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ENVIRONMENTAL RISK ASSESSMENT FOR THE UNREGULATED WASTE DISPOSAL SITES OF MUNICIPAL WASTE IN THE CITY AREA OF BOR[*****]

Abstract

The problem of unregulated waste disposal sites is present not only in Serbia but in the other parts of the Republic of Serbia. Therefore, it is necessary to locate these waste dumpsites, investigate their negative impact on the environment, make environmental risk assessment and start solving this problem. This presentation shows a methodology of the environmental risk assessment for the unregulated waste disposal sites in the city area of Bor. The idea, presented through this methodology, suggests how to understand the risk, how to make the risk assessment so that the owner is informed about possible consequences. In this way, a possibility can be avoided that in fear of unknown and incapable of understanding, the owner might take the precautionary measures at random. With regulated categorization a remediation of waste disposal sites can be done.

Keywords*: unregulated waste disposal sites, municipal waste, environmental impact, risk assessment*

INTRODUCTION

Waste management is considered an activity of public interest. Waste management is performed in a manner which shall ensure the lowest risk in terms of endangerment the human health and environment by control and implementation the measures to reduce pollution of water, air and soil, dangers to animals and plants, risk of accidents, explosions or fire, negative effects to the natural landscape and natural resources of special value, level of noise and odors. Waste management is defined by these legal acts: The Waste Management Strategy for the period 2010-2019 ("Official Gazette of RS", No, 29/10 and revised draft from 2015), Law on Waste Management ("Official Gazette of RS, No. 36/09 and 88/10,14/16), Council Directive 75/442/EEC on Waste (Framework Directive) and Council Directive 99/31/EC on landfills.

The problem with formation of unregulated landfills is particularly pronounced, both in the city of Bor and in other local communities and surroundings, that is, in the entire territory of the Republic of Serbia. It is obvious that unregulated landfills of municipal waste are formed by the roads, often in the immediate vicinity of cities, watercourses, in watercourses in

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forests and so on. Illegal formation of landfills and their uncontrolled expansion has a negative impact on land, watercourses (surface and groundwater), as well as flora and fauna. It should be noted that this way of disposing municipal waste must be prohibited and prevented because it causes the soil degradation and can increase the concentration of heavy metals in the soil, which can result in deteriorating the environmental quality and quality of human health. Therefore, it is necessary to identify and locate all unregulated landfills in the city of Bor, as well as in the other local communities, to carry out the environmental risk assessment and their impact on the environment and then propose measures for remediation, protection and improving the environmental quality.

For that purpose, in the city of Bor, a project was launched within which the following activities were carried out:

- identification and mapping of area polluted by the illegal landfills for municipal waste,
- consideration of the needs for improvement the technical capacities of waste management equipment and establishment a laboratory for testing the waste samples,
- consideration of possibilities for cleaning up the identified illegal landfills,
- elaboration of a study on local and best practices in the field of municipal waste management,
- implementation of forums and education for raising the awareness of improvement the municipal waste management practices.

The expected results of research are:

- identification, risk assessment and remediation the illegal landfills for municipal waste,
- map of contaminated areas from illegal municipal waste
- defined equipment for the improved waste management and establishment of a laboratory for testing waste samples,
- consideration of the scope of needs for remediation the illegal landfills for municipal waste,
- elaboration strategy, politics and study about best practices in the field of municipal waste management,
- elaborated directives for implementation the forums for raising awareness for improvement the municipal waste management practices.

Background

Bor is a city and administrative center of the Bor District in eastern Serbia. Map of the city is shown in Figure 1.

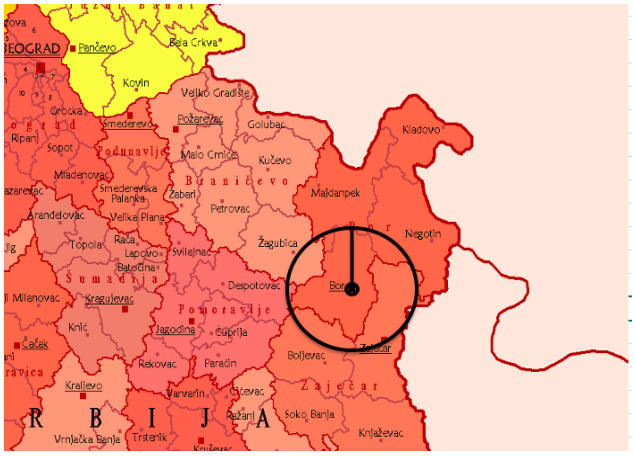

Figure 1 *Map of the city administrative area and Bor District*

Basic information about the city of Bor are shown in Table 1.

Table 1 *Basic information about the city of Bor(4)*

Info/the city of Bor	
Area	856 km^2
Number of settlements	1 urban+13 rural
Total on register*	48.615(34.160 in the urban settlement)

*According to the 2011 census

2 MUNICIPAL WASTE MANAGEMENT IN THE CITY OF BOR

The municipal waste management system in Bor is based on the collection, transport and disposal of municipal waste. The number of inhabitants who receive the provisional services of taking waste in the city of Bor is 48.615. Containers of different loads (from 1 to 5m^3), dump trucks and loaders are used for the waste collection with the predominant share of biodegradable waste being 51,73%. Other types of waste are paper, cardboard and plastic bags (Figure 2).

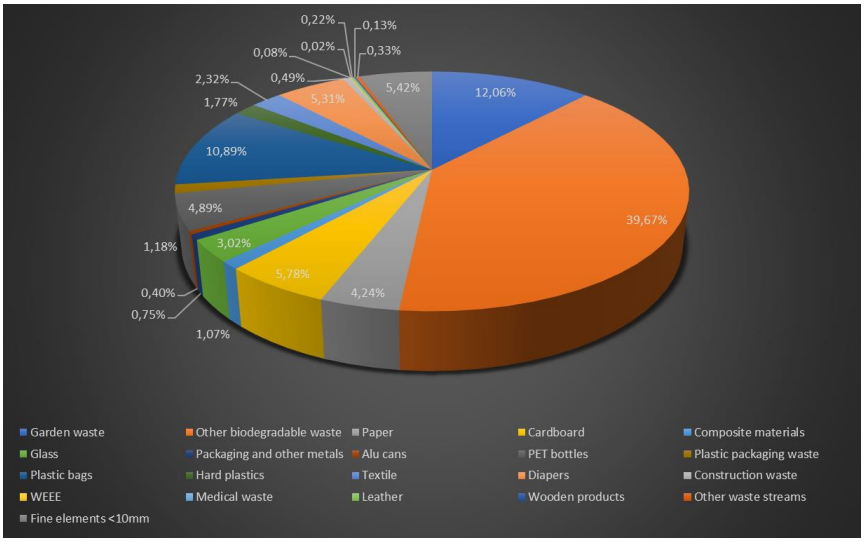

Figure 2 *Composition of municipal waste in Bor* [5]

In the city of Bor decisions were made related to the field of waste management, which derive from the laws and by-law acts that define this area:

1) The decision to determine the location for temporary disposal of construction waste and waste from demolition of buildings on the territory of the municipality of Bor, No.501-89/2010-I of 25/05/2010 ("Official Gazette of the Municipality of Bor", No.9/10)

2) Decision on the adoption of the Local Waste Management Plan for the territory of the Municipality of Bor 2010-2020, No.501-18/2011-I of 28/01/2011 ("Official Gazette of the Municipality of Bor", No.2/11).

Decision on determining the location of the center for separate collection and storage of recyclable components of municipal waste, No. 353-2/2012-I of 7/7/2012 ("Official Gazette of the Municipality of Bor", No.8/12).

3 IDENTIFICATION OF THE ILLEGAL LANDFILLS IN THE AREA OF THE CITY OF BOR

An illegal landfill is a place, a public area, where the unregulated landfill types of waste are located and which does not meet the conditions established by the regulation governing the disposal of waste in landfills.[6] The Bor city Authority has initiated a process to identify and map illegal municipal landfills in all local communities including the urban and rural areas, and database has been established containing a description of locations, their number and other useful data. 63 illegal landfills of municipal waste were identified, out of which 26 in urban areas and 37 in rural areas.[5]

After identification of the illegal landfills, it was necessary to do the mapping and perform an environmental impact assessment. Mapping is performed according to *By-law on Methodology for Collecting Data about Composition and Amounts of Municipal Waste on the Territory of Local Government Unit ("Official Gazette RS", No. 14 of 21/02/2020).*

Mapping and identification of illegal landfills include sampling and laboratory analysis of collected samples. These data are put into map so that a spatial arrangement of a chart can be made.

Table 2 *Records of illegal landfills in the city area of Bor* [9]

RECORD OF ILLEGAL LANDFILLS IN THE CITY AREA OF BOR						
LOCAL COMMUNITIES	**STREETS-LOCATION**	**NORTH**	**EAST**	**SURFACE AREA**	**DEPTH**	**VOLUME**
LC NOVO SELIŠTE	Vase Pelagića 121	44.07°	22.09°	200m²	0.4m	80m³
LC STARI CENTAR	Bus station fence	44.0751°	22.1025°	40m²	0.3m	12m³
	Majdampečka	44.0766°	22.1034°	100m²	0,5m	50m³
	Čočetova	44.0769°	22.1026°	40m²	0,5m	20m³
	Gradska bolnica	44.0793°	22.0928°	80m²	0.3m	24m³
LC SEVER	Kestenova 53	44.0832°	22.0978°	40m²	1m	40m³
	Dositeja Obradovića 38	44.0868°	22.0915°	15m²	0.5m	7.5m³
	Homoljska 15	44.0825°	22.0894°	70m²	0.4m	28m³
	Vojske Jugoslavije 32 i 34	44.0899°	22.0907°	375m²	0.2m	75m³
LC BREZONIK	At the stadium	44.0984°	22.0904°	30m²	0.2m	6m³
	Dečanska	44.0961°	22.0912°	20m²	0.2m	4m³
	Zmajevo 1	44.0953°	22.0950°	40m²	0.4m	16m³
	Landfill of the open pit	44.0953°	22.0869°	600m²	0.6m	360m³
LC RUDAR	Overpas	44.0698°	22.1034°	40m²	0.5m	20m³
LC SLOGA	At the stadium	44.0600°	22.1061°	115m²	0.4m	46m³
	Flee market	44.0614°	22.1081°	45m²	0.5m	22.5m³
	Pavla Orlovića	44.0584°	22.1173°	35m²	0.2m	7m³

LC NOVI GRADSKI	Rubber dump at the brickyard	44.0500 °	22.1126 °	45m²	0.6m	27m³
	Cementary landfill	44.0480 °	22.1137 °	800m²	4m	3200m³
	Under the brickyard	44.0500 °	22.1143 °	300m²	0.4m	120m³
LC METALURG	Ljube Nešića at the bridge	44.0515 °	22.0947 °	30m²	0.5m	15m³
LC BANJSKO POLJE	Mihajla Pupina	44.0596 °	22.0555 °	15m²	0.3m	4.5m³
	At the well	44.0692 °	22.0591 °	160m²	0.2m	32m³
LC MLADOST	Dr.Milovanovića	44.0649 °	22.0956 °	30m²	0.4m	12m³
	Kučajna	44.0639 °	22.0943 °	140m²	0.3m	42m³
LC BOR 2	V.Nazora to No.30	44.0580 °	22.0848 °	50m²	0.4m	20m³
LC SLATINA	Mountain embankment	44.0396 °	22.1600 °	40m²	0.2m	8m³
	Pripor	44.0318 °	22.1522 °	32m²	0.5m	16m³
	Exit from the village (along the river)	44.0362 °	22.1740 °	2000m²	0.3m	600m³
	Main landfill (near fattening farm)	44.0313 °	22.1813 °	400m²	0.4m	160m³
LC OŠTRELJ	Ogašu mika-village	44.0684 °	22.1664 °	400m²	0.3m	120m³
	Valja mika	44.0700 °	22.1759 °	200m²	0.5m	100m³
	Danijela Janošević	44.0637 °	22.1770 °	100m²	0.3m	30m³
	Bypass from Antić to Brezonik	44.0744 °	22.1359 °	245m²	0.15m	36.75m³
LC BRESTOVAC	Lakuri (hill above the village)	44.0359 °	22.0872 °	64m²	0.3m	19.2m³
	Next to the Brestovac bridge	44.0468 °	22.0778 °	scattered		
	At the exit from the village towards Metovnica	44.0317 °	22.0991 °	600m²	2m	1200m³
	Next to the transformer near Dokić	44.0339 °	22.0976 °	150m²	2m	300m³
	The old road to Šarbanovac D. Blagojevic	44.0259 °	22.0956 °	2000m²	3m	6000m³
	At the fairgrounds	44.0335 °	22.0908 °	200m²	0.5m	100m³
	At the village cemetery	44.0404 °	22.0973 °	3000m²	2m	6000m³
	Above the fairgrounds	44.0009 °	21.9954 °	600m²	1m	600m³
	The beginning of Dj.Jakšić Street	44.0078 °	21.9868 °	300m²	0,5m	150m³
	The fourth district near Roškić	44.0167 °	21.9861 °	40m²	0.5m	20m³
LC ŠARBANOVAC	Nestor creek	43.9683 °	22.0649 °	rasuto	0.1m	
	Šarbanovac cementary	43.9560 °	22.0874 °	40m²	0.5m	20m³
	Old mill-gap-spring	43.9258 °	22.0851 °	250m²	0.3m	75m³
	Baba Jona	43.9178 °	22.1230 °	50m²	0.3m	15m³
LC METOVNICA	Suva reka entrance to the village	43.9818 °	22.1650 °	60m²	0.3m	18m³
	Exit from the village	43.9638 °	22.1360 °	400m²	0.2m	80m³
	At the train station	43.9319 °	22.1578 °	100m²	0.2m	20m³
LC DONJA BELA REKA	At the confluence of two rivers	44.0725 °	22.2076 °	800m²	0.5m	400m³
	Exit from the village towards Pescar	44.0789 °	22.2127 °	40m²	0.2m	8m³
LC LUKA	At the fairgrounds	44.1721 °	22.1852 °	80m²	0.5m	40m³
	Next to the stadium	44.1693 °	22.1836 °	20m²	0.6m	12m³

LC GORNJANE	Behind the house	44.24409 °	22.0615 °	30m²	0.2m	6m³
	Mala kulma	44.25036 °	22.06306 °	50m²	0.2m	10m³
LC BUČJE	Under the cemetery	44.13893 °	22.14515 °	150m²	1m	150m³
	Under the quarry	44.14663 °	22.13889 °	300m²	2m	600m³
LC KRIVELJ	Banjica near the stadium	44.1370 °	22.0926 °	1200m²	0.2m	240m³
	At the cemetery	44.1195 °	22.10121 °	50m²	1m	50m³
BOR LAKE	Across from the public fountain	44.1031 °	22.1031 °	25m²	0.3m	7.5m³
	Pirot settlement	44.0710 °	22.0316 °	25m²	1m	25m³

4 THE ENVIRONMENTAL RISK ASSESSMENT METHODOLOGY FOR THE UNREGULATED LANDFILLS

Risk assessment takes into account the probability and consequences of events. Methodology is a systematic tool for determining the assessment of the nature, effect and extent of exposure which a sensitive receptor may experience in relation to a particular hazard.

Experiences from the Environmental Protection Agency's Code of Practice in Ireland have been used to optimize this methodology for assessing the risk of illegal municipal waste dumps.[1]

The environmental risk assessment methodology from illegal municipal landfills helps to make decisions that ensure that the sites having the greatest risk to human health and environment are cleaned and rehabilitated.

The environmental risk assessment for the unregulated waste landfills, developed by the methodology, has been adopted and optimized to meet the project objectives using the available data. The key issues taken into account for the environmental risk assessment of municipal waste are:

- Factor A-area contaminated by the municipal waste (area covered by the municipal waste),
- Factor B-receptor (any human habitat and/or settlement and/or wells near an illegal landfill for municipal waste that may be polluted),
- Factor C-distance of public water supply facility (sanitary zones for water supply or public water supply, endangered by the illegal landfills for the municipal waste),
- Factor D-distance of surface watercourses (distance of surface water bodies from the illegal landfills of municipal waste).

To assess the risk to the environment from the illegal landfills of municipal waste, the following criteria are defined for the selected factors, shown in Tables 3-7:

Table 3 *Factor A-area contaminated by the municipal waste*

Waste type	Criterion of factor A: Area contaminated by the municipal waste (m^2)			
	≤100	>100≤200	>200≤500	>500
Municipal	0.1	0.2	0.5	1

Table 4 *Factor B-receptor*

Criterion of factor B: Receptor	B1: Presence of human habitat	B2: Presence of water supply wells
On or within 50 m of the waste body	3	5
Greater than 50 m but less than 250 m of the waste body	2	3
Greater than 250 m but less than 1km of the waste body	1	1
Greater than 1 km of the waste body	0	0

Table 5 *Factor C-distance of the public water supply facility*

Criterion of factor C-distance of the public water supply facility	
Within 100 m of the site boundary	5
Greater than 100 m but less than 300 m	3
Greater than 300 m but less than 1km	1
Greater than 1 km	0

Table 6 *Factor D-distance of the surface watercourses*

Criterion Factor D-distance of the surface watercourses	
Within 50 m of the site boundary	3
Greater than 50 m but less than 250 m of the site boundary	2
Greater than 250 m but less than 1km of the site boundary	1
Greater than 1 km of the site boundary	1

The results of the environmental risk assessment from the illegal municipal landfills are obtained using the equation:

$$RISK=A \times (B1+B2+C+D)$$

Table 7 *Risk classification*

Rang of risk scores	Risk classification
Greater than 50% of the sum of points 1 to 16	Very highest risk
Between 30 - 50% of the sum of points 1 do 16	Highest risk
Between 20 - 30% of the sum of points 1 do 16	Moderate risk
Between 10 - 20% of the sum of points 1 do 16	Lowest risk

The following settings are used for identification, analysis and mapping the location of illegal landfills for municipal waste:

- waste that is present in the illegal landfills is mostly municipal waste,
- public water supply is provided for the city of Bor and there are no wells,
- half of rural settlements receive water from the rural water supply systems, and the other half from individual wells,
- presence of people near the illegal dumps is estimated using Google map measuring a distance between the given coordinates and the nearest houses,
- geologically it is considered that the landscape of Bor is mostly karst.

Table 8 *Application of the method for the environmental risk assessment of municipal waste on the field*

Location	Factor A	Factor B1	Factor B2	Factor C	Factor D	RISK
MZ Brezonik Open pit mine area (G15)	1	3	1	1	1	=6 (Highest risk) 37.5 % of the sum of points 1 do 16
Donja Bela reka village -At the confluence of two rivers (S10)	1	2	3	1	1	=7 (Highest risk) 43% of the sum of points 1 do 16
Zlot village The beginning of Djure Jakšića Street (S37)	0.5	2	3	0	1	=3; (Lowest risk) 18.75% of the sum of points 1 do 16
Bor Lake Across the public fountains (S5)	0.1	2	0	0	1	=0.3 (Lowest risk) 1.87% of the sum of points 1 do 16

Practical check of the environmental risk assessment from the illegal landfills for municipal waste for urban and rural conditions, and the village with a water supply network (village Zlot), and rural conditions and the village near the water-course (Donja Bela Reka), as well as the weekend settlement near Bor Lake.

Figure 3 shows the urban and suburban illegal landfills with a risk assessment.

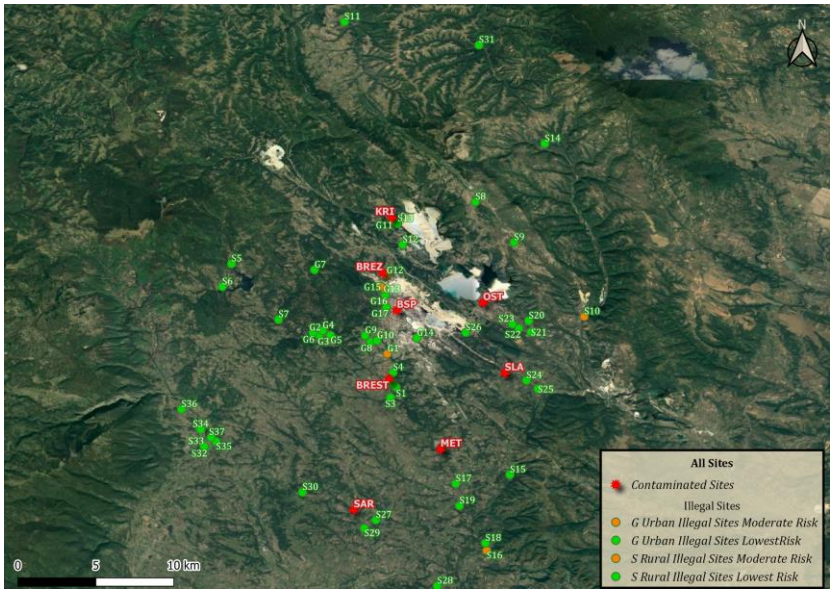

Figure 3 *Shows the urban and suburban illegal landfills with a risk assessment* [7]

5 CONCLUSION

The most significant impact of the illegal municipal waste landfills on the environment and public health are those related to the proximity of watercourses and long-term contamination due to the movement of waste water and of course the uncontrolled incineration of municipal waste where smoke, particles and gases are emitted into the atmosphere. The formation of a team for assessment the risk of illegal landfills for the municipal waste is one of the possibilities that provides a flexible and practical approach to solving this problem. It is concluded that formation a team to assess the risk of illegal landfills for the municipal waste can make significant contribution to the protection of environment and human health. Given the large number of uncertain issues in this research area in the field of risk assessment for the illegal municipal landfills, it is believed that the application of presented methodology of the average risk from various municipal landfills at the local community level is valuable and necessary to improve understanding and inform the public, as well as giving priority to solve the problem of remediation the illegal landfills for the municipal waste at the local community level. The presented methodology is a useful tool for gaining the insight into evaluation of the environmental health and safety management system. As such, it can be used as a relatively quick and inexpensive substitute for research which spends time and money, such as long-term monitoring projects or control studies. This model of the environmental risk assessment for the illegal municipal landfills has the character of an expert assessment and can be widely applied in the other local communities for the environmental health and safety management system and it can provide useful contribution relevant to the operational and strategic planning for the environmental protection.

Results of the applied methodology for ethe environmental risk assessment for unregulated landfills are:

- identification and mapping of 63 locations of illegal landfills for municipal waste in the area of the city of Bor;
- performed risk assessment and determined risk priority indicators and viewing the scope of needs for sanitation of illegal landfills for municipal waste;
- based on identification, mapping, quantity assessment, environmental risk assessment for the unregulated landfills for the municipal waste, adequate decisions, to supply the required equipment for advanced waste management as well as to establish a laboratory for testing waste samples, can be made;
- based on identification, mapping, quantity assessment, environmental risk assessment for the unregulated landfills for municipal waste, the strategy and politics can be defined in detail, as well as plans and programs for the effective and efficient municipal waste management;
- elaborated guidelines for the implementation of forum for raising awareness of the need for implementing best practices for municipal waste management;

In addition to everything that has been said in this study, an important role will be played by raising the people's awareness on the environmental protection and proper waste management.

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