Research Paper

Oil pollution of groundwater in Dobruja Area

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ABSTRACT: *This article analyzes the oil pollution of groundwater with reference to the waters in the Dobrogea area. A number of 10 groundwater bodies have been identified, delimited and described in the hydrographic space. Following the chemical analysis of the water samples taken from the groundwater bodies, exceedances were found (according to the Drinking Water Law no. 458/2002), the following were registered for the indicators: nitrates, nitrites, ammonium, phosphates, organic substances, chlorides, hardness total and oil product. The main pollutants and the existing pollution level are reviewed. Also the pollutant recovery techniques are analyzed and this article presenting the experimental results of the application of the thermal treatment of the underground layer of polluted water.*
KEYWORDS: *Oil pollution, groundwater, Dobruja area, thermal recovery,*

I.   INTRODUCTION

In addition to surface water, pollution is often widespread in groundwater. Pollution of these waters is more dangerous than pollution of surface waters, because in addition to the fact that these waters are the main source of drinking water, determining the polluted area, the amount of pollutant and the date of pollution and who is the polluter are questions that are quite hard to answer.

The soil layer covered by various contaminants discharged to the surface does not have a sufficient capacity to retain harmful substances. Because of this, such pollutants are found in the aquifer, such as: synthetic detergents, phenols, cyanides, pesticides, insecticides, herbicides, salts from the use of chemical fertilizers, residues from the nuclear industry [1].

Petroleum hydrocarbons are an important class of groundwater contaminants. Water-soluble hydrocarbons, especially alkylbenzenes, dissolve, severely affecting water quality. At the same time, some water-soluble components, such as benzene, are carcinogenic [2]. Petroleum products can be disposed of in groundwater and as a result of accidental spills on the ground. The contact of oil with the soil causes changes in the physical, chemical and biological properties of the soil, due to the volatilization of light compounds, stratification and selective migration of the pollutant on the soil profile, depending on the polarity of the components [3]. Thus, saturated hydrocarbons penetrate to greater depths, followed by aromatic hydrocarbons, while polar components such as asphaltenes remain on the surface as a compact film, creating anaerobic conditions that reduce microbial metabolic activity [4].

This paper analyzes the oil pollution of groundwater with reference to the waters in the Dobrogea area and depollution techniques.

II.   GROUNDWATER RESOURCES ON THE DOBRUJA AREA

The main structures in Dobrogea, from the point of view of groundwater resources, develop in carbonate formations strongly affected by a karstic fissure system [5].

Based on the lithostructural and hydrological criteria, three aquifer systems could be structured:

1. Quaternary aquifer system - which consists of loess and loessoid clays, deluvial clays, sands and banks. Of these, the most widespread are loessoid deposits, of variable thickness (20-30 m) and with vertical permeability [6].

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2. The Sarmatian aquifer system - Eocene - which consists of Eocene calcareous sandy deposits and Sarmatian limestones that due to the fissure system that affects them, form a unitary hydrodynamic system. The thickness of these deposits is between 0 - 300 m [6].

3. The Cretaceous - Jurassic - aquifer system is composed of Jurassic, Barremian and Cretaceous carbonate formations, unequally distributed spatially due to the vertical movement of tectonic blocks. This aquifer system corresponds to the most important structure in Dobrogea, with thicknesses that in some places exceed 100 m [7].

In the Dobrogea - Litoral hydrographic space, a number of 10 groundwater bodies were identified, delimited and described. Groundwater resources, with depths between 0 - 300 m, represent approx. 3172 million m^2/year (100.6 m^2/s), of which 84.8 m^2/s from the deep layers of very good quality and 15.8 m^2/s drinking water with a higher mineralization coming from the groundwater [7].

Groundwater area is (Figure 1):

a. Groundwater bodies belong to the fissural-karstic type (Triassic and Sarmatian age) are RODL01 (Tulcea), RODL02 (Babadag), RODL03 (Hârşova-Ghindăreşti) and RODL04 (Mangalia-Cobadin),
b. Porous-permeable groundwater bodies type (Holocene deposits, Middle-Upper Pleistocene, Jurassic-Cretaceous).RODL05 (Central Dobrogea), are RODL07 (Danube Meadow), RODL09 (Northern Dobrogea) and RODL10 (Southern Dobrogea),
c. Groundwater bodies belong to the karst-fissural type (of Jurassic age) are RODL06 (Wallachian Platform) and RODL08 (Casimcea) belong to the karst-fissural type (of Jurassic age).

Figure 1

III. MONITORING ACTIVITY AND POLLUTION LEVEL

The monitoring activity aims to assess the state of water quality, monitor pollution sources, conduct studies and research on groundwater (Figure 2) [8].

Monitoring the state of water quality in a certain area involves determining the characteristic parameters of groundwater in all subdomains of the aquifer, over long periods of time.

Monitoring the sources of pollution consists in the activity of observing the areas with groundwater that can be potentially polluted. In this situation, the observation wells must be designed and located so that the migration of oil pollutants can be detected [9].

The 10 groundwater bodies assigned for management to the Dobrogea Litoral Water Basin Administration have a monitoring network consisting of 101 monitoring points (boreholes or springs) (Figure 1.2.), And the monitoring frequency is one analysis per year in the case of bodies of water. deep groundwater (RODL03 -Hârşova-Ghindăreşti, RODL04 - Cobadin-Mangalia and RODL06 - Wallachian Platform) and two analyzes per year for groundwater bodies (RODL01 - Tulcea, RODL02 - Babadag, DobR00, RODL07 Danube floodplain (Hârşova-Brăila), RODL08 - Casimcea, RODL09- North Dobrogea and RODL10- South Dobrogea).

Exceedances (according to the Drinking Water Law no. 458/2002) were registered for the indicators: nitrates, nitrites, ammonium, phosphates, organic substances, chlorides, total hardness, petroleum product [10].
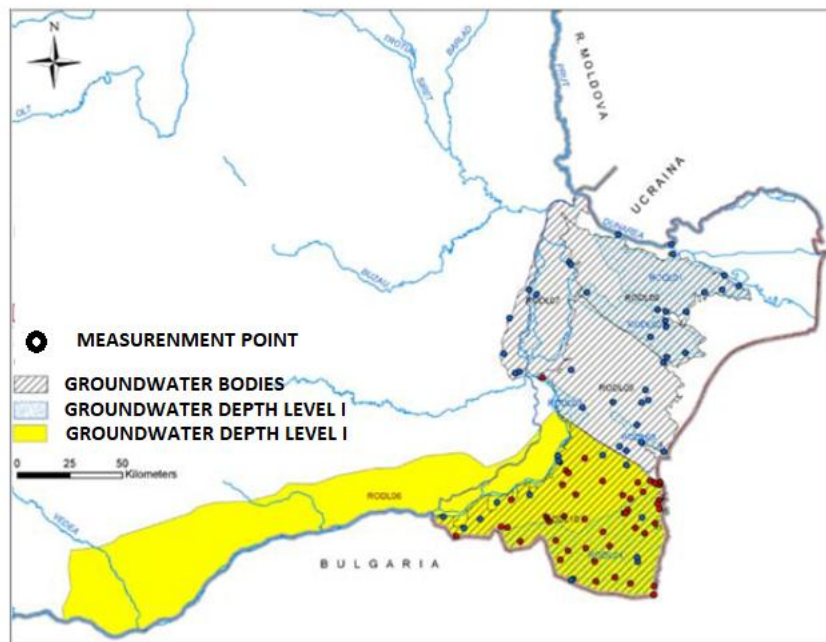
Figure 2

Following the monitoring of these waters, a residual pollution with petroleum products was found in the areas of Poarta Albă, Port Ovidiu, Castelu (Figure 3).

Figure 3

IV. SOURCES OF GROUNDWATER POLLUTION

The sources are multiple, being able to be located: at the surface of the land, in the underground, above the groundwater level and below the groundwater level.

The sources of soil and groundwater pollution with petroleum products from the territory of Dobrogea are: the pipes that supply the scaffolding parks, the accidental oil spills and the reservoir water from the separator parks, the wells, the oil storage and treatment stations, the stations of compressors and pipelines, sludges, installations for the transport and storage of petroleum products and injection water, old disused wells, scrapped installations and equipment in specially designed places [11].

Groundwater pollution can also come from airborne pollutants that are carried by the wind, deposit on the ground and are washed away by precipitation, infiltrating underground [12].

Other sources of groundwater pollution can also be waste from the refining and petrochemical process, these can be acid tar, used soil (sludge), deposits in tanks where oil products are stored, spent catalysts from various processing processes, organic solvents, halogenated and macromolecular compounds, used sludges from biological wastewater treatment plants in refineries [13].

V.   TRANSPORT OF POLLUTANTS IN THE UNDERGROUND ENVIRONMENT

Aquifer oil pollution comprises several phases that can be grouped into two major stages:

- the stage of migration of the pollutant starting from the source has as effect a pollution by its cantonment in its capillary area (located above the groundwater) in the form of a floating residual layer [14];

- the stage of transfer of soluble hydrocarbons from waste oil to groundwater having as effect a chemical pollution, increasing the content of organic substances, the pollution affected and by the effects of biodegradation of the pollutant stored in the vegetable soil or groundwater of the groundwater aquifer.

These stages underlie the aquifer pollution mechanisms which comprise four important phases [15,16,17]:

1. Migration of the polluted phase;
2. Exchange between petroleum product and groundwater;
3. Transport and dispersion of traces of hydrocarbons in groundwater;
4. The evolution over time of the pollutant-water transfer.

The transport of soluble pollutants is achieved by:

-        Advection - the transport of the pollutant by the natural current of the underground water, at its average speed;

-        Diffusion - transport of the pollutant due to the concentration gradient that is achieved between the different points of the aqueous solution of the respective substance; ¬

-        Dispersion - as a mixing phenomenon produced between the liquid solution and the clean water, resulting in the dilution of the solution, ie the reduction of the pollutant concentration in the groundwater.

Transport of insoluble pollutants - pollutants that may exist as a separate phase in the underground environment are coded as [18,19,20]:

- NAPL (Non Aqueous Phase Liquids) are liquid substances, immiscible with water and lighter than water, they float on the surface of groundwater, such as petroleum hydrocarbons, kerosene, fuels used in transport, etc.

- DNAPL (Dense Non Aqueous Phase Liquid) defines substances immiscible with water, which have a higher density than water, which is why they cross the aquifer, depositing on the bedrock, such as chlorinated hydrocarbons and biphenyl polychlorinated products.

In this way, so-called "feathers" or "bags" of such pollutants are made in the underground environment as shown in Figure 4 [21,22].
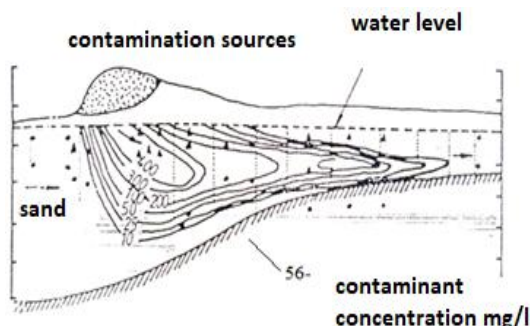
Figure 4

The physical, chemical and biological factors involved in the transport of pollutants in the underground environment, lead to effects such as: dilution, filtration, adsorption, chemical and biochemical reactions and transformation reactions [23,24].

VI.   EFFECTS OF GROUNDWATER POLLUTION WITH PETROLEUM PRODUCTS

The effects of groundwater pollution with petroleum products will always be harmful, toxic and long-term, especially since it is vital to our lives, so we must protect the environment and take safety measures to avoid the consequences of pollution.

There are several components or classes of compounds that come from crude oil that have toxic properties.

The most important and well-known compounds and their potential aspects on human health are briefly described below [25]:

a) Benzene and toluene are constituents of crude oil and have a significant solubility in water. Toluene remains in water for longer periods than benzene, because the former has a higher boiling point. Benzene is a carcinogenic compound, and if it is above l00 ug/L in water it causes fatigue, headaches and the risk of cancer. The permissible limit for benzene in drinking water is 0.2 ug/L. Toluene is a less toxic compound than benzene, but in higher concentrations it causes headaches, nausea, fatigue.

b) Polycyclic aromatic hydrocarbons (PAHs) are a class of more than 20 organic compounds, some of which are known to be extremely toxic to human health. These compounds have very limited solubility in water, but can be continuously infiltrated into water in the form of oil tar balls for long periods of time. Many PAHs are shown to be mutagenic in bacterial systems and produce skin tumors in some animals, due to this it is assumed that some forms of skin cancer seen in humans are due to exposure to some PAHs. A limit of 0.0004 ug / L drinking water was set for these compounds, and a limit of 0.001 ug / L was established for benzopyrene, a carcinogenic compound.

c) Phenolic compounds are known to be present in crude oil. They are mostly non-toxic in very low concentrations, but some chlorophenols, products that result from the chlorination of phenols, are reported to be toxic if consumed even in low concentrations in drinking water. For example 2,4,6-trichlorophenol is carcinogenic. Many phenols can be detected by their odor and taste at concentrations below 1 ug/L.

d) Chloroform and Total trihalomethanes - do not come mainly from crude oil, but can be formed in water by chlorination as a result of the reaction between chlorine and some constituents of crude oil. Chloroform and other halogenated compounds, included in the class of total trihalomethanes, are known to have carcinogenic properties.

e) Phthalate esters are esters of phthalic acid are reported to be a class of contaminants, usually found in water from industrial use based on plastics. A concentration of 0.5 ug / L has been suggested as a threshold value for all phthalates. This class of compounds is considered toxic to humans.

f) Mineral oils are a class that is not very soluble in water. Some of these compounds can be toxic, but most of them are harmless, but due to the unpleasant smell and taste, people tend to refuse to drink water that contains mineral oils even at concentrations much lower than the toxic thresholds. The allowed limit is 50 ug / L.

Pollution of groundwater with petroleum products has a detrimental effect on both humans and flora and fauna, as the compounds present in crude oil and petroleum products are toxic. To prevent harmful effects, it is good to monitor groundwater contaminated with toxic substances from petroleum products and to take depollution measures.

VII.   GROUNDWATER DEPOLLUTION BY THERMAL METHODS

Under thermal remediation measures, all physical, chemical or biological processes that take place in the underground environment are temperature dependent [26] .

Therefore, heat treatment methods aim to increase the temperature of the underground environment. This increase in temperature has a dual role: increasing mobility and transforming them into easier-to-recover forms [27].

The most used heat treatment methods are: steam injection, hot air or hot water, electric heating, heating by radio waves, heating by thermal pipes, optical fibers and depollution by electroacoustic methods.

The general principle, which underlies the thermal remediation methods, is to heat the contaminant environment to different temperatures, in order to extract, neutralize, destroy or immobilize oil pollutants.

Thermal methods have been used successfully in recovering oil from the field in the secondary and tertiary phases.

The advantages of thermal methods are:

• rapid implementation, rapid effects, remediation is obtained in the shortest possible time, even for less permeable areas;

• accelerates biodegradation and abiotic decomposition and transformation reactions, desorption of pollutants attached to solid soil particles;

• increases the water solubility of pollutants;

• remediation is performed in standard parameters;

• achieving the level of remediation at imposed standards can lead to a remediation efficiency of over 99%;

• the remediation period is very short 6-8 weeks.

Disadvantages of thermal methods can be:

• efficiency is limited for heterogeneous soils;

• loss of part of the thermal energy;

• expensive for soils with high humidity or containing clay;

• pumped water treatment is often an expensive and technologically difficult process;

• difficult to control the dynamics of pollutants remobilized by heat treatment, they can reach areas difficult to anticipate.

7.1. Steam injection

The injection of steam helps to recover in a short time the volatile, semi-volatile and insoluble organic pollutants retained in the structure of the porous environment.

The method is attractive for compounds with a higher density than water.

This remediation technology comprises an underground steam generation and injection system, a recovery system, a condensed pollutant collection and treatment system.

It was found that 80% of the oil product is recovered in the first 30 minutes after the introduction of steam.

The method involves the following steps:

- injection of steam into the polluted underground environment;

- vapor recovery;

- collecting and treating the resulting condensate, as shown in Figure 5, but the steam can also be injected inside the polluted area or under the polluted area.
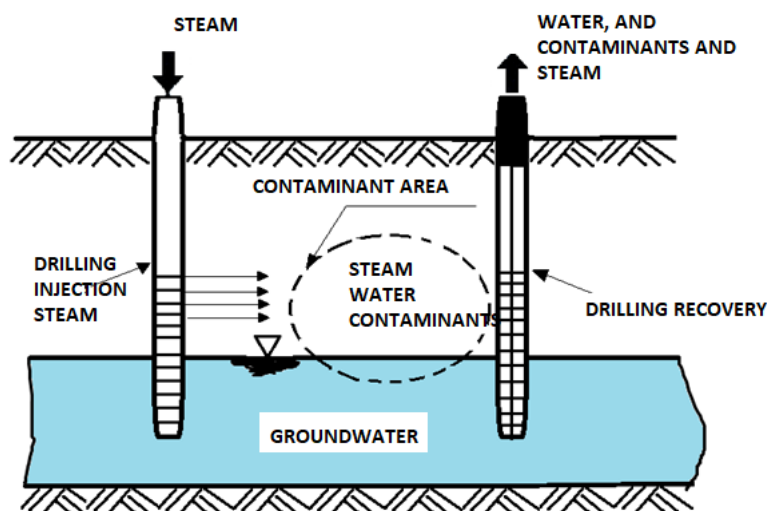

Figure 5

7.2. Heating by radio waves

Underground areas polluted with solvents and fuels, whose boiling temperature is 80-100 °C, cannot be remedied by heating with steam or hot water, because it is difficult to achieve such temperatures in situ.

Radio wave heating is determined by the electromagnetic energy of waves in the radio frequency band.

The heat generation mechanism is similar to that of microwave ovens.

The method involves the following component systems:

- a system for distributing the energy of radio frequency waves;

- a system for generating, transmitting, monitoring and controlling radio frequency waves;

- a system for treating and handling condensed gases and liquids;

- a vapor collection system.

However, the method is effectively applied only to homogeneous sandy soils, but it is expensive.

The high temperatures generated by this method destroy the microbiota involved in bioremediation, but especially in the formation of soil humus.

7.3.Electric heating

In the ground, electrodes connected to a power source are planted, as shown in Figure 6.

The method does not give uniform heating if the electrodes are not used carefully.

In the polluted underground environment can be made a network of electrical conductors, consisting of metal pipes that when the current passes through them, the earth heats up, causing its drying and evaporation of volatile compounds.
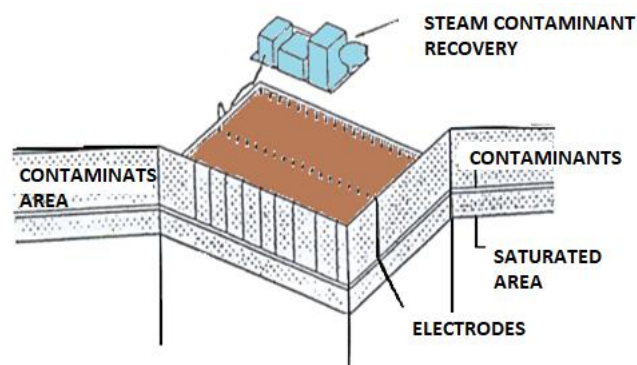
Figure 6

7.4.Other techniques for underground heating

Recently, other techniques are being developed that are only at the beginning of their development.
The best known are:
- thermal pipes;
- hot air injection;
- optical fibers;
- depollution by electroacoustic methods.

VIII.   EXPERIMENTAL STUDY ON THE RECOVERY OF PETROLEUM PRODUCTS FROM SOIL AND GROUNDWATER

In conducting the experimental study, we simulated a water and soil pollution with:
a. a light petrol with a density of 0.7556 g/cm^3,
b. a heavy diesel with a density of 0.9454 g/cm^3,
which was poured over a soil composed of gravel and sand with a bed of water.

In the first stage we simulated a thermal extraction of the two products and a mixture of 50% heavy diesel, 50% light gasoline from a soil composed of gravel and sand moistened with water.

To recover the products from the soil we used the distillation apparatus, in which we heated the product that contaminated the soil at various temperatures and then cooled it with water, as seen in Figure 7.

IX.   NUMERICAL MODELING OF THERMAL RECOVERY OF PETROLEUM PRODUCTS

To make a numerical model that:
a. describe how to recover gasoline, diesel and a mixture of soil and groundwater,
b. be used as the first equation in the analysis of the recovery of mixtures of petroleum products,
We created an experimental model consisting of:
a. a bed of sand and gravel measuring between 1 mm and 1 cm,
b. two petroleum products, namely hydrophilic gasoline and heavy diesel,
c. a mixture of hydrophilic gasoline and heavy diesel,
d. a mixture of the two products and water.

Figure 7

The hydrophilic gasoline used has the properties:
The mass of hydrophilic gasoline is 37.78 grams at a volume of 50 ml.
That is, the density of hydrophilic gasoline used is 0.7556 grams / ml.

The water used has the properties:
The used water was taken from the navigable channel.
The mass of water is 50.71 grams at a volume of 50 ml.
That is, the density of water used is 1.0142 grams / ml.

The diesel used has the properties:
The mass of diesel is 47.27 grams at a volume of 50 ml.
That is, the density of diesel used is 0.9454 grams / ml.
The determination temperature was 15 ° C.

Table 1. Extraction of hydrophilic gasoline in soil moistened with water

Temperature of distillation, ^{o}C	Time of measurement, minutes	Recovered volumes, ml.	% volume,
50	0	0	0
84	3	10	20
88	5	15	30
90	7	20	40
110	11	25	50
130	16	30	60

The first drop began to appear at a temperature of 50 ^{o}C.

Table 2. Extraction of heavy diesel in soil moistened with water

Temperature of distillation, ^{o}C	Time of measurenment, minutes	Recovered volumes, ml.	% volume,
50	0	0	0
84	23	10	20
88	28	15	30
90	43	20	40
110	57	25	50
130	63	30	60

The first drop began to appear at a temperature of 211 degrees ^{o}C.

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Table 3. Extraction of the mixture of hydrophilic gasoline and diesel in the soil moistened with water

Temperature of distillation, °C	Time of measurenment, minutes	Recovered volumes, ml.	% volume,
55	0	0	0
100	17	10	20
110	25	15	30
149	31	20	40
180	33	25	5
209	39	30	60

The first drop began to appear at a temperature of 55 degrees °C.

The present study is intended to be a numerical model of the extraction of the petroleum product from a soil moistened with water.

Table 4. The final results for a wetting of the soil polluted with 10% by volume

Volume recovery, ml	Temperature of distillation, °C, hydrophilic gasoline gasoline,	Temperature of distillation, °C diesel	Temperature of distillation, °C moisture	Time recovery hydrophilic gasoline, minutes	Time recovery diesel, minutes	Time recovery mixure, minutes
0	50	211	55	0	0	0
10	84	244	100	3	23	17
15	88	248	110	5	28	25
20	90	254	149	7	43	31
25	110	273	180	11	57	33
30	130	288	209	16	63	39

In order to study the behavior of the thermal extraction of the petroleum product, we chose as a model the linear regression starting from equation (1):

$$Y = a + b \cdot X \tag{1}$$

For all the above data we determined the equations by a mathematical model through the MATHCAD program and then we checked the model if it is appropriate.

The evolution of the hydrophilic gasoline temperature compared to the extracted volume is given by equation (2):

$$Y = 54.054 + 2.168\ X \tag{2}$$

The values of the Student distribution for this case give us the values $\alpha = 0.05$ and $n = 2$ degrees of release, in the value 2.920 and calculated gives us the value 1.922, so the model is adequate.

Table 5. Experimental and calculated temperatures for gasoline at different volume fractions recovery

% Recovery volume	Recovery volume, ml	Temperature of distillation to hydrophilic gasoline (experimental determined) °C	Temperature of distillation to hydrophilic gasoline (based by relationship 2) °C
0	0	50	54.054
20	10	84	75.734
30	15	88	86.574
40	20	90	97.414
50	25	110	108.254
60	30	130	119.094

Also, the Fisher test gives us the value 0.923 less than 3.24 value.

The evolution of diesel temperature compared to the extracted volume is given by equation (3):

$$Y = 214.027 + 2.284\ X \tag{3}$$

The values of the Student distribution for this case give us the values $\alpha = 0.05$ and $n = 2$ degrees of release, results the value 2.920 and calculated gives us the value 1.952, so the model is adequate.

Also, the Fisher test gives us the value 0.953 less than 3.24 value.

The evolution of the hydrophilic gasoline -diesel mixture temperature compared to the extracted volume is given by equation (4):

$$Y = 50.162 + 4.903\ X \tag{4}$$

The values of the Student distribution for this case give us the values $\alpha = 0.05$ and $n = 2$ degrees of release, results the value 2.920 and calculated gives us the value 1.277, so the model is adequate.

Also, the Fisher test gives us the value 0.971 less than 3.24 value.

The gasoline recovery time equation versus the volume extracted is given by equation (5):

$$Y = -0.703 + 0.422 \, X \qquad (5)$$

The values of the Student distribution for this case give us the values $\alpha = 0.05$ and $n = 2$ degrees of release, results the value 2.920 and calculated gives us the value 1.956, so the model is adequate.

Also, the Fisher test gives us the value 0.956 less than 3.24 value.

Table 6. Experimental and calculated temperatures for diesel at different volume fractions recovery

% Recovery volume	Recovery volume, ml	Temperature of distillation to diesel (experimental determined) °C	Temperature of distillation to diesel (based by relationship 3) °C
0	0	211	214.027
20	10	244	236.865
30	15	248	248.284
40	20	254	259.703
50	25	273	271.122
60	30	288	282.547

Table 7. Experimental and calculated temperatures for the gasoline-diesel mixture at different volumes

% Recovery volume	Recovery volume, ml	Temperature of distillation to gasoline-diesel mixture (experimental determined) °C	Temperature of distillation to gasoline-diesel mixture (based by relationship 4) °C
0	0	55	50.162
20	10	100	99.189
30	15	110	123.703
40	20	149	148.216
50	25	180	172.73
60	30	209	177.09

The equation for diesel recovery time from the extracted volume is given by equation (6):

$$Y = -0.865 + 2.219 \, X \qquad (6)$$

The values of the Student distribution for this case give us the values $\alpha = 0.05$ and $n = 2$ degrees of release, the value 2.920 and calculated gives us the value 1.984, so the model is adequate.

Also, the Fisher test gives us the value 0.984 less than 3.24 value.

Table 8. Recovery time at different volumes of gasoline, experimental and calculated

% Recovery volume	Recovery volume, ml	Experimental recovery time, hydrophilic gasoline, min	Calculated recovery time, hydrophilic gasoline, min
0 %	0	0	-0.703
20 %	10	3	3.514
30 %	15	5	5.622
40 %	20	7	7.730
50 %	25	11	9.838
60 %	30	16	

The equation of the recovery time of the petrol-diesel mixture with respect to the extracted volume is given by equation (7):

$$Y = 2,054 + 1,368 \, X \qquad (7)$$

The values of the Student distribution for this case give us the values $\alpha = 0.05$ and $n = 2$ degrees of release, results the value 2.920 and calculated gives us the value 1.965, so the model is adequate.

The Fisher test also gives us a value of 0.965 which is less than 3.24.

% Recovery volume	Recovery volume, ml	Experimental recovery time, diesel, min	Calculated recovery time, diesel, min
0 %	0	0	-0.865
20 %	10	23	21.324
30 %	15	28	32.419
40 %	20	43	43.514

50 %	25	57	54.608
60 %	30	63	

Table 9. Recovery time at different volumes of diesel, experimental and calculated

Table 10. Recovery time at different volumes of diesel-hydrophilic gasoline mixure, experimental and calculated

% Recovery volume	Recovery volume, ml	Experimental recovery time, diesel-hydrophilic gasoline mixure, min	Calculated recovery time, diesel-hydrophilic gasoline mixure, min
0 %	0	0	2.0540
20 %	10	17	15,730
30 %	15	25	22,568
40 %	20	31	29,405
50 %	25	33	36,243
60 %	30	39	

The experiment aimed to recover 60% of the pollutant, namely light fractions, because they are much more soluble in water and with a larger area of pollution.

Heavy fractions are less soluble in water and are also more easily transported by the water flow during washing.

An experimental model similar to the soils from Dobruja was used, namely green schists filled with chernozem. In green shales, groundwater is not circulating, so we considered only a water wash of the analyzed soil and not a total filling (only 10% of the volume).

X. CONCLUSION

The 10 groundwater bodies assigned for management to the Drobuja Water Basin Administration have a monitoring network consisting of 101 monitoring points (drilling or springs), and the monitoring frequency is one analysis/year in the case of deep groundwater bodies (RODL03: Hârşova - Ghindăreşti, RODL04: Cobadin - Mangalia and RODL06: Platforma Valahă) and two analyzes per year for groundwater bodies (RODL01: Tulcea, RODL02: Babadag, RODL05: Dobrogea Centrală, RODL: RODL- Brăila), RODL08: Casimcea, RODL09: North Dobrogea and RODL10: South Dobrogea).

It should be noted that in the last year there were exceedances (according to the Drinking Water Law no. 458/2002) on the indicators: nitrates, nitrites, ammonium, phosphates, organic substances, chlorides, total hardness.

These exceedances are due to the presence of pollutants from:

a. treatment of soils with excess chemical fertilizers (nitrates, nitrites),

b. the lack of domestic water collection networks and their efficient treatment - ammonium (the existence of individual sanitary groups without watertight watertight basins for domestic water collection),

c. the presence of oil pipelines and petroleum products that have polluted the soil for years due to technical accidents and criminal attacks (organic substances).

It should be mentioned the existence of two historical pollutions with petroleum products in Dobruja, namely in the Caraiman-Constanţa area (due to oil and oil products leaks from storage tanks, oil polluted water transport systems and OIL TERMINAL oil products, such as and in Ovidiu Port due to the damage in 2000 of an oil pipeline and the loss in the soil of about 100 tons of product.

This paper analysed how to heat treat a groundwater polluted with petroleum products.

We made in the laboratory an experimental model similar to the pollution in Ovidiu Port, we heat treated this soil moistened with water and polluted with petroleum products (diesel, gasoline and a mixture of diesel and gasoline).

The results obtained by heat treatment in the laboratory of a soil moistened with water and polluted with petroleum products were processed graphically and mathematically, also managing to write the regression equations of the behavior of these pollutants during heat extraction.

The paper presents a fairly recent bibliography and analyzes the present studies on the scientific and technical market in Romania and in the world.

It should be mentioned that this paper managed to bring for the first time in the specialized literature the mathematical model through the MATHCAD program of extraction of pollutants from groundwater by heat treatment, applicable to pollution in Ovidiu Port.

Given that the pollution of a site (groundwater) with petroleum products is difficult to rehabilitate the method presented in the paper is much more useful than the current methods (namely extraction of pollutants by vitiation and depollution by drainage), because the recovery time is shorter 70% lower).

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