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DETERMINING LEACHATE QUANTITY AT BRIJESNICA REGIONAL SANITARY LANDFILL IN BIJELJINA

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ABSTRACT

One of basic problems faced in practice of landfill waste treatment is a problem relating to landfill leachate. The intensity of their production, thus their quantity, depends on numerous factors: landfill age, waste types, microclimatic parameters and similar. This leachate must not be discharged directly into the environment without its previous collection and treatment.

Key words: *landfill, waste, waste waters, leachate*

INTRODUCTION

Brijesnica regional landfill is located in the western part of the municipality of Bijeljina. It is about 2 km away from the eastern side of the town, and about 1.5 away from the north-western and western parts. Currently, the landfill is in its operative phase, meaning in a phase of depositing waste into sanitary cells. Approximate area of the landfill is 4.5 ha. In sanitary sections were installed protective insulation materials – special geomembranes and other materials that guarantee groundwater protection, in line with requirements of the EU directives. The landfill has a leachate collection system and a biogas collection system. An equalization pool was built to accept leachate from the landfill body with a recirculation system and return of leachate into the active cell.

So-far researches have demonstrated that landfill leachate represents a medium whose contents and quantity significantly change during a landfill's life span [1,2]. Waste landfill filtrates belong to the most problematic types of waste waters, both from the viewpoint of the aspect of toxicity, and in terms of selecting adequate techniques for their treatment [3,4]. Researches have also shown that every waste landfill represents a separate system, and in these terms contents and quantity of leachate exclusively depend on the landfill's character.

EXPERIMENTAL PART

Visual HELP 2.2 programme package was used to determine leachate quantity and hydrological simulation of the landfill.

Help Model

Model HELP (Hydrologic Evaluation of Landfill Performance), is a comprehensive program that is used for design, evaluation and optimisation of landfill hydrology, as well for assessment of how fast the groundwater renews. Model HELP was used and recognised throughout the world as an accepted standard for landfill hydrology modelling . It became integral part of projects that involve functioning and permits for shutting down the landfills [5].

Model HELP is a quasi-two-dimensional hydrological model that consists of several layers, which demands the following input data:

- Weather data (parameters of precipitation, solar radiation, temperature, evapotranspiration)
- Soil properties (porosity, soil capacity, wilting point and hydrological conductivity)
- Project data (bases, systems for collection of leachate and run-off waters, surface gradient)

HELP uses techniques of numeric resolution, which explain the effects of surface storage, snow melting, run-off, infiltration, evapotranspiration, vegetative growth, moist storage in soil, lateral draining beneath the surface, leachate recirculation, unsaturated vertical draining and percolation through soil, geomembranes, or composite bases.

Profile designing

Landfill profile was formed with the aim of predicting expected leachate quantity and hydrological simulation. Figure 1 shows a formed landfill profile in VHELP. Profile that was formed contains all existing landfill layers. Data from design documentation and data on waste quantity that is currently disposed at the landfill were used in the profile forming; it is to say entering the parameters required by the programme package. During profile design, weather data were generated based on selected data from the meteorological station in Loznica that is about 15 km away (air distance) from subject location and whose historic data on weather are contained in the programme package database, which enables it to make a simulation for the oncoming period for which we wish to make this hydrologic simulation. In this case was made a hydrologic simulation for the following 25 years, what is envisaged landfill usage period. Figure 2 shows a simulation of expected precipitation per years.

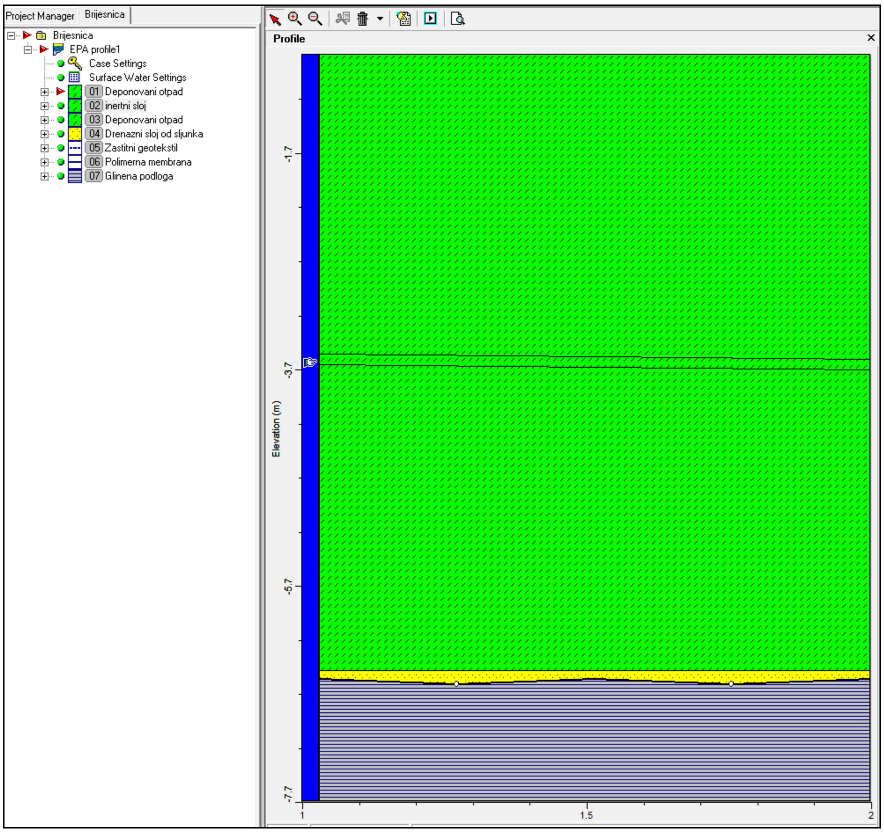

Figure 1 Brijesnica landfill profile in HELP Model

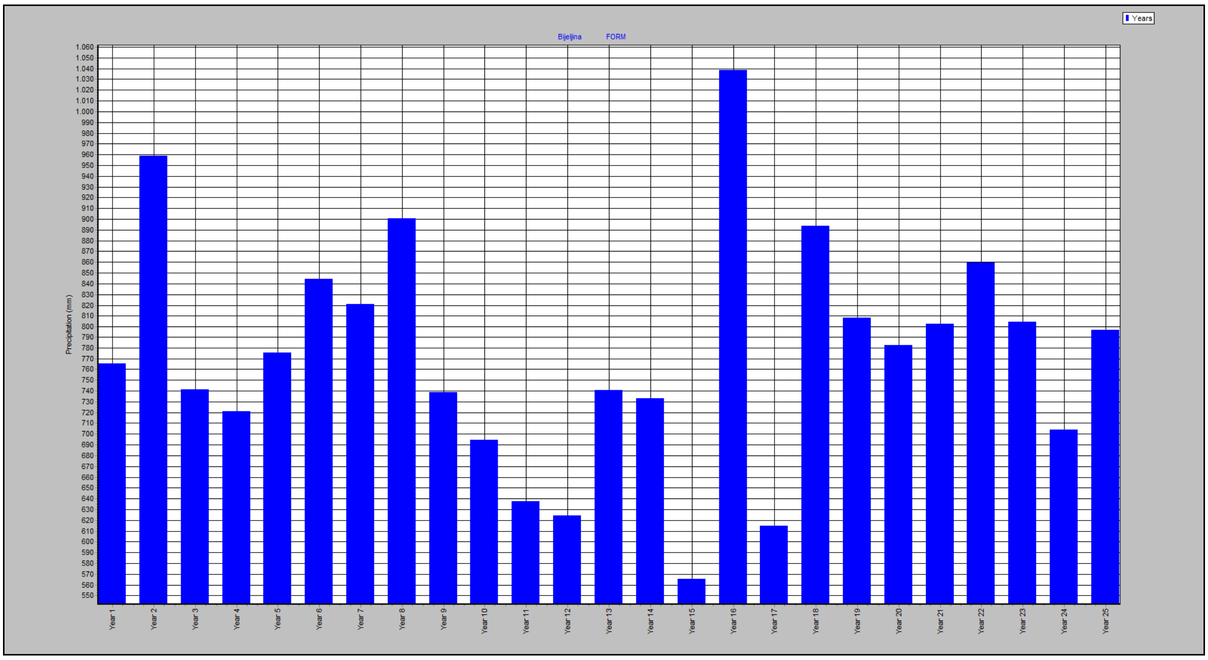

Figure 2 Simulation of expected precipitation for a period of 25 years

RESULTS

When the landfill profile was formed, model was launched in which we simulated total volume of leachate that is filtrated through the landfill bottom during a period of 25 years, and we assessed total volume of other constituents in the water balance. Model simulation results are shown in table 1.

Table 1 Hydrologic simulation of Brijesnica regional landfill a period of 25 years

	Year-1 (m3)	Year-2 (m3)	Year-3 (m3)	Year-4 (m3)
Precipitation (m3)	7.6540E+04	9.5870E+04	7.4130E+04	7.2100E+04
Runoff (m3)	0.0000E+00	6.1509E+03	7.2953E-02	1.1869E+03
Evapotranspiration (m3)	6.0839E+04	5.5414E+04	6.2365E+04	5.2936E+04
Change in water storage (m3)	1.3156E+04	2.9076E+04	4.0906E+03	9.3719E+03
Water budget balance (m3)	-1.1495E-03	-1.4398E-03	-1.1133E-03	-1.0828E-03
Soil water (m3)	2.4864E+05	2.7772E+05	2.8181E+05	2.9118E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage recirculated from Layer 6 (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 6 (m3)	2.0016E+01	4.3162E+01	6.4435E+01	7.2504E+01
Percolation or leakance through Layer 8 (m3)	2.5255E+03	5.1855E+03	7.6101E+03	8.5332E+03

	Year-5 (m3)	Year-6 (m3)	Year-7 (m3)	Year-8 (m3)
Precipitation (m3)	7.7530E+04	8.4430E+04	8.2110E+04	9.0070E+04
Runoff (m3)	2.6523E+03	7.5465E+02	5.3012E+02	2.7926E+03
Evapotranspiration (m3)	5.4363E+04	5.9472E+04	6.3010E+04	7.0872E+04
Change in water storage (m3)	1.0609E+04	1.2926E+04	5.9586E+03	3.1781E+03
Water budget balance (m3)	-1.1644E-03	-1.2680E-03	-1.2332E-03	-1.3527E-03
Soil water (m3)	3.0179E+05	3.1471E+05	3.2067E+05	3.2385E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage recirculated from Layer 6 (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 6 (m3)	8.3745E+01	9.5515E+01	1.0690E+02	1.1212E+02
Percolation or leakance through Layer 8 (m3)	9.8225E+03	1.1182E+04	1.2504E+04	1.3115E+04

	Year-9 (m3)	Year-10 (m3)	Year-11 (m3)	Year-12 (m3)
Precipitation (m3)	7.3860E+04	6.9470E+04	6.3780E+04	6.2400E+04
Runoff (m3)	4.7115E+02	1.3469E+03	3.0975E+03	2.6152E+03
Evapotranspiration (m3)	5.3215E+04	5.9367E+04	4.6961E+04	4.7123E+04
Change in water storage (m3)	6.4978E+03	-5.1642E+03	-5.0255E+01	-1.0099E+03
Water budget balance (m3)	-1.1093E-03	-1.0433E-03	-9.5788E-04	-9.3715E-04
Soil water (m3)	3.2639E+05	3.2518E+05	3.2513E+05	3.2412E+05
Snow water (m3)	3.9555E+03	0.0000E+00	0.0000E+00	3.3501E+00

Lateral drainage recirculated from Layer 6 (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 6 (m3)	1.1592E+02	1.1799E+02	1.1673E+02	1.1588E+02
Percolation or leakance through Layer 8 (m3)	1.3560E+04	1.3803E+04	1.3655E+04	1.3555E+04

	Year-13 (m3)	**Year-14 (m3)**	**Year-15 (m3)**	**Year-16 (m3)**
Precipitation (m3)	7.4070E+04	7.3320E+04	5.6570E+04	1.0383E+05
Runoff (m3)	1.7927E+03	3.5419E+03	8.4557E+01	6.8276E+02
Evapotranspiration (m3)	5.0113E+04	6.1004E+04	4.1482E+04	7.1624E+04
Change in water storage (m3)	7.7552E+03	-5.6483E+03	1.1297E+03	1.6946E+04
Water budget balance (m3)	-1.1124E-03	-1.1012E-03	-8.4960E-04	-1.5594E-03
Soil water (m3)	3.3188E+05	3.2623E+05	3.2736E+05	3.4430E+05
Snow water (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage recirculated from Layer 6 (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 6 (m3)	1.2213E+02	1.2226E+02	1.1760E+02	1.2355E+02
Percolation or leakance through Layer 8 (m3)	1.4287E+04	1.4300E+04	1.3757E+04	1.4454E+04

	Year-17 (m3)	**Year-18 (m3)**	**Year-19 (m3)**	**Year-20 (m3)**
Precipitation (m3)	6.1470E+04	8.9350E+04	8.0850E+04	7.8210E+04
Runoff (m3)	3.1577E+03	4.5358E+03	0.0000E+00	2.8438E+03
Evapotranspiration (m3)	4.5131E+04	6.6982E+04	5.0939E+04	5.3640E+04
Change in water storage (m3)	-3.1045E+03	1.5081E+03	1.2640E+04	3.7203E+03
Water budget balance (m3)	-9.2319E-04	-1.3419E-03	-1.2142E-03	-1.1746E-03
Soil water (m3)	3.4120E+05	3.4271E+05	3.5322E+05	3.5907E+05
Snow water (m3)	0.0000E+00	0.0000E+00	2.1307E+03	0.0000E+00
Lateral drainage recirculated from Layer 6 (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 6 (m3)	1.3794E+02	1.3826E+02	1.4613E+02	1.5223E+02
Percolation or leakance through Layer 8 (m3)	1.6148E+04	1.6185E+04	1.7124E+04	1.7854E+04

	Year-21 (m3)	**Year-22 (m3)**	**Year-23 (m3)**	**Year-24 (m3)**
Precipitation (m3)	8.0260E+04	8.5960E+04	8.0440E+04	7.0390E+04
Runoff (m3)	3.1854E+02	0.0000E+00	8.1508E+02	9.8689E+02
Evapotranspiration (m3)	6.2599E+04	6.0291E+04	5.1619E+04	5.3523E+04
Change in water storage (m3)	-1.7163E+03	6.6213E+03	8.2537E+03	-4.7874E+03
Water budget balance (m3)	-1.2054E-03	-1.2910E-03	-1.2081E-03	-1.0572E-03
Soil water (m3)	3.5735E+05	3.6396E+05	3.7223E+05	3.6744E+05
Snow water (m3)	0.0000E+00	1.6381E+01	0.0000E+00	0.0000E+00
Lateral drainage recirculated from Layer 6 (m3)	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 6 (m3)	1.6089E+02	1.6079E+02	1.6658E+02	1.7406E+02
Percolation or leakance through Layer 8 (m3)	1.8898E+04	1.8887E+04	1.9586E+04	2.0493E+04

	Year-25 (m3)	**Total (m3)**
Precipitation (m3)	7.9710E+04	1.9367E+06
Runoff (m3)	9.2466E+02	4.1283E+04
Evapotranspiration (m3)	5.9133E+04	1.4140E+06
Change in water storage (m3)	-4.6395E+02	1.3149E+05
Water budget balance (m3)	-1.1971E-03	-2.9087E-02
Soil water (m3)	3.6698E+05	8.2151E+06
Snow water (m3)	0.0000E+00	6.1059E+03
Lateral drainage recirculated from Layer 6 (m3)	0.0000E+00	0.0000E+00
Lateral drainage collected from Layer 6 (m3)	1.6955E+02	2.9569E+03
Percolation or leakance through Layer 8 (m3)	1.9947E+04	3.4697E+05

Table 2 shows the analysis of leachate quantity that is expected in comparison to expected precipitation quantity.

Table 2 Analysis of leachate quantities per years in comparison to expected precipitation

	Year-1 (m3)	**Year -2 (m3)**	**Year -3 (m3)**	**Year -4 (m3)**
Precipitation (m^3)	76.540	95.870	74.130	72.100
Leachate through the drainage layer (m^3)	2.525	5.185	7.610	8.533

	Year-5 (m3)	**Year-6 (m3)**	**Year-7 (m3)**	**Year-8 (m3)**
Precipitation (m^3)	77,530	84,430	82,110	90,070
Leachate through the drainage layer (m^3)	9,822	11,182	12,504	13,115

	Year-9 (m3)	**Year-10 (m3)**	**Year-11 (m3)**	**Year-12 (m3)**
Precipitation (m^3)	73,860	69,470	63,780	62,400
Leachate through the drainage layer (m^3)	13,560	13,803	13,655	13,555

	Year-13 (m3)	**Year-14 (m3)**	**Year-15 (m3)**	**Year-16 (m3)**
Precipitation (m^3)	74,070	73,320	56,570	103,830
Leachate through the drainage layer (m^3)	14,287	14,300	13,757	14,454

	Year-17 (m3)	**Year-18 (m3)**	**Year-19 (m3)**	**Year-20 (m3)**
Precipitation (m^3)	61,470	89,350	80,850	78,210
Leachate through the drainage layer (m^3)	16,148	16,185	17,124	17,854

	Year-21 (m3)	**Year-22 (m3)**	**Year-23 (m3)**	**Year-24 (m3)**
Precipitation (m^3)	80,260	85,960	80,440	70,390
Leachate through the drainage layer (m^3)	18,898	18,887	19,586	20,493

	Year-25 (m3)	**Total for 25 years(m3)**
Precipitation (m^3)	79,710	**1,936,700**
Leachate through the drainage layer (m^3)	19,947	**346,970**

Figure 3 shows a graphic depiction of a relation between expected leachate quantities (blue line) and expected precipitation quantity (red line).

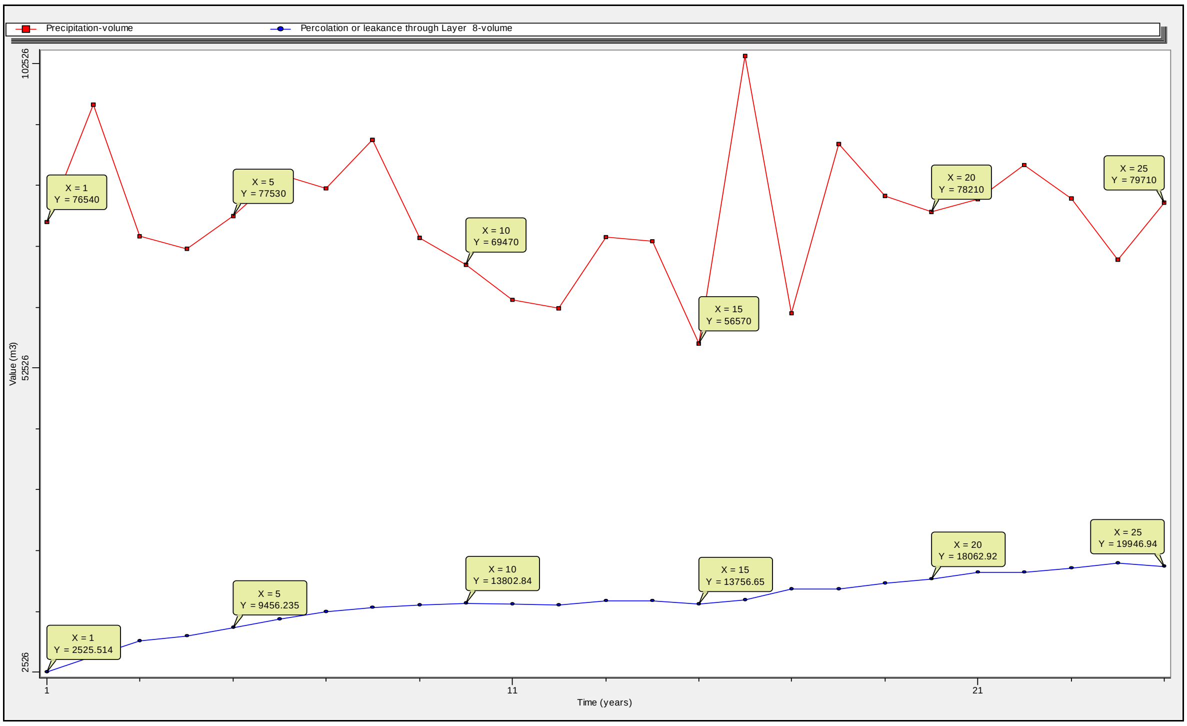

Figure 3 Graph of percolate filtrate quantity in comparison to precipitation for a period of 25 years

DISCUSSION

Previous tables provide entire hydrologic simulation of the landfill, table 1, and an overview of leachate quantities that are expected at Brijesnica landfill in comparison to precipitation quantity, table 2).

Total precipitation quantity for 25 years amounts to 1,936,700 m^3, and total leachate quantity amounts to 346,970 m^3, which means that out of total precipitation quantity 18 % percolates through the landfill body. The rest of the water is surface run-off, evaporation, waste-bound water, lateral drainage.

Although it can be seen that precipitation quantities vary in years, quantity of leachate filtrate is rather constant with moderate tendency to increase, which is a consequence of the recirculation system that was taken into consideration while setting up the landfill profile. Beside climatic factors and collection system, leachate quantity was conditioned by the quantity of water found in waste, soil topography and type of material used in the landfill construction and landfilling technology itself.

Thus, the largest quantity of leachate of 20,493 m^3 is expected in the 24^{th} year, whereas the lowest quantity of 2,525 m^3, was envisaged in the 1^{st} year.

Observing the entire period of 25 years, average daily leachate quantity amounts to about 38 m^3/day.

CONCLUSION

One of elementary problems faced in practice of landfill waste treatment is a problem relating to landfill leachate [7]. This leachate must not be discharged directly into the environment without its previous collection and treatment. EU Directives and legislation impose more and more rigorous requirements for treatment degree and maximal allowed intake of hazardous substances in natural watercourses, which requires a high degree of waste leachate treatment.

Determining leachate quantity is a critical project parameter because the quantity and pollution of generated leachate significantly impact landfill operation costs, especially in cases when collection and treatment of this water is anticipated [8].

A possibility of hydrologic simulation of landfills in a phase of designing enables us to have insight into expected quantities of leachate during a landfill's life span, it shows us dependence of leachate quantity on materials that are used and planned landfilling technology, and alleviates the selection of leachate treatment technology, which can significantly reduce future costs of landfill construction and operation.

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