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CONTAMINATED SITES. PRACTICE OF SOLID WASTE MANAGEMENT IN A DEVELOPING COUNTRY (SERBIA)

The issue of inappropriate municipal solid waste management is the key obstacle for the achievement of sustainable development in Serbia and Western Backa County (Vojvodina Province, Serbia). The paper presents contribution to waste management planning in Western Backa County, with the framework how to proceed with waste data gaps which is often case in developing countries. Having in account that the case study presented is a good example of situation in EC candidate and potential candidate countries in Balkan region, the method presented in the paper provides solid base to be taken in account when approaching practice of waste management in any developing country.

1. INTRODUCTION

The management of solid waste is one of the challenges facing any urban area in the world. Although in developing countries the quantity of solid waste generated in urban areas is low compared to industrialized countries, the municipal solid waste management (MSWM) still remains inadequate [1]. A typical solid waste management system in a developing country displays an array of problems, including low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control, etc. [2].

Serbia is a developing country in Europe, bordering with EU countries and other Western Balkan countries in various stages of eventual EU accession. The state of waste management in the Republic of Serbia is far below EU targets [3]. As opposed to practice of waste management in developed European countries, a general state of waste management in Serbia is inadequate and it poses public health and environmental hazards [4], and waste management plans at regional and local levels have to be developed [5].

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The latest EC 2010 Progress Report [5] shows that similar situation is in all EC candidate and potential candidate countries in Balkan region. In Croatia, sustained efforts for remediation of existing landfills and hot-spots and further establishment of systems for collection and management of various categories of waste are needed. In the former Yugoslav Republic of Macedonia a system to deal with waste data collection, recording and reporting is still not in place. In Albania, no permanent waste monitoring takes place and no official databases exist. In Bosnia and Herzegovina, no concrete steps were taken to establish systems for recycling and recovering priority waste streams. In Montenegro, the establishment of an efficient system for waste data collection, analysis and reporting is essential for sound policy making and particular attention needs to be given to implementation of the waste management strategy at local level. In Kosovo under UNSCR 1244/1999 establishment of an integrated waste management system has not begun. Comparative analysis for hazardous waste management is separately presented [6].

The National Waste Management Strategy (NWMS, 2003) in Serbia is the first fundamental document in the creation of conditions for a rational and sustainable waste management at the national level. According to requirements of the NWMS, establishment of a region consisting of several municipalities for integrated waste management presents the only sustainable waste management solution [7].

In above noted situation in Balkan, analysis and research presented in this paper presents strong rational and scientific, management and governance value. The overall objective of the paper is to present an environmentally and economically sustainable municipal solid waste management system in the one waste management Serbian Region (Western Backa Region) which is composed of a few municipalities (Sombor, Apatin, Kula, Odzaci and Bac), to serve as an implemented example of the Solid Waste Management Plan for Vojvodina Province and Serbia and to demonstrate waste management practice in developing countries.

2. WASTE MANAGEMENT PRACTICE IN SERBIA

Waste management in Serbia is inadequate. It is difficult to estimate the potential environmental benefits of an improved waste management because of the lack of data. According to EU Commission Progress Report for Serbia (2009), progress can be reported on waste management in Serbia, with the adoption of the Law on Waste Management (LWM) and the Law on Packaging and Packaging Waste [8]. The LWM stipulates that each municipality develop a municipal waste management plan; subsequently, municipalities must then organize themselves into regions and prepare regional waste management plans based on the local plans [3]. New EU Commission Progress Report for Serbia (2010) also provides information about progress in the area of waste management. A regulation on establishing the plan for the reduction of pack-

aging waste for the period from 2010 to 2014 has been adopted, following the adoption of laws on waste management. In addition, the updated National Waste Management Strategy (NWMS) was adopted in 2010. The NWMS provides guidance on the implementation of waste legislation. It establishes systems for the management of specific waste streams. However, one of the key obstacles to the achievement of NWMS goals is lack of plans of waste management at regional and local levels which have to be developed [9].

Waste volume in the Republic of Serbia is hard to estimate. The main reason is lack of information on waste qualitative and quantitative analysis, i.e. data base of quantities, characteristics, especially content, and classification of waste [4]. Only ca. 60% of municipal solid waste is collected in Serbia. Average person generates approximately 318 kg of waste per annum or 0.87 kg per day, which is lower than the European average. On average, each European produces nearly a half ton of waste per person every year. However, there are wide disparities within the EU and each country has its own particular waste production profile [10].

Waste disposal, especially hazardous waste disposal, is an obvious problem in the Republic of Serbia. Namely, the existing urban disposal sites are mainly disorganized, with no additional equipment or protection measures. Officially, there are about 180 disposal sites of municipal solid waste across Serbia, not counting a large number of illegal waste dumps in rural areas [11]. As a consequence of regionalization process in waste management, current, poorly managed municipal landfills are to be closed in accordance with remediation and closure design documents, to ensure the long-term protection of human health and the environment, and to minimize the need for long term post-closure maintenance.

3. CURRENT WASTE DATA AND MANAGEMENT PRACTICE IN THE WESTERN BACKA REGION

Data are collected from available sources [12, 7] and waste management practice analyzed by common indicative performances [13, 14].

Population covered with the municipal waste collection system in the region. Organized collection of the municipal waste covered 155 943 inhabitants (or 67.72%) out of the total 230 279 inhabitants living in the region which included 100% inhabitants of urban and 34,8% inhabitants of rural settlements. Organized waste collection covered all urban settlements, while coverage of the rural settlements was significantly bad with different results for included municipalities.

Amount and composition of the collected municipal waste. Companies having the duty of waste collection and its transport to the disposal site do not perform measuring procedure of waste quantities, nor do they have proper equipment for performing this procedure.

Since there is no data on the amount of waste in the region, estimation of the amount of generated waste was performed taking into account all significant criteria which affect the level of waste generation. The amount of the waste per inhabitant for the urban settlements of Sombor, Apatin, Kula and Crvenka, which account for the most significant share of the industrial production, was estimated at the level of 1.3 kg daily or 474.5 kg annually. The same measure for the urban settlements of Odzaci and Bac was estimated to be 1 kg per inhabitant daily or 365 kg per inhabitant annually, while for rural settlements with dominant agricultural production the same measure was estimated to be 0.6 kg per inhabitant daily or 219 kg per inhabitant annually. Estimation of the amount of waste generated in the region during 2007 was performed based on the previously specified coefficient values for average daily waste production and the data on population covered with the services of organized waste collection (Table 1) [7].

Table 1

Estimated amount of collected waste in 2007

Sombor	Apatin	Kula	Odzaci	Bac	Region
Annually collected waste [t]					
25.576	10.214	18.118	4.889	4.452	63.249
Urban areas [t]					
24.423	9.167	13.981	3.628	2.222	53.421
Rural areas [t]					
1.153	1.047	4.137	1.261	2.230	9.828

It is very difficult to assess the composition of waste generated in the region, because there is no accurate data on the amount of waste transported to the disposal site, and the separation of waste is not being done. For the needs of this paper, acquired data on the morphological composition of waste is taken from the Strategic framework for the waste management policy (2002) and the data presented in the Study of the Spatial Layout of the Regional Landfills and Transfer Stations on the Area of AP Vojvodina (The Study for Vojvodina, 2006) [15, 16].

Present state of the equipment for waste collection and transport. Municipal waste is most often collected in the containers of 1100 dm³ and 5000 dm³ of volume or in the cans of 120 dm³ and 140 dm³ of volume, though; a lot of different untypical tanks are used for this purpose. The waste collection equipment is not on the satisfactory level for various reasons: there are not enough containers in the most of the inhabited places; in the most of the rural settlements there are no receptacles at all; existing receptacles are mostly worn out and it is necessary to replace them, etc.

Obsolete machinery used for waste transport is also a significant problem. Most of the vehicles are more than 10 years old and the vehicles that are not envisaged for this

purpose are often used for it, which largely minimizes the effect of the public municipal enterprises and the frequency of municipal waste removal.

Waste disposal. The only method of waste management in the region is disposal. Waste is disposed on the municipal disposal sites, which are more or less neglected. On the territory of the observed region, there is no sanitary municipal waste disposal site. The characteristics of the disposal sites in the region are: the majority of the disposal sites are placed very close to the settlements; the measurements or rough selection of waste materials is not performed on any of them; the majority of disposal sites is not fenced and there is no protection service; they do not possess facilities for the collection of landfill gasses and leachate waters etc. Currently, and for sure in future, (some of) this sites will be in category of contaminated sites, looking for remediation options [17].

4. SYSTEMATIC RECOMMENDATION FOR SOLVING OF INADEQUATE WASTE MANAGEMENT ISSUE IN THE OBSERVED REGION

The assessment of the future amount of the waste. The assessment of the amount of solid municipal waste [7] which will be generated in the region from 2008 to 2033, was performed (Table 2) for the three characteristic periods:

- 2008–2013 – the extension of the population scope with 100% organized waste collection and building of the system (regional landfill and its facilities),
- 2013–2023 – establishment of the system for the collection and recycling planned,
- 2023–2033 – stable functioning of the previously introduced implemented system.

Table 2

Expected amount of waste in the period 2012–2033

Sombor	Apatin	Kula	Odzaci	Bac	Region
Generated waste in 2012 [t/year]					
36.920	12.997	19.428	9.875	4.760	83.980
Generated waste in 2022 [t/year]					
43.014	15.171	22.690	11.361	5.500	97.736
Generated waste in 2032. [t/year]					
48.906	17.281	25.860	12.757	6.202	111.006

The potential amount of the waste is determined for the specified number of inhabitants, in the specified time frame, by specific amount of waste generated per cap-

ita by day, while taking in to account possible changes in the number of the inhabitants and the enlargement of the system for the organized waste collection. By the end of the planning period, 111 006 t of the waste will be generated in the region annually; this amount will be fully covered by the organized waste collection.

Waste collection and transport equipment. Having in mind the need for the introduction of the standardized equipment for the waste collection, in order to achieve the compatibility of the transport vehicles and the waste receptacles, it is proposed to implement the use of containers of 1.1 m³ (group housing) and bins of 120 dm³ (individual households) [7]. Table 3 shows the results of the assessment of the necessary number of the waste receptacles for the region up to the end of the planned period.

Table 3

Assessment of the number of receptacles
in the Region up to the end of the planned period

Sombor	Apatin	Kula	Odzaci	Bac	Region
Until 2013					
18.725	7.089	9.629	5.830	2.971	44.244
Until 2023					
21.752	8.261	11.217	6.695	3.430	51.355
Until 2033					
24.659	9.395	12.751	7.502	3.866	58.173

In order to establish the functional system of the organized waste collection and transport in the region it is necessary to replace the obsolete vehicles with new ones in the shortest possible period of time. The new vehicles should be compatible with the system of collection and suited for the waste collection. The results of the assessment of the necessary vehicles number for the region up to the end of the planned period are presented in the Table 4.

Table 4

Assessment of the vehicles number in the Region
up to the end of the planned period

Sombor	Apatin	Kula	Odzaci	Bac	Region
Until 2013					
10	4	5	3	2	23
Until 2023					
11	4	6	3	2	26
Until 2033					
11	4	6	3	2	26

Transfer stations. In order to solve the problem of the distance of specific municipality centres from the location of the regional landfill and to minimize the cost of waste transport it is necessary to construct the transfer stations in some of the municipalities. SNWMS (2003) foresees the construction of the transfer stations on the locations that are more than 20 km away from the regional landfill [11].

The location “Rancevo” (7 km away from the town of Sombor) was selected for the construction of the regional landfill through the analyses of the macrolocations suitable for the development of the regional sanitary landfill [16].

Based on the previously mentioned parameters, research of the area of the region, it was concluded that the optimum solution in the envisaged region is to construct three transfer stations: waste reload and transport from the municipality of Kula (46 km away from the regional landfill), municipality of Odzaci (37 km away from the regional landfill) and the municipality of Bac (56 km away from the regional landfill).

System of waste separation and recycling. It is recommendable to implement both primary and secondary recycling in the region. Until separation of waste in the place of origin becomes available, that is, until the population of the region accepts primary recycling, it is useful to anticipate the possibility of separation of secondary raw material from non-selected municipal waste. One of the most available solutions in terms of technology and investments is the establishment of the facility for manual separation of secondary raw material from the total waste stack on the regional landfill until 2013.

Table 5

Estimated amount of recyclable waste components

Waste component	Contents [%]	Amount [t/day]		
		2012	2022	2032
Paper	26	11.96	27.85	47.44
Plastic	8	5.52	10.71	17.03
Glass	5	1.15	5.36	9.12
Metals	6	1.38	6.43	10.95
Rubber	1	0.23	1.07	1.82
Textile	4	0	0	0
Organic waste	40	0	42.84	72.99
Other	10	0	0	0
Total	100	20.24	94.26	159.35

Calculation of the amount of potential recyclable waste components [7] during planned period of 25 years was performed (Table 5). Total amount of waste which will be generated in the region until 2013 is estimated to 230.08 t/day. By introducing primary recycling this amount could be reduced for 2.24 t/day. If the tendency of increased proportional separation of useful components from the total waste stack is

continued in the last planned period, it is possible to reduce the total amount of waste for 2032 from estimated 304.12 t/day to estimated 159.35 t/day.

The landfilling of biodegradable municipal waste (BMW) is common in the region and in every other part of Serbia. The landfilling of BMW is of environmental concern because its decomposition results in the production of landfill leachate and greenhouse gas emissions and because a potentially valuable resource is being wasted [17]. With respect to the EU Directive on waste areas and the prohibition of biodegradable waste disposal to waste areas, recycling, composting and anaerobic digestion became significant as an alternative option for treating biodegradable waste in the region [18]. Total amount of organic waste, which will be generated in the region until 2033, is estimated to ca. 73 t/day or 26.64 t/year. By diverting this amount of organic waste away from landfill to recycling and recovery operations such as composting, anaerobic digestion and material recycling, a valuable resource can be produced from the waste, and the exploitation of virgin resources and the total amount of waste for landfill can be reduced for 19% to the end of planning period. This shows that reduction of the biodegradable fraction to landfilling as required for EC countries will not be easy to achieve without radical actions supporting with investments.

Regional landfill: determination of sanitary landfill volume. Results, based on the calculations of the total amount of waste that will be generated in the region during the planned period of 25 years, show that the total amount of municipal waste until 2033 will be around 2 047 826 t. According to the calculation of the separation of useful waste components from the total municipal waste stack, the amount of recyclable components that can be separated in the region until 2033 is around 879 032 t. It is concluded that the amount of waste to be disposed at the regional landfill equals approximately 1 170 000 t of waste in the next 25 years. Taking cover material into account, it is necessary to provide the landfill body with the volume of around 1 730 000 m³ for the needs of the region in the next 25 years.

Regional landfill: area determination of the sanitary landfill. Determination of needed space for landfilling is tightly correlated with the disposal height. Optimum height limit will range from 10 to 15 m. Based on the approximately defined future volume of the landfill body and its optimum height, it can be estimated that the needed area for the future landfill covers around 11–17 ha. Taking into account the area for all facilities in the complex and the optimum area of buffer zone, it is estimated that the total area of future regional landfill will cover between 14–20 ha.

Regional landfill: landfill technology. It is recommended to use modern technology of landfilling in the regional landfill in the municipality of Sombor which includes existence of: protective cover, composite cover system, operating landfill area, system for the collection of leachate waters and composite protective system.

5. CONCLUSION

Recommendations given in this document provide flexible framework for adequate waste management in the West Backa Region (Serbia) until 2033. The authors believe when presenting this documented case study of practice in developing countries, as well as EC candidate and potential candidate countries, to contribute to systematic approach to anticipated problems common in all mentioned countries no matter where in the world. Moreover, they represent concrete contribution to the infrastructure demands, as well as presenting framework how to ensure the long-term protection of human health and the environment from inadequate waste management (and prevent contamination and/or conduct efficient remediation of contaminated sites) not only in the observed region, but also in any other domain of the Autonomous Province of Vojvodina and the Republic of Serbia.

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