ANNALS OF THE UNIVERSITY OF CRAIOVA – SERIES GEOGRAPHY
Vol. 11/2008, pag. 5-18

MAN INDUCED IMPACT ON THE ENVIRONMENT AS A RESULT OF HYDROCARBONS' EXPLOITATIONS WITHIN THE AMARADIA HILLS

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Abstract: The contents of the present research comprises the case studies of two areas, which are referential for the exploitation of hydrocarbons in the Amaradia Hills, with major impact on the environment: Brădeşti area, in the south-west of the region and Vârteju area, situated norther, on the Plosca brook valley, a tributary of the Amaradia river.
The paper aims at evaluating the pollution degree which affects the components of the environment, within the extraction areas of hydrocarbons, in order to point out the necessity of the precautionary measures to reduce the negative impact on the environment, all this with a view to applying the principles of sustainable development of the region.

Key words: pollution sources, pollution types, environment components, the Amaradia Hills

GEOGRAPHICAL POSITION

The Amaradia Hills, the hydrocarbon deposits are placed in, represent a subdivision of the Olteţ Piedmont, which is the largest subunit of the Getic Piedmont. It is placed in the south of Romania, between the Carpathian Mountains and the Romanian Plain (Fig.1: The geographical position and main subdivisions of the Getic Piedmont).

NATURAL BACKGROUND WITHIN THE AMARADIA HILLS

• *The relief*

The Amaradia Hills are limited by the Gilort valley in the west, the Olteţ valley in the east and the Jiu valley in the south-west; in the central part, the region is crossed by the hydrolographical axis of the Amaradia, wherefrom the name of the unit. In the northern part, piedmont hills stand out (400-500 m), highly

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fragmented, which develop northwards to southwards, as prolong peaks (Muierii Hill), with 5-7 ° to 7-9º inclination of the slopes.

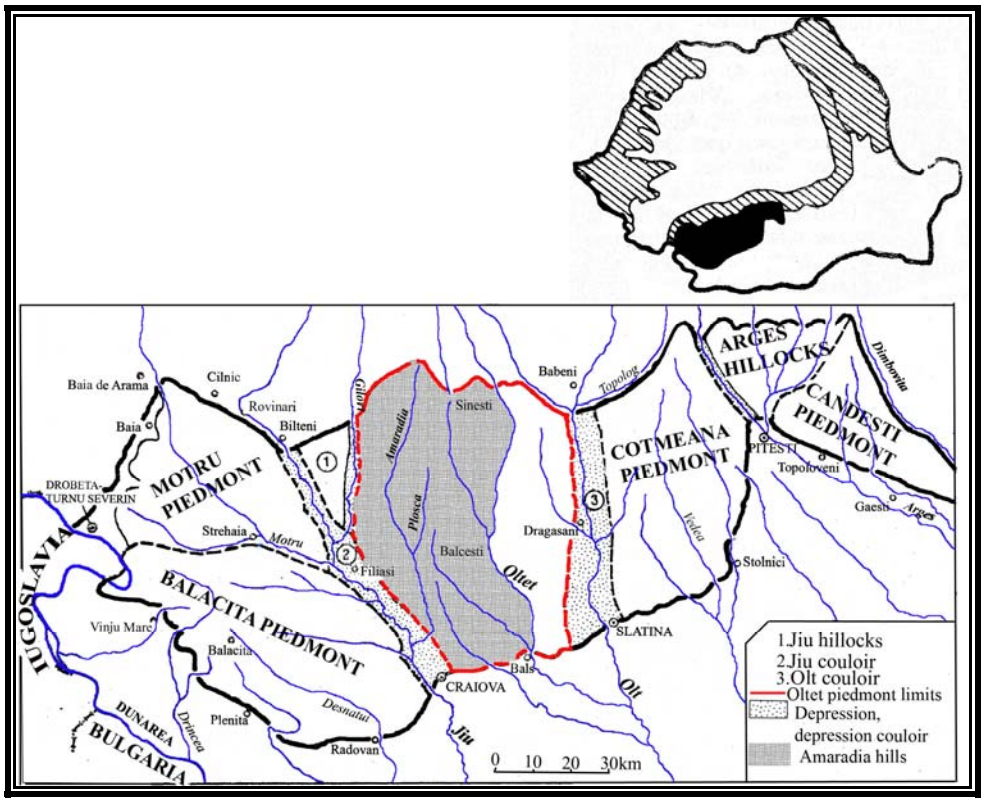


Fig. 1 – The geographical position and main subdivisions of the Getic Piedmont (processed apud „Geografia României" vol IV,1992)

In the south, the altitude drops to 250 m and the relief resembles hilly plateaus, with smooth hill top aspect, such as Brădeşti-Melineşti hills, situated between the Jiu valley in the west and the lower course of the Amaradia river in the east. Southwards, they join together with the high medium terraces level of Jiu river, well developed oh the left part of the valley, with a large bridge (3-4 km breadth) and an extended river meadow (5-6 km breadth).Taking into account the overall aspect and the economic land use, this unit stands out as a high piedmont plain. (Fig. 2: The map of the morfological units within the Amaradia Hills).

• *The hydrographical network* is represented by Amaradia river, which completely materializes its hydrographical basin within the piedmont, having as tributaries a series of brooks, Plosca being the most important of these, most of them having a torrential regimen. In the south-western part, the Jiu valley stands out with its tributary, Almăjel and the lower reach of Amaradia river, that flows into the Jiu north-westwards from Craiova municipality.

The phreatic lies 15 m deep in the piedmont and slopes' area, up to 6-11m deep in the glacises' and fans' area in the meadow and up to 3-4 m deep in the meadow itself.

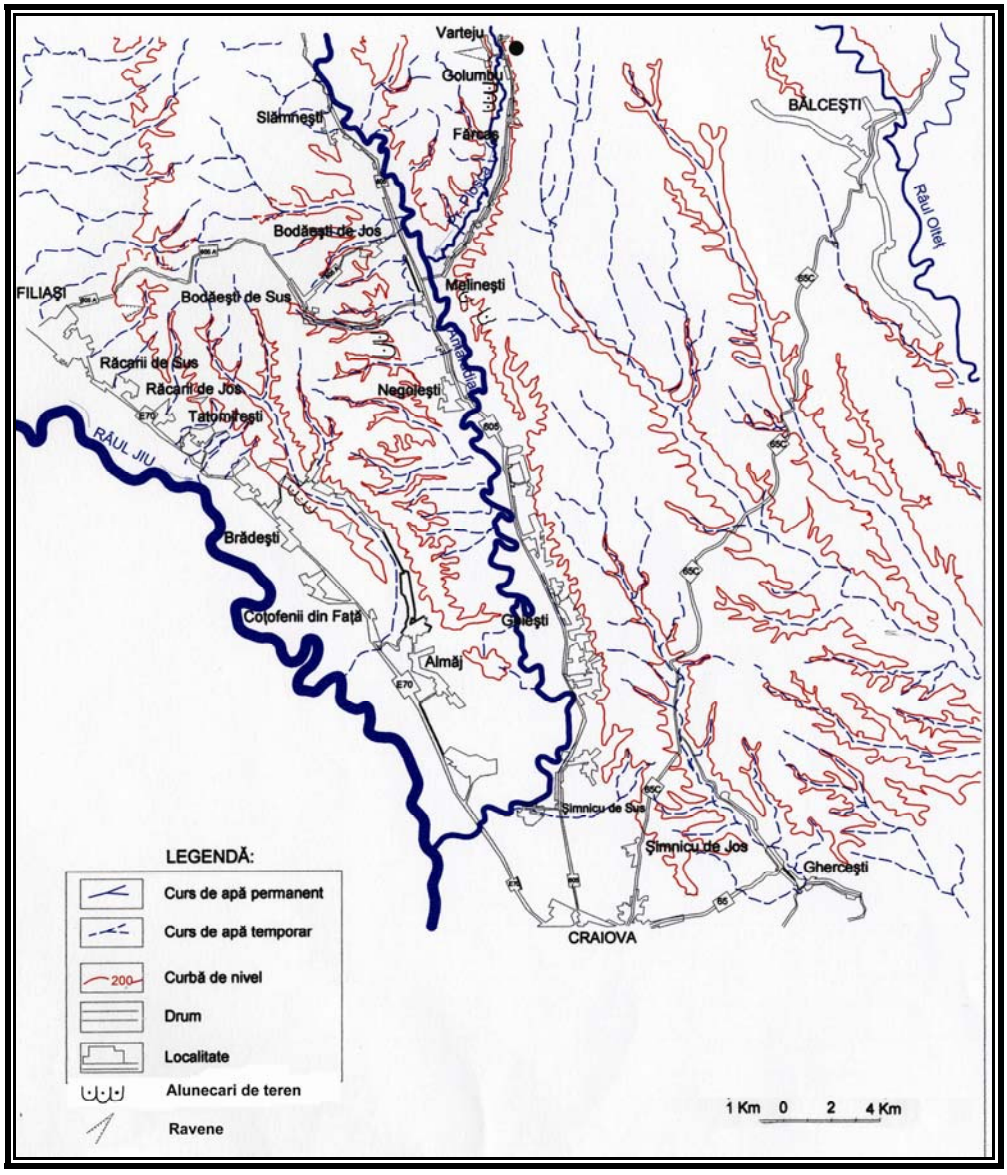


Fig. 2 The map of the morfological units within the Amaradia Hills

• *The vegetation* corresponds to the deciduous trees layer on the plateaus and versants, with thermophilous species of Turkey oak (*Quercus cerris*), Hungarian

oak (*Quercus frainetto*), evergreen oak (*Quercus petraea*) and other arborescent species.

The shrub layer comprises species of hedgethorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), cornel tree (*Cornus mas*), bloody twing (*Cornus sanguinea*), elder tree (*Sambucus nigra*), blackberry bush (*Rubus idaeus*) etc. The undergrowth layer develops according both to the intensity of the light which reaches the forest pit, but also to the thermal and soil conditions.

The natural grasslands are represented by grass associations, differentiating with respect to the local relief conditions, the degree of wetness or the flood regimen.

The azonal vegetation shows up along the humid valleys, made up of osier willows (*Salix fragilis*), asp tree (*Populus tremula*), black alder (*Alnus glutinosa*), frock and meadows.

• *The climate* is continental temperate, characteristic for low hills, with an yearly average temperature of 10 degrees Celsius and the average rainfall of about 550 mm/ year. The eastwardly and westwardly winds are dominant.

• *The soils*

In the northern part of the piedmont hills, there are the following specific soils: brown-luvical soils on the plateaus, vertisoils on narrow plateaus with slightly inclined surfaces, regosoils on steep slopes and alluvial soils within riverbeds. The colluvial soils develop near the secondary valleys, on the glacis units and the debris, debris fans.

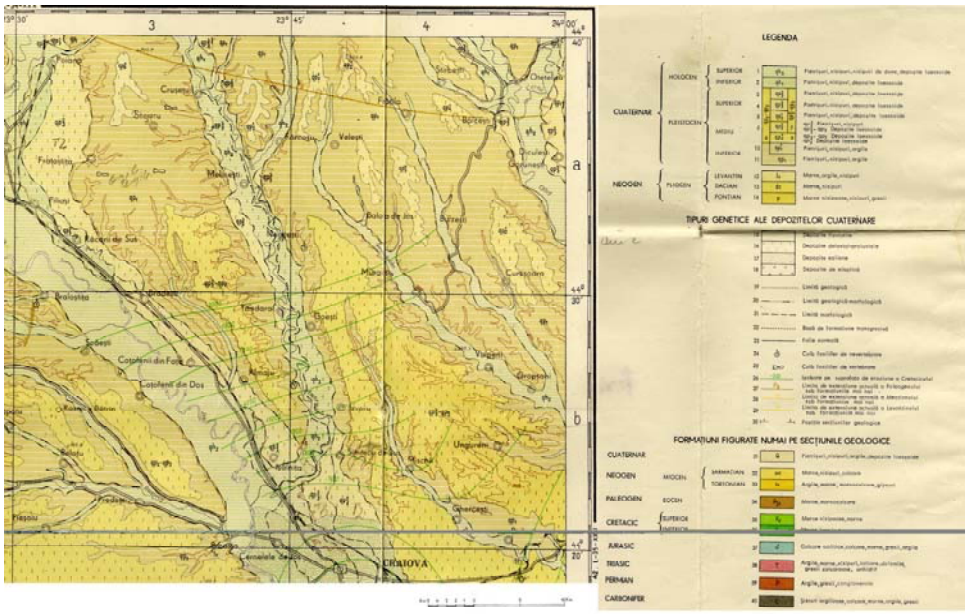
The brown argiliferous-illuvial soils, the brown-reddish soils, the levigated chernozems and the alluvial soils appear in the southern part of the hilly plateaus.

GEOLOGY OF THE AMARADIA HILLS

From the genesis point of view, but also the structural one, the Getic Piedmont (all its units included) belongs to the Getic Depression, in which the sedimentation process began from Triasic (Senonian) and continued untill Cuaternary. The piedmont rocks accumulations have been stored on the crystalline fundament of the Moesic Platform, also known as The Valachian Platform, which inclines from the south to the north and plunges under the Getic Depression deposits (the Carpathian Avanfose), that used to make up the largest marginal unit between the Carpathians and the Balcans. The sedimentation process was interrupted by the tectonic movements, whose impact has also influenced the platform area, in the Getic Basin, but also the sedimentation conditions (including deep marine conditions, coarse, overlapping, lagoon, low depth lake or swamp conditions). This fact is certified by the existence of mineral deposits that formed in these conditions.

In the sedimentation process, four cycles have been identified which belong to Paleozoic, Mezozoic and Neozoic.

The oil and gas accumulation, which were connected to Wallachian foundation structures, have been outlined and exploited especially onto the southern part of the Olteţ Piedmont (Vârteju, Melineşti, Negoieşti, Brădeşti, Şimnic, Ghercești). The hydrocarbons have been outlined in the geological strata of Triasic, Jurasick, Sarmatian and Meotian. The drillings in this area outlined several formation types from Triasic (siliceous, ferruginous and argillaceous sandstones etc.); Jurasic (yellowish-grey sandstones, loamy clays etc.); Badenian (conglomerates, arenaceous limestones, quartzites etc.), Sarmatian (marly facies); Meotianul (sand banks, marly formation), which are doubled by the cuaternary deposits of sands, scuds, pluvial and aeolian build-ups) (Fig. 3. The geological map of the Amaradia Hills).



(Fig. 3. The geological map of the Amaradia Hills).

THE EVOLUTION OF HYDROCARBONS EXPLOATATIONS, THEIR PRIMARY PROCESSING AND THE TECHNOLOGICAL PROCESS. POLLUTING SOURCES

The exploitation of the oil and gas deposits from the Amaradia Hills region began almost four decades ago, respectively in the 1970's in Brădeşti area and three decades ago, in 1979, in Vârteju area. All this time, the exploitation have spread on more areas, as it follows: in Brădeşti area, the exploitation is placed on the south-western side of the hills, at the contact with the upper terrace (and on its bridge) of the Jiu river (Almăj, Coţofenii din Faţă, Tatomireşti, Răcari), then north-eastwards, on the Amaradia valley (Negoieşti, Melineşti, Bodăieşti, Slămneşti) and on the Plosca brook valley) at Fărcaş, Golumbu, Vârteju). In the southern part of Muierii Hill there are the areas of Şimnic and Gherceşti.

The technical installation that ensures the technological process of obtaining hydrocarbons, through a series of operations and processes are by and large made of the following major components: the extraction wells, the pipes that ensure the trasportation of the fluids (oil, gas, formation water), separators platforms, where the oil, gas and formation water are separated. Actually, it is not this technological process, developed within an enclosed system, that is in itself polluting, but, moreover, the local damages generating formation water, oil leaking that leads to disseminated soil pollution in the oil exploitation pipe fields (Photo 1).

Accidental polluting sources are unfortunately found on each and every segment of the technological process.

Photo 1. Well - Park 1 Brădeşti

• At pumper wells there appear accidental pollution phenomena because of the damages of the surface or underground equipment, which requires repeated

interventions; there are also other different technological operations outside the well square.

• The transportation pipes make up a complex network in the extraction field of hydrocarbons, having the following functions: oil and formation water pipes, gas pipes, mixer conduits, water input lines. They may constitute accidental polluting sources for surface waters and soils, especially when there may appear a series of cracks and breaches caused by: their interior or exterior corrosion, hidden cracks of the tubular material, the crossing of problematic areas: waters, main roads, railways, localities, as it is shown in the adjoining images. (Photo 2, 3, 4)

These phenomena require the surveillance personnel's permanent monitoring of pipes functioning, an immediate, efficient intervention being compulsory.

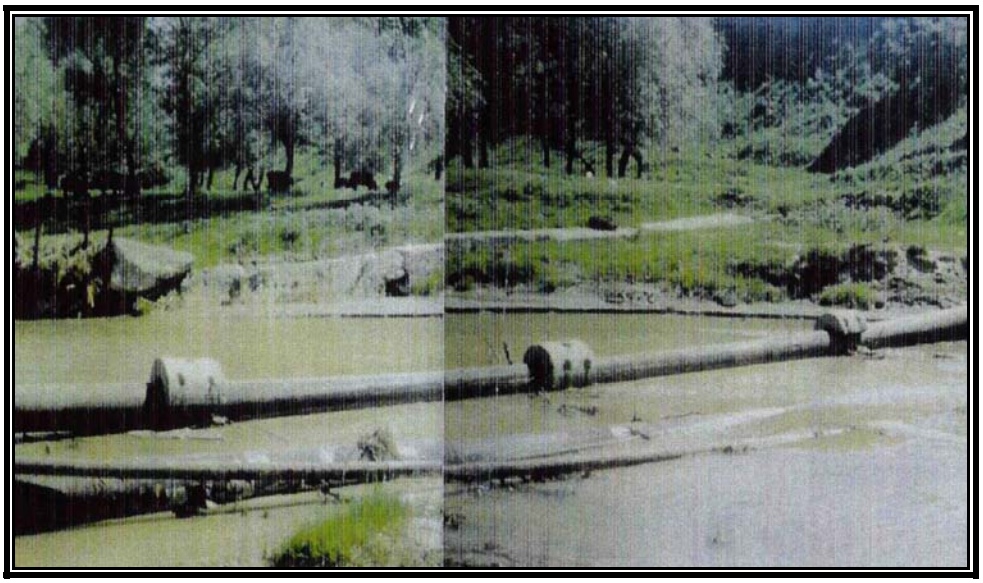


Photo 2. Formation water collecting pipe, that goes over the Amaradia river

• The separator platforms are important technological installations, placed in a progressive line between the production wells and the oil deposit, which are equipped for the separation of the extraction fluids.

The accidental pollution in this area is represented by oil and salty**,** residual water leakings, which can be disseminated both on the soil and in the water table, through infiltration.

Still, the major ecological disasters have been caused by the explosion of drilling wells that immediately caught fire and collapsed because of the gas pressure in the deposit. It is the case of Brădeşti well, which exploded in 1986, giving birth to a crater, 15 m deep and 100 m in diameter, in which there have been accumulations of oil, formation water leakings, mud drilling and precipitation water. Another example is represented by the explosion of Vârteju drilling well in 1984, which also collapsed, forming another crater, subsequently filled with salty

formation water, petroleum residues. This covered 100 hectares that have been drawn out of the agricultural circuit (Photo 5 a, b).

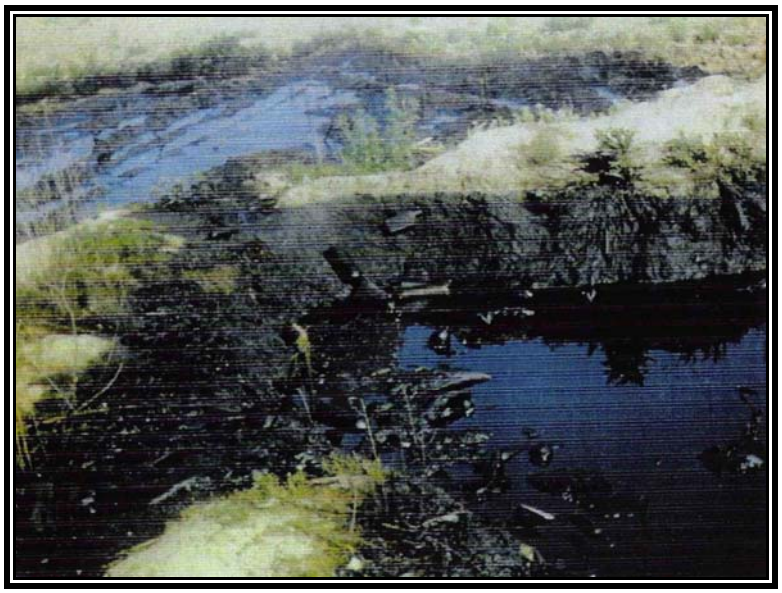


Photo 3. Oil leakings caused by the breakage of an oil collecting pipe (Brădeşti)

Photo 4

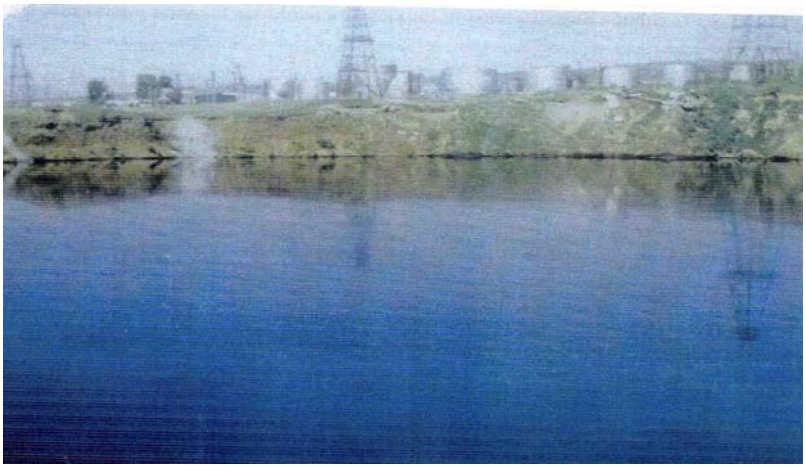


Photo 5 a

Photo 5 b

Photo 5 a, b: The lakes formed in the craters of eruption at Bradeşti well (a) and Vârteju (b)

The neighbouring surfaces have also been damaged by the dissemination of the liquid overflow, which generated negative transformations in the geochimical natural status of the soil, on which vegetation never grew again forming the so-called „desert islands" or „industrial deserts". Because of the salts accumulation and the friable geologic structures, the torrential erosion appeared on the lacked of vegetation slopes, deep ravines and landslides formed (Photo 6).

Photo 6: Degraded landscape on the eastern slope of Golumbu Hill (salt crust and deep ravines)

IMPACT OF OIL AND GAS EXTRACTION ACTIVITIES ON THE ENVIRONMENT COMPONENTS

• *The alteration of soil properties*

The soil represents the environmental component that endures the most powerful agression because of the hydrocarbons extraction, resulting the specific pollutants: not only the formation water dominated by sodium chloride and sulphates, but also the petroleum residues.

The analysis of several soil samples taken from different representative areas and 20-40 cm depth indicated a chloridic soil salinization, according to the ratio between the chloride (Cl^-) and natrium (Na^-) ions, which are predominant compared to the inferior proportion of the sulphates ions (SO_4^{-2}).

The soil samples, also called control samples, have been collected on the route of the collectors from the visibly affected areas by the leakings of formation water. The sample was collected from an area cultivated with wheat, at a distance of 50 metres from the polluted area. The analysis of the samples has been made with the help of the specialists in the Regional Office of Pedological and Agrochemical Studies; the indicators taken into consideration were the ones whose values had been influenced by pollution with formation water and petroleum products, as pollutants specific to hydrocarbons exploitation, respectively petroleum products and the ions proceeding from the formation water.

In order to establish the salinization degree, the values of the chloride and changeable sodium concentration have been comparatively analyzed, but also the total salts content. The value of chloride concentration in the main control sample is 23 mg/kg for the 20-40 cm depth level and the control samples have a much

higher chloride concentration, over 27 times, for the same level. The salinization sample is established having in view the percentage between the Cl^- and the SO_4^{-2} content in miliequivalents (me) as it follows: chloruric salinization ≥1,1 and sulphatic salinization $Cl^-/ SO_4^{-2} \leq 1,0$.

In order to establish the salinity degree of the sample it has been outlined the following scale used for the salinity specific to the middle texture of the soil (Table 1).

Table 1

The scale used to measure salinity		
THE APPRECIATION OF SALINITY INTENSITY TAKING INTO ACCOUNT THE SALT CONTENTS		
Chloruric	Sulphatic	Salinity
Limits of total salt contents (mg/100g soil)		
<100	<150	Not salinized
101-250	151-350	Insufficiently salinized
251-600	351-900	Moderately salinized
601-1000	901-1500	Highly salinized
>1001	>1501	Very intensely salinized

The same significant differences are registered between the main sample and the control sample when talking about the total salt contents (Table 2).

This analysis demonstrates that the soils in the areas affected by water pollution are highly salinized because of natrium chloride salts concentrations and that sulphatic salinity is beyond the alert (admissible) limit.

The petroleum residues pollution exceeds the intervention limit in some areas where the oil pipes, the oil decantation deposits are damaged. A mixed pollution has been frequently recorded, especially with salty formation water and petroleum residues.

Table 2

The main sample	Cl^-	SO_4^{-2}	Cl^-/ SO_4^{-2}	Salinization Type	The total containing in salts	Intensity of salinization
	me/100g				mg/100g	
49	38,10	0,0	>1,1	Cloruric	2440,2	V. intense
50	22,70	0,0	>1,1	Cloruric	1466,9	V. intense
51	34,00	0,05	680	Cloruric	2106,0	V. intense
52	17,60	0,08	220	Cloruric	1074,9	V. intense
53	57,50	0,10	575	Cloruric	3515,1	V. intense
54	106,0	0,10	1060	Cloruric	6420,1	V. intense
55	78,20	0,05	1564	Cloruric	4732,4	V. intense
56	23,70	0,10	237	Cloruric	1458,5	V. intense
57	141,8	0,70	202,5	Cloruric	8511,7	V. intense
58	86,10	0,40	215,0	Cloruric	5229,0	V. intense
61	145,2	0,45	322,6	Cloruric	8773,1	V. intense
62	66,70	0,15	444,0	Cloruric	4067,0	V. intense
59	0,55	0,0	>1	Cloruric	62,2	Not salinized
60	0,65	0,0	>1	Cloruric	66,3	Not salinized

• *The effects over phreatic waters and surface waters*

The infiltration of salts-filled formation water damages the quality of the phreatic waters, the main source for the supply of the population. The water samples taken from various settlements (Brădeşti, Coţofenii din Faţă, Vârteju, Almăj) show dangerous overtaking of maximum admissible concentrations, especially at chlorides and phenols.

Both in Brădeşti and Vârteju areas, the quality of phreatic waters has been damaged, especially because of the explosion and collapse of the wells, affecting the drinking water supplying the fountains in the neighbourhood.

Also, the industrial waters coming from the industrial platforms Brădeşti and Vârteju are not safe to be evacuated in the emissaries, because they overtake the maximum concentration allowed for petroleum residues, chlorides and phenols. This aspect has been pointed out following the lab analyses.

• *The transformations over the relief*

The two artificial craters, formed after the eruption and collapse of the two wells at Brădeşti and Vârteju, in which salty, residual and meteoric waters have installed, forming genuine lakes that have lasted for more than 3 decades.

The frequent appearance of gravitational processes of versants crumbling in the neighbourhood of the Vârteju lake, with a lower base level, but also landslides as permanent risk fenomena, doubled by the friable lithological deposits: sands, clays, gravels, lack of vegetation.

The increase of the slopes' degradation process, which are covered by salts crusts and lack vegetation, on which torrents, deep ravines, landslides develop, forming the so-called „bad lands", as it is illustrated on the eastern versants of Golumbu Hill at Vârteju (Photo 7).

Photo 7: The eastern slope of Golumbu Hill, covered by salt crusts and deeply ravined (at Vârteju)

• *Impact on the settlements*

Within oil exploitation areas, the settlements have been damaged because of the distortion of environment conditions in which they have developed: first of all, through phreatic water quality depreciation, supplying the natives' fountains in Brădeşti, Vârteju, Coţofenii din Faţă etc; secondly, the accumulating salt crusts damaged soil quality, generating bad lands, the typical case being at Vârteju, where people have abandoned their settlements and useless lands.

In conclusion, the pollutants that affect the environmental components of the analysed areas – Brădeşti and Vârteju – are represented by: the acid solutions from the formation water, the oil residues, the well cuttings or the bore mud detritus.

The ground surface spread or the infiltration of these pollutants in this area, may become permanent polluting source if the breakdown-generating problems are not controlled in due time.

MEASURES TO PREVENT ACCIDENTS WITH ENVIRONMENTAL EFFECTS

The hydrocarbons exploitations impose a series of technical installations, part of a complex technological process, in which there appear damages, malfunctions and accidental pollutions with severe environmental implications.

First of all, technical measures are highly necessary, which specialists in the domain know very well, but they have to be rigorously put into practice:

- the projection of all categories of pipes, taking into consideration all factors that cause damages (cracks, breaches);
- recapture and elimination of the pollutant products on the field;
- the responsible, immediate and efficient intervention of the surveillance staff, the professionalism of specialized teams that must remedy the damages;
- applying measures to recreate a natural fertility status of the soil;
- planting trees that are specific to the region;
- The monitoring of environment factors in order to maintain the functional equilibrium, but in accordance with human activities of valorizing the natural resources, thus contributing to the sustainable development of Amaradia Hills region.

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*** Date oferite de Agenţia Regională de Mediu Oltenia.