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NEURONAL MODDELING OF WATER PROPERTIES ON OIL FIELD

Reem Sabah Mohammad[1], Doru Stoianovici[2] , Timur Chis[2] , Daniel Iancu[1]

[1]Ph.D. School, Oil-Gas University Ploiesti, Romania

[2]Oil-Gas University Ploiesti, Romania

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Abstract: **This article presents a neural model regarding the treatment of oil field waters, separated from the products extracted from the wells, in order to use them in the reservoir pressure restoration process. The models for separating petroleum products from these waters are also presented. The contamination and treatment of waste water is also described, as well as the definition of this phenomenon from several points of view. This article shows the classification of polluting agents and details the contamination of waters with hydrocarbons, the effects of this contamination, as well as methods and techniques for ameliorating the effects of water pollution with petroleum products.**

Keywords: **water properties, oil field, neuronal model, water treatment.**

I. INTRODUCTION

Surface and underground waters have important destinations in industry, agriculture, transport and represent the source of drinking water for humans and living things.

The development of the economy has determined important changes in aquatic systems.

Surface waters have undergone morphological changes due to human activity.

The multitude of water destinations deeply affects the quality of its natural cycle.

In the absence of successive monitoring of water in different activities, a complete picture of the consequences of affecting water quality cannot be provided, often the effects being disastrous.

In general, the waters used by humans, no matter for which purposes, are loaded with different physical, chemical or biological elements, changing their composition, resulting in the phenomenon of pollution.

Depending on the presence of organic and inorganic compounds, water can be classified into:

- very good water resulting in drinking water through a simple treatment;
- second category water, resulting in slightly contaminated water, but which can be processed in order to obtain drinking water through a more complex process;
- inadequate water for obtaining drinking water.

Water represents the support of human life and well-being. It stores nutrients and other life-sustaining minerals.

Water is the living environment for countless microorganisms, which carry out multiple biochemical transformations.

In fact, a large part of the biodiversity on our planet is found in water and not above it [1].

Due to these considerations, I chose this work, the way of preserving and conserving water being decisive in terms of the ecosystem in which we carry out our activity, and when the ambient ecosystem is out of balance, the very health or even the life of the human population will be affected, on next to the damage suffered by fauna and flora.

The quality of drinking water, waste water and sewage treatment systems are big problems that any country in the world (and especially countries that exploit oil fields) has to solve on the way to aligning with international quality standards.

One of the causes of exceeding quality standards regarding wastewater treatment and water treatment is the lack of money.

The implementation of directives in the field of water supply and wastewater treatment involves considerable financial efforts.

Establishing the origin and qualitative characteristics of wastewater requires knowledge of the industrial technological process for a judicious design of treatment plants.

So it is necessary to know the origin of the main tributaries and their main characteristics in order to define the purification method.

Another element that was the basis of the choice of this theme is the fact that naturally, as has been demonstrated over the years, those who produce the imbalance are responsible for restoring normal conditions.

In this sense, contrary to many who believe that greening, protection and depollution should be handled by ecologists, my opinion is that those who created the pollution should handle it best because they know best what kind of pollutant they are dealing with and what characteristics it has.

So in the case of pollution with oil products, the ones who have the responsibility, both according to the law and good morals, are the oil workers, those who deal with the extraction, processing and transportation of oil products.

II. WATER POLLUTION BY OIL

Environmental pollution has become one of the most debated problems of contemporaneity and one of the first order for the management of society, that is why we are facing such a vast and complex subject.

Man and the environment are inseparable entities, man's existence being dependent on the environment, and environmental factors (air, water, soil) can change, following their use by man. This is how pollution appears, an implicit aspect of life, in the course of which some products, resulting from physiological processes and the activity of humans and animals, become residues that can inconvenience the good life depending on their nature and quantity. It can be said that pollution has accompanied man since his appearance on Earth [2].

In the past, when the low population density and the almost exclusive use of natural products, human life did not differentiate much from the simple way of existence and not so many residues were produced.

Along with the great scientific advances, their quantity and nature has diversified and fundamentally changed.

In the last decades, the process of degradation of the environmental factors on our vast planet had an increasingly worrying evolution, the amount of pollutants reaching figures that exceed any imagination. Removing pollution is a matter of correcting the errors that cause it. The decision to fight must exist right from the moment when the evil is denounced as such, and the current technical-scientific means can solve the pollution problems.

Pollution is defined as the introduction of contaminating materials into an environment, materials that cause instability, disorder and lead to discomfort or even damage to the health of living organisms in that environment. The pollutant can be a substance or a source of energy such as: noise, heat or light. Polluting substances can be of unnatural or natural origin, in which case they are considered pollutants if they exceed natural levels.

The problem of polluted waters presents an important interdisciplinary character that involves a multitude of skills of different natures:

- Environmental, for the evaluation of the risk of contamination of surface water, subsoil, underground water, the atmosphere, as well as for the application of remedial methods;
- Technological, for choosing appropriate remedial technologies and for defining process parameters;
- Legal, for defining legislative competences and responsibilities;

- Economic, in order to know and compare the economic costs of different remediation technologies.

Pollution is a complex phenomenon with the following characteristics;

- pollution increases due to the numerical growth of mankind, the increase of human needs and the development of new technologies
- the increase in pollution is exponential with the factors that generate it;
- the admissible limits of pollution are not known, because we do not know the supporting capacity of the ecosphere;
- there is a general tendency to underestimate the effects of pollution, the causes being multiple: the high cost, ignorance, the delay in the appearance of the ecological effects of the pollutants.

In the highly developed areas of human society, the vital elements: air, water, soil - are invaded by masses of residues that exceed the natural power of transformation and integration into environmental factors, which become insufficient and unusable by humans.

Smoke, dust, harmful gases are poured into the atmosphere from the chimneys of factories, from the exhaust pipes of automobiles, from the vents of industrial enterprises and, to a lesser extent, from smoking tobacco.

Effluents loaded with organic residues of all kinds and microorganisms discharged from household activities or with various substances originating from the various branches of industry flow into the water sources.

Garbage from cities or industrial waste accumulates on the ground in huge quantities, but also many other residues from industry or even accidental spills of some chemical substances.

Oil pollution is one of the biggest environmental problems facing soils.

This is due to the dependence that man has accepted on this natural resource, acceptance which was mainly based on the boost given to the economy by the use of oil.

Also, the development of the automobile industry and the need for the population to use these technological innovations represented an important pillar in the human-created dependence on oil and its products.

Hydrocarbons that appear in different living environments can have two origins:

- human activities - fuel burning, wood use, oil processing, accidental or malicious spills of crude oil or products processed from it, etc.;
- natural processes - oil releases, natural gas emissions.

The toxicity of oil and oil products is divided into two categories:

- With immediate effect,
- With long-term effect,

Immediate toxicity is caused by:

- Saturated hydrocarbons that can cause the death of organisms and young forms at high concentrations;
- Aromatic hydrocarbons are the most toxic;
- Olefinic hydrocarbons have an intermediate toxicity between the previous ones.

Long-term toxicity refers to fractions of the pollutant in water, in very low concentrations, which interfere with numerous chemical messengers, with a role in the nutrition and reproduction of many aquatic organisms, producing ecological imbalances.

The oil reaching the water undergoes transformations, and the formation of the film on the surface of the water causes effects such as:

- decrease in the amount of light entering the water leading to a decrease in the intensity of plant photosynthesis;
- decreases oxygen in the water;
- some volatile products of the oil film evaporate and reach the atmosphere;

- heavier fractions gradually sediment.

Due to the action of the wind, the film of oil is carried towards the shore, invading beaches, coastal areas, tidal areas - areas rich in flora and fauna, which sometimes end up having direct consequences on human settlements.

The main polluting agents are [3]:

- chemical substances: pesticides; oil, crude oil, gas; heavy metals (Zn, Pb, Cd, Hg) fertilizers; organic substances.
- physical factors: noise; radioactive isotopes; the heat.
- biological factors: pathogenic germs and other microorganisms.

The main substances that pollute the waters are hydrocarbons, heavy metals, herbicides, pesticides, but also pathogenic germs and other microorganisms.

Heavy metals can even come from some heavy petroleum products, these products having the tendency to include in the molecule such metals as: Pb, Zn or Hg.

It is also true that they are not found in impressive quantities, but they differ quite a lot from the geographical area and the depth from which the crude oil was extracted.

A greater possibility of pollution exists when metals extracted from crude oil or petroleum products are not stored according to environmental protection norms and accidents can occur.

Also, in the composition of some types of pesticides, herbicides and fertilizers, different types of hydrocarbons extracted from crude oil can be found, and their use in excess or over a long period of time can produce the same effects as pollution with petroleum products as such.

A. Contamination of waters with hydrocarbons

Petroleum products have affected significant surfaces both in the exploitation areas of oil and gas deposits and around petrochemical and transport installations.

Water pollution occurs mainly due to the loss of hydrocarbons (sometimes accompanied by salt water) through cracks in the collecting pipes, produced by rusting or intentional perforation by gasoline traffickers.

Qualified workers are hired to detect such cracks, but sometimes several days can pass from their detection to the actual repair of the pipes, during which time the environment is already compromised, usually on surfaces of many square meters.

Currently, about 60% of the surface waters are contaminated with products of petroleum origin (hydrocarbons, solvents, etc.) used as a source of energy in the petroleum industry, as well as the chemical industry.

There is a multitude of polluting products that affect surface and underground waters, such as: fuels and oils, oxygenated products, hydrocarbon residues, crude oil, other products resulting from exploitation (saturated and unsaturated aliphatic hydrocarbons, as well as monocyclic aromatic and polycyclic).

These types of products (especially hydrocarbons) pose a risk of harm, affecting the quality of underground water, which becomes unsuitable for use for a long time (drinking water, for irrigation or various industrial uses).

They also present risks for human health, for the biological environment and for vegetation, the aromatic compounds having a strong mutagenic and carcinogenic character and, last but not least, they affect the safety of the environment, presenting risks of explosion and fire, when floating petroleum products on the water table they reach the basement of various buildings.

All these risks are related, first of all, to the mobility of the polluting product.

Usually, soil pollution with oil residues manifests itself in the upper part of the soil, but once the oil products reach the underground, where both aerobic and anaerobic conditions are met, they undergo important chemical transformations. Most authors believe that the rate of degradation of petroleum products in the soil depends on the concentration of oxygen in the soil or, in other words, on the degree of aeration of the polluted soil.

Different concentrations of oxygen can be found in the basement, which lead to different rates of biodegradation of petroleum products.

The decrease in oxygen concentrations may be due to the chemical oxidation of compounds with high oxidizing potential (olefins, intermediate oxygenated derivatives, etc.) or the increase in bacterial populations that metabolize hydrocarbons and implicitly consume oxygen.

Oxidation begins with the formation of peroxides, primary alcohols and monocarboxylic acids, the final stage of degradation consisting in the formation of carbon dioxide, water and the cellular material of microorganisms.

Biodegradation is accelerated in the presence of substances called nutrients (compounds with phosphorus, potassium, nitrogen), humidity and a relatively constant temperature, factors that lead to a rapid growth of bacterial populations.

Also, degradation can result in intermediate products with high water solubility or high volatility that lead to the spread of pollution at an increased rate.

B. Remediation of waters polluted with oil residues

The development of the oil industry, both extractive and processing, including the transport of extracted oil, is sometimes accompanied by the appearance of unforeseen secondary phenomena, with harmful effects on the environment. One of these aspects is water pollution with oil residues with or without salt water, as well as other oil products resulting from the oil extraction activity.

Oil radically changes the properties of water, it forms an impermeable film on its surface that prevents the circulation of water in the soil and the exchange of gases between the soil and the atmosphere, producing asphyxiation of plant roots and favoring the manifestation of reduction processes.

Oil, being rich in organic carbon (98% hydrocarbons), increases the carbon/nitrogen ratio in the soil, negatively influencing the microbiological activity and nutrition of plants with nitrogen.

Oil-polluted waters have variable characteristics depending on the intensity of the pollution, the time interval that has passed since the date of the pollution, during which some processes of self-degradation of the oil have occurred through the volatilization of some of its components or even biodegradation processes.

Under the conditions of oil pollution, the waters become poorly productive or unproductive, often being completely removed from the fish circuit.

According to some authors, plant life begins to be affected when a quantity of oil greater than 1 l/m^3 is spilled into the water.

Acting as an excessively aggressive external factor, pollution affects, first of all, the chemical and biochemical processes in plants and soil, followed by weakening the resistance of individual and collective organisms to diseases, pests and other adversities. Ecological imbalances are still triggered in the chain, with unfavorable consequences on the stability, vitality, regeneration capacity and on the multi-functionality of aquatic and terrestrial ecosystems.

In the waters polluted with hydrocarbons, a characteristic evolution of the microflora is observed in the sense of the strong stimulation of the total microflora

Microorganisms, nitrogen-fixing, denitrifying and sulfur-reducing bacteria use oil as a source of carbon and energy, leading to a partial mineralization and oxidation of oil.[4]

Water pollution with hydrocarbons can also be caused by natural gas leaks from buried pipelines. The consequence of this type of pollution is the oxygen deprivation of the vegetation located in the area adjacent to the cracked pipes, because the oxygen in the gaseous phase of the waters is exhausted due to the oxidation of the methane gas in the waters by microorganisms.

Water is therefore support and living environment for natural and anthropogenic ecosystems.

Absolutely all forms of water pollution have disastrous effects on the ecosphere, and restoring water quality is a long-term process, or impossible.

Within the amelioration measures, the way of production and manifestation of pollution (crude oil, crude oil and salt water, other chemical products), the depth of penetration and the degree of loading of water with polluting agents must be taken into account, the modification of some initial characteristics of the water and way of producing pollution [5].

Wastewater treatment represents the set of measures and procedures by which the mineral and organic impurities contained in the wastewater are reduced below certain limits so that these waters no longer harm the emissary in which they are discharged and their use is no longer endangered.

The purification processes are, to a large extent, similar to those that take place during self-purification, but they are directed by humans and take place at a much higher speed.

The purification procedures are physical-mechanical and chemical in nature.

Following the application of these processes, the main products are purified water that is discharged into the emissary or is used for irrigation or other uses and sludge that is removed from the treatment plant and used.

The complexity of industrial processes, the coexistence of sometimes very different technologies in the same unit, the variability of waste water flows and the concentrations of impurity substances, make water treatment processes very diverse.

For this reason, there is no single technology for wastewater treatment, but there are several steps (stages) of treatment that remove harmful substances from water, as follows:

- The mechanical stage – consists in the removal from the waste water of bodies that float or can be brought to a floating state. In the mechanical purification stage, the coarse and fine suspensions are retained with the help of grills, sieves, sandblasters and decanters;

- The chemical or physico-chemical stage acts to remove major impurities from the wastewater. For this, coagulation-flocculation is used, the transformation of toxic elements into hardly soluble compounds by precipitation, oxidation into non-toxic compounds, retention by adsorption, ion exchange, etc.;

- The biochemical step is suitable for waste water with a high content of organic substances (fats, proteins, sugars, etc.) coming from urban sewage networks in the food industry, agro-zootechnical sectors.

The treatment procedures are applied in successive steps corresponding to the degree of purification sought.

In a first stage, the solid particles in suspension are removed from the waste water by gravity sedimentation:

- Wastewater stripping with steam or gases is used to remove volatile compounds dissolved in water, e.g. H_2S, NH_3, mercaptans;

- Incineration, applies to stripped gases, sludges, residues or even difficult-to-treat waters;

- Air flotation serves to remove oils and petroleum products from water;

- Coagulation serves to remove colloidal suspensions from water with the help of chemical reagents. As coagulation reagents, iron or aluminum salts are used, which act through their hydrolysis products;

- Biological or biochemical purification is used for the removal of organic impurities in colloidal or dissolved state from waste water through their metabolism by microorganism cultures. Biological purification is carried out in two stages. In the first stage, the rapid removal of substances in colloidal suspension takes place and in the second, slower stage, the biosorption of the dissolved substances by the microorganisms from the activated sludge continues.

Apart from these long-lasting agro-pedo-ameliorative measures, the research undertaken worldwide aims to discover faster and more efficient methods.

Some of these researches are aimed at finding a chemical compound to neutralize oil residues, such as organic solvents.

Another direction of research is the development of biological methods for the degradation of crude oil by using hydrocarbon-consuming microorganisms, which would clean the water of oil[8].

Among the preventive measures are those related to the construction of dikes surrounding the extraction wells to prevent oil from leaking onto the neighboring surfaces, the construction of access roads to the wells using prefabricated concrete slabs, the systematization and insurance against theft from the pipelines for the transport of fluids, the decommissioning access paths to wells or scrapped objectives, careful supervision of the way the oil workers' activity is carried out.

III. METHODS OF TRETMENTS OIL-POLLUED WATER

In order to be able to discuss the remediation techniques of polluted areas, it is necessary to distinguish between the terms contaminated and polluted.

In numerous publications, these terms are defined differently, therefore we consider it necessary to clarify from the beginning of this chapter the fact that a contaminated area can be defined as an area that has a chemical state that deviates from the normal composition, but that does not have a negative effect on the biocenosis.

On the other hand, a polluted area is one in which an element or a substance is present in a much greater quantity than in its natural state in the environment, respectively from the abiotic and/or biotic components.

Thus, it can be said that the areas are not polluted if the pollutant does not exceed a threshold concentration that affects the human and animal population or the primary producers, respectively the biological processes.

Pollution can have different sources, such as: chemical spills, improper storage, etc.; whether they occur consciously or accidentally, they pose a danger to both human health and flora and fauna.[38]

In order to solve the problems associated with pollution, both of terrestrial and aquatic ecosystems, remedial technologies have been developed.

Remediation can be defined as "the management of polluted areas to prevent, reduce and eliminate damage to the health of the human population, or the environment as a whole".

To make the decision to apply a remedial technology, its feasibility is studied based on financial considerations, the time required for complete depollution, and the efficiency of the technology.

The remediation techniques are very varied and can be classified into two large categories: ex situ and in situ, the selection of the remediation technology being a very important initial decision.

The ex situ techniques, applicable to both terrestrial and aquatic ecosystems, are effective and fast because in the case of polluting soil, it is excavated and moved to an unpolluted surface, specially arranged ("dig and dump"), followed by physical, chemical, technical treatment, solidification/stabilization, etc.

In the case of aquatic ecosystems, and we are referring here to underground water, pump and treat methods are known.

Both soil excavation and groundwater pumping are simple activities, or can be combined with aeration techniques, or can be used in conjunction with a more advanced technology consisting of biostimulation.

In situ techniques involve treating the pollutant by stabilizing or removing it, but without the need to remove the water.

It is thus self-evident that using this technique reduces the impact on the environment and implicitly the costs of remediation.

The oldest in situ techniques include contaminant solidification and stabilization and have been known since the 1950s in the United States as cemented S/S techniques.

Solidification consists in changing the physical properties of the pollutant, including an increase in volume and a decrease in permeability, which leads to the reduction of water infiltration and the encapsulation of the pollutant, thus preventing its penetration or spread in the environment.

Following the change in the physical properties of the pollutant, it is transformed into a much less mobile, toxic or soluble form, which leads to a decrease in the degree of toxicity and to the elimination of storage costs.

Using this method, the adjacent ecosystems can be protected and the infiltration of the pollutant into the water table can be prevented.

Another classification can be made according to the principle of remediation:

- physical treatments;
- chemical treatments;
- biological treatments;
- complex treatments that combine two or all three types presented above;

A classification can also be made depending on the final effect on the polluting agents:

- treatments completed with the destruction of pollutants;
- treatments to extract or separate pollutants;

The main harmful substances of industrial wastewater are organic substances (expressed by CBO_5), suspended substances, toxic substances and heavy metals.

The recovery of valuable substances from waste water is aimed at valorizing them and reducing the discharged harmful substances.

There is industrial wastewater and municipal wastewater.

When they have low flows, it is recommended to purify them together, but this solution must be well founded. But there are cases when specific and expensive materials are needed for industrial wastewater.

For example, industrial wastewater may contain organic substances (expressed as CBO5). Either the organic loading of the waters at the treatment plants can cause disturbances in their operation, because oxygen is necessary for aerobic processes, respectively aerobic bacteria, which oxidize the organic substance.

Substances in floating suspension (crude oils, oils) prevent the absorption of oxygen on the surface of the water and therefore self-purification, clog the filters for water treatment. Suspended substances that settle on the bottom of the receiver (accumulation basin) make it difficult to treat the water. Acids and alkalis lead to the destruction of aquatic fauna and flora, of vessels for navigation.

Inorganic salts lead to an increase in water salinity and, sometimes, can cause an increase in hardness, which produces deposits on the pipes, increasing their roughness and reducing the transport capacity, heat transfer to the boilers. As for example magnesium sulfate, bicarbonates and soluble carbonates.

Heavy metals (Pb, Cu, Zn, Cr, etc.) have a toxic action on aquatic organisms, also inhibiting the purification processes (self), CBO_5 and CCO, nitrogen and phosphorus salts (nutrients) produce the rapid development of algae.

But in recent years, industrial technological processes use new toxic substances (phytopharmaceuticals, nitrochlorobenzene, etc.) that are difficult to determine.

Radioactive substances in the water of the receptors are established by law.

The color of the water prevents the absorption of oxygen and the phenomenon of photosynthesis in self-purification.

The bacteria in the wastewater can be pathogenic (bacillus anthracis) and infect the receptors.

Since waste water has different flow rates and random concentrations over time, it is necessary to equalize the waste water before the treatment stations, which is achieved with equalization basins, located upstream of the treatment station, but after the pre-treatment stations, designed to remove coarse insoluble impurities or heavy (with grills, sieves, sand filters).

IV. A NEURAL MODEL TO WATER INJECTION TREATMENTS

In first case I analysis the water injection in oil fields.

Raw injection water was analyzed to determine pH, electrical conductivity (EC), amount of chloride, sulfate, bicarbonate, organic acids (acetic acid), calcium, magnesium, sodium, potassium, iron, total suspended solids, total extractable crude oil and hydrocarbon content.

The distribution of suspended particles was determined using the particle distribution analyzer by laser beam diffusion, for raw water (except water from the oil deposit) and for treated water.

Water treatment was done by sequential dosing and mixing of aluminum-based coagulants and polymeric flocculants (polyacrylamide-based, of anionic, nonionic and cationic type) in the currently produced water.

A dose of 0.15-0.52 ml/l of coagulant as supplied was introduced, after 5 minutes of gentle mixing another 1,5-2,5 ml/l of diluted flocculant solution (1-1,5 g/l) was added, and after another 5 minutes of reaction the water is allowed to settle for several minutes and is then filtered through a polyurethane foam (PUF) cartridge.

About 20 different types of coagulants and 15 types of polymers were tested on all water sources, but only the best recipe is written in the table of results. Water samples treated in this way were analyzed for total suspended solids, crude oil content, particle size distribution and filtration time through a 0,55 micron (60 mm diameter) membrane using a filtration system at vacuum.

These determinations were made immediately after treatment and several days later.

In all cases, the amount of suspensions increases with time and changes the particle size distribution.

Filtration times longer than 3,5-4,5 minutes per 250-300 ml indicate a significant clogging effect due to suspended particles.

In terms of particle size, for a 25-35 mD permeability reservoir, the largest particles should ideally be below 3 μm in diameter.

Regarding the maximum allowed value for the total content of suspensions and crude oil, the recommended value is 1,5-2.5 mg/l for each.

The water resulting from the exploitation of the hydrocarbon deposit will be treated mainly to meet the discharge conditions into surface water, and only secondarily for its reuse as technological water for the production of steam or re-injection into the deposit.

Current deposit conditions are described in Table 1

The models is created by this input values:

Table 1: Inpput value of oil fields.

Oil field parameters	
Permeability	2500 mD
Rate of production, m^3/zi	9000
pH	7,5-7,9
EC, μS/cm	30.300
Bicarbonate, mg/l	2800
Organic acidity (acid acetic), mg/l	1700
Salt , mg/l	7700
Sulfate, mg/l	50
Calcium, mg/l	130
Magnezium, mg/l	60
Sodium, mg/l	6000
Potassium, mg/l	35
Iron , mg/l	2.9-3,1
Ammonia, mg/l	0,1
The total amount of suspension, mg/l	130
Particle distribution 10% 50% 90%	 7.0 μm 30 μm 70 μm
Extrable substaneces, mg/l	250
Total hidrocarbons, mg/l	200
Chemical oxigen consumation (CCO-Cr), mg/l	0,1
Phenols mg/l	0,1
Benzene μg/l	550
Toluene μg/l	10
Xilene μg/l	30
Naphthaene μg/l	1,8

No chemicals are used in the treatment process, only air flotation cells with a very low efficiency (only about 10% of the crude oil is removed). Sand filters are installed after flotation, backwashed every 2 weeks.

The efficiency of sand filters is approximately 75% (suspension before filtration with a value of 120 mg/l, after filtration the value is 30 mg/l.

The following changes are proposed to the current installation:

- eplacement of air flotation cells with closed cells of pressurized type for gas flotation. Low pressure (about 2-3 bar) high CO_2 gas and a water pump (if the current system is to be retained) will be required to supply the float cell. If the efficiency of the flotation cells to remove crude oil and solid suspensions is insufficient, coagulant/flocculant solution could be added previously;
- renewal of sand filters.

This raw water has a strong tendency to scale calcium carbonate, which requires frequent treatment with hydrochloric acid in the production wells and in the transport pipelines, in combination with injection of scale inhibitor into the production wells.

Due to the high carbonate content, the coagulant/flocculant treatment cannot be used without prior adjustment of the pH from 7.5-7.9 to 6.2-6.3.

This can be achieved with approximately 8 m Ech acid/l of water or 45 kg Ech/day, corresponding to a quantity of approximately 3700 l of concentrated hydrochloric acid solution per day, being a utopian solution.

Acidity can also be obtained from redissolving carbon dioxide in water, in a ratio of 280 l of low-pressure gas, with 50-60% CO_2/m^3 water, corresponding to a total amount of about 2200 m^3/day of CO_2 gas in large percentage, introduced into the flotation cells.

This will also reduce scaling in the piping to the injection wells and may improve permeability in the reservoir due to the acidity buffer provided by redissolved CO_2.

A disadvantage of CO_2 injection can be the increased rate of corrosion in the water drain lines and injection wells, but this can be controlled by dosing the corrosion inhibitor starting in the flotation cells.

The off gas from the flotation cells will contain a high concentration of VOC components including benzene and should be incinerated or destroyed as it is a hazardous emission.

Crude oil is light, paraffinic type, with a density of 0.820, viscosity of 10.7 cP at 30°C, the freezing point is +25°C, and the density difference between water and crude oil at 30°C is sufficient of sea (0.999-0.820= 0.179 kg/ m^3).

When treating with coagulant/flocculant, the following substances were used:

- acid 5 m Ech/l (185 mg pure HCl, or 0.5 ml 40% solution);
- coagulant FD 1470 E , or FD 3500 (120 mg/l or 850kg/8500 m^3);
- flocculant AN 925 *2mg/l or 16kg/ 8000m^3).

Large variation in filtration times indicates water instability.

Some gray particles produced by bacteria appear in the treated water after about a day, and it is recommended to test a biocide treatment.

The parameters of the water resulting from the exploitation of the deposit subjected to flotation and flocculation are presented in table 2

Table 2: Water tratement results.

Water injection properties	
Suspension amount total, mg/l	10
Particle distribution, µm 10vol % 50vol % 90vol %	 0.45 µm 0.56 µm 0.85 µm

Hydrocarbures in water, mg/l	1.45	
Filtration times, sec, membrană 0.45μm	about 6 days	Imediate
50 ml	48	35
100 ml	249	65
150 ml	688	125
200 ml	-	155
250 ml	-	195

Based on the water analysis performed, the current data from the field and the test performed on the injection water, we proposed the following limiting parameters, presented in table 3.

Table 3: Limiting parameters of water injection in oil fileds

Limiting parameters	
Particle in suspension	about 2 mg/l
Particle dimension	About 2 microni
Oil rate	about 2 mg/l
O_2	about 0,02 mg/l

V. CONCLUSION

Based on the parameters we presented above, it is recommended to treat the water with a system that includes:

- gas flotation with chemicals (clarifier/coagulant);
- filter with filter materials, with chemicals (flocculant/coagulant);
- guard filter (cartridge type);
- biocide SRB (sulfur reducing bacteria), scale inhibitor, pH control, Oxygen Scavenger (chemical solution used to consume oxygen).

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