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THE PROTECTION AND TREATMENT OF WASTEWATER

Tutorial

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The tutorial contains issues of protection and treatment of wastewater, properties and classification of wastewater, the patterns of water consumption and sanitation in economic sectors, as well as methods for rationing water consumption and sanitation. The tutorial outlines the calculation of wastewater indicators, as well as the use of treated wastewater for circulating and re-supplying water, which largely determines the level of water consumption, sanitation and protection from surface water pollution and protection of natural resources.

This tutorial is intended for undergraduates who study in the specialty 6M073100 - Life safety and environmental protection.

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The contents

Preface

At all times people's settlements and the location of industrial facilities were realized in close proximity to fresh water reservoirs used for drinking, hygienic, agricultural and industrial purposes. In the process of water use by man, it changed its natural properties and in some cases became dangerous in terms of sanitation. Subsequently, with the development of engineering equipment of cities and industrial facilities, a need arose to organize ways to divert polluted waste streams of water through special hydraulic structures.

The development of productive forces as one of the important problems puts forward the protection of the environment and in particular of water sources from pollution. The main tasks of protecting the water basin are both the rational use of water resources and the treatment of wastewater to the level of requirements for their discharge into water bodies.

At present, the importance of fresh water as a natural raw material is constantly increasing. When used in everyday life and industry, water is contaminated with substances of mineral and organic origin. This water is usually called sewage water.

The existing deficit in Kazakhstan in water resources (about 60% of the water comes from other countries) requires the economical use of both surface water and groundwater in agriculture. These waters, as a rule, should be subject to pre-treatment to meet the requirements for their quality.

Depending on the origin of waste water, they can contain toxic substances and pathogens of various infectious diseases. Water management systems of cities and industrial enterprises are equipped with modern complexes of gravity and pressure pipelines and other special facilities that implement the diversion, purification, neutralization and use of water and formed sediments. Such complexes are called a drainage system. The construction of drainage systems was necessitated by the provision of normal living conditions for the population of cities and populated areas and the maintenance of a good state of the natural environment.

The importance and scope of measures to protect the environment is increasing every year. One of such measures is wastewater treatment. Therefore, one of the most pressing problems at the present stage is the development of a modern system of wastewater disposal of domestic and industrial wastewater, ensuring a high degree of protection of the environment from pollution.

Pollution of the environment adversely affects the condition of water bodies, increasing the concentration of pollution in which can lead to the development of irreversible processes in them, contributing to their progressive depletion. Therefore, wastewater treatment that meets the requirements of water pollution protection is of paramount importance as an element of a controlled and controlled human influence on nature, calculated for a long period. The protection, complex use and reproduction of water resources, providing for protection from pollution and depletion, deep cleaning of contaminated sewage at sewage treatment plants with their subsequent use in technical water supply, as well as all-round reduction and even termination of discharge of industrial sewage into rivers are of great importance.

Protection of the environment, the radical use of water resources is of particular importance for Kazakhstan, which among the countries of the Commonwealth of Independent States is the country with the lowest water resources.

Proper treatment of wastewater requires reuse before disposal in water bodies or in soil. Wastewater treatment also pursues other goals, for example, keeping clean water reservoirs that are resting places, preserving fish resources. At the same time, the construction of only large treatment facilities does not solve existing problems. It is necessary to expand the network of small sewerage facilities, which have not yet been given proper attention.

The need for the construction of small treatment plants is increasing in connection with the implementation of a broad program of housing construction, the construction of individual houses, cottages, as well as health and education facilities.

The particular importance is the development of a modern system of wastewater disposal of domestic and industrial wastewater, ensuring a high degree of protection of the environment from pollution.

The most significant results were obtained in the development of new technological solutions for the efficient use of water in wastewater systems and in the treatment of industrial wastewater.

The prerequisites for the successful solution of these tasks in the construction of drainage systems are developments carried out by highly qualified specialists using the latest achievements of science and technology in the field of construction and reconstruction of drainage networks and treatment facilities.

1 Technological control of wastewater treatment processes

General Provisions. Control over the operation of sewage treatment plants and wastewater discharges is carried out to prevent and stop pollution of water bodies with untreated and under-treated wastewater, and also reuse them in industry and agriculture. It includes the registration and registration of treatment facilities; checking the efficiency of wastewater treatment; determination of the influence of discharged wastewater on water bodies and technological processes; issuance of instructions for improving the operation of treatment facilities.

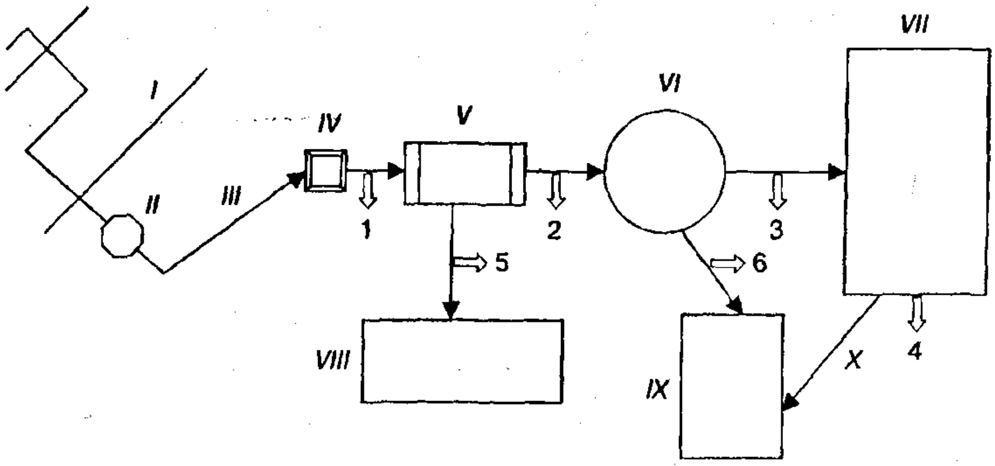
Inspection of treatment facilities involves the study of design data, technological scheme and regulations for the operation of treatment plants, as well as their passports; familiarization with the previously issued permission to discharge treated sewage; verification of the fulfillment of previously issued instructions for improving the operation of treatment facilities. At the same time, the work of the laboratory, which carries out departmental control over the operation of the treatment facilities, is monitored. Moreover, special attention is paid to staffing it with qualified personnel, equipping with the necessary equipment, adherence to procedures, periodicity and volume of wastewater analysis agreed upon with the water protection authorities, and sampling points and procedures, keeping records, studying laboratory analysis of wastewater entering treatment plants construction, and comparison with design data.

During the inspection, the compliance with the regulations for the operation of each structure and the organization of accounting for the amount of water to be purified are checked. Pay attention to the degree of automation of technological processes, the supply and dosing of reagents, the operation of pumping stations, scraper mechanisms in sedimentation tanks, the regulation of the operation of aeration facilities, methane tanks, mechanical dehydration of precipitation, chlorine disinfection and other processes, determine the compliance of the facilities in operation with designed ones.

If necessary, samples are taken and waste water analysis is carried out to determine the degree of their purification both at treatment facilities in general and in separate stages. The place, time and method of taking samples depend on the purpose of the inspection being carried out and are determined in each specific case, taking into account the operating mode of the treatment facilities and the possible time variation in the composition and consumption of wastewater (figures 1.1-1.3).

Table 1.1 gives the characteristics of the composition of the samples indicated in figures 1.1-1.3 and a list of definitions that must be satisfied with their contents.

It should be noted that sampling takes place without fail at the entrance and exit from the treatment facilities or the cleaned stage of treatment, taking into account the time of passage of sewage through the facilities.



I — drainage network; II — pumping station; III— penstock; IV— well - pacifier; V— sand trap; VI — primary sump; VII — biological ponds, filtration fields; VIII — sand areas; IX — sludge areas; X — drainage channel;
⇒ — places of sampling of waste water.

Figure 1.1 - Scheme of biological wastewater treatment plants in natural conditions, indicating the places of sampling (1-6) for laboratory monitoring

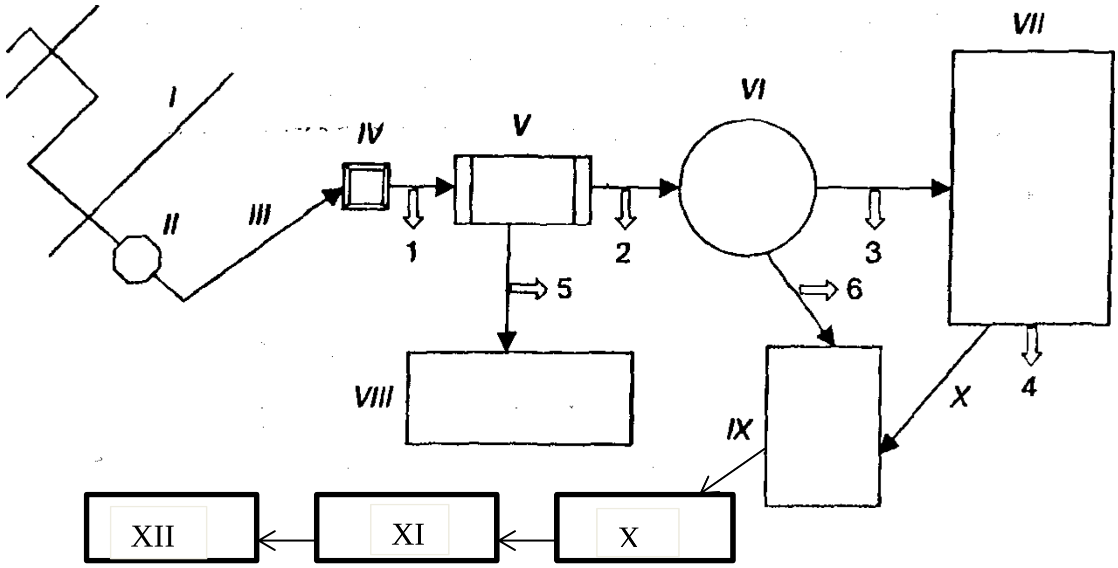
In recent years, at the same time as physical and chemical analyzes of the treated water, biological studies have been carried out using living organisms. As a test object, one organism is selected from the following four categories:

- bacteria (Pseudomonas, Mycobacterium, Escherchia Coli and etc.);
- alga (Chlamydomonas, Dunaliella, Selenastrum and etc.);
- invertebrates (mostly crustaceans, but also worms, protozoa, etc.);
- fish (trout, minnow, guppies, carp and Brachydanio).

These tests can be either static or dynamic. In static, for example, the behavior and physiological reflexes of fish in a laboratory aquarium filled with water are studied. Observation of the vital activity of experimental fish is carried out with the help of instruments placed also in the aquarium and working in an autonomous mode. If toxic substances are brought in the water, the physical state of the fish deteriorates, which is fixed by these devices.

In dynamic conditions, biological tests are used to determine the accidental contamination of a watercourse. Usually fish are used (most often trout or carp).

The standards for control of waste water discharges for environmental protection should be established on the basis of the best available technologies (BAT), taking into account economic and social factors.



I-VI — the same as in the figure 2.1; VII — chlorination;
VIII — bristle type mixer; IX — secondary sump; X — the waste collector;
XI — sand areas; XII — sludge areas;
$\Rightarrow$ — places of sampling of waste water.

Figure 1.2 - Scheme of mechanical sewage treatment plants in natural conditions with indication of sampling sites (1-9) for laboratory monitoring

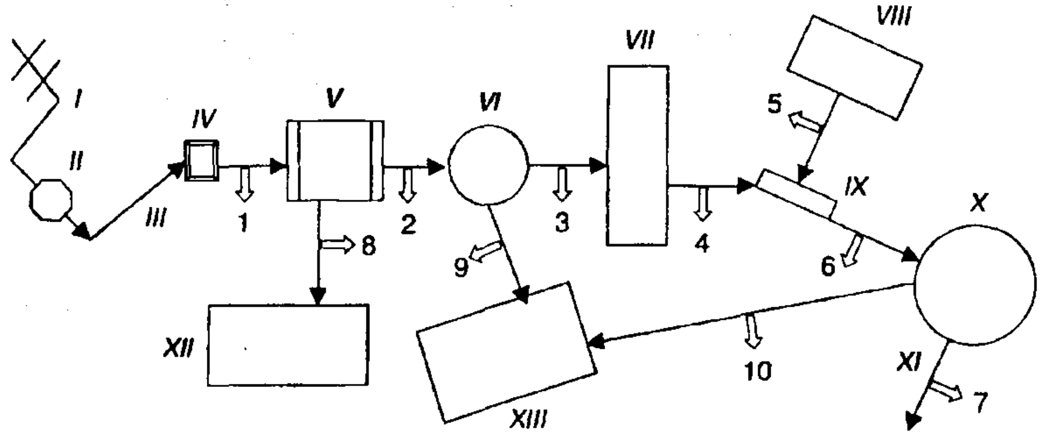
At present, the following BATs are widely used: complete biological purification, complete biological purification with post-treatment, biological purification with complete oxidation, biological purification with nitride-neutralization and physic-chemical purification.

The indicators that are achieved with these technologies are given in table 1.2. It can be seen from the table that the best available technologies used in the main indicators, with the exception of phosphates, comply with the regulations established in the countries of the European Economic Community.

It should be noted, however, that for most regions the removal of phosphates to concentrations below 2 mg/dm^3 is impractical, since 70-80% of this biogenic element enters water bodies with unorganized waste water.

Of the existing technologies, the best indicators for the removal of organic substances and ammonium nitrogen are provided by biological purification facilities with complete oxidation (the construction of extended aeration).

A feature of this type of structures is increased by 1.5-2 times the volume of aeration, secondary settling tanks smaller dimensions and low sludge growth.



I-VI — the same as in the figures 1.1 and 1.2; VII — biofilter; VIII — chlorination; IX — bristle type mixer; X — secondary sump; XI — the waste collector; XII — sand areas; XIII — sludge areas;
⇒ — places of sampling of waste water.

Figure 1.3 - Scheme of biological wastewater treatment plants in artificially created conditions with indication of places for sampling for laboratory monitoring

Table 1.1 - Characterization of the sampling sites indicated in figures 1.1-1.3 and a list of relevant definitions

№ sampling points	Sampling points in the process of wastewater treatment	The name of indicators		
		Physical characteristics	Chemical ingredients	Bacteriological parameters
1	2	3	4	5
1	Raw wastewater entering the treatment plant	+	+	+
2	Wastewater after sand trap	+	-	-
3	Wastewater after primary sump	+	-	+
According to the figure 1.1				
4	Biological ponds, filtration fields, irrigation fields	-	+	+
5	Sediment after sand trap	+	-	-
6	Sediment after the primary sump	+	+	-
According to the figure 1.2				
4	Concentration of chlorine	-	+	-
5	Waste water after chlorination	-	+	-
6	Wastewater after purification plants	+	+	+

Continuation of the table 1.1

1	2	3	4	5
7	Sediment after sand trap	+	-	-
8	The same after the primary sump	+	+	-
9	The same after the secondary sump	+	+	-
	According to the figure 1.3			
4	Waste water after the biofilter, aeration basin	-	+	+
5	Concentration of chlorine	-	+	-
6	Waste water after chlorination		+	-
7	Wastewater after cleaning on structures	+	+	+
8	Sediment after sand trap	+	-	-
9	The same after the primary sump	+	+	-
10	The same after the secondary sump	+	+	-

Note - The sign (+) indicates the need to determine the indicator, and if the sign (-) is not sampled, no water analysis is performed.

Almost the same indicators are achieved on biological treatment facilities with nitride-denitrification, but in a constructive way they are much more complicated, so the BATs is preferable as a simpler and cheaper technology.

An approximate list of analyzes and composition of waste water for the main methods for their purification is presented in table 1.2.

Based on the results of control analogues, the efficiency of the treatment facilities is determined and the adequacy of sewage treatment on them is estimated.

The facilities for physico-chemical treatment of domestic sewage (BAT-5) are used when long breaks in the supply of sewage (sanatoriums, rest homes) or at a low temperature are possible.

However, at present, the use of this technology is not widely used, since the presence of reagent plants makes it difficult to operate and leads to additional pollution of the environment with waste reagents.

The most widespread are classical structures of complete biological purification, which, with relatively low capital and operating costs, provide a high degree of retention of organic and suspended substances (up to 90-95%).

Table 1.2 - Exemplary list of analysis and composition of wastewater for basic methods for their purification

Cleaning method	Cleaning construction	Expected cleaning effect	List of analyzed indicators
Mechanical	Sump horizontal and vertical	Decrease in the content of suspended solids, increase in transparency and decrease in Biochemical oxygen demand (BOD_5)	Coloring, odor, transparency, suspended solids, content of sludge by volume
	Sump two-tier	Decrease in the content of suspended solids, increase in transparency and decrease in BOD_5 for the liquid phase of wastewater. Change in the properties of the sediment (improvement in appearance, elimination of stench, destruction of its colloidal structure, compaction)	Coloring, odor, transparency, suspended matter, sludge content by volume, type of sludge, the smell, the pH of the water-sludge
Biological	Filtration fields, irrigation fields, biological ponds, cleaning with biofilters, aerotanks with full or partial purification	The mineralization of organic matter, and the decrease in the content of suspended solids change in the composition, changing the organoleptic properties of wastewater (coloration, transparency, odor)	Temperature, pH, color, transparency, odor, sediment by volume, suspended matter, dissolved oxygen, oxidability, BOD, stability, nitrogen of nitrates and nitrites, specific pollutants. If necessary, the activated sludge is analyzed
Chemical	The facility for the neutralization of acidic and alkaline industrial wastewater, the construction of a complete or partial discharge of waste water from harmful substances	Averaging the pH value to the value established by the calculation. Reduction of the content of harmful substances in wastewater to the limits established by calculation. Changes in the external properties of wastewater (discoloration, odor elimination, increased transparency)	pH, color, odor, transparency, harmful substances characteristic of this object; Residual quantities of reagents (if necessary)

2 Pollution composition and methods of wastewater treatment

2.1 Composition and properties of waste water

Sewage is natural water that has been in use and, as a result, has received pollution, which has changed their chemical composition and physic-chemical properties. Waste water includes domestic and industrial, as well as atmospheric water, discharged from the territories of settlements.

Domestic wastewater enters the drainage network from apartment houses, household premises of industrial enterprises, public catering complexes and medical institutions. In the composition of such waters, fecal sewage and household waste are distinguished, pollution by various household waste, detergents. Domestic wastewater always contains a large number of microorganisms, which are the products of human life. Among them may be pathogenic. A special feature of domestic waste water is relatively constant in their composition. The main part of organic contamination of such waters is represented by proteins, fats, carbohydrates and their decomposition products. Inorganic impurities are quartz sand particles, clays, salts formed in the process of human activity. The latter include phosphates, hydrogen carbonates, ammonium salts (a product of urea hydrolysis).

Production wastewater is formed as a result of technological processes. The quality of waste water and the concentration of pollutants are determined by the following factors: the type of industrial production and raw materials, the modes of technological processes.

Atmospheric wastewater is formed as a result of precipitation. This category of waste water includes meltwater, as well as water from watering the streets. In atmospheric waters, a high concentration of quartz sand, clay particles, debris and oil products washed off the streets of the city is observed. Pollution of the territory of industrial enterprises leads to the appearance of impurities in storm water characteristic for this production. A distinctive feature of storm runoff is its episodicity and pronounced unevenness in terms of discharge and pollution concentrations.

Impurities of sewage are divided into organic, mineral, biological.

Organic:

a) vegetable origin: remains of plants, fruits and grains, paper, vegetable oils and others (the main chemical element of this kind of pollution is carbon);

b) animal origin: physiological isolation of humans and animals, remnants of muscular and fatty tissues of animals, glutinous substances and others (the main chemical element of this kind of pollution is nitrogen, as well as phosphorus, sulfur and hydrogen);

c) the mineral pollution of natural waters includes clayey and sandy particles, which cause turbidity of water, and ions of salts, which determine its mineralization;

d) bacterial and biological - various microorganisms: yeast and mold fungi, small algae and bacteria, including pathogens (pathogens of typhoid fever, paratyphoid, dysentery, cholera and others).

The composition of wastewater and its properties are evaluated by the results of a sanitary and chemical analysis, which includes, in order with standard chemical tests, a whole range of physical, physico-chemical and sanitary bacteriological definitions. The indicators of the sanitary and chemical analysis of the composition of waste water allow one to assess the possibility of using certain methods and technologies for water purification.

Sewage in its origin and formation are divided into 5 groups: domestic, industrial, mixed (urban), livestock and storm water.

Domestic wastewater is a drain from residential buildings, baths, laundries, canteens and other household facilities. In terms of chemical composition, these waters are constant and contaminated mainly by physiological waste and all sorts of household waste. Characterized by the stability of mineralization, not exceeding 2 g/l. Contain in a certain amount of nitrogen, phosphorus, potassium, which are valuable fertilizers for soils. According to Stroganov S.N., from one person a day comes on average: nitrogen 1.5 - 3.5 g, phosphorus 1.5 - 1.8 g, potassium 3.7 - 4.2 g, chlorine 9 g and suspended solids 30 .... 50 g. Their concentration in wastewater depends on the rate of wastewater disposal. The higher the rate of wastewater disposal, the less concentrated waste water becomes. The water-removed value is not constant and changes even during the day, therefore, the composition of the sewage changes.

Domestic waste water is favorable from the point of view of irrigation, but when using them, high demands are placed on their sanitary condition. They are characterized by an alkaline reaction, low bichromate oxidizability. Their mineralization lies mainly in the range 800 ... 1500 mg/l.

The fertilizing value of household wastewater is low: 1000 m^3 of treated sewage is approximately equivalent to 4 ... 6 tonnes of manure. To apply a full norm of nitrogen fertilizers (120 - 200 kg) to the soil, it is required to supply 10 to 12 thousand m^3 of sewage per year per 1 hectare, which is 3 to 5 times higher than the need for irrigation.

Industrial wastewater comes from industrial interprises, factories and factories. There also belong to the water produced by the extraction of ores and coal. The chemical composition of industrial wastewater is very diverse and primarily determined by the type and technology of production.

A significant organic content substances mentioned in the wastewater of textile and paper industry, boiler, etc. glue. Enterprises. Their use for irrigation with a mixture of domestic wastewater provides a good natural biological soil purification.

Great value for agriculture have wastewater food industry. They contain a significant number of nutrients. However, they contain a large number of suspended solids, which needs to be upheld.

Wastewater sugar factories typically have high potassium content. They are formed during the plant's operation, from September to February months, therefore, they are used mainly for carrying out water recharge irrigation. Wastewater sugar plants free from pathogenic microorganisms and helminth eggs. Therefore, they can be used for irrigation immediately after mechanical cleaning.

Industrial wastewater, in most cases after a certain treatment, is suitable for supply to wastewater treatment plants. At many enterprises, the technology of production, raw materials or water consumption norms change over time, which requires constant monitoring of the water composition and appropriate adjustments in the irrigation system.

Suitable and useful for irrigation are industrial cans of canning, sugar, starch-loach, alcohol, brewing, yeast and dairy plants.

The most difficult and dangerous waste water are the chemical industry. They can contain many harmful substances and heavy metals (salts, chromium, copper, tin, lead, fluorine, phenol, formaldehyde, caprolactam, etc.). The use of such succulent waters requires detailed study of their chemical composition and careful preparation.

Mixed waste water (urban) is a mixture of domestic, industrial and storm drains. The chemical composition of such waters depends on the proportion of industrial wastewater in the common sewerage runoff. Wastewater in cities of regional centers is more often of mixed origin.

Cattle-breeding runoff is formed when stabling the animals. At large cattle-breeding farms, the daily flow of manure is estimated at hundreds of tons. They are a semi-dispersed mass, consisting of water, solid inclusions and gases. They are distinguished by a high content of nitrogen, phosphorus and potassium. Their use in crop production is the most rational way in terms of disposal. Before using them for irrigation, they must undergo thorough preparation. Preparatory work includes: separation of foreign objects, grinding of coarse impurities, separation into solid and liquid fractions, homogenization.

Annually, as the volume of production and population grows, so does the volume of waste water, about 20-30%, especially in urban sewage. Therefore, the need to recycle or rationally use them today, especially in agriculture, is an urgent problem. The use of wastewater for irrigation of agricultural crops would save a huge amount of water resources, which are so lacking in vegetative periods of plants.

The greatest interest from an ecological and agricultural point of view is represented by urban wastewater, the volume of which is continuously growing. Wastewater is characterized by a wide range and content of a large number of ingredients with varying degrees of toxicity. They can not be considered as one with stable properties. The concentration of elements and substances containing in sewage is diverse.

A complicated situation now exists in the location of waste water in the cities of the regional centers. In the next 15-20 years, when the volume of sewage will increase by 1.5-2.0 times, industrial methods of cleaning can not provide protection of watercourses due to the large amount of residual pollution discharged even with purified effluents.

When using wastewater and water from natural water bodies for irrigation, their essential differences in chemical composition should be taken into account. They all contain a large amount of suspended sediment, organic compounds and nutrients. In connection with the presence of dyes and coloring agents, all types of sewage have a high color. Coloring of sewage is various: gray, blue, pink, whitish-gray, yellowish-whitish, brownish-brown, etc.

Sewage is characterized by the presence, in a significant amount, of a suspended sediment that gives them turbidity. These waters always have a specific smell (fecal, phenolic, putrefactive, etc.). The chemical composition of wastewater is extremely diverse. The reaction of the medium (pH) is not the same. There are water sour, weakly acidic, alkaline, less often neutral. Wastewater is characterized by a high concentration of dissolved substances, which contain not less than one third of organic substances. Thus, in sewage waters of sugar, starch and hydrolysis plants contains more than 50% of organic substances.

For many wastewater types, unlike natural wastes, a high content of biogenic substances - compounds of nitrogen, potassium and phosphorus, necessary for soil enrichment is characteristic.

2.2 Sanitary and chemical indicators of wastewater pollution

The complexity of the composition of wastewater and the inability to determine each of the pollutants lead to the need to select indicators that characterize certain properties of water without identifying individual substances.

A full sanitary and chemical analysis involves the determination of the following parameters: temperature, color, odor, transparency, pH, dry residue, dense residue and ignition loss, suspended substances, settling substances by volume and mass, permanganate oxidability, chemical oxygen demand (COD), biochemical oxygen demand (BOD), nitrogen (common, ammonium, nitrite, nitrate), phosphates, chlorides, sulfates, heavy metals and other toxic elements, surfactants, oil products, dissolved oxygen, bacterial count, coliform bacteria (coliforms), helminth eggs. In the number of mandatory tests of complete sanitary and chemical analysis, urban sewage treatment plants can include the determination of specific impurities entering the drainage network of settlements from industrial enterprises.

Temperature is one of the important technological indicators. The function of temperature is the viscosity of the liquid and, consequently, the drag force of the settling particles. the temperature is of paramount importance for biological purification processes, since the rates of biochemical reactions and the solubility of oxygen in water depend on it.

Painting - one of the organoleptic characteristics of wastewater quality. Fecal wastewater is usually poorly colored and has a yellowish-brownish or gray hue. The presence of intense coloration of various shades is evidence of the presence of industrial wastewater. The color intensity is determined for the colored sewage by dilution to a colorless color, for example 1: 400; 1: 250, etc.

Smell is an organoleptic indicator that characterizes the presence in the water of smelling volatile substances. Usually, the smell is qualitatively determined in a sample with wastewater with a temperature of 20 °C and is described as fecal, putrefactive, kerosene, phenolic, etc. With an unclear smell, the determination is repeated, heating the sample to 65 °C. Sometimes it is necessary to know the threshold number - the smallest dilution at which the smell disappears.

The concentration of hydrogen ions is expressed by the pH value. This indicator is extremely important for biochemical processes, the speed of which can be significantly reduced by a sharp change in the reaction of the medium. It has been established that wastewater supplied to biological treatment facilities should have a pH value in the range of 6.5 to 8.5. Production wastewater (acidic or alkaline) must be neutralized before discharge into the drainage system to prevent its destruction. Urban wastewater usually has a slightly alkaline reaction medium (pH = 7.2-7.8).

Transparency characterizes the total contamination of sewage with undissolved and colloidal impurities, without identifying the type of contamination. Transparency of urban wastewater is usually 1-3 cm, and after cleaning it increases to 15-30 cm.

The dry residue characterizes the total contamination of sewage by organic and mineral impurities in various aggregative states (in mg/l). This index is determined after evaporation and further drying at t = 105 °C of a sample of sewage. After calcination (at t = 600 °C), the ash content of the dry residue is determined. On the ratio of organic and mineral parts of contaminants in the dry residue can be judged on these two indicators.

A dense residue is the total amount of organic and mineral substances in a filtered sample of sewage (mg / l). It is determined under the same conditions as the dry residue. After calcining the dense residue at t = 600 ° C, the ratio of the organic and mineral parts of the soluble sewage contaminants can be estimated. When comparing the calcined dry and dense residues of urban wastewater, it is determined that most of the organic contaminants are in an undissolved state. At the same time, mineral impurities are more in a dissolved form.

Suspended substances - an indicator characterizing the amount of impurities that is retained on a paper filter when filtering a sample. This is one of the most important technological indicators of water quality, which makes it possible to estimate the amount of precipitation formed in the process of wastewater treatment. Moreover, this indicator is used as the estimated parameter when designing the primary sumps.

The amount of suspended substances - one of the major standards for the calculation of the required degree of wastewater treatment. Losses on ignition of suspended solids are determined in the same way as for dry and dense residues, but usually not expressed in mg / l, but as a percentage of the mineral part of suspended solids to their total amount by dry matter. This indicator is called ash content. The concentration of suspended solids in urban wastewater is usually 100-500 mg / l.

The settling substances are a part of the suspended substances settling on the bottom of the settler cylinder for 2 hours settling at rest. This indicator characterizes the ability of suspended particles to settle, allows us to estimate the maximum sedimentation effect and the maximum possible amount of sediment that can be obtained under quiescent conditions. In urban sewage settling substances on average 50-75% of the total concentration of suspended substances.

Oxidability is the total content of reducing agents of organic and inorganic nature in water. Organic substances constitute the overwhelming part of reducing agents in urban wastewater. Therefore, it is believed that the value of oxidation is completely related to organic impurities. Depending on the nature of the oxidizer used, chemical oxidizability is distinguished if a chemical oxidant is used in the determination, and biochemical, when aerobic bacteria play the role of an oxidizing agent. This indicator is called the biochemical oxygen demand (BOD). In turn, the chemical oxidizability can be permanganate (oxidizer $KMnO_4$), bichromate (oxidizer $K2Cr_2O_7$) and iodate (oxidizer KJO_3). The results of determining the oxidizability, regardless of the type of oxidant, are expressed in mg/l O_2. Bichromate and iodate oxidation called chemical oxygen demand or COD - degree of water contamination by organic substances.

BOD - oxygen equivalent of the degree of contamination of sewage with biochemically oxidized organic substances. BOD determines the amount of oxygen necessary for the life of microorganisms involved in the oxidation of organic compounds. BOD characterizes the biochemically oxidizable part of organic wastewater pollution, which are primarily in dissolved and colloidal states, and also in the form of suspended matter.

Nitrogen is in wastewater in the form of organic and inorganic compounds. In urban wastewater the main suit of organic nitrogenous compounds are substances of protein nature: feces, food waste. Inorganic nitrogen compounds are represented by reduced NH_4 + and NH_3 and oxidized forms*:* NO_2^- and NO^-_3. Ammonium nitrogen in large quantities is formed by the hydrolysis of urea - the product of human life. In addition, the process of ammonification of protein compounds also leads to the formation of ammonium compounds. In urban wastewater before their treatment, nitrogen in oxidized forms is usually absent. Nitrites and nitrates are reduced by a group of denitrifying bacteria to molecular nitrogen. Oxidized forms of nitrogen can appear in sewage only after biological treatment.

The sources of phosphorus compounds in wastewater are physiological discharges of people, wastes of human economic activity and certain types of industrial wastewater. Concentrations of nitrogen and phosphorus in wastewater are the most important indicators of sanitary and chemical analysis, which are important for biological purification. Nitrogen and phosphorus are essential components of the composition of bacterial cells. They are called biogenic elements. In the absence of nitrogen and phosphorus, the biological purification process is impossible.

Chlorides and sulfates are indicators whose concentration affects the total salt content.

The group of heavy metals and other toxic elements includes a large number of elements. To toxic heavy metals carry: iron, nickel, copper, lead, zinc, cobalt, cadmium, chromium, mercury. *To toxic elements*, which are not heavy metals - arsenic, antimony, boron, aluminum, etc. The source of heavy metals is industrial wastewater of machine-building plants, electronic, instrument-making and other industries. Heavy metals are contained in the form of ions and complexes with inorganic and organic substances in wastewater.

Synthetic surfactants (organic surfactants) are organic compounds consisting of a hydrophobic and hydrophilic parts that cause the dissolution of these substances in oils and water. Approximately 75% of the total number of manufactured synthetic surfactants falls on the share of anionic substances. Second place in production and use is occupied by non-ionic compounds. Two types of surfactants are present in urban wastewater.

Petroleum products are nonpolar and low-polar compounds extracted with hexane. Concentration of petroleum products in water bodies is strictly standardized. At urban treatment facilities, the degree of detention of oil products does not exceed 85%. oil content is also limited in the waste water arrives at the station.

Sanitary-bacteriological indicators include the determination of the total number of aerobic saprophytes, bacteria of the E. coli group and analysis for helminth eggs. Microbial contamination estimates the total number of wastewater microorganisms and indirectly characterizes the degree of water contamination by organic substances – sources of food aerobic saprophytes. This indicator for urban wastewater varies between 106-108. Figure 2.1 shows the indicators determined in the study of the composition of waste water.

2.3 The main provisions of the rules of protection of surface water from wastewater pollution

Correct consideration of the self-cleaning capacity of the reservoir makes it possible economically and justifiably to design the treatment facilities where the wastewater is purified to the required extent. Calculation of the required degree of sewage treatment, discharged into the body of water, is carried out according to the following indicators: by the number of suspended solids, the consumption of dissolved oxygen, the permissible BOD of a mixture of river and sewage, the change in the value of the active reaction of the water of the reservoir, and also the maximum permissible concentrations of toxic impurities and other harmful substances.

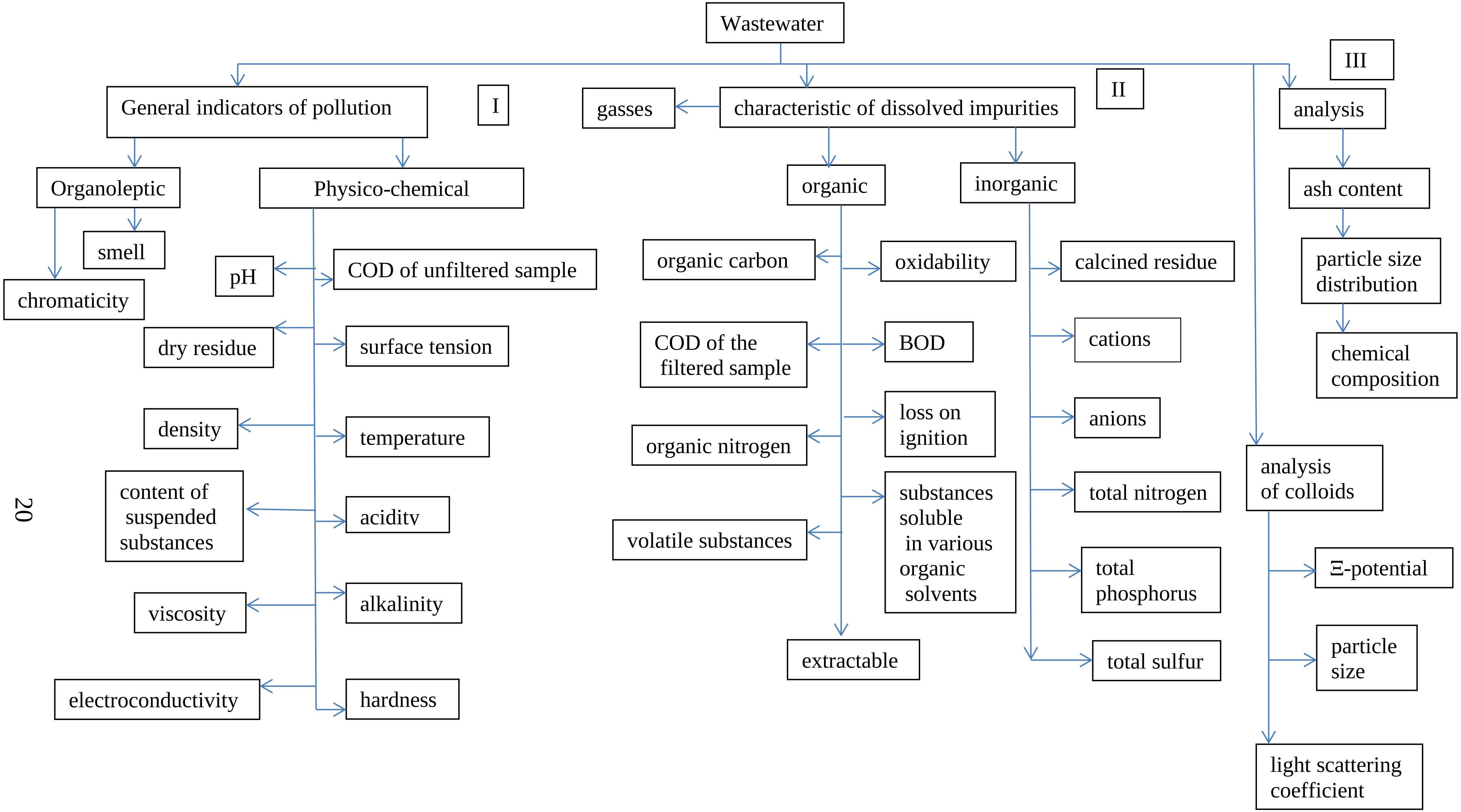


Figure 2.1 - Indicators, defined in the study of the composition of waste water

In Kazakhstan, a system of water quality regulation based on the maximum permissible concentrations (MPC) of harmful contaminants that do not have harmful effects on the human body and the condition of the reservoir as a whole has been adopted. Based on the MPC, designate a set of technological and sanitary measures to prevent pollution of the reservoir when designing and reconstructing industrial enterprises, and also calculate and establish standards for maximum permissible drain (MPD), which when entering the reservoirs do not create a pollution level exceeding the MPC.

Wastewater comes mainly to reservoirs. Wastewater before discharge is to be partially or completely cleaned. As it is known, in the water reservoir contains a certain amount of oxygen that can be partly used for the oxidation of organic matter entering the reservoir together with the waste water. Thus, the reservoir has some self-cleaning ability, i.e. in it, under the influence of microorganisms - mineralizers, organic substances can be oxidized, but the content of dissolved oxygen in water will fall. Consequently, the degree of sewage treatment at treatment plants before discharging them into a reservoirs of water must be reduced.

The stationary volume of various types of natural waters does not give a complete picture of the water resources that humanity can have. All human needs in water are met by freshwater resources, including rivers, lakes and groundwater, the total volume of which is only 0.3% of the hydrosphere. The seeming inexhaustibility of these waters is associated with a very intensive continuous renewal of fresh water in the course of the natural cycle. Thus, the volume of river water resumes on average every 12 days, or more than 32 times during the year. It would seem that the reserve of unused fresh water is great, the concern about the depletion of water resources is premature. However, the volume of pure natural waters polluted by wastewater reaches 5500 km^3 (table 2.1).

The water of rivers, lakes and reservoirs into which wastewater is discharged is not suitable for domestic and drinking water supply. One of the reasons for the depletion of water resources is the pollution of wastewater.

Even for the average assessment of the river by 40% consist of wastewater. As far as river resources are distributed unevenly in the world, in regions with developed industry and agriculture, river water manages to repeatedly go through the anthropogenic cycle of use.

First of all, we define the understanding of certain terms. From the point of view of possible contamination of surface water bodies, the danger is not the process itself, but its quantitative expression.

Table 2.1 - Water consumption for domestic purposes (km^3)

Type of water supply	Water intake from a source	Irreversible consumption	Discharge of wastewater	The volume of clean water contaminated with wastewater
Domestic - drinking	98	56	42	600
Livestock raising	40	30	10	400
Industry	200	40	160	4000
Power Engineering	225	15	210	600

Pollution of surface or ground water is a direct and indirect influence, changing the composition or properties of water. It limits or can limit its use for purposes that the water satisfied in its natural state.

Protection of the natural environment is a complex of legal, organizational and scientifically grounded measures protecting it from pollution, depletion and unjustified losses.

There are two aspects of the integrated use of water resources. The natural aspect determines the interconnection and interaction of water resources with soil, forests and other components of nature. The domestic aspect provides satisfaction and mutual coordination of requirements of various branches of a national economy and establishes sequence and the sizes of satisfaction in water.

The main water protection measures are currently:

– rationing of water consumption and water disposal;

- improvement of production and compliance with technological discipline;
- organization of circulating water supply and in-line production and cycles;
- creation of low- and non-waste production;
- maximum utilization of valuable substances;
- rational allocation of productive forces;
- ecological audit of operating enterprises and technologies.

Negative socio-economic aspects of pollution of the environment and the water basin are as follows:

- general deterioration of the quality of life (deterioration of health, working conditions, etc.);
- loss of working time (for example, due to illness), that is, a decrease in the efficiency of the use of labor resources;
- reduction of the national economic value of labor resources;
- intensification of corrosion processes.

As a rule, the violation of ecological balance occurs as a result of human intervention. Surface waters are considered contaminated if their composition or properties have changed under the influence of direct or indirect, industrial or household activities of the population, as a result of which water has become unsuitable or unsuitable for one or several types of water use.

Sanitary condition of the reservoir is a combination of physicochemical, micro and hydrobiological indicators characterizing the reservoir from the point of view of its use in communal water supply. Water is considered to be suitable for this type of water, if any of the indicators of the composition or properties of the water quality is not broken it after discharge of sewage.

The main documents that regulate the conditions for release of waste water into reservoirs are as follows:

- rules for the protection of surface waters from pollution by waste water;
- rules for the sanitary protection of coastal areas of the seas;
- sanitary rules for river and lake vessels.

All these documents are based on the following basic provisions:

- the restriction for the discharge of waste water into water bodies is not their quality, but the quality of water in the settlement point of water use;
- all normative indicators differ depending on the type of water use and refer to the composition of water in the same settlement point;
- Critical conditions are the worst conditions for possible dilution of wastewater in a reservoir near water use sites;
- allowance is made for the processes of water self-purification, if this process and its dynamics are well studied under specific conditions.

In accordance with the regulations in water bodies prohibited from discharging wastewater:

- which can be eliminated by improving the technology, maximizing use in recycling water supply systems or by installing non-waste productions;
- containing valuable waste or substances that can be disposed;

– containing raw materials, reagents, products and intermediates in quantities exceeding the established norms of technological losses;

- containing substances for which the maximum permissible concentration (MPC) is not established;
- containing cube remnants and technological waste.

The requirements for the conditions for the production of wastewater are distributed:

a) for the existing releases of all types of industrial and domestic sewage of populated areas, separately standing residential and public buildings, communal, medical, transportation facilities, industrial enterprises, including mine waters, waste water from water cooling, oil production, waste water from irrigated and drained territories and other wastewater of any objects irrespective of their departmental subordination;

b) on all projected wastewater releases of newly constructed, projected and expandable enterprises and institutions. According to the Rules for the Protection of Surface Waters, all reservoirs are divided into two categories: water objects for domestic – drinking, cultural - domestic water use and facilities for fishery purposes.

In turn, the first category is divided into objects that are used for centralized and non-centralized domestic - drinking water supply and water supply of food enterprises and facilities that are used for bathing, sports and relax.

The second category is divided into objects that are used to preserve and reproduce valuable fish species that are highly sensitive to oxygen, and objects for all other types of fisheries activities.

The norms given in the Rules refer to the following sections:

- located on flowing water bodies at a distance of one kilometer above the nearest point of water use;
- on inaccessible ponds and reservoirs - to sections located at a distance of one kilometer in all directions from the water use point.

Normative indicators consist of general indicators and indicators for harmful and toxic substances. General indicators include: suspended substances, floating impurities, smells, flavors, color, temperature, pH, mineral composition, dissolved oxygen, biological oxygen demand (BOD), pathogens. Harmful substances are also included in the overall indicators, but since they are very diverse, then MPC is established for each of these substances.

The maximum permissible concentration is established according to the sign of the harmful effect (impact on human health, on the organoleptic properties of water or on the general condition of the reservoir), which is characterized by the lowest threshold or subthreshold concentration. That is, harmful substances are normalized according to the principle of the limiting index of harmfulness (LIH).

LIH is the most likely adverse effect of the lowest concentrations of a harmful substance. LIH shows the direction in which the adverse effects primarily occur.

For example, if as a result of the conducted studies of the substance the threshold of influence on the sanitary condition of the reservoir was found at the level of 2 mg/l, the organoleptic threshold at the level of 0.5 mg/l, and the current concentration for the sanitary-toxicological trait is 0.01 mg/l . In this case, the LIH for this substance will be sanitary-toxicological. Hence this substance is primarily dangerous in terms of its effect on human health, and this danger will manifest itself at lower concentrations, which may have a harmful effect on the sanitary regime of the reservoir and its organoleptic properties.

According to LIH, all harmful substances for water bodies of the first category are divided into three groups:

- substances that have a sanitary-toxicological LIH;
- substances that have a common sanitary LIH;
- substances having an organoleptic LIH.

For fishery water bodies, pollutants can additionally have a fishery and toxicological LIH.

According to the current rules, when discharging waste water with harmful substances into reservoirs, the following condition must be observed:

$$\sum_1^i \frac{c_{act}^i}{c_p^i} \le 1, \tag{2.1}$$

where C_{act}^i - actual or calculated concentration of a substance in the calculation section;

C_p^i – MPC of the substance, that is, the total fraction of the concentrations of substances with the same LIH should not exceed unity. For combinations of substances with different LIH, the condition remains the same, but addition occurs in groups with one LIH. As a result, this leads to the fact that for each individual pollution, the C_{atct}^i will decrease:

$$c_{act} \le c_p \left(1 - \sum_1^i \frac{c_{act}^i}{c_p^i}\right). \tag{2.2}$$

According to the formula, each substance of one group of LIH can be present in the calculated range at a concentration not exceeding the concentration of the right-hand side of the inequality.

Below are the permissible norms for the composition and properties of water in reservoirs at drinking water use points (table 2.2).

The conditions for the discharge of sewage into water bodies are strictly regulated by the "Rules for the Protection of Surface Waters from Pollution by Wastewater " and the "Regulations for the Sanitary Protection of the Coastal Areas of the Seas". All water bodies are divided into use for drinking and cultural - domestic purposes and use for fishery purposes.

The main permissible changes in the composition of water in water objects after the release of treated wastewater in them are shown in table 2.3.

Harmful and poisonous substances are diverse in their composition, and therefore they are normalized according to the principle of the limiting hazard index (LIH), which is understood as the most likely adverse effect of each substance (table 2.4).

Table 2.2 - General requirements for the composition and properties of water for water objects at the points of household - drinking and cultural - domestic water use

Indicators of composition and properties of water	For household - drinking water supply	For bathing, sports, as well as for reservoirs within the boundaries of populated areas
1. Suspended substances	0.25 mg/l	0.75 mg/l
2. Floating impurities	must not be	must not be
3. Temperature	The summer water temperature as a result of wastewater drainage should not increase by more than 3 °C compared to the average monthly temperature of the hottest month in the last 10 years	The summer water temperature as a result of wastewater drainage should not increase by more than 3 °C compared to the average monthly temperature of the hottest month in the last 10 years
4. Coloring	It should not be detected in a column of 20 cm	It should not be detected in a column of 1 cm
5. Reaction	Limits of pH 6.5-8.5	Limits of pH 6.5-8.5
6. Минеральный состав	Should not exceed the dry residue 1000 mg/l, including: chloride 350 mg/l, sulphate 500 mg/l	
7. Dissolved oxygen	Not less than 4 mg/l	Not less than 4 mg/l
8. Biochemical oxygen demand	Not more than 3 mg/l	Not more than 6 mg/l
9. Pathogens of diseases	Must not contain. It is necessary to clean up to the coli-index no more than 1000	Must not contain.
10. Toxic substances	Must not contain	Must not contain

Table 2.3 - The main permissible changes in the composition of water in water bodies after the release of treated wastewater in them

Indicator of composition and properties of water	Requirements for the composition and properties of water in a water body by water use categories and designation			
	household - drinking and cultural- domestic		Fishery	
	I category	II category	I category	II category
Temperature	May be increased by not more than:			
	3 °C in relation to the average monthly temperature of the hottest month		5 °C in relation to the natural temperature of water	
Suspended substances, mg/dm^3	May be increased by not more than:			
	0.25	0.75	0.25	0.75
	For reservoirs containing low water more than 30 mg/dm^3 natural mineral substances content is allowed to increase by 5%			
pH	Should not exceed 6.5-8.5			
Mineral composition	The dry residue should be <1000 mg/dm^3		Not standardized	
The presence of dissolved oxygen	Must be at least 4 mg/dm^3		> 6 mg dm^3	In winter, under ice> 4 mg/dm^3, in summer> 6 mg /dm^3
BOD_{full} at temperature 20 °C, mg/dm^3	Should not exceed			
	3	6	3 (in the winter if the oxygen content is reduced for ponds categories I to 6 mg/dm^3; for ponds II category up to 4 mg/dm^3, it is only allowed to discharge water that does not affect BOD)	

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Table 2.4 - Maximum permissible concentration of harmful substances

Substance	Norm, mg/l	Substance	Norm, mg/l
According to the sanitary-toxicological limit value of harmfulness		According to the sanitary-toxicological limit value of harmfulness	
Aniline	0.1	Ammonia (by nitrogen)	2.0
Benzol	0.5	Cadmium	0.01
Beryllium	0.0002	Caprolactan	1.0
Vanadium	0.1	Copper	0.1
Wolfram	0.1	Nickel	0.1
DDT (dichlorodiphenyl trichloromethylmethane)	0.1	Sulphides	Absence
Molybdenum	0.5	Titanium	0.1
Arsenic	0.05	Chlorine is active	Absence
Naphthol	0.4	Zinc	1.0
Nitrates (in terms of nitrogen)	10.0	According to the organoleptic limiting hazard index	
Rodanides	0.1	Barium	4.0
Ртуть	0.005	Petrol	0.1
Lead	0.1	Iron	0.5
Selenium	0.001	Kerosene	0.1
Strontium	2.0	Oil polysulphide	0.1
Antimony	0.05	Other oil	0.3
Tellurium	0.01	Picric acid	0.5
Fluorine (in compounds)	1.5	Carbon disulfide	1.0
Chlorobenzol	0.02	Phenol	0.001
Carbon tetrachloride	0.3	Chrome (Cr^{+6})	0.1
		Chrome (Cr^{+3})	0.5
		Ethylene	0.5

When evaluating water quality in water reservoirs for drinking and cultural - domestic purposes use three types of LIH: sanitary-toxicological, general sanitary and organoleptic. For fishery reservoirs are used two more types of LIH: toxicological and fishery (table 2.5).

The optimum temperature of the water going for drinking should be no higher than 11 °C and not lower than 7 °C. Water with high temperature contains little soluble gases, so it quenches thirst badly and is unpleasant to taste. The temperature of wastewater in accordance with “Sanitary norms and rules 2.04.03-85” should be not less than 6 °C and not more than 30 °C, since it affects the vital activity of microorganisms leading a biological purification process. At a temperature below 6 °C bioremediation practically stops.

Table 2.5 - Maximum permissible concentrations of certain harmful substances in the water of fishery water bodies

Substance	MPC, mg/l
Ammonia	0.1
Ammonium salt	5.0
Cadmium	0.005
Cobalt	0.01
Magnesium	50.0
Copper	0.01
Arsenic	0.05
Nickel	0.01
Oil and oil products in dissolved and emulsified state	0.05
Lead	0.1
Carbon disulphide	1.0
Phenols	0.001
Chlorine free	Absence
Cyanides	0.05

The smell and taste of water depends on the temperature of the gases dissolved in the water and on the chemical composition of impurities. The intensity of smell and taste is determined by a five-point system (table 2.6).

Table 2.6 - Assessment of the intensity of smell in scores

Intensity of smell	Score
No: no perceptible smell	0
Very weak: found by an experienced researcher	1
Weak: does not attract the attention of the consumer	2
Perceptible: easily detectable, water is regarded as substandard	3
Distinct: attracts attention, makes water unsuitable for drinking	4
Very strong: the smell is so strong that it makes water unsuitable for drinking	5

The quality and intensity of taste and smack determine organoleptic LIH. There are four types of taste: salty, bitter, sweet and sour. The other types of taste are called smacks.

The intensity of taste and smack is determined by a five-point system in the same way as the smell.

The taste and smell of water can change under the influence of wastewater entering the pond. For example, phenol containing in drains, gives the water the taste and smell of carbolic acid.

Natural waters are often turbid due to the presence in them of suspended particles of clay, sand, silt, organic suspensions. Wastewater can increase the turbidity of water. Therefore, the transparency of the water is determined. Pure water, taken in a small volume, is colorless. Other shades indicate the presence in the water of various dissolved and suspended impurities. The cause of the change in water can be colloidal iron compounds, suspended and colored substances of industrial waste and mass development of algae.

Entering reservoirs, harmful substances can accumulate and their concentration, constantly increasing, can reach critical values. Therefore, self-purification of water in reservoirs plays an important role. If not for this help of nature, then despite all the measures applied, the cumulative capacity of harmful substances would have long ago led to the death of reservoirs.

2.4 Calculations of releases and degree of wastewater treatment

Wastewater discharge limits are established on the basis of calculations of the maximum permissible discharge (MPD). The MPD is understood as the mass of a substance in wastewater, the maximum permissible for disposal with the established regime at a given point of a water body per unit of time in order to ensure the quality of water in the calculation line:

$$MPD = q \cdot S, \tag{2.3}$$

where q - the maximum hourly average flow rate, m^3/h;

S - the concentration of contaminants, g/m^3.

In the specific case, when establishing a limit for the diversion of sewage into a reservour and for predicting the degree of contamination of a water body downstream of the projected release, the calculation of the value of the MPD is made on the basis of the balance equation. The balance takes into account the background concentration, hydrological, hydraulic and hydrodynamic features of the water body.

Calculation of MPD is held by the largest average hourly costs of the actual wastewater effluent period of descent. The concentration *S*, necessary for the calculation of the MPD at the wastewater discharge within the boundaries of the village, take the value of not more than MPC meet the requirements established for the composition and properties of water bodies of water in places of water use.

When calculating the degree of wastewater treatment, it is assumed that the dilution rate *n*, characterizing the intensity of dilution of effluents by the water of the reservoir, is known. For flowing water bodies, this value can be determined through the flow of water or by the concentrations of individual pollutants:

$$n = \frac{a \cdot Q + Q_0}{Q_0}, \tag{2.4}$$

where Q_o – consumption of wastewater;

Q - consumption water of the reservoir;
a - a coefficient that depends on the hydraulic mixing conditions.

$$n = \frac{C_t - C_r}{C - C_r}, \tag{2.5}$$

where C_t - concentration of pollution in treated wastewater;
C_r - concentration of pollution in the water of the reservoir before discharge of effluents (background concentration);
C - concentration of pollution in the calculated range.

In other words, this is the ratio of excessive pollution concentrations at the point of discharge of effluents to similar concentrations in the section under consideration.

For non-current reservoirs, the Ruffel and Lapshev method is used. The method is applicable for dispersing and concentrated discharges with a flow velocity greater than 2 m/s. It is assumed that the outlet is located away from the shore, and the depth at the outlet of more than 30 diameters of the outlet. The smallest dilution at a distance:

$$n = A\cdot(0,21\cdot L/d_o)^{p\cdot s}, \tag{2.6}$$

where A - the parameter that determines the dilution with a scattering output (for concentrated A=1);
L - the distance from the outlet to the calculated line;
p - a parameter that depends on the degree of flow of the reservoir and the load on it in the drains;
s - a parameter determined by the relative depth of the reservoir.

If we know the speed of flow in the pond:

$$p = V_n(0,000015V_0+V_n), \tag{2.7}$$

where V_n - the speed of flow;
V_o - the speed outflow of effluents.

The value of S depends on the depth H at the point of release:

$$S = \frac{0.6325\cdot H}{360+(\frac{V_n}{V_0})^{10^5}} + 0.875. \tag{2.8}$$

When determining the possibility of draining the wastewater of a projected enterprise in a reservoir, first of all, the degree of dilution of wastewater by river water is calculated. Dilution of wastewater is a process of reducing the concentrations of pollutants in watercourses and reservoirs, resulting from the mixing of wastewater with natural waters. The intensity of the dilution process is qualitatively characterized by the degree of dilution, which is determined by the formula:

$$n = \frac{\gamma Q + q}{q}, \tag{2.9}$$

where n - the degree of dilution of wastewater by river water;

Q - consumption of river, m^3/s;

q - estimated wastewater consumption, m^3/s;

γ - coefficient of displacement.

The displacement coefficient is always less than one. As far as the influence of wastewater is estimated at the nearest water use point, this point also needs to determine the degree of dilution. The consumption of the river is a geometric characteristic. It is determined empirically by the relevant hydrogeological organizations. Since the rivers have not the same runoff, both over the years and during the year, the worst conditions are taken for calculations, i.e. the smallest average monthly consumption at 95% of the provision. At 95% provision of the annual water runoff, low-water years on the river occur once in 20 years.

During the design, the average monthly consumption of the river and the displacement coefficient are taken from the hydrometric service data, and the wastewater consumption is determined by calculation or by analogy with an operating enterprise of similar profile.

After determining the degree of dilution of wastewater, it is necessary to consider the possible deterioration of the quality of water in a river or in another reservour of water as a result of discharging wastewater into it.

Normative indicators of water quality depend on the presence of suspended substances, floating substances, taste, color, temperature, pH, mineral composition, dissolved oxygen, BOD, pathogens, poisonous and harmful substances.

2.4.1 Determination of the degree of wastewater treatment from suspended substances.

The required degree of wastewater treatment according to the content of suspended substances is determined by the formula:

$$E_{SS} = \frac{C_{WW}^{SS} - C_0^{SS}}{C_{WW}^{SS}} \cdot 100\%, \tag{2.10}$$

where E_{ss} - the required degree of purification,%;

C_{ww} - initial concentration of suspended substances in the wastewater before purification, mg/l;

C_o^{ss} - the calculated concentration of suspended substances in treated wastewater before discharge into the reservoir, mg/l.

The calculated concentration of suspended substances in treated wastewater before discharging them into a reservour of water is determined by the formula:

$$C_0=C_{ss}-C_p\ , \qquad (2.11)$$

where C_{ss} - the concentration of suspended substances in the river's water before discharge of wastewater, mg/l;

C_p - permissible increase in the content of suspended matter in the river after discharge of wastewater, mg/l, for reservoirs in drinking water supply of food enterprises C_p=0.25 mg/l, and for fishery reservoirs and reservoirs of cultural-domestic use C_p = 0.75 mg/l.

2.4.2 Calculation of the degree of wastewater treatment according to BOD of a mixture of river water and wastewater.

When wastewater enters rivers and reservours, the decrease in the concentration of organic substances, expressed in BOD, is due to not only dilution, but also self-purification.

The concentration of wastewater, in which the BOD of the river's water at the nearest point of water use below the runoff of wastewater will not be more than the accepted standards, are found by the formula:

$$L_o = \frac{n-1}{10^{-KT}}\left(L_p - L_{rw}\right) + \frac{L_p}{10^{-KT}}\ , \qquad (2.12)$$

where L_p - the maximum allowable BOD value of a mixture of wastewater and river water, equal to 4 mg/l;

L_{rw} - BOD of river water before wastewater discharge, mg/l;

K - constant rate of oxygen consumption by wastewater;

T - time of water flow from the discharge site to the calculated site, day.

When solving the equation, the values are difficult to calculate, so tables 2.8 and 2.9 are compiled, in which the limits K and T are adopted, which cover all cases of practical importance.

If the calculated L_0 is greater than the actual BOD of the L_{ww} wastewater to be discharged into the river, biological treatment of the wastewater is not required.

If L_0 is less than the BOD of sewage L_{ww}, then biological treatment before discharge into the body of water is mandatory until the calculated value.

The required degree of wastewater treatment and river water by BOD is determined in this case by the formula:

$$E_{BOD} = \frac{L_{ww}-L_0}{L_{ww}} \cdot 100\%\ , \qquad (2.13)$$

where L_{ww} - the total biochemical demand of waste water in oxygen, mg/l.

When calculating the oxygen regime of a reservour of water, it starts with absorption of dissolved oxygen by wastewater of river water in the place of their descent. If the amount of dissolved oxygen in the river water is not lower than 4 mg/l for the first two days, the reduction will not occur in the future. The formula for determining the calculated dissolved oxygen concentration of wastewater is as follows:

$$C_c = \frac{n-1}{0.4}\left(C_r - 0.4C_{BOD} - C_p\right)\cdot\frac{C_p}{0.4}, \tag{2.14}$$

where C_c - the calculated concentration of dissolved oxygen of waste water, mg/l;

Cr - the content of dissolved oxygen in river water before discharge of sewage, mg/l;

C_{BOD} - biological need of river water in oxygen, mg/l;

C_p - the maximum permissible concentration of dissolved oxygen, which should be in the calculated discharge of wastewater, 4 mg/l;

0,4 - factor for recalculation of total oxygen consumption in a two-day.

Table 2.7 - Value of K at different temperatures of river water

°C	K	°C	K	°C	K
0	0,04	15	0,08	24	0,12
5	0,05	18	0,09	26	0,13
9	0,06	20	0,1	28	0,14
12	0,07	22	0,11	29	0,15

Table 2.8 - The value of the value 10^{-KT} with the variables K and T

K	T, day									
	0,25	0,5	1	1,5	2	2,5	3	4	5	6
0,04	0,981	0,955	0,912	0,87 1	0,83 2	0,79 4	0,759	0,692	0,631	0,57 5
0,06	0,966	0,933	0,87 1	0,813	0,76 9	0,70 8	0,661	0,57 5	0,50 1	0,487
0,08	0,955	0,91 2	0,83 2	0,76 9	0,692	0,63 1	0,557	0,48 9	0,40 8	0,331
0,11	0,944	0,89 1	0,794	0,70 8	0,63 1	0,57 2	0,50	0,39 8	0,31 6	0,25 1
0,12	0,933	0,87 1	0,75 9	0,661	0,57 5	0,50 1	0,436	0,33 1	0,25 1	0,19 1
0,14	0,91 2	0,85 1	0,72 4	0,617	0,52 5	0,447	0,332	0,275	0,20 0	0,14 5
0,16	0,912	0,83 2	0,692	0,57 5	0,47 9	0,39 8	0,331	0,19 9	0,15 9	0,11 0
0,18	0,903	0,81 3	0,66 1	0,537	0,437	0,355	0,288	0,19 1	0,12 6	0,08 3
0,20	0,891	0,79 4	0,631	0,50 1	0,393	0,31 6	0,25	0,16 8	0,10 0	0,06 3
0,22	0,88 1	0,77 0	0,60 3	0,47 8	0,36 3	0,28 3	0,219	0,132	0,07 9	0,04 9
0,24	0,87 1	0,75 9	0,575	0,437	0,35 1	0,25 1	0,191	0,11 0	0,063	0,036
0,26	0,86 1	0,74 1	0,55 0	0,407	0,302	0,22 4	0,16	0,09 1	0,05 0	0,02 5
0,28	0,85 1	0,72 4	0,52 5	0,38 0	0,27 5	0,19 9	0,145	0,07 6	0,03 6	0,02 1
0,30	0,84 1	0,70 8	0,50 1	0,33 5	0,25 1	0,17 8	0,127	0,06 3	0,032	0,01 0
0,40	0,79 4	0,63 1	0,39 8	0,251	0,15 8	0,10 0	0,063	0,04 9	0,01 0	0,00 4
0,50	0,75 0	0,565	0,31 6	0,17 8	0,10 0	0,05 6	0,032	0,03 2	0,00 3	0,00 1

If the calculated concentration less than that which is characteristic of the slope projected to the wastewater, i.e. less L_{ww}, then they must be cleaned. Then the required degree of purification is determined by the formula

$$E_{BOD} = \frac{L_{ww} - C_c}{L_{ww}} \cdot 100\% \ . \qquad (2.15)$$

Calculation of the oxygen regime of wastewater and the required degree of their purification according to the dissolved oxygen content is performed to determine contamination of wastewater with organic substances.

2.4.3 Calculation of the degree of wastewater treatment by pH change.

According to the general requirements for the composition and properties of water in reservoirs at points of cultural - domestic water use, the reaction (pH) should not exceed beyond the limits 6.5 ... 8.5.

The permissible concentration of acid in waste water is found by the formula:

$$C_{pc} = (n-1)X_a \ , \qquad (2.16)$$

where X_a - the maximum amount of acid, which can be added to 1 liter of river water, mg-eq/l (found according to Cherkinsky's schedule).

The required degree of wastewater treatment from the acid is determined by the formula:

$$E_a = \frac{C_a - C_{pc}}{C_a} \cdot 100\%, \qquad (2.17)$$

where C_a - the acid content in the wastewater mg-eq/l.

2.4.4 Temperature calculation of wastewater before discharging into a reservoir.

The calculation is made taking into account the sanitary requirements: the summer temperature of the river water should not increase as a result of draining the wastewater by more than 3 °C.

The maximum permissible temperature of wastewater is determined by the formula:

$$t_{ww} = \left(\frac{\gamma Q}{q} + 1\right) \cdot t_p + t_{max}, \qquad (2.18)$$

where t_p - the permissible temperature increase (3 °C);

t_{max} - maximum temperature of river water in the warmest month before the discharge of sewage.

We compare the obtained value with the temperature of the wastewater. If the temperature of wastewater is less than the calculated value, special measures to reduce the temperature of the wastewater are not necessary. If the temperature of wastewater is more than calculated, it is necessary to cool the wastewater before discharging them into the reservoir.

2.4.5 Calculation of the degree of wastewater treatment from harmful substances.

If the wastewater contains several harmful substances, then all the components in the waste water are divided into groups with the same LIH.

For example, in wastewater there are arsenic, mercury, lead, nickel, zinc.

In table 1.2, we determine that arsenic, mercury and lead belong to the group of substances of sanitary-toxicological LIH, and nickel and zinc belong to the group of substances of general sanitary LIH.

Then we determine the sum of the ratios of the concentrations of the substances of each group in the waste water to their maximum permissible concentrations:

$$\frac{C_{ww1}}{MPC_1} + \frac{C_{ww2}}{MPC_2} + \cdots + \frac{C_{wwn}}{MPC_n} = C_{ww.} \qquad (2.19)$$

After this, we calculate the sum of the ratios of the concentrations of these substances in the water of the reservoir before the wastewater is discharged to their MPC:

$$\frac{C_{s1}}{MPC_1} + \frac{C_{s2}}{MPC_2} + \cdots + \frac{C_{sn}}{MPC_n} = C_s. \qquad (2.20)$$

And determine the required degree of purification according to the formula:

$$E = \left(1 - \frac{(n-1)C_s}{C_{ww}}\right) \cdot 100\%. \qquad (2.21)$$

2.4.6 Conditions for discharge wastewater into reservoirs.

The conditions for the discharge of sewage into water bodies are determined by the "Rules for the Protection of Surface Waters from Pollution by Wastewater " and the "Regulations for the Sanitary Protection of the Coastal Areas of the Seas".

In accordance with these rules, reservoirs of drinking and cultural-domestic water use and reservours used for fishery purposes are distinguished.

Water reservoirs for drinking and cultural - domestic water use. Norms of water quality in the areas of these reservoirs used are established according to two types of water use:

- the first one - for centralized and non-centralized drinking water supply, as well as water supply for food industry enterprises;

- the second - for bathing, sports and recreation of the population.

The second type of water use also includes sections of reservoirs located within the boundaries of settlements.

The following normative indicators of the water quality of the reservoir have been established.

Dissolved oxygen. The amount of oxygen dissolved in the water reservoir after mixing wastewater with it in any period of the year in the sample taken at 12 noon of the day should not be less than 4 mg/l.

Biochemical oxygen demand. BOD_{20} for water bodies of the first type of water use should not exceed 3 mg/l, and for water bodies of the second type of water use - 6 mg/l.

Suspended substances. The content of suspended solids in the water of the reservoir after the discharge of wastewater into it should not increase by more than 0.25 mg/l for water bodies of the first type of water use and more than 0.75 mg/l for water bodies of the second type of water use.

Active reaction of water. The active reaction of the water of the reservoir (pH) after mixing with it of wastewater should be not less than 6.5 and not more than 8.5.

For the water of reservoirs, there are also normative indicators for coloring, the presence of toxic substances, floating impurities, pathogens, smells and smacks, mineral composition and temperature. Poisonous substances should not be contained in concentrations that may have a direct or indirect adverse effect on the health of the population.

Fisheries reservoirs. There are two types of use of such reservoirs:

the first - for the reproduction and conservation of valuable fish species,

the second - for all other fishery purposes.

Water quality indicators of fishery reservoirs must comply with the norms established reservoirs for drinking and cultural - domestic water use. At the same time, according to some indicators, higher demands are placed on the water of fishery reservoirs. In winter, the amount of oxygen dissolved in the water of fishery water reservoirs of the first type of use should not be less than 6 mg/l, and the water-soluble pool of the second type of use - 4 mg/l. The biochemical oxygen demand of BOD_{full} should not exceed 3 mg/l.

The content of radioactive substances in the water of any reservoirs near the places of release of wastewater polluted by them should not exceed the maximum permissible concentrations established by the Main State Sanitary Inspectorate.

The required degree of wastewater treatment is determined by the number of suspended solids contained in them, the consumption of dissolved oxygen by a mixture of wastewater and water in the reservoir, the permissible BOD of the mixture of pond waters and wastewaters, the change in the active reaction of the reservoir water and other indicators, taking into account the self-cleaning capacity of the reservoir.

The self-cleaning ability of reservoirs is understood as a reduction in the concentration of contaminants due to biochemical, chemical and physical processes taking place in the reservoir.

2.5 Methods for wastewaters purification

Mechanical cleaning is performed to separate insoluble impurities from wastewater. In structures for mechanical cleaning, the heaviest and largest slurries are first identified, followed by the main masses of insoluble contaminants. The following methods are used for this:

1) Percolation - the retention of the largest contaminants and partially suspended substances on gratings and sieves.

2) Settling - isolation from suspended waters of suspended solids under the action of gravity on sand grains (for the isolation of mineral impurities), sumps (for the retention of smaller settling and floating impurities), as well as oil traps, oil- and resin- traps. A variation of this method is centrifugal settling, used in hydrocyclones and centrifuges.

3) Filtration - the retention of a very fine suspension in a suspended state on screened and granular filters.

In the case of uneven generation of industrial wastewater before feeding to treatment facilities, they are averaged over the flow and concentration in averagents of different designs.

The settling method, together with the fermentation of precipitation, is used in combined installations for the purification of small amounts of wastewater on septic tanks, two-level settling sump and clarifier- digestion.

At present, as an independent method, mechanical cleaning is rarely used. This possibility exists, if using only mechanical cleaning, the discharged water in the reservoir acquires the required quality, which ensures its return to the technological process.

In general, mechanical cleaning is used as a preliminary step before biological treatment or as a post-treatment of effluents.

Biological wastewater treatment is carried out for the extraction of dissolved and colloidal organic substances during their oxidation or reduction with the help of microorganisms capable of performing their mineralization in the course of their vital activity. It can occur in natural and artificial conditions.

The biological treatment facilities under natural conditions are divided into filtration (biological ponds and oxidation channels). In the first, wastewater is filtered through soil containing aerobic bacteria that receive oxygen from the air, in the second, wastewater flows through a reservoir where oxygen is supplied by reaeration or mechanical aeration.

In artificial conditions, bio-and aerofilters, aerotanks, compact units with mechanical aeration are used. Wastewater treatment in these facilities is more effective, because they provide artificial conditions for providing more favorable conditions for the life of microorganisms (mainly due to the large intake of oxygen in the air).

The essence of the process of biological wastewater treatment is that in the process of filtration through soil or granular loading, organic wastewater pollution is retained on it, forming a biological film inhabited by a large number of microorganisms. The film adsorbs colloidal and dissolved substances, a fine suspension, and they are converted into mineral compounds by aerobic bacteria in the presence of oxygen. Atmospheric air penetrates well into the soil to a depth of 0.2 - 0.3 m, where the most intensive biochemical oxidation takes place.

Nitrogen of ammonium salts is converted into nitrates and nitrites, and organic carbon - into carbonic acid. At great depths, where the penetration of air is difficult, oxidation occurs due to denitrification, i.e. due to the oxygen released during the decomposition of nitrites and nitrates. Practically the wastewater treatment process takes place in a layer up to 1.5 m. The indicator of the intensity of the wastewater treatment process in individual wastewater treatment plants is their oxidative capacity, i.e. the number of grams of oxygen obtained from 1 m^3 of construction per day and used to reduce BOD wastewater, the oxidation of ammonium salts to nitrates and nitrites, and to increase the content of dissolved oxygen in them.

Biological purification can be used with the following indicators of sewage quality: pH - within the limits of 6.5 - 8.5; temperature - within the limits of 6 - 30 °C; salt content - up to 10 g/l; the content of harmful substances that can adversely affect microorganisms should not exceed the established MPC; the ratio of BOD/COD = 1.2; the absence of undissolved resins, oils and fuel oil in the treated water; BOD_{20} - up to 500 mg/l, and for aerotanks with dispersed discharge of wastewater - up to 1000 mg/l; the ratio of biogenic elements to every 10 mg/l BOD_{20} wastewater should be not less than: phosphorus - 1 mg/l and nitrogen - 5 mg/l.

Physico-chemical methods are used mainly for the purification of industrial wastewater, and the treatment of urban wastewater, taking into account technical and economic indicators, is used very rarely.

Methods of physico-chemical treatment of industrial wastewater include: reagent purification, sorption, extraction, evaporation, degassing, ion exchange, ozonation, electroflotation, chlorination, electrodialysis, etc.

For the treatment of industrial wastewater, flotation is also used, introducing air and foaming agents (surfactants, alumina, animal glue, etc.) into the effluent. Floating air bubbles and particles of foaming agents absorb the contaminants and lift them to the surface of the liquid in the form of a foam that is continuously removed.

Industrial wastewaters from technological processes very often contain alkalis and acids. Most acidic effluents contain soluble salts of heavy non-ferrous metals, which must be separated from the waste water.

Acidic and alkaline wastewater is subjected to chemical purification to prevent:

- corrosion of sewage treatment plant materials;
- violations of biochemical processes in water bodies;
- sedimentation from wastewater of salts of heavy metals.

Chemical cleaning can be used as an independent method before the supply of industrial wastewater to the circulating water supply system, as well as before running them into reservoirs.

Sometimes the problem arises of removing from the waste water the biogenic elements - nitrogen and phosphorus, which, getting into the reservoir, contribute to the enhanced development of aquatic vegetation. Nitrogen is removed by physico-chemical and biological methods, phosphorus is usually removed by chemical precipitation using iron, aluminum or lime salts.

The use of chemical purification in a number of cases is advisable before biological or physico-chemical purification. The main methods of physico-chemical treatment of industrial wastewater are neutralization and oxidation.

Acid and alkaline wastewater before being discharged into industrial wastewater or reservoirs should be neutralized before reaching pH value of 6.5-8.5. When neutralizing wastewater, it is allowed to mix acidic and alkaline wastewater for their mutual neutralization.

Neutralization is the chemical reaction between an acid and a base. Neutral wastewater has pH of 6.5-8.5. The wastewater with pH <6.5 and pH>8.5 is subjected to neutralization.

A great danger is represented by acidic effluents, which are formed much more than alkaline. In chemical cleaning, the following neutralization methods are used:

- mutual neutralization of acidic and alkaline wastewater;
- neutralization with reagents;
- filtration through neutralizing materials.

The choice of neutralization method depends on many factors: the type and concentration of acids polluting the industrial effluent, the rate and mode of supply of waste water for neutralization, the presence of reagents, the local conditions in which the cleaning takes place, etc.

As a rule, the regimes for discharging wastewater containing acids and alkalis are different. Acidic waters are usually discharged within a day evenly and have a constant concentration, alkaline waters are discharged periodically as they accumulate. In this regard, for the alkaline water is often arranged a regulating tank. The volume of the reservoir is determined by the daily intake of alkaline water. From this tank alkaline water is evenly discharged into the reaction chamber where mutual neutralization takes place.

3 Mechanical cleaning facilities of wastewater

3.1 Gratings

Gratings are used for the detention of large and fibrous materials from the wastewater and the facilities are pre-cleaning. The main element of the grids is a frame with a row of metal rods parallel to each other and creating a plane with gaps through which water is filtered. Rods of rectangular, rectangular with a rounded part, round and other forms are used for the device of gratings.

Rods of rectangular shape are used more often than others. The thickness of the rods is usually 6-10 mm, the width of the clearances between the rods is usually taken to be 16 mm. Gratings can be installed on the main pumping station, in this case the width of the clearances will be 20 - 60 mm, and this depends on the brand and size of the pumps.

Gratings are set to channel expansion, called cameras. Movement of water occurs by gravity. The gratings are divided into vertical and inclined, as well as movable and fixed. Gratings are cleaned by rakes. For easy removal of dirt, gratings are often installed at an angle to the horizon: α =60-70°. With a large number of trapped waste (more than 0.1 m^3/day), their removal and recovery from water - is mechanized. The detained pollution is crushed on special crushers, and then either dumped into the water flow, or transported to the methane tanks for fermentation.

The size of the gratings is determined from the condition of ensuring in the gaps of the gratings an optimum speed of 0.8-1.0 m/s at the maximum flow of wastewater. At higher speed, the trapped contaminants are "pushed" through the gratings. At a lower velocity in the broadened portion of the channel front grating begin to precipitate coarse fractions of sand.

Based on the total width of the gratings, the necessary number of working gratings is selected. In addition, 1-2 reserve gratings are installed and provide a bypass channel for passing water in the event of an emergency clogging of gratings.

Hammer crushers are used to crush garbage extracted from sewage. They work when supplying technical water in them at a rate of 40 m^3 per 1 ton of waste.

3.2 Sand trap

Sand traps. Insoluble substances (sand, slag, glass crumb, etc.) of 0.15-0.25 mm in the waste water can accumulate in sumps, methane tanks, thereby reducing the productivity of these structures. Sediment containing sand is poorly transported through pipelines.

Sand traps are used for preliminary separation of undissolved mineral impurities (sand, slag, glass combat, etc.) from wastewater under the influence of gravity.

In the direction of water movement, the sand traps are divided into horizontal, vertical, and rotational fluid. The latter type is divided into tangential and aerated.

Horizontal sand traps are elongated in terms of structures with a rectangular cross-section (figure 3.4). The most important elements of the sand trap are:

- input and output channels;
- a bunker for collection of sediment, located at the beginning of the sand trap;
- in addition, in the sand trap there is a mechanism for moving the sediment into a bunker and a hydroelevator for sand removal.

In addition, hydromechanical systems are used to move the sediment. They are flushing pipelines with sprays laid along the bottom in trays. A variation of this type of sand traps is the sand trap with a circular movement of the liquid. Horizontal sand traps are used at a flow rate of more than 10000 m^3/day, and horizontal sand traps with a circular motion up to 70000 m^3/day.

The horizontal sand trap consists of a flowing and sedimentary part.

Length of the flowing part, m:

$$L=\upsilon\cdot t\ , \qquad (3.1)$$

where υ - the speed of the liquid at the maximum flow rate;

t - the residence time of the liquid in the sand trap, taken for at least 30 s.

The area of the live section of the sand trap, m^2:

$$w=q/\upsilon, \qquad (3.2)$$

where q- the maximum flow rate of wastewater, m^3/s.

The required number *n* of compartments is determined by setting the working depth *h* and the width of each compartment *b*. The working depth *h* is assigned somewhat more than the depth of the flow in the supply channel, but not more than 1 m. The width *b* is usually 0.5-2 m.

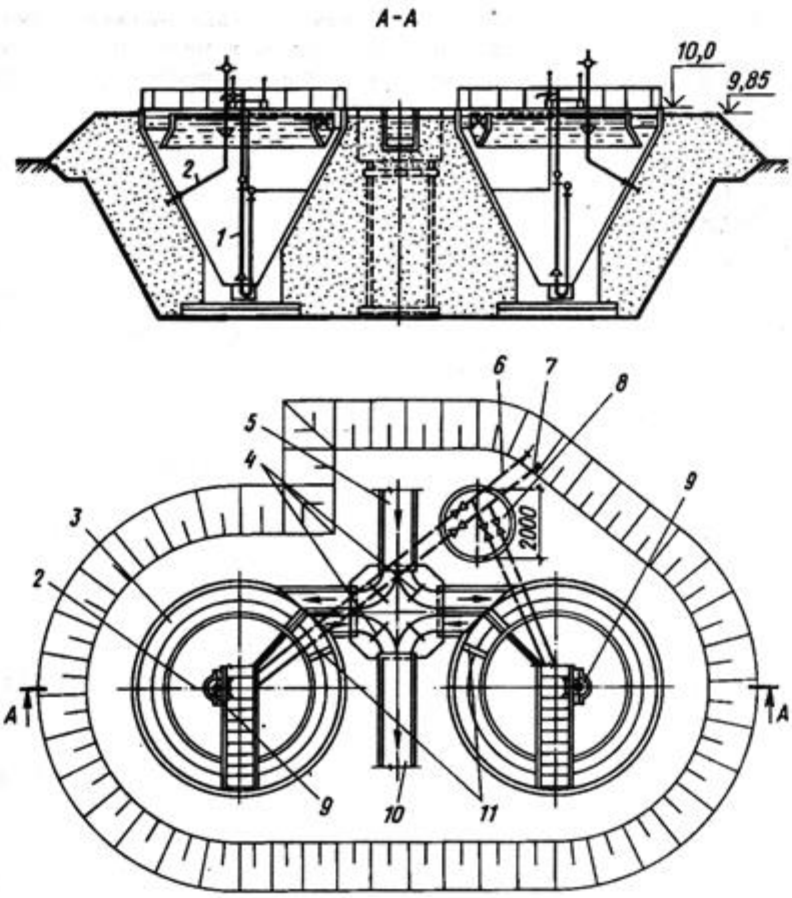
The volume of the sedimentary part of the horizontal sand trap *m* is determined by the conditions of accumulation in it of a two-day volume of precipitating sand.

A horizontal sand trap with a circular movement of water is shown in figure 3.1.

The ring tray, through which the wastewater passes, works like an ordinary horizontal sand trap. The precipitating sand accumulates in the conical part of the sand trap, where it is removed by a hydroelevator located in the center of the sand trap.

Vertical sand traps successfully operate at a number of sewage treatment plants. Sand traps have a cylindrical shape with a water supply on the tangent from two sides, and the outlet - a ring tray.

Tangential sand traps have a circular in plan shape and tangential water supply, which provides a helical fluid motion along the tangent to the walls of the sand trap. On the periphery, water moves down, and in the center - up. The area of application of tangential sand traps is at flow rate of wastewater to 75000 m^3/day.



1 - hydroelevator; 2 - pipeline for the removal of floating impurities;
3 - trough; 4 - watergate; 5 - supply tray; 6 - slurry pipeline;
7 - pipeline for working liquid; 8 - switch camera; 9 - a device for collecting pop-up impurities; 10 - outlet tray; 11- semisubmersible shields.

Figure 3.1 - Horizontal sand trap with circular movement of water

Aerated sand traps are elongated in plan and rectangular, polygonal or close to elliptical cross-section. Along one of the walls of the sand trap is laid an aerator of perforated pipes at a depth of 2/3 of the total depth. Due to this, the flow acquires a rotational movement with its movement at the bottom from one wall to the other. The summation of translational and rotational movements leads to a helical motion of water along the sand trap. The longitudinal speed is 0.05-0.10 m/s, the rotational speed is 0.3 m/s. Aerated sand traps are used at an flow rate of more than 20000 m^3/day. The advantages of this sand trap include the stability of work with changes in consumption and good washing of sand from organic materials.

A more rational method of treating sediment from sand trap is washing, dehydrating and drying sand and then using it in construction. To do this, can use special sand bunker, adapted for the subsequent loading of sand into vehicles. Such bunkers are calculated for 1.5-5 days storage of sand.

3.3 Sumps

Sumps. Settling is the simplest, least labor-consuming and cheapest method of separating coarse dispersive impurities from the waste water, the density of which differs from the density of water. Under the influence of gravity, contaminants settle to the bottom or float to the surface.

Settling facilities used in sewage treatment facilities are classified as:

a) for the technological role:

- primary sumps (for clarification of waste water);
- secondary sumps (for settling water that has undergone biological treatment);
- tertiary sumps (for post-treatment), sludge compactors, sediment collectors;

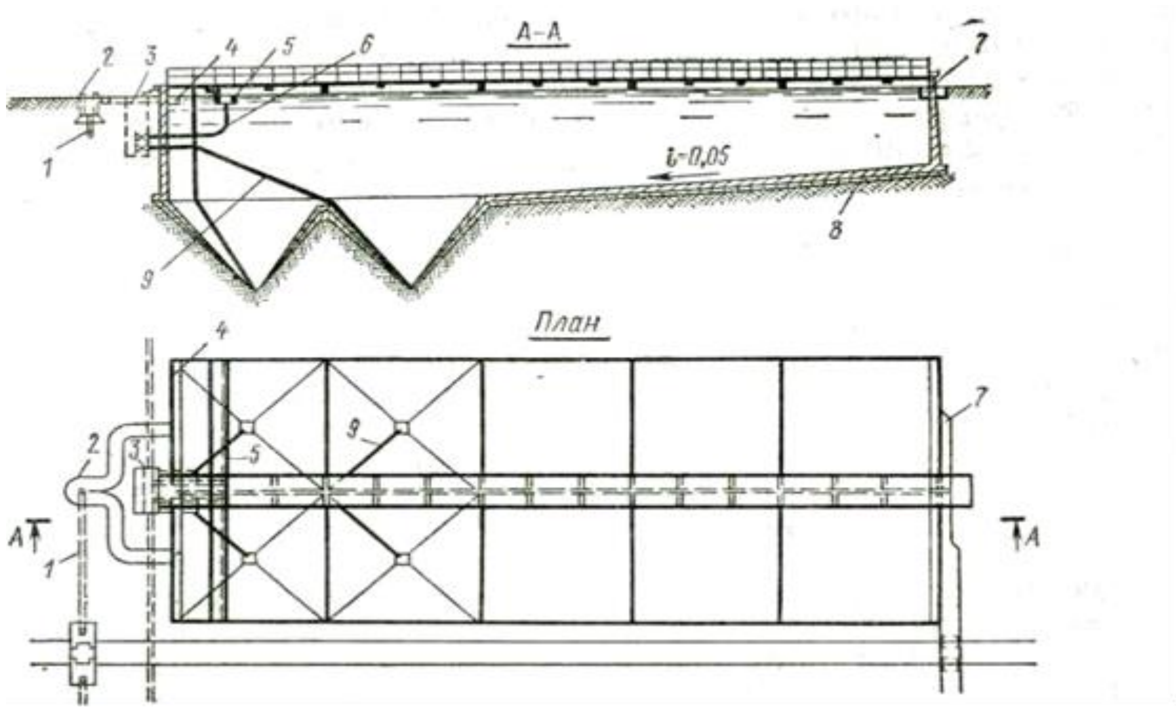
b) in the direction of flow of water:

- vertical;
- horizontal;
- radial (varieties: with central, peripheral and radial mobile water inlet);
- inclined thin-layered (depending on the scheme of movement of water and sediment are co-current, countercurrent and cross).

Horizontal sumps (figure 3.2) are applied on the sewage treatment plants productivity 15-100 thousand m^3 /day. They are rectangular in plan reservoirs, separated by longitudinal partitions into several compartments. The flow of water in them moves horizontally. The advantages of horizontal sumps include the possibility of their blocking with aerotanks. Disadvantages - increased consumption of reinforced concrete in comparison with round sedimentation tanks and unsatisfactory work of mechanisms for raking up the sediment, especially in winter.

Vertical sumps are used in treatment plants productivity of 2-20 thousand m^3/day. They are round in the plan reservoirs with a conical bottom, in which the stream of clarified water moves in a vertical direction. Vertical sumps are with a central inlet of water, with a descending-ascending movement of water, with a peripheral inlet of water.

Vertical sumps with a descending-ascending movement of water are more perfect. Wastewater enters in the central part of the sump and is distributed over the area of the clarification zone through the jagged weir where the downward movement of the water flow occurs.



1 - sag pipe; 2 - distribution camera; 3 - sludge well; 4 - supply tray;
5 - fat tray; 6 - a fatty pipe; 7 - collecting tray; 8 - bottom; 9 - sludge pipe.

Figure 3.2 - Horizontal sump

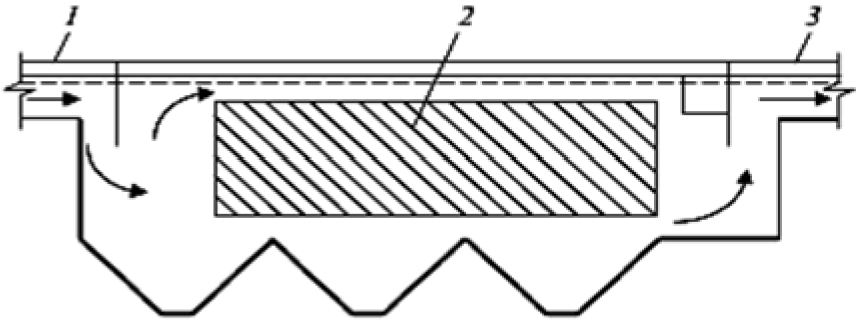
Calculation of horizontal tanks is to determine the size of the flow (sludge) and sedimentary units. Main weight of suspended substances has time to drop out before water enters the annular zone, where the water is bleached and collected by the peripheral tray. The clarification effect in such sumps is 60--65%. Advantages of vertical sumps are simplicity of construction and convenience in operation, a disadvantage is the great depth of structures.

Radial sumps have a circular shape of reservoirs in plan. In them wastewater flows to the center of the sump and moves radially from the center to the periphery. The speed varies from the maximum at the center to the minimum significance at the periphery. The formed sediment moves to the sludge pit with scrapers located on a rotating farm. The diameter of typical radial sumps is 18-50 m. They are used in sewage treatment plants with a productivity of over 20 thousand m^3/day. The lightening effect reaches 50-60%. The advantages of radial sumps include ease of operation and low specific material consumption. The disadvantage is a decrease in the coefficient of volume use due to high speed gradients in the central part.

At present, shelf or thin-layer sumps are very widespread. They have a water distribution, sedimentation, water catchment and sedimentary zones (figure 3.3).

The settling zone is divided in height by shelves with a distance between them up to 15 cm. The sediment slides into the silt pit, from where it is periodically removed. Pop-up substances are collected in the bosom between the sections and are removed through the tray. A number of constructions of thin-layer sumps are known.

Bioflocculation - a method of intensifying the sedimentation process, which consists of adding active sludge (biofilm) to the wastewater and aerating the resulting mixture. At the same time, the efficiency of clarification increases to 60-80%, and the decrease in BOD - by 40-50%. Bioflocculation is carried out in facilities such as pre-aerators and bifloculators.



1 - supply of sewage; 2 - thin-layered block; 3 - tap of clarified water.

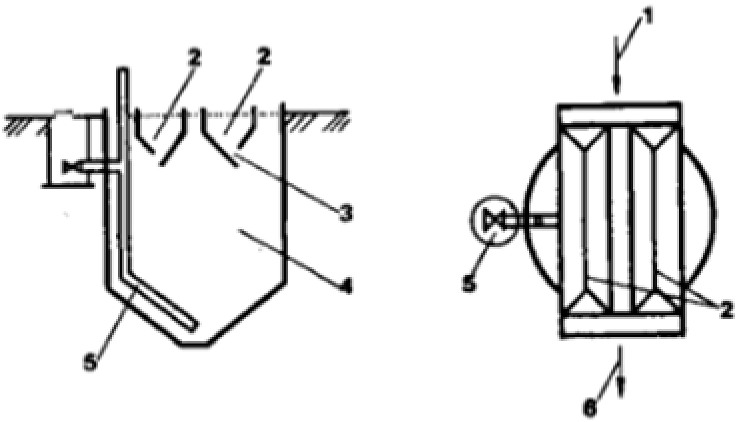
Figure 3.3 - Horizontal sump with thin-bed blocks

The pre-aerators are made of the form separate, built-in or attached to the primary settling facilities. Preliminary aeration increases the clarification effect by 10-15%.

Bio flocculators are created on the base of horizontal, vertical and radial sumps. For this, aerators are equipped in them, so that a suspended layer forms in the settling zone, which facilitates clarification of the wastewater filtered through it.

The two-stage sumps are cylindrical or rectangular with a conical or pyramidal bottom (figure 3.4).

Wastewater comes after the gratings and sand traps in the sumps. The clarification zone in the two-tier sumps is located in the troughs in the upper part of the structure and is a horizontal sedimentation tanks.



1 - wastewater supply; 2 - sedimentary troughs; 3 - longitudinal slits;
4 - septic part; 5 - sludge pipe; 6 - production of clarified water.

Figure 3.4 - Two-stage sump

The precipitated suspended substances flows through the longitudinal slots into the septic part of the sump, where the sediment is compacted and fermented. The lower faces of the gutters overlap each other by 0.15 m, which prevents contamination of clarified water by rotting products released during the fermentation of the sediment. The depth of the gutter is 1.2-1.5 m. The calculation of a two- stage sump is to determine the dimensions of the sedimentary trough and the sludge camera.

Sediment trough is calculated as a horizontal settler. In this case, the residence time of the water in the gutter is taken to be 1.5 hours.

The total volume of gutters is determined by the formula:

$$W_g=q \cdot t, \qquad (3.3)$$

where q - the calculated flow rate, m^3/s;

t - length of stay of water in the gutter, s.

The effectiveness of detention of suspended substances in the gutter is 40-50%. The speed of water movement in them is 4-7 mm/s.

The length of the gutters *L*, m, is taken in to accordance with the selected diameter.

Usually two-stage sumps arrange with two gutters. Single gutters are used for small diameters of sumps (up to 5 - 6 m).

The capacity of the sludge camera of two-stage sumps per person is taken in depending on the average temperature of wastewater in winter (table 3.1).

Table 3.1 - Capacity of the sludge camera of two-stage sumps

Average winter temperature of wastewater	6	7	8,5	10	12	15	20
Volume of the sludge camera W_{sl}, l, per person	110	95	80	65	50	30	15
Duration of fermentation, days.	210	180	150	120	90	60	30

With the subsequent supply of water to the filtration fields, the capacity of the sludge camera of two-stage sumps can be reduced, but not more than 20%.

Total volume of the sludge camera:

$$W_t=W_{sl} \cdot N_g \, , \qquad (3.4)$$

N_g - given the number of inhabitants.

In the presence of industrial wastewater, similar in composition, the additional volume of the mud chamber can be determined by the equivalent number of inhabitants and the ratio:

$$N_e=M_d/65, \qquad (3.5)$$

where M_d is the daily amount of dry substance in the sludge of industrial wastewater, g;

65 - amount of sediment *g* on dry substance per person per day.

The lower part of the sludge camera for better sliding mud make a cone with an angle of inclination of the generator, equal to 30°.

The central layer between the sludge camera and the gap of the gutter is taken equal to 0.5 m, the elevation of the side of two-stage sumps above the surface of the water is 0.5 m.

The most common are monolithic and prefabricated reinforced concrete two-stage sumps, which are built according to standard designs (table 3.2).

To the disadvantages can be attributed a large amount of sludge, which increases the cost of the structure, and the greater depth of the sump makes it unprofitable to use them at a high level of groundwater.

The sediment from two-stage sumps is removed by a sludge pipe with a diameter of at least 150 mm under a hydrostatic head of not less than 1.6 m.

Table 3.2 - Basic dimensions of typical two-stage sumps from monolithic and precast reinforced concrete

The main parameters	The design of structures						
	Monolithic				Prefabricated		
Diameter, m	6	6	9	9	9	12	12
Overall height, m	7,6	8,8	8,5	9,7	8,5	8,2	9,4
Throughput, m^3/hour at the settling period 1,5 hour	13,7	13,7	37,5	37,5	31	67	67

At an average annual air temperature of up to 3.5 °C, sumps with a capacity of up to 500 m^3/day are located in a heated room, and at 3,5 – 6 °C in not heated.

The effect of cleaning on BOD_{full} on two-stage sumps reaches 25 - 60%, on suspended substances 45 - 70%.

Averagers.

Averager - the facility is designed to equalize the amount of waste water and the concentration of pollutants entering the treatment. Distinguished averaging flow rate and averaging the concentration of incoming wastewater. As a rule, the averaging of substances in wastewater in a colloidal or dissolved form is carried out.

The use of the averaging method makes it possible to optimize the operation of all treatment facilities, reduce the amount of reagents used in physicochemical methods of purification, and reduce the cost of electricity, i.e. to increase the economic effect, as well as to achieve an optimal operating regime for biological treatment facilities.

At low flow rates and periodic discharge of water, contact averagers are used. However, as a rule, flow-type averagers are used, which are performed in the form of multi-channel reservoirs or reservoirs with agitating devices.

The type of averager is chosen depending on the nature and amount of undissolved components (for example, suspended substances), as well as the dynamics of wastewater supply.

Multi-channel averagers are used to equalize volley discharge of wastewater with suspended substances content of hydraulic size up to 5 mm/s at a concentration of up to 500 mg/l.

Averaging in such devices occurs by distributing the flow of water, which is divided into several jets flowing through the corridors of the averager. Corridors have different lengths (or widths), so in the collecting tray the water jet mixed with different concentrations of pollutants received by the averager at different times.

At low flow rates and periodic discharge of water, contact averagers are used. However, as a rule, flow-type averagers are used, which are performed in the form of multi-channel reservoirs or reservoirs with agitating devices.

There are the following types of flow averagents:

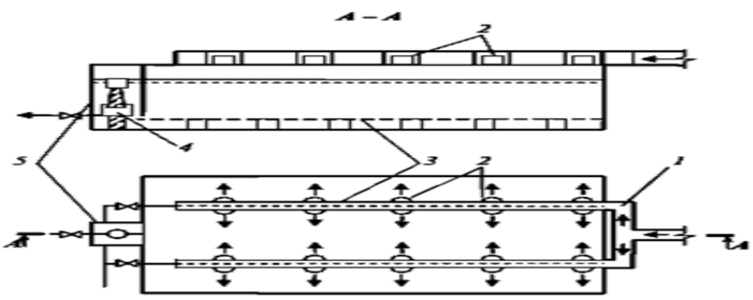
- multichannel - rectangular (Vanyakin DM constructions) and round ones (designs of Shpilev DA) in plan, with uneven distribution of water flow through channels;

- mixing averages (mixers with stirring devices) of bubbling type and with mechanical stirring.

The bubbling-type averaging mixer (figure 3.5) should be used for averaging the composition of the wastewater with the content suspended solids up to 500 mg/l with hydraulic size up to 10 mm/s at any mode of their receipt.

Averaging in this case is achieved by means of intensive mixing provided by bubbling wastewater with air.

One of the important conditions for effective averaging is the maximally uniform distribution of wastewater by the area of the bubbling type averager. For this purpose, the system of feeding trays with bottom spillway windows or triangular weirs is used.



1 - the feeding tray; 2 - the inlet openings; 3 - bubbler;
4 - the final device; 5 - outlet chamber.

Figure 3.5 - The average with bubbling water

4 Constructions biological wastewater treatment

4.1 Biological Filters

Biological filters - water treatment constructions where biochemical wastewater treatment occurs when they are filtered through a granular charge, the grain surface of which is covered by a biological film inhabited by aerobic bacteria and lower organisms that oxidize the adsorbed organic contaminants of wastewater.

Biological filter is a reservoir of rectangular or circular cross-section with a double bottom made of brick, concrete or stone. To the upper hole in the form of a grate with a total area of holes at least 5 - 8% of the filter area, a filtering load is placed from pebbles, gravel, slag, expanded clay, plastic blocks or rings. The solid bottom serves to collect filtered water. The bottom is given a slope of at least 0.01 to the collecting trays, which are arranged at a distance of 3 to 4 m from each other with a slope of 0.005 to 0.02. The walls of the biofilter tower 0.5 m above the level of load which, depending on the desired reduction in BOD, may have a height of 1 - 4 m. Waste water is fed to biofilters after clarification in a primary sumps and distributed over the surface load using perforated gutters, sprinklers, swinging gutters, jet irrigators.

Biological filters, in which the wastewater to be purified are continuously filtered through the loading layer, are called continuous biofilters - the waste fluid is fed to their surface evenly at short intervals. By productivity, continuous biofilters are divided into drip, high loaded and tower. By the way they are supplied with air, both can be subdivided into biofilters with natural and artificial (aerofilters) ventilation.

Drip biofilters are used for complete biological treatment of small amounts of wastewater (up to 1000 m^3/day). Their main elements: a filter layer of a porous material, consisting of several layers with different grain sizes or pieces; Fencing walls, arranged along the perimeter of the filtering layer; hole bottom (drainage), on which the filtering layer is located; a continuous bottom located under the drainage; distributing devices (for distribution of a waste liquid on a surface of a filtering layer), collecting trays collecting cleaned liquid from a continuous bottom and taking away it in secondary sump. The load per 1 m^3 of filter material is 0.5-1 m^3/day, so the filter provides almost complete biochemical oxidation of contaminants and a decrease in BOD_{20} of purified water to 15 mg/l. The height of the drip filters is assumed to be 1 to 2 m, the size of the loading fractions is 30 to 50 mm, and in the lower supporting layer with high 0.2 m - 60 to 100 mm.

4.2 Aerotanks

Aerotanks represent the construction of biological wastewater treatment, the oxidation of organic contaminants in which occurs due to the vital activity of aerobic microorganisms forming a flocculent accumulation - active sludge. Part of the organic substances in the aerotank is oxidized, and the other provides an increase in the bacterial mass of the activated sludge. The oxidative process is uneven: in the aeration tank - faster, and as approach the end - more slowly.

Depending on the method of aeration, the arrangement with secondary sumps, the method of discharge of wastewater from active sludge, distinguish:

- aerotanks – mixers;
- aerotanks – displacers;
- aerotanks – sump;
- aeroaccelerators;
- contact and stabilization aerotanks;
- aerotanks – illuminators;
- oxytank;
- aerooxidants;
- biotenes.

Aerotank - mixer, is characterized by a uniform supply of wastewater and activated sludge along the length of the structure and a uniform drainage of the silt mixture. *Aerotank - displacer*, characterized by a concentrated release at the beginning of the construction of wastewater and circulating sludge and drainage of the sludge mixture at the end of it. *Aerotank - sump*, combines an aerotank and a secondary sump, in which a higher effect of clarification of the mud mixture and an increase in the concentration of active sludge in the aerotank is achieved due to the suspended silt layer. *The aeroaccelerator* is an aerotank - a sump of circular shape in shape and with a mechanical turboaerator that allows to increase the recirculation of the sludge mixture without the use of pumps, improve the oxygen regime in the sediment bowl and increase the oxidizing capacity of the structure. *Aerotank - illuminator*, consists of the departments of aeration and clarification, operating as a suspended filter and an oxidation reactor. *Biotenk* is an aerotank with a plastic charge that increases biomass, using free-floating active silt and a biological film formed on the feed material. *Oxytenk* - aerotank with the use of technical oxygen.

Typically, the aerotank - the reservoir of rectangular section is rectangular, in which the waste liquid is slow, mixed with activated sludge. The air introduced by pneumatic or mechanical devices mixes the treated liquid with active sludge and saturates it with oxygen necessary for the life of bacteria. The process of complete wastewater treatment proceeds in three stages. In the first stage, immediately after mixing of wastewater with activated sludge, adsorption of impurities and the decomposition of easily oxidizing substances occur on its surface. As a result, for 1-2 hours the BOD of wastewater is reduced by 50-80%, and the oxygen dissolved in water is almost completely consumed for oxidation. In the second stage, slowly oxidized substances are oxidized, and the activated sludge is regenerated, i.e. its active properties are restored, which decrease by the end of the first stage. The rate of oxygen consumption at this stage is less than at the beginning of the process, and dissolved oxygen accumulates in the water. The total duration of the cleaning process in aerotanks is 6-8 hours for domestic wastewater and can be increased up to 10-20 hours with joint cleaning of domestic and industrial wastewater.

4.3 Facilities for preliminary aeration and biocoagulation

Biological methods of purification in artificial conditions.

Circulating oxidation channels (COC) are used to complete and incomplete biological treatment of household - domestic wastes and related wastewater with a calculated temperature of at least 25 °C at flow rates up to 1400 m^3/day. The composition of the water treatment system includes gratings or gratings - crushers, circulating oxidative channel, secondary sumps, the contact reservoir, chlorination, sludge sites. The cleaning process takes place in the regime of extended aeration with a low load on the active sludge and deep mineralization. Excess sludge mixture from the COC is diverted to the secondary sump, where the active sludge separates from the water. The circulation sludge is returned to the COC, and the purified water from the sump is transferred to the contact reservoir for disinfection and subsequent discharge into the reservour.

Aerotanks with immersed rotating discs are a kind of aerotanks with mechanical aeration. The principle of their work is to draw air into the wastewater directly from the atmosphere by the rotating parts of the aerator and mix it with the entire contents of the aerotank. The disc aerator of the domestic design is a disk having on the lower side radially arranged blades of the flow stabilizer, which is installed under the aeration device with a small gap. The frequency of rotation of the disk relative to the vertical axis, depending on the diameter of the aerator, is accepted to be 3.5-4.5 m/s.

Oxytenk is a highly effective biological wastewater treatment plant using pure oxygen and high concentrations of activated sludge. The distinctive features of the oxytenk are:

- high efficiency of using oxygen;
- a significant reduction in the total volume of the structure;
- the possibility of automatic regulation of the supply of oxygen is adequate to the speed of its consumption.

In the upper part of the apparatus above the water surface, a high oxygen content is maintained in the gas mixture in the aeration zone of the oxytenk, so that it is possible to provide large concentrations of dissolved oxygen in the sludge mixture with little energy consumption for its dissolution. The high content of dissolved oxygen in the sludge mixture not only increases the rate of oxidation, but also allows increasing the dose of active sludge in the structure.

5 Constructions for physico-chemical wastewater treatment

5.1 Wastewater treatment by flotation

Wastewater treatment by flotation.

In the practice of wastewater treatment, there are often situations when biological treatment facilities can not provide efficient work, for example, due to long interruptions of sewage water supply, instability of energy supply and also the presence of compounds toxic to biocenoses and a number of others in wastewater. The peculiarity of the structures for physical and chemical wastewater treatment is the speed of putting into operation, which is important in solving life support tasks, including in emergency situations.

In the schemes of wastewater treatment plants in populated areas, methods such as flotation, coagulation and sorption can be applied at different stages of water treatment.

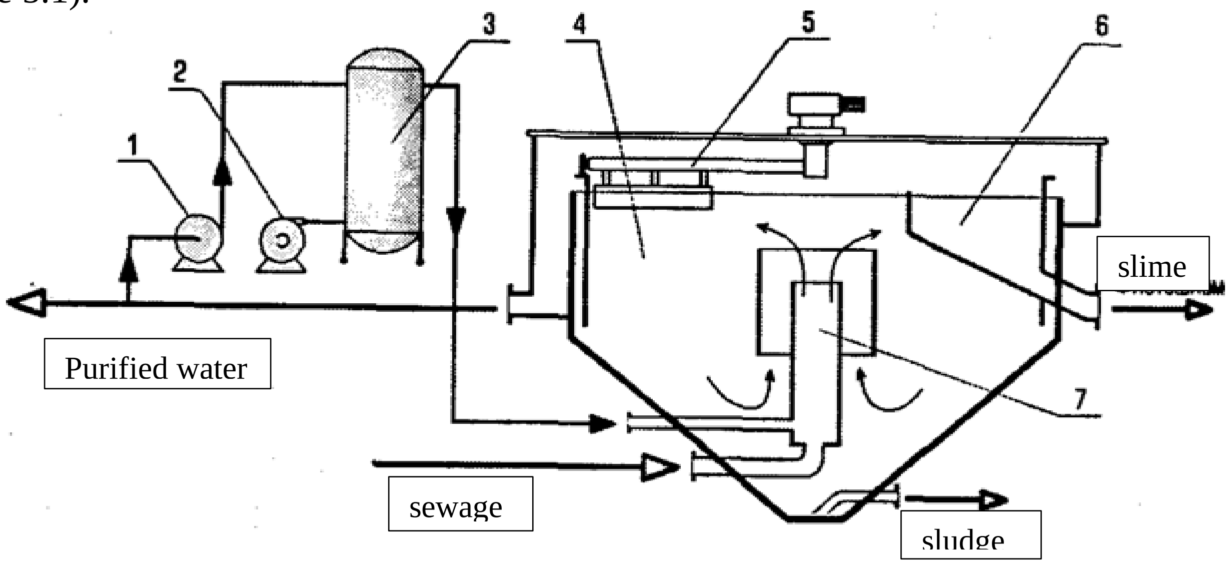
Flotation is one of the types of adsorption-bubble separation, based on the formation of floating agglomerates of contaminants with a dispersed gas phase and their subsequent separation as a concentrated foam product.

In accordance with the classification of urban wastewater pollution, flotation allows the extraction of coarse fresh impurities, characterized by the indicator "suspended substances", the presence of floating substances and surfactants.

In the technological processes of treatment plants in populated areas, flotation with compressed production of a dispersed gas phase has the greatest application. The gas phase obtained by this method has a large specific surface area and adhesive activity. Flotation complexes, formed on its basis, have a high rate of floating up to 20 mm/s. This significantly reduces the separation of pollutants compared to settling.

Functional flotation facilities perform the tasks of preliminary clarification of incoming sewage, post-treatment of wastewater from suspended solids and surfactants, as well as functions of sludge separation at different stages of sediment processing.

The flotation structure consists of a flotation camera and auxiliary equipment (figure 5.1).



1 - circulating pump; 2 - the compressor; 3 - pressure tank;
4 - flotation camera; 5 - scraper mechanism; 6 - a collection of flotation sludge;
7 - distribution system of water and water-air mixture.

Figure 5.1 - Scheme of flotation structure

According to the shape of the flotation camera there are rectangular or circular in the plan depth of not more than 3 m. Inside the camera there are distribution devices of water and water-air mixture coming in for cleaning, directing partitions, devices for maintaining the constancy of the water level in the structure, collecting and removing sediments and fleet sludge. The auxiliary equipment includes an installation for saturating the water with air at an excess pressure of 0.3 – 0.6 MPa.

A part of the stream of purified water under pressure is fed into the pressure tank (saturator). The compressor also supplies air. It is also possible to supply air through a water-air ejector installed on the bypass line of the pump. The amount of air supplied depends on the initial concentration of pollutants and can vary from 40 to 15 dm^3 per 1 kg of extractable substances at their initial concentration of 0.2 to 1 g/l, respectively. Water, saturated with air, from the saturator enters the flotation camera, where a sharp decrease in pressure occurs. Emerging air bubbles form with contamination of the fleet complexes, which float up to the open surface of the flotatop. The floating mass is continuously removed by mechanisms or by scraping the foam into the foam box.

The use of flotation after the construction of complete biological treatment of urban wastewater can significantly improve many water quality indicators. Table 5.1 provides data on the flotation of biologically treated wastewater.

Table 5.1 - Results of flotation treatment of urban wastewater after complete biological treatment structures

Significative	Wastewater		Average cleaning effect,%
	incoming	clearing	
Suspended substances, mg/l	8-25	4-12	50
BOD_5, mg O_2/l	10-25	4,5-11	55
COD, O_2/l	40-110	24-39	45
Surfactant, mg/l	1,5-6,5	0,5-4,2	67

In addition, removal of nitrogen compounds by 15-20%, iron ions by 23-26%, chromium ions by 11-18%, ether-extracted substances by 25-28% was noted.

Among other structures of gravity separation of pollution, flotatops are more efficient, smaller in size, technological flexibility and controllability. Disadvantages are dependence on electricity and more electricity consumption.

5.2 Wastewater treatment by coagulation

Wastewater treatment by coagulation. Wastewater in populated areas contains 50-60% of the pollutants that are related to the colloidal by their physicochemical properties. Colloidal dispersed particles are not precipitated or retained by conventional filters. Their size is conventionally in the range of 1-100 nm. They form stable systems, by external signs similar to true solutions.

Reagents-coagulants are used to improve the efficiency of wastewater treatment from colloidal contaminants. Mineral coagulants are hydrolyzed metal salts.

As coagulants, aluminum sulfate $Al_2(S0_4)_3 \cdot 18H_20$ is often used, sodium aluminate $NaAlO_2$ aluminum hydroxochloride $Al_2(OH)_5Cl$; more rarely - tetraoxosulphates of aluminum-potassium and aluminum-ammonium. Aluminum sulphate was widely used. When coagulated, aluminum sulfate reacts with the hydrocarbonates present in the water, or specially added alkaline reagents, to form poorly soluble bases. Recently, aluminum hydroxochloride has been used successfully, for which a lower alkaline water reserve is required.

Iron-containing coagulants are, first of all, sulfates of ferric and ferric iron $Fe_2(S0_4)_3 \cdot 2H_20$, $Fe(S0)_4 \cdot 3H_20$ and $FeS0_4 \cdot 7H_20$, as well as ferric chloride $FeC1_3$. Since iron has a transitional valency, the listed reagents can be used not only for coagulation, but also for conducting oxidation-reduction reactions followed by sedimentation.

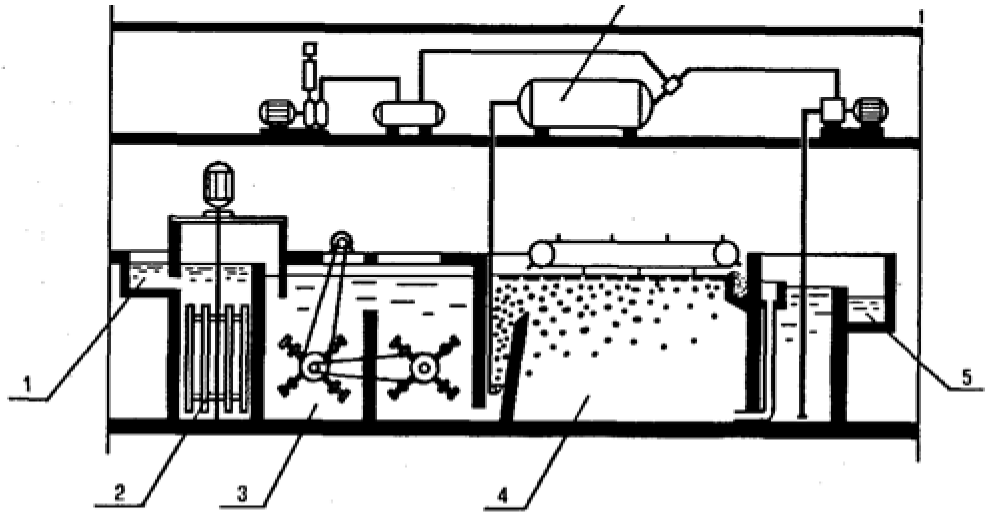
The technological complex for coagulation of wastewater includes the main facilities for mixing the treated water with coagulant solutions, formation of large flocculants of settling compounds, clarification of water, as well as auxiliary structures and equipment for storage, preparation and dosing of reagents.

For effective coagulation, it is necessary to provide the most favorable conditions for the reactions of hydrolysis of coagulants, interaction with contaminants and the formation of strong sludge flakes. Therefore, the mixing of the coagulant with water should take place so that a large number of small aggregates are formed immediately, which later become the centers of crystallization of poorly soluble compounds.

Coagulants are mixed with treated wastewater in mixers. By design features the faucets are cloisonne, perforated, washer and vertical. The process of flocculation is carried out in the flocculation camera. Cameras of flocculation by the type of flow can be vortex, cloisonne, vortex, and also with mechanical stirring.

In sumps of a vertical, horizontal or radial type occurs separation of formed dispersed system of hydrolyzed coagulant and contaminants. It is possible to use flotatops and clarifiers for these purposes.

In the technology of urban wastewater coagulation, different schemes are used that ensure the best cleaning results in specific conditions. The main differences between these schemes are the choice of reagent injection points in the technological chain of structures and their supply modes. For the purification of urban wastewater, the most appropriate is a two-stage sewage treatment scheme. At stage I sedimentation is carried out in the primary sump without coagulant, at stage II - treatment of wastewater with coagulants and flocculants followed by clarification in a sump or a flotatop. In Figure us 5.2 give an example of a technological complex for coagulation of wastewater, made in the form of a monoblock of structures.



1 - supply channel of wastewater; 2 - mechanical mixer; 3 - flocculation camera; 4 - the flotatop; 5 - drainage channel of purified water; 6 - system of preparation of a water-air mixture.

Figure 5.2 - Combined structure of physico-chemical wastewater treatment

The study of the composition of dissolved organic contaminants showed that 62-66% of the compounds belong to the group of organic acids, 8.2-9.6% exhibit the properties of bases, and 28.4-34.0% are neutral. Considering the adsorption of impurities on the coagulation hydroxides removed 30-40% of the total weight of organic substances in solution. The greatest efficiency of water purification is achieved on organic bases (up to 70%), the lowest - on organic acids (up to 20%).

Phosphorus compounds in a dissolved state form slightly soluble phosphates of aluminum, iron or calcium and precipitate during coagulation. Complex and insoluble forms of phosphorus are removed by sorption on flakes of hydroxides.

The removal of heavy metals occur as a result of the sorption and precipitation of their hydroxides, the completeness of which depends on the pH of the wastewater and the properties of metals.

Thus, in the process of coagulation and subsequent separation of precipitation and waste water, not only suspended matter can be removed, but also organic colloidal impurities, some dissolved contaminants, including those having surface-active properties, phosphorus compounds, salts of heavy metals, etc.

The use of flotation for separation of coagulated impurities at the same time with an increase in the rate of extraction of impurities increases the efficiency of water purification by suspended substances, surfactants, COD.

Table 5.2 shows the results of coagulation of urban wastewater that have undergone complete biological treatment, followed by flotation.

Table 5.2 - Results of post-treatment of waste water by coagulation with subsequent flotation

Significative	Wastewater		Average cleaning effect,%
	incoming	clearing	
Suspended substances, mg/l	18-40	6-10	71
BOD_5, mg O_2/l	20-35	4,5-11	73
COD, O_2/l	90-170	35-70	60
Surfactant, mg/l	4-20	1,3-6	70

As a coagulant, ferric chloride is used in an amount of 0.5-1.0 mg-eq/l. The duration of water treatment in the compression flotation unit is 20 min. Coagulation followed by sedimentation is practically ineffective with respect to removal of ammonium nitrogen. Other drawbacks of the method include the need to use reagents and increase the amount of precipitated precipitation.

5.3 Adsorption Treatment of Wastewater

Adsorption Treatment of Wastewater.

Sorption is an equilibrium dynamic process of absorbing substance from the environment by a solid, liquid or gas. The absorbing substance is called a sorbent, and the absorbed substance is called a sorbate. Adsorption is the sorption of substances by the surface layer of a solid sorbent.

Sorption methods relate to the most effective for deep purification of wastewater from dissolved organic substances. Sorption cleaning can be used alone or together with other methods of preliminary and deep wastewater treatment.

As sorbents in urban sewage treatment plants, natural materials, waste from certain industries and active coals are used. Natural porous materials such as peat, active clays and industrial waste - ash, coke fines, silica gels, alumogels, etc., possess low sorption capacity and high filtration resistance. Sorption capacity is the mass of absorbed contaminants per unit volume or mass of a sorbent (kg/m^3, kg/kg).

The sorption process is carried out by filtering the wastewater through a layer of tightly packed sorbent. After biological treatment facilities, non-pressure filters are used. The rate of filtration depends on the concentration of organic substances dissolved in the wastewater and varies within the range of 1-12 m/h at grain size of the sorbent 0.8-5 mm. The most rational direction of filtering - from the bottom up, since in this case the entire section of the filter is uniformly filled and air bubbles and gases that enter the sorbent layer together with the wastewater are relatively easily displaced.

A significant increase in the efficiency of treatment facilities is also ensured by combining the reagent treatment of wastewater with an adsorption purification step - by filtration through a layer of active coal. So, if it is necessary to achieve deep purification of wastewater in treatment plants with a limited territory, a process can be applied according to the scheme: coagulation of flotation sorption.

Replacement of sedimentation tanks with flotatops having a zone of precipitation of heavy impurities, several times reduces the duration of the separation stage of coarse impurities of wastewater.

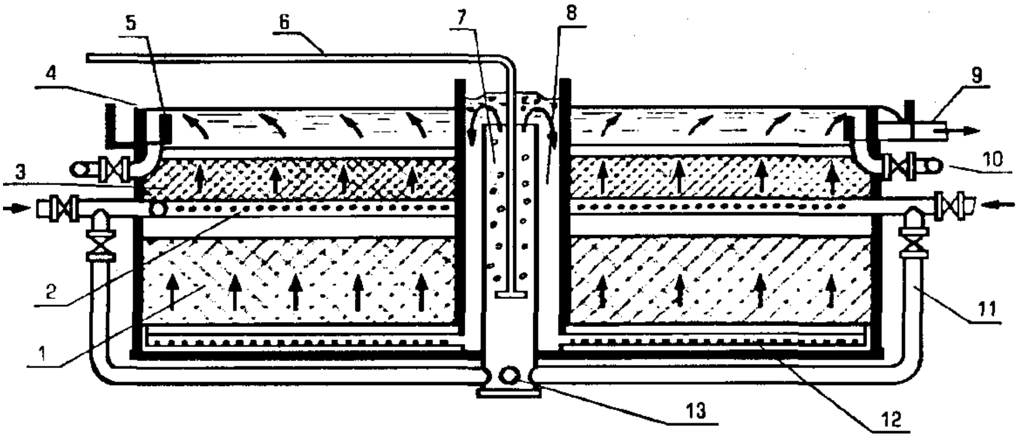
Biochemically resistant organic substances, microquantities of ions of heavy metals, radioactive isotopes, mercury, residual chlorine, ammonium nitrogen, bacterial and other contaminants are removed from the water during the adsorption post-treatment. Approximately it is assumed that 1 kg of coal removes about 0.5 kg of pollutants estimated by COD. The results of adsorptive post-treatment of sewage are given in table 5.3.

In the process of long-term operation of adsorption filters, a biofilm forms on the surface of the loading grains, which disrupts their normal operation, increases head losses. At the same time, increasing biofilm promotes deeper purification of water by BOD and nitrogen content. This phenomenon was taken as the base for the development of a deep wastewater treatment plant - biosorber.

Table 5.3 - Results of the operation of adsorption filters after complete biological treatment of municipal wastewater

Significative	Wastewater		Average cleaning effect,%
	incoming	clearing	
Suspended substances, mg/l	10	1	90
BOD_5, mg O_2/l	47	9,5	80
COD, O_2/l	31	7	77
Surfactant, mg/l	13	2,5	81

Biosorbers combine biochemical and physicochemical processes occurring in the suspended and dense layers of active coal. The installation scheme is given in Figure 5.3.



1 - weighted layer of active coal; 2 - drainage system; 3 - dense layer of active coal; 4 and 5 - weirs of purified and wash water; 6 - the air duct; 7 - airlift; 8 - degassing camera; 9 and 10 - drainage of purified and wash water; 11 - the circulation pipeline; 12 - water distribution system; 13 - wastewater supply.

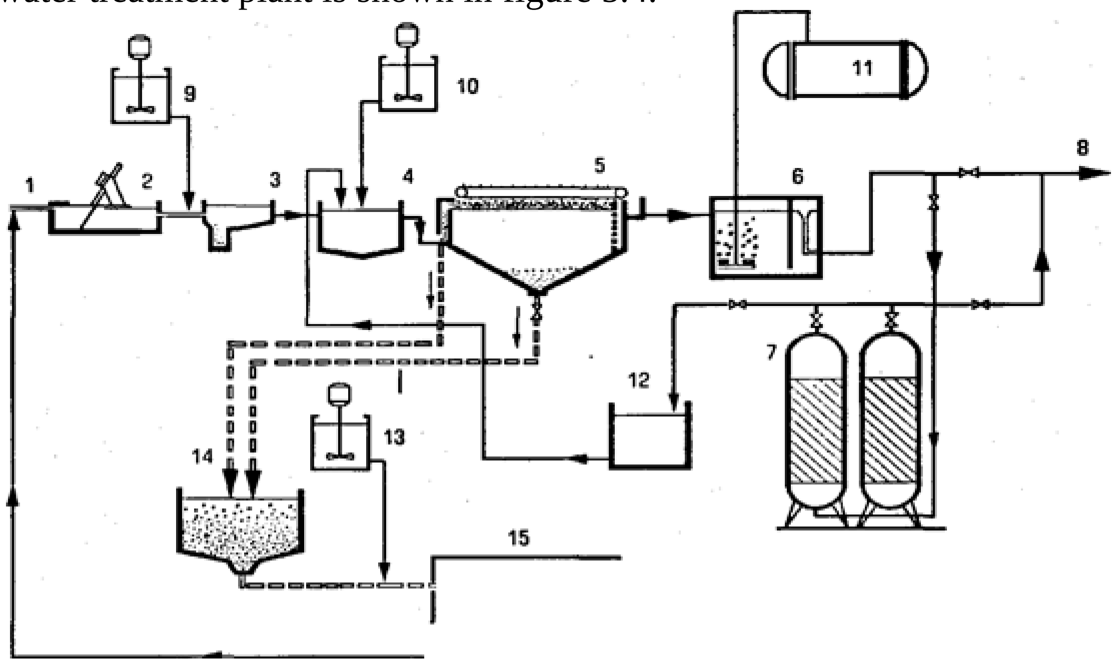
Figure 5.3 - Biosorber of the FGUP NIIV design

The reservoir is filled with two layers of sorption loading: the bottom layer is fluidized, the upper layer is dense. Direction of water movement from bottom to top. The speed of water in the lower layer is 9 m/h, in the upper layer - 3-5 m/h. The oxidizing power of the biosorber according to the BOD is 1.6-1.8 times, and for the COD it is 4-6 times higher than the oxidizing power of the aerotank.

In the biosorber, activated carbon does not require a separate regeneration.

Based on the tasks of wastewater treatment in populated areas of the construction, physicochemical treatments can be the basis of the technological process or a part there of in combination with other facilities, for example, mechanical or biological purification.

The simplest scheme of a station for physico-chemical wastewater treatment involves coagulation and separation of coagulated contamination from water during sedimentation or flotation. Such a scheme can be implemented in a short time on the basis of both new and old mechanical cleaning facilities. Schematic diagram of such wastewater treatment plant is shown in figure 5.4.



1.8 - supply of wastewater and removal of purified water; 2 - grating; 3 - sand trap; 4 - flocculation camera; 5 – sump - flotatop; 6 - the contact camera; 7 - adsorption filters; 9 - supply of coagulant; 10, 13 - supply of flocculant; 11 - ozonizer; 12 - reservoir of dirty washing water; 14 - sediment sealant; 15 - filter press.

Figure 5.4 – Scheme of station with three-physical-chemical wastewater treatment

A significant increase in the efficiency of treatment facilities is also ensured by combining the reagent treatment of wastewater with an adsorption purification step - by filtration through a layer of active coal. So, if it is necessary to achieve deep wastewater treatment in treatment plants with a limited territory, a technological process can be applied according to the scheme: coagulation - flotation - absorption. Replacement of sedimentation tanks with flotators having a zone of precipitation of heavy impurities several times reduces the duration of the separation stage of coarse impurities of wastewater.

The treatment facilities constructed according to this scheme provide for the efficiency of wastewater treatment in the settlement in terms of COD - 85%, BOD_5 - 96, suspended substances - 90 phosphates - 95, surfactants - 95, nitrogen - 57%. The effectiveness of reducing ammonium nitrogen depends significantly on the adsorption filter loading material.

If it is necessary to extract the nitrogen compounds from the waste water in depth, the technological schemes are supplemented with a purification step based on one of the physicochemical methods having selective action or on the biological process of nitrification-denitrification.

Wastewater treatment plants, designed for more complex schemes, are characterized by high intensity and depth of contamination removal in all main indicators. In a number of cases, this allows the use of treated wastewater in circulating systems in industrial enterprises and in agriculture. Schemes of such treatment plants, as a rule, combine the methods of mechanical, physico-chemical and biological treatment of water. And the technological sequences and combinations of them may be different.

Since the physico-chemical methods of wastewater treatment are based on the attraction of additional energy from external sources, the costs of their implementation are greater than those using the system's own energy (mechanical and partly biological).

6 Structures for processing sewage sludge

6.1 Septic tanks, two-stage sumps and clarifiers-digester

Septic tanks (conventional and two-stage), two-stage sumps and clarifiers, rotors refer to facilities for joint clarification and sludge digestion. *The septic tank* is a rectangular or circular reservoir in which suspended solids precipitate and rot. The water in it is settled for 1 to 4 days, and the sediment is stored for 6 to 12 months. In the sedimentary part of the septic tank there is mainly acidic fermentation, in which the particles of the sediment are raised upward by the bubbles of the evolved gases and form a crust on the water surface. Wastewater from the septic tank acquires an unpleasant smell of hydrogen sulphide, can rot, have acid reaction and can be biologically cleaned worse than with conventional sedimentation. Septic tanks are easy to operate and can be cleaned 1 to 2 times a year. Apply septic tanks usually for wastewater treatment from individual buildings or a group of buildings with a population of up to 500 people (flow rate of wastewater up to 50 m^3/day, then entering the fields of underground filtration, into sand and gravel filters).

The total volume of the septic tank consists of sludge and sediment parts and crusts. The volume of sludge determined from the calculation part 60 or 120 l/person, when cleaning the septic tank, respectively, once every six months or a year. Two-stage septic tanks, in which there is a settling the trough, which separates water from flowing rotting sludge, more committed than usual. They significantly reduce the removal of suspended matter with clarified water, eliminates its stench, facilitates the cleaning of the septic tank and improves the sanitary conditions for the staff.

The two-stage sump is a reservoir of round or rectangular cross-section. In the upper part (the tier) there are sedimentary troughs, which are horizontal sumps (water velocity 1.5 - 5 mm/s, settling time 1.5 hours), and in the lower part (septic) sediment is precipitated from the sedimentation tanks, where he is fermented.

The supply and discharge of wastewater into horizontal sumps is made through prefabricated and drainage trays with semi-submerged boards. The cross section of the trough consists of two parts: the upper rectangular and the lower trapezoidal. A longitudinal slit 12-15 cm wide is arranged in the bottom of the troughs, through which the sediment enters the septic part. Clarified wastewater is diverted through trays. Removal of the fermented sediment from the sump is carried out along the sludge pipes under the hydrostatic pressure of the water column. Two sedimentary troughs are arranged in each sump. The depth of the sedimentary troughs is not more than 2 m. Wastewater with the help of trays is distributed over both troughs and, flowing through them at low speed, is released from suspended substunces.

The sediment is fermented in the sludge chamber, first acidic, and after 2-4 months methane, which becomes permanent with the proper operation of the structure. The clarified water is in contact with the rotting sediment and the evolved gases at the same time less than in the septic tank. However, this can not be completely avoided, and the emerging particles of the sediment enter through the cracks and worsen the effect of the clarification of the wastewater. The diameter of a single sump is assumed to be equal to the length of the trough, and the diameter of the paired sumps is half the length. The cone of the bottom of the sump is 120°, the number of troughs is 2, the height of the bead above the liquid level is not less than 0.3 m, the height of the neutral layer between the upper boundary of the sediment and the bottom of the trough is 0.5 m, the total depth of the sump is not less than 7 m.

The clarifiers-digester consists of a clarifier with natural aeration and a concentrically arranged digester around it. Wastewater through the tray is fed into the central tube, to the end of which a reflective shield with bent up edges is attached. A set of 0.6 m, due to the difference in marks of liquid levels in the supply chute and clarifier, should ensure the movement of liquid in the central pipe at a rate of 0.5 to 0.7 m/s, necessary for sucking air from the atmosphere. The water-air mixture is directed from the pipe reflective shield in the flocculation camera. Here, spontaneous coagulation of contaminants occurs. After that, the liquid enters the settling zone from below, passing here through the layer of the formed suspended sediment. The clarified liquid is collected in the upper zone of the clarifier by a peripheral tray connected to a discharge pipe.

The sediment formed on the bottom of the clarifier enters the receiving tank of the pumping station through the pipe. From there, the sediment is pumped into the rotor through a pressure pipe, terminating over the rotor with two half-rings with processes directed at an angle of 45 °C to the surface of the sediment. The same pipeline serves to mix the sediment, and in this case the sediment is directed through the pipe to the receiving tank of the pumping station, where it is pumped to the upper zone of the rotor. Floating on the surface of the clarifier, light substances are collected in the pocket, from which the pipe is sent to the decay chamber. A mature precipitate is released to the sludge pads for drying, and then used as a fertilizer.

6.2 Methane tanks

Methane tank is a round or rectangular reservoir serving to digest sediment from sumps and excess activated sludge.

To intensify the anaerobic process of decomposition of the precipitate, it is heated and mixed. The sediment can be heated by a sharp steam injected into the methane tank by means of an ejector, or by steam introduced into the suction pipe of the pump, which delivers the precipitate to the methane tank. The precipitate is stirred with agitators, hydroelevators and pumps that take up the sediment from the lower part and feed it to the upper part of the methane tank.

The process of decomposition of the organic substance of the sediment proceeds in the methane tanks as well as in the septic chamber of the two-stage sump, but with greater intensity due to heating and mixing.

Distinguish between mesophilic and thermophilic fermentation. When mesophilic fermentation in a methane tank is maintained at 33 °C, with thermophilic – 53 °C.

The choice of the fermentation regime is made on the base of technical and economic calculations, sanitary and epidemiological requirements and the method further sludge treatment. The amount of gases formed during fermentation (methane and carbon dioxide) depends on the amount and composition of the sediment, and the intensity of their separation is from the fermentation temperature and the loading regime of the methane tank with fresh portions of the sediment. In methane tank the degree of decomposition of organic substance is on average 40%. Fat-like substances and carbohydrates are most decomposed.

The volume of the methane tank depends on the moisture content of the loaded sludge and the temperature of the fermentation. It is determined by the daily dose of the loaded sludge (loading dose). The loading dose is the percentage of the amount of daily loaded sludge to the useful volume of methane tanks.

The gas released in the methane tanks is collected and burned in boiler plants or used as a fuel for gas-cylinder vehicles. The steam produced in the boilers serves to warm up the sediment in the methane tanks and to heat the plant's production facilities.

At large stations, to regulate the pressure in the gas network and to accumulation of gas, wet gasholders are set up, the volume of which is calculated to store 2-4 hours of gas flow.

Continuous loading and unloading of sludge is used at large capacity stations.

The most rational is the operation of methane tanks in a direct-flow scheme, in which the loading and unloading of sediment occurs simultaneously and continuously. Such a regime creates favorable temperature conditions in the methane tank, since it eliminates the cooling of the roaming mass from the salvos of colder raw sludge and silt and ensures uniform gas evolution during the day. The sediment is fed through the dosing chamber to the upper zone of the methane tanks and discharged from the conical part of the bottom.

6.3 Sludge platforms

Sludge platforms serving for sludge dewatering, represent a planned land, divided by the card earthen ridges (figure 7.3).

Humidity of sediment is 90-97%, most often 97% (fermented sediment from methane tanks), periodically poured into individual cards of the size (10 ... 40) X (60 ... 120) m and dried. The height of the sediment layer, which is put on the map at a time, is 0.2-0.25 m. The dried sediment has a moisture content of 75-80%.

Sludge sites are usually arranged on a natural base with a depth of groundwater not less than 1.5 m from the top of the cards. With a lack of territory, as well as in the occurrence of groundwater at a depth of less than 1.5 m on the sites, tubular drainage is arranged.

Pipes are laid in ditches, filled with rubble or gravel with a particle size of 2-6 cm. Distance between drainage ditches is taken equal to 6 -8 m. The minimum depth of the ditch is 0.6 m, the slope is 0.003.

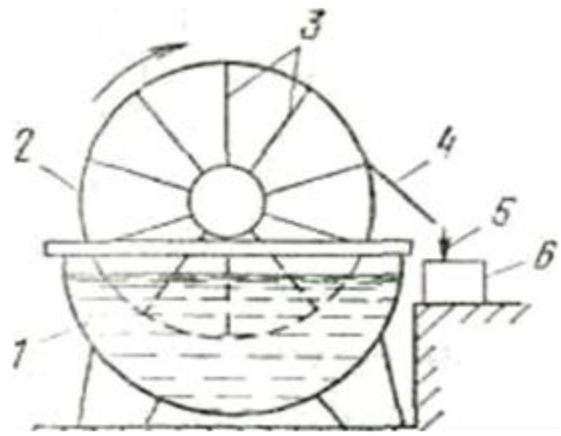
The dried sediment is used as a fertilizer. To collect the sediment, use a scraper or bulldozer. The collected sediment is loaded into vehicles using an excavator. In winter, the frozen sediment is split into blocks and transported to the fields.

Dimensions sludge platforms appoint depending on the amount of sediment, its characteristics (raw or fermented) and climatic conditions. The rate of loading of the sediment per m^2 of area depends on the type of sediment, climatic conditions, presence or absence of drainage and averages 0.8-2 m^3 per year. The actual area is taken to be 20-40% more useful, since part of the area is necessary for the construction of roads, rollers and ditches.

For the drying of sediment on sludge platforms, especially at large treatment plants, large areas of land are required. In connection with this recently found increasingly prevalent mechanical sediment dehydration: vacuum filtration, centrifugation and filter pressing. The method of mechanical sludge dewatering is chosen taking into account its physicochemical properties.

6.4 Facilities for mechanical dewatering of sediment, its thermal drying and combustion

Mechanical dewatering of digested sediment in sewage treatment plants of high productivity most often carried out on vacuum filters. Vacuum filter (figure 6.1) is a horizontal cylindrical drum, covered with capron or chlorovinyl filter cloth.



1 - dewatered sediment, 2 - drum; 3 - radial partitions; 4 - knife, 5 - dewatered sediment, 6 - conveyor for sediment.

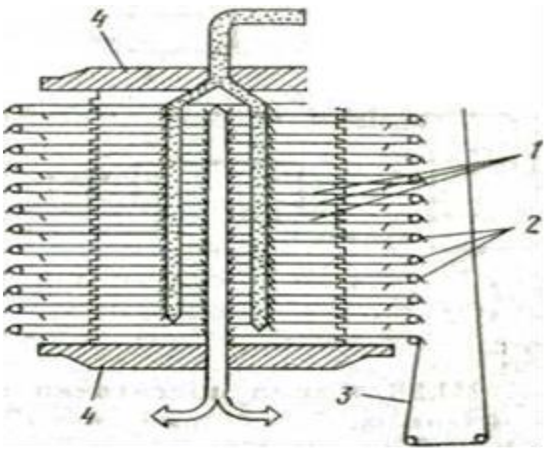
Figure 6.1 - Scheme of vacuum filter

Drum divided into several sectors and partially submerged in a trough with a fermented sediment, slowly rotates. In his sectors, immersed in a trough, a vacuum pump creates a vacuum, as a result of which the precipitate adheres to the filter tissue, and water, having passed through this fabric, falls inside the drum, from where it is taken through the pipe.

The sediment was separated from the tissue with a knife. To facilitate the removal of sediment in the area of the knife, the compressor creates an increased pressure. The dehydrated has a moisture content of 78-80%.

Dimensions of the vacuum filter drum are determined by the amount of treated sediment taking into account the performance of the filter, which is accepted on average equal to 20-25 kg of dry sediment per 1 m^2 of the filter surface in 1 hour.

For sludge dewatering use also filter presses of the type FPAKM. The filter consists of several filter plates and filter tissue, stretched between them by means of guide rollers.



1 - filter plates; 2 - guide rollers; 3 - filter tissue; 4 - supporting plates.

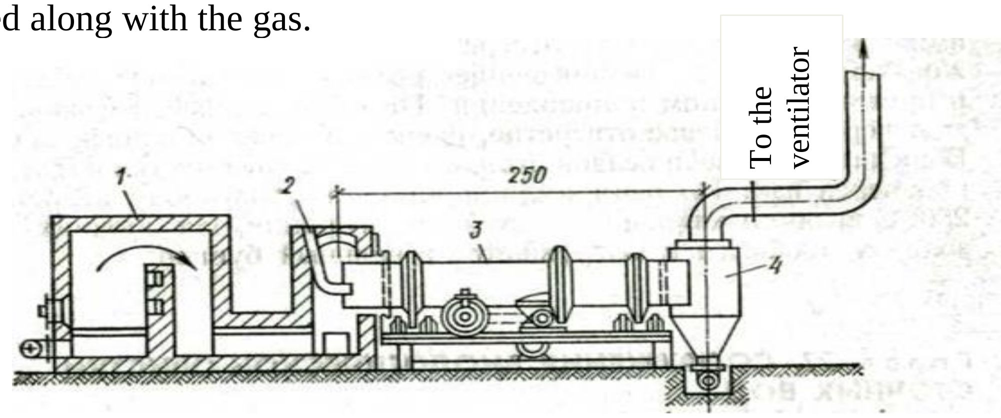
Figure 6.2 - The scheme of the device of the automated filter press with horizontal cameras (FPAKM)

Support plates are connected between each other by four vertical supports, which take the load from the pressure inside the filter plates.

For the thermal treatment of sediment, there are several apparatuses: tumble dryers, pneumatic dryers, dryers with boiling layer.

The drum dryer (figure 6.3) consists of a firebox 1, a drum 3, a charging camera 2 and an unloading camera 4. At a drum rotation frequency of 0.5-4 minutes the dried sediment slowly moves to the discharge camera. The gases fed to the drum dryer have a temperature of 700-800 °C. The exhaust gases have a temperature of 250 °C and can be used to heat the sediment in scrubbers or heat exchangers. After thermal drying, the moisture content of the precipitate is 30-35%, and it can be used as a fertilizer.

Pneumatic dryer, is a vertical pipe-shaft, through which a continuous flow hot flue gases are pumped. The shaft is placed above the mill-crusher, where the sediment is crushed to a powdery state. Powder is picked up by a current of gases and carried away to the pipe, where it is dried instantly. Evaporated moisture is carried along with the gas.



1 - circulating active sludge; 2 - excess active sludge; 3 - pumping station; 4 - secondary settling tank

Figure 6.3 - Drum dryer

Aeration tanks refer to biological wastewater treatment structures in artificial conditions.

Usually they are made in the form of long ferro-concrete reservoirs (corridors) 3-6 m deep and 6-10 m wide. The clarified liquid entering the aeration tank mixes with the activated sludge.

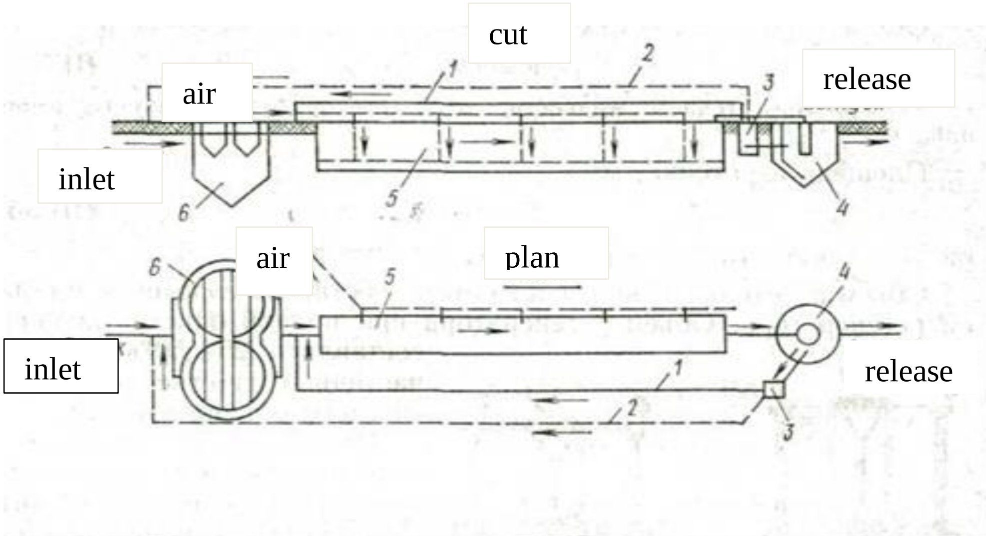
Activated sludge - a cluster of microorganisms, capable of adsorbing organic pollutants on their surfaces and oxidizing them in the presence of air oxygen. A mixture of clarified sewage and activated sludge is blown through the entire length of the aeration tank.

Figure 6.4 shows the scheme of operation of the aeration tank. From the aeration tank the mixture of wastewater with activated sludge is sent to the secondary sump, where the active sludge is deposited and then returned to the aeration tanks. This sludge is called a circulating activated sludge.

The mass of sludge in aeration tanks is continuously increasing as a result of the growth of microorganisms and the sorption of organic contaminants. Removal of activated sludge from secondary sump increases with increasing concentration in aeration tanks and the quality of purified water decreases.

To prevent this, part of the activated sludge (excess activated sludge) does not return to the aeration tanks, but is directed to the sludge compactors.

The process of decomposition of organic matter in the aeration tank proceeds in three phases. The sorption of organic contaminants on active sludge flakes and oxidation of easily oxidizing organic substances occurs in the first phase. At the same time, the MIC of the wastewater decreases sharply. Difficult-oxidizing organic substances are oxidized and regeneration of the activated sludge takes place, that is, the recovery of its sorbing ability in the second phase. Nitrification of ammonium salts occurs in the third phase.



1 - circulating active sludge; 2 - excess active sludge; 3 - pumping station; 4 - secondary settling sump; 5 - aeration tank; 6 - primary sump.

Figure 6.4 - Scheme of operation of the aeration tank

Aeration tanks can be used for partial and complete wastewater treatment. Partial purification is used, if local conditions allow the use of self-cleaning ability of the reservour.

Regenerators - facilities are arranged to ensure the stable operation of aeration tanks, in which the sorbing capacity of the activated sludge is restored. Sludge in the regenerators is constantly aerated. Part of corridors of aeration tanks is usually singled out under regenerators. There are a number of schemes for the operation of aeration tanks. Aeration tanks - mixers, two-stage aeration tanks and aeration tanks with step aeration are also used, except for single-stage aeration tanks with or without regeneration, working for full or partial purification.

Aeration tank – mixer is used usually for cleaning industrial wastewater with a high concentration of organic contaminants. The waste liquid is fed to the aeration tank mixer dispersed along its length in order to improve the use of oxygen.

The estimated volume of the aeration tank depends on the consumption of waste water, its contamination with organic substances, the amount of air supplied and the concentration of activated sludge.

The duration of aeration or residence time of the wastewater in the aeration tanks is determined by the formula:

$$t = \frac{L_a - L_e}{a(1-S)\rho}, \tag{6.1}$$

where L_a and L_e - BPK_{20} flowing into the aeration tank the waste liquid and BPK_{20} purified liquid, mg/l;

a - the dose of sludge taken in the aeration tanks, working at full cleaning, equal to 1.5 g/l; for partial cleaning - 2 g/l; in regenerators - 4 g/l;

S - ash content of sludge equal to 0.3;

ρ - speed of oxidation of contaminants, mg, BOD per hour for 1 g of ashless material, determined according to table 42 of Sanitary norms and rules RK 4.01-02-2001.

Specific air flow, m^3 per 1 m^3 of wastewater, should be determined by the formula:

$$D = \frac{z(L_a - L_e)}{K_1 K_2 n_1 n_2 (C_p - C)}, \tag{6.2}$$

where Z - the specific of oxygen, mg per 1 mg of BOD_{20} removed during purification (0.9-1.05);

L_a and L_e - the same as in formula (4.6);

K_1, K_2, n_t, n_2 - coefficients that take into account the type of aeration tank, the depth of its immersion, the temperature of wastewater and their properties (values of these coefficients are taken in accordance with Sanitary norms and rules RK 4.01-02-2001);

C_p - the solubility of oxygen in the liquid; C - the concentration of oxygen; dissolved in a liquid, located in the aeration tank (1-2 mg/l).

The volume of the aeration tank, m^3:

$$V=Q\cdot t, \tag{6.3}$$

Q - flow rate of waste liquid;

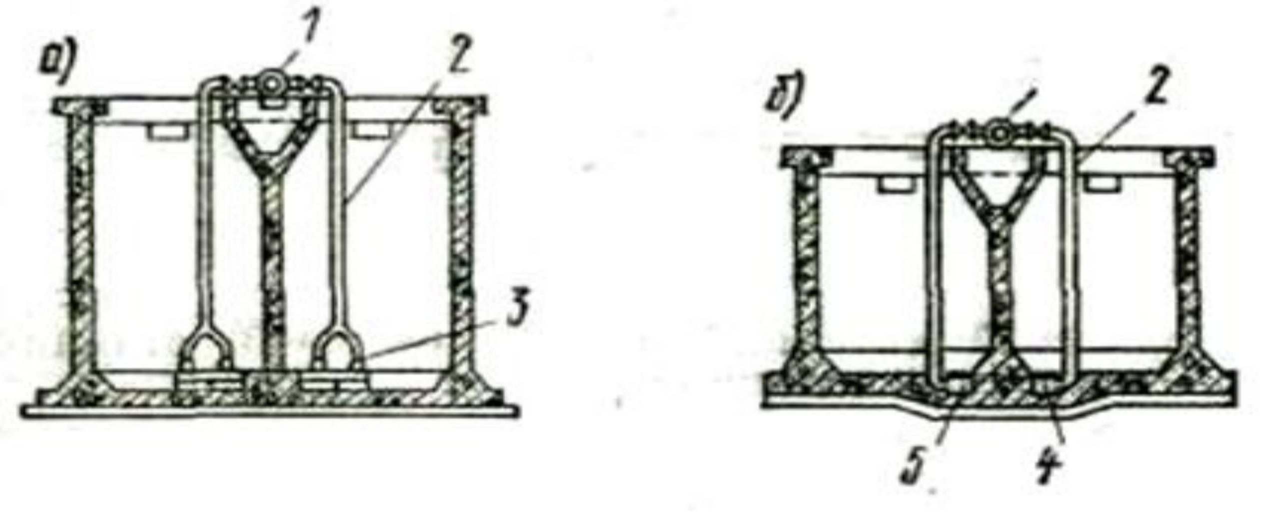
t - duration of aeration.

Area of aeration tank, m^2:

$$F=V/H, \tag{6.4}$$

where H - the working depth of the aeration tank, assumed to be 3-6 m.

The volume *V* of the aeration tank actually includes the volume of the aeration tank and the volume of the regenerator. The volume of the regenerator at full purification should be 25-50%, and with partial purification - 50% of the estimated volume of the aeration tank.



a - perforated pipes; b - filter plates; 1 - air duct; 2 - riser; 3 - perforated pipe; 4 - filter plate; 5 - air channel of sewage liquid with compressed air and aeration tank with mechanical aeration.

Figure 6.5 - Air distribution in the aeration tank

The rating area of the aeration tanks is divided into sections, each of which consists of several corridors (two to four). A part of the corridors (one to two) is allocated for regenerators. The sewage fluid passes successively from one corridor to another. The length of aeration tanks is usually assigned within 50-130 m. The ratio of the width of the corridor to the working depth of the aeration tank should be taken from 1: 1 to 1: 2.

Aeration tanks are purged from the waste liquid with compressed air and mechanical aeration with aeration. The air in the aeration tanks is fed by blowers through the air duct system. Air distribution in the aeration tank is made through porous ceramic materials (filter plates, ceramic pipes, synthetic tissue).

Air usually enters the perforated pipes or into the channel, at the top of which filter plates are laid. The risers depart from the main main duct, located on the longitudinal wall of the aeration tank. The distance between risers is assumed to be within 20-40 m. Perforated pipes are placed on one side of the aeration tank corridor along its length to allow circulation of the flow in cross section. Holes in them with a diameter of 2-2.5 mm are placed at a distance of 10-15 cm from each other. The filter plates are arranged in one to three rows also on one side of the aeration tank corridor along its length.

Pre-aerators and biocoagulants are used in those cases when in the waste fluid it is required to reduce the suspended substances content by a larger amount than the primary sump can do. Pre-aerators are arranged in front of the primary sumps in the form of separate or attached or built-in structures, and biocoagulators are combined in sumps.

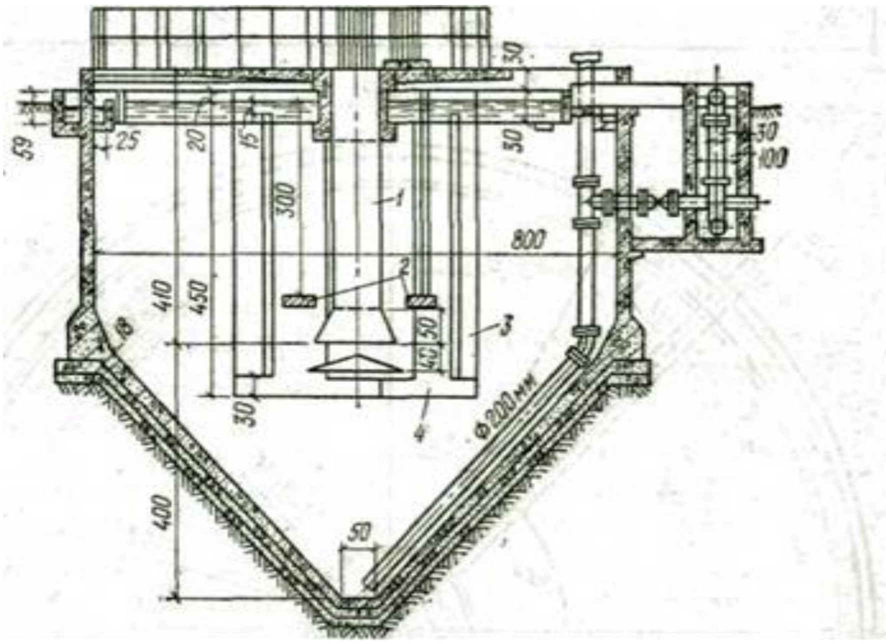


Figure 6.6 – Biocoagulant

The water-air mixture moves in the camera upwards and through pockets 3 it descends downwards, heading to the settling zone. In the settling zone, the liquid passes through the suspended layer, is clarified and taken off the annular tray. The amount of air supplied is 0.5 m^3 per 1 m^3 of wastewater. Before feeding to the biocoagulant, activated sludge or biological film must be regenerated within 24 hours. The speed of water movement in the biocoagulant settling zone should be no more than 0.8-0.85 mm/s.

Secondary sumps and sludge compactors.

The wastewater passed through the aeration tanks contains active sludge, and the liquid that has passed through the biofilters contains a biological film. Secondary sumps are used for the retention of activated sludge or a biological film. They are located after aeration tank and biofilters. Secondary sumps are horizontal, vertical and radial depending on the flow direction. The maximum speed of fluid flow is assumed equal to 5 mm/s for horizontal and radial sumps, and for vertical sumps it is assumed equal to 0.5 mm/s.

Time of stay of the wastewater in the sumps after the aeration tanks operating at full purification is 2 hours, after the drifting biofilters and aeration tanks operating for partial purification - 0.75 hours, and after the highly loaded biofilters - 1.5 hours.

Active sludge settling in the sumps is pumped back to the aeration tanks. The consumption of the circulating activated sludge is 30-70% of the discharge of the waste liquid entering the aeration tanks. The humidity of the active sludge discharged from the secondary sumps is 99.2-99.5%.

The structures of vertical secondary sumps are similar to those of vertical primary sumps. Typically, vertical secondary sumps are used at small and medium capacity stations, and radial sumps are designed for radial stations.

Excess activated sludge from secondary sumps is sent to the sludge compactors, which serve to reduce its humidity content before feeding it to methane tanks from 99.2-99.5 to 95-98%. At the same time, the volume of sludge is reduced by 4-10 times. Sludge compactors are vertical and radial. Their designs are similar to those of sumps. Time of stay of the sludge in the radial compactors is 5-14 hours, in the compactors of the vertical type 10-16 hours. Sludge compactors of a radial type arrange with sludge – suctions and sludge – scrapers. The compacted sludge is discharged under a hydrostatic head of 0.5-1 m through weirs.

7 Disinfection of wastewater and let it out the reservoir

7.1 Disinfection of wastewater

Disinfection of wastewater has the purpose of destroying the remaining pathogenic bacteria in them and reducing the epidemiological danger when discharged into surface reservoirs. Wastewater is prohibited to be discharged into reservoirs, containing pathogens of infectious diseases. Sewage, which is dangerous in epidemiological terms, can be discharged into the reservoirs only after cleaning and disinfection. In this case, the amount of lactose-positive coliforms (index LPC) in the wastewater should not exceed 1000 cells/dm^3.

From the experience of wastewater treatment, it is known that during the initial sedimentation the total number of bacteria decreases by 30-40%, and after the stage of biological treatment (on biofilters or aeration tanks) - by 90-95%. This proves the need for special methods of decontamination of treated wastewater to ensure their epidemiological safety.

Currently, methods of water disinfection can be divided into two main groups - chemical and physical. Chemical methods include oxidative and oligodynamic (exposure to noble metals ions); chlorines, chlorine dioxide, ozone, potassium permanganate, hydrogen peroxide, hypochlorites of sodium and calcium are used as oxidants. Physical methods include heat treatment, ultraviolet irradiation, ultrasound exposure, irradiation with accelerated electrons and gamma rays. The choice of the method of decontamination is carried out on the base of data on the flow and quality of treated sewage, the conditions for the supply and storage of reagents and conditions for energy supply, the availability of special requirements.

7.2 Disinfection of water by chlorination

The method of chlorination of wastewater is most widespread. The bactericidal effect of chlorine and its derivatives is explained by the interaction of hypochlorous acid and hypochlorite with substances that make up the protoplasm of bacterial cells, as a result of which the latter die. However, there are certain types of viruses that are resistant to chlorine. Active chlorine is dissolved molecular chlorine and its compounds are chlorine dioxide, chloramines, organic chloramines, hypochlorites and chlorates. There are active free chlorine (molecular chlorine, hypochlorous acid and hypochlorite) and active bound chlorine, which is part of the chloramines. The bactericidal action of free chlorine is much higher than that of the bound chlorine. Chlorine is introduced into the waste water in the form of dissolved chlorine gas or other substances forming active chlorine in water. The amount of active chlorine brought in per unit volume of waste water is called the chlorine dose and is expressed in grams per 1 m^3 (g/m^3).

In accordance to Sanitary norms and rules RK 2.04.03-85, the calculated dose of active chlorine, which provides a bactericidal effect, should be taken: after mechanical treatment of sewage - 10 g/m^3; after incomplete biological treatment - 5 g/m^3; after complete biological treatment - 3 g/m^3. The level of residual chlorine should be at least 1.5 g/m^3, and a period of at least 30 minutes. Chlorine added to wastewater must be thoroughly mixed with it.

The decontamination unit of treatment plants consists of an installation for obtaining a solution containing active chlorine (chlorine water), a mixer of chlorine water with treated water and a contact reservoir that provides the necessary period of decontamination.

Chlorination with liquid chlorine. The factories supply chlorine in bottles weighing up to 100 kg and in containers weighing up to 3000 kg, as well as in railway tanks with a capacity of 48 tonnes. Liquid chlorine is stored at a pressure of 0.6-0.8 MPa to prevent evaporation.

The hydrolysis of chlorine in water occurs when it is dissolved:

$$C1_2 + H_20 \leftrightarrow HClO + HC1.$$

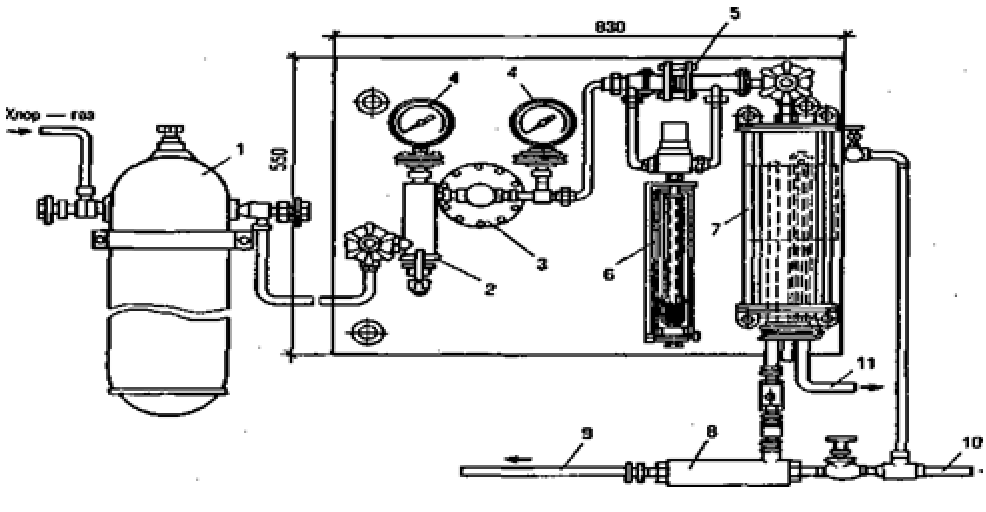
Part of hypochlorous acid HCl dissociates with the formation of a hypochlorite $OC1^-$ ion, which is a disinfecting substunces.

Chlorination with liquid chlorine is the most widely used method of water disinfection at medium and large water treatment plants.

The incoming reagent is pre-evaporated due to the low solubility of liquid chlorine. Then the chlorine - gas is dissolved in a small amount of water, the resulting chloric water is mixed with the treated water.

The chlorine dosage occurs in the phase of the gaseous substance, the corresponding gas doses are called chlorinators. Chlorators are divided into two main groups - pressure and vacuum. Vacuum chlorators provide greater safety of personnel in chlorination. Chlorators of proportional and constant flow are used, as well as automatic chlorators that maintain a given concentration of residual chlorine in water. In our country, constant-flow vacuum chlorators of the "LONII-STO" type have become most widespread (figure 7.1).

Chlorinator AXB-1000 with a chlorine productivity of 2 to 12 kg/h is its counterpart and is currently produced. These substances are less dangerous to handle, the process of their preparation and supply is much simpler - almost the same as using a coagulant.



1 - intermediate cylinder; 2 - the filter; 3 - reducer; 4 - manometers; 5 - measuring diaphragm; 6 - rotameter; 7 - the mixer; 8 - ejector; 9 - a pipeline of chlorine water; 10 - tap water; 11 - overflow and emptying.

Figure 7.1 - Chlorinator LONII-STO

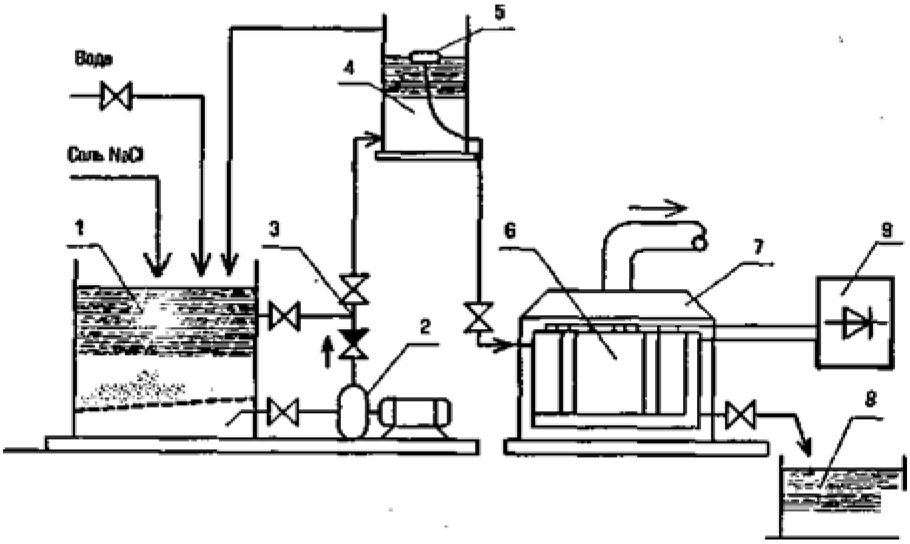
The commercial product $CaCl_2O$ or $Ca(ClO)_2$ is dissolved in a solution tank with mechanical stirring. The number of tanks is not less than two. Then, the solution is diluted in a feed tank to a concentration of 0.5-1% and is fed into the water by solution and suspension slurries.

Tanks should be made of wood, plastic or reinforced concrete given the corrosive activity of the solution. Pipelines and fittings should be made of corrosion-resistant materials (polyethylene or vinyl plastic).

Chlorination of water with sodium hypochlorite. Sodium hypochlorite NaClO can be used in sewage treatment plants, where daily chlorine consumption does not exceed 50 kg / day, and transportation, storage and preparation of toxic chlorine are associated with difficulties. This reagent is produced at the site of application, using electrolysis solutions of common salt solution (figure 7.2).

Solution NaClO is prepared in a solution tank, close to saturated - 200-310 g/l. Mechanical devices, circulating pumps or compressed air are used for mixing.

Electrolyzers may be flowing or non-flowing type, the most widely used last. They are a bath with a stack of plate electrodes installed there. The electrodes are usually graphite, connected to a direct current source.



1 - solution tank; 2 - the pump; 3 - distribution tee; 4 - working tank; 5 - float-dispenser; 6 - electrolyzer; 7 - exhaust ventilation hood; 8 - storage tank of sodium hypochlorite; 9 - direct current source.

Figure 7.2 - Diagram of the installation for the production of sodium hypochlorite by electrolysis

As a result of hypochlorous acid reaction with caustic soda, hypochlorite is formed:

$$NaOH + HCl \rightarrow NaCLO + H_2O.$$

At the station it is necessary to have at least three electrolyzers, which are installed in a dry, heated room.

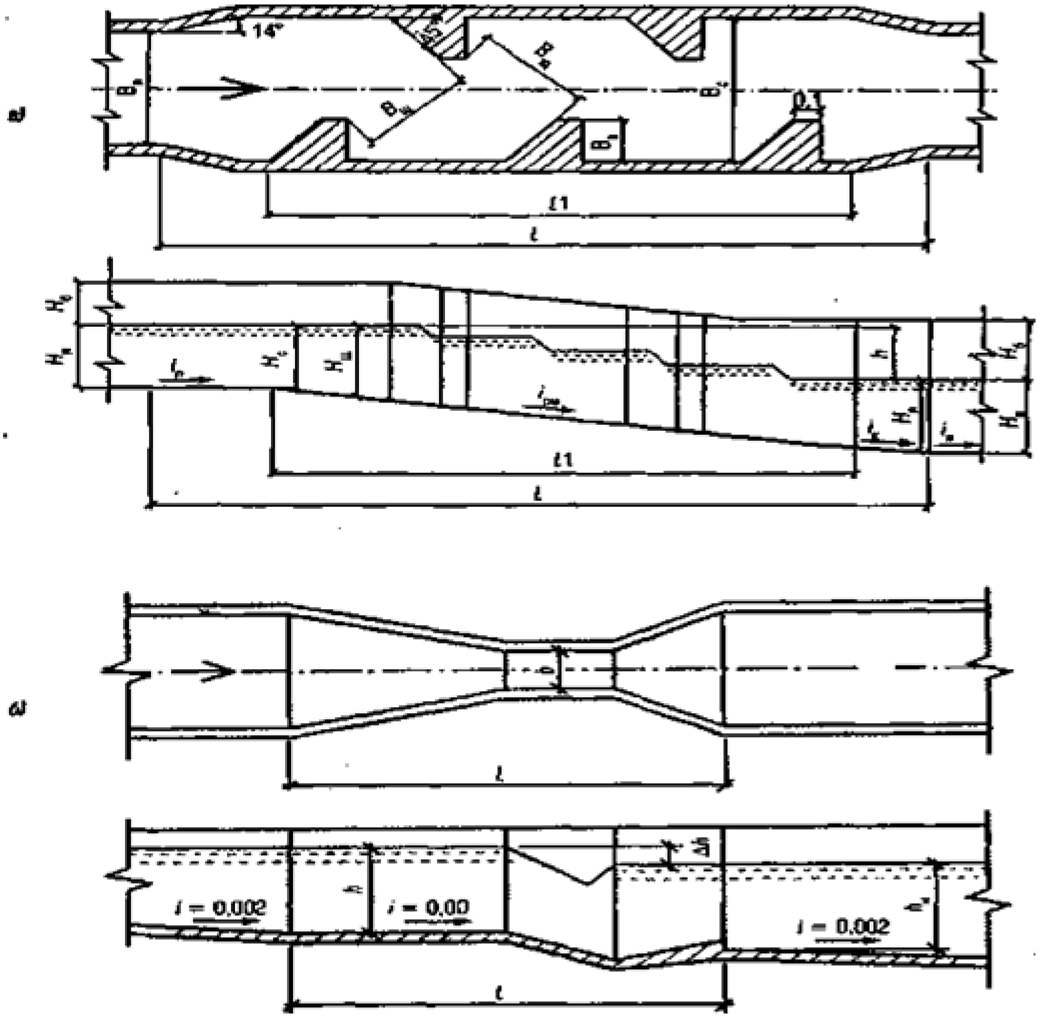
Pipelines should be in an electrolysis bath for water cooling. Umbrella for exhaust ventilation is installed above the electrolyzer to remove the evolved gases..

The high position of the electrolyzer should ensure NaClO solution is supplied to the storage tank by gravity.

The storage tank is placed in a ventilated room, the dosage of hypochlorite solution in water is produced by an ejector, a dosing pump or other device for supplying solutions and suspensions.

Mixers of chlorine water with treated water are divided into three types: ruff (at the flow rate of wastewater to 1400 m^3/day), the Parshal's tray (figure 7.3) and in the form of a container with pneumatic or mechanical stirring.

Contact reservoirs are designed to provide the estimated duration of contact of treated wastewater with chlorine or sodium hypochlorite. They are designed as primary horizontal sumps in an amount not less than two, without scrapers, the period of stay of wastewater for 30 minutes. The flow time of the wastewater in the release is taken into account in this case. The periodic removal of the formed sediment (approximately every 5-7 days) is provided in the contact reservoirs and its transfer to the receiving camera of the treatment structures.



a - ruff type; b - type of Parshal's tray.

Figure 7.3 - Mixers of chlorine water

7.3 Disinfection by ozonation

Ozone (O_3) is an allotropic modification of oxygen, the strongest of the currently known oxidants. Like chlorine, ozone is a highly toxic, poisonous gas. This unstable substance is self-decomposing, forming oxygen.

Ozone has a high oxidation-reduction potential. It exhibits high reactivity in relation to various kinds of water impurities, including nonbiodegradable compounds and microorganisms. The process of oxidation occurs at the interaction of ozone with the water impurities. One of its advantages over other oxidants from the hygienic point of view is the inability to substitution reactions (and the difference from chlorine). When ozonizing additional impurities are not added to the treated water, and the probability of formation of toxic compounds is much lower than in the case of chlorination.

The bactericidal effect of ozone is explained by its ability to disrupt metabolism in a living cell due to the shift in the equilibrium of the reduction of sulfide groups to inactive disulphide forms. Ozone very effectively disinfects spores, pathogenic microorganisms and viruses.

Interest to the use of ozone for wastewater treatment has emerged and the connection with its potentially lesser hazard for reservoirs. The residual ozone dissolved in water completely decomposes in 7-10 minutes and does not come in the pond. Highly toxic halogen-organic compounds are not formed when water is treated. Typically, the use of ozone for wastewater treatment has a dual purpose - to provide decontamination and improve the quality of purified water. In addition, decomposed, unreacted ozone molecules enrich the water with dissolved oxygen.

Approximate dose of ozone for urban wastewater disinfection, which has undergone complete biological purification is 8-14 g/m^3. The required contact time is about 15 minutes. If the purpose of ozonization is not only disinfection, but also post-treatment of waste water, it is possible to increase the dose of ozone and the duration of contact. When ozonizing biologically treated urban wastewater with a dose of ozone of about 20 g/m^3, water COD decreases by 40%, BOD_5 by 60-70%, surfactant by 90%, water stains by 60%, almost completely disappears odor, in addition to complete disinfection. A large number of factors affect the reactions of ozone in water and therefore more accurately its dose is determined experimentally.

7.4 Disinfection with ultraviolet radiation

The most common non-reagent method of disinfection of wastewater is the use of bactericidal ultraviolet (UV) radiation, acting on various microorganisms including bacteria, viruses and fungi.

The disinfection effect of UV radiation is caused by the irreversible damage of DNA and RNA molecules of microorganisms in wastewater due to photochemical exposure to radiant energy. The influence of radiant energy involves the rupture or alteration of the chemical bonds of an organic molecule as a result of the absorption of radiation energy.

The degree of inactivation of microorganisms by UV radiation is proportional to its intensity I (MW/cm^2) and the irradiation time T (s). The product of these quantities is called the radiation dose D (mJ/cm^2) and is a measure of bactericidal energy, acting on microorganisms.

The dose of irradiation is taken at least 30 mJ/cm^2 for the design of UV disinfection of waste water.

Positive sanitary and technological aspects of the use of UV radiation for disinfection of sewage:

- a short contact time;
- elimination of the formation of toxic and carcinogenic products;
- the absence of a prolonged biocide effect, which have a negative impact on the body of water - the wastewater receiver;
- absence of necessity to store hazardous materials and reagents.

This method of disinfection is most applicable in sewage treatment plants of low productivity (up to 20000 m^3/day). UV-plants are effective in disinfection of wastewater that has undergone qualitative biological treatment or after-treatment on coarse-grained filters, since the presence of suspended substances significantly reduces the bactericidal effect.

Special mercury-quartz and mercury-argon lamps with special glass are used as sources of UV radiation. Glass has increased transparency in the UV spectrum due to the absence of oxides of Fe_2O_3, Cr_2O_3, V_2O_3 and heavy metal sulfides absorbing UV rays. Lamps of low pressure have a power consumption of 2-200 W and an operating temperature of 40-150 °C, high-pressure lamps - power in the range of 50-10000 W at an operating temperature of 600-800 °C.

Pressure and non-pressure type installations, which are with immersed in water sources of radiation (lamps) and unloaded used for disinfection of wastewater.

Pressurized installations of the UDV series of factory production for disinfection of water with a productivity of 6 to 1000 m^3/h and a radiation dose of 45 mJ/cm^2 are used in our country.

Low-pressure bacterialidal lamps type DB-75-2 with a service life of 12000 h (1.5 years) are used in installations. Also equipment for installations of higher productivity of non-pressure type is used.

8 Afterpurification of wastewater

8.1 Afterpurification of wastewater by filtration

For this purpose, the most filtration on drum grids with 0.5-1 mm cells at a speed of 40-50 m/h is widely used, followed by filtration on filters with granular loading. Straight-fast filters are used for post-treatment of biologically treated wastewater. Preference should be given to fast filters with flow direction from the bottom to the top, as well as multi-layer carcass-filling and coarse-grained filters.

The filtering speed is 5-15 m/h. Decrease of BPC_{poly} by 70-80%, COD by 30-40%, suspended solids - by 80-90% is achieved by filtration through granular loading of biologically treated wastewater.

Flushing of the filters is carried out with water with a suspended substance content of up to 20 mg/l or water-air flushing. Devices for hydraulic or mechanical loosening of the upper loading layer should be provided on fast filters with water moving from above. The intensity of washing of the fast sand filters with the bottom and top rinsing is about 16-18 $l/(s \cdot m^2)$ for 6-8 min, and for two-layer filters - 14-16 $l/(s \cdot m^2)$ for 8-10 min.

Water-washing with the following regime: air purging with an intensity of 18-20 $l/(s \cdot m^2)$ for 1-2 minutes; water-air flushing with an intensity of 6-7 $l/(s \cdot m^2)$ for 4-5 minutes is used for countercurrent fast filters. The duration of the filter cycle is used: for quartz flow-through filters 12 hours at the initial content of suspended substances 15-20 mg/l and 8 hours at 20-40 mg/l; for countercurrent and two-layer filters 24 hours with the initial content of suspended substances 15-20 mg/l and 16 hours at 20-30 mg/l.

The water after washing the filters is exposed to sedimentation for 2 hours, and then fed to the aeration tanks, and the sediment comes in the structure for sludge treatment. Periodically, once in 3 months, the loading of the filters is chlorinated, for which the filter is filled essentially with chlorine water with a chlorine concentration of 0.2-0.3 g/l.

Recently, carcass-filling filters (CFF) have been used more often for afterpurification of biologically treated wastewater. A feature of the kinetics of extraction of suspended substances is that the gravel framework retains large particles of suspended matter in an amount up to 40% equalizes the load on the slurry and thereby provides a more uniform dispersed composition of the suspended substances penetrating the second filter layer.

In this case, the active sludge accumulating in the filter load does not lose its biochemical activity. The efficiency of afterpurification of wastewater at the CFF is: 80-95% for suspended substances; to reduce the amount of BOP_{poly} - 66-89%; the decrease in the COD value is 24-40%.

Optimum technological and design parameters of CFF: filtering speed - 10 m/h; the size of gravel carcass fractions - 40-60 mm; the size of the sandfill fractions - 1-1.25 mm; the height of the sand backfill - 0.9 m and the total height of the gravel carcass - 1.8 m.

Optimum parameters of water and water-air washing of CFF:

- with a water washing: the intensity of the washing water supply is 20-22 $l/(s \cdot m^2)$, the washing time is 8 minutes;

- with water-air washing: the washing water flow rate is 12-14 $l/(s \cdot m^2)$; the intensity of the air supply is 20-22 $l/(s \cdot m^2)$; duration of washing 10 min.

8.2 Sorption of residual organic substances on activated carbon

Sorption - the process of absorption of a solid body of contaminants from the wastewater fluid (absorption) or pollution is deposited on its actively developed surface (adsorption), or come in a chemical interaction with it (chemisorption). For the purification of industrial wastewater, adsorption is most often used.

For this, the sorbent is in a crushed form added to the wastewater to be purified (solid) and mixed with wastewater. Then the sorbent, saturated with contaminants, is separated from the water by sedimentation or filtration. The most frequently treated waste water is passed continuously through a filter loaded with a sorbent.

As sorbents are used: active coal, coke fines, peat, kaolin, sawdust, ash, etc. The best, but expensive sorbent is active coal. To restore the sorption capacity, the active carbon undergoes regeneration with caustic soda, steam or heat treatment. The sorption method can be used, for example, for cleaning industrial sewage containing arsenic, hydrogen sulphide, etc. A disadvantage of adsorption purification is its relative high cost.

The appearance of afterpurification is associated with a continuous increase in water consumption and, accordingly, the formation of sewage. In this case, despite the high efficiency of existing treatment facilities, the total amount of residual contamination carried out with purified water exceeds the self-cleaning capacity of reservoirs.

The possible degree of removal of contaminants in the processes of tertiary treatment is almost unlimited and is determined by the conditions for the discharge of the treated wastewater or their subsequent disposal.

In dessision the overall problem of depletion and prevention of water pollution great importance repeated and multiple use of water and, first of all, the use of treated wastewater for irrigation in agriculture, and also as a source of technical water supply for industrial enterprises.

In areas that are severely deficient in water, cleaned municipal wastewater is already being used, even for the replenishment of groundwater resources. The requirements for the afterpurification of wastewater at their subsequent reuse are determined by the technology of the enterprises to which they are directed, which in turn determines the variety of possible technological schemes, methods and facilities for the preparation or afterpurification of wastewater.

The possibility and advisability of reuse of sewage are determined by sanitary, technical and economic factors. The possibility and efficiency of irrigation of agricultural fields with biologically cleaned domestic wastewater is well known.

Such use of domestic wastewater can simultaneously be considered as a method for their afterpurification, which ensures a high degree of removal of residual contaminants and, in particular, phosphorus and nitrogen compounds. However, in this case, serious sanitary and epidemiological measures are taken to prevent the spread of infectious diseases through soil and growing vegetables and fruits, as well as protect the health of agricultural workers.

Despite the existence of a certain positive experience of irrigation of meadows and agricultural fields with cleaned urban and industrial wastewater, still many questions remain to this day unclear. First of all issues related to the accumulation of plants harmful chemical compounds contained in wastewater for human and animal health.

Certainly, the existing irrigation technique needs further improvement. Therefore, the possibility of using treated wastewater for irrigation of agricultural fields in each specific case is established by the health authorities of the Ministry of Health and the basin inspectorates of the Ministry of Land Reclamation and Water Management.

The seasonality of irrigation, and consequently the need to create large storage tanks, the high cost of irrigation systems, the laboriousness of irrigation works, as a rule, limit the scope of this method of using wastewater in areas experiencing an acute shortage in water.

With the appearance of synthetic surfactants (surfactants) in domestic waters and the increase in the content of phosphorus compounds (as a result of the use of synthetic detergents for washing), irrigation of treated drainage waters of meadow drained areas is resorted to as the reception of afterpurification of domestic wastewater from these substances.

It is absolutely obvious that in the technological processes of the food, meat and dairy, pharmaceutical industries, the use of purified domestic wastewater is excluded.

8.3 Release treated wastewater in the reservoir

The design of lei out must ensure good mixing wastewater with water reservoir, that allows you to better use the self-cleaning ability of the latter.

Dischares are concentrated when waste water is *discharged* through one hole, and *diffusing* when there are several holes. There are also *shore* and *channel* discharges.

Coastal issues are unflooded and flooded. In the case of un-flooded coastal discharges, the sewage outflow is slightly higher than the water level in the river. With flooded coastal releases, a coastal well is set up and the wastewater outflow occurs under the water level, to the reservoir.

According to the design, the most dispersive channel discharges are most perfect. Such discharges end with an outlet head in the form of a horizontally placed conical tube, on the lateral surface of which there is a notch with transverse guides. This provides good mixing.

Very efficient mixing of wastewater with the waters of the reservoir provides the design of a scattering filter jet release in the form of a steel perforated pipe with a metal holder welded to it along its entire length with slotted holes. The clip is filled with coarse gravel or crushed stone.

The choice of the design of the release and its location is determined by technical and economic calculations.

8.4 The influence of anthropogenic activities on water quality

Main sources of water pollution.

Water quality is determined by both natural and anthropogenic factors. The greatest influence on water quality is anthropogenic activity, manifested in the intensive development of industry, energy, agriculture, transport and municipal services. The main sources of pollution are: industrial and household waste water, diffuse pollution sources (mineral fertilizers, pesticides, smoke emissions, etc.).

Great damage to reservoirs is caused by industrial sewage, containing toxic substances, which are harmful to aquatic ecosystems. The greatest amount of pollution in the absence of the required degree of purification comes from oil refining, chemical, pulp and paper, metallurgy, textile and other industries. The volume and composition of industrial effluents depend on the production capacity of each enterprise and the technology adopted on it.

In the conditions of further intensification of agricultural production increasing importance is being placed on the introduction of fertilizers and the use of various pesticides. However, when applying fertilizers and especially when using pesticides, their negative impact on water quality in reservoirs and streams is not always taken into account. Significant damage can be caused by thermal and nuclear power plants that discharge thermal water into natural and artificial water bodies, violating the thermal, hydrochemical and hydrological regimes.

Importantly, that the pollution coming from the atmosphere degrade the quality of natural waters. In some cases, they constitute up to 15-20% of the total load of the reservoir by contamination. Among the pollutants of natural waters should also include water transport, rafting and the corresponding work, dumps of mining developments, etc. To a large extent water management activities, including various ameliorative works have an influence on the quality of water. Especially these works affect on hydrochemical and hydrobiological regimes of watercourses and ponds, creating reservoirs. Communal wastewaters include fecal sewage, both organized and concentrated, and unorganized and dispersed. An important role is played by storm sewage, the concentration of impurities in which, especially in the initial period, can reach very high values.

Pollutants can be divided into: mineral, organic and bacterial.

Mineral pollution: sand, clay, solutions and emulsions of salts, acids, alkalis, mineral oils and other substances.

Organic contamination can be of plant and animal origin. There are easy-oxidizable compounds, for example, household, food and other wastewater, and heavy-oxidized solutions, usually products of the chemical industry.

Bacterial contamination: various microorganisms in the form of yeast and mold fungi and bacteria, including pathogens. The latter have an exclusively animal origin.

Of all types of pollution, oil products and phenolic compounds are most common, which have a negative impact on water and living aquatic organisms, even in small concentrations.

Pollution of reservoirs with surface-active detergents (surfactants) leads to the formation of persistent foam and a significant deterioration in sanitary indicators. The greatest danger to natural waters and living organisms is radioactive waste. Therefore, their discharge into water bodies is unacceptable.

All harmful substances affect on organoleptic, general sanitary, toxic and fishery water quality, changing its physical properties (transparency, color, smell, etc.) and chemical composition. At the same time there are floating formation and deposition of new bacteria, viruses, fungi. As a result, the quality of water in rivers and reservoirs may not be suitable for water use and water use.

The water quality of water bodies is assessed by physico-chemical, biological and microbiological indicators, the analysis of which makes it possible to determine whether the watercourse in question corresponds to the requirements of water users-water users, according to the current legislative acts. The criterion for assessing the admissibility of loading of water sources by pollutants is the maximum permissible concentration (MPC) of harmful substances in water bodies, as well as their general sanitary characteristics. The requirements for the quality of water in rivers, lakes, seas are developed in the form of MPCs for water supply sources, water bodies, located within populated areas, in the recreation area and others. In Kazakhstan, the rules for permissible discharges of polluted substances are defined for each production, city or village, based on the MPC of harmful substances in the water use zone - water consumption.

Pollution of rivers and reservoirs with harmful substances.

A significant amount of pollution is discharged with wastewater from cities and towns and industrial enterprises. Effluent during the time (day, week, year) occurs unevenly, having, as a rule, daily highs (morning and evening) and a deep night minimum. The composition of the waste water depends on the source of pollution and varies with time, and the daily fluctuations in the content of the various ingredients are 3-4 or more times. Pollution in wastewater can be divided into undissolved, colloidal (particles from 0.1 to 0.001 mm) and dissolved substances. The bacterial state of rivers and reservoirs depends on the content of pathogenic and indicator bacteria in them, indicating the possibility of pathogenic microbes in the waste water. Urban wastewater contains up to 40% of suspended solids, up to 10-20% of colloidal and up to 40-50% of dissolved substances.

When assessing the quality of natural waters, it is necessary to know the load of pollution entering them. For household wastewater, the amount of pollution per inhabitant per day is determined according to the "Sanitary norms and rules" in grams:

- for suspended substances - 65;
- for BOD up to 60-75;
- for nitrogen of ammonium salts - 8-9;
- for phosphates - 1.7;
- for chlorides - 9.

The processes of self-purification are caused by the combination of many factors, including solar radiation, the activity of microorganisms and aquatic vegetation.

8.5 Measures for the prevention of depletion and pollution of natural waters and improve their quality

Throughout the history of the development of society, the relationship between man and nature is characterized by the extraction from it of valuable components necessary for the existence and development of people. This is reflected in the production of agricultural products, the development of minerals and the discharge of manufactured goods, the harvesting of timber and valuable vegetation, fishing, hunting for animals and birds. All this leads to disruption of natural communities and their gradual depletion.

Almost to the last time, humanity did not care about the restoration of the natural potential, without regard for the fact that it is not inexhaustible and that the self-regulatory capacity is not unlimited.

This is largely related to water resources, land, intensive use of which in certain regions, contributed to their intense exhaustion and pollution. Further development of society is inconceivable without strict implementation of a system of social, ecological and technical-economic measures. It is necessary to prevent serious ecological changes in natural ecosystems and to create conditions for their normal functioning for a long time. Of particular importance in this connection is the establishment of the maximum possible loads of anthropogenic influence both on individual elements of natural communities and on their complexes.

Progressive pollution of the environment, and primarily natural water, is due not only to the ever increasing scale of industrial and agricultural production, the growth of cities, but also to a large extent by the imperfection of their technologies.

There are three main ways to combat pollution:

- creation of non-waste production facilities that allow the disposal of all remaining waste;
- reducing the amount of raw materials used to produce a unit of production, therefore, it makes it possible to reduce the total amount of harmful emissions;
- purification of all emissions to the biosphere, which is associated with significant costs for the construction and operation of treatment facilities, as well as the need to recycle the remaining waste.

A permanent system for implementing a set of measures aimed at preventing the depletion and contamination of water resources should include the following interrelated sections:

- greening of industrial, agricultural production and urban economy;
- purification of natural and waste water;
- ameliorative measures.

1. The following recommendations should be based on the ecological technology of production of various types of products:

- place new facilities in accordance with available water resources and permissible environmental pressures on the natural environment;

- reduce specific water consumption;

- switch to recirculating water supply systems and consistent use of water within a single enterprise;

- use waste water for the needs of other enterprises;

- introduce separate wastewater treatment systems;

- to extract valuable constituents from industrial and sewage waste;

- apply measures of economic impact by introducing fees for consumed and discharged water.

The most radical way to protect water resources from depletion and pollution is to stop discharging wastewater into rivers and reservoirs.

2. In modern conditions purification of natural and waste water is of great importance. Probably in the long term, as continuous improvement of wasteless industries, the role of the main treatment of waste water will be somewhat reduced. However, it will retain its importance of afterpurification of waste water in the implementation of a comprehensive program to protect water resources from pollution.

3. A special place in the prevention of the depletion and pollution of natural waters belongs to a complex of meliorative measures. By their nature, they are different, and the implementation of most of them requires considerable funds and time. Among the reclamation measures are:

- the most complete use of the bioclimatic potential of each region in order to obtain sufficiently high and stable yields;

- location of crops with regard to water availability of river basins, oblasts and rayons;

- optimization of the use of fertilizers and pesticides in order to ensure an adequate level of agricultural production and to prevent pollution of surface and groundwater;

- reduction of water losses for filtration, evaporation and non-productive discharges;

- introduction of the most progressive methods of soil moistening;

- rational use of reservoirs and maintenance in them of the proper quality of water;

- implementation of a comprehensive program to combat the harmful effects of floods, mudflows, landslides, water erosion, etc .;

- forest conservation measures.

The main ways to improve the quality of water.

Ways to improve the quality of water and the composition of water treatment facilities depends on the requirements that the consumer makes to the quality of water and the quality of natural water. These requirements are as follows: smell and flavor at a temperature of 20 °C not more than 2 points; chromaticity on a platinum-cobalt scale of no more than 20; transparency on the font is not less than 30 cm; turbidity not more than 2 mg/l; total hardness of water no more than 7 mg eq/l.

In drinking water should be: lead no more than 0.1 mg/l; arsenic not more than 0.05 mg/l; fluorine not more than 1.5 mg/l; copper not more than 3.0 mg/l; zinc not more than 5.0 mg/l. In 1 ml of water, the total number of bacteria determined by the number of colonies after a 24-hour cultivation at 37 °C is not more than 100, and the number of E. coli in 1 liter of water is not more than three; the content of iron and manganese is not more than 0,03 mg/l; the active reaction of water pH should be within the range of 6.5-9.5; in the water must be absent chlorophenol odors.

Optimum temperature of domestic and drinking water 7-10 °C; (the maximum permissible 35 °C). In the water used for drinking water supply, the dry residue should not exceed 1000 mg /l; the chloride content should not exceed 350, and sulfate 500 mg/l.

The main ways to improve the quality of water for domestic and drinking purposes: clarification; discoloration; disinfection.

Clarification of water - removal of suspended substances from it. Depending on the required degree of clarification used: sedimentation of water in sedimentation tanks, hydrocyclones; clarification of water by passing it through a layer of previously formed suspended sediment and so-called clarifiers with suspended sediment; Filtering of water through a layer of a granular filter or filtration through grids and fabrics.

To achieve the desired effect, water clarification takes place in sumps, clarifiers and on filter units with granular filter loading for the purpose of intensifying the process, i.e. to the action of salts of polyvalent metals. At the same time, the water is significantly discolored.

Discoloration of water - elimination or discoloration of various colored colloids or solutes. For this purpose, water is subjected to coagulation, various oxidizers (chlorine, nitrogen, potassium permanganate) and sorbents (active carbon) are used.

Disinfection of water is carried out to destroy the pathogenic bacteria and viruses contained in it. Most often, chlorination of water is used, as well as other methods of disinfection (ozonation, bactericidal irradiation, etc.).

Methods and installations for water demineralization.

Distillation, ion exchange, freezing and electroanalysis are used and are more widespread for the desalination of saline waters.

The process of distillation is the evaporation of highly mineralized water followed by the condensation of steam, as a result fresh water is obtained. A single-stage evaporative plant consists of a steam boiler, an evaporator, a heat exchanger for steam condensation, pumps, pipelines, instrumentation, expanders, etc. Multi-stage evaporative plants are several consecutive evaporators. While distillation method is relatively expensive and difficult to operate the installation.

Use of of sediment of wastewater. Using the sediment (sludge) formed in the course of wastewater treatment is of great importance for agriculture and for urban green plantations. At the same time farms can receive it at wastewater treatment stations free of charge.

Sediment of urban wastewater contains 50-85% of organic substances, of which 80 consists of carbohydrates, fatty acids and proteins. The content of organic matter in the fermented sediment is reduced to 50%.

Mature sediment is harmless and is used as a fertilizer. According to its indicators, the sediment is not inferior to manure. It is easily humunized and increases the water permeability of the soil. The content of biogenic elements in the sediment depends on the dry substance content, the nature of wastewater treatment and others.

The use of wastewater sediment depends to a large extent on the crops grown. It is recommended to use a sediment for fertilizing meadows and cereals. Especially effective is the use of sludge on mineral soils that are poor with humic substances if fertilizing the land not more than once every five years. It is recommended for five years to introduce into the soil not more than 20 tons of dry substance sediment per hectare. In this case, it is necessary to take into account the nature and degree of wastewater treatment, crop species, and the content of toxic substances.

9 Using of wastewater

Currently, the total area of irrigation by sewage in Kazakhstan is 8-10 thousands ha (30-35 thousands ha). The slow development of agricultural irrigation fields (AIF) is explained by the poor knowledge of many technical, economic and environmental aspects of this problem, inadequate experience in operating AIS systems in various zones, the need for winter storage facilities, the lack of coordinated interdepartmental "Sanitary norms and rules," a small number of specialists, well familiar with the design, construction and operation of systems.

Types of wastewater used for irrigation.

Household, industrial and mixed wastewater, i.e. there are almost all types of liquid effluents can be used for irrigation of agricultural crops in AIF. When deciding whether to use wastewater, in particular production, it is necessary to take into account: composition of effluents, climatic data, relief and hydrogeological conditions; soil cover and vegetation, hydrogeological and chemical characteristics of the water intake; agricultural use of irrigation, irrigation regime and a number of other factors. Household and municipal mixed waters of small towns and villages are considered suitable for their composition for irrigation in different natural conditions.

It is believed that mixed wastewater of large cities, past biological treatment is suitable for feeding to AIF, because the MPC requirements for water discharged into the water intake are much higher than in irrigation water.

As recommended by the rules on water protection and technical conditions for the design of canalisation, individual enterprises or shops where waste water is formed, which are dangerous for contamination of water receivers or soil, should have local treatment facilities, and highly toxic waste must be destroyed or buried. Suitable and useful for fertilizer irrigation are industrial sewage: canning, sugar, starch-treacle, alcohol, brewing, yeast, dairy plants.

Wastewater from sugar factories contain many organic substances and can be classified in the middle category according to fertilizer efficiency. They contain: nitrogen (N) - 40-50 mg/l; potassium (P) - 60-70 mg/l; phosphorus (P) - 3-6 mg/l.

Wastewater from starch plants is characterized by an increased concentration of suspended and dissolved substances, as well as acidic reaction: nitrogen (N) - 85-105 mg/l; potassium (K) - 100-280 mg/l; phosphorus (P) - 10-50 mg/l. A high concentration of these wastewater requires 2-3 times their dilution or liming of soils.

Wastewater from dairy plants is quite suitable for irrigation and does not require special preparation: nitrogen (N) - 35 mg/l; potassium (K) - 25 mg/l; phosphorus (P) - 17 mg/l; calcium (Ca) - 150 mg/l.

Wastewater of meat-packing plants have significant fluctuations in concentration (N, P, P, average 290:100:140), so they need to be diluted. Wastewater must be treated in a clarifier, and also subject to biological treatment. Use of these wastewater for AIF is recommended when growing herbs for the production of vitamin herbal flour.

Wastewater of alcohol-vodka and yeast plants (N, P, P, on the average 200:300:480) is difficult to biological purification at facilities and can be used for irrigation after 1.5-2 fold dilution under conditions of periodic liming of soil in sufficient and surplus zones humidification.

Less rich in fertilizers (N, P, P - 30:10:100) drains of brewing, malting and canning (fruit and vegetable) plants.

Sewage of textile enterprises in terms of their chemical composition are suitable for irrigation. Since the content of phosphorus and nitrogen in them is insignificant, they can be effectively used in the AIF for diluting livestock sewage (liquid manure).

Preparation of wastewater for irrigation.

Before filing for irrigation as well as before discharge into the water intake all household and mixed municipal waste water, according to regulations should pass complete preparation, as well as processing wastewater sediment.

Depending on the characteristics of the wastewater, their physico-mechanical properties and chemical composition, there may be no separate elements in the purification system (for example, greasers), but additional facilities or installations for the removal of specific components from effluents, for neutralization, dilution, elimination or cooling of water should be included.

Biological ponds (BP) are used instead of biofilters on small sewage facilities in areas with an average annual temperature above 0 °C. For more northern regions, BP are used seasonally at a water temperature above + 4 °C. There are flow (step) and contact BP, called BOCS (biological oxidation contact stabilization). More efficient treatment of wastewater is ensured by the successful interaction of various hydrobiological factors. After the end of the cycle in BOCS ponds, wastewater is safe from a sanitary position and is epidemiologically harmless. The depth of the sewage ponds is 1-1.5 m, the ratio of length and width in the plan is 2:1 and 3:1.

Calculated loads for BOD5 to 250 - 300 kg/ha per day. It depends on the climatic conditions, and the number of steps usually take 2 to 4.

The depth of filling of contact ponds is 0,5 - 0,8 m, the time of stay in them drains is 8 - 10 days, the load on BOD is from 60 to 120 kg/ha. These ponds are arranged with sections, each of which is designed to receive one - two-day volume of wastewater.

The organization of recycling water use at AIF, of course, reduces the sanitary requirements for the preliminary treatment of wastewater from pollutants of biogenic origin, but increases the requirements for the chemical composition of the runoff so that in the soil there is no accumulation of harmful components to toxic concentrations.

Schemes of agricultural irrigation fields.

The choice of areas for the arrangement of AIF and schemes of the location of their elements is determined by the following factors:

- natural conditions;
- economic use of the territory;
- the current state and prospects for the development of agriculture, its effectiveness;
- the availability of labor and irrigation experience;
- availability of transport links and sources of energy conservation;
- characteristic of discharged sewage;
- data on the integrated use of water resources in the basin of this water intake;
- composition of water users and prospects for their development;
- volumes of water consumption and water disposal;
- forecasts of water quality;
- presence of recreational water protection zones;
- number of water users in industry, agriculture, forestry or fisheries.

Usually, for the placement of AIF recommend the use of an area with slopes of 0.0005-0.01 (up to 0.03), characterized by low fertility and high filtration properties of the soil.

There are three types of existing AIF:

- providing reception and irrigation by wastewater throughout the year;
- providing reception of wastewater in the regulating tanks and use only during the growing season;
- providing reception and irrigation only in the growing season.

The integrated value of the AIF is to increase the fertility of soils and the yield of agricultural crops and is combined with the post-treatment of wastewater. All this ensures the protection of natural waters from pollution.

The main task of designing a general scheme of AIF in each specific case, with a certain combination of factors discussed earlier, choose the most optimal variant of the layout of the scheme that meets the requirements of rational use and protection of natural resources.

Under a certain irrigation regime with wastewater, in addition to the water balance of the soils and the fertilizer capacity of the effluents (N, P, P), they are usually tested for MPC of toxic and harmful substances entering with effluents into the soil. This is especially true of weakly diluted drains.

It should be noted that the calculations of the water balance should take into account not only the aeration zone, but also the groundwater zone. Irrigation rates during the vegetation period are assigned as for conventional irrigation. They depend on the moisture capacity of soils, the irrigation techniques, the vegetation period and range from 200 to 1000 m^3/ha. Irrigation rates for individual crops at the AIF are often set at 20-50% higher than for conventional irrigation.

Use of warm waters for agriculture.

The intensive development of thermal and nuclear power is associated with the expenditure of large amounts of water, a significant part of which is discharged back into rivers, lakes and reservoirs, causing their thermal pollution and disturbance of aquatic ecosystems. Therefore, the maximum utilization of processed heat is an actual task.

The water required for the operation of thermal and nuclear power plants is mainly spent on steam generation in boilers and condensation of the exhaust steam. In addition, they are used to cool steam, oil, gas, air, bearings and when working on solid fuels - for hydraulic removal of ash and sludge.

As a rule, all wastewater of power facilities is suitable for irrigation. When collecting them in reservoirs, the temperature of the upper layers of water is 8 to 15 °C above the temperature of the bottom layers. This difference largely depends on the parameters of the reservoir, the climatic features, the time of the year, the volumes and temperature of the incoming wastewater.

Therefore, it is more expedient to take the water for irrigation from the upper layers ponds and reservoirs.

Depending on the location of the power plants and the parameters of the equipment installed on it, the temperature of the waste water varies within the following limits: in winter 10-20 °C; in the spring 20-25 °C; in summer 35-40 °C. The positive effect of warm waters on the germination of crops is most noticeable in the spring and autumn periods, which is due to the heat deficit at this time of year. When watering with warm water is not recommended to allow a significant difference in air, water and soil temperatures. It is a depressing effect on many plants.

The use of warm water for fish farming.

As the experience of recent years has shown, waste water from thermal and nuclear power plants can be successfully used for the needs of fisheries in inland ponds.

The most promising areas in the development of fish farming with the use of warm waters should be considered the creation of full-scale aquaculture farms of industrial type with swimming pools, reticulated nets, workshops for the incubation of caviar, workshops providing production of live food.

These f`arms carry out a continuous technology for obtaining planting material and growing fish throughout the year; use of cooling reservoirs as feeding ponds for heat-loving fish (carp, etc.); the organization of nurseries for the cultivation of planting stock for commercial farms; creation of highly productive pond farms.

10 Protection of water bodies and the fight against harmful effects of water

Protection of water bodies.

Water objects shall be protected by:

- natural and technogenic pollution by harmful dangerous chemical and toxic substances and their compounds;
- thermal, bacterial, radiation and other pollution;
- clogging with solid, insoluble objects, industrial, domestic and other origin wastes;
- exhaustion.

Water objects to be protected in order to prevent:

- violation of environmental sustainability of natural systems;
- causing harm to the life and health of the population;
- reduction of fish stocks and other aquatic animals;
- deterioration of water supply conditions;
- reducing the ability of water bodies to natural reproduction and purification;
- deterioration of the hydrological and hydrogeological regime of water bodies;
- other adverse events that adversely affect the physical, chemical and biological properties of water bodies.

Protection of water bodies is carried out by:

- presentation of general requirements for the protection of water bodies to all water users carrying out any use of them;
- presentation of special requirements to certain types of economic activity;
- improvement and application of water protection measures with the introduction of new technology and environmentally, epidemiologically safe technologies;
- establishment of water protection zones, protective bands of water objects, zones of sanitary protection of drinking water supply sources;
- conducting state and other forms of control over the use and protection of water bodies;
- application of measures of responsibility for non-compliance with the requirements for the protection of water bodies.

The central and local executive bodies of the regions (cities of the republican significance, the capital) in accordance with the legislation of the Republic of Kazakhstan adopt measures compatible with the principle of sustainable development for the conservation of water bodies, prevention of their pollution, debris and depletion, and for the elimination of the consequences of these phenomena.

Physical and legal persons that affect the condition of water bodies are obliged to comply with environmental requirements established by the environmental legislation of the Republic of Kazakhstan and conduct organizational, technological, forest amelioration, agrotechnical, hydro technical, sanitary and epidemiological and other measures to protect water bodies from pollution, contamination and exhaustion.

Pollution of water bodies is the discharge or entry into water bodies of objects and pollutants other ways, deteriorating the quality of the state and making it difficult to use water bodies.

In order to protect of water bodies from pollution is prohibited:

- the use of pesticides, fertilizers in the spillway area of water bodies. Disinfection, disinsection and deratization measures for the spillway area and the sanitary protection zone for water bodies are carried out in agreement with the authorized body in the field of sanitary and epidemiological welfare of the population;
- dumping and disposal of radioactive and toxic substances in water bodies;
- discharge into water bodies of sewage of industrial, food objects that do not have treatment facilities and do not provide effective cleaning in accordance with the standards;
- carrying out on the water objects of blasting operations, which use nuclear and other types of technologies, accompanied by the release of radioactive and toxic substances.

Protection of water bodies from clogging.

Clogging of water bodies is the ingress of solid, industrial, domestic and other wastes in them, as well as suspended particles, as a result of which the hydrological state of the water body deteriorates and water use becomes more difficult.

Discharge into water bodies and burial of solid, industrial, domestic and other wastes in them is prohibited.

Clogging of spillway areas of water bodies, ice cover of water bodies, glaciers with solid, industrial, domestic and other wastes, washing of which will result in deterioration of the quality of surface and underground objects, is not allowed.

Protection of water bodies from depletion.

The depletion of water bodies is the reduction of the minimum permissible level of flow, surface water reserves and the reduction of groundwater resources.

In order to prevent the depletion of water bodies, individuals and legal entities that use water bodies are required to:

- do not allow over-limit irrevocable withdrawal of water from water bodies;
- do not allow bathing and sanitation of livestock, construction of buildings leading to the depletion of water bodies, on the territory of water protection zones and land plots;
- carry out water protection measures.

Water protection measures aimed at preventing water bodies from depletion carried out by natural and legal persons are preliminary agreed with the authorized body in the field of use and protection of the water fund, the authorized state body in the field of environmental protection and the authorized body for study and use of mineral resources.

Water protection zones and strips of water objects and water management structures.

Water protection zones and stripes with special conditions of use are established to maintain water objects and water facilities in a state corresponding to sanitary and environmental and ecological requirements, to prevent pollution, contamination and depletion of surface waters, and also to preserve the animal and plant life.

Water protection zones, strips and the regime of their economic use are established by local executive bodies of the regions in agreement with the authorized body in the field of use and protection of the water fund on the basis of approved project documentation agreed with the authorized body in the field of environmental protection and land resources management, and in the mudflow regions additionally and with the central executive body of the Republic of Kazakhstan for emergency situations.

In forests located on water protection zones and coastal protective bands, cutting of the main use is prohibited. It is allowed to carry out intermediate cutting and other forest management measures that ensure the protection of water bodies.

The use of forests of water protection zones is carried out in agreement with the authorized body in the field of use and protection of water resources in accordance with the forest and water legislation of the Republic of Kazakhstan. The rules for the establishment of water protection zones and strips are approved by the Government of the Republic of Kazakhstan.

Zones of sanitary protection.

In order to protect the waters used for drinking water supply of medical, spa and other recreational needs of the population, the local executive bodies of the regions establish sanitary protection zones. The procedure for establishing sanitary protection zones and sanitary protective bands is determined by the authorized body in the field of sanitary and epidemiological welfare of the population.

Water objects can be declared as zones of extreme ecological situation or ecological disaster if, as a result of economic activities or natural processes, changes occur that threaten the health of the population, the animal and plant world, and the state of the environment. The Government of the Republic of Kazakhstan declares an emergency ecological situation on water bodies or river basins and groundwater deposits.

Land plots in water protection zones and strips of water objects and water facilities can be provided for temporary use to individuals and legal entities in the manner established by the legislative act of the Republic of Kazakhstan on land, subject to compliance with established requirements for the regime of economic activity. The state control over compliance with the requirements for the regime of economic activities in water protection zones and bands is carried out by the authorized body in the field of use and protection of the water fund, by the authorized state body in the field of environmental protection, by the central authorized body for land resources management within their competence.

Features of protection of underground water objects.

Individuals and legal entities, whose productive activities can have a harmful effect on the state of groundwater, are obliged to monitor groundwater and take timely measures to prevent pollution and depletion of water resources and the harmful effects of water.

In the catchment areas of groundwater, which are used or can be used for drinking and domestic water supply, it is forbidden to place burials of radioactive and chemical wastes, landfills, cemeteries, cattle cemeteries and other objects that affect the condition of groundwater. It is forbidden to irrigate land with wastewater, if this affects the condition of groundwater.

Small water bodies and features of their protection. Small water bodies include natural water bodies having the following dimensions: on closed water objects - with the area of the water mirror to ten hectares; along rivers - watercourses up to two hundred kilometers.

The use of water resources of small water bodies, as a rule, is carried out in the order of general water use. Use of water resources of small water bodies in the order of special water use is possible after study by the authorized body in the field of use and protection of the water fund of the consequences of such water use on their condition and in the presence of the positive conclusion of the state ecological expertise. Measures for their protection and restoration are envisaged in order to prevent the depletion, pollution and degradation of small water bodies in basin programs for the protection of water bodies.

Knowledge of all the features inherent in the integrated use and protection of water resources is extremely necessary for engineering and technical workers, whose activities are to a greater or lesser degree connected with water. The integrated program for the use of natural resources in recent years is determined by the trend of active application of economic methods of regulation and use of natural resources. First of all, we are talking about the introduction of payment for the use of natural resources.

Such mechanisms exist in the international practice of environmental management (USA, Japan, Poland) and have confirmed their effectiveness.

According to this principle, a corresponding regulatory and legal framework has been created, and management and control issues have been resolved. The formation of an economic mechanism for the use of natural resources in a market economy will take place in the following areas:

- accounting and socio-economic assessment of the natural and resource potential and economic conditions of the territory, planning of environmental protection and rational use of natural resources, financial and credit mechanism of nature use;

- economic incentives (establishment of tax, credit and other benefits to enterprises and organizations), payment of nature use, economic impact on violators of nature protection legislation;

- improvement of organizational and economic methods of nature management.

The role of water in human activity as a factor in increasing the efficiency of social production.

Water resources, until recently considered inexhaustible and affordable, quickly passed into the category of resources, the lack of which would seriously impede sustainable economic development, and in some regions of the world be the main cause of conflict situations between individual states.

Water participates in all spheres of human life and is an indispensable component of agrarian and industrial production, ecological balance of the natural environment and becomes the most valuable resource of the country.

According to some estimates, about a third of the world's population will experience a constant shortage of water after 30 years.

The reasons for this are obvious:

- increase in demand for water as the population increases rapidly;
- deterioration of the quality of existing water resources as a result of environmental pollution;
- an increase in the demand for water in the rapidly developing industry and agriculture.

Worldwide freshwater consumption annually increases by 2-3%.

It is known that the reserves of fresh water are not unlimited. Therefore, in the face of increasing demand for its quantity and increasing the variety of its uses, the need to protect and manage water resources is becoming more urgent than ever. After all, serious disagreements over the use of scanty water supplies can eventually lead to no less serious conflicts between countries.

Requirements to improve the quality of the environment and reduce the risk to human health are becoming ever more insistent.

In the world, more than 1 billion people do not have the opportunity to use water that is harmless to health, and 1.7 billion people live in unacceptable sanitary conditions. Polluted and contaminated water annually causes the death of millions (3 million) people. Since water pollution is a serious and pervasive problem, its purification is of paramount importance. This process is directly connected with a whole range of scientific, technical, economic and political factors and does not have national, regional and international borders.

The revealed trends show that at present a water crisis is ripening in a number of regions. Its approach is most noticeable in the Middle East and North Africa, where the annual water consumption per capita is - 1247 m^3, if you compare it with 18742 m^3 in North America and 23103 m^3 in Latin America, in Kazakhstan 2500-2700 m^3. In the near future, the main obstacle to the development of agricultural production (and others) in many areas will be a shortage of water, rather than land.

In many countries, water scarcity is explained by its wasteful use of water resources. The loss of water due to leaks, filtration and inadequate accounting is from 40 to 60%.

The coordinated activities of many different organizations are required to conserve freshwater supplies. Education, training and the strengthening of local organizations and governing bodies can help in overcoming some of these obstacles.

References

1 Панов В.П. Теоретические основы защиты окружающий среды.- М.: Высшая школа, 2010. – 248 с.

2 Гидрохимические показатели состояния окружающей среды. Под ред. Т.В. Гусева. - М., 2008. - 366 с.

3 Воронов Ю.В., Яковлев С.В. Водоотведение и очистка сточных вод.- М.: Ассоциации строительных вузов, 2006. - 704 с.

4 Ветошкин А.Г. Теоретические основы защиты окружающей среды. - Москва: Высшая школа, 2008. - 340 с.

5 Денисова В.В. Промышленная экология. - Москва, 2007. - 324 с.

6 Жандаулетова Ф.Р. Учебное пособие «Охрана и рациональное использование водных ресурсов и почв». Алматы, 2015. – 115с.

7 Серов Г.П. Техногенная и экологическая безопасность в практике деятельности предприятий. - Москва, 2007.

8 Обзор «Водные ресурсы Казахстана в новом тысячелетии». - Алматы, 2004.-132 с.

9 Авраменко И.М. Основы природопользования. - Ростов - на- Дону, 2004.-320 с.

10 Экологические проблемы и энергосбережение. под ред. В.Д.Карминский. - М., 2004. – 268 с.

11 Проект отраслевой программы «Водосбережение». - Астана: МООС, 2004.

12 Серов Г.П. Техногенная и экологическая безопасность в практике деятельности предприятий. - М., 2007.- 309 с.

13 Степановских А.С. Охрана окружающей среды. – Алматы, 2008. – 400 с.

14 СНиП РК 4.01.-02-2001 (СНиП 2.04.02.-84) Водоснабжение. Наружные сети и сооружения. - Астана, 2002.

15 СНиП РК 4.01.-03-2002 (СНиП 2.04.03-85) Канализация. Наружные сети и сооружения. - Астана, 2003.

16 Концепция экологической безопасности Республики Казахстан. МООС. – Астана, 2004.

17 Водный кодекс Республики Казахстан. - Астана: БИКО, 2012. - 64 с.

18 Брюхань Ф. Промышленная экология. - Москва, 2011. - 278 с.

19 Павлов А. Н. Экология: рациональное природопользование и безопасность жизнедеятельности. Учеб. пособие /А. Н. Павлов. – М.: Высш. шк., 2005. - 343с.

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