RISK ASSESSMENT INDUCED BY A NON-COMPLYING LANDFILL OF MUNICIPAL WASTE TO ENVIRONMENTAL WATER COMPONENT

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Abstract

This paper presents the results of evaluating the environmental risk induced by the activity of non-compliant municipal landfills of class "B", in a period of over four decades. Storage locations analyzed presents a number of particularities: is situated in a hilly area, with an energy of about 40 m of relief, marked by the presence of a stream with flow influenced by precipitations, in proximity of an emissary Slatina rivulet.

Starting from the principle that the environmental risk is defined as the product between the probability of appearance of some threats to the quality of the components of the environment and their consequences (severity of the effects), the base of investigations was relationship source-path-receiver.

Assessment hazard and effects was realized on the basis of the results of quality investigations the soil, groundwater, and leachate transported by stream and surface water flood thus highlighting the sources of danger and their route of transmission.

Ecotoxicological characterizations for surface water and leachate, to taken in consideration the results of acute lethal toxicity tests performed in laboratory on fresh water fishes (Carasius auratus) and acute immobilization of water flea Daphnia Magna Status species (Cladocera crustaceans).

The studies were conducted in accordance with the methods OECD 203 and 202 published in Regulation (EC) 440/2008 with any future changes in Regulation (EC) 761/2009.

Quantifying the risk of occurrence of a serious risk underlined induced of the groundwater and surface water – Slatina rivulet. Development of tree chart of the adverse effects allow formulation of the measures necessary to be applied in risk management process in order to eliminate causes of danger and/or restriction of adverse effects generated of the WATER environment component.

Keywords: pollution, risk assessment, ecotoxicity

Introduction

It is necessary in this study "risk assessment induced by a non-compliant landfill", to answer the questions:

- what are sourses the generate danger;
- what are the characteristics of these dangers – the duration and intensity;

- What environmental components where or will by targate for these dangers;
- Adverse effects on environmental quality of components of the site;
- in what area will be felt the adverse effects;
- What consequences will be to the effects adverse generated.

The study area will include site and surrounding areas of the landfill. The study was developed for waste landfill located in a hilly area, with an energy of about 40 m relief, marked by the presence of streams showing water, spring and rainy seasons.
The landfill has existed for over 40 years and has a deposit area of 25,683 mp.
Observations from the area have revealed next aspects: - landfill site is focused on the valley torrent; - meteoric waters that drain the leachate storage percolate torrent valley; - torrent valley slopes present traces of current geomorphologic processes, landslides; - slopes based on small streams that drain occurring in torrent; - cracks du to landslides (cliffs of separation) facilitates water infiltration into th soil and feeds the little springs at the base of slopes.

Torrent valley downstream of the deposit, on where and leachate flows from storage, is marked by excess moisture (theoozing) because of water accumulation on the slopes in flinch deposits.

The main potential sources of environmental pollution components are due to the mass of waste washing by water from precipitation and which leads to: the formation of leachate; leachate leakage through the bed of the river valley passing through torrent Slatina, infiltration into the groundwater in the landfill until the confluence with the torrent and river Slatina.

Exprimental part

Investigation of leachat quality was archived by collecting and analyzing samples in campaigns in March 2010 and May 2011.
The Table no. 1 presented quality indicators investigated, the methods of analysis used, analyze quality indicators values and limit values permitted according to NTPA001/2005 for dangerous substances according to GD no. 351/2005 for inland and transitional.

Table no. 1

Quality indicators	UM	Limit values according to NTPA001/2005	leachat March 2010	leachat May 2011	Analysis methods
0	*1*	*2*	*3*	*4*	*5*
pH	unit pH	6,5-8,5	7,1	8,2	SR ISO 10523-2009
CCOCr	mg O_2/l	125	**739,2**	**2280**	SR ISO 6060-96
CBO_5	mg O_2/l	25	**242,1**	**761,2**	SR EN 1899/1-03;/2-02
Nitrite	mg/l	1	0,224	<0,006*	SR ISO 6777-96/A99:2002
Nitrate	mg/l	25	**25,69**	**155**	SR ISO 7890/1-00
Amonium	mg/l	2	**136,9**	**514,5**	SR ISO 7150/2-01
Substances extractable with organic solvents	mg/l	20	**<20 (1,0)****	**<20 (1,0)****	SR 7587-96
Total phosphorus	mg/l	1	**2,88**	**1,94**	SR EN ISO 6878:05
Total iron	mg/l	5	**4,7**	**16,89**	SR 13315-96/C91:2008
Total chromium	mg/l	1	**0,286**	**0,294**	SR EN 1233/2003

0	1	2	3	4	5
Cd	mg/l	0,2	0,01	0,019	SR ISO 8288-01
Cu	mg/l	0,1	0,025	0,1	SR ISO 8288-01
Pb	mg/l	0,2	<0,01*	0,196	SR ISO 8288-01
Zn	mg/l	0,5	0,065	0,453	SR ISO 8288-01
Total disolved substances	mg/l	2000	**2324**	**6665**	STAS 9187-84
Ni	mg/l	0,5	-	0,331	SR ISO 8288-01
Phenols	mg/l	0,3	-	**0,323**	SR ISO 6439-01/C96:2006
Sulfates	mg/l	600	-	95	STAS 8601-70
Materials in suspension	mg/l	35	-	**1012**	SR EN 872/2005
According HG no. 351/2005					
Thrichloretylene	µg /l	10	-	<0,05*	SR EN ISO 10301/2003
Thetrachloretylene	µg /l	10	-	<0,05*	SR EN ISO 10301/2003
Chloroform	µg /l	12	-	<0,05*	SR EN ISO 10301/2003

* - method limit values ** - value is for information (limit method is 20 mg/l)

Investigation revealed a leachate as non-compliant. Quality indicators: organics matters (CCOCr and CBO_5), ammonium, nitrate, total phosphorus, filterable residue, total iron, phenols and MTS had values above the limit allowed according to NTPA 001/2005, which induces a significant contribution of pollutants in natural receptor (Slatina river).

To assess the level of environmental pollution of SOIL component in area potentially affected activities in location analysis. Samples were taken from 4 sections on 2 deep levels (0-10 cm, 30-40 cm); 1 section soil – Witness – the same depth from pasture area, in 3 campaigns: March 2010, September 2010 and May 2011.

Samples were taken at distances of approx. 2-4 m from the waste deposit. Analysis methods used it was standard methods.

Investigations on the quality of soil from inside of the landfill, revealed:

- Values of the quality indicators presented changes in time and reflects the influence of activity;
- No recording significant pollution.

To identify the pathway of transmission of pollutants from soil it was investigated the permeability.

Depending on soil permeability test results and other special factors lendfill can highlight the next conclusions:

- meteoric water from lendfill site, thanks to special geomorphological zone, these have the next paths transfer: same will infiltrate into th soil/subsoil to groundwater, and another part will participate in steam flow on the slope (by gually erosion, surface cleaning).

- water infiltration in soil is a process that behavs differently: slow in the presence of clay textures with low hydraulic conductivity and fast in areas where crocks are a direct consequence of the side event geomorfological processes.

- meteoric waters can transporting pollutants in soil by surface cleaning on the slope (reaching directly into the stream) or, by percolation and groundwater leaching.

These are ways of transmitting of the hazard though th soil in area analyzed. Geomorphological peculiarities are identified as target of danger of pollutants in soil to be the torrent crossing th landfill, and the groundwater.

To highligh of the effects induced by the work carried out on underground water , sampls wer takn from the 3 existing monitoring wells on site.

The limit values for quality indicators analyzed according to Law no. 458/2002-Drinking Water Act, supplemented and amended by Law no. 311/2004, for priority hazardous substances limits imposd by GD. 351/2005 and analysis methods used are presentd in Table no.2.

Table no. 2

No.	Quality indicators	Analytical methods	Drinking Water Act Law no. 458/02
1	pH	SR ISO 10523-2005	6,5-9,5
2	CCOCr	SR ISO 6060-96	5
3	MTS	SR EN 872-2005	nenormat
4	Ammonium	SR ISO 7150/2-01	0,5
5	NO_2^-	SR ISO 6777-96/A99:2002	0,5
6	S^{2-}	SR ISO 10530-97	0,1
7	Substances extractibile with organic solvents	SR 7587-96	nenormat
8	Phenols	SR ISO 6439-01/C96:2006	nenormat
9	Total cyanide	SR ISO 6703-1/98	0,050
10	total cromium	SR EN 1233/2003	0,05
11	Nickel	SR ISO 8288-01	0,02
12	Lead	SR ISO 8288-01	0,01
13	Zinc	SR ISO 8288-01	5
14	Copper	SR ISO 8288-01	0,1
			HG no. 351/2005
15	Trichlorbenzene	SR EN ISO 6468-00	0,4
16	Trichloretylene	SR N ISO 10301-03	10
17	Tethrachloretylene	SR N ISO 10301-03	10
18	Anthracene	SR EN ISO 17993-04	0,063
19	Chloroform	SR N ISO 10301-03	12
20	Dichlormethane	SR N ISO 10301-03	8,2
21	Hexachlorbenzene	SR EN ISO 6468-00	0,0004
22	Naphthalene	SR EN ISO 17993-04	2,4
23	HAP	SR EN ISO 17993-04	0,1
24	Octylphenol	SR EN ISO 18857/1-07	0,122

The results of investigations made in campaigns: March, June, Sptember 2010 and March 2011 are presented in Table no. 3.

Table no. 3

Quality indicators	unit	March 2010		June 2010	September 2010			March 2011		
		F1	F2	F3	F1	F2	F3	F1	F2	F3
0	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Hydrostatic level	m	-0,4	-1,2	0	- 0,6	- 1,1	+ 0,3	0	-1	0
Depth	m	9,0	6,0	-	-	-	-	-	-	-
pH	unit pH	7,4	6,9	7,1	7,4	6,8	7,4	7,0	6,7	6,9
CCOCr	mg O_2/l	**12**	**6**	**9,6**	**6,12**	**9,0**	2,88	3,6	**6,8**	3,2
MTS	mg/l	23	76	108	16	34	22	12	32	14
NH_4^+	mg/l	0,257	0,243	0,175	0,256	**0,864**	0,122	0,23	**0,73**	0,12
NO_2^-	mg/l	0,018	0,028	0,316	0,01	0,053	0,023	<0,006*	0,18	0,13
S^{2-}	mg/l	<0,02*	<0,02*	<0,02*	<0,02*	<0,02*	<0,02*	<0,02*	<0,02*	<0,02*

0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Substances extractibile with organic solvents	mg/l	<20 (0,1)**	<20 (0,1)**	<20 (0,1)**	<20 (0,2) **	<20 (0,1) **	<20 (0,2) **	<20 (0,1) **	<20 (0,1) **	<20 (0,4**)
Phenols	mg/l	0,011	0,013	0,01	0,015	<0,002*	<0,002*	0,02	0,02	0,025
Total cyanide	mg/l	<0,002*	<0,002*	<0,002*	-	-	-	<0,002*	<0,002*	<0,002*
Cr total	mg/l	<0,005*	<0,005*	<0,005*	-	-	-	0,02	0,02	0,02
Ni	mg/l	<0,004*	<0,004*	<0,004*	-	-	-	**0,07**	0,02	0,013
Pb	mg/l	<0,01*	<0,01*	<0,01*	-	-	-	**0,028**	**0,031**	0,01
Zn	mg/l	0,127	0,047	0,018	-	-	-	0,036	0,02	0,013
Cu	mg/l	0,008	0,009	0,009	-	-	-	<0,003*	0,005	0,004
Trichlorbenzene	µg/l	<0,005*	<0,005*	<0,005*	-	-	-	<0,005*	<0,005*	<0,005*
Trichloretylene	µg/l	2,06	1,57	<0,05*	-	-	-	0,33	0,42	<0,05*
Tethrachloretylene	µg/l	**46,78**	**30,07**	<0,05*	-	-	-	0,38	0,36	<0,05*
Anthracene	µg/l	<0,02*	<0,02*	<0,02*	-	-	-	<0,005*	<0,005*	<0,005*
Chloroform	µg/l	5,61	4,01	<0,05*	-	-	-	0,13	1	0,88
Dichlormethane	µg/l	<0,05*	<0,05*	<0,05*	-	-	-	<0,05*	<0,05*	<0,05*
Hexachlorbenzene	µg/l	<0,005*	<0,005*	<0,005*	-	-	-	<0,005*	<0,005*	<0,005*
Naphthalene	µg/l	<0,005*	<0,005*	<0,005*	-	-	-	<0,005*	<0,005*	<0,005*
HAP	µg/l	<0,005*	<0,005*	<0,005*	-	-	-	<0,005*	<0,005*	<0,005*
Octylphenol	µg/l	<0,01*	<0,01*	<0,01*	-	-	-	<0,01*	<0,01*	<0,01*

* - method limit values ** - value is for information (limit method is 20 mg/l)

There was evidence of impaired the groundwater quality: the presence in all monitoring campaigns of an organic load (expressed as COD) over the allowed limit, recording values as indicators of ammonium, phenols, nickel and lead than legally allowed limit values.
To quantify the risk induced on ground water were used the following criteria:

Risk = P x C

where: P – the likelihood of danger;
C – consequences (severity) effects on the environment

Quantifying probability of occurrence (P) is on a scale of 1 to 4, whose conversion is:
1 = unlikely
2 = very small probability
3 = moderate probability
4 = highest likelyhood

Quantification of consequences (C) is also on a scale of 1 to 4, whose conversion is:
1 = minor effects (local, with low risk to the environment);
2 = moderate effects (hazardous to the environment)
3 = serious effects (spills of toxic materials that pose a threat to the environment)
4 = catastrophic effects (the environmental damage in all it's components, with reduced neutralization and long recovery)

When $R \geq 6$ is considered a significant environmental impact.

Table no. 4 Risk assessment induced to groundwater

Activity	Danger	Likelyhood (P)	Receiver	Effects	Gravity	Risk
Non-compliant waste storage	leaching by rainwater deposit and training of contaminants (organic loading content, ammonium, metals);	**4**	Under-ground water	- deterioration of groundwater quality	**2**	**8**
	- the spreading of material deposited on the land site; - leaks of contaminated water on the ground of site;	**3**	Soil/ subsoil and under-ground water	- afected de terain quality on site; - migration of contaminants in ground water; - deterioration of groundwater quality	**2**	**6**

<u>Induced effects on surface water quality by waste disposal area</u>

The investigation realized in the area followed assessing the environmental pollution of surface water component and sampling consisted of Slatina river areas upstream and downstream of the confluens with the torrent in months: Martch, June, September, Octomber 2010 and Martch, May 2011.
Interpretation of results was done according to Order no. 161/2006 approving the Norms concerning the classification of surface water quality in order to establish the ecological status of water bodies which provides five ecological status for rivers and natural lakes: very good (I), good (II), moderate (III), weak (IV) and bad (V) on the basis of quality chemical and physico-chemical, biological and hydromorphological.

The results of investigations carried out on surface water quality and sediment discharge upstream and downstream torrent highlights:

- torrent cumulated leachat generated by rainwater percolating deposit surface and present fluctuating flow values;

- discharge to the river Slatina lead to change it's flow and quality downstream of the confluence;

- contribution to the torrent in organic loading, ammonium, nitrate, total phosphorus and metals (Cu, Fe, Pb, Ni) leads to charges in river quality status of most cases occurring in downstream (V) poor quality class.

Table no. 6. The results of investigation

Nr	Quality indicators	Unit	Marth 2010		June 2010		September 2010		Octomber 2010		Marth 2011		May 2011	
			up	down	up	down	up	down	up	down	up	down	up	down
1	pH	unit pH	7,9	8,0	7,9	6,5	8,1	7,7	8,2	7,3	7,2	7,5	8,1	8,1
2	CCOCr	mg O_2/l	16	96,8	23,5	614	24	139,2	25	124	17,2	24	72	436,8
3	CBO_5	mg O_2/l	7,1	35,1	6,9	210	8,8	47,3	10	39	4,6	6,9	20,4	143,7
4	$N\text{-}NH_4^+$	mgN/l	0,04	14,6	0,095	108,9	0,169	3,79	0,163	37,02	0,127	8,63	0,113	78,87
5	$N\text{-}NO_3^-$	mgN/l	0,34	1,35	0,81	6,4	0,296	4,15	0,325	2,93	0,84	1,42	0,143	5,72
6	$N\text{-}NO_2^-$	mgN/l	0,032	0,053	0,008	0,077	0,005	0,46	<0,006*	<0,006*	0,01	0,09	<0,006*	<0,006*
7	P total	mg/l	0,099	0,396	0,01	1,28	0,086	0,228	0,108	1,04	<0,02*	<0,02*	0,045	0,665
8	Total disolved substances	mg/l	1084	1204	1370	3552	3170	3408	3104	3178	1350	1390	2320	3280
9	SO_4^{2-}	mg/l	-	-	-	-	-	-	-	-	-	-	102	153
10	Cr total	mg/l	<0,005*	<0,005*	<0,005*	0,16	<0,005*	<0,005*	<0,005*	<0,005*	0,023	0,019	<0,005*	0,019
11	Cu	mg/l	0,01	0,012	0,011	0,027	0,008	0,009	<0,003*	0,069	0,005	0,004	0,01	0,024
12	Zn	mg/l	0,014	0,031	0,015	0,074	<0,001*	0,006	<0,001*	0,012	0,008	0,016	0,008	0,122
13	Cd	mg/l	0,007	0,008	0,007	0,014	0,009	0,016	0,01	0,012	<0,001*	<0,001*	0,009	0,014
14	Pb	mg/l	<0,01*	<0,01*	<0,01*	<0,01*	<0,01*	0,096	0,08	0,088	0,022	0,032	<0,01*	0,082
15	Fe total	mg/l	1,0	1,04	0,98	1,98	1,83	8,96	0,47	0,96	0,96	0,98	2,8	15,65
16	Nickel	mg/l	-	-	-	-	-	-	-	-	-	-	0,056	0,119
17	Phenols	mg/l	-	-	-	-	-	-	-	-	-	-	0,007	0,016
18	Thrichloretylene	µg /l	-	-	-	-	-	-	-	-	-	-	-	<0,05*
19	Thetrachloretylene	µg /l	-	-	-	-	-	-	-	-	-	-	-	<0,05*
20	Chloroform	µg /l	-	-	-	-	-	-	-	-	-	-	-	<0,05*

Ecological status under Ordr no. 161/2006	I	II	III	IV	V
	very good	good	**moderate**	weak	bad

For ecotoxicological caracterization and assesment of the effects generate by:

- leachate derived from municipal landfill site;
- and natural receptor – Slatina river (downstream of the point of discharge of leachate) were conducted in laboratory acute lethal toxicity studies with different organisms, characteristic of two rings of the food chain, namely:

- acute lethal toxicity test dulcicoli fish (*Carassius auratus* 1 year old) – accordance with OECD Method 203;
- acute immobilization test with Daphnia magna Status *(Cladocera Crustacea)* – accordance with OECD Method 202;

Ecotoxicological data presented above have highlighted the following issues:

- tested waters (leachate and surface water – downstream) presents acute toxic effects on fish (Carasius auratus) and crustaceans (Daphnia magna);
- increased toxic effects of leachate sample stands out, which should reduce the toxicity of these waters, to the no observed effect concentration of all organisms studied, for example, by performing a dilution of 1:99;
- surface water samples taken downstream of the point of discharge of leachate revealed acute toxic effects on aquatic organisms; This water can be considered the quality of wastewater in view of the physico-chemical content and toxicity.
- Leachate sample are included in Class IV – hight acute toxicity to aquatic and surface water samples – downstream in Class III – acute toxicity to aquatic life.

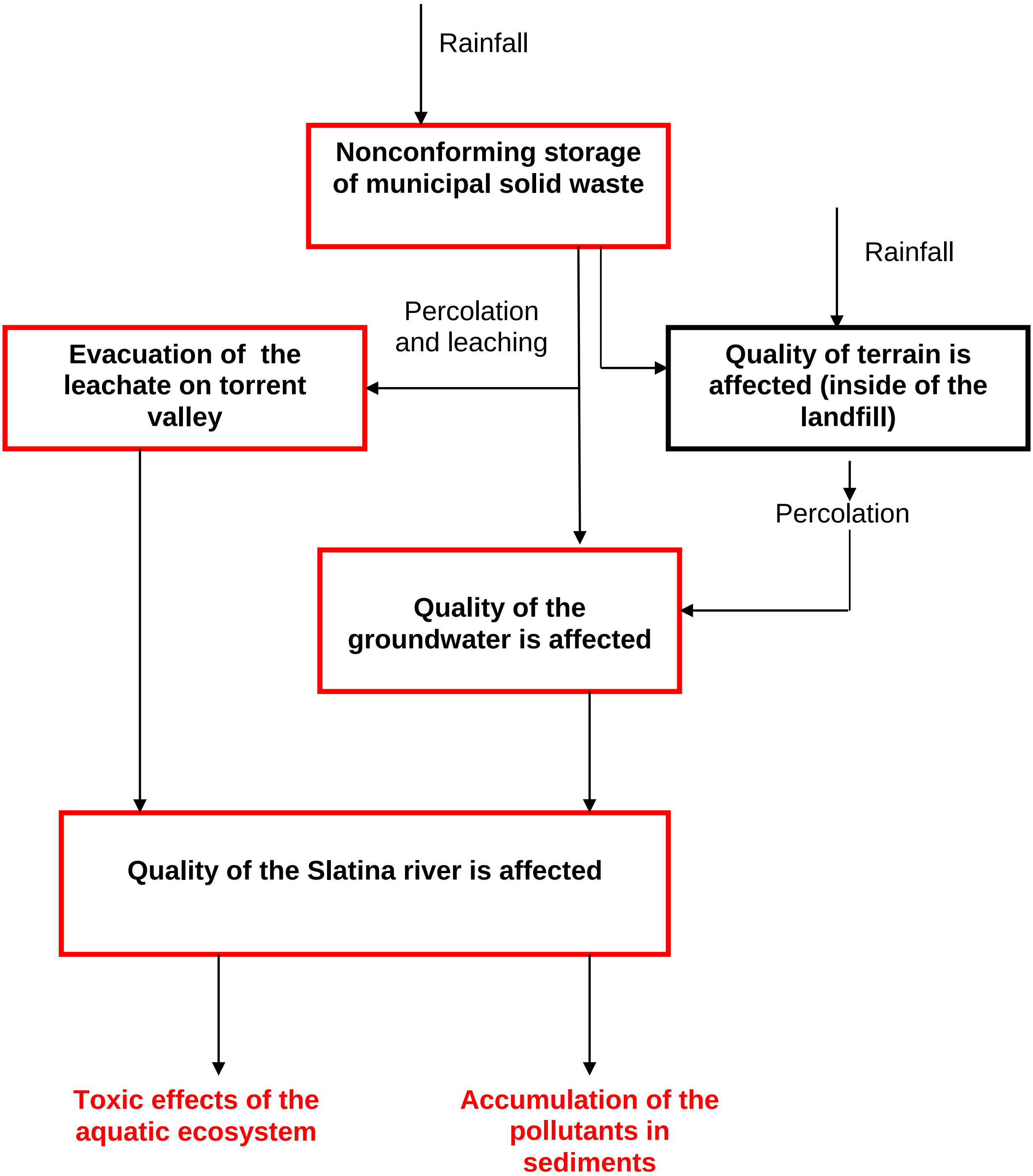
Table nr. 6 Risk assessment induced to natural receptor - Slatina river

<table>
<tr><th>Activity</th><th>Danger</th><th>Likelyhood (P)</th><th>Receiver</th><th>Effects</th><th>Gravity</th><th>Risk</th></tr>
<tr><td rowspan="2">Storing non-compliant household waste</td><td>- Deposited by percolating meteoric waters;
- Training of contaminants in groundwater;</td><td>4</td><td>Contaminant transport in groundwater and surface water</td><td rowspan="2">- Slatina river degradation downstream of deposit
- Accumulation of contaminants in sediment
-acute toxic effects on aquatic ecosystem</td><td rowspan="2">3</td><td rowspan="2">12</td></tr>
<tr><td>- Deposited by percolating rainwater and leachate disposal torrent valley formed insurface water
- Transport of contaminants (organic loading, ammonia, nitrates, metals content, etc.) in surface water</td><td>4</td><td>Surface water (river Slatina receiver)</td></tr>
</table>

CONCLUSIONS

- Environmental risk assessment generated by activities carried out by Tg. Neamt municipal waste disposal was performed in accordance with the methodology stipulated in MAPPM Order no. 184/1997, Annex A.4.
- Based on the principal that environmental risk is the product between the likelihood of harm the quality of environmental components and their consequences (severity of effects), the analyses was conducted on the sours-pathway-receptor relationship.
- The "tree diagram" highlights the adverse effects of the generated causes of danger and induced effects:
  - leaching by the rainwater of landfill conduct to formation of leachate and affect the quality of the groundwater;
  - the leachate discharge directly in torrent valley (in rainy periods) generates the degradation of the Slatina river quality and to appear a acute toxic effects on aquatic ecosystem.
- Following the elimination of the causes of danger and/or limit/eliminate adverse effects on environmental component WATER (surface and underground water) is recommended to apply the following steps in the process of the risk management:
  - Torrent route change by creating a improvement to stop crossing the landfill: routing to upstream and discharge in river downstream of landfill;
  - Fitting of guard channels for rainwater run-off taking on the slopes from the proximity of the landfill, all its contour, to limit the penetration of mass of the landfill and direction to the downstream;
  - development of amenities: drainage systems and leachate collection and application of a treatment process before discharge into a natural receiver;
  - realize of waste storage in landfill so that to minimize the spread of waste, without affecting the soil nearest landfill and the associated structures (guard channels, drains);
  - development works of the surface of landfill at reaching the final rate in accordance with GD 349/2005 with a waterproof layer over which will add a layer of topsoil for the installation of herbaceous vegetation (grasses). This will achieve a reduction in the amount of water that percolation of deposit, which will induce and reduce the amount of leachate results;
  - continue monitoring quality of the surface and groundwater.

TREE DIAGRAM of the adverse effects



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