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ВПЛИВ ФІЗИЧНИХ І ОКЕАНОГРАФІЧНИХ ФАКТОРІВ НА РОЗШИРЕННЯ ЗОНИ ЗАБРУДНЕННЯ КАСПІЙСЬКОГО МОРЯ (ПІВНІЧНО-СХІДНА ПРИБЕРЕЖНА ЗОНА АЗЕРБАЙДЖАНУ)

Мета - вивчити поширення забруднення, спричиненого природними та антропогенними факторами, в акваторії Каспійського моря, найбільшого закритого басейну світу, за фізичними та океанографічними факторами.

Методика. У статті використано методи обробки статистичних показників та обрано метод Брукса-Коха для розрахунку висоти підйому (ΔH0) стічних вод у стратифікованому середовищі.

Результати. В акваторії Азербайджанської Республіки забруднення Каспійського моря найбільше відбувається на Апшеронському півострові. Основна причина цього полягає в тому, що територія багата запасами нафти і газу, а також багато нафтовидобувних підприємств. Крім природних факторів, таких як вітер, температура і течії, на поширення забрудненої нафтою морської води також впливають антропогенні фактори.

В результаті аналізу фізичних і океанографічних факторів ми визначили, що глибина стічних вод при їх скиданні в море повинна бути більше 70 метрів. Основною причиною цього є те, що скинуті на глибину стічні води змішуються з холодними, а з часом і важкими придонними течіями. Коли стічні води, змішані з чистою морською водою, піднімаються на поверхню, вони продовжують змішуватися в проміжних шарах, оскільки їх вага важча, ніж шар над ним. Основна причина, чому це відбувається лише в Каспійському морі, полягає в тому, що температура морської води підвищується, а не знижується з глибиною.

Той факт, що коефіцієнт турбулентного перемішування, розрахований для підтвердженої в статті площі, становить 104-106, свідчить про те, що пульсація концентрації посилюється зі збільшенням діаметра осаду стічних вод. Така ситуація створює умови для змішування стічної води з навколишньою водою.

Наукова новизна. Вивчено вплив фізичних і океанографічних факторів на зміну, розширення і поглиблення площі стічних вод в акваторії Каспійського моря. Також розраховано коефіцієнт турбулентної дифузії забруднення в прибережних зонах.

Ключові слова: водотоки, стічні води, очисні споруди, зона забруднення, турбулентна дифузія.

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THE EFFECT OF PHYSICAL AND OCEANOGRAPHIC FACTORS ON THE EXPANSION OF THE POLLUTION AREA OF THE CASPIAN SEA (NORTH-EASTERN COASTAL ZONE OF AZERBAIJAN)

Aim. Our main goal is to study the spread of pollution caused by natural and anthropogenic factors in the water area of the Caspian Sea, the largest closed basin in the world, according to physical and oceanographic factors.

The methodological basis of the article. The article uses methods of processing statistical indicators and selects the Brooks-Koch method to calculate the rise height (ΔH_0) of wastewater in a stratified environment.

Results. In the water area of the Republic of Azerbaijan, the pollution of the Caspian Sea occurs mostly in the Absheron Peninsula. The main reason for this is that the area is rich in oil and gas reserves and there are many oil production enterprises. In addition to natural factors such as wind, temperature and currents, anthropogenic factors also influence the spread of oil-contaminated seawater.

As a result of the analysis of the physical and oceanographic factors, we determined that the depth of sewage should be more than 70 meters when it is discharged into the sea. The main reason for this is that the sewage dumped in the depth is mixed with the cold, and with time, heavy bottom currents. As sewage mixed with clean seawater rises to the surface, it continues to mix in the intermediate layers because its weight is heavier than the layer above it. The main reason why this happens only in the Caspian Sea is that the temperature of the sea water increases instead of decreasing with depth.

The fact that the turbulent mixing coefficient calculated for the area confirmed in the article is 104-106 shows that the concentration pulsation intensifies with the increase in the diameter of the sewage sludge. This situation creates conditions for the mixing of waste water with the surrounding water.

Scientific novelty. The effect of physical and oceanographic factors on the change, expansion and deepening of the area of sewage in the Caspian Sea water area was studied. Also, the turbulent diffusion coefficient of pollution in coastal zones was calculated.

Keywords: streams, sewage, treatment plants, pollution area, turbulent diffusion.

Introduction. Nature is considered the pinnacle of the living world, and excessive human activity leads to environmental degradation. The ruthless use of natural resources given by nature, harmful wastes thrown into nature, hundreds of thousands of extraneous artificial substances disrupt the natural balance of water, soil, forests and atmospheric air [6]. Some natural and anthropogenic factors that occur in the Caspian Sea and on its coast have a great influence on ecological processes. Over the past 100 years, the fauna and flora of the Caspian Sea have been significantly reduced, some have been completely destroyed, large areas have turned into "dead zones". Petrochemical and metallurgical industries, the processing of non-ferrous metals, thermal power plants, the burning of household waste, motor vehicles and other factors play an important role in the pollution of the Caspian Sea [7].

Current climate changes: pollution and level fluctuations of the Caspian Sea affect its ecological condition, as well as the living conditions of the population living in the coastal zones of the sea [1,2]. The ecological system of the Caspian Sea is a single natural complex consisting of two components - environment and biota. The water masses of the Caspian Sea are formed as a result of the influence of continental currents and sea surface evaporation. The formation and movement of water masses, as well as the change of the sea surface, is a single process that takes place from the surface to the bottom from north to south. The main reason for the pollution of the Caspian Sea is local pollution from various sources. The basis of the pollution of the Caspian Sea from the coastal strip is caused by the uncontrolled (without treatment and neutralization) discharge of waste water formed in large oil enterprises into the organized streams.

Research methods. Methodological bases of the article are the processing methods of statistical indicators, and the Brooks-Koch method is used to calculate the height of the sewage head (ΔH_0) in the environment.

In the presented article, the sources of pollution available in the coastal zone of the Absheron Peninsula and the devices used to clean them are studied. The effect of physical-oceanographic processes on sea currents was also studied, and the linear dependence of the rising rate of wastewater from the depth of the sea to the surface was analyzed.

Analyzes and discussions. The article discusses the sources of pollution in the northeastern coastal zones of the Caspian Sea and the degree of their influence on the ecological state of the sea. [3]. At the same time, the characteristics of the power and operation of treatment plants in the coastal zones of the Absheron peninsula of the Caspian Sea are studied. The influence of deep-water physico-oceanographic processes on sea currents is studied. The linear dependence of the rising rate of wastewater from the depth of the sea to the surface is described.

Climate changes occurring on Earth (drought, continuous rains, abnormal temperature changes) have their effect on all living and natural world. From this point of view, the role of water bodies in the existence of life on our planet is huge. Climate changes occurring in the world also have their effect in our republic. So, from the 1990-years until now, the level of the Caspian Sea has risen and fallen several times, so that such natural phenomena to the flora and fauna of the sea has shown its impact dramatically. The current state of the Caspian Sea shelf along the coast requires a number of measures.

As you know, there are the following methods of disposal of waste in the sea:

• prevent discharging untreated sewage into the sea [6];

• total elimination of waste on land to prevent dumping of waste into the sea or purposeful (in watering greens) being used;

• passed through complete cleaning (norm and according to standards) discharge of waste water into the sea.

Operation of treatment facilities operating in the territory of the city of Hovsan. Hovsan is registered as one of the main polluting sources in Absheron territory. In addition, oil pollution is mainly caused by the inefficient operation of unserviceable cleaning facilities operating in oil refineries. Due to the improper management of wastes (production water, oily mud, drilling mud, etc.) formed in the onshore oil field under the State Oil Company of the Republic of Azerbaijan "Azneft" PU, thousands of hectares of land were polluted with oil and hundreds of large and small oil ponds were formed, hundreds of hectares of territory were swamped and caused a sharp disturbance of the ecological balance. One of the main reasons for oil contamination of land areas in the production area of oil and gas extraction departments is the lack of timely and current maintenance of the equipment and communication lines.

As the drilling mud formed in the oil drilling area accumulates around the drilling wells or is buried in the area, it causes oil contamination of the soil and leads to an increase in radioactivity in that area.

The following are important for reducing pollution in the Caspian Sea:

• Prevention of the untreated discharge of waste water formed in large industrial enterprises (NQCI, Oil Refineries, Chemical industrial enterprises, etc.) into the streams connected with the Caspian Sea;

• Replacing the equipment used in oil and petrochemical enterprises with those that meet modern requirements;

• Replacing the hydrotechnical facilities operating in the open sea and under the control of the NGCIs, which have been in continuous operation for a long time, with facilities that meet modern requirements;

• Underwater laying of communication lines intended for the transportation of oil, passing through piers and pier platforms;

• If oil pollution is detected, immediate action should be taken to eliminate it.

In modern times, the role of biological treatment facilities in preventing pollution of the Caspian Sea is of great importance. That is, complete biological treatment of wastewater lowers 80-85% of organic pollutants in them. However, discharge of wastewater into the sea after treatment both must be strictly controlled and this process science must be learned properly. On the other hand, one of the main directions is the study of the process of partial self-cleaning of the sea from waste, and on its basis acceptable waste limits are set. The term "self-cleaning" The term "self-cleaning" includes a complex of the following factors: physical-oceanographic, biological and physical-chemical. Maximum self-cleaning of water for the specified parameters can be obtained during discharge only The maximum self-purification of waters according to the indicated parameters is possible only during discharge into the sea at great depth and at a long distance. At present, in the coastal zones of the Apsheron Peninsula of the Caspian Sea (the coast Modular devices installed by ETSN, as well as biological devices operated on platforms (including facilities) dozens of biological wastewater treatment facilities have been installed. And if their operation is not strictly controlled, sea pollution occurs in areas along the Absheron Peninsula, as well as the beach. When installing biological treatment plants, it is important to know the place of their exit to the sea and injection line length.

Thus, the main feature of the deep discharge of treated wastewater is the maximum use of natural oceanographic factors, more precisely, hydrotechnical systems, density stratification of the thickness of the water layer, turbulent diffusion and exchange, hydrochemical and biological regimes of the basin using engineering devices, etc. sea [4,5].

It is known that the discharge of water in the treatment plant operated in the territory of Hovsan is planned at a distance of 3 km from the coast and at a depth of 7-8 m. However, due to certain reasons, the works have been left unfinished, and now the treated sewage is being thrown into the sea through the emergency line of the station. The opening of the Hovsan Aeration station outlet to the seabord and the flow distance is small. The neutralization process with chlorine cannot be completed in untreated wastewater. This has a negative effect on biodiversity of the Caspian Sea in that area.

Based on the analysis of physical and oceanographic factors we suggest dumping the sewage to a depth of not less than 70 m (in the south-east direction). The density stratification of sea water is more favorable for such deep currents. Under these conditions, sewage water dumped to a depth of 70 m and then is first mixed with cold, then heavy bottom currents. As the resulting mixture rises from the bottom to the surface, it becomes heavier than the layer of water on the surface. This means that such mixed water continues to mix in the intermediate layer. On the Absheron shelf, the density of layers is more noticeable, with temperature gradients sometimes up to 5°C per 1 m. This situation is not observed in other seas. In conventional density at depths of 70 m and more, it is 1.5+2.0% more than at the surface of the sea. Such layers are observed throughout the year for 8-10 months, at depths of 100 m and more [3]. First, the case when horizontal flows are not transferred (U=0) is considered for the most unfavorable case of the sewage head height. To solve the problem, specific initial values of waste discharge are accepted. The capacity of the treatment plants put into operation is 400 thousand m³/day and the capacity of this facility in the project can grow up to 600 thousand m³/day. Therefore, calculations were made according to Q=4.6 and 6.9 m³/s. However, the main conclusions and suggestions are made based on Q=6.9 m³/s. Height of water (ΔH_0) at rest is calculated differently in a stratified environment. We choose the Brooks-Koch method, which is more suitable for our conditions and is expressed as:

$$\Delta H_0^3 = \frac{4\xi q_0}{\alpha\sqrt{g}} \cdot \frac{\sigma_1 - \sigma_\alpha}{(d\sigma_0 / dz)^{3/2}} \qquad (1)$$

Here ξ is the dimensionless parameter of the height of the water jet, which is on average 2.7; α is the inclusion parameter of the surrounding liquids in the rising slag (according to Fehn α=0.82+0.093); q_0-string is the flow rate of the liquid ejected per unit length of the source; σ_α, σ_1, σ_0-conventional densities of wastewater at the discharge depth of sea water, at the height of the water layer; on the z-source; $d\sigma_0/dz$-density gradient (vertical); g is the acceleration of gravity.

As expected, along the depth of the sea since the salinity of the water does not change, the conditional density is determined according to the temperature profiles. The density of runoff water is taken as ρ_0=1.0. In the formula (1), coefficient k is added to the above values of the constant. For linear sources, this coefficient should take into account the ripples interference. A Δ report was then carried out for different flow conditions. a) 1 jet stream (point source);

b) discharge in the form of a linear source.

Flow through a diffuser with various holes n=10,100. Report was carried out for all ranges of conditional density (Fig. 1). The optimal depth of water flows and the number of holes can be determined for a linear source according to the constructed graphs of analysis of average prices of Q and n and also different values of $\mathbf{dp_{\alpha}/dy}$ for seasons and months.

Analysis of the distribution index by months of $\mathbf{dp_{\alpha}/dy}$ and the graph in Figure 1 allowed to find the height of ascent of wastewater for the months of the year (Figure 2a) in Hovsan district. There is no flow in very few cases. The flow system that mixes the wastewater is one of the main deep sea waste factors. Usually, as you go from the coast to the open sea the speed of the currents increases. The analysis indicators of observation experiments shows that the proposed waste water discharge area is located mainly located in the zone of the south direction of currents.

The place of the shedding in the zone of main currents is explained as follows:

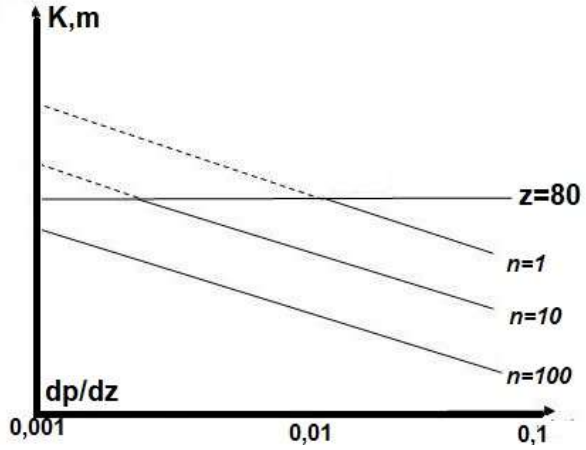


Fig.1. The change of lifting height of wastewater depending on $d\rho_0/dy$ gradient in a stable condition: the number of pulses of the linear source

a) Wastewater will be constantly and intensively removed from the place of discharge, that is, there will be no process of settling of these waters through accumulation.

b) In this zone, the waste water comes into contact with the surrounding clean water and mixes with them quickly. It should be added that the stability of flows is noted in the indicated region. We have used the method presented by Zats to calculate the effect of flow velocity on the lifting height of wastewate [1]. Here, the lifting height ΔH of wastewater in the moving medium (n>0) is determined according to the following rule:

$$\Delta H_u = K_u \cdot \Delta H_0, \quad (2)$$

Here K_u- is a function which depends on the speed of the flows

The function $K_u=f(u)$ is shown by the following expressions:

$$K_u \approx 1-0{,}67u^{0,6} \quad (3)$$

$$K_u \approx 1-0{,}93u^{0,4} \quad (4)$$

for the case if the expression (3) differs little from the density of the environment of the linear source ; (4) is for certain average situation.

Then expression (2) will be as follows:

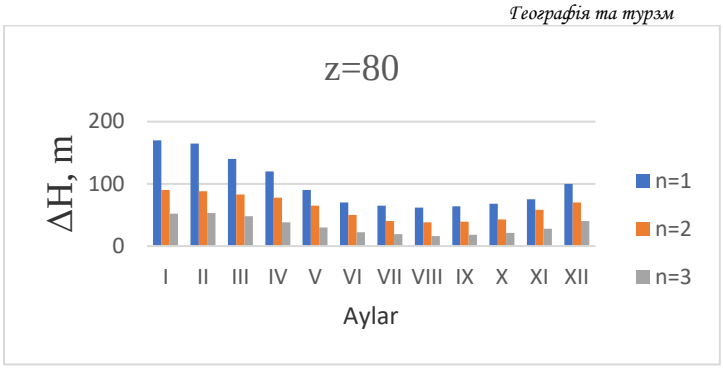
$$\Delta H_u \approx (1-0{,}67u^{0,6}) \cdot \Delta H_0 \quad (5)$$

$$\Delta H_u \approx (1-0{,}93u^{0,4}) \cdot \Delta H_0 \quad (6)$$

Here, ΔH_0 is determined from the expression (2).

Reports were made for outputs from both 1-port and 10- and 100-port linear diffusers. The obtained results are shown in figure 2.

a)



b)

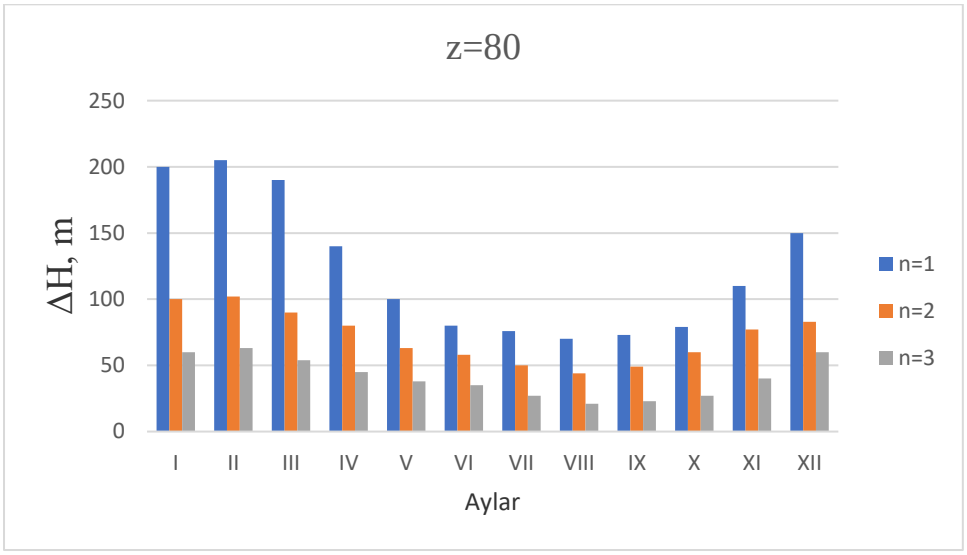


Fig.2. The change by month of lifthing height in different conditions during the discharge of wastewater in the Absheron shelf of the Caspian Sea

Conclusion: The results of the analysis show that a one output discharge is not appropriate.

Because, at this time the linear source can reach the water surface in a stable environment during 8 months of the year and during 6 months of the year taking into account the flows (fig 2).

Non-linear and with 10-hole output rise to the surface of the water for a stable environment the duration is 4 months, and it is 2 months taking into account flows. For warm months, the maximum rise does not exceed 40 m (from the seabed), a 100-hole linear outlet is considered more convenient, because the linear source of the waste water is suitable for a stable environment, but also to control the speed of the currents.

The maximum climbing height is 20-30 m for the summer months and and it does not exceed 50-60 m for the winter months. Favorable oceanographic conditions also include a sufficient increase in horizontal turbulence with distance from the coast. The coefficient of turbulent diffusion plays a key role in the process of mixing wastewater. Therefore, in our study, we paid special attention to this issue. The average value for these parameters in the region that we represent is twice the estimated price. This is primarily due to the fact that the speed of the currents increases with distance from the coast and the scale of whirlpools increases. This ratio is calculated according to Richardson's "4/3 law": $R= C \cdot \varepsilon \cdot l^{4/3}$

Here C is constant, ε is dissipation rate of turbulent diffusion and is $6 \cdot 10^{-3}$ sm^2 according to our estimate. The determination of such regularity is very important in the modeling of pollution processes.

The value of the turbulent mixing coefficient in the presented region was calculated by statistical methods and ranges from 104 to 106. The results of the experiments conducted on the diffusion of mixtures artificially thrown into the sea in the presented region showed that the pulsation of concentrations intensifies with the increase in the diameter of the linear flow [2]. This situation creates conditions for the mixing of wastewater with the surrounding water.

Theoretical and practical significance. Seabed topography in the represented region well suited for this task. The slope of the surface is close to 7°. This is one of the most difficult sections of the bottom of the Caspian Sea.

This tendency creates conditions for the discharge of heavy mixtures into the sea.

Finally, we note that the area that we provide for waste disposal is an experimental one, based on an analysis of our indicators and the available hydrological data of this region. Here, the main role of biological and chemical factors in the self-purification of waters was not taken into account.

Therefore, the proposed article does not respond to the complete solution of the issues as a whole. Here, only a part of the issues of important environmental importance and scientific interest have been considered.

Therefore, the proposed article does not respond to the complete solution of the issues as a whole. Here, only a part of the issues of important environmental importance and scientific interest have been considered.

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