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PRACTICAL ASPECTS OF HYDROGEOLOGICAL INVESTIGATIONS AND ASSESSMENT OF THE ENVIRONMENTAL COMPONENTS POLLUTION IN URBAN AREAS. CASE STUDY

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Abstract. In the frame of the legislative regulations in Romania, the geological environment is defined as all geological structures from the top (topographical surface) up to the deep soil layers, the groundwater and the geological formations. It is considered that in overall geological structures from the topographic surface to a depth at which the human activities are presence or to the depth at which they significantly influence and directly the human development, this is the field of the environmental geology. This paper presents applied aspects regarding assessment methods of the geological environment, respectively hydrogeological investigations in a case study. Conducting *in situ* and laboratory investigations allowed the assessment of the state of pollution of the polluted land remaining after a fuel storage objectives were removed by demolition (underground tanks, pipelines, pumps and fuel distribution ramp). The main conclusions drawn from the investigations carried out lies in the identification of the significant pollution of soil and groundwater, with localisation in the area of the fuel tanks. By modelling the processes of the migration of the pollutants in the vadose zone was identified a ongoing process affecting strong the first aquifer and exists the probabilities as the second aquifer developed in sandy formations ('Mostistea' sands) to be affected by the pollution by oil products. Recommendations necessary for intervention in the shortest time, for restoration of the polluted area were made.

Keywords: vadose zone, pollution, aquifer, hydrogeology.

AIMS AND BACKGROUND

The purpose of this study is identification and assessment of the pollution (soil and underground water) by applying hydrogeological methods combined with geochemical investigations and finally the necessary recommendations were made for the restoration of environmental components affected[1].

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About 80% of the world populations live in the big cities and towns and one in 6 Europeans live in metropolis of more than 1 million residents[2]. The pressure on natural environment witch exists around large cities is under-lined in numerous studies regarding metropolisation[3–5].

Industrial activities carried out in urban areas introduce new pressures on already stressed environment components by development of the urban infrastructure[6]. Closure of many economic activities or industrial objectives requires quality assessment of the environmental factors required for evidence of pollution remaining after removing potential sources of pollution.

The study area is located in Bucharest inside a company specialised in construction of equipments of galvanised metal. This company had a fuel deposit consists of six fuel oil tanks with a capacity of 31.5 t each. Fuel tanks were buried in a concrete construction equipped with waterproofing isolation, to protect infiltration into the soil in the case of breakdown.

The tanks were protected against corrosion by painting the outside and were provided with manholes. Fuel distribution was achieved by means of 2 pumps in concrete cast, situated in an area located 120 m east of the storage area. The tanks have been removed and holes resulting from extraction of tanks were filled with soil provide from inside the company. To build a new infrastructure, the pollution assessment of soil and the groundwater was required in areas where they circulated petroleum products.

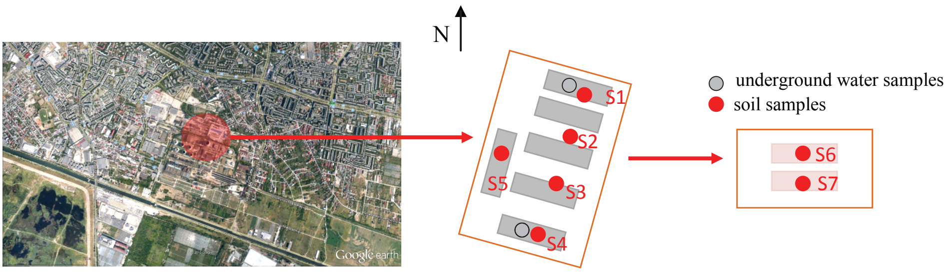
Hydrogeological investigation relied to knowledge, methods and methodologies recognised at nationally and international levels[7–12].

EXPERIMENTAL

Study area is shown in Fig. 1.

The experimental part was conducted in 2 directions:

● Investigations on the quality of soil in areas designated and considered potentially contaminated with petroleum products, the effect induced by fuel storage and delivery activities by collecting and characterising a total of 17 samples of soil from the 7 pits: in the ‘A’ location of fuel tanks and in the ‘B’ where there were located fuel distribution pumps. Investigations on groundwater quality by intercepting saturated zone and sampling of 2 samples of groundwater in the ‘A’ zone. The soil samples collected were analysed in the laboratory to determine quality indicators by applying standard methods of testing: moisture, total petroleum hydrocarbons (TPH).



Location of study area, urban area of Bucharest

Location of fuel tanks area, **‘A’ zone**

Location of distribution pumps area, **‘B’ zone**

Fig. 1. Study area

● Hydrogeological investigation was conducted at the site to assess the particular conditions of migration of the petroleum in the ‘vadose zone’ of the first aquifer, the migration is conditional by suction potential. To measure this we used a data logger from Decagon, type EM50 with humidity sensors connected:

– simple sensor, model Decagon, type 10HS that provides a transmission to an analog electromagnetic method to measure the moisture of soil, without direct contact with the soil;

– tri-parameter sensor model Decagon, type 5TE, which measures soil moisture, temperature and electrical conductivity;

– capillary suction sensor Decagon, type MPS-1 that causes pore suction capacity compared to a set of tiles with known capacity, based on the dielectric constant of ceramic tiles, depending on the degree of water saturation.

RESULTS AND DISCUSSION

Laboratory analytical results for soil and groundwater are presented in Table 1.

The analytical results obtained in the determination of the quality indicator ‘TPH’ highlight a significant pollution with oil products in the placement of the fuel tanks with location in the profile S2, S3 and S4 levels deep ... –3 –3.5 m, respectively area below the bottom of the fuel tanks.

TPH analytical results of the ‘filling material’ sample (sample from 0... –3 m depth) show that this material does not make any contribution to the pollution of this area.

Estimation of the soil affected by oil pollution is done at 30 m^3, respectively, layer located between –3 and –4 m over an area of 30 m^2 in area bounded by S2, S3 and S4, and their proximity.

Table 1. Analytical results for soil and groundwater samples

No	Sample symbol (depth)	Dry matter[a] (%)	TPH[b] (mg/kg d.m.)	TPH[b] (mg/l)
1	S1 (300 cm)	77.37	322.12	–
2	S1 (350 cm)	76.13	199.89	–
3	S2 (300 cm)	87.72	3921	–
4	S2 (350 cm)	83.53	3039	–
5	S3 (300 cm)	85.58	4025	–
6	S3 (350 cm)	84.34	2832	–
7	S4 (300 cm)	83.79	2114	–
8	S4 (350 cm)	84.60	1146	–
9	S5 (300 cm)	79.86	493.68	–
10	S5 (350 cm)	78.18	340.09	–
11	sample of filling material	86.70	49.86	–
12	S6 (50 cm)	87.86	891.76	–
13	S6 (100 cm)	87.63	118.17	–
14	S6 (150 cm)	85.86	45.48	–
15	S7 (50 cm)	87.34	141.72	–
16	S7 (100 cm)	85.57	43.68	–
17	S7 (150 cm)	82.98	31.18	–
18	underground water-1	–	–	10040
19	underground water-2	–	–	52400

[a] Dry matter (d.m.) is measured using analytical balance and represents the percentage of the mass of the sample completely dried; [b] TPH – total petroleum hydrocarbons.

Suction measurement results are shown in Fig. 2. They show that the values decrease with depth in 'vadose zone', which favours depth migration of pollutants (petroleum products), which can be seen in Fig. 3 where is shown the distribution of TPH in 'vadose zone' based on analytical results obtained from the analysis of soil samples taken from the site.

Assessment was conducted and a one-dimensional groundwater flow and contaminant migration in 'vadose zone' with software UnSat Suite. For modelling were used: lithologic information for building a representative soil columns filler identified the site investigation; humidity measured to depths of 3.5 m, suction potential determined to depths of 3.5 m, the TPH contents determined on soil samples (considering the worst case of total solubility of petroleum hydrocarbons).

Lithological column used for modelling has 5 lithological sequences:

Layer 1: 0.00–1.00 m clay soil

Layer 2: 1.00–1.25 m sandy clay

Layer 3: 1.25–2.25 m fine sand

Layer 4: 2.25–2.75 m sandy clay

Layer 5: 2.75–5.00 m medium sand with clay.

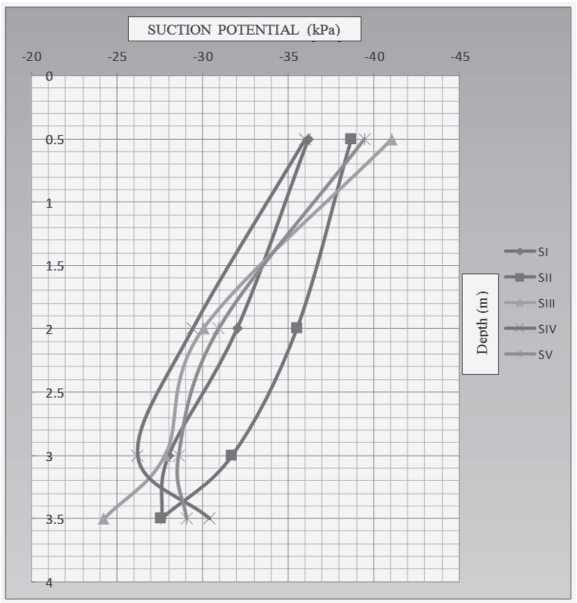


Fig. 2. Suction potential variation with depth

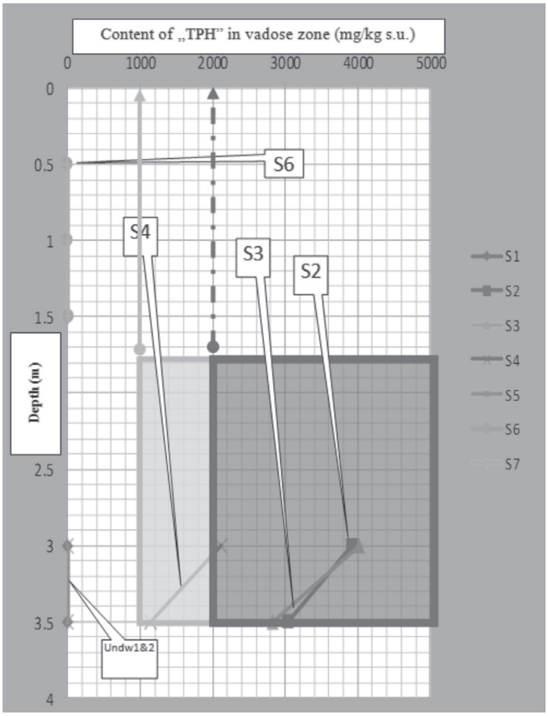


Fig. 3. Distributiion of TPH in 'vadose zone'

Humidity measured vertically varies between 15 and 30%. It was considered constant throughout the simulation period because we were able to make multiple measurements to know the seasonal variation.

TPH contents determined are presented in schematic form by 2 spline curves type. For calibration of the model was used a curve reflecting the unfavourable situation. Based on the incorporation of the elements of the 'vadose zone' was simulated the condition of THP content distribution for migration time of 1000 days, which calibrated satisfactory the distribution of the measurements (Fig. 4).

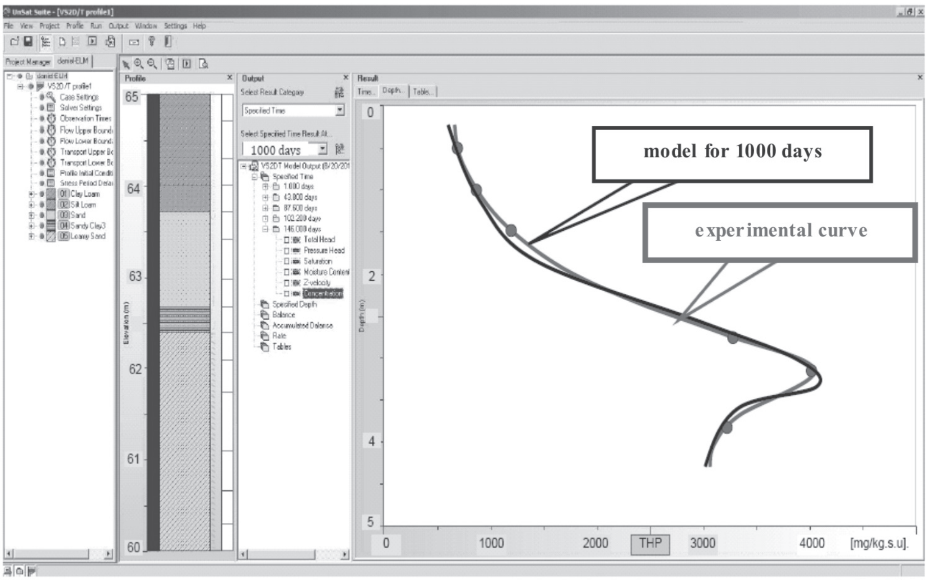


Fig. 4. Distribution of the measurements of TPH in 'vadose zone' using UnSat Suite software

The model built for migrating vertically in the 'vadose zone' of the petroleum products on the site studied, allow the following conclusions:

– vertical migration is slow;

– the source of the pollution is about to collapse, the maximum concentration of TPH is at a depth of 3.0 m, here goes over a period of 1000 days;

– some of the petroleum products migrated in 'vadose zone' reached the first aquifer and are driven by advection on direction NNE-SSW.

The design of the petroleum migration modelling in the first aquifer is essential to enabling a quantitative modelling:

– assessing the current expansion of the contaminated area;

– assessing the dynamics of the contaminated area;

– prognosis of a mitigate of the contamination;

– design remediation methods and tools.

CONCLUSIONS

The study of the hydrogeology of the site analysis highlights that in the study area lithological formations allow migration of contaminants in groundwater extending the hydro-regional Bucharest.

Migration of pollutants at the site has two components:

● Migration vertically (top to bottom) of contaminants:

– in the 'vadose zone' of the first aquifer, the piezometric level placed at a depth of 3.6 to 4 m in the study area;

– from bottom layer of the first aquifer, semi-permeable, to the Mostistea aquifer by drain phenomenon.

● Migration horizontally, parallel to the flow direction:

– first aquifer (NNE- SSW direction);

– Mostistea sands aquifer (NW-SE direction).

On-site investigation results indicate:

● significant pollution of soil with petroleum products (the threshold for intervention) in the 'A' zone (located between –3 and –3.5 m depth). An estimated volume of soil affected by 30 m^3;

● significant pollution of groundwater in the first aquifer (based on samples taken from the 'A' zone).

Shaping probable migration signals the next evolution of the area investigated:

● migration of petroleum in the area is ongoing 'vadose zone';

● petroleum products have reached the first aquifer and are driven NNE- SSW direction (general direction of flow in the aquifer);

● no premises drained contamination by a second aquifer, the sands of 'Mostistea' .

The recommendations made to the operator for remediation of polluted zone with petroleum products were:

● removal of the source of groundwater pollution (residual soil affected by oil pollution in the unsaturated zone);

● monitoring of groundwater quality in both aquifers downstream of the contaminated by achieving:

– a piezometer for the first aquifer,

– a piezometer for the second aquifer (the sands of 'Mostistea'),

– construction of a model for the migration of the petroleum products in the groundwater from the site in order to achieve a remediation project (through technological intervention or natural attenuation).

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