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THE LATEST MOST ENVIRONMENTALLY FRIENDLY METHODS OF WATER PURIFICATION IN TERMS OF ITS ORIGIN

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Every year the problem of wastewater treatment to provide drinking water to the urban network becomes more urgent. Pollution of water resources because of wastewater discharges from various enterprises, agricultural and domestic emissions require the development of an effective method of water purification and preparation for safe use.

The article discusses the various stages of the water treatment process: from mechanical purification to the use of chemical and biological methods and assesses the impact of each stage on water quality and composition. The relevance of the topic is caused by the need to improve existing water treatment systems to reduce the negative impact on the environment and ensure sustainable development of urban infrastructure.

Wastewater is water that, after being used for domestic or industrial purposes, is discharged through a wastewater disposal system (a set of sanitary and hygienic measures and technical devices that ensure the removal of wastewater outside the production area). This process is carried out through drainage systems and industrial and domestic wastewater. Depending on their origin, wastewater is divided into three main categories: domestic; industrial; and atmospheric.

Wastewater has very different compositions and properties. Understanding the composition and properties of impurities is an important prerequisite for choosing the right treatment methods and developing an optimal technological plan for treatment facilities. Wastewater is a complex system of dissolved, colloidal and insoluble organic and mineral pollutants. The composition of industrial wastewater is very diverse and depends on the type of production and technical processes used. There are several methods of wastewater treatment: mechanical, physical, chemical, and biological. Mechanical methods of wastewater treatment involve removing insoluble and partially colloidal impurities from water. Chemical methods of wastewater treatment include neutralization, oxidation, and reduction. Biological methods are considered the main way to treat wastewater from the oxidation of organic impurities. The physicochemical method is based on the electrolysis of water on an insoluble electrode and the flotation effect. *Key words:* domestic wastewater, industrial wastewater, atmospheric wastewater, chemical methods, physical methods, biological methods.

Новітні найбільш екологічні методи очищення води з точки зору її походження. Феденко Ю.М., Куценко А.О., Ткачук А.О.

З кожним роком стає більш актуальна проблема очищення стічних вод для забезпечення міської мережі питною водою. Забруднення водних ресурсів в результаті скидання стічних вод з різних підприємств, сільськогосподарських і побутових викидів потребує розроблення ефективного методу очищення та підготовки води для безпечного використання.

У статті розглядаються різні етапи процесу водопідготовки: від механічного очищення до застосування хімічних і біологічних методів, а також оцінюється вплив кожного етапу на якість та склад води. Актуальність теми викликана необхідністю покращення існуючих систем водопідготовки з метою зменшення негативного впливу на середовище та забезпечення сталого розвитку міської інфраструктури.

Стічні води – це води, які після використання в побутових або промислових цілях людини скидаються через систему водовідведення (комплекс санітарно-гігієнічних заходів і технічних пристроїв, що забезпечують видалення стічних вод за межі виробництва). Цей процес здійснюється за допомогою дренажних систем і промислових і побутових стічних вод. Залежно від походження стічні води поділяються на три основні категорії: господарсько-побутові; виробничі; атмосферні.

Стічні води мають дуже різні склади та властивості. Розуміння складу і властивостей домішок є важливою умовою правильного вибору методів очищення та розробки оптимального технологічного плану очисних споруд. Стічні води – це складна система розчинених, колоїдних і нерозчинних органічних і мінеральних забруднювачів. Склад промислових стічних вод дуже різноманітний і залежить від типу виробництва і використовуваних технічних процесів. Існує декілька методів очищення стічних вод – це механічні, фізичні, хімічні, біологічні. Механічні методи очищення стічних вод полягають у видаленні з води нерозчинних і частково колоїдних домішок. До хімічних методів очищення стічних вод відносять методи нейтралізації, окиснення та відновлення. Біологічні методи вважаються основним способом очищення стічних вод від окислення органічних домішок. Фізико-хімічний метод заснований на електролізі води на нерозчинному електроді і ефекті флотації. *Ключові слова:* побутові стічні води, промислові стічні води, атмосферні стічні води, хімічні методи, фізичні методи, біологічні методи.

Introduction. Wastewater is water that, after being used for domestic or industrial purposes, is discharged through a wastewater disposal system (a set of sanitary and hygienic measures and technical devices that ensure the removal of wastewater outside the production area). This process is carried out through drainage systems and industrial and domestic wastewater [1-3].

Depending on the origin, wastewater is divided into three main categories:

– domestic;
– industrial;
– atmospheric.

Domestic wastewater is generated in residential buildings and service facilities such as showers and

toilets. It is usually contaminated with detergents and excrement. Most of the suspended solids are cellulose, and other organic contaminants include fatty acids, carbohydrates, and proteins. The unpleasant odor of this wastewater is caused by the breakdown of proteins under anaerobic conditions. The composition of domestic wastewater is relatively constant and contains mainly organic pollutants in undissolved, colloidal and dissolved states (approximately 60 %) and a variety of bacteria and microorganisms, including pathogens. Industrial wastewater is generated because of the use of water in industrial processes and mining. They are discharged through industrial or public drainage systems. The most characteristic and dangerous pollutants in industrial wastewater are organic substances with long decomposition times, including extractive substances (mainly oil products), phenols, synthetic surfactants, heavy metals, and various pesticides. In addition, industrial wastewater may contain toxic substances (e.g., waste of electroplating plants) and pathogenic bacteria (e.g., waste from tanneries meat processing plants, etc.) [4].

Atmospheric runoff is formed by rain and snowmelt in residential areas of villages and areas of villages and on the territory of industrial enterprises. In modern cities atmospheric runoff contains not only sand and debris washed off the roads, but also organic substances. These substances can be classified as domestic wastewater, as they are often slightly contaminated by their composition. Pollution of the of an industrial enterprise leads to the appearance of impurities that are specific to a particular product. Rainwater drainage is characterized by ephemeral nature and strong heterogeneity of flow rate and concentration of pollutants. Depending on the sewage system domestic wastewater, industrial wastewater, or household wastewater, industrial wastewater and atmospheric wastewater enter the municipal sewer system and form municipal wastewater. The composition of wastewater is mainly characterized by the content of organic pollutants in undissolved, colloidal and dissolved states. Organic pollutants come from a variety of sources, including vegetable origin (fruits, vegetables, plant residues, paper, etc.) and animal origin (physiological human and animal excretions, organic acids, tissue residues of organisms, pathogenic bacteria, yeast). and mold). fungi – the so-called bacterial and biological pollution). Domestic wastewater contains approximately 40 % of mineral pollutants and 60 % organic pollutants [5-8].

Atmospheric wastewater contains mainly mineral pollutants and to a lesser extent organic pollutants. The composition and concentration of industrial wastewater varies widely, as it depends on the type of production, manufactured products, and the specifics of the technological of the technological process. Industrial wastewater is divided into two main categories: polluted wastewater and uncontaminated (conditionally clean) [9].

Contaminated industrial wastewater contains various impurities and is divided into three groups [10].

Mostly contaminated with mineral impurities (metallurgical machine-building, ore and coal enterprises, plants producing mineral fertilizers, acids, construction products and materials, etc.)

Mostly polluted by organic impurities (meat, fish, dairy, pulp and paper, chemical, microbial, plastics, rubber, etc. industries) [11-13].

Pollution by mineral and organic impurities (oil production, oil refining, petrochemicals, textile and light industry, pharmaceutical industry, factories producing canned food, sugar, organic synthetics, paper, vitamins, etc.)

Atmospheric runoff is formed by rain and snowmelt in residential areas of villages and on the territory of industrial enterprises. In modern cities, atmospheric runoff contains not only sand and debris washed off the roads, but also organic substances. These substances can be classified as domestic wastewater, as they are often slightly contaminated by their composition. Contamination of the territory of an industrial enterprise leads to the appearance of impurities specific to certain products. Rainwater drainage is characterized by its ephemeral nature and strong heterogeneity in flow rate and pollutant concentration. Depending on the sewage system, domestic wastewater, industrial wastewater or domestic wastewater, industrial wastewater and atmospheric wastewater enter the urban sewer network and form urban wastewater. Due to the different degree of wastewater pollution and its sources, when designing drainage systems, the possibility of extracting different types of wastewaters together or separately, as well as their treatment together or separately, is considered. The main characteristics of wastewater include the amount of water measured in l/s, m^3/s, m^3/h, m^3/shift, m^3/day, etc. Type of pollutant and its concentration (measured in mg/l or g/m^3). An important characteristic of wastewater is the degree of uniformity of its generation and discharge into the drainage system, which is usually determined by the heterogeneity of the wastewater flow throughout the day during the year. These characteristics are considered when planning a drainage system [14, 15].

Overview of the features of wastewater treatment of various origins

Before being discharged into a water body, wastewater must be treated at a wastewater treatment plant. To do this, we need to know the composition and quality of these waters. Pollution is classified by source as follows [16]:

- mineral;
- organic;
- biological;
- bacterial.

Mineral contaminants include sand, clay particles, slag, solutions of mineral salts, acids and alkalis, mineral oils, etc.

Organic pollution is of plant or animal origin. Vegetable pollution includes residues of vegetables, fruits, cereals, paper, etc. The main chemical element

in this type of pollution is carbon. Animal pollutants include human and animal physiological waste, animal muscle and fatty tissue residues, and adhesive substances containing large amounts of nitrogen. Organic pollutants can be classified into nitrogen-free pollutants, pollutants containing carbon, hydrogen and oxygen, and pollutants containing nitrogen. The main organic pollutants in domestic wastewater are carbohydrates and fats. Such water contains many monosaccharides, such as glucose and lactose (milk sugar), and disaccharides, such as sucrose. Polysaccharides such as cellulose and starch are also components of domestic wastewater and are not soluble in water but are in suspension and often form an important part of the solid phase. The pollutants contained in domestic wastewater can be in undissolved, dissolved, or colloidal states. Undissolved contaminants that remain on paper filters are often called suspended solids. Organic contaminants pose the greatest health risk. The content of dissolved organic pollutants is estimated using the values of biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Domestic wastewater typically has a BOD value of 100 to 400 mg/l and COD value of 150 to 600 mg/l, indicating a high level of pollution. Such water can deteriorate within 12–24 hours when stored at 20 °C. Organic pollutants make up a significant portion of municipal wastewater, approximately 45–58 %. Mineral and other impurities make up 42–55 % each. Organic pollution of wastewater promotes the development of various microorganisms and bacteria, which leads to biological and bacterial contamination, increasing the risk of infectious diseases [17–19].

Wastewater treatment methods are divided into mechanical, chemical, physicochemical, and biological, and when these methods are used together, they are called combined methods. The choice of approach depends on the type of pollution and its harmfulness. Methods for the treatment of polluted industrial water can be divided into several groups: mechanical, physical, physical-mechanical, chemical, physical-chemical, biological and integrated methods [20]. Mechanical methods of wastewater treatment consist in removing insoluble and partially colloidal impurities from water. The waste contained in wastewater (paper, rags, bones, various industrial wastes, etc.) is collected in preliminary screens. Mechanical treatment can remove up to 60–75 % of insoluble contaminants from domestic wastewater and up to 95 % from industrial wastewater. Many of them are valuable pollutants used in production [21].

Grids and nets are used for filtration, and coarse dirt (bags, rags, plastic, large items and objects) is also filtered. The cleaning device works on the principle of installing a special mesh that traps large particles of dirt. Then the purified water enters the fine mesh, and small particles of dirt are trapped in it. Finally, a microfilter removes particles and insoluble substances [22].

Chemical methods of wastewater treatment include neutralization, oxidation, and reduction. Chemical treatment can be used as a preliminary stage of biological treatment or as a subsequent treatment method. Both chemical and physicochemical treatment are used only in industrial environments and require preliminary mechanical treatment. Chemical treatment reduces the number of insoluble pollutants by up to 95 % and soluble pollutants by up to 25 % [23].

For example, neutralization is a method of treating contaminated water that can be returned to a normal pH (6.5–8.5). This process neutralizes acids and alkalis and turns them into safe substances. When treating wastewater from industrial plants, it is necessary to deal with such contaminants. Even if acidic wastewater is mixed with alkaline wastewater, it can be neutralized simply by mixing. To neutralize acidic water, alkaline waste, caustic soda, soda, chalk, and limestone are used. To achieve this method, companies install filters and various devices [24].

The main methods of neutralization include:

– mixing acid and alkaline liquids;
– introduction of reagents;
– filtering of acidic wastewater with the use of neutralizing substances;
– alkaline dissolution of gases;
– introduction of an ammonia solution into acidic wastewater [25].

So, wastewater is a complex system of dissolved, colloidal and insoluble organic and mineral pollutants. The composition of industrial wastewater is very diverse and depends on the type of production and technical processes used. There are several methods of wastewater treatment: mechanical, physical, chemical, and biological. Mechanical wastewater treatment methods involve removing insoluble and partially colloidal impurities from water. Chemical methods of wastewater treatment include neutralization, oxidation, and reduction. Biological methods are considered the main way to treat wastewater from the oxidation of organic impurities. The physicochemical method is based on the electrolysis of water on an insoluble electrode and the flotation effect.

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