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VARIATION IMPACT LEACHATE FROM LANDFILLS BRIJESNICA ON QUALITY OF SURFACE AND GROUND WATER

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ABSTRACT

Regional Landfill Brijesnica is located in the northeastern part of Bosnia and Herzegovina, and the western part of the municipality of Bijeljina, and began work in 2010, with an approximate area of 4.5 ha. The sanitary cells are built with protective insulating materials - special geomembranes and other materials that guarantee the protection of groundwater. The landfill has a system to collect leachate and biogas collection system. An equalization pool was built to accept leachate with a recirculation system with the return of leachate into the cell. Leachate from the equalization basin is in the monitoring period directly discharged into surface flows (Majevički kanal).

In this study, to determine the state of pollution of surface and groundwater first a hydrogeological analysis of the immediate area of the landfill was done. The analysis of the results of the monitoring of leachate, surface water and groundwater in this dump for a period of four years was done. Monitoring of these waters was made in all four seasons during several hidrological years in order to define a degree of pollution of surface and groundwater. Based on the results of analysis the undeniable impact of leachate from the landfill to the surface was determined but not in groundwater.

Keywords: *seepage, surface water and groundwater, the level of pollution*

INTRODUCTION

Regional landfill "Brijesnica" is located in the west of Bijeljina Municipality. It is about 2 km away from the eastern part of town, and about 1.5 km away from north-western and western side. Currently, the first and second landfill cells, approximately 4.5 ha, are in operative phase, i.e. in the phase of disposing waste.

Waste from the municipality of Bijeljina and four neighboring municipalities in the region (Ugljevik, Teočak, Lopare i Čelić) is disposed at this regional landfill. The landfill was build and put into operation in 2010 with the aim of rehabilitating the existing and constructing a new regional sanitary landfill within the World Bank project "Solid waste Management in B&H".

Protective isolation materials are built in sanitary cells – special geo-membranes and other materials, which guarantee protection of groundwater. Landfill has a leachate collection system and a biogas collection system. Problem with removing surface and groundwater from the landfill "Brijesnica" was

solved by installing the system of longitudinal and transversal PE and concrete drainage pipes. For of evacuation of superficial outtake, a network of protective channels was built along the edge of operational body. Thus, all leachate from the landfill is collected through drainage channels (pipes) and brought in waterproof pool. A modern device for leachate treatment constructed and put into operation in 2014 at this landfill; it works on the principle of reverse osmosis.

At the wider region of sanitary landfill location (diameter 1.5 km) are located stream Brijesnica and Majevički kanal. The stream Brijesnica with torrential character collects water from surrounding hills below the village of Brijesnica. The stream dries up during the summer and in winter drains the atmospheric water (data on water flow and water quality do not exist). Brijesnica stream flows into Majevički kanal at about one mile north of the landfill. In the topographic terms the position of Majevički kanal is such that all surface water from the area of the landfill gravitates toward it.

The drainage channel that collects storm water from the hills above the landfill and from the village Brijesnica flows into Majevički kanal in the south side of the landfill. Regional Landfill is located at the area west of the route of Majevički kanal, whose direction is south - north from watercourse Dašnica, and on the west side it borders the village of Hase.

The landfill is protected from mountain waters by circumferential channel as well as by circumferential channel on the north side which flows into Majevički kanal. To the south of the landfill is located a drainage channel that drains flood waters from the surrounding hills and from the village of Brijesnica.

Total of eight monitoring wells were constructed at the landfill for the purpose of grounwater monitoring. Those monitoring wells are located in two profiles perpendicular to Majevički kanal, and the installation was performed immediately upon completion of the drilling process. Position of monitoring wells is shown in distribution scheme of of measurement points (Figure 2).

Analyzing geomorphological forms of relief in wide area of research, as well as geological structure of the wider area, we can reliably say that there are two hydro complexes in the research area and wider, which clearly define terrain hydrogeological conditions by their characteristics and functions. Detailed investigations of the micro location of the future landfill clearly confirmed this concept. Generally, from the hydrogeological point of view, the terrain represents a bilayer environment where top, roof seam layer (silty - clayey sediments) represents a relative hydrogeological barrier, while the lower, gravel layer, represents relative hydrogeological collector - reservoir of underground water (Figure 1).

It has been proved through several works that landfills or open damps represent serious threaten to surface and underground water resources [1], especially those landfills that are constructed and operate without impermeable layers for reduction of potential contamination. The danger degree largely depends on waste composition at the landfill and generated leachate volume, as well as landfill location in relation to the water body, groundwater and surface water [2].

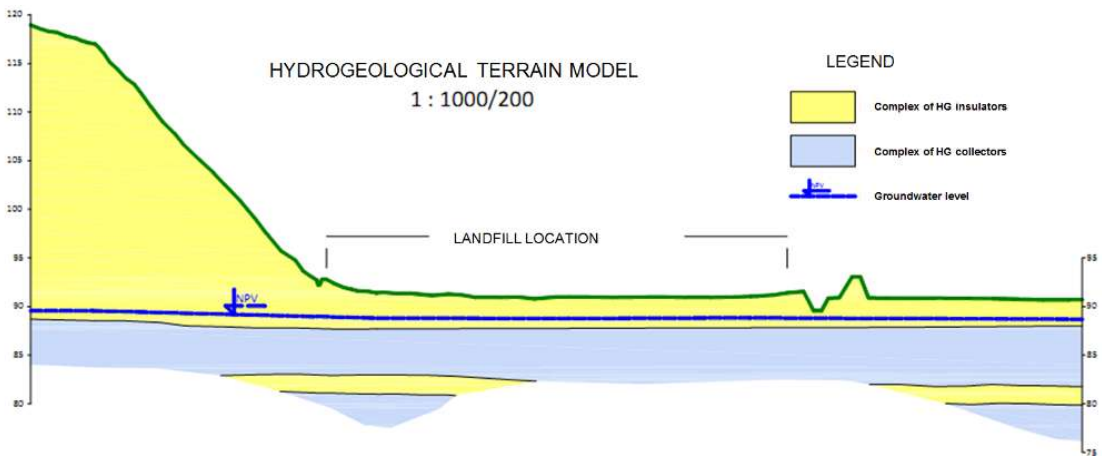

Figure 1 Hydrogeological model of the terrain landfill Brijesnica

At the landfill Brijesnica is performed continuous monitoring of leachate (on exhausted pipe of equalization pool) as well as monitoring of groundwater in the landfill surrounding (at total of 8 monitoring wells) and monitoring of surface water in the landfill surrounding (channel K-1 and channel K-2). Distribution of monitoring points is shown on Figure 2.

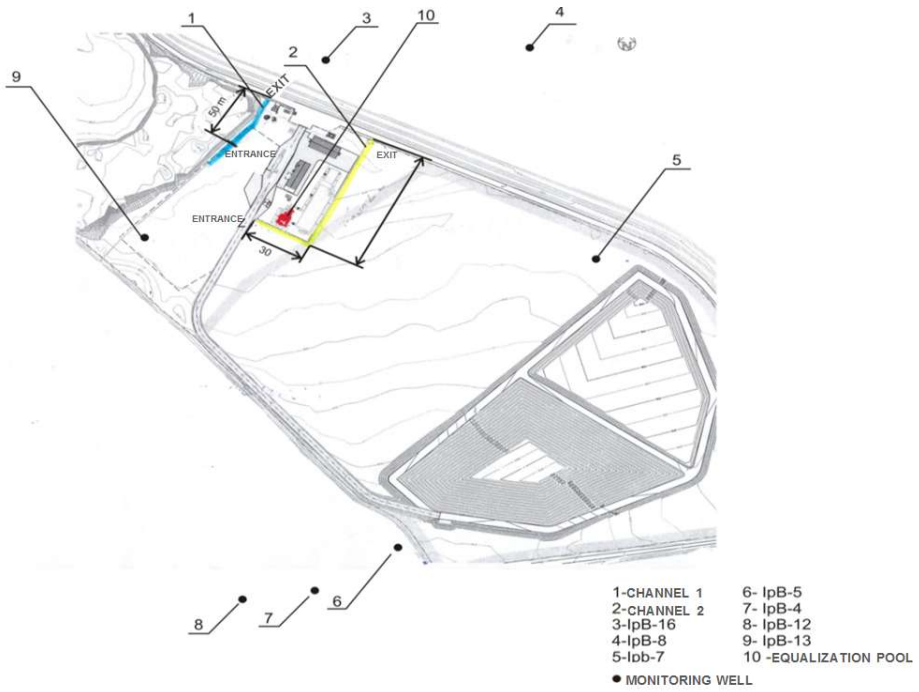

Figure 2 Scheme of places for sampling water at the landfill "Brijesnica"

MATERIAL AND METHOD

Samplings and analyses of leachate, surface and groundwater are performed in accordance with standard norms for waste waters sampling i.e.:

- BAS ISO 5667-11 – Water quality – Sampling
- BAS ISO 5667-14 – Water quality – Sampling – Guidance on quality assurance and quality control of environmental water sampling and handling
- BAS ISO 5667-3: Water quality – Sampling – Guidance on the preservation and handling of water samples.

As well as domestic legislation in this field, i.e. Rulebook for waste water discharged into surface waters [3-4].

The analyses are performed in period: September 2009 - December 2013.

Water sampling was performed at the following locations:

- Leachate – output tube of equalization basin
- Groundwater – monitoring wells IpB-5, IpB-7, IpB-8, IpB-13, IpB-15 and IpB-16
- Surface water: Majevički kanal (K1 and K2)

Sampling was carried out in four different time periods (seasons). Analyses of samples of leachate, surface water and groundwater from sanitary landfill Brijesnica were performed in an accredited laboratory "Sistem Qualita With", Pale, using standard methods for testing of water and wastewater [5-13].

RESULTS AND DISCUSSION

The testing results of leachate for period 2009-2013 for basic physical-chemical parameters are shown in table 1.

The results of analyses of groundwater based on physical-chemical parameters are given in the table 2, while the results of physical-chemical water composition of Majevički kanal presented through basic statistic parameters for multi-year monitoring period (2009-2013) are given in the table 3.

Monitoring of waters at the landfill Brijesnica was performed from 2009 to 2013. Total number of processed data is 57. Most of the data was obtained through analyzes of leachate and surface water, i.e. 80% of the data. Analysis of wastewater using monitoring wells were carried out from 2011 to 2013, and these measurements comprise 20% of processed data.

From total data for surface water (20 data), equal number was sampled during 2011 and 2013, that includes 60% of processed data for surface water. The minimum number of samples was taken in 2009 i.e. one sample. 25 samples of leachate were sampled at the landfill Brijesnica that represents 45% of all samples taken at the landfill. The largest number of samples was taken in 2012 i.e. 36%, then in 2013 (28%) and in 2011 (24%). In 2009 was not taken any sample of leachate, so it is noted that the sampling of leachate at the landfill Brijesnica were performed during the four years period, from 2010 to 2013.

Table 1 Results of the analysis of leachate from the landfill Brijesnica for defined parameters

Parameter	Unit	2010	2011	2012	2013	Mean	* Limit value
pH	-	8.26	8.99	8.81	7.23	8.47	6.50-9.00
Electroconductivity	$\mu S/cm^2$	2.193,3	4.073,3	2.930,3	1.384,4	2.807	-
Total susp. solids	mg/L	4.69	11.79	106.10	16.08	53.38	35
BOD_5	mgO_2/L	96.17	152.80	115.20	11.28	102.14	25
COD	mgO_2/L	259.37	451.50	555.60	38.80	403.89	125
NH_4-N	mgN/L	51.77	62.60	591.8	1.593.8	551	10
Total phosphorus	mgP/L	78.86	67.80	52.22	193.69	98.76	3
Total Kjelhdal nitrogen	mgN/L	0.370	0.338	0.207	0.290	0.270	-

Table 2 Results of analysis of groundwater in the landfill environment Brijesnica for defined parameters

Monitoring well	Year	pH	Electroconductivity /20°C µS/cm	Total susp. solids g/m^3	BOD_5 g/m^3	COD g/m^3	NH_4-N g/m^3N	Total P g/m^3P	Total Kjelhdal nitrogen g/m^3N
Ip B 15	2011	7.83	580	31.32	4.82	19.37	0.296	0.156	1427
Ip B 15	2013	6.93	876	2.42	1.76	4.53	0.06	0.007	0
	Median	7.38	728	16.87	3.29	11.95	0.178	0.0815	713.565
IpB 5	2011	7	625	1.88	1.82	7.38	0.013	0.027	0.028
IpB 5	2013	7.02	756	1.36	2.32	5.46	0.158	0.013	0
	Median	7.01	690.5	1.62	2.07	6.42	0.0855	0.02	0.0805
IpB 16	2011	7.11	540	1.1	0.86	3.78	0.198	0.009	0.323
IpB 16	2012	6.88	726	17	1.49	5.9	0.483	0.022	8894
IpB 16	2012	7.13	594	2.83	1.68	4.35	0.017	0.013	0.127
IpB 16	2013	7.03	754	31.3	3.58	17.4	0.426	0.026	6231
	Median	7.08	674	17.065	2.63	10.875	0.2215	0.0195	3115.56
IpB8	2011	7.27	512	7.74	3.32	11.27	0.145	0.0272	1447
IpB7	2012	7.36	523	4.22	2.26	11.3	0.051	0.213	0.131
IpB 13	2013	7.3	457	42.6	5.32	21.54	0.551	0.03	8173
MDK**		6.8-8.8	400-600		2-5	6.0-10	0.10-0.20	0.010-0.030	/

**Reference values according to *Regulation on water classification and categorization of water streams*

Table 3 Results of the analysis of physical-chemical composition of the water Majevički kanal

Parameter	Unit	N	Min.	Max.	Range	Median	Mean	St. dev.	Water Class
pH	--	30	6.71	10.300	3.59	7.305	7.45	0.67	1
Electroconductivity	µS/cm	30	15.67	8.320	8.304.33	517.5	1.168.42	1.895.8	4
Total susp. solids	mg/L	18	1.1	134.4	133.3	18	30.05	35.62	5
Tot. dry matter	mg/L	25	234.00	4.778.43	4.544.43	358.19	994.17	1.366.54	-
BOD_5	mgO_2/L	19	0.86	135.00	134.14	4.2	18.19	35.14	3
COD	mgO_2/L	30	3.78	888.30	884.52	17.99	80.20	184.36	4
Total P	mgP/L	19	0.083	1.843	1.842.99	0.327	157.40	478.24	5
Cuprum	µg/L	30	0.5	176.2	174.7	14.82	18.95	31.493	2
Zink	µg/L	19	1.6	1.439.00	1.437.4	8.33	92.18	280.33	2
Cadmium	µg/L	11	0.00	0.220	0.220	0.188	0.188	0.98	5
Nicl	µg/L	29	0.85	24.10	23.25	5.75	6.39	5.87	2

Based on water physical - chemical composition of the recipient (Majevički kanal) and in accordance with the Regulation on water classification and categorization of water streams certain comments to the results of the surface water at the sanitary landfill Brijesnica site can be given. Surface water quality in which landfill leachate drain (Majevički kanal) show a constant tendency of increased concentrations, mostly of those pollutants that are increased in leachate (BOD, COD, total nitrogen, total phosphorus, chloride, etc.).

Since the leachate from the landfill flow into Majevički kanal without prior treatment as well as the fact this channel is the recipient with relatively poor yield, the direct impact of leachate on the water quality of a the receiver was expected. Basically, this channel does not have a steady stream, but also serves to collect the surrounding storm water during periods of intense rainfall. Therefore, it considers artificial water facility, which does not have its hydrodynamic stability, and in periods of scarce rainfall may even dry up. In this period undiluted leachate directly discharged in the stream represent only flow of the stream.

In accordance with the Regulation on water classification and categorization of water streams RS, Majevički kanal, as an integral part of the River Drina, is classified as Class II of watercourses (moderately polluted watercourse, whose waters cannot be used as drinking water and for human consumption before pre-treatment). According to the mentioned Regulation, the water classified as class II represents water that after appropriate treatment (coagulation, flocculation, sedimentation, filtration and disinfection) can be used for drinking; Water in its natural state can be used for swimming, water sports, and for the growth of carp fish species. However, the analysis results of this surface stream showed that the water of Majevički kanal can be classified from class II to V, based on results for most of the analyzed parameters.

To be specific, during the entire test period, the values of many parameters were increased and thus classified water of the stream as highly polluted water. Based on the above, it can be clearly concluded that there is a direct impact of leachate discharged from the landfill *Brijesnica* on surface water of Majevički kanal. Also, due to its composition, the leachate would not be allowed to discharge into the receiver, before an appropriate treatment [14].

In order to determine the relevant impact of landfill leachate on the surrounding groundwater quality, the comparison of water quality between upstream and downstream monitoring wells (position in relation to landfill location) was performed. Groundwater pollution may be a natural phenomenon caused by various organic decomposition processes in the soil and therefore it is important to compare the qualitative parameters of groundwater that drains into landfill and waters leaching from the landfill.

Change of the groundwater levels in analyzed monitoring wells indicates the phenomenon of increased monitoring wells self-outflow. This means that perceptions directly infiltrate into ground so the ground water level is directly dependent on the sludge in the precipitation environment. During groundwater monitoring the groundwater levels in the range of 88.0 - 89.5 m above sea level were observed. Depending on the terrain morphology, the level of groundwater reservoir was on the relative depth of 1.9 m (ascertained in monitoring well IpB8) to 27.7 m (ascertained in monitoring well IpB12). Variations in groundwater level are relatively small, i.e. the multi-annual level did not exceed value of 3.0 m.

Bearing in mind location of monitoring wells IpB4, IpB5, IpB12 immediately above the landfill the lowest levels of ground water were noted in them. The analyzed samples in those monitoring wells could represent the groundwater quality outside the landfill influence zone, because the sampling point is located upstream from the landfill. The water from all monitoring well had weak smell. Small sediment content in monitoring wells during the monitoring confirms the fact that there is about environment with larger filtration characteristics built from gravel layers.

With this observation the several years monitoring circle has been closed based of which the appropriate conclusions about the landfill Brijesnica leachate influence on groundwater can be drawn. As a result of multi-year groundwater observation in these monitoring wells, it can be concluded that the most representative monitoring well for evaluation of the landfill waste decomposition process influence on groundwater quality could be taken the monitoring wells downstream from the landfill (IpB7, IpB8, IpB16).

Electroconductivity of groundwater and water in general depends on the water mineralization degree. Bearing in mind that the measured values of groundwater electrocunductivity are above the reference value it can be concluded that here is about pretty mineralized waters. This is a natural phenomenon and the same values were identified at monitoring wells located upstream and downstream from the, that indicates the existence of a local influence, i.e. the existence of several micro aquifers that are influenced differently by the leachate.

Several works proved that landfills or open dumpsites posed a serious threat to the groundwater and surface water resources [15], especially those landfills built and put into operation without impermeable layers for reduction of potential contamination. The danger degree largely depends on waste composition at the landfill and generated leachate volume, as well as from the landfill site in relation to the water body, groundwater and surface water [2].

Accordingly, waste leachate discharge in receivers may lead to significant reduction of dissolved oxygen in water while in extreme situations it can completely disappear, so there is a complete extinction of the aquatic life in some waters without purification of contaminated leachate prior to discharge. This is particularly expressed in the case of receivers with low flow rates and during dry periods when water flow is additionally reduced. Due to its characteristics leachate influence on surface water in the vicinity of the landfill is evident, especially in the terms of organic and nutrient pollution [16].

Many authors come up with results regarding the landfill leachate influence on the surface water. Thus, many researchers [17] concluded that the leachate directly mixed with surrounding surface waters without pre-treatment causing severe pollution of water and soil in the landfill vicinity. Particularly were recorded leachate impact on increasing of biological pollution (BOD, COD), ammonia nitrogen and heavy metals in the surrounding surface waters [18].

Also, the results of these investigations indicate to the necessary water treatment prior to discharge into surface water or surrounding soil. Due to the direct influence of leachate composition on quality and composition of surface flows in which they are discharged, the impacts on aquatic communities can also be expected.

When it comes to Majevički kanal, where biotic world is poorly developed, the consequences can be felt by next receiver, i.e. the Drina River basin. Also, due to the slow flow in Majevički kanal during the summer months, and due to the increased inflow of nutrients through the leachate, the eutrophication and direct impact on aquatic world changes and the oxygen content in the water can occur. The sensitivity of fish to the toxic substances effects (eg. heavy metals) increases when dissolved oxygen level decreases [19].

CONCLUSION

Based on performed investigations of leachate, surface and groundwater at the location of landfill Brijesnica, the following can be concluded:

- The analysis results of landfill leachate show that the most of analyzed parameters exceed given limit values so they must not be discharged into surface or groundwater before adequate treatment.

- The level of underground water in observed monitoring wells at the landfill location is directly correlated with atmospheric perceptions depending on upstream and downstream zone of regional landfill. With increase of precipitation the groundwater level also rises.
- Landfill leachate directly influence quality of surface water (Majevički kanal), that is confirmed in physical-chemical analyses of surface water.

- The ground water analyses results show that the value of certain parameters deviate from the reference value, but there is no possibility to bring landfill leachate influence to the surrounding groundwater in a direct connection, given that significant variations in groundwater quality were not registered during the monitoring. This is supported by the fact that regional landfill Brijesnica was constructed with complete system for landfill bottom protection (multi-barrier protection) as well as the fact that all leachate are collected in equalization pool through drainage collecting system pipes, and finally discharged into Majevički kanal.

- Different pressure and mineral composition of groundwater leads to the conclusion that the layers are independent from each other, but it is certain that there is no direct impact of leachate to the groundwater in the downstream part of the landfill.

- Final evaluation of landfill Brijesnica leachate influence on surface water and groundwater in monitoring period show that leachate from disposed waste were leached partly directly in the ground water, while the most of the leachate were leached directly into Majevički kanal. The degree of groundwater and surface water pollution is not high, but future monitoring of this water have to be performed, in order to avoid contamination on wider scope or some other unintended consequences.

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