Dynamics of Microbiological Water Quality Indicators in the North Caspian Sea

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Abstract. Microbial researches of water sampled in summer period of 2015-2017 years in the North Caspian Sea around prospecting wells were held. Sampling realized according to conventional methods in area of five oil fields. There are Rakushechnaya, Sarmatskaya, West-Sarmatskaya, and, Khvalynskaya areas. Relative abundance of saprotrophic microorganisms and total number of bacteria found in water samples were studied. There are three indexes were used for quantity evaluation: Razumov index, water purity level and saprobity index. Study had shown non-uniformly distribution of different groups of microorganisms and their concentrations in the water samples from fields. At the same time the water monitoring had shown the existence of very purify (xeno- and oligosaprobic) and dirty (poly- and hypersaprobic) zones in the Northern Caspian Sea. However, the population dynamics of the saprotrophic microorganisms and the total number of bacteria in summer period of 2015-2016 years around oil fields indicate about successful processes of self-purification of waters and recover of ecosystem after human impact.

1. Introduction
The Caspian Sea as any ecologic system in the modern world suffers the increasing human influence by itself. This impact is related to industrial and domestic wastes, oil production and water transport. The sea ecosystem resistance to impacts is mainly provided by microorganisms with different adapting capability and metabolic processes plasticity [1,2,3]. The monitoring investigations spented by researchers during the last century provide the data about the microbiological role in productivity and self-purification of the North Caspian Sea [4, 5, 6].

The objective of investigation is water quantity evaluation on the base of data about the ratio of indicator microorganisms groups (saprotrophic) to the total abundance in the bacteria plankton in different oil fields. Were investigated the materials gathered during three summer seasons. There are 20 water samples were studied annually in July-August 2015-2017 years.

Microbiome activity as chemical and biological processes are more intensive in this season. These processes increase concentration of organic compounds available for the bacterial plankton. At the result of processes were increase of the total number to their maximums [4].
The sampling depth in the investigated areas is from 5 to 30 meters. The water temperature is 11 – 29 °C in 2015 year, 7 – 29,3 °C in 2016 and 9 – 26,5 °C in 2017. pH had interval 6.4 – 9.28 in 2015, 8.4 – 9.1 in 2016 and 7.9 – 8.5 in 2017. The of dissolves oxygen fluctuated from 4.0 to 7.5 g/l in 2015, 4.8 to 6.7 g/l in 2016 and 4.0 to 8.3 g/l in 2017.

Microbiological composition in water samples studied by common methods [9,10,12]. The results of the analyses showed different distribution of the total microbial number and saprotrophic bacteria concentrations. The results shown at picture 1 – 3 below.

As shown at the picture 1 maximum value of the total number was in Shirotnaya station (point III3) and in the Sarmatskaya station (point C2), in 2016 – in the points P2, P11 (Rakushechnaya station) and the point 3C1 (West - Sarmatskaya station). The maximum value of total microorganism’s number was fixed at P5 (Rakushechnaya station). Compare of maximums of three years values shown that the maximum total number was fixed in 2015 in the point III3 (14 mln.cells/ml). Minimum values were registered in the point X4 in 2015 and in the point X3 (Khvalynskaya station), in the point P11 (Rakushechnaya station) in 2017.

Maximum of saprotrophic microorganisms were observed in Rakushechnaya field (point P7) – 200 thousand cells/ml in 2015. The maximum was there in 2016 – 360 thousand sells/ml. The total decrease of saprotrophic concentration was in all points in 2017. The maximum quantity was in the Rakushechnaya field (point P2). The minimum number of saprotrophic microorganisms was registered in the points of Rakushechnaya and Khvalynskaya fields. The minimum value of saprotrophic microorganisms concentration was registered at the Rakushechnaya field in 2017 (point P11).

Evaluation of the water purify level was made in accordance with the recommendations [7,8,11]. There were used next parameters: the total number of bacterial cells, the quantity of the saprotrophic bacteria and of Razumov index (interrelation of the first indicator to the second) [13,14,15]. The results shown in figure 3.
The saprotrophic microorganisms, thousand of cells/ml

The saprotrophic microorganisms, thousand of cells/ml

Figure 2. The number of saprotrophic microorganisms at 2015-2017 years: X1,X2,X3,X4 – points of Khvalynskaya field, III1, II112, III3, III5 – Shirotnaya, P1,P2, P4, P5, P6, P7, P8,P9, P11 – Rakushechnaya, C1,C2 – Sarmatskaya, 3C1, 3C2 – West-Sarmatskaya.

Figure 3. The value of Razumov index in 2015-2017 years.

High values of the Razumov index, that verify very purify waters, were fixed in Khvalynskaya field during all years (point X1). Also high values were at point P2 of the Rakushechnaya field in 2015 and 2016 years.

Lowest values of Razumov index (verify strong water pollution) (K<100) were registered in the point X4 (Khvalynskaya field), 3C2 (West - Sarmatskaya station) in 2015. The minimum Razumov index was in point P7 of the Rakushechnaya field. The minimum of 2017 year was in the point P2 (Rakushechnaya field).

Although there were the maximum values of Razumov index in the point P2 two years before.

The results of comparative analysis water quality for three shown in the table 1.
Table 1. The water quality classes and saprobity of the monitoring station in 2015-2017.

| The station       | Year | Water quantity classes | Level of contamination                          | Saprobity* |
|-------------------|------|------------------------|------------------------------------------------|------------|
| Khvalynskaya      | 2015 | I-V                    | very purify - dirty                            | O, P, A    |
|                   | 2016 | I-III                  | very purify-moderate polluted                  | X, O       |
|                   | 2017 | II-III                 | very purify-moderate polluted                  | O          |
| Shirotnaya        | 2015 | IV-VI                  | moderate polluted - dirty                       | B, A       |
|                   | 2016 | II-III                 | very purify –moderate polluted                 | B, O       |
|                   | 2017 | II-III                 | very purify-moderate polluted                  | O, B       |
| Sarmatskaya       | 2015 | II-IV                  | very purify- moderate polluted                 | B, A       |
|                   | 2016 | II-III                 | very purify-moderate polluted                  | B, O       |
|                   | 2017 | II-III                 | very purify-moderate polluted                  | A, O       |
| Rakushechnaya     | 2015 | I-VI (IV)              | very purify-moderate polluted, dirty           | X, P, A    |
|                   | 2016 | II-IV                  | very purify-moderate polluted                  | A, P, O, B |
|                   | 2017 | II-IV                  | very purify-moderate polluted                  | A, B, O    |
| West-             | 2015 | IV                     | moderate polluted                              | A          |
| Sarmatskaya       | 2016 | II-III                 | very purify-moderate polluted                  | B          |
|                   | 2017 | II-IV                  | very purify-moderate polluted                  | B, A       |

* Saprobity: O – oligosaprobic, P- polisaprobic, A - alpha mesosaprobic, B- beta mesosaprobic, X – xenosaprobic.

The data analyze of 3 years period shown 5 levels of water purify (from very clean to dirty) described in Khvalynskaya field) in 2015 year then the number of classes decreased to three (from very clean to moderately polluted) in 2016 year. In 2017 the quality classes at Khvalynskaya station became less (II and III). Saprobity changed in the direction of increasing the purity water that characterize all points as very purify.

In 2016 the situation became better, so the quality level is very clean (II class) - moderately polluted (III class).

The water from Sarmatskaya field also improved its quality, as the quality class changed from II-IV to II-III (very purify – moderately polluted).

The field Rakushechnaya was characterized by different quality classes (from I to VI) in 2015. In 2016 it decreased to II-IV classes. (Very purify-moderately polluted).

At the West-Sarmatskaya field in 2015 all water samples had class IV. In 2016 all waters had 2 classes – very purify and moderately polluted. In 2017 there were 3 classes, from very purify to moderately polluted.

The data about changes of the total microorganism’s number in the water obtained during the researches, indicated a trend towards a decrease of this value. The average concentration decreased and the maximum values of the total number in water also decreased. At the same time, the total concentration of microorganisms in the "clean" point increased.

2. Conclusions

Analyzing the change of the saprotrophic microorganisms’ quantity in the period from 2015 to 2017, it should be noted a significant decrease of the average abundance of this group in the water. The research results indicate a decrease of amount of available organic matter in the aqueous phase at the result of biological and physical-chemical self-purification processes. The maximum saprotrophic concentrations associated with the proximity of sampling points to the sources of organic pollution, or with the completion of the destructing oil pollution processes.

In general, we can conclude the presence of self-purification processes after antropogenic influence.
3. References

[1] Zaytsev V F, Monakhov S K, Kurapov A A 2008 Environmental monitoring of the Caspian sea in the Russian Federation Vestnik AGTU. 6 (47) pp 195-198

[2] Kurapov A A, Umerbaeva R I, Gridneva V V 2010 Microorganisms in processes of the destruction of oil in reservoirs South of Russia: ecology, development 5(4) pp 86-88

[3] Kulikova I Yu Microbial value of the Northern Caspian Sea waters in the conditions of the field development of hydrocarbon deposits Issledovano v Rossii: elektr. nauchnyy zhurnal http://zhurnal.apc.refarn.ru/articles/2005/118.pdf

[4] Sokolskiy A F, Vinnikova V N, Petrovicheva E V, Umerbayeva R I, Sokolskaya E A, Abdurakhmanov G A, Pankov A G 2008 Long-term changes in the state of microflora and evaluation of the trophic status of the Northern Caspian Sea Zhashchita okruzhayushchey sredy v neftegazovom komplekse 7 pp 46-49

[5] Ostrovskaya E. Uglavododorody v vode i donnykh otlozheniakh Severnogo Kasiya 2015 12-ya Mezhdunarodnaya konferentsiya na sredizemnomorskoy pribrezhnoy sredy (MEDCOAST) pp 599-610

[6] Tait R D 2016 Benthos response following petroleum exploration in the southern Caspian Sea: Relating effects of nonaqueous drilling fluid, water depth and dissolved oxygen Marine Pollution Bulletin 110 520-527

[7] GOST 17.1.5.05-85 Nature protection Hydrosphere General sampling requirements for surface and marine waters, ice and precipitation

[8] GOST 17.1.5.01-80. Nature protection Hydrosphere General requirements for sampling of bottom sediments of water bodies for pollution analysis

[9] Tepper E Z 2004 Workshop on Microbiology: pod red G I pp 256

[10] 1983 Guidelines on hydrobiological analysis of surface water and sediments pod red V A Abbakumova Leningrad Gidrometeoizdat pp 240

[11] GOST 17.1.3.07-82 Nature protection Hydrosphere Rules of water quality control of reservoirs and watercourses

[12] 1984 Methods of General bacteriology pod red. F Gerkhardta i dr Moskva. Mir pp 264

[13] Lastovka O N 2005 Problems of using sanitary and microbiological indicators in the water quality monitoring system Pit'evaya voda 4 30-31

[14] Kolotova O V, Sokolova I V, Vladimtseva I V, Shmeleva E O, Vodovsky N B 2017 Bacterial community of pelagic zone and sediments of the North Caspian sea during 2015-2016 years South of Russia: ecology, development 12(4) pp 120-137

[15] Kireeva I Yu 2015 Application of microbiological indexes is in the estimation of quality of water Nauchnyj al'manah 6(8) pp 157-160

[16] Vorob'eva I B, Vlasova N V, Naprashnikova E V 2017 Assessment of the ecological state of water bodies of the Baikal natural territory (south-western coast of Lake Baikal, Listvyanka settlement) Voda: himiya i ekologiya 6 pp 86-93

[17] Bakaeva E N, Nikanorov A M 2015 Biological approaches to the assessment of the toxicological status of aquatic ecosystem Izvesstiya vuzov. Severo-Kavkazskij region. Seriya: Estestvennye nauki 1(185) pp 72-83

[18] Berezovskaya V A 2008 Methods of estimation of ecological state of water bodies Vestnik Kamchatskogo gosudarstvennogo tekhnicheskogo universiteta 7 pp 119-122

[19] Chajkov Y S 2011 Returning to the problems of the Caspian Astrakhanskij vestnik ekhologicheskogo obrazovaniya 1 pp 43-87

[20] Akulova O B, Bukatyj V I, Popov K P 2017 The content of dissolved organic matter in water reservoirs of different trophic level Vestnik Altajskogo gosudarstvennogo agrarnogo universiteta 3(149) 100-106