ENVIRONMENTAL RISKS INDUCED BY THE PRESENCE OF DANGEROUS POLLUTANTS IN MUNICIPAL LANDFILLS SURROUNDING AREAS

Adriana Cuciureanu, Gheorghe Batrinescu, Bogdan Stanescu,
Ramona Dumitrache

National Research and Development Institute for Industrial Ecology – ECOIND,
71-73 Drumul Podu Dambovitei St., sector 6, 060652, Bucharest, Romania,
phone: +40/21/4106716; fax: +40/21/4100575; 4120042;
e-mail: ecoind@incdecoind.ro

ABSTRACT

The issue of waste management is among the priority concerns for environmental protection both nationally and internationally.
The continuous growth of human activities has economic, social and environmental implications. Among the environmental problems caused by human activities, the municipal waste management has gained a priority for environmental protection. Emissions from municipal landfills negative have impact on all environmental components, "air", "water" and "soil".
Landfills are acknowledged as generating impact and risk to the environment and public health.
Composition and typology of waste deposited on landfill of municipal waste is extremely different. They may contain a number of compounds which often shows a dangerous character.
By default, they are found in emissions from storage and hazards to the environment.
The paper highlight specific cases, the risks associated with these pollutants in adjacent deposits areas.

Keywords: environmental risk, municipal landfills, dangerous pollutants

I. INTRODUCTION

The safe management of municipal waste for the environment has gained a special character due priority in applying the method of final disposal through landfilling. [1]
It is well known that waste landfilling has most negative effect on the environment, especially in parallel with using inadequately set up places, without facilities to ensure the environmental protection.
Composition and typology of waste deposited on landfill of municipal waste is extremely different and shall be constituted as important environmental risk factors. [2]
The effects may occur in the short, medium or long term, with the variable amplitude (local, regional or global).
This paper presents relevant aspects regarding the environmental risks induced by a municipal waste landfilling , into a non-compliant landfill, with more than 30 years old, which is ceased the activity of 3 years.

The risk analysis has been conducted to *source-pathway-receptor relationship* with the objectives:

- identifying the hazards induced by non-complying landfills of municipal waste
- quantifying the risk induced on environmental components (air, soil, surface water), after the cessation of activities

The ecological risk assessment analysis answer to the following questions [3]:

- What are the sources that generates hazards?
- What are the characteristics of these dangers – the duration and intensity?
- What environmental components were or will be target for these dangers?
- Which will be the adverse effects on environmental quality of components of the site?
- In what area the adverse effects will be felt?
- What consequences will be adverse effects?

II. EXPERIMENTAL PART

Materials and methods

A landfill conceptual model shown in Fig. 1 is the basis in the environmental risk assessment [4].

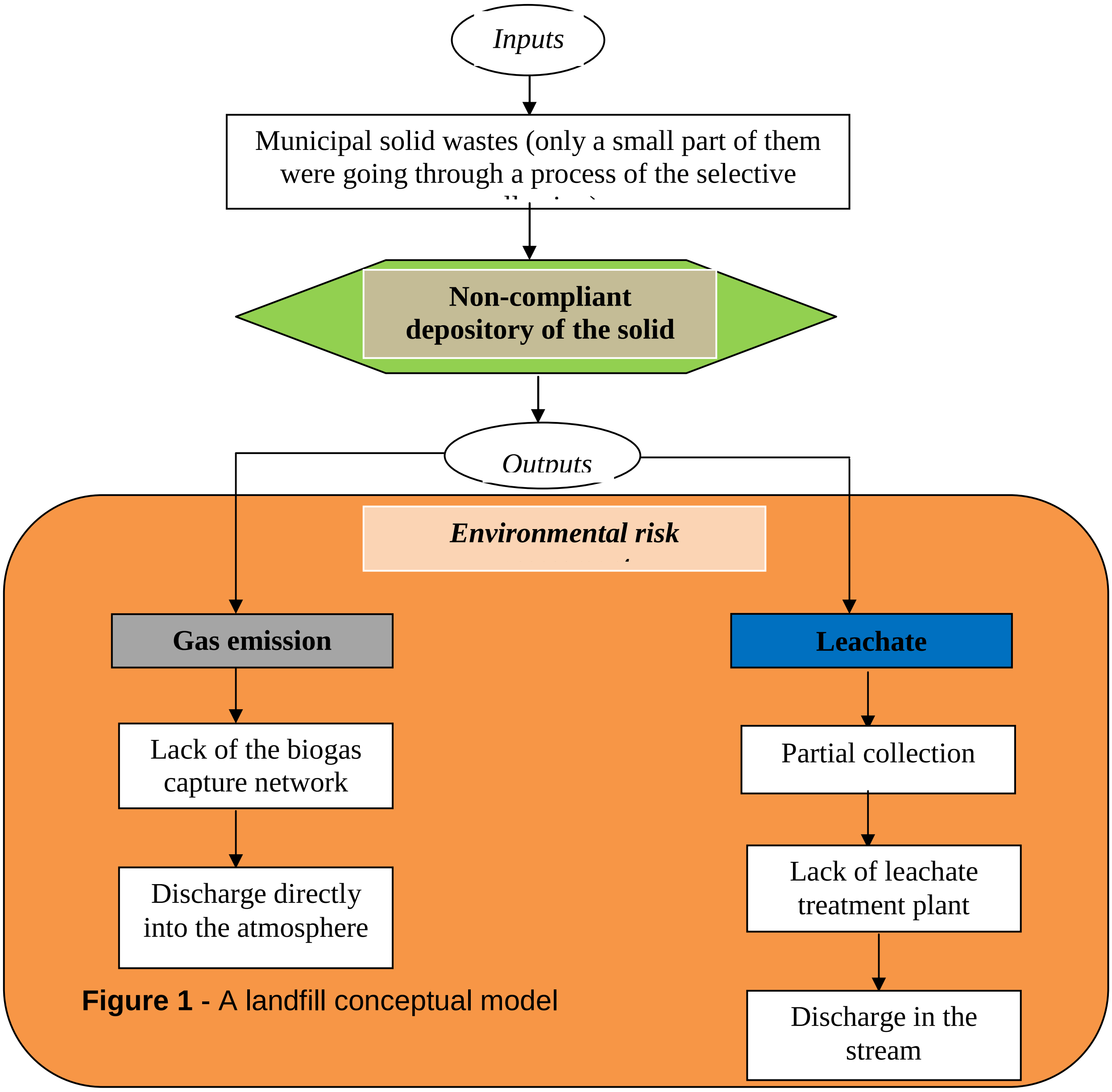

Figure 1 - A landfill conceptual model

Risk analysis as case study aimed non-compliant municipal waste landfill, located in Region 6 NW of Romania, in the vicinity of Cluj Napoca, Romania (Fig. 2). This is the experimental field – Pata Rat.

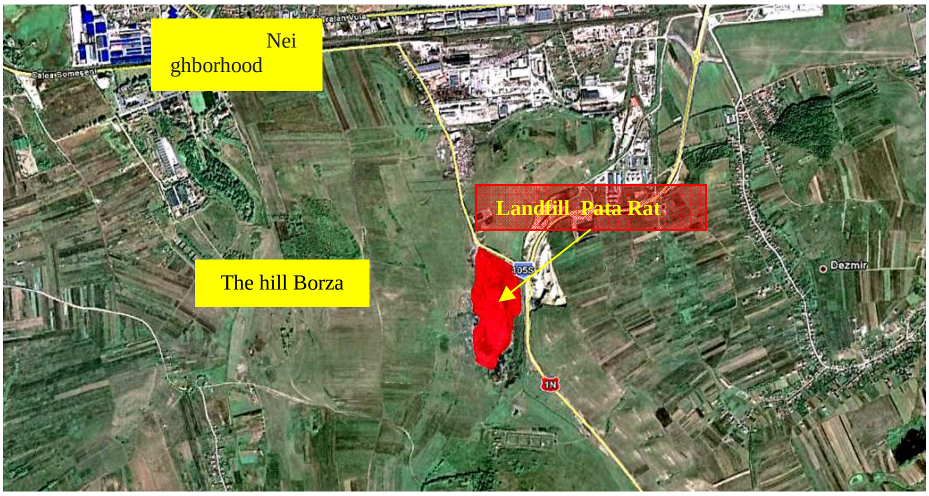

Figure 2 - Location of the landfill Pata Rat (image source: Google Earth,2013)

The area which have been considered in the risk assessment included both the landfill site and the immediate vicinity.

The potential hazards have been taken into consideration allowing the analysis of:

- the induced risk on the air by the deposit gaseous emissions
- the induced risk on the soil, surface water by the drained of leachate collected at the base of the deposit

Some details about the site Pata Rat (experimental field) are the following:

- minimum distance to populated areas is approx. 1.5 km
- the estimate surface is 160,000 square meters
- is located in a hilly area (down the hill Borzas) with an energy of relief to about approx. 80 m
- is crossed at the base by the Zapodie river, tributary of the Somes Mic river, on the eastern side
- on River valley there are areas with humidity excess, swampy areas, where it accumulates after rainfall, significant quantities of leachate; anthropogenic drainage was achieved by excavating the bed of the stream channel (Fig. 3)
- in the NE-E in perimetral channel only partially leachate is collected (on the length of max.300m) to drainage into a retention area (Fig. 4)

	
Figure 3 – The stream channel	**Figure 4** - The retention area who collected the leachate

The experimental field (showed in Fig. 5) consists of:

- Two points of air measurements (A1, A2)
- Five points of soil sampling (S1÷S5)
- Two points of leachate sampling (L1, L2)
- Two points of surface water sampling (Upstream, Downstream)

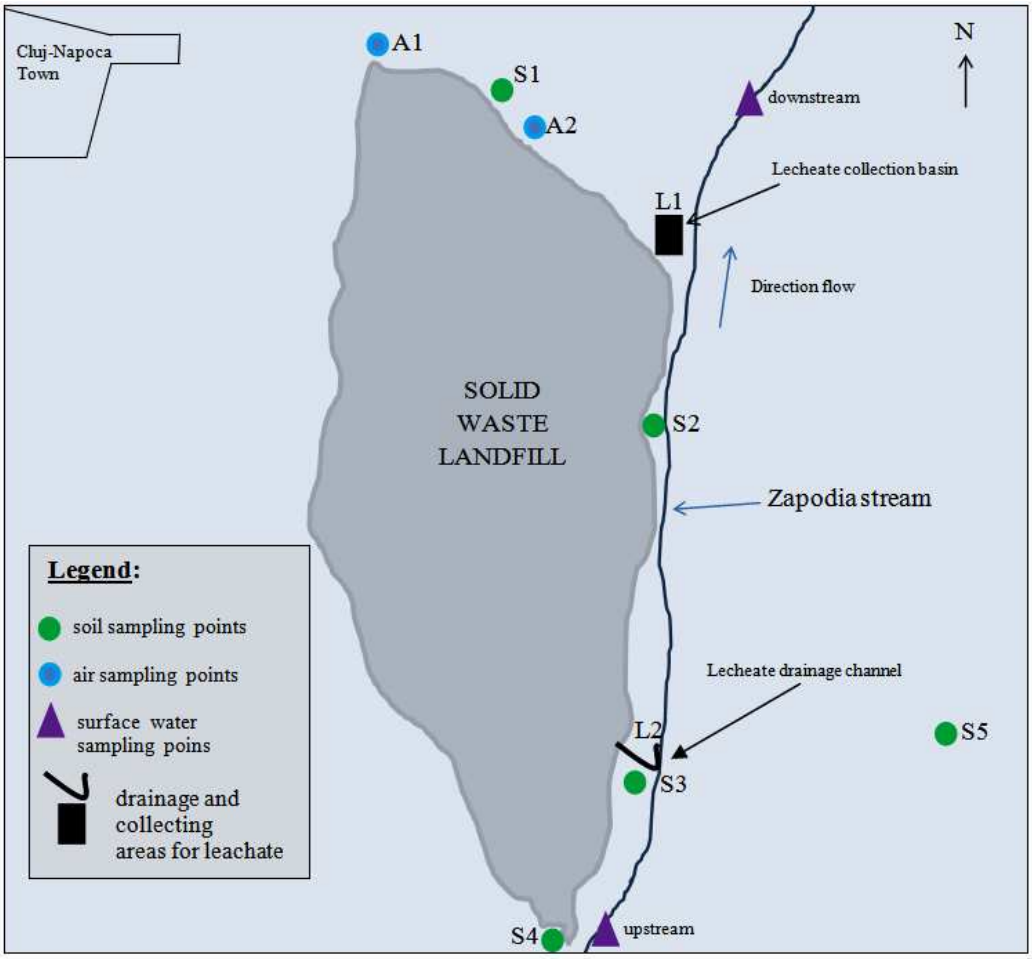

Figure 5 - The experimental field

Air quality assessment has been performed in relation to standard STAS 12574 per 1987 "Air in protected areas. Terms of Quality "[5] and Romanian Parliament Law 104 per 2011 regarding "Ambient air quality", limit values for sulphide dioxide, nitrogen dioxide, nitrogen oxide, particulate matter (PM10, PM2.5), lead, benzene and carbon monoxide. [6]
The soil quality assessment has been performed in relation to compliance criteria stipulated in national legislation by Ministry of Waters, Forests and Environmental Protection- Order 756/1997 for approving legislation on environmental pollution assessment [7] and in relation to a sample soil from an area unaffected by deposit, also.
The leachate quality assessment has been performed in relation to Normative 001 per 2005 [8].
The surface water quality assessment has been performed in relation to Ministry of Environment and Water, Order no. 161 per 2006 approving the Norms concerning the classification of surface water quality in order to determine the ecological status of water bodies [9].
For quantifying the risk has been used the following equation:

$$R = P \times C$$

Where: R- the risk
P- probability of occurrence
C- consequences (severity) effects on the environment

Quantifying probability of occurrence (P) is on a scale of 1 to 4:
1= unlikely
2= very small probability
3= moderate probability
4 = high probability

Quantifying the consequences (C) is on a scale of 1 to 4:
1= minor effects (local, with low risk to the environment)
2= moderate effects (presenting hazard to the environment)
3= serious effects (spills of toxic materials that poses a threat for environment)
4 = catastrophic effects (the environmental damage in all its components, with reduced neutralization and long recovery)

When $R \geq 6$ it is considered that the environmental impact is significantly[3].

III. RESULTS AND DISCUTIONS

The sources generating potential hazards they identified were:
- the gaseous emissions from deposit as a result of waste biodegradation, containing besides the main components (CH_4, CO_2) small quantities of VOC, disagreeable odor volatile, H_2S, SO_2, NO_x, NH_3, depending on the composition of wastes
- dust and slight residues present in deposit

- the smoke resulted due to uncontrolled burning, dependent on the composition of wastes and of possible occurrence of mixtures flammables, explosive
- the leachate resulting from percolating of the meteoric waters, with different composition, organic or inorganic, containing dissolved species or in suspension

The potential hazards receptors included the landfill site and the immediate vicinity are:
- Atmosphere - as a result of the dispersion of landfill gaseous emisions, dust, smoke
- Soil / subsoil - by leachate drain, infiltration in depth
- Surface water - by leachate drain on the slopes

Adverse effects of the environmental components are emphasized by the performed investigations.

a) Investigations aimed at assessing the air environmental component, pollution in areas potentially affected by activities of the site analyzed. Measurements were performed in the 2 points (A1, A2 shown in figure 5) of observation for the ambiental air quality control as follows: short-term, ground-level air quality indicators determining SO_2, NO_2, VOC (expressed as total organic carbon), hydrogen sulphide, particulate matters PM 10. We use the following equipment: dust and gas samplers type P491, PM10 ECO Tecora, ThermoFid VOC analyzer, spectrophotometer Cintra, Mettler Toledo laboratory analytical balance.

The results are summarized in Table 1.

Table 1 The result of the air quality control.

No.	Indicators	u.m	A1	A2	Sampling period
1	PM10	mg/cm	0.183	0.086	13 hours
2	NO2	mg/cm	0.174	0.098	1 hour
3	SO2	mg/cm	0.092	0.055	1 hour
4	NH3	mg/cm	0.144	0.194	30 minutes
5	H2S	mg/cm	0.007	0.009	30 minutes
6	TOC	mg/cm	8.63	7.91	1 hour

The air quality in the vicinity of municipal landfill is main affected by the emission of particulate matter (PM 10). It should be noted important contribution to air pollution brought by vehicles (garbage special vehicles) passing through the area. Also, in adverse weather conditions impact of the landfill is felt over a large area, the fact that the landfill is not yet fully covered there still allows uncontrolled burning of wastes which favors the production of aerosols that reach to far distances. Also, the smell arising from the processes of decomposition of the waste is felt throughout the year, intensity and propagation distances varying larger influenced by the weather conditions.

b) The performed investigations had follow the level of the environmental pollution in areas potentially affected the soil environmental component by the activities in the site analyzed and characterization of the soil samples in the vicinity of the landfill. They collected soil samples from four locations (Figure 5), two levels of depth (0-10 centimeters and 30-40 centimeters) for each location (S1, S2, S3, S4) and a sample soil from a site pottential unaffected by the solid waste storage area (S5). For all the soil samples collected were subjected to determine the quality indicators presented in Table 2: pH, dry substances, humus, total petroleum hydrocarbons, sulphates, ammonium, Kjeldahl nitrogen, nitrate, cadmium, total chromium, copper, nikel, lead, zinc and chlorides. In analytical tests performed are only standardized methods used.

Table 2 The result of the quality indicators of the soil samples analyzed

No	Indicators	u.m	S1/1	S1/2	S2/1	S2/2	S3/1	S3/2	S4/1	S4/2	S5/1	S5/2
1	pH	pH units	7.6	7.9	7.5	7.5	7.6	7.5	7.9	7.7	7.5	7.6
2	TPH	mg/kg d.s.	388.6	159.2	810	802.7	67.7	66.4	54	53.9	48.2	50.5
3	Dry substance (d.s.)	%	90.06	88	98.57	98.7	80.28	81.8	80.07	78.07	87.49	80.76
4	Humus	% d.s.	0.36	0.41	1.21	1.01	0.77	0.22	0.39	0.32	0.25	0.24
5	Kjeldahl N	% d.s.	0.132	0.194	0.111	0.108	0.291	0.27	0.337	0.302	0.244	0.222
6	NH4	mg/kg d.s.	136.2	127.5	105.5	102.2	116.0	123.2	87.47	83.24	125.8	131.26
7	NO3	mg/kg d.s.	33.42	36.11	104.6	102.6	139.0	140.0	1403	1402	65.95	41.86
8	Sulphates	mg/kg d.s.	460	392	123	183	174	110	305	272	109	101
9	Clorides	mg/kg d.s.	95.4	121.2	56.0	35.1	41.6	37.5	727.7	719.9	45.3	33.8
10	Cadmium	mg/kg d.s.	1.19	0.93	1.23	1.15	1.36	1.24	0.89	0.93	1.17	1.31
11	Zinc	mg/kg d.s.	93.34	76.51	96.54	112.7	65.76	59.03	45.66	42.9	57.47	58.74
12	Lead	mg/kg d.s.	35.26	37.45	54.73	120.0	25.43	23.81	26.55	22.48	18.38	17.42
13	Chromium	mg/kg d.s.	23.85	24.39	26.54	39.25	18.73	16.21	21.52	23.79	24.19	21.98
14	Nickel	mg/kg d.s.	56.05	54.96	22.32	36.12	52.08	47.87	43.82	46.87	52.28	55.15
15	Copper	mg/kg d.s.	57.16	52.04	42.39	56.76	29.78	28.52	33.78	36.64	28.04	28.91

The soil environmental component is affected primarily by large areas covered by the solid waste disposal (an estimated area of 16 hectares). All values determined in the samples were below the limits imposed by the Ord.756/1997. The comparison to the control sample (S5) reveals the influence of the landfill produced by the dispersion of the air emissions, and by leakage due gully erosion coming from landfill slopes.

c) Investigations on leachate quality were performed by sampling from drainage channel (L2) and collection basin (L1). Sampling was performed according to the international standard for water quality ISO 5667/97-6 "Guide for the sampling of rivers and streams", the storage and the transportation of samples in bottles sealed and preserved according to indicators determine, in acid or base midle. The samples were determined quality indicators: pH, COD, BOD, ammonia, nitrates, nitrites, sulphates, chlorides, total chromium, cadmium, copper, lead, zinc, nickel. Analysis of two leachate samples taken is presented in Table 3.

Table 3 The result of the quality indicators of the leachate samples analyzed

No.	Indicators	u.m	L1 sample	L2 sample
1	pH	pH units	7.2	8,3
2	COD	mgO_2/l	3360	4920
3	BOD	mgO_2/l	1241.2	1878,4
4	NH_4^+	mg/l	1300	1143
5	NO_3^-	mg/l	33.4	31,5
6	NO_2^-	mg/l	<0.006*	<0,006*
7	Sulphates	mg/l	26.3	342,4
8	Clorides	mg/l	4524.1	3132,1
9	Copper	mg/l	0.027	0,212
10	Zinc	mg/l	0.017	0,388
11	Lead	mg/l	0.025	0,027
12	Total Chromium	mg/l	0.227	4,935
13	Nickel	mg/l	0.41	0,69
14	Cadmium	mg/l	0.03	0,026

* - the detection limit of the method

The leachate quality investigation revealed unconforming indicators: organic loading (expressed as COD and BOD), ammonia, nitrate, chloride, copper, chromium and nickel showed values above permissible limits according Normative 001 per 2005, which induces a significant contribution of pollutants to receiving waters nearby the landfill.

d)The performed investigations had follow the induced effects of the solid waste disposals on the surface water quality. Sampling locations consisted in areas situated upstream and downstream of the discharge of the leachate. Sampling points can be found in Figure 5. Sampling procedures respect the same requirements as for leachate standard with storage and transportation in bottles sealed and preserved according to indicators determined in acid and base middle. In the samples were determined quality indicators (Table 4): pH, COD, BOD, ammonia, nitrates, nitrites, substances extractable in organic solvents, sulphates, chlorides, total chromium, cadmium, copper, lead, zinc, nickel.

Table 4. The result of the quality indicators of the surface water samples analyzed

No.	Indicators	u.m	Upstream	Downstream
1	pH	pH units	7.7	7.8
2	COD	mgO_2/l	10	30.4
3	BOD	mgO_2/l	4	10.7
4	NH_4^+	mg/l	0.15	6.3
5	NO_3^-	mg/l	0.86	1.51
6	NO_2^-	mg/l	0.012	0.04
7	Sulphates	mg/l	216.44	207.8
8	Clorides	mg/l	396.72	480.24
9	Copper	mg/l	<0.003*	0.005
10	Zinc	mg/l	0.005	0.006
11	Lead	mg/l	<0.01*	0.021
12	Total Chromium	mg/l	<0.005*	<0.005*
13	Nickel	mg/l	0.021	0.035
14	Cadmium	mg/l	0.003	0.005

* - the detection limit of the method

Interpreting the results of the investigations on surface water quality was performed according to Order 161 per 2006 which provides five ecological status for rivers and lakes: very good (I), good (II), moderate (III), poor (IV) and bad (V) on the basis of quality chemical and physico-chemical, biological and hydromorphological.

In the case of the landfill is induced a pollution to river by discharges the leachate leads to change its status to the upstream downstream as follows:

- from grade I in upstream section to grade III (moderate) in downstream section – the effect induced by loading organic content expressed as "COD" and lead;
- from grade I (very good) in upstream section to grade V (bad) in downstream section - the effect induced by nitrogen content of ammonium;
- from grade I (very good) in upstream section to grade II (good) in downstream section - the effect induced nitrogen content of nitrates;
- from grade II (good) in upstream section to grade III (moderate) in downstream section - the effect induced by nitrogen content of nitrite and nickel.

*
* *

The results presented above have enabled quantification of the risk according to the methodology. This quantification is represented schematically in Fig. 6.

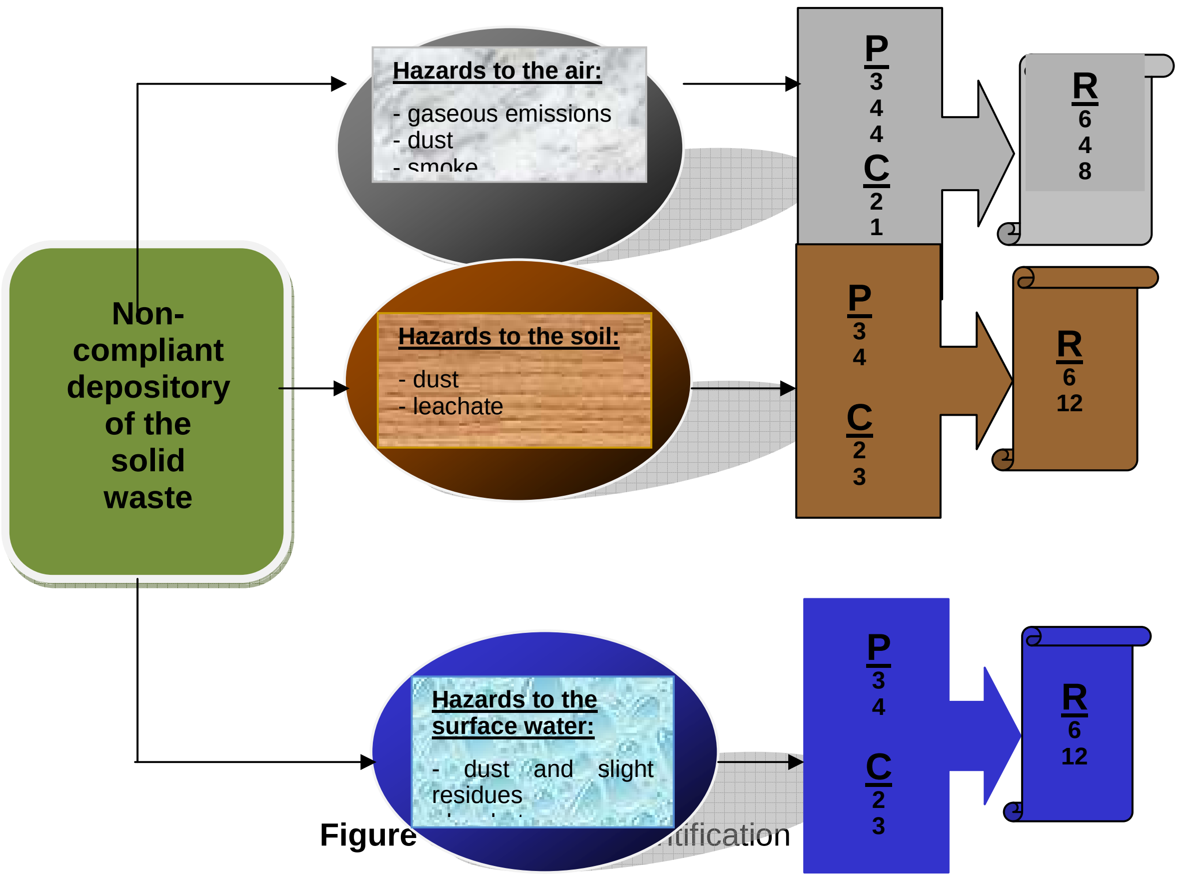

Figure ...tification

IV.CONCLUSIONS

Quantifying the adverse effects of the environmental components and the potential hazards generated by the non-compliant depository of the solid waste have shown significant risks induced on environmental in landfill site and the immediate vicinity.
The non-conformity of the deposit (the lack of a gaseous emissions capture system, fact that the is not yet fully covered and occurring thereby uncontrolled burning which favor the production of aerosols in the felt on long distances, the lack of a system to capture and treatment of of leachate drained) makes the environmental risk to remain at a high level, even after cessation activity.

REFERENCES

[1] S.M. Al-Salem, P.Lettieri, J.Baeyens, Recycling and recovery routes of plastic solid waste (PSW): A review, *Waste Management*, 2009, 29, 2625-264

[2] Popita Gabriela-Emilia, Popovici Antoanela, Hategan Raluca Mariana, *Developing a municipal urban waste management integrated system in Cluj County*,AES Bioflux 3(2):194-205, 2011, ttp://www.aes.bioflux.com.ro/home/vol. 3

[3] G. W. Suter II, B.E. Sample, et all - *Approach and Strategy for Performing Ecological Risk Assessments,* 1995 – Revision

[4] EA (March 2003), *Hydrogeological Risk Assessment for Landfills*,Environmental Agency Rio House, Waterside Drive, Aztec West Alomondsbury, Bristol BS32 4UD, p.12.

[5]***Romanian standard STAS 12574 per 1987 "Air in protected areas. Terms of Quality "

[6]*** Romanian Parliament, Law no. 104 from 15 June 2011 regarding quality of the ambient air, the Official Journal of Romania no. 452 from 28 June 2011

[7]*** Ministry of Waters, Forests and Environmental Protection, Order no. 756 din 3 November 1997 approving the regulation on environmental pollution assessment, the Official Journal of Romania no. 303bis from 6 November 1997

[8]*** NTPA 001/2005 - Standard concerning the conditions of wastewater discharge into natural receptors

[9]*** Ministry of Environment and Water, Order no. 161 from 16 February 2006 approving the Norms regarding surface water quality classification to determine the ecological status of water bodies, the Official Journal of Romania no. 511 from 13 June 2006.