ORIGINAL ARTICLE

Hydrologic and hydrochemical condition of the mid-Caspian Sea

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Abstract

Background and Objective: The author surveys the research papers investigating the differences in the temperature and salt levels in the sea and ocean waters depending on the space-time factors as well as rivers inflow. These differences are explained by the fact that ocean and marine areas have a high density of biological resources, as well as an anthropogenic load. **Methods:** Current data on the hydrochemical condition of the mid-Caspian Sea as a whole and its individual regions allocated to the exploration and development of oil fields show that this condition is formed mainly under the influence of natural processes. **Results:** Analytically defined silicon form in sea water is metasilicon acid. Except the dissolved state, silicon is in sea water in the form of colloidal solutions of polysilicon acids. Variability of silicon concentration in natural waters generally depends on processes of diatomic seaweed activity and its destruction. **Conclusion:** The author concludes that the hydrochemical condition of the marine environment within the range of inherent fluctuations does not hamper the development of oil fields on the Caspian shelf.

Key words: Biogenous elements, bioresources, space-time factors

INTRODUCTION

Huge number of scientific works is devoted to features study of temperature and salt level change in water taking into account influence of space-time factors, as well as a river drain in the seas and oceans. These changes can be explained by the fact that oceanic and sea areas differ in high concentration of bioresources and anthropogenous loading. Collecting detailed information on the biological communities inhabiting these water areas and their hydrological conditions is very important for ecological situation observation and its improvement. A large number of works is also devoted to features study of the hydrochemical regime of the Caspian Sea.[1-12] Works of the specified and other authors, as well as data of the Dagestan SCMS, formed the basis of the hydrologic-hydrochemical conditions analysis for the habitat of water organisms in the western part of the mid-Caspian Sea given below.

High concentration of bioresources is noted in coastal waters of the mid-Caspian Sea. During research study on the hydrological regime and bioproductivity near the Caspian Sea, it has been revealed that temperature and salt level of waters in the western coastal zone of the Caspian Sea exert impact on advection of the northern Caspian Sea waters. In this regard, the year-round salinity level goes down, the same happens also to temperature of coastal waters in the western Caspian Sea during the winter period in comparison with waters of east Caspian Sea. The Volga drain is the basic element influencing formation of water mass in the northern Caspian Sea.[13] In addition, the drain influences temperature and salinity level near the shelf of mid-Caspian waters. Research by Akhmedova written in a co-authorship (1995-1999) state that the processes taking place near the shelf in the western part of the mid-Caspian Sea are the main components of the general process of sea shift and Volga water masses at a stage of the northern and central Caspian Sea waters intermingling.[14,15] The superficial drain from the Dagestan territorial zone at the same time also exerts the impact at an interaction stage of the Samur, Sulak, and Terek rivers with the sea.

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METHODS

Temperature condition of the Caspian Sea waters is formed under the influence of the annual thermal balance components course. The main source of heat is short-wave solar radiation inflow (direct and disseminated by the atmosphere). A part of this total radiation does not enter water, being reflected, and returns to atmospheric air. The main source of losses is evaporation and effective radiation. One more component of balance is convective and turbulent heat exchange between the sea and the atmosphere; it changes seasonally. In the spring and summer, when water is warmer than air, the sea gives out heat. Heat exchange during the year has a negative sign. On average the Caspian Sea thermal balance changes a sign 1 month later.[16]

In the northern part, the Caspian Sea mainly loses heat: In a year, almost the loss exceeds the absorption twice. The central Caspian Sea has neutral balance of heat, the southern has a positive balance. The lack of heat in northern part of the sea is compensated by transfer of heat from the southern Caspian waters due to their movement on the north on east half of the sea.

Temperature distribution of the sea surface has both latitude and zone distinctions. The annual differences reaching 27°C in the north decrease to 18°C to the south. At a vertical, these differences are leveled at depths of 25, 100 and 200 m, they average 12.3 and 10°C, respectively.

In coastal shallow areas of the Caspian Sea water heats up to the bottom in the summer, and in the winter is cooled and has temperature, identical on depth, in deep-water areas it is stratified (interlaid). Transfer of heat in depth of the sea is carried out by hashing processes: In the top layer - wind-wave, in underlying layers - convective.

In the winter, the greatest horizontal contrasts of water temperature on the sea surface and its smallest changes down are observed. Surface temperature, as a rule, goes down starting December by February and changes from 0°C near an ice edge to 11°C at the southern coast. Due to a considerable heat accumulation water temperature, in the central regions of deep-water parts of the sea is slightly higher, than at coast.

In February, the prevailing temperature on a surface of the mid-Caspian Sea equals to 5-7°C. Down temperature is uniform in a layer from a surface to the horizon of 50 m in the winter. On average in the Caspian Sea, it changes to the horizon of 80-100 m a little, and below seldom falls to 4.9°C at a bottom.

The spring warming up, more noticeable in coastal shallow water, begins in March. In a northern part of the sea, it is slowed down by a considerable expense of heat on thawing of ices. In April, in a middle part of the sea temperature of 9-10°C prevails. The greatest temperature increase of water comes from April to May, in turn at the end of a season it makes 13-14°C.

Everywhere as a result of spring warming up below the less dense surface water the thermocline - a layer with rather big gradients of temperature and density which in deep-water areas of the sea is formed of in 10-15 m from a surface is formed.

In June, temperature increase of the water reaching at the end of the month its maximum still continues. At such level it remains approximately until the end of August and on the sea surface is characterized by uniform distribution. On average, the Caspian Sea water temperature equals to 24-25°C. The maximum values of water temperature reach 29°C in summer; minimum, when cold deep waters rise - 11°C. At this time under the top layer of water 20 m thick the thermocline is most pronounced, and the sharpest distinction of temperature down is observed.

For the summer season existence of negative water temperature anomalies is in middle part of the sea is common. At the west bank, the area with the lowered water temperature of 22-23°C is allocated. These anomalies are connected with the phenomenon of colder deep waters raising on the sea surface, negative surge creating a coastal local, and sometimes considerable zone of temperature fall.

Cooling of the sea begins starting September. The convective hashing promoting alignment of temperature in the layer, considerable on thickness, captured by convection develops in the autumn period. In October, average water temperature in the Caspian Sea equals to 15-18°C. Higher temperature in deep-water parts is common to the areas remote from coast. In November, temperature on a water surface varies from 10°C up to 18°C depending on air temperature.

RESULTS

According to the Dagestan, SCMS in the Makhachkala district, the average temperature of sea water makes 3°C in winter. In 1954, the temperature minimum in this sea area made 0.2°C, and in 1948 a temperature maximum - 6.6°C was established. According to data of the spectral analysis, temporary fluctuations with frequency in 2-3 years, 4-5 years, and 11-12 years differed in strong variability of average winter water temperature.

In the Figure 1 excess of average temperature during the winter period for the 20th century (since the end of 1920 temperature increased approximately by 0.8°C) is noted. In the spring, average water temperature in the Makhachkala district equals 9°C, the temperature maximum of water in the sea was recorded in 1966 (11.1°C), and at least in 1969 (5.1°C).

According to the spectral analysis, during fluctuations 2-3 and 4-5 years were celebrated active changes in average water temperature in the spring. In the XX century, since the end of 1920, average spring temperature increased by 0.4°C

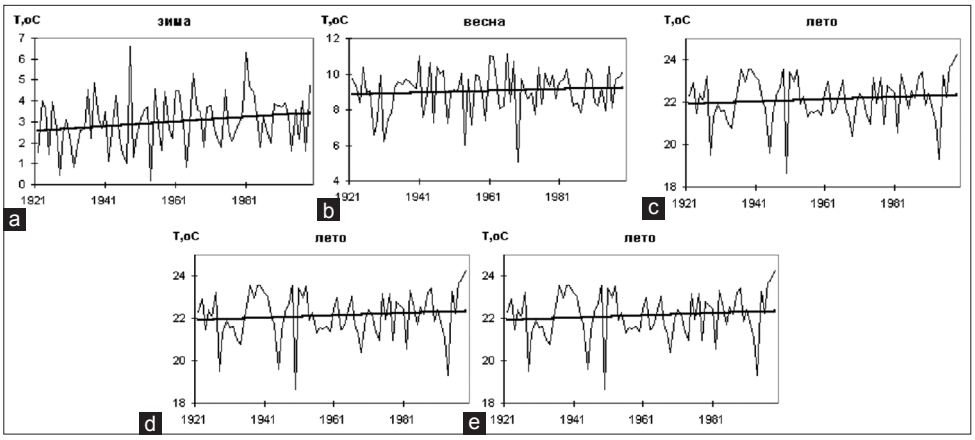

Figure 1: Long-term changes of sea water temperature on the Dagestan shelf of the Caspian Sea according to observations on GMS Makhachkala (1921-1999). (a) Весна means to spring, (b) Зима means to winter, (c) Лето means to summer, (d) Осень means to fall (autumn), (e) Год means to year

that in comparison with the analysis of the winter period signifies that changes were unintensive.

Water temperature in the Makhachkala district during a summer season averages 22.1°C. In 1950, the temperature minimum equaled to 18.6°C in the summer, and the maximum was recorded in 1999, then water temperature rose to 24.3°C. Similarity of summer, winter, and spring season in this area is that during the XX century average temperature during these seasons steadily increased. Hence, since the end of 1920, average temperature increased by 0.4°C in the summer, as well as in the spring. While in the fall average water temperature in the Makhachkala district makes 15.5°C. In 1993, the temperature minimum - 13.3°C was recorded, and in 1937 temperature increased to 18.2°C. Unlike other seasons the fall was noted not by increase in average water temperature, and, on the contrary, by its decrease. By the end of the XX century, decrease in average autumn temperature by 0.4°C was noted, so degrees of its increase and was noted in the spring in the summer. In the Makhachkala district, average water temperature in a year makes 12.4°C. In 1969, the lowest temperature of sea water in this area - 10.6°C, the highest in 1966 - 14.1°C is recorded. Looking through long-term variability of average annual temperature of sea water during the XX century, we see an obvious linear tendency to increase.

During the period from 1933 to 1987, within the general time interval for all ranks the coefficient of a linear ratio of the sea level, low temperature of winters, as well as volume of the Volga drain in different areas of temporary changeability was revealed.

Watching the Dagestan coast during the winter period, experts of the Dagestan SCMS revealed temperature increase of water near Chechen Island (for February - from 1.2°C), at the city of Derbent - to 2.4°C. In the north of the Dagestan shelf during the winter periods often there is a steady ice cover which in severe winters in this area extends also to the southern areas of the shelf. Since March water in the sea gradually gets warm, that is, especially noticeable in shallow water from north side of the shelf, therefore, differences in water temperature between the southern and northern parts of the shelf become less noticeable. In northern areas, water temperature on a surface is half-degree higher, than in a benthonic zone. If to consider the southern areas, then there are no vertical gradients and, on the contrary, temperature increase is noted closer to the bottom. In the Caspian and Makhachkala districts, in a zone of the average shelf so-called "spot" is observed concerning waters with the lowered temperature as here isobaths of 10 and 20 m are brought closer to the coast and water gets warm more slowly in comparison with northern areas. While in a northern zone of the Dagestan shelf low temperature is noted, the penetration of cold waters from the northern Caspian Sea exerts impact on it. In March, water gets warm unstably. For example, in northern zones of the shelf, as well as on the sea water surface the temperature deviation is more noticeable, than in the southern zones in near ground area.

Closer to the middle of spring a current of cold waters in a northern part of the shelf, as well as cold "spot" in the central part of the shelf become less noticeable and disappear completely over time. In May, in this area fall of temperature comes from the north to the south, near Chechen Island - from 18°C, near the city of Derbent - to 14.7°C. According to forwarding data, water temperature near the Dagestan shelf during the summer period is distributed evenly, unlike its vertical distribution. For the summer period in coastal zones, there is a formation of the thermocline (an oceanic layer with a vertical negative temperature gradient) which is settling down on the horizons for this reason on the stations located behind borders of a twenty-meter isobath in the near-bottom layer, water temperature is 10-15°C, colder than superficial. In an early autumn, in September, temperature is distributed uniformly on surface. In November, spatial distribution of superficial temperature increases to 2°C in the north southern direction and therefore at this particular time it is, especially interesting to watch distribution of temperature

closer to the middle of the coastal part when here the mark of cold waters appears again. In time, it is possible to observe uniform water temperature regardless of depth here again.

In the southern coastal areas on surface water temperature is warmer, than in a benthonic zone, and in a northern part, the opposite is observed. The tag origin of "cold waters" can be explained by the high level of waters thermal reserve in the northern Caspian Sea inflowing into a northern part of a coastal zone. High rates of a mean square deviation are the main confirmation that at emergence of "a cold tag" temporary and spatial heterogeneity of the temperature field is noted. The nature of temporary and spatial variability of water temperature near the Dagestan shelf is influenced by waters of the central and northern Caspian Sea.

The average value of sea water salinity in the Makhachkala district during the period from 1947 to 1999, according to the Dagestan SCMS, made 9.84%, the maximum indicator noted in 1969 in the winter - 11.64%, minimum - in 1990 - 7.19% of salinity. During a spring season salinity equals to 10.54%, in 1953 the salinity level reached its maximum - 12, 70%, and in 1963 the smallest indicator of salinity equaled to 8.64%. In the Figure 2, it is visible how from the middle of the XX century the average value of sea water salinity during the spring period gradually decreases. In the mid-forties sea water salinity decreased by 1.64%, and it is even lower, than in winter. Average water salinity in the Makhachkala district makes in the summer 10.50% differing little from average values of salinity in spring. In 1950, during the summer period the highest salinity level - 12.17%, and in the summer of 1995 the lowest salinity level - 8.95% was noted. In addition, from the Figure 2 it is visible that from the second half of the XX century average salinity during the summer season decreased slightly, but these not so obvious, as during the spring and winter periods.

By the end of XX century, water salinity decreased by 0.58%. In the fall average values of salinity in the Makhachkala district make 10.34%. The maximum salinity was noted in the fall of 1982 - 12.24%, and the lowest in 1989 - 8.05%. Since the second half of the XX century steady decrease in level of sea water salinity during the summer period was noted that is visible in the Figure 2, but in comparison with other seasons these changes were not so obvious. From the middle of 1940 water salinity became 0.50% less.

The annual indicator of average salinity makes 10.33%, the maximum value in 1982 made 11.55%, and minimum was recorded in 1991 - 9.28%. Changeability of the average salinity level in a year for many years has the pronounced negative linear direction that is visible in the Figure 2. This direction demonstrates considerable decrease in salinity, since the middle of the XX century that is quite expected as when studying all four seasons of a situation developed similarly. Already from the middle of 1940, the average

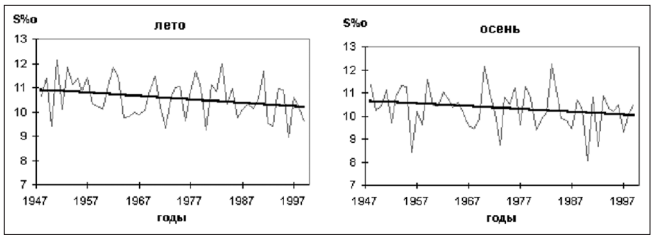

Figure 2: Long-term changes of water salinity on the Dagestan shelf of the Caspian Sea according to GMS Makhachkala observations (1947-1999). Лето – Summer, Осень – Fall, Годы - Years

annual level of sea water salinity in the Makhachkala district decreased by 1.04%. It once again confirms that near the Dagestan shelf waters of the northern and central Caspian Sea actively interact.

The Caspian Sea waters in comparison with waters of other seas are strongly freshened that affects all its biology. For example, the main congestions of transmigrant fish (roach, bream, and pike perch) inhabit the water with 8% salinity. At higher salinity, congestion of fishes are unstable, and salinity higher than 13-15% is pernicious for them. Increase in salinity to 9-10% and above catastrophically affects quantitative development of saltwater mollusks (food for fishes); plentifully they develop in a zone with salinity about 7%.[17]

Salinity makes direct impact on sea biology - even its smallest changes affect hashing and stratification of water masses. Salinization of waters of the northern Caspian Sea causes intensive vertical winter circulation and enrichment of waters in the central and southern Caspian Sea oxygen.

As a first approximation, the central Caspian Sea can be regarded as a zone of north and south Caspian waters mixture which western coast experiences additional freshening influence of the Volga stream and drain of the Dagestan rivers.[15,18,13] Naturally, fields' formation of water salinity areas of the central Caspian Sea is also influenced by winds and circulation of waters. Besides, in certain coastal areas the river drain, atmospheric precipitation, and evaporation exert impact on salinity of the top layer.

Primary efficiency of reservoirs which is a basis of all subsequent links of a trophic chain, is defined by existence of biogenous elements - compounds of phosphorus, nitrogen, and silicon. In sea water, mineral nitrogen is in a form of ions of $NH_{4\ ammonium}^{+}$, $NO_{2\ nitrites}^{-}$, and $NO_{3\ nitrates}^{-}$. Ions of ammonium are the primary form of nitrogen in the course of biochemical decomposition of fossils. Under the influence of the oxygen which is contained in sea water, nitrogen of ammonia is oxidized at first in a nitrite form, and then - in nitrate. All forms of nitrogen are consumed by phytoplankton with comparable speeds, and the nitrites which are contained in water in small quantities are spent quicker than other forms.

Phosphorus takes the second place after nitrogen in food requirements of plants - it is a part of the macropower connections capable to reserve and spend energy in processes of cellular exchange. Character of the phosphatic forms which are present in sea water is very complex, but the prevailing form consumed by plants is $PO_{4\ \text{ortho-phosphate}}^{3-}$. Concentration of orthophosphate in sea water depends on mineralization degree, pH of the water environment, and content of the calcium forming almost insoluble connections with it. Owing to this fact in certain physical and chemical conditions phosphorus can drop out in a deposit and pass into the category of the limiting factors.

In the winter around water exchange between the northern and central Caspian Sea concentration of phosphates in a layers of water makes about 20 mkg/L. In the shallow western and east coastal parts which are adjoined to the area of water exchange, concentration of phosphates increases to 30 mkg/L. In the central parts of the mid-Caspian Sea, in the top active layer of 0-100 m concentration of phosphates vary within 20-30 mkg/L, and lower than 100 m to a bottom increase to 40-55 mkg/L. Some researchers explain the increased content of phosphates around the apsheron threshold by the activity of mud volcanoes.[19]

In the spring, concentration of phosphates around water exchange between the northern and central Caspian Sea decreases. The spring high water, on one hand, increases concentration of phosphates on the western coast, on the other – strengths photosynthetic processes, promotes decrease in content of phosphates and formation of a subsurface concentration minimum. During a spring season in mid-Caspian Sea, there is strengthening of phytoplankton vegetation. During the summer period concentration of phosphates between the northern and central Caspian Sea and on mid-Caspian Sea increases a little in a water exchange zone.[20] In general distribution of phosphates to surfaces of the mid-Caspian Sea is characterized by increase in concentration from the north to the south. In the fall the average content of phosphates in waters of the northern Caspian Sea reaches an annual maximum - 13 mkg/L.

Analytically defined silicon form in sea water is metasilicon acid. Except the dissolved state, silicon is in sea water in the form of colloidal solutions of polysilicon acids. Variability of silicon concentration in natural waters generally depends on processes of diatomic seaweed activity and its destruction. In the Caspian Sea, waters phosphates and nitrites can pass into the category of the limiting elements because of consumption by phytoplankton; this does not happen to silicon, its content in sea water is rather big.

Total receipt of biogenes to the Caspian Sea in a year makes about 41 thousand tons of phosphorus, 607 thousand tons of nitrogen, and 730 thousand tons of silicon. More than 80% of biogenes, the sea receives with a river drain, and other 20% - with underground waters, atmospheric precipitation, agricultural, household and industrial drains, aeolian substance, allocations from ground deposits, from soil of the washing-away coast and destructed organic substances, as well as due to the atmosphere bacteria and blue-green seaweed. The most part of the biogenes which came to the sea settles in ground deposits (more than 95% of annual absorption) that provides their efficiency, a part assimilates phytoplankton in the course of photosynthesis, a part is withdrawn along with the caught fish.

Shortage of biogenes, naturally, leads to decrease in a bioproductivity of the sea. However, it is important that between those a certain ratio stays. Under optimum conditions the maintenance of the most available forms of nutrients in a water phase (the mineral dissolved compounds of nitrogen and phosphorus) has to correspond to a stoichiometric ratio of N:P of phytoplankton which makes 7. For the Caspian Sea, this indicator makes 4.4. In a receipt part of biogenous substances balance of the Caspian Sea the river drain is defining. About 80% of a river biogenous drain fall to the share of Volga and in rough approach, except for certain local sites, the scheme of "food" of the Caspian Sea nutritious salts can be submitted as follows: Volga → beach of Volga → northern Caspian Sea → central Caspian Sea → southern Caspian Sea. Shallowness of the northern Caspian Sea, lack of accumulative deep zones, good heating, and flowing of all water weight provide high turnover of biogenous elements and is unique to high bioproductivity. According to the Volga drain distribution on reaches in alignment. Top Lebed supplies the Volga water with biogenous substances the western part of the Caspian Sea more than east.

On the western coast of the Caspian Sea around an estuarial beach of Terek the increased content of nitrites, especially in winter time is observed. The maximum concentration of nitrites in open Caspian Sea waters is during the winter period that is explained by decrease in their consumption phytoplankton during the cold period. Concentration of nitrites from the west increases by the east, from the north - decreases by the south.

In the fall in a water exchange zone between the northern and central Caspian Sea the content of nitrites decreases in all water thickness. In the fall concentration of nitrites in the western regions of the central and southern Caspian Sea increases to 5-7 mkg/L. The increased content of nitrites in the Baku bay during all seasons is explained by constant intake of pollutants. On other water area of the central and southern Caspian Sea the content of nitrites does not exceed 2 mkg/L in the fall.

Winter concentration of nitrates in euphitic layer of the mid-Caspian Sea makes 40-70 mkg/L. In mid and southern Caspian Sea in the winter they are intensively consumed in the course of photosynthesis therefore their concentration sharply decreases.

In the fall to the beginning of photosynthesis processes weakening because of decrease in temperature there is an enrichment of the sea nitrates.

In the winter, the western waters of the mid-Caspian Sea contain ammonium nitrogen in the quantity of 2-10 mkg/L. Waters of east part are more enriched - 20-40 mkg/L. During the flood period (April-May), in regions of preestuarial seashore of Terek the content of ammonium nitrogen increases by 3-4 times in comparison with the winter period. At the beginning of the warm period (June-July), the content of ammonium nitrogen, keeping in general the nature of spring distribution, considerably decreases. However, in August-September at reduction of photosynthetic activity of phytoplankton and as a result of oxidation of nitrogen-containing parts of organic substance, its contents increase in all water area.

Variability of silicon concentration in natural waters generally depends on processes of diatomic seaweed activity and its destruction. However, at the same time, the content of silicon acid in the Caspian Sea waters is rather big, process of organic substance phytoplankton producing is not limited by the content of silicon. Unlike nitrites and phosphates which are quite often consumed by phytoplankton to analytical zero, as a rule, it does not happen to silicon.

Considerable impact on the biogenes maintenance in the Caspian Sea waters is exerted by the level regime. In process of decrease in sea level overgrowing the highest water vegetation of a shoal zone of an estuarial beach increases, and in some years during vegetation the area occupied with vegetation can make 85% of all area in a zone. At this time, here about 40% of biogenous substances and N ratio accumulate: P decreases to 4 in the summer.

Complexity of differentiation of an anthropogenous component is that the biogenous river drain is integrated result of a number of natural and technogenic factors to which the water content and duration of the rivers high water, commissioning the cascade of reservoirs, influence of industrial, household, and agricultural drains belong.

As it was noted above, the drain of biogenous elements in the sea has rigid relation with a water drain. However, the content ratio of N, P, and Si and their forms in river water does not depend on fluctuations of a river drain.[18] Therefore, as criterion of exarticulation of anthropogenous factors of river waters eutrophy, it is possible to use biogenous elements ratios. Moreover, the most indicative is the anthropogenous intake of nitrogen and phosphorus, the relation of their concentration to content of the mineral dissolved silicon which anthropogenous factors do not influence much. The study features change of temperature and salt level in water taking into account influence of space-time factors, as well as river inflow into the seas and oceans shows that changes can be explained by the fact that oceanic and sea areas differ in high concentration of bioresources and anthropogenous loading. The Dagestan beach differs from other regions of the central Caspian Sea in a high trophicity (mass of the substances involved in biological circulation) which is caused by advection of the north Caspian waters rich with biogenes. Contribution to replenishment of phosphorus and nitrogen reserves on a beach many times over surpasses their receipt with waste and river waters from the Dagestan territory.

CONCLUSION

Modern data on the hydrochemical regime of the mid-Caspian Sea in general and its certain areas allocated for search and development of oil fields show that this regime is formed generally under the influence of natural processes. Hydrochemical parameters of the marine environment within variability inherent do not interfere with development of oil trade on the shelf of the Caspian Sea.

REFERENCES

1. Bruyevich SV. Hydrologics of the central and southern Caspian Sea. Works Caspian Sea Complex Study 1987;4:352.
2. Bruyevich SV. O climate changes in the basin of the Caspian Sea according to a soil chemical research. In: Book: Superlong-Term Forecasts of Level of the Caspian Sea. M.: Academy of Sciences of the USSR Publishing House; 1957. p. 48.
3. Vinetskaya AS. The hydrochemical regime of the Northern Caspian Sea after control of a Volga drain, Tr. CaspNIRHA. The South of Russia: Ecology, Development 1968;10(2):78-99.
4. Vinetskaya NI. Long-term and seasonal changes of the hydrochemical regime of the Northern Caspian Sea before control of the Volga River drain, Tr. CaspNIRHA. Russian Journal of Biological Invasions 1962;1(4):4.
5. Katunin DN. Hydroecological bases of ecosystem processes formation in the Caspian Sea and delta of the Volga River. Astrakhan: Publishing House of KASPNIRKH; 2014. p. 478.
6. Katunin DN. Northern Caspian Sea. Salinity, Caspian Sea. Hydrology and Hydrochemistry. Moscow: M.: Science; 1986. p. 117-28.
7. Katunin DN. Central and Southern Caspian Sea. Hydrochemical Conditions, Caspian Sea. Hydrology and Hydrochemistry. Moscow: M.: Science; 1986. p. 194.
8. Kasymov AG. Hydrochemical Common to the Mid Caspian Sea. In: Book: Biology of the Central and Southern Caspian Sea. Moscow: M.: Science; 1967. p. 10-28.
9. Kasymov AG. About need of an integrated approach to studying biology of the Caspian Sea in connection with falling of level and strengthening of industrial pollution. Biology of the central and southern Caspian Sea. Moscow: M.: Science; 1968. p. 3-9.

10. Kosarev AN. About distribution of oxygen in central and southern parts of the Caspian Sea, Complex researches of the Caspian Sea. M. Vol. 1. Moscow: MSU Publishing House; 1970. p. 185-96.
11. Pakhomova AS. Biogenous elements in waters of a deep-water part of the Caspian Sea, Chemical resources of the seas and oceans. Moscow: M.: Science; 1970. p. 167-82.
12. Pakhomova AS. Hydrochemics of the Caspian Sea, L.: Gidrometeoizdat. 1966. p. 344.
13. Butayev AM. Main Biogenous Food Sources of Coastal Sea Communities Dagestan, Thesis. The International Conference Devoted to the 275 Anniversary of RAS and the 50 Anniversary of DNTs RAS. Makhachkala; 1999. p. 218.
14. Akhmedova GA. Influence of the Volga Drain on Hydrological Conditions in the Western Shelf of the Central Caspian Sea, Thesis. V Conferences, Dynamics and Thermics of the Rivers, Reservoirs and Coastal Zone of the Seas, Moscow; 1999. p. 161-2.
15. Akhmedova GA. Hydrologcs and Hydrochemistry of the Dagestan Part of the Caspian Sea, Caspian Region: Economy, Ecology, Mineral Resources. Moscow: Art International Conference; 1995. p. 99-100.
16. Maximov VM. Reference Guide of the Hydrogeologist. Moscow: Publishing House, Subsoil; 1979. p. 512.
17. Protasov VR. Electric and Acoustic Fields of Fishes. Moscow: M.: Science; 1973. p. 232.
18. Butayev AM. Current state and possible development directions of an ecosystem of the Caspian Sea. II Vestn. DNTs RAS. International Seminar Theses (Rostov-on-Don) 1999;4:85-95.
19. Apollov BA. Caspian Sea and its pool, M.: AHCCCP; 1986. p. 118.
20. Sanina LV. Summer phytoplankton of the Mid Caspian Sea during rise in sea level and in comparison with the previous years, sea hydrobiological researches. Moscow: VNIRO Publishing House; 2000. p. 38-48.

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