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# ENVIRONMENTAL STUDY REGARDING POLLUTION IN OIL EXTRACTION AREAS, BACAU DISTRICT, ROMANIA. III POLLUTION OF THE GROUND WATERS

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**ABSTRACT**
*Oil industry development likes as extraction and as well as production is sometimes accompanied by pollution phenomena apparition with prejudices effects on our environment and the peoples health.*
*In oil extraction areas appear soil, ground waters and surface waters pollution phenomena with oil residuum with or without salty water.There are other residual oil products resulted from exploting activities, plus the losses from pipes transporting oil or oil products. This paper is part of a series of papers dedicated to researching environment pollution in oil extraction areas in Bacau district, Romania. The paper present researches concerning ground waters pollution in oil extraction areas in Bacau district on five villages area.*
*The researches made allowed established the device of pollutant migration from soil into ground waters, the identification pollution sources, the establishing pollution causes. Based on the obtained results we have identified necessary measures for reducting of existing pollution effects and pollution prevent by environmental factors and pollution sources monitoring.*
**Keywords:** environment, oil, oil rigs, pollution, ground water, salty water.

## 1. INTRODUCTION

Oil industry development likes as extraction and as well as production is sometimes accompanied by pollution phenomena apparition with prejudices effects on our environment and the peoples health.
In oil extraction areas appear soil, ground waters and surface waters pollution phenomena with oil residuum with or without salty water.There are other residual oil products resulted from exploting activities, plus the losses from pipes transporting oil or oil products.[1,2]
The pollution of soil and ground waters with oil from oil extraction areas has connection with stokage, delivery and handling oil, this operations create inevitable losses because of flows from pipes, tanks. In this cases has place a pollutant migration from soil into ground waters having as result chemical pollution of them. This is realised through: increases of concretised organic substances of content over level admitted limits, the appearance and persistence of an unpleasant taste or specific smell of oil products.
Treating pollution and depollution soil separately from underground waters would be incorrect and limitative, because of the connections between these two environment components.
So, if the soil is affected by pollution then there is the risk for the underground waters to be contaminated by the transfer of the pollution agent from soil surface towards depths.[3,4]

Because of this cause, the pollution and depollution research methods are taking in account the soil-underground water system.
The oil pollution mechanism of soil-underground water system is a complex mechanism that implies a few important steps:

a) the polluting phase migration;
b) the exchange between the oil product and the underground water;
c) the drawing and dispersion of hydrocarbon traces in underground water;
d) the evolution in time of pollution agent-water transfer.

a) The polluting phase migration
From its source, the oil pollution agent infiltrates in the soil first vertically under gravity effect and sometimes because of the movement of residual waters or rain waters.
The vertical migration mode through the soil layers to the underground water surface depends on their homogeneity and porosity, by:
- through the layers with small granulation, the oil pollutant migrates towards the phreatic water level by unpredictable directions;
- through alluvial layers type with thick granulation or through filling deposits, the oil pollutant migrates under a bell form.
If the pollution agent quantity exceeds the retaining capacity of the infiltration domain then, after some time, the oil spreads on the underground water surface in a lenticular form.
b) The exchange between the oil product and the underground water
At the contact of phreatic water with the infiltrated oil, a transfer of soluble hydrocarbon takes place, from residual oil to water, the exchange coefficient increasing with the speed of the water.
c) The drawing and dispersion of hydrocarbon traces in underground water
This step consists in the drawing of dissolved substances in aquifer which is actually the most important chemical contamination.
d) The evolution in time of pollution agent-water transfer.
The phreatic water contamination evolution includes a phase of conjugation of evaporation, absorption, and degradation actions which depends on a series of parameters of the soils affected by : pH, humidity, soil temperature.
Some oxidation products from the soil and underground can action on inter-facial tension of oil-water and can lead to a new mobility of the polluting phase, this amplifying the water contamination process.
This paper is part of a series of papers dedicated to researching environment pollution in oil extraction areas in Bacau district, Romania.
The paper present researches concerning ground waters pollution in oil extraction areas in Bacau district on five villages area.

## 2. MATERIALS AND METHODS

Oil extraction in Bacau district takes place on an extended surface, these containing 8 departments, 22 oil parks and approximately 100 functioning oil rigs when the study was made. [5]
Considering the size of the territory where the oil extraction activity takes place and the pollution sources, we've made an analytical program of investigations for determining a general basis of environment elements pollution.
One of the steps in environment evaluation was the investigation of the water as enviromental factor, and respectively the underground water. The investigation program consisted in three steps: the sample collecting phase, the samples evaluation phase and the evaluation and analysis of the obtained results.
The underground water sheet investigation for determining the possible contamination there were collected a number of samples from wells from villages in the extraction areas.
Test drawing locations and the needed physico-chemical indicators are presented in table number 1.
The polluted water samples were analysed according to the current standards.[6,7]
The pollution degree evaluation was determined using the standards of drinking water because in Romania there are no specific standards for underground water quality.

*Table 1: Drawing ground waters test points*

| Test no. | Drawing points | Physico-chemical indicators |
|---|---|---|
| P1 | Water test from well – Sarata village, in front of house no. 239 | Physical indicators:pH<br>General chemical indicators<br>• $NH_4^+$ (mg/L)<br>• $PO_4^{2-}$(mg/L)<br>• Fe (mg/L)<br>• $CN^-$ (mg/L)<br>• $NO_3^-$ (mg/L)<br>• $Ca^{2+}$ (mg/L)<br>• $SO_4^{2-}$ (mg/L)<br>• $Cl^-$ (mg/L)<br>• filterable residuum (mg/L)<br>• organic substances CCO-Cr ($mgO_2$/L) |
| P2 | Water test from well – Solont village, in front of house no. 457 | |
| P3 | Water test from well – Pietrosu village, in front of house no. 807 | |
| P4 | Water test from well – Modarzau village, in front of house no. 80 | |
| P5 | Water test from well – Zemes village, in front of house no. 83 | |

Alert and intervention thresholds relevance on underground waters pollution is presented in table no.2.

*Table 2: Alert and intervention thresholds relevance*

| No. | Situation | Pollution level | Observation |
|---|---|---|---|
| 1. | $C_{measured} < AT$ | IP | It's not necessary to establish special measurements |
| 2. | $IT > C_{measured} > AT$ | PP | There is a potential impact on waters |
| 3. | $C_{measured} > IT$ | SP | There is an impact on waters |

$C_{measured}$ – Indicator's measured concentration ; IP – Insignificant pollution; AT – Alert threshold PP – Possible pollution; IT – Intervention threshold ; SP – Significant pollution

## 3. OBTAINED RESULTS

For drawn tests, after the analysis, we have obtained physico-chemical parameters values presented in table no.3.

*Table 3: Physico-chemical parameters values and maximum admitted concentrations*

| Analysed indicator | **Obtained value** | | | | | |
|---|---|---|---|---|---|---|
| | Test number: | | | | | |
| | P1 | P2 | P3 | P4 | P5 | MAC (max) |
| $NH_4^+$ (mg/l) | 0,03 | 0,03 | 0,11 | 0,09 | 0,02 | 0 |
| $NO_3^-$ (mg/l) | 68,40 | 228,50 | 56,20 | 29,10 | 43,50 | 45,00 |
| $CN^-$ (mg/l) | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,01 |
| $Ca^{2+}$ (mg/l) | 161,18 | 172,69 | 161,68 | 230,26 | 230,86 | 100,00 |
| $Cl^-$ (mg/l) | 151,51 | 141,41 | 121,21 | 272,72 | 121,68 | 250,00 |
| $SO_4^{2-}$(mg/l) | 280,00 | 246,00 | 204,00 | 150,00 | 42,00 | 200,00 |
| CCOCr($mgO_2$/l) | 20,00 | 24,00 | 12,00 | 11,00 | 22,00 | 3,00 |
| Fe(mg/l) | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,10 |
| FR (mg/l) | 1152 | 1087 | 1054 | 990 | 772 | 100-800 |
| $PO_4^{2-}$(mg/l) | 0,70 | 0,10 | 0,10 | 1,30 | 1,30 | 0,10 |
| pH | 7,19 | 7,99 | 7,54 | 7,01 | 6,18 | 6,5-7,4 |

MAC – Maximum admitted concentration; FR-Filterable residuum.

Comparing the obtained results for physico-chemical indicators with maximum admitted concentration, according to present standards, we've made an evaluation of ground water pollution level, presented in table no. 4

*Table 4: Pollution level evaluation*

| Test No. | Analysed parameters / Pollution type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $NH_4^+$ (mg/l) | $NO_3^-$ (mg/l) | Fe (mg/l) | $Ca^{2+}$ (mg/l) | $Cl^-$ (mg/l) | $SO_4^{2-}$ (mg/l) | CCO-Cr ($mgO_2$/l) | $PO_4^{2-}$ (mg/l) | FR (mg/l) |
| P1 | SP | SP | IP | SP | IP | SP | SP | SP | SP |
| P2 | SP | SP | IP | SP | IP | SP | SP | PP | SP |
| P3 | SP | SP | IP | SP | IP | SP | SP | PP | SP |
| P4 | SP | IP | IP | SP | SP | PP | SP | SP | SP |
| P5 | SP | PP | IP | SP | IP | IP | SP | SP | PP |

IP – Insignificant pollution ; SP – Significant pollution ; PP - Possible pollution ; FR-filterable residuum ;

## 4. CONCLUSIONS

The conclusions were drawn after evaluating the pollution degree, after analyzing the obtained results and finding the actions that are necessarily for avoiding further pollution.

Concerning the pollution degree determined from the analysis of the obtained results we can conclude the following:

- at every water sample taken, we obtained values that exceeded the intervention threshold of the following indicators: $NH_4^+$, $Ca^{2+}$, CCO-Cr, which indicates a significant pollution with oil residuum;
- at samples P1,P2,P3 we've determined a significant pollutions with $NO_3^-$ and $SO_4^{2-}$;
- all samples don't correspond with the drinking water standards from the quality point of view, fact that represents a high degree of risk for the local population.

During the study we've identified as pollution sources: oil leaking in rigs and pipes area, overflows at reservoirs damaged transport pipe.

In this area there are needed the following measures to reduce pollution: damage prevention by determining the technical status of transport pipes, of equipments and machines, periodically remaking rigs and reservoirs embankments, transporting and adequate depositing of broken machines.

Also, a series of works are needed, to limit the soil pollution near oil rigs and also some depollution works with punctual execution, dependent on the manifestation way of the pollution phenomena.

When accidental pollution occurs, the following measures are imposed: limit pollutant spreading by isolating the source, mechanical recovery of the pollutant, pollutant neutralizing by direct treatment on oil pellicle by chemical neutralisation, hydrocarbons absorption on special materials, oil pellicle incinerating, oil pellicle bio-degrading with bacteria.

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