AES BIOFLUX
Advances in Environmental Sciences - International Journal of the Bioflux Society

Determinations regarding the influence of the leachate drainage to surface water bodies adjacent to municipal landfills

[1]Dan-Vlad Jaşcău, [1]Alin Pop, [2]Liana Mureşan, [1]Elena M. Pică

[1] Faculty of Materials and Environmental Engineering, Technical University Cluj-Napoca, Romania; [2] Environmental Protection Agency Cluj-Napoca, Romania. Corresponding author: D. V. Jaşcău, jascau.dan@im.utcluj.ro

Abstract. Waste storage represents a global practice, thus many problems regarding the quality of the environment and human health occur. In Romania, the landfill issue is similar to an environment crisis with significant repercussions on the environment, especially because of the large number of non-compliant municipal landfills. The placement of the municipal landfills near the surface waters increases the degree of exposure and the risk of contaminating the waters with pollutants from the complex composition of the leachate. The current study shows a municipal landfill located near surface water and analyses the composition and the pollution degree generated by the leachate drained in the body of the surface water.
Key words: environment, surface water, pollutants, waste landfill.

Introduction. The leachate resulted from the non-compliant municipal waste landfills is a complex liquid, loaded with pollutants drained from landfilled wastes. The causes of leachate production are in general precipitations, evaporation, surface runoff or infiltrations (Heyer & Stegmann 2001). US-EPA (United States-Environmental Protection Agency) explain the leachate comparing it with coffee (the water that passes down through the ground) (US-EPA 2012).

The regimen regarding the quantity and the quality of the leachate is influenced by o few important factors like climatic conditions in the placement area of the waste landfills, open surface of waste landfills, exploitation methods or composition of landfilled wastes. The high potential of water contamination by leachate from the waste landfills has led to important concerns to reduce its quantity (SEPA 2000).

Yin et al (2009) conducted an experimental study in order to reduce the quantity of leachate by using sawdust. It was revealed that by applying a layer of sawdust at the bottom of the waste landfill, the quantity of leachate is reduced by up to 600 m^3 to 500 tons of degrading waste.

Numerous studies have shown the negative impact of leachate on surface and ground waters near municipal waste landfills (Sadej et al 2009; Fatta et al 1999; Mor et al 2006). The leachate generated by municipal solid wastes from non-compliant waste landfills has become a serious environmental issue in many cities around the world (Kale et al 2009).

One of the most important factors regarding the causes of the quantities of leachate generated nationally derives especially from the structure of municipal wastes, where it is registered 57.82% of biodegradable wastes that represent the wet fraction of municipal wastes (NEPA 2012).

In Romania, in the beginning of 2014 there were 33 waste landfills that were compliant with the legal dispositions and a number of 46 non-compliant municipal waste landfills, which will cease their activity during 2014-2017, which is mandatory by the legal frame.

Another 55 municipal waste landfills have ended their activity during 2010-2014 including the 6 municipal waste landfills in Cluj County, where the current study was conducted (NEPA 2014; Official Gazette 2005). This emphasizes the importance and ampleness of surface waters contamination by leachate drainage in surface and ground waters.

Because of the lack of compliant waste landfills in Cluj County or systems for collecting the leachate generated in non-compliant waste landfills, there was registered leachate drainage in surface and ground waters, leading to severe effects on the environment (Nyame et al 2012).

The current study aims to analyse the impact of the leachate generated from the non comliant municipal waste landfill of Huedin city upon the surface waters in its vicinity. Therefore, there have been taken water samples from the Crisul Repede river in the upstream and downstream of the leachate leakage confluence with the Crisul Repede river.

Material and Method

Study area. The study area is located in the North-West region of Romania, in Cluj County, at the Huedin city boundary. Huedin city has a surface of 61 km^2 and an altitude of 556 m. It is crossed by the Crisul Repede river, Cluj-Oradea railway and the E 60 European road (www.primariahuedin.ro). The number of inhabitants is 9.346 according to the latest census from 2011 (NIS 2014).

The municipal waste landfill is located between the following geographical coordinated: 46°52'31.52'' N and 46°52'26.60'' N North Latitude and 23° 0'5.20'' E and 23°0'22.90''E East Latitude.

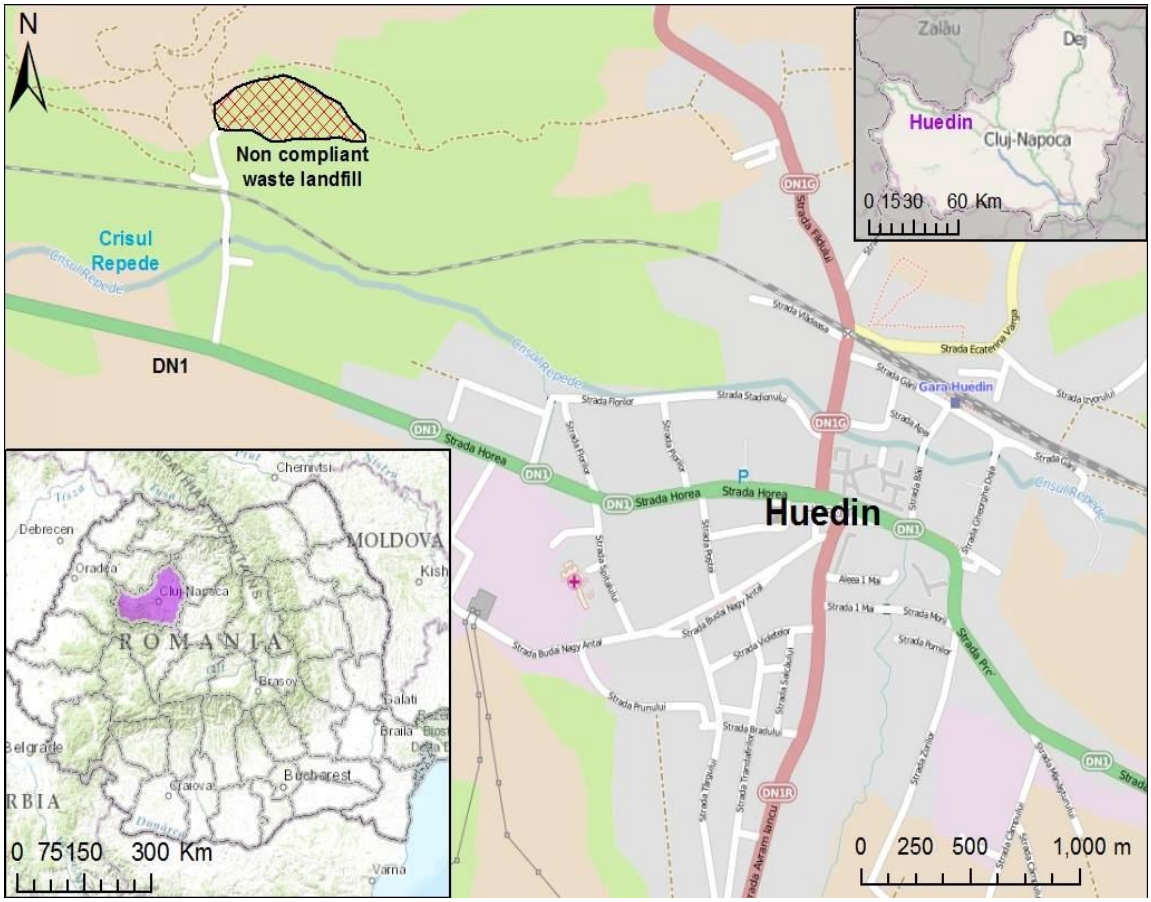

Figure 1. Location of the non-compliant municipal waste landfill and vicinity (QGIS 2012).

In the vicinity of the landfill there are pastures and agricultural lands in the Northern and Eastern region, Crisul Repede river (located on a distance of approximately 300 m) and

agricultural lands in the Southern region and houses in the Western region at a distance of 100 m (Figure 1).

The municipal waste landfill has been functioning since 1970 and used for the storage of mixed municipal wastes (Figure 2). In 2009, its surface reached 1.19 ha with a stored quantity of 171.667 m^3. The height of the wastes was approximately 10-12 m. During 2009-2012, a volume of 79.127 m^3 was deposited, which led to the waste landfill's surface increase (Cluj County Council 2014).

Figure 2. The Huedin non-compliant waste landfill.

Sampling. The water samples were taken in the dry season, at the end of July (31.07.2014). Even so, rain still occurred during that period of time. At the time when the samples were collected, the weather conditions were favorable (T = 25^{o}C). A Global Positioning System (GPS) was used for locating the sample prelevation points.

The GPS data was introduced in the Google Earth program with the aim of locating exactly the prelevation points of the samples from the Crisul Repede river (Figure 3). The GPS coordinates of the P1 prelevation point are: 46°52'16.31"N, 23° 0'3.90"E, and for the P2 prelevation point are: 46°52'16.26"N, 23° 0'3.23"E.

Figure 3. The prelevation points of the surface water samples (Google Earth 2009).

Two prelevation points were established, named P1 - Upstream prelevation point and P2 - Downstream prelevation point. The water samples were taken in demineralized containers and labeled. In P2 prelevation point (Downstream) it was considered taking the sample from the optimal mixing point of the leachate drained in the surface water. In the Figure 4a there can be seen the drainage ditch of the leachate towards the Crisul Repede river. Figure 4b shows the confluence and mixing point of the leachate with the surface water.

Figure 4a. The leachate's drainage ditch.

Figure 4b. The leachate-water mixture.

Sample evaluation. The samples collected were transferred to the analysis laboratory 1 hour after they were taken, while being kept cool. The samples were analyzed according to the standard water analysis methods. For each sample taken there were determined the following physical and chemical parameters: temperature (°C), pH (pH units), electrical conductivity (µS/cm), COD (Chemical Oxygen Demand - Mn), (mg O_2/L), N (mg N/L), NH_4^+ (mg/L), NH_3 (mg/L), P (mg/L) and $(PO_4)^{3-}$(mg/L).

The physical indicators (pH, electrical conductivity and temperature) were analyzed in the laboratory with WTW 340i multiparameter (Wissenschaftlich-Technische Werkstätten).

Results and Discussion. The water samples analyzed, underline the impact of the leachate drained in Crisul Repede river. Table 1 presents the physical water quality indicators. An important factor in this study is the dilution (the dilution degree) of the leachate in the surface water.

The estimated flow of the leachate drainage at its confluence with Crisul Repede river is approximately 1-3 L/s and the Crisul Repede river's flow can reach 1-2 m^3/s in the area of confluence with the leachate generated by the municipal waste landfill.

Table 1

The analysis results for physical indicators of the water samples

Sample	*Temperature [°C]*	*pH*	*Conductivity [µS/cm]*
P1 (upstream)	23.7	7.84	705
P2 (downstream)	24.1	7.85	765

The results regarding the pH and electrical conductivity of the samples indicate an insignificant difference between the two prelevation points, remaining within the normal range.

Table 2 offers data about the chemical indicators analyzed from the two samples. A significant difference can be observed in the case of COD-Mn where, in P2 prelevation point, the concentration value is 3 times higher compared with P1 prelevation point. The N_{total}, NH_4^- and NH_3 concentration increases 5 times downstream, while in the case of $(PO_4)^{3-}$ and P_{Total} , the increase is insignificant.

Table 2

The analysis results for chemical indicators of water samples

Sample	*COD-Mn [mgO_2/L]*	*N_{Total} [mg/L]*	*NH_4^- [mg/L]*	*NH_3 [mg/L]*	*$(PO_4)^{3-}$ [mg/L]*	*P_{Total} [mg/L]*
P1 (upstream)	8.18	0.34	0.44	0.41	0.48	0.16
P2 (downstream)	26.25	1.84	2.37	2.24	0.54	0.18

Figure 5 was realised with the purpose of stressing the differences recorded between the two water samples prelevation points. The negative impact of the leachate on the quality of the surface water from Crisul Repede river can be seen, despite the significant dilution degree. Up next a comparison of the results obtained with the surface water quality regulations is presented.

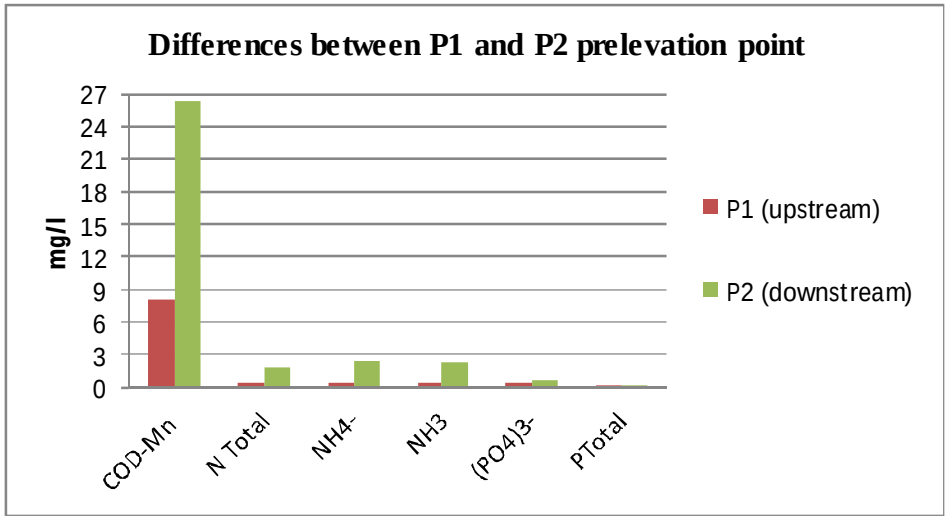

Figure 5. The difference between the results of the analysis in P1 and P2 prelevation points.

In Romania, the 161/2006 Order classifies surface waters on five classes, according to their ecological state: I - Very good, II - Good, III - Moderate, IV - Weak, V – Bad (Official Gazette 2006). Table 3 was carried out in order to see the differences and to simplify the process of evaluating the quality of the analyzed surface water. It presents the results obtained according to the values of each water quality class.

Table 3

Classification of the results obtained in the water quality class

Sample	*COD-Mn*	*N_{Total}*	*NH_4^-*	*NH_3*	*$(PO_4)^{3-}$*	*P_{Total}*
P1 (upstream)	Class II	Class I	Class II	Class I	Class IV	Class II
P2 (downstream)	Class IV	Class II	Class IV	Class II	Class IV	Class II

There can be seen some changes in the quality of the water, especially in the COD-Mn and NH_4^- indicators which pass from the "Good" quality class (II) to the Weak quality class (IV). Excepting $(PO_4)^{3-}$ and $P_{Total,}$ which don't suffer changes regarding the water quality class, all the other factors pass from a superior quality class to an inferior quality

class. The quality of the water in P1 prelevation point fails in the first and second classes except for $(PO_4)^{3-}$ which fails in the fourth quality class.
The source of this indicator may be caused by the evacuation of treated waters in the Crisul Repede river. The water treatment plant in Huedin city is located at a distance of approximately 150-200 m upstream from the P1 prelevation point.

The quantity of leachate taken by the Crisul Repede river varies according to the season or the quantity of precipitations. Therefore, the concentrations of the analyzed indicators may show fluctuations.

Due to the lack of the landfill surface layer, the influence of the quantity of rainfall is an important factor regarding the generation of leachate quantities.
Also, the composition of the landfilled waste is another factor that influences leachate generation.

According to the National Report on the State of Environment (NEPA 2012), the composition of waste in Romania is dominated by the wet fraction of municipal solid wastes, which is biodegradable waste.

The amount of biodegradable waste is 57.82% from the total of the municipal wastes generated and collected (NEPA 2012). This type of waste generates large quantities of leachate compared to the other types of waste in the municipal solid waste structure. On a legal level, evacuation of the polluted waters that exceed the limits established in the technical normative before mentioned is forbidden, with the aim of protecting the population's health and the environment (Official Gazette 2002).

Conclusions. The study regarding the determination of the contribution of the leachate drained in surface waters shows that there is a negative influence of the leachate generated by the non-compliant municipal waste landfills on the quality of surface waters.

Also, in the case of $(PO_4)^{3-}$, high values occur upstream from the confluence of drainage leachate from the non-compliant municipal waste landfill with the Crisul Repede river. The high value from the P1 prelevation point (Upstream) may be determined by the evacuation of the water from the wastewater treatment plant in Huedin.

It can be seen in most of the analyzed indicators that the quality of the water decreases in P2 prelevation point compared to P1 prelevation point from the "Very Good" state (I) to the "Good" state (II) or from the quality "Good" class (II) to the "Weak" class (IV).

Collection and treating the leachate generated by the non-compliant municipal waste landfill are necessary for avoiding leakage in surface waters. These steps are imposed by the law.

The closure of the non-compliant municipal waste landfill in Huedin city is necessary and represents a priority for decreasing the impact on human health and on the environment, generated by the leachate drainage in the surface and ground waters.

The presence of the non-compliant municipal waste landfill turned the area into a vulnerable and exposed to pollution area. The analysis of the leachate before the confluence with the Crisul Repede river and the analysis of the heavy metals in the surface water highlights the impact created by the leachate drainage in surface waters near the non-compliant waste landfills.

Acknowledgements. This paper is supported by the Sectorial Operational Programme Human Resources Development POSDRU/159/1.5/S/137516 financed from the European Social Fund and by the Romanian Government.

References

Fatta D., Papadopoulos A., Loizidou M., 1999 A study on the landfill leachate and its impact on the groundwater quality of the greater area. Environ Geochem Health 21:175-190.

Heyer K. U., Stegmann R., 2001 Leachate management: leachate generation, collection, treatment and costs. Ingenieurbüro für Abfallwirtschaft. On line at: http://www.ifas-hamburg.de/pdf/leachate.pdf
Kale S. S., Kadam A. K., Kumar S., Pawar N. J., 2009 Evaluating pollution potential of leachate from landfill site, from the Pune metropolitan city and its impact on shallow basaltic aquifers. Environ Monit Assess 162:327-346.
Mor S., Ravindra K., Dahiya R. P., Chandra A., 2006 Leachate characterisation and assessment of groundwater pollution near municipal solid waste landfill site. Environ Monit Assess 118:435-456.
Nyame F. K., Tigme J., Kutu J. M., Armah T. K., 2012 Environmental implications of the discharge of municipal landfill leachate into the Densu River and surrounding Ramsar Wetland in the Accra Metropolis, Ghana. J Water Resource Prot 4:622-633.
Sadej W., Lulinski Z., Posluszny J., 2009 Impact of municipal landfills on quality of ground and surface waters. Contemporary Problems of Management and Environmental Protection 4:71-93.
Yin J., Jiang B., Wu X., Liang L., Liu X., 2009 Study on reducing leachate production by saw powder adding. J Water Resource Prot 4:281-285.
*** http://www.primariahuedin.ro/
*** Cluj County Council (CCC), 2014 On line at: https://www.google.ro/#q=depozitu+de+deseuri+menajere+neconform+huedin+2014
*** Google Earth, 2009 US Department of State Geographer, Geo Basis.
*** NIS - National Institute of Statistics, 2014 On line at: http://www.recensamantromania.ro/rezultate-2/
*** NEPA - National Environmental Protection Agency, 2012 Annual report - The state of the environmental factors in Romania, Chapter 6, Waste Management, pp.171. On line at: http://www.anpm.ro.
*** NEPA - National Environmental Protection Agency, 2014.The situation of municipal waste landfills, Romania, pp.1. On line at: http://www.anpm.ro/docfiles/view/132747
*** Official Gazette of Romania, 2006 Order 161/2006, part I, No. 511/13.06.2006.
*** Official Gazette of Romania, 2005 Law 349/2005, Part 1, No. 394/10.05.2005.
*** Official Gazette of Romania, 2002 Technical regulations establishing load limits pollutant industrial and municipal wastewater to discharge into the natural receptors, No. 187/20.03.2002.
*** Quantum GIS (Geographic Information System) Development Team, 2012. Quantum GIS-Geographic Information System, Open Source Geospatial Fundation Project. On line at: http://qgis.osgeo.org
*** SEPA - Swedish Environmental Protection Agency, 2000 Leachate emissions from landfills, Swedish Environmental Protection Agency, Stockholm, Sweden, ISSN 1102-6944, pp.5.
*** US-EPA, 2012 United State - Environmental Protection Agency. On line at: http://www.epa.gov/pesticides/glossary/f-l.html#l

Rceived: 12 February 2015. Accepted: 14 April 2015. Published online: 24 April 2015.
Authors:
Dan-Vlad Jaşcău, Technical University of Cluj Napoca, Materials and Environmental Engineering Faculty, Romania, Cluj Napoca, Muncii Avenue, No. 103-105, e-mail: jascau.dan@im.utcluj.ro.
Alin Lenuţ Pop, Technical University of Cluj Napoca, Materials and Environmental Engineering Faculty, Romania, Cluj Napoca, Muncii Avenue, No. 103-105, e-mail: av.alinpop@yahoo.com.
Liana Mureşan, Environmental Protection Agency, Romania, Cluj-Napoca, Dorobantilor Street, No. 99, e-mail: liana.muresan@arpmcj.anpm.ro.
Elena Maria Pică, Technical University of Cluj Napoca, Materials and Environmental Engineering Faculty, Romania, Cluj Napoca, Muncii Avenue, No. 103-105, e-mail: empica@yahoo.com.

How to cite this article:
Jaşcău D.-V., Pop A. L., Mureşan L., Pică E. M., 2015 Determinations regarding the influence of the leachate drainage to surface water bodies adjacent to municipal landfills. AES Bioflux 7(2):252-258.