RESEARCHES ON GROUNDWATER POLLUTION IN THE AREA OF INDUSTRIAL WASTE DUMPS

CERCETĂRI PRIVIND POLUAREA APELOR SUBTERANE ÎN ZONA DEPOZITELOR DE DEŞEURI INDUSTRIALE

LUCA M.[1], BĂLAN R.[2], CHIRICA Ştefania[1], LUCA Al. L.[3]
e-mail: mluca2015@yahoo.com

Abstract. *Industrial waste dumps in exploitation or conservation represent a high risk of groundwater pollution. The Moldovan area has a large number of industrial waste dumps for mine waste, slag and ash from thermal power stations and steel plants, technological waste, etc. The degradation of the constructive structure of the deposits allows the underground infiltration of pollutants and contamination of water sources. The case study highlights the movement of a complex of pollutants from the landfill of a metalworking plant into the underground water. During the research measurements were made in observation drills and laboratory determinations were performed. The processing of the experimental data showed substantial overshoots in the following physical and chemical indicators: total iron (Fe +), ammonium (NH4), hardness, potassium permanganate (KMnO4), sulphates (SO4-) and chlorides (C1-). Contaminants from the landfill polluted groundwater and surface water sources for several localities.*
Key words: industrial waste, pollution, diffusion, groundwater, ground, air

Rezumat. *Haldele de deşeuri industriale aflate în exploatare sau în conservare prezintă un risc ridicat de poluare a apelor subterane. Zona Moldovei prezintă un număr mare de halde deşeuri industriale pentru steril de mină, zgură şi cenuşă de la termocentrale şi combinate siderurgice, reziduuri tehnologice etc. Degradarea structurii constructive a depozitelor permite infiltrarea în subteran a poluanţilor şi contaminarea surselor de apă. Studiul de caz întocmit evidenţiază deplasarea în apa subterană a unei complex de poluanţi proveniţi de la depozitul de deşeuri a unei fabrici de produse metalice. Pe perioada cercetărilor s-au efectuat măsurători în foraje de observaţie şi s-au realizat determinări de laborator. Prelucrarea datelor experimentale au arătat depăşiri substanţiale la următorii indicatori fizico-chimici: fier total (Fe^{+}), amoniu (NH_4), duritate, permanganat de potasiu ($KMnO_4$), sulfaţi (SO_4^{-}), cloruri (Cl^{-}) şi azotiţi (NO_2). Contaminaţii proveniţi din depozitul de deşeuri au poluat sursele de apă subterană şi de suprafaţă pentru câteva localităţi.*
Cuvinte cheie: deşeu industrial, poluare, difuzie, apa subterana, sol, aer

INTRODUCTION

Industrial waste is stored in premises located inside or outside economic objectives. Some deposits were made without considering the risk of environmental pollution. The design did not analyze in detail the nature of the

[1]"Gheorghe Asachi" Technical University of Iasi, Romania
[2] "Prut-Barlad" Water Basin Administration, Iasi, Romania
[3] "Polias-Instal" Company, Iasi, Romania

waste to be stored and its evolution over time, as well as its influence on the construction structure of the deposit. At present, landfills in exploitation or conservation represent a high risk of pollution of groundwater, soil, air and human health. In this case one can enumerate (Bălan, 2010).

- ash dumps from thermal power plants for the production of electricity and heat;
- slag slags in the steel industry;
- landfills in the chemical and building materials industry,
- landfills in the hydrocarbon industry, etc.

All landfills of this type produce groundwater contamination for small but also long periods. The effect of pollution causes the removal of groundwater sources from the water supply circuit.

The amount of hazardous industrial waste generated in Romania has declined steadily in recent years due to the reduction of the activity of large economic units. In this context, landfills in operation or in the conservation area will have to be systematized and exploited safely. In the polluted areas ecological reconstruction works must be carried out to reduce and prevent the risk of accidental pollution of the environment (Luca, 2004).

A number of industrial deposits must be closed or rehabilitated to meet the new environmental protection standards and standards in the area of waste disposal sites.

MATERIAL AND METHOD

The research material consists of the first industrial waste deposit at S.C. Bearings S.A. Barlad. The Industrial Waste Depot is located in the Barlad River meadow in the north of Barlad. Industrial waste disposal was done outside the factory on the slag dump located to the east and at a distance of 1000 m from the Barlad River and about 600 m from the Simila River. This deposit is a model of environmental pollution in the absence of reconstruction measures for the protection of the underground environment. The landfill has changed over time in shape, waste treatment, environmental protection, etc. Waste storage was done by stacking, on unpolluted and permeable land for liquid and leachate (Bălan, 2010).

The research methods included field studies to take ground and groundwater samples, dusts from the air. The samples taken from the site and the area adjacent to the deposit were analyzed in the laboratory. Experimental results were processed using a set of specialized computing programs.

The forecasting of the pollution phenomenon of the groundwater pollutant concentrations and the depollution phenomenon has been achieved by using a special pollutant transport study program in the underground environment (the FEFLOW program) (Charbeneau, 2000; Bălan, 2010; de Marsily, 1994).

RESULTS AND DISCUSSIONS

In the landfill there are various wastes such as nature and environmental hazards: inert laminae from emulsion treatment, carbide, ion-exchange filters, petroleum products, dirt, ash, refractory brick, etc. The land area occupied by the

deposited material is about 1.6 ha, of which the area adjacent to the heterogeneous landfill of the land is about 0.5 ha.

The landfill of industrial waste with its diverse composition also has a significant pollutant over time (during operation and post-conserving) on the soil. Soil pollutants are trained in the soil, which, under the effect of rainfall, are transported vertically and horizontally at various distances.

Table 1

Indicators used for soil pollution in the landfill area (Balan, 2010)

No. crt.	Point of harvest	H_{rec} (m)	Indicators analyzed (Concentrations, ppm/dry soil)					
			Pb	Fe	Zn	Cu	Mn	Cd
1	Waste storage	5	93	**1684**	86	17	184	1.79
		30	88	**1328**	72	8.3	156	1.24
2	Between the industrial waste landfill and the petroleum product depot	5	84	**1740**	297	85	145	1.86
		15	71	**1417**	235	61	108	1.52
C_{ad}			250/ 1000	250/ 1000	700/ 1500	250/ 500	2000/ 4000	5/10

H_{rec} - harvest depth; C_{ad}- Maximum permissible concentration according to O.M. no. 756/1997 - alert threshold / intervention threshold

During the monitoring process periodic measurements were carried out at different collection points in the area adjacent to the deposit. Field and processed data are presented in table 1 and table 2.

Table 2

Indicators analyzed for soil pollution in the landfill area (Balan, 2010)

No. crt.	Point of harvest	H_{rec} (m)	Indicators analyzed (Concentrations, ppm/dry soil)					
			Cr^{6+}	Cr tot	Ni	Mg	pH	S_{ex}
1	Waste storage	5	0.11	15.8	8.4	111.4	7.28	44.70
		30	0.08	12.5	5.5	120.7	7.52	44.45
2	Between the industrial waste landfill and the petroleum product depot	5	0.26	20.4	11.2	172.0	7.91	**286**
		15	0.22	17.1	9.6	125.0	7.89	**316**
C_{ad}			10/ 20	300/ 600				200/ 500

H_{rec} - harvest depth; C_{ad}- Maximum permissible concentration according to O.M. no. 756/1997 - alert threshold / intervention threshold ; S_{ex}- extractable substances

From the analysis of the processed data (tab. 1, tab. 2) that comprise the measurements performed on the soil at different depths (5 m, 15 m and 30 m) it is observed that for most of the indicators studied the ppm/dry soil concentrations

established by O.M. no. 756/1997, do not exceed the alert and intervention thresholds except the chemical indicator Fe. The research highlighted the following (Bălan 2010):

- the Fe concentration in dry soil at a depth of 5 m, both in and around the warehouse area, exceeds the 6.96 times the alert threshold and 1.74 times the intervention threshold;

- the Fe concentration in dry soil at 15 m depth in the area adjacent to the landfill, respectively between industrial waste landfill and oil product depot exceeds the 5.6 times the alert threshold and 1.41 times the intervention threshold;

- the Fe concentration in dry soil at 30 m depth in the storage area exceeds 5.31 times the alert threshold and 1.32 times the intervention threshold.

At the "extractable substances" indicator, exceedances were recorded at ppm / dry soil concentrations, compared to the alert threshold established by O.M. no. 756/1997, between the industrial waste deposit and the oil products warehouse. The following can be mentioned (Bălan, 2010):

- at a depth of 5 m, the concentration of extractable substances in dry soil exceeds 1.43 times the alert threshold;

- at the depth of 15 m, the concentration of extractable substances in dry soil exceeds the 1.58 times the alert threshold.

The circulation of groundwater contaminated with pollutants from the deposit mass is tributary to the fluctuation of the water level on the Simila and Barlad rivers and the rainfall regime. The analysis shows the following:

- during periods of low water on the two rivers or during abundant rainfall on the landfill, the underground water can move from the deposit to the Simila and Bârlad water courses; the pollution of the groundwater and the water from the two rivers is caused by this pollution;

- during periods of water rise in the two rivers and without abundant precipitation on the landfill, the groundwater movement is made in the opposite direction; thus transporting pollutants from the rivers to the underground of the deposit.

Since 2000, a series of thorough analyzes have been initiated on the influence of the closed industrial waste deposit on environmental factors and especially on groundwater. The number of groundwater quality monitoring drillings has been increased to 14. Drillings have been located at characteristic points of influence of the industrial platform. The study period was 2004-2010.

The processing of water samples taken from drillings highlighted groundwater quality parameters and their variation over time. F7 drilling presented significant parameters on groundwater quality and negative impact of industrial waste landfill. The F7 drilling is located in the northern part of the old industrial waste dumps and was made of PVC pipe with Dn 200 mm at a depth of 4 m. The phreatic layer was intercepted at a depth of 2 m from the natural ground quota. The results of the research are presented in table 3 for data taken from the F7 drilling.

Table 3

Analysis of physic-chemical indicators determined for F7 water (year 2006)

Quarter	pH	Chloride (mg/L)	NH_4 (mg/L)	$KMnO_4$ (mg/L)	NO_2 (mg/L)
I	7.5	**652.2**	**7.84**	*	**7.84**
II	8	90.75	**1.64**	**23.98**	0.05
III	8	207	**1.61**	**26.38**	0.05
IV	8	124.7	**6.75**	**23.10**	**1.73**
$C_{m,an}$	7.87	**268.66**	**4.46**	**24.48**	**2.41**
C_{ad}	**6.5 ÷ 9.5**	**250**	**0.5**	**5**	**0.5**

$C_{m\,in}$ average annual concentrations; C_{ad}- maximum admissible concentrations according to the Drinking Law no. 311/2004

In figure 1 is the graphical variation of the quarterly variation in concentrations of physic-chemical indicators in drilling F7 (chlorides, suspended matter, potassium permanganate and nitrate) compared to the maximum admissible concentrations (Drinking Law No. 311 of 2004; Bălan, 2010).

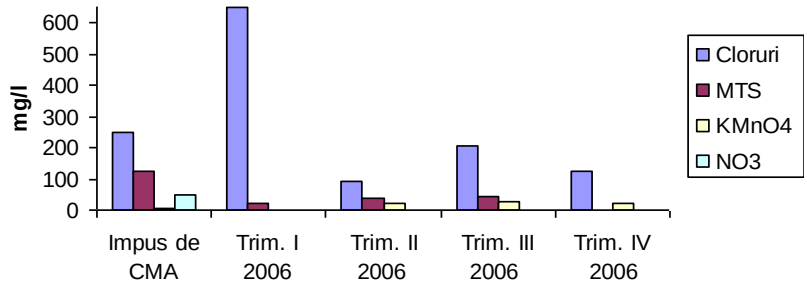

Fig. 1 Quarterly variation of concentrations (mg/L) in monitoring period in drilling F7 for year 2006 (Bălan, 2010).

The analysis and data processing results in the following (Luca *et.al*, 2012):

- in the chlorine indicator, quarterly values were recorded between 90.75 mg/L and 652.2 mg/L; the analysis of the processed data shows that the determined value of 652.2 mg/L, monitored in the first quarter of 2006, exceeds by 250 mg/L and 2.6 times the limit imposed by law;

- the quarterly values between 23.10 mg/L and 26.38 mg/ L were recorded at the potassium permanganate indicator; the analysis of the processed data shows that the values determined over the whole monitoring period (II, III and IV quarters of 2006) do not fall within the limit imposed by the law; the recorded values exceed the required limit (5 mg/ L) about 5 times; the same situation occurs also at the maximum permissible annual concentration (exceeding about 5 times the admissible limit);

- for the indicators of suspended matter and nitrates, the average quarterly values were determined which fall within the normal limits imposed by the Drinking Law no. 311/2004;

- quarterly values were recorded in the ammonium indicator in the range of 1.61mg/L and 7.84 mg/L; from analysis of the results it is observed that the monitored values, in I, II, III and IV quarter 2006, do not fall within the required limit (0.5 mg/L).

From the physic-chemical parameters processing of the samples taken from the drilling, the value of some indicators exceeds the limits imposed by the law. Thus, at F_2 - Albița Simila, F_4 - Stana and F_5 - East waste dumps, there are exceedances of nitrates (NO_2) and ammonium (NH_4) (tab. 4) (Bălan, 2010).

Table 4

Values of the water quality parameters taken from the F2 drilling – Riverbed Simila

CMA cf. Env.Aut.	Cl	NH_4	CCOMn	Extract.	$Cr6^+$	NO_2	pH	MTS
Trim. I	*	0,50	*	*	0,05	0,30	8,5	*
Trim. II	60	0.43	21.67	0	0	**0.53**	6.8	56
Trim. III	48	**0.75**	20.16	0	0	**0.61**	7,0	40
Trim.IV	55	0.21	22	0	0	**0.58**	7,0	50
Av. 2004	54.33	0.463	21.276	0	0	**0.573**	6.93	48.7

CONCLUSIONS

1. Industrial or conservation landfills are a permanent source of air, soil and subsoil pollution in the location area.

2. Research has shown that the landfill industry has negatively influenced the groundwater from the Bârlad River and the Simila River meadow.

3. The soil in the adjacent industrial waste site is polluted mainly by Fe in dry soil at a depth of 15 m where the concentration exceeds the 5.6 times the alert threshold and the 1.41 times the intervention threshold.

4. The underground water from the analyzed industrial waste site is polluted in special mode of the nitrates and ammonium.

REFERENCES

1. Bălan P. R., 2010 - *Contribuții la creşterea siguranței în exploatare a haldelor de steril în privința reducerii potențialului de poluare.* Teză de doctorat, Universitatea Tehnică „Gheorghe Asachi" din Iaşi, p. 267.

2. Charbeneau R., J. 2000 - *Groundwater Hydraulics and Pollution Transport*. Prentice Hall, New Jersey, SUA.

3. Luca M., 2004 - *Considerații privind fenomenul de poluare indus de haldele de steril minier.* Internațional Conference „Disaster and Pollution Monitoring" Universitatea Tehnica „Gh. Asachi" Iaşi.

4. **Luca M., Balan R.P., Mănescu A., Luca Al.L., 2012** - *Modelling pollution transport of the industrial waste underground Conference on Modelling Fluid Flow (CMFF'12).* The 15th Event of International Conference Series on Fluid Flow Technologies, Budapest, Hungary, p. 523-530.

5. **de Marsily G**., **1994** - *Hydrogéologie, comprendre et estimer les écoulements souterrains et le transport des polluants.* Écoles des Mines de Paris (Paris VI).

6. *** O.M. no. 756/1997

7. ***, Drinking Law No. 311/2004