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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy (Doctor of Science)

APPLICATION OF A NEW CLASS OF NANOCOMPOSITES IN THE ENVIRONMENTAL MANAGEMENT OF FORMATION WATER FROM OLD OIL FIELDS
(In the example of Siyazan oil fields)

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GENERAL CHARACTERISTICS OF THE WORK

The topic relevance and elaboration degree. Against the background of global climate changes, environmental protection and measures to combat pollution are one of the main issues that have attracted attention all over the world in recent times. It is no coincidence that the declaration of 2024 by the President of the Republic of Azerbaijan as the "Year of Solidarity for the Green World" brought forward the implementation of environmental improvement measures in various fields in our Republic as a problem that meets the requirements of the day. Since the oil industry still maintains its priority at the current stage of our economic development, compliance with environmental norms and rules in the improvement of technological approaches plays an important role in the formation of a healthy lifestyle and living environment.

In the oil and gas industry, the volume of formation water, which consists of a mixture of various organic and inorganic compounds, is considered the most important waste stream due to its impact on the environment. Discharge of stratified water, which varies qualitatively and quantitatively along the horizons, into the natural environment causes the emergence of serious environmental problems. The various methods applied in the treatment of such waters are not considered to be very effective in removing oil and oil products, as well as dissolved elements from the water. In addition, after using many chemical methods with high cleaning costs, hazardous wastes are generated, which need again to be disposed.

The activity of oil and gas extraction enterprises causes changes in the components of natural complexes and ecosystems, as well as the formation of natural and man-made ecosystems. The study of environmental aspects of the influence of oil-gas-field technogenesis on the transformation of environmental components allows to assess the impact of such systems on the environment, as well as to expand and deepen the understanding of the regulation of the results of such an impact.

If measures are not taken to neutralize dangerous oil pollution, which continues to increase year by year, the area of soil and water

pollution is expanding, and the manifestation of the consequences of the negative impact is observed long after the pollutant enters the environment.

Determining the condition of waste formation waters generated in oil production enterprises and the possibilities of their use is one of the urgent problems in our current era. It was determined from the conducted researches that the treatment of waste water with reagents to increase oil yield in oil fields does not make their use in repeated technological processes very efficient.

One of the most important issues facing the modern oil and gas industry is to achieve the maximum extraction of oil from the formation, as well as ensuring environmental safety. For this, the irrigation method is widely used, which requires complex technological equipment, water preparation, transportation and injection system.

Despite the importance of the listed problems, the issues of rational use of water resources and ensuring environmental safety in the oil and gas extraction industry have not yet been solved. So, in order to increase the oil production coefficient in the irrigation process, processing of formation water content with nanotechnologies at the atomic-molecular level and creating a closed water cycle in field conditions leads to the rational use of these waters.

Currently available methods for the treatment of formation water are usually expensive or do not provide a sufficient degree of treatment, and also require the installation of a large-scale auxiliary equipment system (reagent farm, slurry (waste) storage, etc.) in the fields. From this point of view, the application of nanostructured systems in preparing the composition of groundwater in closed water supply systems according to the condition is of great theoretical and practical interest.

In general, although the composition of the well product produced in oil and gas extraction is rich in toxic components, the justified scientific-methodical assessment of the hazardous effect of formation waters separated from oil on the environment has not yet been fully developed. Thus, despite the fact that during the development of liquefied deposits more water than oil is produced, there is no comprehensive system of measures for the reduction of environ-

mental risks in the management of the volume of these waters, and there are no reservoirs for the liquidation of useless volume in technological processes. Since the toxic effect of such waters on the natural environment creates serious problems, their disposal issues should be solved based on scientific and theoretical knowledge, as well as environmental monitoring in oil fields should be perfected. Taking into account that oil and gas extraction is one of the industries that require water, therefore, the methods used for the efficient use of reservoir water in repeated technological processes are developed in accordance with theoretically based norms.

The richness of the composition of produced waters with various chemical toxic substances, as well as the non-compliance of the used techniques and technologies with environmental regulations cannot completely prevent the chemical pollution of the natural environment with these components. Despite the recent decrease in the profitability of oil production, since the oil industry plays a leading role in the fuel-energy complex, the effective use of groundwater resources within the framework of measures to protect economic stability and environmental protection in accordance with ecological norms is considered one of the important socio-economic issues.

With this, development of various methods of cleaning, disposal and processing of groundwater from pollutants, regulation of quality indicators based on nanocompositions and elimination of useless volume, while ensuring environmental safety, are urgent issues.

The object and subject of the research. Siyazan oil fields, constituents of produced water, collector properties of rocks, mechanism of action with nanocompositions, technology of impact on the well bottom zone and liquidation reservoirs were taken as **the research object** of the dissertation work .

The subject of the research consists in the preparation of formation waters produced from watered old oil fields for technological processes in accordance with environmental requirements and conditions, the use of nanotechnologies, the management of useless volume and the improvement of the methods of regulating water quality indicators.

The purpose and objectives of the research. The main purpose of the dissertation work is to develop the methods of applying nanotechnologies in increasing the efficiency of produced water and managing the waste volume for repeated technological processes in the development of old oil fields within the requirements of reducing the impact on the environment and ensuring environmental safety.

In order to achieve the main goal, the following **issues** were set and solved in the dissertation work.

1. Development of the scientific and theoretical basis of the optimal variant of decontamination and treatment of formation waters, taking into account geological-technological parameters and the impact on the environment during the development of Siyazan oil fields.

2. Determination of the arsenal of functional problems and ecological consequences in the well bottom zone for the management of produced waters, classification according to the hydrochemical composition, degree of mineralization, anions and cations for individual wells.

3. Detection of the factors that are important to be taken into account to ensure environmental safety during the treatment of the bottom zone of wells with various purposes (exploitation, injection, utilization) with nanocompositions and acids, assessment of the impact on the environment.

4. Evaluation of quantitative changes in the amount of resin and mechanical mixtures, kinematic and dynamic viscosity, physicochemical indicators under the influence of various nanocompositions on oil samples taken from the water surface of receiving reservoirs.

5. Determining the effect of nanocompositions on the degree of mineralization of reservoir waters, on the quantitative indicators of oil-derived resin mixtures, as well as on the rheological properties of oil samples.

6. Reducing the impact on the environment and the consequences of unwanted geochemical processes, eliminating the useless volume of groundwater while ensuring ecological stability, and preparing proposals for the selection of a liquidation reservoir, working out the scientific basis.

7. Assessment of hydrogeotechnological parameters, determination of geochemical requirements for selection of suitable rocks and horizons, development of ecologically safe closed technology, taking into account possible consequences for the environmental management of formation waters of "Siyazanneft" OGES.

Research methods. In order to solve the issues raised in the thesis, the methods of analyzing the physical and chemical properties of substances, the elements of geophysics and ecological-technological management theory, the methods of determining the level of pollution of water and oil constituents, and waste formation water in accordance with the requirements of the accepted standards were used. The analysis of formation, sea and waste waters was carried out according to the enterprise standard of the "Oil Gas Scientific Research Project" Institute, the dimensions of aluminum nanoparticles in the nanocomposition were measured by X-ray diffractometry, and their visual images were measured by scanning electron microscopic measurement.

The main provisions submitted for defense.

1. The method of improving the technological-field processes of Siyazan oil fields, geological, technological, hydrodynamic parameters of which have changed as a result of technophysical effects during the development period.

2. Technological approaches that allow increasing the efficiency of the use of conflicting formation waters produced from different horizons in repeated technological processes and minimizing the impact on the environment.

3. The method that ensures the efficiency of the mineralization rate of regional waters rich in aggressive components for geological-technological conditions and minimizing environmental risks taking into account the field infrastructure of the deposit.

4. Disposal technology with N-series nanocompositions, which effectively affects the aggressive properties of groundwater, which causes the destruction of the natural landscape of the surrounding areas, soil salinization, while ensuring environmental safety.

5. Technology of processing nanocomposites, ensuring the elimination of environmental problems arising in the well bottom zone due to various technical reasons and environmental protection.

6. A disposal method based on N-4 nanocompositions treated with a new metal nanoparticle, which allows to the reduce capillary forces in the formation environment, the wetting of the rocks and the reduction of the interfacial surface tension between the formation fluid and the rock, allowing the increase of the oil recovery coefficient .

7. During the operation of deposits, disposal of large volumes of industrial waste water, as well as methods of utilization of wastewater for technological processes, regardless of the concentration, toxicity degree and transformation of the chemical substances contained in it.

8. The main principles and geochemical requirements that ensure the ecological management of formation waters of "Siyazanneft" OGES and the selection of a suitable liquidation reservoir.

Scientific novelty of the researche.

1. In Siyazan oil fields, the geological, technological, hydrodynamic parameters were investigated, taking into account the influence of formation waters on the environment, and the relationship between the degree of mineralization and chemical components and physical properties was determined.

2. The technology of ecologically safe processing of oil fields with nanotechnologies in accordance with geological conditions was proposed by ensuring the change of the physical-chemical composition of formation waters and the minimization of man-made effects on the formation.

3. The arsenal of environmental damage caused in the well bottom zone due to wear and corrosion of underground and surface hydrotechnical facilities designed for the management of formation waters was determined, it was shown that the effect of N-2 nanocompositions is more effective in protecting such waters from microbiological pollution.

4. In order to ensure environmental stability, a new technological method has been proposed that ensures the reduction of resin,

mechanical mixtures, kinematic and dynamic viscosity in the oil samples taken from the surface of formation waters.

5. Taking into account the chemical composition of formation waters and the geological parameters of rocks, an efficient method of influencing the water-well system with different nanocompositions was proposed, and the principle of using N-2 nanocompositions in the technology of well bottom field development and the preparation of formation waters according to the condition was developed.

6. Changes of the composition and rheological parameters of the oil samples of the "Siyazanneft" oil refinery with the influence of new N-4 nanocompositions were evaluated, and a technically efficient processing method, which ensures environmental safety by increasing the oil yield coefficient was proposed.

7. The scientific basis of the selection of the liquidation reservoir by preventing the influence on the parameters of the environment was worked out, and the hydrogeotechnological parameters for the ecological-technological management of the volume of groundwater were evaluated.

8. A new environmentally safe closed technological method has been developed, which allows reducing the impact of pollutants in formation waters, and geochemical requirements for the selection of suitable rocks and horizons for the liquidation reservoir have been determined.

Theoretical and practical significance of the research.

1. Based on the results of experimental studies, the proposed multifunctional nanocomposite disposal technology of formation waters in field conditions can be both economically and practically effective in solving technical complications arising in heterogeneous geological conditions.

2. The technology of effecting the stable oil emulsion in formation waters with the proposed new class of nanocompositions will further increase the efficiency of using these waters in technological processes. At the same time, the utilization method with multifunctional N-series nanocompositions is an effective technology for developing the bottom zone of wells with different purposes (exploita-

tion, injection, utilization) consisting of terrigenous rocks, and is of great practical importance in increasing the oil yield coefficient.

3. The proposed technology for reducing sulfate-reducing bacteria that causes corrosion of field equipment using N-2 nanocompositions is of special theoretical importance in predicting the reliability of field hydraulic facilities, as well as in building environmental management models.

4. The new N-2 and N-4 series nanocompositions are distinguished by their wide practical significance in increasing the efficiency of the injection process for formation pressure relief.

5. The technical requirements put forward in the selection of the liquidation reservoir for the management of the volume of formation water produced together with oil from the watered wells of the Siyazan oil fields are of theoretical importance in the development of the scientific basis of the regional ecological programs for environmental protection. In the current field conditions, the disposal method of formation water with N series nanocomposites can be applied as an effective technology that ensures the minimization of man-made effects on the formation.

Approbation and implementation. The main provisions of the dissertation were discussed at the seminars of the "Petrochemical Technology and Industrial Ecology" department of the ASOIU, as well as at the following scientific and technical conferences:

1. "Prospects of innovative development of chemical technology and engineering" International Scientific Conference, SSU, Sumgait, November 28-29, 2019.

2. "Bulatovsky Readings" IV International Scientific and Practical Conference, Moscow, March 31, 2020.

3. A scientific conference of young researchers and doctoral students dedicated to the 100th anniversary of ASOIU, Baku, May 7-8, 2020.

4. "Russian science in the modern world" L International scientific and practical conference, Moscow, November 31, 2022.

5. LIII International Scientific-Practical conference «Euroasia-Science», Research and Publishing Center «Actualnots.RF». Moscow, May 15, 2023 (2 reports).

The results of the dissertation can be applied in the improvement of technological approaches used in the process of oil production, as well as in the preparation of regional environmental programs for oil zones.

Name of the organization of the thesis paper performance. Dissertation work was performed at Azerbaijan State Oil and Industry University.

The total volume of the thesis paper, taking into account the volumes of individual structural sections. The introduction to the dissertation consists of 15454, chapter I-83854, chapter II-39273, chapter III-42187, chapter IV-26552 signs, totaling 207080 signs were explained in the text were signed.

MAIN CONTENT OF THE WORK

In the introduction the relevance of the topic is justified, the goals and objectives of the research are defined, the main propositions defended, scientific innovation, the theoretical and practical significance of the work are explained, and information is given about its approval and application.

In the first chapter of the dissertation, the tectonics, geothermal indicators and collector characteristics of the rocks of Siyazan oil fields were investigated, the environmental aspects and classification of formation waters were given, the possibilities of applying nanotechnologies at the field-industrial scale were considered, and the methodological approaches of reuse of formation waters while ensuring environmental protection were given.

Here, the nature of the environmental problems arising at different stages related to the activity of the oil and gas extraction industry has been determined, and it has been shown that the scale of the environmental damage detected at the last stage of field development is wider. Depending on the conditions of location in the underground layers, degree of mineralization, chemical composition, influence on the environment, the classification of formation waters was carried out, and the relationship of its mineralization and chemi-

cal composition with physical properties during the working period was explained.

The possibilities of applying nanotechnologies in the oil and gas extraction industry have been investigated, and the application of metal nanoparticles has been presented as an innovative approach in most fields of oil and gas extraction.

Here, from the point of view of protecting the parameters of the environment, the possibilities of processing and using groundwater for other requirements were investigated. In the end, the environmental requirements for the water injected into the formations were defined, and the mechanisms of treatment of poorly mineralized waters were considered to increase production.

The second chapter of the dissertation is dedicated to the disposal of groundwater, methods and means of cleaning it from pollutants to ensure environmental safety, and the properties of the used reagents are investigated. First of all, the nature of the main components that form formation waters, the consequences of their discharge into the environment were explained. The essence of the stages of groundwater treatment is explained, the characteristics of pollutants as a heterogeneous and homogeneous system are determined based on the L.A. Kulsky classification scheme of water treatment.

Here, the functions of the constituents of the reagents used in water purification are investigated, the procedural sequence of coagulants obtaining and their fields of application are given. It was shown that the amount of coagulants used in water dilution depends on the physico-chemical properties of water, and the working principle of horizontal and vertical sedimentation devices operating with the coagulation method was presented.

Similarly, the functional scheme and activity structure of the open-type treatment unit used for water treatment for formation pressure recovery (FPR) is given, and the working principle of the closed-type treatment unit is explained in detail.

The essence of using the electrodialysis method in the purification of groundwater from salts and other pollutants has been explained, and at the same time, the advantages and disadvantages of this method have been mentioned. Then, the essence of the flotation

method, which is used in the separation of dispersed particles that cannot settle in water, was explained, and it was shown that its efficiency depends on the type of pollutants in the water, the density of the liquid, and other parameters. It was also noted that simple procedures in the gas flotation method, durability and reliability are its advantages.

In this chapter, it is also shown that the ion exchange method is efficient in the implementation of desalination procedures for the case where the initial amount of salt in the water is low.

At the end of the chapter, the essence of the adsorption method used to purify water from pollutants and improve its quality is explained, and it is shown that the use of activated charcoal as an adsorbent is more efficient in this method. At the same time, the effects of various parameters on the efficiency of adsorbents were shown.

In the third chapter of the thesis, the factors affecting the permeability of the well bottom zone (WBZ) in the process of development of Siyazan oil fields were investigated, the potential characteristics of individual oil fields were evaluated, and the dilution rates of the working well fund were given taking into account the actual parameters (table 1).

Table 1

Division of working well stock according to the degree of dilution

The name of the oil field	Number of water wells	Wetting rate, %				
		2	2-20	20-50	50-90	>90
Siyazan-Nardaran	86	5	3	5	40	14
Saadan	242	94	16	86	41	5
Amirkhanli	121	19	1	48	51	2
Zaghli-Zeiva	81	26	1	5	36	13

Here, using different approaches, the classification of formation waters according to the chemical composition of individual wells was carried out, the degree of mineralization and pH indicators according to the depth were presented, and the hydrochemical com-

position of the formation waters of different deposits according to anions and cations was systematically presented.

In the third chapter, it was also shown that due to the technical obsolescence of the hydrotechnical facilities designed for the management of formation water, such water is not prepared in accordance with the condition, the well bottom area is polluted in a short period of time, the permeability decreases, the absorption capacity of the wells decreases, and thus serious environmental problems appear. During the development of monoclinal oil fields in Siyazan, it was shown that the condition of the surrounding landscape was disturbed, the equipment used was corroded, in short, irreversible environmental damage occurred.

In addition, the content of the samples taken from the formation water was checked, and as a result of the analysis, it was determined that the water was exposed to high microbiological pollution (table 2).

Table 2

The results of formation water analysis conducted at the "Oil and Gas Scientific Research Project" Institute

Unit of measurement	Cations							Mineral mg/l	SRB volume/ml	FeB volume/ml	SME volume/ml
	$Na^{+}+K^{+}$	Ca^{2+}	Mg^{2+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}	CO_3^{2-}				
mg.eq/l	534	8.0	22	525.48	0.56	36,34	2.13	33743	3/10	6/10	7/10
mg.eq, %	47,34	0.70	1.9	46,34	0.04	3.22	0.18	33743			
mg/l	12293.5	160	264	18630	52.84	2216.7	127.8	-			

Taking into account what has been said, it has been shown that in 1987-2010, the process of watering the layers was stopped, and currently, 15 out of 33 wells used for the purpose of disposal have not been watered.

Thus, the technology of influencing the WBZ with different purposes with nanostructured compositions was proposed. At the same time, it has been shown that the treatment of production wells with acids is associated with certain difficulties, even in some experiments, an example of a drop in production was shown, the degree of dissolution of rocks and minerals in the mechanism of impact on formation water, the rate of reaction of rock minerals with composi-

tion, the possibility of formation of insoluble reaction products, etc. the importance of considering the parameters is justified.

At the same time, acid treatment of terrigenous rocks for cleaning production wells, use of surfactants for initial removal of sediments, application of vibration treatment technology, hydraulic fracturing of layers, etc. the characteristics of such methods were investigated and their shortcomings were explained.

Thus, in the same chapter, in the selection of the technology for the treatment of WBZ, consideration of the causes of pollution, the mineralogical composition of rocks, filtration properties and properties of liquids is set as the main requirement, and results of laboratory studies conducted with synthesized nanostructured polymer-based nanocomposites carried out in "Geotechnological problems and chemistry of oil and gas" SRL operating under ASOIU have been taken as basis.

Physico-chemical analysis were carried by adding 7.5 ml 10% compositions of BAF-1 and BAF-2 nanostructured polycrystalline powders to 250 ml water sample obtained from the treatment of kerosene fraction alkaline waste (KFAW) and alkalized diesel from fraction waste (ADFW) (figure 1).

Fig. 1. Mixture of BAF-1 and BAF-2 nanostructured polycrystalline powders

The results of the analysis conducted with N-1 and N-2 nanocompositions of the sample of produced water taken from "Siyazanneft" OGES storage are given in tables 3 and 4.

In the conducted analyses, the component content of the compositions according to conventional names was as follows;

N-1 – KFAW + (BAF-1+BAF-2);
N-2 – ADFW + (BAF-1+BAF-2);
N-3 – liquid glass with ADFW + 5%;
N-4 – ADFW + 0.5% Al (40-60 nm).

Table 3

Effect of formation water of N-1 nanocomposition on chemical indicators

No	Addition volume, ml	Chemical composition of produced water, mg/l						Type of water
		CO_3^-	HCO_3^-	$Na^+ + K^+$	Cl^-	Ca^{2+}	Mg^{2+}	
1	0	-	0.1584	1.9802	1.2733	0.0111	0.0308	MgCl2
2	7.5	-	0.1488	1,888	1,1861	0.0190	0.0386	MgCl2

Thus, after adding N-1 nanocomposition to the produced water sample with minerality of 34.54 g/l, the minerality decreased to 32.81 g/l, and the hardness increased from 3.08 mg.eq/l to 4.12 mg.eq/l. As it can be seen from Table 4, with the addition of N-1 nanocomposition, HCO_3^- and $Na^+ + K^+$ ions slightly decreased, while the slight increase of Ca^{2+} and Mg^{2+} ions decreased the amount of Cl^- ions.

A visual representation of the change of chemical composition due to the effect of N-1 nanocomposition on the water sample taken from the reservoir of produced water intake (RFWI) is given in figure 2.

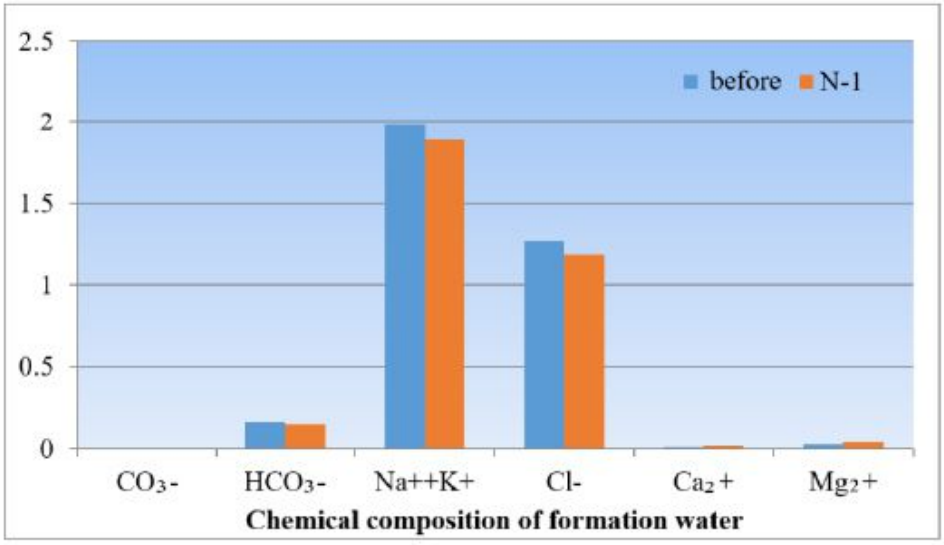

Fig.2. Visual representation of the effect of N-1 nanocomposition on the chemical parameters of a produced water sample

According to that sample, it was observed that the minerality of the produced water decreased by 1.73 g/l, and the hardness increased by 1.04 mg.eq/l.

Table 4

Effect of formation water of N-2 nanocomposition on chemical indicators

No	Addition volume, ml	Chemical composition of formation water, mg/l						Type of water
		CO_3^-	HCO_3^-	$Na^+ + K^+$	Cl^-	Ca^{2+}	Mg^{2+}	
1	0	-	0.1584	1.2733	1.9802	0.0111	0.0308	$MgCl_2$
2	7.5	0.036	0.1776	1.1594	1,768	0.0158	0.0337	Alkaline water

In this case, the minerality of the reservoir water decreased from 34.54 g/l to 31.91 g/l, and the hardness increased from 3.08 mg.eq/l to 3.56 mg.eq/l after the addition of N-2 nanocomposition. As it can be seen from table 4, after adding N-2 nanocomposition, CO_3^-, HCO_3^-, Ca^{2+} and Mg^{2+} ions increased, while $Na^+ + K^+$ and Cl^- ions decreased.

A visual representation of the effect of N-2 nanocomposition on a water sample taken from RFWI is given in figure 3.

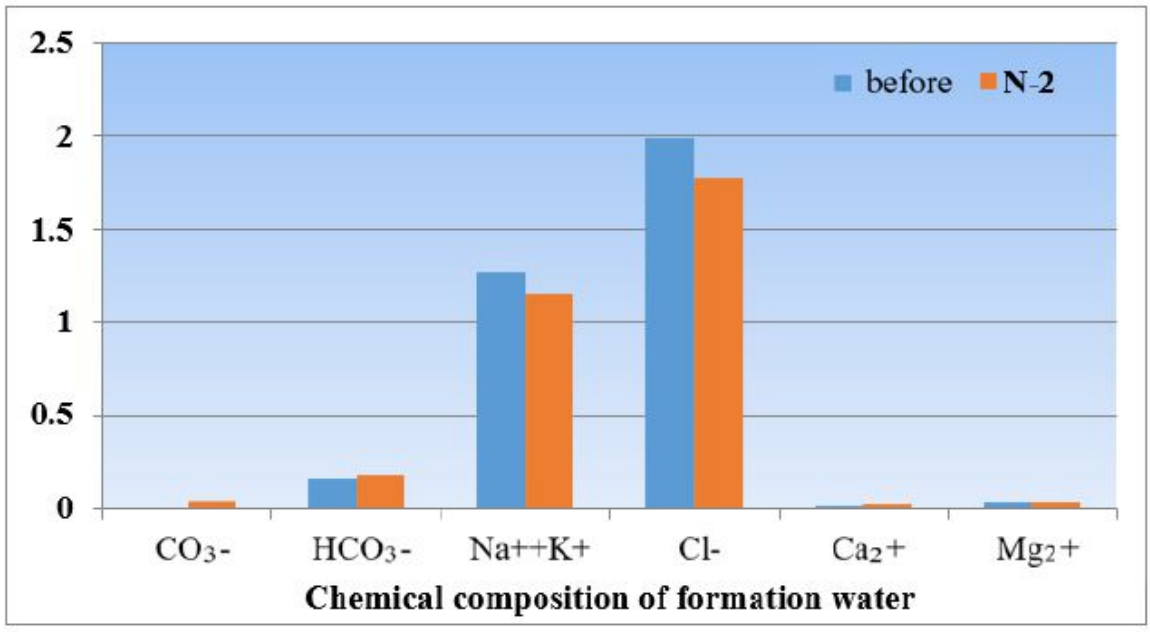

Fig.3. Visual representation of the effect of N-2 nanocomposition on a water sample taken from RFWI

A comparative analysis of the effect of N-1 and N-2 nanocompositions on produced water samples was also conducted here, in the first case, it was observed that the acidity increased significantly, that is, soft water turned into water with medium acidity, and in the second case, minerality decreased, and with a slight increase in acidity, the water changed to an alkaline type.

Then, in the same chapter, the quantitative change of surface tension with the addition of different nanocompositions (table 5) to 20 ml of formation water taken from RFWI was presented (figure 4).

Table 5

Surface tension indicators of formation waters with the addition of various nanocompositions

Composition	Amount of composition type	Surface tension, δ
0	Without extras	94,575
N-1	KFAW 1.0% nanostructured polycrystalline powder, 1.4 ml	47.2875
N-2	ADFW 1.0% nanostructured polycrystalline powder, 1.4 ml	43.65
N-3	Bottle of 5.0% liquid in ADFW, 1.4 ml	54.5625

In addition, the analysis of the oil sample taken from the formation water surface of the RFWI of the "Gil-gilchay" irrigation station (IS) was carried out (table 6), and it was determined that 97% of its composition consists of resin and up to 50% of mechanical mixtures. After adding N-1 nanocompositions to that sample, it was determined that the amount of resin in the composition decreased by 20%, the kinematic viscosity was 87.1 sSt, and the dynamic viscosity was 86.73 sSt (table 7).

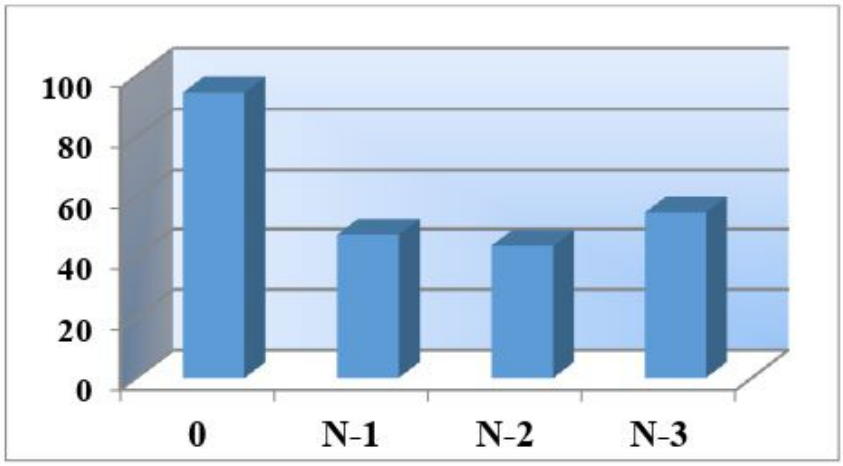

Fig.4. Visual representation of the effect of different nanocompositions on the surface tension index of produced waters

Table 8 shows the results of the changes observed after the oil sample collected in the same manner was affected by N-2 nanocompositions.

Table 6

Results of physical-chemical analysis of oil sample collected from produced water surface

No	Indicators	Results
1	Specific gravity of oil, kg/cm ^{3}	910.0
2	N sample, %	49.83
3	Oil, %	0.17
4	Mechanical mixtures, %	50.0
5	Resin, %	96.0
6	Kinetic viscosity, sSt (50 ^{0}C)	130.0
7	Dynamic viscosity, sPz	128.66

Table 7

Change of physical and chemical properties of oil after addition of N-1 nanocomposition

No	Indicators	Before addition	After the addition
1	oil , kg/cm ^{3}	910.0	910.0
2	N sample, %	49.83	49.83
3	Oil , %	0.17	0.17
4	Mechanical mixtures, %	50.0	50.0
5	Resin, %	96.0	76.0
6	Kinetic viscosity, sSt (50 ^{0}C)	130.0	42.9
7	Dynamic viscosity, sPz	128.66	41.91

As it can be seen from table 8, the effect on the oil sample was higher in this case, the amount of mechanical mixtures decreased by 16.0%, the amount of resin decreased by 36.0%, the kinematic viscosity decreased by 100.6 sSt, and the dynamic viscosity decreased by 100.07 sPz.

Table 8

Changes observed due to the effect on oil taken from the produced water surface of N-2 nanocomposition

No	Indicators	Before addition	After the addition
1	Oil , kg/cm ^{3}	910.0	910.0
2	N sample, %	49.83	65.5
3	Oil , %	0.17	0.5
4	Mechanical mixtures, %	50.0	34.0
5	Resin, %	96.0	60.0
6	Kinematic viscosity, s S t (50 ^{0})	130.0	29.4
7	Dynamic viscosity, sPz	128.66	28,59

A visual presentation of the changes in the oil sample collected from RWFI of "Gil-gilchay" SM under the influence of N-1 and N-2 nanocompositions is presented in figure 5.

By adding N-2 nanocomposition to produced water samples taken from the reservoir of "Ata-chay" field was analyzed by scientific research project institute and sulfate reduction bacteria 10^2

cell/1ml has been found, but after adding such bacteria wasn't observed.

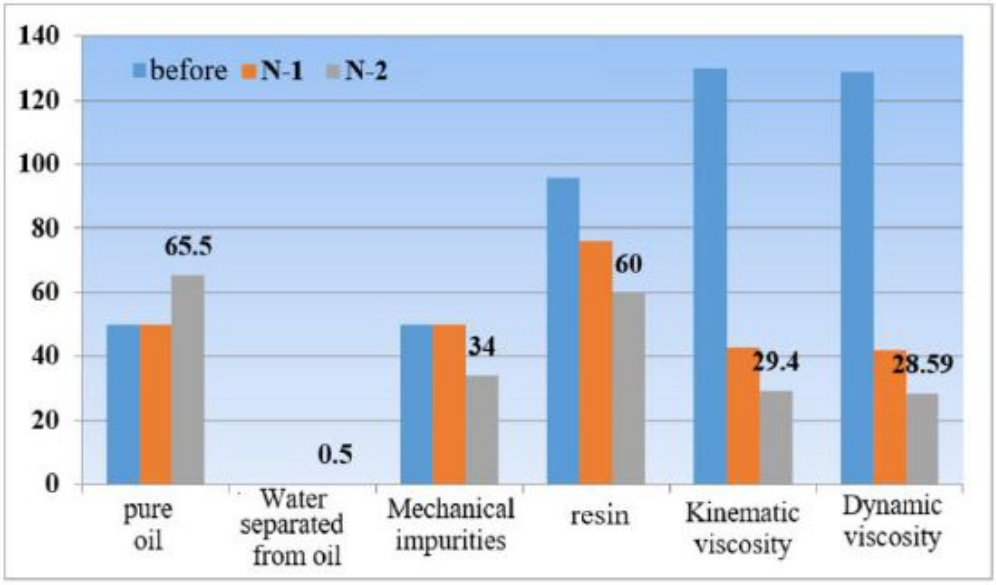

Fig. 5. Comparative presentation of the effects of N-1 and N-2 nanocompositions on oil sample collected from RWFA of "Gil-gilchay" SM

Analogous studies were conducted for oil samples taken from the Pirallahi field of Absheronneft Oil and Gas, and the results of physicochemical analysis with the addition of N-1 and N-2 nanocompositions allowed to determine the observed changes (table 9).

As it can be seen from table 9, no water was separated from the oil, due to the effect of N-1 nanocomposition, the amount of pure oil decreased by 6.67%, and the kinematic viscosity decreased by 95.4 sSt, the increase percentage of mechanical mixtures was equal to 6.67, the amount of resin and remained unchanged (20%). The effect of N-2 nanocomposition on the oil sample was carried out by adding the same amount of condensate, a decrease of 1.67% in the amount of mechanical mixtures, 12.0% in the amount of resin was observed, and the kinematic viscosity decreased by 191.92 sSt. A visual representation of the effects of N-1 and N-2 nanocompositions on the oil sample of the produced waters of the Pirallahi oil field is given in figure 6.

Table 9

Physico-chemical analysis results of the oil sample taken from the surface of produced waters of the Pirallahi field of "Absheronneft" OGES

No	Indicators	As usual	N-1 Under the influence of NK	N-2+condensate Under the influence of NK
1	Specific gravity of oil, kg/m ^{3}	-	915.0	915.0
2	Mechanical mixtures, %	10.0	16.67	8.33
3	Resin, %	20.0	20.0	8.0
4	Water separated from oil, %	0	0	0.17
5	Pure oil in the sample, %	90.0	83.33	91.5
6	Kinematic viscosity, sSt	216.72	121,32	24.8
7	Dynamic viscosity, sPz	214.77	120.01	24.01

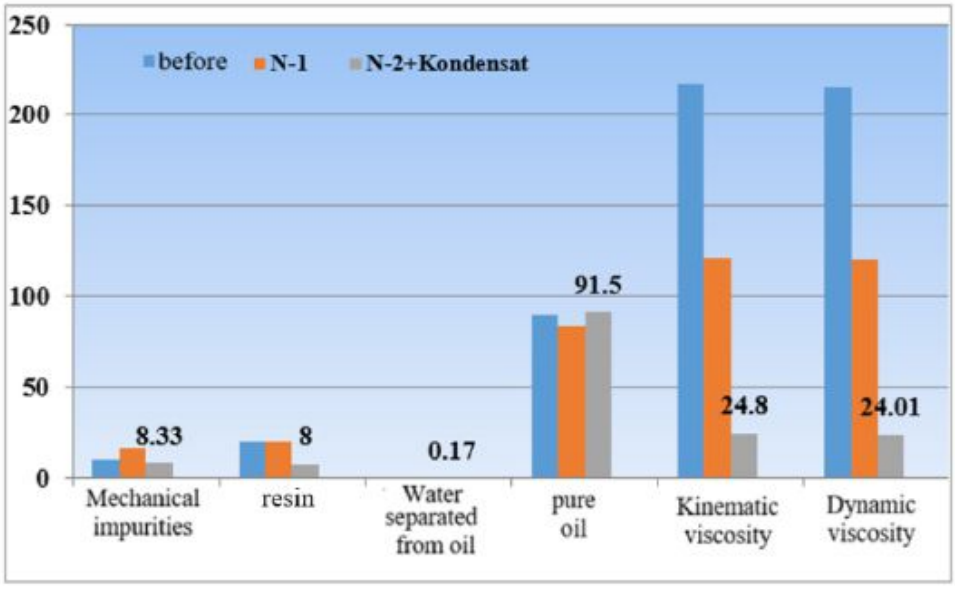

Fig.6. Visual presentation of the effect of N-1 and N-2 + condensate nanocompositions on an oil sample taken from the Pirallahi oil field produced waters

Continuing laboratory studies, 30 ml of N-2 nanocomposition and 30 ml of condensate were added to a 20.8 g resin sample taken from the oil surface of the produced water of the Pirallahi oil field,

and the mixture was filtered after 48 hours, only 0.174 g of resin substance remained, and the dissolved resin was 99.16 % 12 g of N-1 nanocomposition was added to the second resin sample of 26.11 g, and after filtration, 8.46 g of resin remained, 67.6% resin was dissolved. Similarly, adding 12 g of N-3 nanocomposition to 30 g of third resin sample, the mixture was filtered, 7 g of resin remained after filtration, and the soluble resin was calculated as 76.0%.

4 g of mechanical mixture remained after filtering by adding 20 ml of N-2 nanocomposition to 15 g of mechanical mixture sample taken from the Pirallahi field of Absheron OGES. The remaining mechanical mixture was 9 g after filtering by adding the same volume of N-1 nanocomposition to the same sample.

The same researches were carried out on the produced water sample of Bibiheybat OGES, and the results of physico-chemical analysis with the addition of N-1, N-2 and N-3 nanocompositions are shown in table 10.

Table 10

(50^0 C) with the addition of nanocomposition to the oil sample taken from the produced water surface of the Bibiheybat OGES

No	Indicators	In ordinary case	N-1 Under the influence of NK	N-2 Under the influence of NK	N-3 Under the influence of NK
1	Specific gravity of oil, kg/m ^{3}	915.0	915.0	915.0	915.0
2	Mechanical mixtures, %	26,67	6.67	3.33	5.0
3	Resin, %	0	0	0	0
4	Water separated from oil, %	0.03	0.16	0.27	0.17
5	Pure oil in the sample, %	73.30	93.17	96.4	94.83
6	Kinematic viscosity, sSt	27.10	12.1	3.2	5.90
7	Dynamic viscosity, sPz	26,67	11.99	3.14	6.45

Although no resin was detected in the oil, the sample had a kinematic viscosity of 27.1 sSt and a dynamic viscosity of 26.27 sPz, but after the addition of N-1 nanocomposition, mechanical mixtures

increased up to 4 times the weight, with a kinematic viscosity of 15 sSt and a dynamic viscosity of 14,282 sPz. has decreased. At the same time, water separated from oil increased by 5.3 times, and the amount of pure oil increased by 19.87%. After adding N-3 nanocomposition to that sample, the mechanical properties decreased by 1.17%, the kinematic viscosity decreased by 6.2 sSt, and the dynamic viscosity decreased by 5.54 sPz. At the same time, separated water increased by 0.01%, pure oil by - 1.66%.

Finally, by adding N-2 nanocomposition to that mixture, physico-chemical indicators were monitored, an increase in the amount of mechanical mixtures, kinematic and dynamic viscosity, and the amount of separated water and pure oil was observed.

Thus, a visual representation of the effect of N nanocompositions on oil samples taken from the produced water surface of Bibiheybat oil field is given in figure 7.

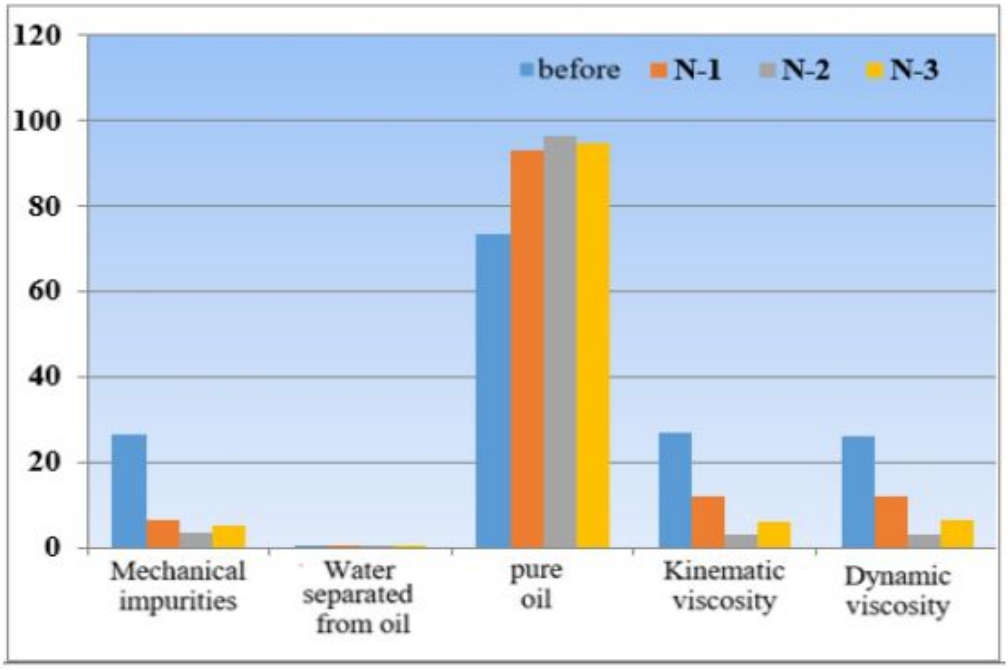

Fig.7. The results obtained from variable indicators by adding nanocompositions to the oil sample collected from the water surface from Bibiheybat oil field

In the same way, 30 ml of N-3 nanocomposition was added to the sample of 13 g of mechanical mixture taken from OGES, and

after 3 days it was filtered and 7 g of mechanical mixture remained. 30 ml of N-2 nanocomposition was added to the 2nd portion of the studied mechanical mixture sample of the same amount, filtered after 3 days, and 4 g of mechanical mixture remained. At the same time, 30 ml of N-1 nanocomposition was added to 13 g of the mechanical mixture and filtered after 3 days, 6 g of the mechanical mixture remained.

The same studies were conducted by adding 30 ml of N-3 nanocomposition to 25 g of the mechanical mixture taken from "Amirov" OGES, after filtering the obtained mixture for 3 days, the remaining mechanical mixture was 15 g. The changes observed as a result of the effect of N nanocompositions on the mixture taken from "Amirov" OGES are presented in figure 8.

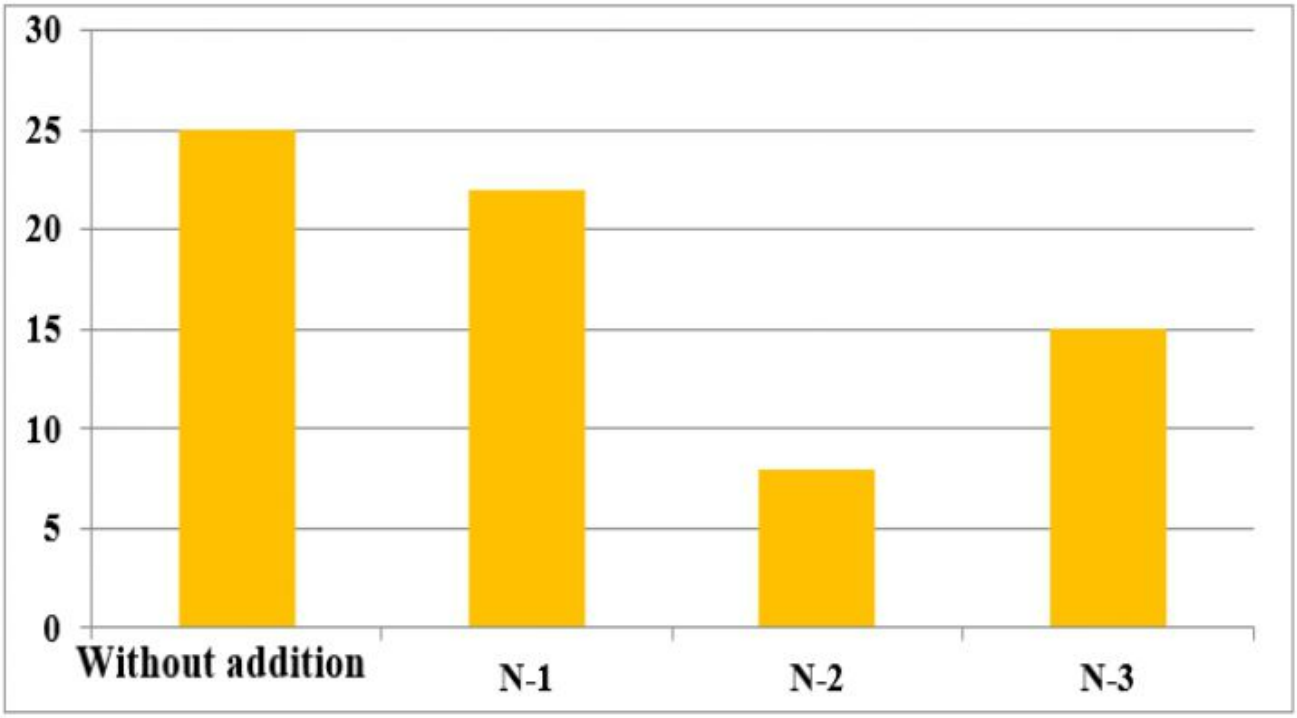

Fig.8. Visual presentation of the effect of N series nanocompositions on mechanical mixtures taken from "Amirov" OGES

In the conducted studies, it was shown that N-2 nanocompositions are more effective for the dissolution of mechanical mixtures.

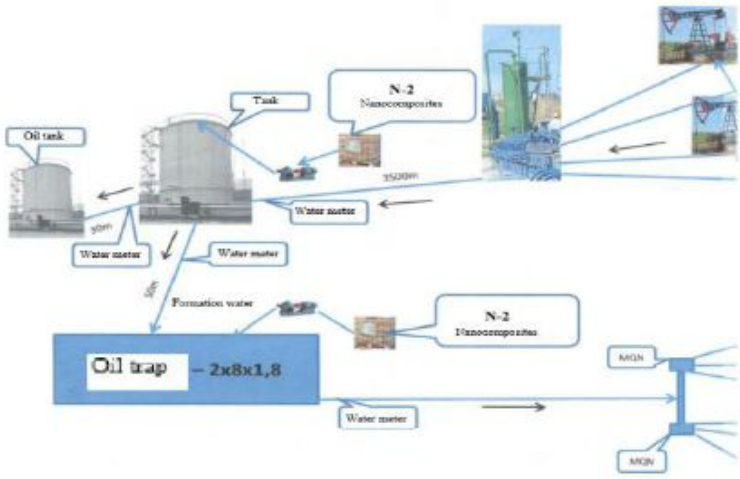

Fig.9. Technological scheme for recirculation of produced waters

The fourth chapter of the dissertation is devoted to the issues of the impact of metal nanoparticle (MNP) compositions on the rheological properties and quality indicators of oil samples, as well as the issues of eliminating the unsuitable volume of formation water for technological processes and selecting liquidation reservoirs by preventing the impact on the parameters of the environment. First, the change of rheological properties was observed after adding N-4 nanocomposition to the oil samples taken from the collection point of "Siyazan" OGES, as a result of the experiments, it was observed that the amount of resin, kinematic and dynamic viscosity, as well as the amount of mechanical mixtures decreased sufficiently (figure 10).

It was shown that depending on the concentration of N-4 nanocomposition affecting the high-viscosity formation water sample, the physical parameters of the produced water change quite a bit, and the hard water turns into alkaline type water (table 11).

Depending on the amount of these nanocompositions, the trend of surface tension changes was observed, and a greater decrease was observed for the 1.0% sample. Also, the elemental composition of Al NP was studied with a Japanese SEM-6610 LU microscope, the measurements were carried out on a Mini Flex diffractometer, and the average size of one crystallite was determined to be 40.6 nm in

the calculations performed using the Evaluation program of the Bruker company.

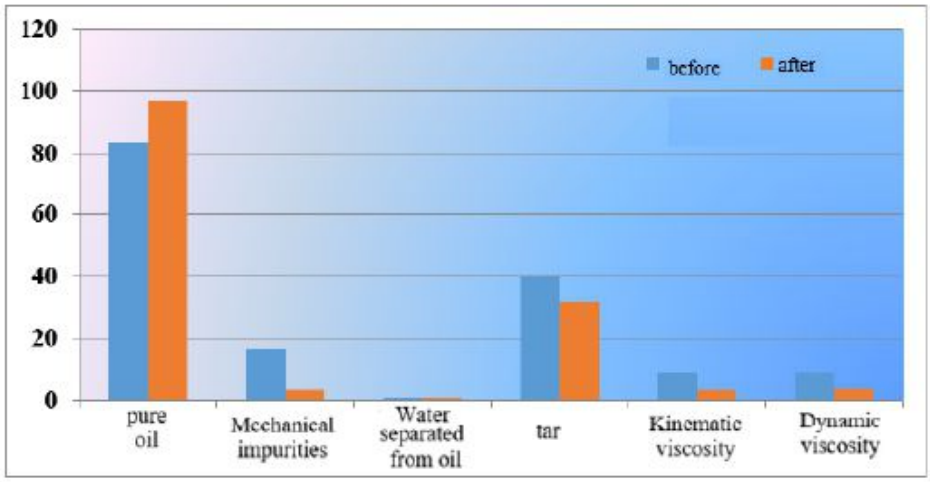

Fig.10. Visual representation of the effect of N-4 nanocomposition on the well oil of "Siyazanneft" OGES

Table 11

Effect of N-4 nanocomposition on water ion content (in 100 ml)

Quantity, ml	Cation			Anion		
	$Na^{+}+K^{+}$	Ca^{2+}	Mg^{2+}	Cl^{-}	CO_3^{-}	HCO_3^{-}
0	46.25	0.90	2.85	47,64	0.21	2.15
2.5	46.98	0.34	2.68	47,49	0.34	2.17
5	48.02	0.26	1.72	46.92	0.52	2.56
7.5	48,41	0.27	1.32	46,58	0.71	2.71

In that chapter, the issue of evaluating and taking into account the hydro-technological parameters of the field was examined by investigating the ecological consequences that may occur in the process of disposal of large volumes of waste water, and it was shown that the absorption capacity of the injection wells deteriorated as a result of the geochemical changes occurring in the water-rock system.

In addition, to reduce the consequences of unwanted geochemical processes, to ensure ecological stability, the demand for the selection of water returned to the liquidation reservoir based on the principle of chemical similarity, and the proposal for the selection of

the liquidation reservoir taking into account the geotechnological conditions have been put forward. Based on the collected data and known facts, fractured-porous-cavernous horizons with high permeability were considered more promising for the purpose of disposal, and the clay-carbonate marl sedimentary layer of the Govundag formation of the Eocene floor was presented as a more favorable rock for the management of the volume of formation water of the "Siyazanneft" OGES has been done. Thus, it has been shown that the 300 m thick rock with hydrophobic properties, which clay-containing formations can serve as top isolation collectors on the bed, belongs to the class of carbonate rocks. Also, it was considered possible to select the limestone sediments of the upper formation of the Cretaceous layer, the marl of the middle formation, and the limestone sediments of the lower formation as a liquidation reservoir. In the end, due to the similarity of the chemical composition, it was shown that the Lower Maykop and Govundag horizons with a depth of 900-1500 m are suitable for hard waters, and the cretaceous layer of the Tabashir floor are suitable for hydrocarbonate waters with a high pH.

MAIN RESULTS OF THE DISSERTATION WORK

1. The geological-tectonic and stratigraphic indicators, geothermal parameters of Siyazan oil fields were investigated, and the environmental significance of using nanocompositions in reducing the impact of formation waters on the natural environment, cleaning and disposal of mechanical mixtures, chemical pollution, and oil products was determined.

2. Within the framework of environmental safety regulations, a selected sample of the appropriate nanocomposition is presented, taking into account the impact effect on water treatment and disposal.

3. Taking into account the chemical composition of formation waters in the production process, the technology of impacting the bottom zone with nanocompositions has been developed in order to eliminate the unavoidable ecological consequences that occur due to the decrease in production and the absorption capacity of the wells due to the pollution of the well bottom area.

4. The main factors that need to be taken into account depending on the characteristics of the impact technology with nanocompositions and the requirements for the selection of the cleaning method have been determined, according to the results of the research conducted with polymer-based nanocompositions synthesized in a special laboratory operating under the National Academy of Sciences, it has been shown that the efficiency of technological operations has increased.

5. With the new N-series nanocompositions, the scientific-experimental basis of N-2 nanocompositions being more ecologically efficient in the reduction of oil products affected by the impact on produced waters of the "Siyazanneft" oil refinery, and in lowering the viscosity of oil, has been worked out.

6. The environmental efficiency of the impact technology with N-2 nanocompositions in reducing the amount of bacteria that cause corrosion of field equipment was justified, and the observed changes in the preparation of produced waters according to the condition were quantitatively assessed based on samples taken from different deposits.

7. In order to reduce man-made effects on environmental components, in the environmental management of produced waters of Siyazan oil fields, where most of the wells have been watered, the identification of the mixed waters returned to the reservoir according to the similarity type, consideration of geotechnical conditions, and the scientific basis of the selection of the liquidation reservoir have been put forward as the main requirements.

8. Taking into account that the process of processing produced waters in open wells weakens the absorption capacity of wells and causes environmental pollution, the environmental efficiency of closed disposal technology based on the proposed nanocompositions of surface water in field conditions using existing hydrotechnical equipment in changing the type of formation water and replacing the ions in the composition with cations has been shown.

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Personal service of the author in scientific articles published together with co-authors

[1,4,5,6,8,10,12,13,14,15,16,17,18] - works prepared by the author freely.

[2,3,7,9,11] - the author defined the problem, developed a new disposal technology and method, planned and performed experimental works, and interpreted the fundamental results obtained from experimental studies.

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