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HYGIENIC ASSESSMENT OF DRINKING WATER DISINFECTION AND PURIFICATION METHODS

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Abstract. This article describes the main methods of purification and disinfection of drinking water, their hygienic significance, advantages and limitations. Special attention is paid to monitoring the physical, chemical and microbiological indicators of water, to safe delivery of water from the source to the consumer, and to assessing the effectiveness of disinfection. It is shown that no single method removes all hazards, and that the multi-barrier approach, combining source protection, treatment, reliable disinfection, sanitary maintenance of pipes and reservoirs, and regular laboratory control, is the most appropriate from the hygienic standpoint.

Keywords: drinking water, hygiene, water purification, disinfection, filtration, coagulation, chlorination, ultraviolet irradiation, microbiological control.

INTRODUCTION

Drinking water plays an important role in maintaining human health. Water is necessary for metabolism, regulation of body temperature and the normal course of physiological processes. However, water sources may become hazardous as a result of domestic wastewater, industrial waste, chemicals used in agriculture and natural contamination. Contaminated water may spread intestinal infections, including cholera, typhoid fever and other pathogens.

Therefore, the preparation of drinking water performs two important tasks: reducing suspended particles and unwanted impurities in the water, and disinfecting disease-causing microorganisms. These processes must be organized on the basis of sanitary and hygienic requirements, taking into account the characteristics of the water source and laboratory results.

Aim of the study: to give a hygienic assessment of the main methods of purification and disinfection of drinking water.

Objectives: (1) to describe the main purification methods; (2) to describe the main disinfection methods with their advantages and limitations; (3) to outline the indicators and principles of hygienic assessment; (4) to present preventive measures and practical recommendations.

MATERIALS AND METHODS

This work is a theoretical and analytical review based on international guidance on drinking-water quality, materials of the World Health Organization and the United States Environmental Protection Agency on water disinfection, and sanitary rules and standards on drinking-water quality and water supply of populated areas. The data were processed by content analysis, comparison and systematization.

The hygienic assessment of water was considered from the standpoint of its safety for consumption, determined on the basis of physical, chemical and microbiological indicators.

Effective hygienic control is not limited to sampling at the treatment facility: samples must be taken in the established manner from the water source, treatment stages, reservoirs and the distribution network. The results are compared with the national sanitary standards in force and the relevant international recommendations. During disinfection, factors such as reagent dose, contact time, water temperature and turbidity are controlled.

Table 1 summarizes the groups of indicators used in assessment.

Table 1

Indicators used in the hygienic assessment of drinking water

Group of indicators	Examples of parameters	Purpose
Physical	Temperature, turbidity, color, odor, taste	Organoleptic and general quality of water
Chemical	pH, mineral composition, nitrates, iron, manganese, heavy metals and other substances specific to the water source	Detection of chemical contaminants
Microbiological	Indicator microorganisms showing intestinal contamination, including E. coli	Assessment of microbiological safety and effectiveness of disinfection

RESULTS

Methods of drinking water purification

Water purification is a set of processes aimed at reducing the turbidity, color, odor and taste of water and some chemical impurities in it. In a conventional water treatment system, the stages of coagulation, sedimentation and filtration are usually applied in sequence. The main methods are summarized in Table 2.

Table 2

Main methods of drinking water purification

Method	Principle	Notes and limitations
Coagulation and sedimentation	Reagents make fine particles aggregate into larger flocs, which then settle	Reduces turbidity and makes filtration more effective; excess reagent may increase residual substances in the water

Method	Principle	Notes and limitations
Filtration (sand, gravel, other layers)	Water passes through filter layers that retain suspended particles	Sometimes also reduces microorganisms; does not always remove all of them
Activated carbon filters	Adsorption of some organic compounds and substances causing odor and taste	Useful for odor and taste; not a universal method
Membrane methods (ultrafiltration, reverse osmosis)	Separation of very fine particles and some dissolved substances	Require regular maintenance and technical control
Aeration	Contact of water with air removes some volatile compounds and converts iron and manganese into a form easier to separate later	Not effective against all contaminants

During coagulation, special reagents are added to the water so that very fine particles join together and form larger flocs, which settle at the sedimentation stage. This lowers turbidity and makes subsequent filtration more effective. The reagent amount is chosen according to the initial quality of the water.

Special chemical methods are selected to reduce certain harmful elements or compounds in water. No purification method can remove all contaminants equally; therefore, the technology is chosen on the basis of laboratory analysis of the water.

Methods of drinking water disinfection

Disinfection is the process of destroying disease-causing microorganisms in water or reducing their activity to a safe level. Purification and disinfection complement each other: even if water looks clear, it may contain dangerous microorganisms. The main disinfection methods are compared in Table 3.

Table 3

Main methods of drinking water disinfection

Method	Mode of action	Advantages	Limitations

Method	Mode of action	Advantages	Limitations
Chlorination	Chlorine and its compounds act against bacteria and many viruses	Residual disinfectant remains in the distribution network and reduces the risk of recontamination	Dose must be strictly controlled; reaction with organic matter may form disinfection by-products
Ozonation	Ozone is a strong oxidant that inactivates many microorganisms	May reduce substances affecting odor and taste	No residual protection in the network, so additional disinfection may be needed; requires special equipment, energy and safety control
Ultraviolet (UV) irradiation	Damages the genetic material of microorganisms and impairs their reproduction	No chemical reagent is added	Turbidity may shield microorganisms; no residual protective effect
Boiling	Makes a small amount of water microbiologically safer	Practical in household conditions	Official recommendations must be followed

Chlorination is one of the most widely used methods. Because disinfection by-products may form when chlorine reacts with organic matter, preliminary purification of the water and compliance with established norms are important. After UV irradiation, the subsequent storage and distribution of water must comply with sanitary requirements, since there is no residual protection.

Hygienic assessment of the methods

The most appropriate approach from the hygienic standpoint is the multi-barrier principle. It combines protection of the water source, the necessary purification stages, reliable disinfection, keeping pipes and reservoirs in sanitary condition, and regular laboratory control. Relying on a single method may not eliminate all hazards: for example, disinfection does not remove some chemical contaminants, and filtration does not always destroy all microorganisms.

Preventive significance and practical recommendations

To ensure the safety of drinking water, the following measures are of great importance:

- establishing sanitary protection zones around water sources;
- preventing wastewater from entering drinking-water sources;
- regular inspection of water facilities and prompt elimination of pipe failures;

- storage of water by the population in clean, covered containers, which should be washed regularly;
- compliance of staff of water supply systems with technological procedures, safe storage of disinfectants and repair of equipment on a set schedule;
- following the recommendations of local health and water supply authorities in the event of emergency contamination or interruption of water supply.

A change in the color, odor or taste of water is not the only criterion of safety; in doubtful cases, laboratory testing or the instruction of the responsible sanitary service is necessary.

DISCUSSION

The findings show that treatment and disinfection cannot replace each other. Treatment reduces turbidity and impurities and prepares water for disinfection, while disinfection addresses the microbiological risk that clear water may still carry. Turbidity also reduces the effectiveness of some disinfection methods, such as UV irradiation, which is why the stages must be considered together.

Each method has advantages and limitations. Chlorination provides residual protection in the network but requires strict dose control because of possible by-products; ozonation and UV irradiation do not provide residual protection, so subsequent storage and distribution become critical; membrane methods require regular maintenance. For this reason, the choice of technology must be based on the characteristics of the source and on laboratory analysis, and the safety of water depends on the entire route from the source to the consumer rather than on one stage.

A limitation of this work is that it is a review and does not present independent laboratory data or specific numerical standards. Studies of particular water sources and supply systems would be a useful direction for future research.

CONCLUSION

Purification and disinfection of drinking water are important directions of protecting public health. Coagulation, sedimentation, filtration and membrane technologies reduce various impurities in water, while chlorination, ozonation, ultraviolet irradiation and boiling serve to reduce the microbiological risk. Each method has advantages and limitations, so the choice is made on the basis of the water source and laboratory analysis.

The safety of water is ensured by regular physico-chemical and microbiological control, protection of sources and delivery of water to the consumer under hygienic conditions.

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