disease
c) fluorosis
d) local craw
e) caries
9. Features of salt composition of water are risk factors on:
a) dysentery

b) to diabetes
c) urolithiasis
d) to hepatitis A

10. Drinking water has to:

a) to have favorable organoleptic properties
b) not to contain salts
c) to be harmless on chemical composition
d) to be safe in the epidemic relation
e) to be safe in the radiation relation

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