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WATER TREATMENT TECHNOLOGIES AND SCHEMES APPLIED AT TASH TES (Tashkent Thermal Electric Station)

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ABSTRACT

In modern water treatment, addressing numerous technological challenges necessitates a strong theoretical foundation. This foundation allows for the rational use of decades of experimental and practical data, its systematization, and the recommendation of sound, generalized water purification methods. The most general and characteristic features of water pollutants are their physical forms in the water. Therefore, as previously noted, the principle of impurity grouping developed in [3,4] is based on the concept of their phase state in water. This phase state is characterized to some extent by the dispersity of the substances and determines the patterns governing the processes occurring in this medium.

Key words: this medium, principles of this approach, natural, industrial, and wastewater impurities

INTRODUCTION

The fundamental principles of this approach, which enabled the classification of diverse natural, industrial, and wastewater impurities (differing in chemical and physical characteristics) into a small number of groups, and provided a scientific basis for water treatment techniques, can be formulated as follows:

1. The phase-disperse state of water impurities, considering their chemical characteristics, determines their behavior in the aquatic environment and their interaction with reagents added during water treatment.

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2. Each phase-disperse state of impurities corresponds to a specific set of treatment methods leading to the desired water quality parameters (conditions) by either altering or maintaining that state.

3. The ability of many impurities in water to change their phase-disperse state under the influence of physical and chemical factors (pH, salinity, temperature, etc.) allows for wide-ranging adjustments to water treatment processes and methods.

Water conditioning technology is divided into processes related to adjusting its physical and chemical properties and disinfection processes (removal of pathogenic bacteria and microorganisms). However, despite the fundamental difference in the objectives of these treatment methods, they can share commonalities depending on the phase-disperse state of the mineral, organic, and biological impurities in the water.

The first group of water pollutants includes suspended substances ranging from fine suspensions to large particles. This also includes bacterial suspensions and other biological pollutants. The removal of these impurities, i.e., water clarification, can be achieved using reagent-free and reagent methods.

Clarification, and partial decolorization without reagents, is accomplished in open, specially constructed basins or reservoirs. The prolonged, relatively calm conditions in these reservoirs promote sedimentation of suspended solids and oxidation of certain impurities. While incomplete clarification may require 1–2 days of settling, partial decolorization takes 1–2 months. This time constraint limits the use of reagent-free clarification and, even more so, decolorization.

Currently, reagent-free removal of coarsely dispersed impurities, such as phytoplankton, utilizes sedimentation, filtration through screens, or micro-straining. Fine suspensions are removed via centrifugation.

Reagent methods for clarification and decolorization involve treatment with chemicals—coagulants (sometimes with flocculants)—which facilitate more complete and rapid sedimentation of suspended particles causing turbidity and color.

Clarification and decolorization processes usually conclude with filtration, where water is passed through a bed of granular material (e.g., sand or anthracite) with particles of varying sizes. Filtration can be slow or rapid. Slow sand filtration is characterized by low filtration rates (0.1–0.3 m/h), the use of fine-grained filter material (with the development of a biological film on its surface), and the absence of pre-coagulation. In rapid sand filtration, the filtration rate is significantly higher (5–12 m/h), larger filter material fractions are used, and the water is pre-treated with coagulants.

During clarification and decolorization, the water is simultaneously freed from a significant number of bacteria, i.e., it undergoes partial disinfection.

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Disinfection can be considered a completely independent, and often the sole, water treatment process (e.g., in waterworks using colorless, transparent surface or groundwater). Disinfection can be achieved using chemical reagents or reagent-free methods.

Reagent methods are those in which chemicals that cause the death of microorganisms are used to disinfect water. Many oxidizing agents and some heavy metal salts (mainly silver and copper compounds) are used as disinfectants. Reagent methods of water disinfection also include the use of turbidifiers (palygorskite, montmorillonite, etc.) with adhesive properties against bacteria, spores and viruses. The subsequent removal of this suspension frees the water from micro-organisms. With non-reactive disinfection methods, water is exposed to ultraviolet rays, ultrasonic waves, high temperature and other factors. The methods used to purify water from substances of the first group are based on physico-chemical processes – adhesion on the surface of granular inert loads, aggregation using coagulants and flocculants, as well as flotation. In addition, oxidants, heavy metal salts, as well as electromagnetic radiation and ultrasound are used for biological contamination. Impurities of the second group, representing different types of hydrophilic and hydrophobic colloidal systems, high molecular weight substances and detergents, capable of changing their aggregativeness depending on conditions, can be removed from water by various methods and technological techniques. This is how water is treated with chlorine, ozone and other oxidizing agents. At the same time, the color of the water decreases, microorganisms are destroyed, hydrophilic colloids that exhibit protective properties against hydrophobic impurities of water are destroyed, which creates favorable conditions for subsequent coagulation, accelerates the process of formation and precipitation of flakes. The main reagents that ensure the removal of colloidal impurities of water and lead to the most complete discoloration of the latter are coagulants. Studies have shown that the degree of hydrolysis of coagulants depends on the pH of the medium, its salt composition and temperature. Aluminum coagulant Al2(SO4)3, the least sensitive iron coagulant FeCl3, is particularly sensitive to these factors. Adsorption on aluminum and iron hydroxides is a selective process. A wider range of contaminants will be delayed by the mixed coagulantal2(SO4)3+FeCl3, which has the advantages of each of the two above. In this case, the coagulation process proceeds satisfactorily in a wider range of pH and temperatures. A significant increase in the coagulation effect is achieved by the addition of flocculants (polyacrylamide, active silicic acid, etc.). The introduction of flocculants, even in small amounts, accelerates the formation of flakes, improves their structure, and leads to rapid and effective clarification of water. Good results of water purification from colloidal impurities are achieved by contact coagulation, i.e. non-stable filtration.

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Classification of water impurities by their phase-dispersed state and the processes used to remove them Table 1.

Heterogeneous systems		Homogeneous systems	
Suspensions (suspensions, microorganisms and plankton)	Colloidal solutions, high molecular weight compounds and viruses	Molecular solutions (gases, soluble organic substances)	Ionic solutions (salts, acids.grounds)
group I ($10^{-2} – 10^{-4}$ см)	group II ($10^{-5} – 10^{-6}$ см)	group III ($10^{-6} – 10^{-7}$ см)	group IV ($10^{-7} – 10^{-8}$ см)
Mechanical reagentless separation	Dialysis, ultrafiltration	Aeration,	Hyperfiltration
Oxidation with chlorine, ozone, etc..	Oxidation with chlorine, ozone, etc..	Oxidation with chlorine, chlorine dioxide, ozone, permanganate.	Conversion of ions into poorly soluble compounds, including oxidation
Flotation of suspensions and emulsions	Coagulation of colloidal impurities	Extraction with organic solvents	Ion separation at different phase states of water
Adhesion, on aluminum or iron hydroxides and highly dispersed materials	Adsorption on aluminum, iron hydroxides and clay minerals	Adsorption on activated carbons and other materials	Fixation of ions on the solid phase of ionites
Aggregation using flocculants	Aggregation using cationic type flocculants	Association of Molecules	Conversion of ions into poorly dissociated ones
Electrofiltration of suspensions and electroconduction of microorganisms	Electrophoresis and electrodialysis	Polarization of molecules in an electric field	The use of ion mobility in an electric field
Bactericidal effects on pathogenic microorganisms and	impact	Biochemical decomposition	Microbial isolation of metal ions

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spores			

For the third group of impurities, which are molecular solutions, the most effective processes for their removal from water are aerated, oxidation, and adsorption. Gases and volatile organic substances dissolved in water (light gasoline, some organic sulfur compounds, low molecular weight esters, low molecular weight carbonyl compounds, etc.) are eliminated by aerating water or treating it with certain chemical reagents. To remove hydrogen sulfide, water is treated with chlorine, to bind excess carbon dioxide – with lime solution, chalk or filtered through marble chips; excess oxygen is eliminated by filtration through iron chips, treatment with sodium sulfate or other reagents. Monatomic and polyatomic phenols dissolved in water, some products of organic synthesis, humic and sulfonic acids are destroyed by the action of strong oxidizing agents. Many substances belonging to the third group are removed from water using activated carbons, the use of which is based on the fact that impurities dissolved in water enter into molecular interaction with the highly developed surface of the carbons and are more or less firmly fixed on it. Hydrophobic compounds are well sorbed on coals, which include water-soluble petroleum hydrocarbons, aramatic hydrocarbons and their derivatives (chlorine phenol), chlorine derivatives of carbons and other compounds poorly soluble in water. Fine-pored coals (grades KAD and BAU) can be used for adsorption extraction of low-molecular compounds from water. To remove substances with larger molecules, such as fulvic acids and humic acids, coarse-pored coals (grades OU and A) are needed. Odors and tastes, depending on the substances that cause them, are eliminated by various methods. Odors and tastes of natural origin caused by products formed during the reproduction and death of microorganisms living in reservoirs and lakes are prevented by treating the reservoir with copper sulfate. At water treatment plants, similar odors are eliminated using strong oxidizing agents (ozone, chlorine dioxide) or adsorbents (activated carbons). The formation of chlorine phenolic odors and tastes during chlorination of water containing phenol and other benzene derivatives in low concentrations is prevented by pretreatment with ammonia. Odors and tastes caused by dissolved gases or salts are removed by appropriate degassing and desalination methods. For the fourth group of impurities, which are electrolytes, the water purification technique is reduced to binding ions to be eliminated into poorly soluble and slightly dissociated compounds using reagents added to water. When choosing reagents, it is advisable to proceed from the values of the product of the solubility of the resulting compounds. In the case of small values, the completeness of purification increases, especially with an excess of the precipitating ion. The presence of foreign salts in the water causes an increase in the ionic strength of the solution, as a result of

which the activity coefficients of reacting ions decrease and the solubility of the precipitate increases. Ion exchange reactions, which take place on the surface of the solid phase (on ion exchange resins), are also used to remove impurities of the fourth group. It is rational to use such processes when the ions to be removed must be retained on a water-insoluble material, replacing them with ions harmless for subsequent use of water. The release of water from ions can be carried out by evaporation, transfer to the solid phase (freezing, formation of gas hydrates) or by adding an appropriate immiscible solvent with water to form two phases, using the uneven distribution of ions between these phases (extraction). In some cases, it is advisable to use the directional movement of ions through the membrane in an electric field (electrodianalysis). Ionic reactions are practically irreversible if, as a result of the interaction of ions, a substance leaving the reaction sphere, a gas, a precipitate, or a weakly dissociated compound is obtained. During stabilization treatment and alkalinization, it should be borne in mind that water is a weak ampholite and when it dissociates, hydrated protons and hydroxyl ions are formed in equal concentrations. In acidic or alkaline waters, one of these components prevails and for its binding, the water is treated with alkaline or acidic reagents, respectively. The binding of water impurities into poorly dissociated complex ions should be considered as an exchange reaction in which water molecules from the inner sphere of ion hydrates are displaced by molecules or ions of ligands forming a more durable complex. The lower the instability constant of the resulting complex ion, the more completely this impurity is extracted from the water.

Softening of water, i.e. removal of ions from it Ca^{2+}и Mg^{2+}, It can be carried out by thermal, reagent and ion exchange methods. Thermal softening methods are based on the transition of calcium and magnesium bicarbonates into poorly soluble carbonates precipitating during boiling of water. In the case of using reagent methods of water softening, soluble calcium and magnesium salts are converted into insoluble compounds using chemical reagents, which are removed by settling and filtration. Water softening by ion exchange is based on ion exchange$Ca^{2+}$and Mg^{2}located in water, on cationite ions (Na+ or H+), through which it is filtered.[5,6]

Recently, a new method of water treatment has become widespread, used to reduce the formation of scale, consisting in passing it through magnetic or electromagnetic devices. As a result of electromagnetic treatment of water, its hardness does not change, but precipitation falls out in the form of small crystals of mobile sludge that does not stick to the heating surface and is easily removed during purging.

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