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# EARTH OIL EXTRACTION – MAJOR ENVIRONMENTAL POLLUTION SOURCE

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**Abstract**

The work presents the negative environmental impact produced by an extraction of crude oil activity. To highlight and quantify the negative effects on the environment produced from such activity, the experimental part has been focused on evidence of samples of soil, water from groundwater aquifers and surface, and the air emissions. The values of quality indicators are presented in graphs and tables, highlighting an activity with all major impact on the environment.

*Keywords:* Crude oil extraction, groundwater aquifers, emission, ecological rehabilitation, ecological reconstruction

## 1. Introduction

For several years, the present productive system and especially the oil extraction activities have an important weight in the generation of polluting products and their negative impact on the environment have been in the process of evaluation.

There is an international consensus as to the need to modify industrial processes in order to decrease the generation of toxic effluents and/or effluents of a polluting character, to increase the recycling of waste, to improve efficiency in transformation and, in all cases, to seek sustainable development for the middle and long term (Dreher et al., 1997; Gupta et al., 2004; Gavrilescu, 2006; Russel, 2006).

Also, these impose actions to respect and preserve the environment while helping to reclaim places that have already been polluted (DAS, 2005; Danielopol et al., 1997; Gavrilescu and Nicu, 2005).

The work presents all sources of pollution and quantifies their effects on the quality of the environment, generated by activities in the extraction of oil deposits – Suplacul de Barcau. Potential sources of pollution of soil, surface water and groundwater, the atmosphere were identified on the examined site, as a result of past and present activities or near it.

The results led to the establishment of measures aimed to minimize the impact of analyzed activity on the environment.

## 2. Case study – crude oil extraction area

The oil exploitations are located in a large area with low hills (up to 400 m) and in the corridor of meadow of Barcau River, which frequently leads to flooding. The relief is relatively plan, with numerous "Craters" that have accumulated rich in salt lakes. The analyzed site: *Crude oil extraction area – The group of earth oil deposits of Suplacul de Barcau* is situated in Bihor county, and covers an area of 3786 $m^2$, including a 225 extraction wells.

The oil deposits of Suplacul de Barcau are exploited through thermal processes such as underground combustion and steam injection cycle. These methods ensure that the degree of oil recovery keeping is from approx. 12% in the primary operation until approx. 50% through these processes. Along with crude oil, are bringing to the surface also significant amounts of gas fuel, with the main ingredients: dioxide and carbon monoxide.

The following types of sources of pollution in the environment results from the flow of technology for the exploitation of oil deposits:

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- permanent sources
- sources with non-permanent and local actions
- accidental sources
- sources in case of major damage due to natural causes.

From the category of permanent risk sources, they can mentioned the gas emission through eruptive craters, which leads to atmosphere pollution with combustion gases, and also to soil pollution, their aspects being of sloppy volcanoes.

Among the reasons causing these phenomena, the followings have been identified:

- technical failure by applying heat methods (corrosion of the column, destroying the ring of cement as a result of the process of cementing);
- gas flow from the oil deposit through blowholes affected by the process of combustion in the operating area;
- the formation of preferential flow paths way of both the gas injection (air) and combustion (carbon oxides and cracking compounds).

Environmental factors that affect the extraction process are: soil; water (both surface and groundwater) and air. For this reason, experimental determinations were based on sampling and analysis of actual indicators of quality of these environmental factors.

*2.1. Soil investigations*

For quantitative evaluation of soil pollution, have been executed a number of 10 drillings at various depths, up to max. 0.5 m depth, in areas adjacent to oil wells, on an area of 1000 $m^2$.

The following analytical methods were used:

- for THP (total petroleum hydrocarbons)– SR/ISO TR 11046/1997;
- pH – instrumental method;

The values of the two determined indicators from the 10 points (drillings) (mg/kg dry soil), and witness sample are found in Table 1. Reporting in this case will be made to the industrial soil.

*2.2. Underground water investigation*

To identify groundwater pollution, groundwater samples have been taken from 5 different locations (existing wells in inhabited areas in the vicinity of the site), which are monitored frequently.

The indicators of quality and methods of analysis used are:

- pH –SR ISO 10523/1997 –electrochimical method;
- Petroleum products – SR 7877-2/1995;
- Chlorides – STAS 8663/1970;
- Phosphates – SR-EN 1189/2000;
- Nitrates – SR ISO 7890-2/2000;
- Nitrites – STAS 12754/1989;
- Ammonium nitrogen– SR ISO 7150-1/2001.

The samples were taken according to standard SR EN 25667-12/2002 and SR ISO 5667-11/2000.

Preservation of evidence was made by acidification and cold storage. Results of tests for the samples from the 6 wells, compared with norms are found in Table 3.

**Table 1.** The characteristics of soil samples taken from the site

| *No.* | *Drilling* | *Depth (m)* | *pH* | *Extractives substances in petroleum ether [ mg/kg dry soil]* |
|---|---|---|---|---|
| 1. | F1 | 0.2 | 7.75 | 20884.30 |
| 2. | | 0.5 | 7.70 | 4362.10 |
| 3. | F2 | 0.2 | 8.15 | 3129.85 |
| 4. | | 0.5 | 7.95 | 112154.90 |
| 5. | F3 | 0.2 | 7.45 | 3054.35 |
| 6. | | 0.5 | 7.60 | 3400.60 |
| 7. | F4 | 0.2 | 6.45 | 24327.50 |
| 8. | | 0.5 | 6.55 | 28087.90 |
| 9. | F5 | 0.2 | 7.5 | 22706.0 |
| 10. | | 0.5 | 7.4 | 21279.6 |
| 11. | F6 | 0.2 | 8.0 | 5039.45 |
| 12. | | 0.5 | 8.05 | 3400.00 |
| 13. | F7 | 0.2 | 5.9 | 3045.70 |
| 14. | | 0.5 | 5.95 | 2215.50 |
| 15. | F8 | 0.2 | 2.88 | 4113.50 |
| 16. | | 0.5 | 2.52 | 5927.10 |
| 17. | F9 | 0.2 | 6.3 | 2965.85 |
| 18. | | 0.5 | 6.4 | 28198.20 |
| 19. | F10 | 0.2 | 7.85 | 2074.10 |
| 20. | | 0.5 | 7.75 | 3199.00 |
| 21. | Witness sample | 0.3 | 6.0 | 185.00 |
| 22. | | 0.5 | 6.05 | 140.00 |

**Table 2**. The reference values according MAPPM Order no. 756/1997

| *Element* | *Normal concentration* | *Alert concentration [mg/kg dry soil]* | | *Intervention concentration [mg/kg dry soil]* | |
|---|---|---|---|---|---|
| | | *Soil for sensitive use* | *Soil for less sensitive use (industrial)* | *Soil for sensitive use* | *Soil for less sensitive use (industrial)* |
| THP | <100 | 200 | 1000 | 500 | 2000 |

Due to the lack of regulations on the quality of groundwater, the results of the analysis were compared with values of the maximum allowable in accordance with:

- Law no. 458/2002 on the quality of drinking water, amended by Law no. 311/2004;
- STAS 1342/1998 - drinking water;
- Dutch List

*2.3. Surface water investigations*

To identify the pollution of surface water on site, samples have been taken from the exhausting water channel after the cleaning station, and before discharging in Barcău River.

The methods of analysis are those specified for groundwater. Results are presented and compared with HGR no. 352/2005 (NTPA 001) and presented in the Tabel 4.

The samples were taken according to standard SR EN 25667-1, 2/2002 and SR ISO 5667-11/2000. On the analyzed site, a number of 3 baskets of harmful exhaust gas (of combustion) and a battery of boilers for steam are running.

The emission indicators of air quality were determined with an automatic analyzer. They are: dust and combustion gases: CO, $SO_2$, NO, $NO_2$.

The used methods are:

- For dust – SR ISO 9096/2005 –gravimetric method;
- For CO, $SO_x$ expressed as $SO_2$, $NO_x$ expressed as $NO_2$ – automatic instrumental method – SR ISO 10396/2001.

**Table 3.** Characteristics of water from groundwater aquifer, taken from the established samples, compared to in force norms

| *No.* | *Analyzed Parameter* | *Sample symbol / Internal code / Registered value / CMA* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *F1* | *F2* | *F3* | *F4* | *F5* | *F6* | *Permissible limits STAS 1342/91* | *Law no. 458/2002 and 311/2004* | *Dutch list* |
| 1. | pH | 7.53 | 7.77 | 7.59 | 7.54 | 7.40 | 7.19 | 6.5-7.4; max. 8.5 | 6.5-9.5 | - |
| 2. | Petroleum products [mg/L] | 0.2 | 0.5 | 0.45 | 0.6 | 0.35 | 0.70 | - | - | 0.42 |
| 3. | Chlorides [mg/L] | 151 | 83 | 32 | 87 | 94 | 230 | 250 max. 400 | - | - |
| 4. | Phosphates [mg/L] | 0.30 | 3.90 | 0.70 | 1.10 | 1.00 | 0.79 | 0.1 max. 0.5 | - | - |
| 5. | Nitrates [mg/L] | 128.8 | 116.1 | 101.8 | 105.0 | 62.10 | 204 | 45 | - | - |
| 6. | Nitrites [mg/L] | 0.03 | 0.03 | 0.17 | 0.04 | 0.04 | 0.25 | 0 - max. 0.3 | - | - |
| 7. | Ammoniacal nitrogen [mg/L] | 2.28 | 2.55 | 3.09 | 2.74 | 2.93 | 1.65 | 0 - max. 0.5 | 0.35 | - |

**Table 4.** Characteristics of surface water samples, compared with the in force norms

| *Nr. crt.* | *Analyzed Parameter* | *Sample symbol / Internal code / Registered value / CMA* | | |
|---|---|---|---|---|
| | | *Channel P1-P5* | *Testing method* | *Permissible limits HGR 352/2005* |
| 1. | pH | 7.30 | SR ISO 10523/1997 | 6,5-8,5 |
| 2. | Petroleum products [mg/L] | 1.00 | SR 7877-2/1995 | 5,00 |
| 3. | Chlorides [mg/L] | 67.00 | STAS 8663/1970 | 500 |
| 4. | Phosphates [mg/L] | 5.4 (din care fosfor = 1.76) | SR-EN 1189/2000 | Fosfor = 1,00 |
| 5. | Nitrates [mg/L] | 27.30 | SR ISO 7890-2/2000 | 25 |
| 6. | Nitrites [mg/L] | 0.05 | STAS 12754/1989 | 1,00 |
| 7. | Ammoniacal nitrogen [mg/L] | 2.15 | SR ISO 7150-1/2001 | 2,00 |

*2.4. Air – emission investigations*

Samples were taken for dust, on the filter with constant mass. Equipment used were taken portable gas and dust, analytical balance, Testo 350XL analyzer, analyzer automatically Sick-MAIHAK model 3006, UV-VIS Spectrophotometer.

The values of the indicators measured in the emissions from 4 fixed emission sources, are found in Table 5.

## 3. Results and Discussion

*3.1. Soil pollution*

Comparing the values of analyzed indicators with the reference values according MAPPM Order no 756/1997, we can conclude the following: pollution is reported with HTP soil, being located in the area of shallow soil, up to 0.5 meters deep. All the samples analyzed exceeded the admissible concentration both the alert and intervention concentration, for the soil with industrial use (Fig. 1). Massive pollution of the soil with petroleum products in the area of crude oil extraction highlights a long-term pollution (past and present activities).

It requires as remedial measures, the ecological rehabilitation of the fields, and decontamination of contaminated soil and ecological reconstruction of affected areas.

3.2. *Underground water quality indicators*

Analyzing the data in Table 3, it is found that exceeded the CMA values was registered for the following indicators:

- Phosphates – CMA exceeded 7 times up to 39 times;
- Nitrates - CMA exceeded by 1.38 times to 2.86 times;
- Ammoniacal nitrogen –CMA exceeded by 3.38 times to 6.18 times.

**Table 5.** Concentrations of quality indicators determined in the fixed sources of emissions, compared to in force norms

| *Section / process* | *Source* | *Pollutant / measure unit* | *Registered value [mg/m$^3$]* | *CMA according to MAPPM Order no. 462/1993* |
|---|---|---|---|---|
| Park no. | Dispersion | Dust | 36.70 | 50 |
| | | CO | 25000 | - |
| | | $NO_x$ ($NO_2$) | 2814 | 500 |
| | | $SO_x$ ($SO_2$) | 394 | 500 |
| Park no. | Dispersion | Dust | 26.70 | 50 |
| | | CO | 4671.5 | - |
| | | $NO_x$ ($NO_2$) | 11.33 | 500 |
| | | $SO_x$ ($SO_2$) | 55.17 | 500 |
| Park no. | Dispersion | Dust | 17.30 | 50 |
| | | CO | 10298.06 | - |
| | | $NO_x$ ($NO_2$) | 35.49 | 500 |
| | | $SO_x$ ($SO_2$) | 717.81 | 500 |
| Battery | Dispersion | Dust | 15.9 | 5* |
| | | CO | 5.20 | 100* |
| | | $NO_x$ ($NO_2$) | 119.6 | 350* |
| | | $SO_x$ ($SO_2$) | 12.2 | 35* |

* - values according to MAPPM Order nr. 756/1997

The "petroleum products" is not limited in the Romanian norms, but his values are very high. In Fig. 2 the concentrations of the indicator "petroleum products" are provided, comparative to the limits allowed by the Dutch list, the only regulation that can be taken into account.

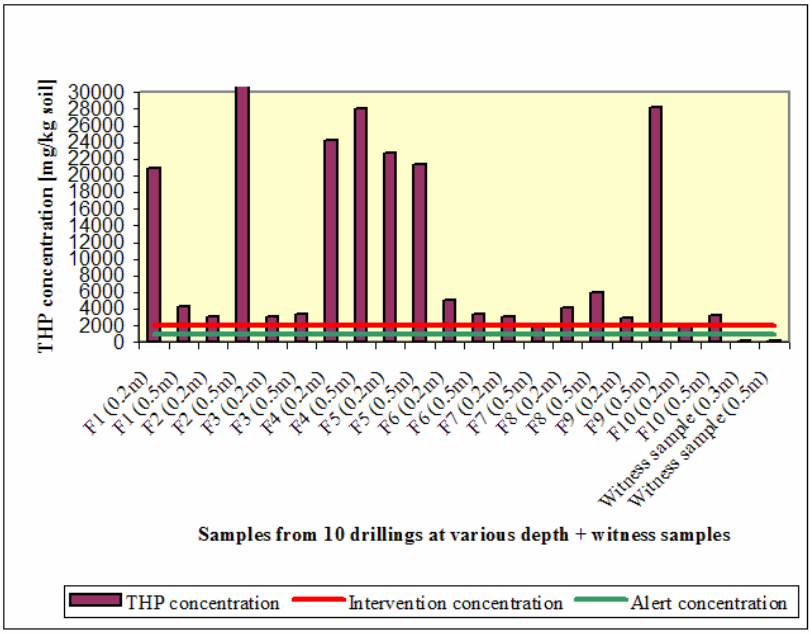


**Fig. 3.1.** THP concentration level in soil compared with the in force norms

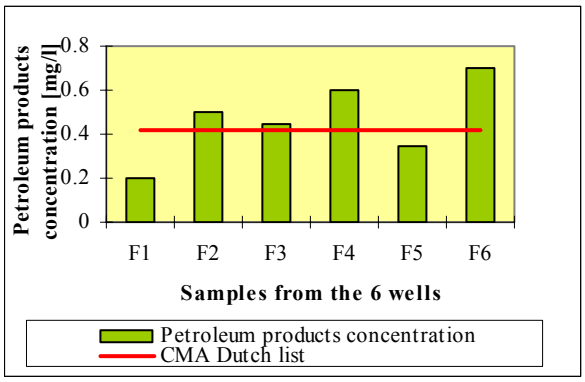


**Fig. 2.** Petroleum products concentration for the 6 monitored drillings

Therefore, water from groundwater aquifers in the vicinity of the site is the not recommended for drinking purposes.

High concentrations of indicators: phosphate, nitrogen and ammoniacal nitrogen are not cause by the oil extraction activities; they can be imported to other sources of pollution in the area (eg. the use of chemical fertilizers in agriculture).

The "petroleum products" present levels of impermissible levels of concentration in the aquifer layer.

### *3.3. Surface water quality indicators*

Fig. 3 shows that the following indicators overshoot the maximum allowed concentration:

- Phosphates – CMA exceeded with 76%;
- Ammoniacal nitrogen – CMA exceeded with 7.5%.

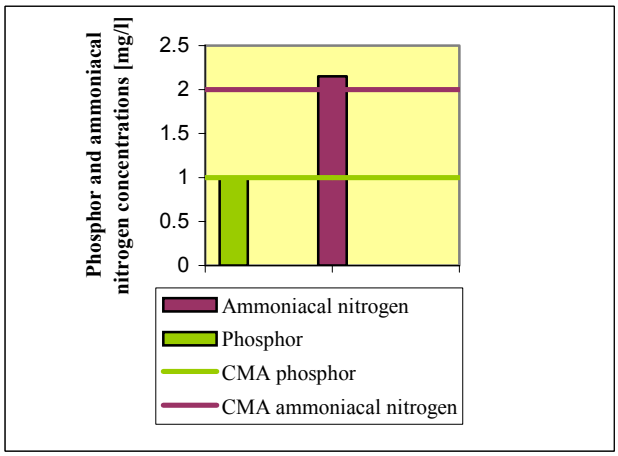


**Fig. 3.** Phosphorous and ammoniacal nitrogen concentrations of in surface water

Therefore, technological waste waters are properly treated, the identified type of contamination being unspecified for oil extraction activity.

### *3.4. Emissions*

MAPPM Order no. 462/1993 establishes the limits for the emission directed in the atmosphere, emissions resulted from the technological process and combustion plants. The graphical representation of indicators that exceed the CMA, in Fig. 4 evidences the following:

- The average concentration of $NO_x$ is 2814 mg/m$^3$ exceeds 5.6 times the norm under the CMA;
- The average concentration of 717.81 mg/m$^3$ $SO_x$ exceeds 1.4 times the CMA under the same regulation.

Emissions of CO are not limited, and the concentrations recorded shows higher values. Also, dust discharged from the battery of boilers exceed the CMA under Order MAPPM No. 756/1997.

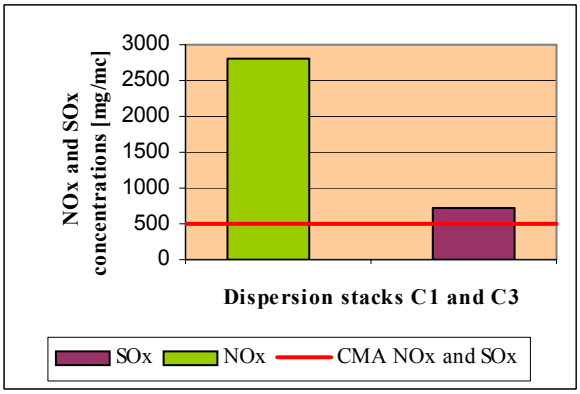


**Fig. 4**. $NO_x$ and $SO_x$ concentrations in emissions from fixed sources

## 4. Conclusions

Experimental researches and determination made on the crude oil extraction site – Suplacul de Barcau, show a significant environmental impact exerted by this activity.

Negative effect is exercised on all environmental factors (water, soil, and air), but the most affected are the soil and groundwater aquifers, which leads to impossibility to use this water as potable water.

Measures to be taken for removing these effects are:

- Ecological rehabilitation of the oil extraction area;
- Decontamination of polluted soil;
- Ecological Reconstruction of the affected land;
- Permanent monitoring of groundwater aquifers and stopping the phenomenon of pollution it.

From research made on site, in the area of the modern well, ecological rehabilitated, it is found that the phenomenon of soil pollution can be controlled and reduced

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