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ASSESMENT OF LEACHATES GENERATION ON SPECIFIC SANITARY LANDFILLS IN REPUBLIC OF SERBIA

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Abstract

In existing review, assessment of leachates on specific sanitary landfills in Republic of Serbia is carried out. Assessment is based on five landfill sites located in different territorial regions of Republic of Serbia and four main factors in accordance with available data. Landfill sites that are taken into consideration are: Regional sanitary municipal solid waste landfill „Duboko“ near Užice, Sanitary municipal solid waste landfill „Meteris“ Vranje, „Regional sanitary municipal solid waste landfill“ in Kikinda, Regional sanitary landfill „Srem-Mačva“in Sremska Mitrovica and Municipal landfill „Aleksandrovačka bara“ Subotica- „Regional landfill“ Ltd. Subotica. Factors which are being represented in this study are waste composition, process of waste, age of landfills, meteorological specifications typical for regional areas of concern. The volume of decomposition of solid waste organic components noticeably affects on filtrate production variations, while waste treatment method selection considerably depends on its composition, whereby accomplishing integration of these two factors. Meteorological parameters, primarily precipitation, affect on intensity of leachate generation, while variations in production of landfill filtrate which are depending on the age of landfill reflect in greater generation intensity in the beginning of landfill life cycle and decreasing throughout its life-cycle. Factors like waste density and oxygen consumption are being considered, but due to lack of data, they are not taken as factors of primary interest. The main goal of this study is research of different factors which primarily effect on intensity and variations of leachates generation quantity of observed landfills on Republic of Serbia territory.

Keywords: Leachates, sanitary landfills, primary factors, leachates quantity

Introduction

The significant problem that occurs with uncontrollable disposal of solid waste and sanitary landfills and illegal landfills represent leachates. General production process comes down to dissolution of solids in the water that filters through the body of the landfill and segregation of dissolved and suspended matters generated by biological and chemical conversion processes which inevitably occur inside the body of the landfill. Landfill filtrate is an entity which is influenced by a number of factors, both within and outside the landfill body. The process of forming the filtrate within the landfill is carried out through four stages, which significantly affect the intensity of their generation. The first phase lasts for a few days or weeks and it is characterized by an aerobic waste decomposition process, which results in making a complex solution with approximately neutral pH value. At this stage, the filtrate may reach the temperature of 80 to 90 degrees Celsius, which is a consequence of heat release during the mentioned process. The described process is significant due to the fact that, if the heat is retained within the landfill body, the following stages will be more intense. The second stage is also called the “acidic stage”. Due to the continuous decomposition process an anaerobic environment is formed in the landfill body. As a result of this process, a low pH value is established (which gave a name to this stage) with high concentrations of soluble degradable organic compounds, ammonia and metals. The third, „methane“ stage in which the filtrate becomes neutral or slightly alkaline with the significant amount of certain pollutants, is established after several months or years. At the fourth stage the decomposition gradually ends and the aerobic conditions within the landfill body can be established again. The qualitative characteristics of landfill filtrate at the end of this process become less hazardous to environment (FTN 2009). The significant part in the process and intensity of the leachates generation has the initial moisture content within the landfill. Organic waste, with an emphasis on food and garden waste, has high initial moisture content, while ashes, glass, paper, metal, and plastic are complete opposites. The said parameter is extremely variable, but it is generally estimated that the initial moisture content of compact waste is 20% (Vojinović-Miloradov & Miloradov 2012). Infiltration, relief, vegetation and surface effects, i.e. cracks on the soil surface, represent external factors that greatly contribute to variations in leachates generation intensity. Infiltration capacity of soil at any moment depends on the moisture content in the soil. Keeping that in mind, we come to the conclusion that if the amount of water is much higher than the infiltration capacity of the soil, a pool of water will be formed. In the opposite situation, the water will be smoothly absorbed by the soil, thereby contributing to the amount of generated leachates. Also, to some extent the relief affects the amount of water that will infiltrate and contribute to the amount of generated leachates. On flat terrain with many depressions water pools will form that will partially evaporate, while the remaining part will be infiltrated in subsequent stages. On steep terrains without depressions, such phenomena will be less manifested. The contribution of vegetation is reflected in retaining some moisture that, after some time, by moving through the stem and with autumn leaf fall, arrives to the soil surface. The heterogeneous structure of the soil that is used to cover the landfill materials, waste settlement, and collection of dry soil, contribute to the formation of cracks in the said covering layer, which accelerates the process of infiltration within the landfill (Vojinović-Miloradov & Miloradov 2012). Estimation of leachates generation, as well as knowing certain parameters are crucial for the optimal planning, sizing and handling of the leachate treatment facilities, in order to prevent the discharge of contaminated filtrates into the surface recipients. Also, for the purpose of treatments of heavily polluted leachates the impermeable films are built in the linings of sanitary landfills, thus preventing the infiltration of leachates into the underground aquifer, as well as their potential contamination. In addition to these factors which inevitably influence the intensity of the leachate generation, the four factors of primary interest will be discussed within the review, and their prevalence and variability on five landfill sites on the territory of the Republic of Serbia.

Factors affecting the amount of creation leachate

Composition of waste

The landfill material in the landfill body is subject to physical, chemical and biological processes, causing much of its decomposition. Joint control factors specific to the physical and chemical decomposition processes are pH values and oxidation-reduction potential. Chemical processes are reflected in chemical reactions such as precipitation, adsorption, desorption and dissolution, while the physical processes include leaching of materials from waste. Biodegradation is the main mechanism of the waste decomposition in the landfill, which significantly affects and controls the said factors. Biodegradation has three phases: aerobic, facultative anaerobic, and methanogenic anaerobic phase. During these three processes the moisture that enters the landfill and leaches through the waste, makes an important factor, because it is a medium that is continuously generated and is also the most optimal means of transport of the pollutants. The important role in the above processes represents the connection of waste composition and the initial moisture content. Organic waste, particularly food and garden waste have high initial moisture content, while ash, glass, paper, metal, and plastic are the complete opposites. Therefore, if organic components dominate in the waste composition, the process of biodegradation will be intensified and, therefore, the intensity of landfill filtrate production will be accelerated. Table 1, Table 2, Table 3, Table 4 and Table 5 shows the morphological compositions of municipal waste typical for the five selected landfill sites.

Table 1. Morphological composition of municipal waste typical for Regional sanitary municipal solid waste landfill „Duboko“ Užice (Gradska uprava za urbanizam, izgradnju i imovinsko-pravne poslove Grad Užice, 2009)

Type of waste	Precentage (%)
Biodegradable waste	39
Paper and cardboard	14,7
Glass	4,4
PET packaging	2,3
Composit plastic	2,0
Metals	2,8
Rubber	9,1
Textile	2,7
Ashes, rubble, slag	3,7

Table 2. Morphological composition of municipal waste typical for Sanitary solid waste landfill „Meteris" Vranje (Centar za razvoj Jablaničkog i Pčinjskog okruga & USAID, 2012)

Type of waste	Precentage (%)
Biodegradable waste	46,8
Paper and cardboard	12,5
Glass	5,6
PET packaging	7,0
Composit plastic	3,5
Metals	0,9
Rubber	0,0
Textile	11,5
Ashes, rubble, slag	5,8

Table 3. Morphological composition of municipal waste typical for „Sanitary municipal solid waste landfill" Kikinda („A.S.A. Kikinda" Ltd., 2010)

Type of waste	Precentage (%)
Biodegradable waste	19,9
Paper and cardboard	14,1
Glass	4,5
PET packaging Composit plastic	1,8
Metals	3,5
Rubber	1,8

Textile	4,8
Ashes, rubble, slag	36,8

Table 4. Morphological composition of municipal waste typical for Regional sanitary landfill „Srem-Mačva“ Sremska Mitrovica (FTN, 2008)

Type of waste	Precentage (%)
Biodegradable waste	45,3
Paper and cardboard	13
Glass	4,1
PET packaging Composit plastic	12,6
Metals	4,7
Rubber	0,5
Textile	12,7
Ashes, rubble, slag	4,3

Table 5. Morphological composition of municipal waste typical for Municipal landfill „Aleksandrovačka bara“ Subotica (a) – “Regional landfill” Ltd. Subotica (b) („PTI“ Novi Sad, 2007)

Type of waste	Precentage (%)	
	(a)	(b)
Biodegradable waste	47,6	22,7
Paper and cardboard	14,4	13,7
Glass	8,8	4,3

PET packaging Composit plastic	13,7	15
Metals	1,3	6
Rubber	-	4,2
Textile	-	6
Ashes, rubble, slag	14,2	18,7

Based on the data of the morphological compositions of municipal waste in the five selected landfill sites, attached in Table 1, Table 2, Table 3, Table 4 and Table 5, the four landfill sites, or Regional sanitary municipal waste landfill "Duboko" Uzice, Sanitary landfill "Meteris" Vranje, Regional sanitary landfill "Srem-Mačva" Sremska Mitrovica and the municipal landfill "Aleksandrovačka bara" Subotica, except for the "Regional sanitary municipal solid waste landfill" Kikinda and "Regional landfill" Ltd. Subotica, all have a high percentage of biodegradable waste. As a consequence, there is a high initial potential for processes of biological decomposition, which are intensified due to the significant proportion of organic matter in the overall municipal waste. The result of this mechanism is also the intensified generation of leachates at all four landfill sites.

Landfill age

A significant factor that contributes to the intensity of leachate generation represents the age of the landfill. Young landfills, whose status is determined depending on the projected period, contain a low pH value and a high content of ammonia and microbiological cultures presented in the landfill. They need to have a high content of essential nutrients in the form of organic waste in order to survive (Šujić 2014). Therefore, in the initial stage of landfill's life, some intense biological processes take place, the continuity of which varies from the percentage of organic components in the waste and thus leachate generation is very strong. The movement of leachates through the landfill depends on the thickness of waste layers, and constitutional layers within the landfill body. An important role in the movement of leachates through the landfill plays the drainage system. Filtering and decantation, i.e. partial purification of landfill filtrate is made within the drainage layer when the filtrate passes through the layer and enters the drainage pipes with slightly less pollution than in the landfill. Due to the lack or dysfunction of the drainage systems on municipal landfills, landfill filtrate leads to the artificial substrate made from HDPE geomembrane, or due to the absence of it, penetrates directly into the location layer with aspiration of infiltration into the underground aquifer and its contamination. In older landfills, an alkaline pH value with continuously high ammonia content is established (Šujić 2014). Also, due to the wear of the organic component, biological processes gradually slow down. Due to the numerous cells in which the waste material is placed within the landfill body and the variation in its density, generation and movement of leachates is reduced, so they need a longer time interval to reach the constitutional layers within the landfill body. However, the heterogeneous nature of the soil used for covering waste material, settlement and collection of dry soil leads to the formation of cracks, and if the landfill is not optimally designed (with a drainage system and an impermeable foil) leachates that reach the location layers will infiltrate intensively.

In order to define the intensity of landfill filtrate generation, an age determination was made on five selected landfill sites.

The disposal of municipal waste in the entire municipality of Kikinda is made on the "Regional sanitary municipal solid waste landfill". "According to the data calculated for the conceptual design, the available volume of the sanitary landfill at the selected location is 582,008 m3. The sanitary landfill exploitation lifetime for the town of Kikinda, including the final coating layer of 0.6 m in the area of 141,120 m2 is 21.3 years ("A.S.A. Kikinda" Ltd. 2010)." Based on these data, we can conclude that the age of the landfill is 8 years.

In the city of Subotica the waste is deposited on the official municipal landfill "Aleksandrovačka bara". "The landfill covers an area of 32 ha, and the waste covers the area of 14.48 ha ("PTI" Novi Sad 2007)." It is used from 1978, from which we conclude that the age of the landfill is 38 years.

Due to an inadequate location and limited capacity, this area represents an interim solution until the construction of the "Regional landfill" Ltd. Subotica. The construction of the regional landfill started in late 2015 and should be completed in January 2017 ("PTI" Novi Sad 2007). The projected lifetime of the landfill is about 50 years, and the time required to fill the two cassettes (out of ten) will be 10 years.

Local governments of Šabac and Sremska Mitrovica decided to jointly solve the problem of waste management on their territories, and in 2006 they signed the Cooperation Agreement between the municipalities on forming the Solid Waste Management Region. On January 2014 the Regional landfill "Srem-Mačva" was granted a license for a probationary period, and put into operation on August 2014 . The condition for obtaining a trial license is to build a separation line (FTN 2008). On this basis, we conclude that the landfill exploitation period is 1.8 years.

Before the opening the Regional sanitary landfill "Duboko" the municipal waste that

was collected in the city of Užice was disposed to "Sarića Osoje" landfill. The exploitation of the landfill began in 1973, while the first project of its recovery was made in 1977, and two concrete dams and circumferential grooves were constructed according to the plan. It was formed in the stream, so landfill leachates and surface water form a joint watercourse that flows downstream to the Carinski potok and Đetinja river. The Regional municipal sanitary waste landfill "Duboko" in Uzice was built in accordance with the Waste Management Strategy for nine municipalities: Užice, Čačak, Bajina Bašta, Požega, Arilje, Čajetina, Kosjerić, Lučane and Ivanjica (Gradska uprava za urbanizam, izgradnju I imovinsko-pravne poslove Grad Užice 2009). The landfill was put into operation on October 19th 2011, and the exploitation project lifetime is 35 years. Based on this data, we conclude that the age of the landfill is 5 years.

The municipal waste collection in Vranje is transported to the city's sanitary landfill "Meteris" in Suvi Do. The landfill was built in 2002, and the projected exploitation period is until 2014 (Centar za razvoj Jablaničkog I Pčinjskog okruga & USAID 2012). We conclude that the age of the landfill is 14 years. It should be noted that the landfill has a coating with a protective geomembrane at the bottom of it.

Based on the provided data and the project landfill periods, we can conclude that the "Regional sanitary municipal waste landfill" in Kikinda, Regional sanitary landfill "Srem-Mačva" in Sremska Mitrovica, and Regional sanitary municipal waste landfill "Duboko" in Užice are young landfills where leachates are still more or less intensively generated. The Municipal landfill "Aleksandrovačka bara" in Subotica and Sanitary solid waste landfill "Meteris" Vranje are old landfills, and the process of leachates generation at these landfills is reduced to a minimum. The parameter "age of the landfill" cannot be applied to the "Regional landfill" Ltd. Subotica, because it is still in under construction, and based on the analysis of the remaining three primary parameters it is necessary to perform the projection of future landfill filtrate generation.

Waste treatment methods

Waste treatment methods are significant in terms of classification and sorting of waste materials in order to select the optimal and affordable treatment technologies of the different types of waste. Therefore, the primary waste separation is a necessary step that must be taken before the selection and implementation of the waste treatment technologies. Application of the primary separation contributes the maintaining of the waste material quality, and thus reducing in economic investment in adequate treatment technologies specific to certain types of waste. By sorting organic and inorganic waste the pollution and reducing the quality of recyclable inorganic waste by organic components and the contamination of the leachates (generated by the decomposition of biodegradable waste) by different chemical contaminants and pollutants that originate from inorganic waste are avoided. Waste treatment methods are also applied in order to reduce the potential waste toxicity or the reduction of the waste volume. For this purpose, the mostly applied physical treatments are baling and cutting. Chemical and biological treatments include destruction processes, such as vacuum pyrolysis, incineration, gasification and waste melting, with the aim of reducing environmental protection-related risks. The product of these processes is precipitation which is deposited, due to the inability of economical treatment and reuse and in accordance with regulations, in the appropriate sanitary landfill.

In the "Regional sanitary municipal solid waste landfill" in Kikinda, the waste is disposed of without treatment, except for medical waste. Disposed municipal waste, without the separation of recyclable materials, is compacted and covered with a layer of inert material. Medical waste is disposed of with previous treatments (inerted in an autoclave), while the solid parts of the waste are grinded in a mill and then disposed of together with the waste generated from the Health Centre and the Institute of Public Health Kikinda ("A.S.A. Kikinda" Ltd. 2010). In the regional sanitary

landfill "Srem-Mačva" in the municipality of Šabac the separation of secondary raw materials is done exclusively on the streets and landfill. 50 containers for PET and plastic foils were placed in residential quarters in this municipality, while there were 40 containers for PET and 5 containers for scrap metal were places in Sremska Mitrovica. No other treatments are being used at the aforementioned landfill (FTN 2008).

The municipalities that will dispose the waste materials at the "Regional Landfill" Ltd. Subotica the processes of primary and secondary separation are used to a greater or lesser extent, depending on the municipality. The quantities of bulky waste in these municipalities are considered to be significant, but are not being recycled. Composting is used in individual households and schools, and there are no cases of major compost sites in the region. One of the main causes of this is undefined humus market that could be produced by green waste composting. Other treatment options were not planned due to economic and field reasons ("PTI" Novi Sad 2007).

On the Sanitary solid waste landfill "Meteris" in Vranje no waste treatment methods are performed before the disposal. The waste is systematically laid upon delivery and flattened by bulldozers in layers of 0.1 to 0.2 m thick, and is compressed by the compactor to a certain density. At each compacted layer the compactor spreads the following thin layer of waste over a flat surface and that layer is compressed again. The process itself represents the creation of landfill cells within the landfill body, and is finished at the end of the working day. There is a hydraulic press for raw materials pressing at the landfill. After collecting recyclables and pressing on the landfill, the PCC "Komrad" delivers them to the companies that have a license issued by the authorities to buy them out. There is a work in progress on the opening of the first compost field on the "Meteris" landfill in Vranje. In the municipality of Užice and the surrounding municipalities, the primary separation is made (Centar za razvoj Jablaničkog I Pčinjskog okruga & USAID 2012).

The Regional sanitary municipal waste landfill "Duboko" in Uzice carries out the secondary separation of PET and other plastics, cans and other scrap metals, paper and cardboard in the Center for waste selection landfill "Duboko". This way the dry component is separated from the wet, and the wet components of waste are sanitary disposed at the landfill cassette of "Duboko", until the treatment technologies for them is adopted (Gradska uprava za urbanizam, izgradnju I imovinsko-pravne poslove Grad Užice 2009).

Moisture that enters the landfill, percolating through waste, pulls contaminants and form leachate, which can possibly penetrate to the groundwaters in the region and pollute them (Vojinović-Miloradov & Miloradov 2012). Therefore, leachates play an important role in transportation of pollutants. Level of their contamination is increases due to the lack of a method of treatment of waste material prior to disposal, but also this factor significantly depends on the previously mentioned factors, primarily on the composition of the waste and meteorological parameters.

Meteorological parameters

Atmospheric precipitation is meteorological parameter that has a significant influence in the leachate generation. The presence of water has a direct influence on landfill's biochemical and physicochemical activity mechanism. The reaction kinetics primarily depends on factors like the amount of rainfall and the time of rainfall or snowfall in a year, i.e. directly affects the amount of the filtrate released from the landfill. In addition, the landfill age as well as the density (compaction) of the deposited material affect the amount of released filtrate. The researches have shown that the average annual rainfall of 750 mm of water residue (20.55 m3ha-1day-1) releases about 5 m3 ha-1 day-1 in older filtrates and denser landfills. This amounts to about 25% of the total quantity of water residue received. In cases of younger landfills with low specific density, the average annual release is 9 m3 ha-1 day-1 of filtrate, or about 40% of the total quantity of water residue received. One part of the remaining water evaporates, and the other one is retained in the landfill. With the decrease of the annual precipitation amount decreases the percentage of water that goes into the filtrate, because more water is bounded in the landfill itself. With the increase of average annual precipitation the percentage of water that goes into the filtrate increases, as the landfill is saturated with water and the redundancy leaves the landfill (Gržetić 1996).

Table 6, Table 7, Table 8, Table 9 and Table 10 shows the annual values of the relevant parameters of atmospheric precipitation in the period from 1981 to 2010 in the selected municipalities. It must be noted that due to the lack of data for the municipality of Užice, the next, geographically the most appropriate measuring station of Zlatibor administrative county was taken, and that measuring station is Zlatibor.

Table 6. Annual value of meteorological parameters – atmospheric precipitation for the period of 1981-2010 on synptoic station Kikinda (RHMZ, n.d.)

Meteorological parameters- atmospheric precipitation	Annual values for the period 1981-2010
Average monthly amount (mm yr-1)	556,3
Maximum daily amount (mm yr-1)	90,1
Average number of days >= 0,1 mm	130
Average number of days >= 10,0 mm	15
Number of days with snowfall	23
Number of days with snow	35
Number of days with fog	35
Number of days with hail	1
Average density of solid sommunal unstable waste (t m-3)	0,341

.Table 7. Annual value of meteorological parameters – atmospheric precipitation for the period of 1981-2010 on synptoic station Sremska Mitrovica (RHMZ, n.d.)

Meteorological parameters- atmospheric precipitation	Annual values for the period 1981-2010
Average monthly amount (mm yr-1)	614,2
Maximum daily amount (mm yr-1)	67,0
Average number of days >= 0,1 mm	133
Average number of days >= 10,0 mm	19
Number of days with snowfall	26
Number of days with snow	33
Number of days with fog	34
Number of days with hail	1
Average density of solid sommunal unstable waste (t m-3)	0,3

Table 8. Annual value of meteorological parameters – atmospheric precipitation for the period of 1981-2010 on synptoic station Palić (RHMZ, n.d.)

Meteorological parameters- atmospheric precipitation	Annual values for the period 1981-2010
Average monthly amount (mm yr-1)	571,1
Maximum daily amount (mm yr-1)	94,3
Average number of days >= 0,1 mm	128

Average number of days >= 10,0 mm	17
Number of days with snowfall	23
Number of days with snow	35
Number of days with fog	41
Number of days with hail	1
Average density of solid sommunal unstable waste (t m-3)	0,2168-0,3930

Table 9. Annual value of meteorological parameters – atmospheric precipitation for the period of 1981-2010 on synptoic station Vranje (RHMZ. n.d.)

Meteorological parameters- atmospheric precipitation	Annual values for the period 1981-2010
Average monthly amount (mm yr-1)	578,3
Maximum daily amount (mm yr-1)	72,2
Average number of days >= 0,1 mm	131
Average number of days >= 10,0 mm	18
Number of days with snowfall	39
Number of days with snow	40
Number of days with fog	65
Number of days with hail	1
Average density of solid sommunal unstable waste (t m-3)	0,3

Table 10. Annual value of meteorological parameters – atmospheric precipitation for the period of 1981-2010 on synptoic station Zlatibor (RHMZ, n.d.)

Meteorological parameters- atmospheric precipitation	Annual values for the period 1981-2010
Average monthly amount (mm yr-1)	1017,3
Maximum daily amount (mm yr-1)	90,1
Average number of days >= 0,1 mm	171
Average number of days >= 10,0 mm	33
Number of days with snowfall	66
Number of days with snow	114
Number of days with fog	134
Number of days with hail	2
Average density of solid sommunal unstable waste (t m-3)	0,183

According to the presented data on annual values of average precipitation, we can conclude that the maximum quantity of filtrate is generated at the Regional sanitary municipal waste landfill of "Duboko" in Užice. A particular problem in the municipality of Užice is the old, but still working landfill "Sarića Osoje", which was formed in the stream, where the landfill leachates and surface water form a joint watercourse that flows downstream from the landfill in the Carinski stream and the River Djetinja, which due to the generation of a significant quantity of landfill filtrate can cause significant risk for surface waters, underground aquifers, surrounding vegetation, and the health of the population. Based on Table 6, Table 7, Table 8, Table 9, Table 10 and the data of the landfills' ages as well as the average density of communal waste in uncompressed condition, it is evident that the average quantity of leachate is generated that should not represent a problem due to the adequate control system on the landfills in Vranje, Subotica, Sremska Mitrovica and Kikinda.

Oxygen consumption

Besides individually affecting the intensity of leachate generation the aforementioned and processed factors also manifest their indirect impact on the parameters important for the quantity and quality of leachates, such as oxygen consumption recorded during the degradative mechanisms of waste material within the landfill body. Representative parameters of oxygen consumption are: chemical oxygen demand (COD), biological oxygen demand (BOD), and biological and chemical oxygen demand ratio (BOD / COD). Chemical oxygen demand represents the oxygen equivalent of the organic matter content that is subject to chemical oxidation under certain conditions, while the biological oxygen demand is the amount of oxygen needed to carry out biological oxidation of the present, biodegradable water ingredients. Pursuant to its mechanism, the said parameters are treated as indicators of the leachates contamination degree by the organic matter. The values of those parameters in leachates vary depending on the direct effects of other parameters that affect the intensity of generation of landfill filtrate, such as waste composition and landfill age. The Table 11 shows the integrated effect between the parameters: waste composition, landfill age and chemical oxygen demand, as well as the value of other significant chemical parameters that affect the quality of the leachates and their generation mechanisms.

Table 11. Comparison of leachates characteristics depending on the parameter " landfill age" (Luo J, et al., 2015)

Parameter	Group 1. Young landfills	Group 2. Average age landfills	Group 3. Old landfills
Age (years)	<5	5-10	>10
COD (mg l-1)	> 10,000	4,000-10,000	<40,000
BOD/COD	0,5-1	0,1-0,5	<0,1
pH	<6,5	6,5-7,5	>7,5
NH3-N (mg l-1)	<400	-	>400
Heavy metals (concetration)	Low to average	Low	Low
Biodegradability	High	Medium	Low

The value of the chemical oxygen demand in the leachates variates in the range of 8500 mg/l to 85000 mg/l. With the increase of age of the disposed material the COD reduces due to the reduction of undecomposed organic material composition. For most of the waste water the parameter BOD5 should be determined. This procedure is done due to the fact that it takes 5 days to decompose much of the present organic matter (70%). First we determine the amount of the dissolved oxygen at the beginning of the incubation period (day one), and then we measure the amount of the dissolved oxygen in a sample after 5 days of incubation at 20°C. The difference between these two values of the quantity of the oxygen dissolved in the sample represents the BOD5 value. The BOD5 values do not reflect the real value of the total BOD, as biological oxidation of organic matter requires more than 5 days. The majority (95 - 99%) of the reactions are completed after 20 days. However, since this period is too long for us to get a result, we usually choose a 5 day period. For most leachates the BOD5 value ranges between 60 - 80% of the total BOD. On landfill sites that are mostly composed of biodegradable components, the ratio of BOD/COD is greater than 0.4. This situation is seen in younger landfills with higher percentage of biodegradable waste in the scope of which intense biological processes take place, while the value of this parameter is less than 0.1 in the older landfills, indicating a reduction of biodegradable matter and thus significantly reducing the number of biological mechanisms. Older landfills have high values of COD and BOD/COD ratio, indicating a reduced presence of biodegradable substances and heavy metals. As a result high pH and NH3-N values are recorded. High concentrations of ammonium (1500 mg/l to 3000 mg/l) that are characteristic for older landfills have an inhibitory effect on microorganisms. The ammonium concentrations above 5800 mg/l are toxic to microorganisms, causing a disruption of biological mechanisms. Suspension of biological mechanisms significantly reduces the leachates generation. This is the case with all old landfills. Based on the shown above we can conclude that the parameters of oxygen consumption, COD and the BOD/COD ratio are very important indicators for identification of landfill age, waste composition, and therefore the assessment of the leachates generation.

Based on the parameters “Waste Composition” and “Landfill Age”, and the shown values of the chemical parameters characteristic for leachates, we can conclude that the values of COD and BOD/COD ratio are high on landfill sites the “Regional sanitary landfill Srem-Mačva” in Sremska Mitrovica, and the “Regional municipal solid waste sanitary landfill Duboko” in Užice. Therefore, the leachates generation on these landfill sites is intensive. The average values of these parameters are recorded in landfill sites “Regional sanitary landfill of solid waste” in Kikinda and “Regional Landfill Ltd.” in Subotica, so the generation of landfill filtrate has the same average level. In addition to the significant share of biodegradable waste in morphological composition of landfill sites “Sanitary landfill of solid waste Meteris” in Vranje and “Municipal landfill Aleksandrovačka bara” in Subotica, the low values of the COD parameters and BOD/COD ratio, as well as their long age, indicate the minimal generation of leachates.

Conclusions

Based on the processed data we can conclude that the four primarily examined factors represent integrated complex. The most important roles have the morphological composition of waste and average annual precipitation, which directly affect the amount of the generated landfill filtrate at the selected landfill sites. Regional sanitary municipal waste landfill "Duboko" in Užice generates the greatest amount of leachates, taking into account the short period of its exploitation, lack of methods of waste treatment before disposal, a significant part of biodegradable waste, the annual value of the average annual rainfall above the determined average, as well as a small average density of the uncompressed solid waste. According to these criteria, the next on the list is the Regional sanitary landfill "Srem-Mačva" in Sremska Mitrovica, then "Regional Landfill" Ltd. Subotica, "Regional sanitary municipal waste landfill" Kikinda, while the lowest generation is at the Sanitary landfill "Meteris" Vranje and Municipal landfill "Aleksandrovačka bara" Subotica. Despite the fact that the last two landfills have a significant share of biodegradable waste, the average annual precipitation amounts are below the established average, and the projected exploitation period of both landfills is exceeded, so the generation of landfill filtrate is reduced to a minimum. The estimates of the landfill filtrate generation intensity are of great importance and represent a necessary step in dimensioning, designing and economic analysis for leachate treatment system, as well as when deciding to reduce the potential risk for polluting surface and underground waters, the surrounding vegetation, and human and animal health. The integration of quantitative and qualitative analysis provides all the necessary information related to the specific leachates in the appropriate area.

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