

# Paradigm shift needed – municipal solid waste management in Belgrade, Serbia

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## Abstract

The aim of this paper is to assess the current state of municipal solid waste management (MSWM) in Belgrade, the capital city of Serbia, by analyzing a legal framework, quantities of generated waste, collection systems, transportation, final disposal, separate collection of recyclables, and waste minimization incentives. The analysis is mostly based on the available data of Public Utility Company “Gradska čistoća”, the only provider of municipal solid waste (MSW) services, *i.e.*, collection, transportation, and disposal. Key features, problems and goals of MSWM system in Belgrade are discussed, and the efficiency of the existing separate collection system of recyclables is reviewed. Finally, some further guidelines are given in order to assure a paradigm shift in the next period.

**Keywords:** municipal solid waste management, waste collection, waste transportation, developing country, Belgrade, Serbia, paradigm shift.

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Municipal solid waste management (MSWM) is a major challenge for countries worldwide, particularly for developing countries like Serbia, and its capital and largest city – Belgrade. Factors like increasing urban population, limited financial resources without advanced technologies for waste treatment and disposal, recently adopted adequate legislation etc. lead to poor waste management, which is a significant environmental problem. The main solid waste disposal method is unsanitary landfill, because of its low cost. Few studies of waste characterization have been conducted in Belgrade. Due to the poor methodology used, the obtained data are still not reliable and great variability is observed. The collection and transportation parts of present MSWM system in the inner city area are well organized, although it might be optimized and improved.

In Serbian national environmental policy, waste management is defined as one of the most important issues of environmental protection. In practice, the situation is not appropriate. Belgrade has a population of around 1.3 million of citizens in the inner city area (according to the 2002 census) [1]. According to preliminary 2011 census data, the population in the inner city area has increased by about 10%, which doesn't have significant influence on daily amount of generated waste per capita [2]. Average daily amount of municipal solid waste generated in 2010 is 1,300 t/day, or 0.97 kg of waste generated daily per capita (based on quan-

ties of generated waste, data registered by Public Utility Company “Gradska čistoća” during 2009 and 2010). Sources of municipal waste are households, offices, schools, other institutions, shops, services, municipal green areas, graveyards, and infrastructure facilities. The Public Utility Company “Gradska čistoća” is the only provider of MSW services, *e.g.*, collection, transportation, and disposal. The waste collection service of the company is organized in ten functional units located on correspondent municipality.

The aim of this paper is to provide an overview of the different elements of existing MSWM in Belgrade, waste generation, waste collection methods, transportation, disposal, and legal framework. Waste management system analysis is carried out based on data from the Public Utility Company “Gradska čistoća”, city reports and strategies. The MSWM system in Belgrade is discussed in terms of key features, main problems and paradigm shift needed. Some concluding thoughts are defined as to how the city can develop a successful MSWM system. Statistical data (population, municipal area, agricultural area) are provided from the official website – Statistical Office of the Republic of Serbia (<http://www.stat.gov.rs/>, January 2011).

## BACKGROUND OF MSW MANAGEMENT IN BELGRADE

### National policy

The National Waste Management Strategy for the period 2010–2019 was adopted on 7<sup>th</sup> May 2010, it is the basic document for rational and sustainable waste management in Serbia. According to the strategy, some of the main requirements are: harmonization of nati-

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onal legislation with EU directives, build-up of institutional capacity and legislation, the right implementation of regulations, increase of education and public awareness. The key principles in Waste Management strategy are: sustainable development, waste management hierarchy, precaution, regionalization, the most optimal environmental option, “Polluter pays” and “Producer responsibility” [3]. The last two principles, “Polluter pays” and “Producer responsibility”, which seem to be so simple, logical and fair, are in fact the most difficult to implement, even in developed countries. The implementation of those principles is not simple because it implies the existence of effective control mechanisms, the necessary economic and social assumptions, and lack of political influence – which is usually not the case [4]. The Strategy envisages the establishment of 29 regional sanitary landfills, as well as a number of other facilities that are expected to help waste management to become more efficient.

#### **The basic Existing legislation related to MSWM**

The Serbian legislation related to MSWM, *e.g.*, The Law on Waste Management [5] and The Law on Packaging and Packaging Waste, was recently adopted (in 2009), and it is harmonized with EU Directives (“Sl. glasnik” RS, br. 36/2009, Official Gazette of the Republic of Serbia, 36/09) [6]. It should be the basis for proper waste management. The aim of the newly implemented laws is to ensure and provide: waste management in a way that does not have a negative impact on human health and the environment; the prevention of waste generation, cleaner technologies development, the rational use of natural resources, as well as the removal of risk of its harmful effects on human health and the environment, the re-use and recycling of waste, the segregation of recyclables from waste and the use of waste as fuel, the development of procedures and methods for waste disposal, the rehabilitation of dumpsites, the monitoring of existing and newly formed landfills, developing awareness of waste management. The adopted legislation related to waste management is also binding for the city of Belgrade.

The Law on Packaging and Packaging Waste is one of the most important legislative acts for waste management in Belgrade, because it defines municipal packaging waste as “waste from primary and secondary packaging that occurs as waste in households (household waste) or industry, crafts, services or other activities (commercial waste), which is similar to waste from households in terms of its nature or composition and is collected within certain territorial units, in accordance with the law”. According to this law, the end user is responsible to sort and/or store separately municipal packaging waste so that it is not mixed with other waste, in order to be forwarded or returned,

collected, re-used, recycled or landfilled in accordance with the law that regulates waste management.

Although recently adopted, the Law on Strategic Environmental Assessment and the Law on Waste Management are already amended in December 2010 because of some problems noticed in the first phase of the implementation process.

#### **Institutional framework**

Institutional framework in waste management refers to institutions, institutional capacities and organizational procedures. An effective waste management system depends on an adequate distribution of responsibilities, jurisdiction and income between federal and local authorities. According to the Law on Waste Management, the local government:

- adopts the local waste management plan, provides the terms and manages its implementation;
- regulates, provides, organizes and implements public management, and unresponsive and non-hazardous waste in its territory, in accordance with the law;
- regulates the billing for services in the field of public management, and unresponsive and non-hazardous waste, in accordance with the law;
- issues permits, approvals and other acts in accordance with the law, keep records and data submitted to the Ministry;
- exercises supervision and control measures with the treatment of waste in accordance with this law;
- performs other tasks defined by the law. Decentralization of administration is accompanied by distribution of financial and administrative responsibilities and capacities for system planning, implementing and functioning in terms of more efficient, responsible and more flexible waste management.

#### **Description of the city of Belgrade**

Belgrade inner city territory is administratively divided into 10 urban municipalities (Stari grad, Vračar, Zvezdara, Palilula, Savski venac, Čukarica, Rakovica, Voždovac, Novi Beograd and Zemun).

#### **MUNICIPAL SOLID WASTE MANAGEMENT IN BELGRADE – OVERVIEW**

Data related to the quantities, composition, characteristics and sources of MSW, along with the socioeconomic variables that determine their production, are fundamental requirements for the designing and planning of sustainable solid waste management. Nevertheless, many municipalities do not have the time or financial, institutional and technical resources to carry out these studies. For the city of Belgrade, detailed research has not been undertaken; the available data were obtained mainly on the basis of an assessment. The availability of data on waste is generally

limited; data are fragmented and based mostly on estimation. The implementation of the reporting system is in an early stage.

Although the sector of solid waste was well developed in Belgrade twenty years ago, the current situation has deteriorated substantially, reflecting ten years of limited investment (1990–2000) and lack of maintenance. Public Utility Company "Gradska čistoća", with around 1,790 employees, is the only provider of MSW services (collection, transportation, recycling, disposal) for the 10 inner city municipalities of Belgrade. The Company is also responsible for street sweeping. Around 80% of the collected MSW in Belgrade is disposed on a single unsanitary landfill – "Vinča". Currently, there is no competition for the company's basic SWM services.

### Waste generation

Some data related to MSW, mostly quantities of collected and disposed solid waste, started systematically to be registered since 1987. The amount of waste collected in Belgrade increased in the period 1987–1991, with an average growth rate of 2%. This trend reversed in the years 1992 to 1995, apparently reflecting the early years of war, conflicts in the region, political situation that led to poverty of the majority of the population. Statistics for the late 1990s are not available for the same reason. The quantity of MSW collected in the year 2000 (303,080 t) and 2001 (360,679 t) has increased significantly with 19% – reflecting a growth of the standard of living. The quantity of collected waste in 2002 (409,203 t) also showed a high growth rate of 13.4% [7].

Generated waste is mostly not sorted at the source, but collected in the same waste bins. There is no official statistics on the overall amount of waste generated in Belgrade. The main source of information on the amount of waste generated is the Public Utility Company "Gradska čistoća", which deals with information of the total quantity of the waste collected and land filled by this company and some other companies that are paying for disposal of their waste to the official landfill. Another limitation factor should be considered when speaking about the quantities of waste collected by the existing system is the activity of the waste pickers, who collect a considerable amount of the recyclables from the containers and sell it on the market. Also, an amount of waste is still disposed on open dumps, mostly along the roads or on some undeveloped area. That is because of the lack of implementation of the national policy, integrated system of waste management and adequate technologies.

The waste generation rate in Belgrade in 2006 was almost 400 kg/capita [8]. Increase of the waste generation rate from 2002 to 2008 is a consequence of significant changes, mostly in Gross Domestic Product (GDP). Increase of GDP is directly related to standard of living improvement and consumption habits of citizens. The more products are consumed, the more waste is generated.

There are still no detailed studies with reliable waste statistics for the City of Belgrade, required for development of an appropriate MSW management system. Data are obtained by Public Utility Company "Gradska čistoća", which measures the mass of waste collection trucks. As seen in Table 1, average quantity of MSW collected by the existing container system in

Table 1. Data on MSW collected in inner city area of the city of Belgrade in 2010 by Public Utility Company "Gradska čistoća", including number of inhabitants by census 2002

Functional unit of the Public Utility Company	Inhabitants <sup>a</sup>	Total quantity of MSW collected <sup>b</sup> t	Waste collected from open dumps total m <sup>3</sup>	Bulky waste total m <sup>3</sup>	„Green waste“ total m <sup>3</sup>	Other types of waste total <sup>c</sup> m <sup>3</sup>	Waste from open dumps + bulky + green + other total m <sup>3</sup>	Total quantity of MSW kg/capita	Total quantity of MSW t/day	Average quantity of collected MSW kg/day/capita
Stari grad	55,543	25,068	0	3,766	16	284	4,066	451	69	1.24
Zvezdara	132,621	50,381	835	7,567	1,398	3,573	13,373	380	138	1.04
Palilula	155,902	56,157	4,474	3,241	1,064	7,715	16,494	360	154	0.99
Vračar	58,386	21,282	42	2,040	1,168	4,287	7,537	365	58	1.00
Voždovac	151,768	50,084	1,154	6,835	1,084	1,420	10,493	330	137	0.90
Savski venac	42,505	28,991	300	5,510	1,732	610	8,152	682	79	1.87
Čukarica	168,508	55,503	2,185	6,646	1,103	2,285	12,219	329	152	0.90
Rakovica	99,000	31,191	142	6,309	496	3,867	10,814	315	85	0.86
Novi Beograd	217,773	61,497	2,774	15,091	562	4,642	23,069	282	168	0.77
Zemun	191,645	78,636	3,129	4,728	213	1,377	9,447	410	215	1.12
Total	1,273,651	458,790	15,035	61,733	8,836	30,060	115,664	360	1,257	0.99

<sup>a</sup>According to census 2002, <sup>b</sup>total quantity of MSW collected by the Public Utility Company "Gradska čistoća" in 2010, <sup>c</sup>includes mostly demolition waste, left by the containers

2010 varies from 1.87 to 0.87 kg/day/capita, with an average rate of 0.99 kg of MSW collected per day per capita. Total quantity of MSW collected in 10 municipalities in the inner city zone in 2010 is 458,790 t, or 1,257 t/day.

### Waste composition

There are no detailed, reliable studies on waste composition for the city of Belgrade. The only official data on waste composition are presented in Table 2 [9].

Table 2. The physical composition of solid waste in Belgrade (wt.%)

Component	Content, %
Garden waste	6.68
Other biodegradable waste	30.93
Paper	10.78
Glass	6.84
Cardboard	8.97
Cardboard – wax	1.74
Cardboard – aluminum	1.20
Metals – packaging and other	1.98
Metals – Al cans	0.40
Plastics – packaging	4.58
Plastic bags	5.61
Plastics	4.73
Textile	5.31
Leather	0.61
Diapers	3.67
Fraction less than 20 mm	5.98

As seen in Table 2, one of the main characteristics of waste composition for Belgrade is a high level of biodegradable waste (37.61%), which is typical for large

cities in developing countries. Another worrying data is the high content of plastic bags (5.61%) that ends up in landfills, by the side roads, river flows, etc.

### Waste collection and transportation, service coverage

#### Waste collection and transportation

In order to provide waste management services to all residents in the ten inner city municipalities, the City of Belgrade has founded the Public Utility Company “Gradska čistoća”. Depending of the urban structure of the parts of each municipality (city centre apartment blocks, suburban apartments blocks, individual houses, structure of the roads, plain or hill territory), the existing MSW collection system includes different types of collection bins, their distribution, load vehicles and routing. Most of the population is served by a curbside collection system, which involves metal, plastic or underground containers of 1.1, 3.2 or 3 m<sup>3</sup> located at designated sites, shared by a number of buildings within specific area.

The waste container number, volume and allocation data are given in Table 3. An average number of waste containers is three per each location, with an average volume of 4 m<sup>3</sup>, and average allocation of 23 container locations per km<sup>2</sup>. As shown in Table 3, those numbers varies according to the urban structure of each part of the municipality. Municipalities in the centre of the city have a higher density of container locations per km<sup>2</sup>. The containers are emptied by specific trucks, depending on the defined dynamic and transported for final disposal to a landfill. There is no brief study on optimization of dynamic and routing of the collection system and is rather done by operator’s estimation. Small “hanging” waste bins and small bins are used for collection of small parts of waste thrown by people when

Table 3. Number, volume and allocation of containers for MSW disposal

Functional unit of the Public Company	Container (1.1 m <sup>3</sup> )		Container (3.2 m <sup>3</sup> )		Underground container (3 m <sup>3</sup> )		Average No. of containers per location	Average volume of containers on each location m <sup>3</sup>	Area (without cultural area) km <sup>2</sup>	No. of locations per km <sup>2</sup>	Small „hanging“ waste bins		Small waste bins	
	No. of containers	No. of locations	No. of containers	No. of locations	No. of containers	No. of locations					No. of bins	No. of locations	No. of bins	No. of locations
Stari grad	924	314	67	34	25	12	3	4	5	72	59	57	348	264
Savski venac	2,184	663	45	32	8	7	3	4	14	50	96	65	279	124
Vračar	1,048	384	40	30	8	5	3	3	3	140	37	29	257	180
Zvezdara	2,266	743	237	143	21	19	3	4	14	65	85	69	179	133
Palilula	4,554	1,377	43	29	0	0	3	4	149	9	97	80	196	107
Rakovica	2,279	692	0	0	0	0	3	4	18	38	144	89	146	74
Čukarica	3,543	1,137	159	123	0	0	3	3	80	16	65	51	193	133
Voždovac	3,011	980	0	0	3	3	3	3	52	19	58	50	190	137
Novi Beograd	6,432	1,551	0	0	21	11	4	5	32	49	392	253	206	124
Zemun	3,329	1,320	27	14	0	0	3	3	50	27	86	74	215	132
Total	29,570	9,161	618	405	86	57	3	4	417	23	1,119	817	2,209	1,41

in the street. Usually small bins are placed along the sidewalk and other areas for public use. While doing street cleaning, workers empty those bins into the curbside containers.

The house-to-house collection system is implemented in specific parts of the municipalities where the structure consists mostly of individual houses. Plastic waste bins of 240 l are distributed to each household. Transportation vehicles visit houses, once a week, at a specific day and time for waste collection. Total number of 30,282 households in 24 housing estates, is covered by this type of waste collection system.

Public Utility Company in cooperation with the City Authorities started a project of installing underground containers of the capacity of 3 and 5 m<sup>3</sup> in 2009. There are 86 underground containers of the capacity of 3 m<sup>3</sup> (Figure 1) installed on 57 locations in 6 municipalities, by the end of 2010 (Table 3). The installation of underground containers of 5 m<sup>3</sup> is expected to begin by the end of 2011. More than 1000 underground containers are expected to be installed by the end of 2012. The mixed household waste is disposed in underground containers. Besides obvious aesthetic characteristics, the new system has a bigger volume, better hygienic characteristics, saves space for parking and pedestrians.

A waste collection vehicle collects the waste from an average number of 300 containers of 1.1 m<sup>3</sup> positioned on a defined territorial block on each tour, or collects the waste from an average number of 470 waste bins of 240 L from individual households on each tour (Table 4). Depending on the position of the collection block, the route longitude extreme values are 48–258 km for the functional unit closest to the landfill (Zvezdara) and farthest (Zemun), respectively. An average route longitude is 115 km. The distance

from the farthest waste collection point to the landfill is around 55 km.



Figure 1. Underground containers – capacity 3 m<sup>3</sup>.

It is necessary to mention that solid, non-household waste, construction-demolition waste, discards generated by industries and workshops is handled through agreements with some private collection services, or by using the special service provided by Public Utility Company “Gradska čistoća”. In any case, those types of waste are mostly disposed at landfill “Vinča” and charged with special fees. Some shopping malls separately collect paper and mixed waste, but there are no data whether they recycle or not.

Another generated waste stream that is not controlled is the waste that ends on open dumps that are formed on inappropriate areas, along the roads, rails, river flows, etc. The open dumps of mixed and demolition waste are formed by some citizens who throw their waste irregularly.

Bulky waste mostly consists of furniture, electrical devices, household appliances Public Utility Company “Gradska čistoća” collects bulky waste free of charge on the first Saturday of every month. Citizens can drop

Table 4. Available functional vehicles capacity for MSW collection

Functional unit of the Public Utility Company	Available vehicles for collection of waste from the containers					Available vehicles for collection of other types of waste (demolition, bulky, open dumps, green waste, other)				
	No. of vehicles	Total daily capacity t	Average No. of tours per day and vehicle	Routs km/day	Transported waste t/day	No. of vehicle s	Total daily capacity t	Average No. of tours per day and vehicle	Routs km/day	Transported waste t/day
Stari grad	12	65	2	583	69	8	18	5	199	2
Zvezdara	14	95	3	838	139	8	26	3	300	4
Palilula	18	159	2	1,135	154	5	16	3	208	6
Vračar	7	47	2	441	59	6	11	4	217	3
Voždovac	22	167	2	972	143	7	14	4	359	6
Savski venac	10	79	2	667	74	7	15	2	256	2
Čukarica	21	198	2	1,463	161	7	13	4	322	4
Rakovica	10	75	2	593	80	5	12	3	312	4
Novi Beograd	19	125	2	1,469	171	7	18	4	301	1
Zemun	22	219	2	2,187	216	5	18	3	236	1
Total	155	1229	2	10,452	1,273	65	161	4	2710	33

off this type of waste by the curbside containers. Unfortunately, the citizens do not respect the rule, so the Public Utility Company collects bulky waste every day, from the locations where it is seen. The City of Belgrade Administration has established Municipal police, in 2010, in order to prevent violation of law especially on public areas. Unfortunately, the impact of this kind of a police is not appropriate when it comes to improper disposal of demolition and bulky waste disposal on public areas.

“Green waste” means garden waste, branches, leaves, etc. In the areas where individual housing is predominant, citizens also throw their garden waste by the containers. Public Utility Company collects this waste and landfills it. Unfortunately, this type of waste is mixed with municipal solid waste and bulky waste, although it might be processed in a different ways, to obtain a fuel or fertilizer, which is a different topic.

Due to the different ways of collection, mechanization used, transportation and the characteristics of the waste collected from open dumps, bulky waste, “green waste” and other types of waste (mostly demolition waste), volumes are estimated in m<sup>3</sup> and it is hard to calculate their mass. In 2010 the volume of these three types of waste stream, collected by Public Utility Company was: open dumps 45,035 m<sup>3</sup>, bulky waste 61,733 m<sup>3</sup> and “green waste” 8,836 m<sup>3</sup>.

#### Service coverage

Total number of 588,322 households and 28,764 companies are covered by the waste collection service, as seen in Table 5.

The waste collection system covers 95.7% of the households in the inner city municipalities, when calculating growth of the population in the period 2002-2011 and the number of the households that pays for the waste collection service presently.

#### Transfer stations

Currently, no transfer stations are used. Some kinds of transfer stations are used when speaking of bulky waste collection, *i.e.*, bulky waste is collected from the streets manually, with small vehicles and transported to a point with bigger, but still limited, space available for storage of this kind of waste. When the capacity is almost full, large transport vehicles transfer the collected bulky waste to a landfill. There is no organized treatment for this waste type.

#### Recycling

Collection of recyclables started in 2003 by Public Utility Company “Gradska čistoća”. Through this service, at the recycling centers, citizens and the industrial sector could sell paper, cardboard, plastic, metal, aluminum (Al) and steel cans, tire and other components. The recycling in Belgrade is conducted in a very primitive way. Collected Al and steel cans are recycled by Recan Fund.

Popularization of recycling has been initiated in June 2009 by installing 39 drop off points for recyclables or 2–6 locations per municipality. Each point includes three containers of 3.2 m<sup>3</sup> (Figure 2), for separate collection of paper, PET packaging and aluminum cans. The participation of citizens is voluntary. This system doesn't fit the awareness for recycling, because of the long distance for most households in the area. There is no motivation system implemented for recycling improvement. The importance of motivation system with its social, economic, organizational dimension is a special topic that won't be discussed in this paper. When the containers are full, the Public Utility Company collects and transports the recyclables to the recycling center, for treatment – manual sorting and baling. This is the only recycling center for the city of Belgrade.

Another type of selection of recyclable components from the MSW functions through the redemption of

Table 5. Data on waste collection service coverage – 95.7%

Functional unit of the Public Utility Company	No. of households	No. of companies	No. of small companies
Stari grad	31,398	11,036	1,490
Savski venac	22,980		783
Vračar	36,399		1,098
Zvezdara	69,168		1,967
Palilula	64,131		1,784
Rakovica	43,915		1,185
Čukarica	76,816		2,233
Voždovac	65,670		1,638
Novi Beograd	97,188		3,368
Zemun	62,227		1,758
Surčin	12,430		424
Total	582,322	11,036	17,728

recyclables at the recycling center of the Public Utility Company. This aspect also has a social implication because there is a number of street collectors that earn money by collecting or extracting recyclables disposed in curbside containers and selling it at the recycling centers. At the beginning of 2011, the informal sector has launched another recycling center with purpose to engage neighboring scavengers. There are no data on collection of recyclables at this center.



Figure 2. Drop off point for recyclables (paper, PET packaging and aluminum cans).

Like in other developing countries, waste pickers are an important constituent of the SWM system. The solid waste collected in the curbside containers is sorted by waste pickers and waste collectors who sell some of the waste materials to companies that can use them. However, during this process the waste is spread around, contaminating the environment. The sorted waste is contaminated with remains of oil and food. This activity also reduces the volume of waste thrown in containers in urban space.

The fourth type of extraction of recyclables is by the activity of waste scavengers, after unloading the vehicles that brought MSW on a landfill. These materials are also contaminated, some of them cannot be recycled/recovered and the remaining ones need to be cleaned before processing, which increases the cost of the process. Scavengers are obliged, by contract, to sell all recyclables to the Public Utility Company. Unfortunately, there is no data on the amount of recyclables collected by this informal sector and their contribution in operational costs of MSW management. This is also an inefficient system – recyclables extracted from the landfill are returned to the recycling center. It should be considered that street and landfill scavengers are competition to the Public Utility Company's recycling system because they "steal" recyclable components from the waste stream. The activity of scavengers, both on the streets and at landfills, has a very complex influence on the municipal waste management system, which is hard to assess. The impact has multiple aspects: social (source of income for this poor, uneducated

population), economic and environmental (reduces the quantity of disposed waste at landfill, minimizes the pollution).

The quantities of all types of recyclable components redeemed by the Public Utility Company at the recycling center are given in Table 6, for 2009 and 2010. As shown, different types of lead batteries are accepted, which reduces its quantities in the municipal waste stream. It should be mentioned that because of the high price of copper (Cu), it often happens that the Cu-cables from the cables infrastructure are stolen by the poorest population. Before selling the copper, they burn the rubber layer on the fields and cause pollution. It should be mentioned that the illegal market of copper and other metals is a serious social and technical problem, the solving of which is in the domain of police work.

Table 6. Recyclables redeemed by Public Utility Company "Gradska čistoća" at the recycling center

Recyclable component	Collected in 2009, t	Collected in 2010, t	Rate 2010/2009
Paper	3,449	2,626	0.76
Iron	184	87	0.47
Tin	655	507	0.77
Copper	8	6	0.77
Brass	2	2	1.13
Aluminum	35	29	0.83
Plastic (all types)	138	227	1.64
Battery lead	3	3	1.04
PET package	550	607	1.10
Tire	578	537	0.93
Aluminum cans	17	13	0.77

In July 2010, one municipality began a pilot-scale project focusing on source separation, by giving plastic bags to households for separation of three types of packaging (PET, Al cans, paper-cardboard). When a bag is filled with those three types of recyclables it should be taken onto the sidewalk outside the residential building in the period 8–10 p.m. on a defined day of the week. The Public Utility Company collects those bags from the sidewalk. As the results in the first few months were positive, it was decided to expand the project onto other municipalities in May–June 2012.

Only a small amount of glass is collected for recycling, by some private companies. The collected glass is exported mostly to Bulgaria, because the Serbian glass industry has failed.

Although the MSW stream consists of huge quantities of organic waste (food scraps and garden waste), it is still not included in separate collection and treatment, due to the lack of proper organization and resources. The Public Utility Company "Zelenilo-Beo-

grad”, which in charge for maintenance of cities green areas (woods, parks, and grass covered areas), collects some healthy herbal material and composts it. This compost is mostly used for non-commercial purposes, but also the fertilization of those green areas. Regardless of this activity, most of the green waste (8.836 m<sup>3</sup>) from households and green city areas ends up in landfills.

Recovery target rates in Belgrade are (in mass% of the MSW): 9.6% for paper and cardboard, 4.5% for glass, 3.8% for plastics and composites and 8.2% for organic waste [7]. By achieving these goals, the expected reduction of the waste stream in 2012 would be 28% or approx. 148 000 t. Unfortunately, the degree of recycling in the period from 2003 until 2008 was significantly lower and the recycling rate predicted by the applied model will probably not be reached until 2012.

#### *The recycling potential of some MSW components in Belgrade*

Considering the total amount of 1,300 t/day (474,500 t/year) of municipal solid waste generated in Belgrade, its composition (Table 2), the estimated average recovery potential of 30% for paper/cardboard, glass, plastics and 70% recovery potential for Al-cans, it is calculated that from the MSW daily stream should be extracted 155 t/day of those recyclable components, which means 12% of total waste generated.

Data on redemption of recyclables (paper/cardboard, glass, plastics, Al-cans) shows that the extracted recyclables shares 0.73% of the waste stream (2010 Public Utility Company “Gradska čistoća”).

The efficiency of drop off points for recyclables (paper, PET packaging and aluminum cans) is very poor because of the activity of scavengers, who tend to destroy lockers and steal paper and Al-cans from the containers. They are not interested in PET packaging because of its big volume, small mass and relatively low price per kg. In 2010 no paper and Al-cans were collected by the placed containers, only 22 t of PET package was collected (0.63% of total amount of recyclables collected).

Another problem related to drop off points is noticed – some households throw their mixed waste into containers assigned to recycling. Detailed analysis should be conducted in order to improve the existing recycling system and to show if the recycling is an economically viable option for Belgrade. It is necessary to pay particular attention to the social dimension of recycling in Belgrade, which seems to have more influence than investment potential. Social factors mean culture, habits, awareness of society and its parts.

Analyzing quantities of recyclables that are collected in 2010, the conclusion is that Belgrade needs two recycling centers, capacity 10 t/day, where the

recyclables would be sorted manually, from the MSW stream collected by the containers and household plastic bags. The investment cost for each recycling center is estimated at 400,000 EUR. This is the lowest price estimated and does not imply installation of advanced technical solutions. Most of the processes are outdated. Considering the redemption and sales prices of defined recyclable components and operative costs, which are 2% of investment per year, the investment recovery period would be 7–9 years. For the developing countries, recycling means to remove waste from the roadside, fields, river flows, rather than cost-effective option.

#### **Household hazardous waste**

There is no separate collection or treatment of any type of hazardous household waste (lead acid batteries, mercury-containing thermometers, household chemicals, paints and other coatings, pesticides, pharmaceutical products, motor oil, poisons, pesticides, herbicides, fluorescent lamps, medical waste, electrical and electronic waste).

#### **Waste treatment and disposal**

The “Vinča” landfill was established in 1978 as one of several municipal landfills. In the mid 1990s, local authorities assigned the “Vinča” landfill to be the only operational landfill for Belgrade metropolitan area MSW disposal. Other municipal landfills needed to be closed and recovered. The landfill is located about 10 km southeast of Belgrade city center, next to the town of Vinča, in the Grocka municipality. The City of Belgrade authorities and Public Utility Company “Gradska čistoća” are responsible for the landfill operation. The landfill site is located on the right side of the Danube valley, surrounded by the agricultural terrain. Presently, it covers an area of 70 ha.

The Vinča landfill plan was initiated by the Master Urbanity Plan (No 17/72) and Detailed Urbanity Plan (No 5/75). Until 1992 (adoption of the existing regulation of the Republic of Serbia (RS 54/92), the site was utilized as a typical dumpsite with no protective measures and monitoring of possible social and environmental impacts. In June 1994, the Belgrade City Assembly decided to expand the existing dumpsite in compliance with regulations from 1992 covering both restorations of the formerly used territory and the planned expansion areas.

The present landfill is regulated according to Regulation No 54/1992 outlining criteria with location, infrastructure, installations, environmental monitoring and requirements for an operating landfill for municipal waste such as Vinča. A number of specific requirements (noise, emissions, water, etc.) are regulated according to a number of specific regulations.



The main non-compliance issues at the Vinča landfill compared to the RS regulation (5/92) are: the bottom is not provided with a 0.5 cm clay layer or geotextile; the disposal of hazardous waste, health care waste and recyclable waste takes place at the landfill; there is no information about the total quantity and type of industrial waste, which is assumed to be disposed; the complete lack of leachate control from the landfill is a clear violation of the RS landfill regulation. Nevertheless, these irregularities are accepted due to the large dilution potential in the river Danube, and a general perception that the landfill has expanded in an uncontrolled way making any attempt for control measures insuperable for the responsible authorities.

Also, the environmental impact from the existing Vinča landfill is very poorly documented. There is no systematic monitoring of any possible impact sources (emission, leachate control, gas, sub-ground influence, surface water run-off to recipients, nuisances as dust, noise, vibration, odor, vermin and birds). Tractor trailers (6), compactors (3) a roller (1), and a dragline (1) are used at the landfill for spreading the waste, compacting and digging.

The Regulation spatial plan for the “Vinča” landfill, adopted by local authorities in 2002, defines enlargement of the landfill complex to 130 ha. The additional capacity would make a landfill operative in the next 15–20 years. The plan also defines the purpose of the space (entrance to the complex, disposal, material recovery plant, development of technologies, sludge treatment plant, green area, other objects, roads and necessary infrastructure).

The existing landfill is unsanitary – the waste is dumped randomly, leveled and compacted using construction machinery. There are no environmental protection measures (no sludge treatment, no degasation of landfill gas, no protection of ground waters), the landfill pollutes water, ground and the air. It is equipped with an electrical balance for registering the mass

of waste. The layer of waste is covered by the inert material layer. There is a system for fluid drainage.

Scavengers are also present at the landfill. They have an agreement with the Public Utility Company and are paid for separation of recyclables.

The “Vinča” landfill receives approximately 2,500 t of municipal waste per day; around 1,500 t is collected by the Public Utility Company.

Quantities of solid waste at the “Vinča” landfill in the period 2003–2010 are given in Table 7. These data includes MSW from 11 urban municipalities, two suburban (Grocka and Barajevo) and other waste haulers.

In 2009, 72% of total landfilled waste was collected by the Public Utility Company, while most of other haulers still disposed waste on open dumps, without paying any fee (Table 8). Due to the start of the implementation of new package of laws related to waste management, including penalties, this rate changed in 2010 – so the quantity of waste collected by the Public Utility Company decreased to 54%. The percent of waste brought to the landfill by third parties increased in 2010. Those companies transport their certificated inert waste to the landfill and pay to the Public Utility Company a fee for its disposal.

Demolition waste of appropriate structure is reused on landfill for waste layer covering and for accessing roads formation.

#### PARADIGM SHIFT NEEDED

A paradigm shift is needed, from Waste Management based mostly on disposal of all MSW fractions, to materials recovery, recycling, waste to energy and other sustainable options.

Some further steps that should be done are:

- Implementation of an efficient “separation at source” system for different municipal solid waste stream fractions (recyclables, organic, hazardous household waste, etc). Adequate capital investments,

Table 7. Quantities of solid waste landfilled at “Vinča” landfill period 2003–2010

Year	2003	2004	2005	2006	2007	2008	2009	2010
Quantity of total landfilled waste, t	461,018	519,108	581,756	710,250	799,226	722,971	733,236	897,412
Quantity of landfilled MSW from 11 urban municipalities, t	416,424	432,585	441,882	463,573	484,792	555,867	528,310	488,637

Table 8. Quantities of different waste types disposed at landfill “Vinča” in 2009 and 2010

Waste type	Landfilled in 2009, t			Landfilled in 2010, t		
	Public Utility Company (A)	The waste brought to the landfill by third party (B)	A+B	Public Utility Company (D)	The waste brought to the landfill by third party (E)	D+E
Municipal solid waste	528,310	57,899	586,209	488,637	57,976	546,613
Demolition	0	142,959	142,959	0	348,022	348,022
Other types	235	3,649	3,884	244	2,413	2,657
Total	528,545	204,507	733,052	488,881	408,411	897,292

equipment and infrastructure needed.

- Adoption of some bye-laws at national and local levels to guide further waste management strategies and decisions.

- Integration & support of informal sector (rag pickers, scrap dealers) for recyclables recovery, managing composting facilities.

- Implementation of extended producer responsibility arrangements.

- Conducting detailed research, based on social factors and Life Cycle Assessment methodology to move towards “zero waste” principle.

- Minimization of construction waste disposal. Increasing its reuse.

- Modification of good practice from the developing countries before their implementation on local level to find a market specific solution.

- Taking the right steps to reduce waste generation rate, to improve recycling, to implement principles such as “Polluter pays”, “Producer’s responsibility”, where possible.

- Improvement of all parts of the existing MSWM system (collection, transportation, recycling, disposal).

## CONCLUSIONS

This paper gives an overview of the current situation in the waste management system in Belgrade, capital of Serbia, with its good and bad practice, illogical parts and complex social factors. The situation in this field is in need of paradigm change in the future. Since the quantity of generated waste is growing continuously and a very low percent of recyclables is separated from the waste stream, an integrated sustainable waste management system is necessary. Also, an adequate system of MSWM could be implemented only if its characteristics and management status are

determined and understood. In order to obtain the necessary data, the city government may start with pilot programs in some part of the town, to promote and implement the most appropriate methods for waste management.

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**IZVOD****NEOPHODNA PROMENA PARADIGMI – UPRAVLJANJE KOMUNALNIM ČVRSTIM OTPADOM U BEOGRADU, SRBIJA**Florina J. Popović<sup>1</sup>, Jovan V. Filipović<sup>2</sup>, Vojislav N. Božanić<sup>2</sup><sup>1</sup>*Gradska uprava grada Beograda, Sekretarijat za komunalne i stambene poslove, Odeljenje za upravljanje komunalnim otpadom, Beograd, Srbija*<sup>2</sup>*Univerzitet u Beogradu, Fakultet organizacionih nauka, Beograd, Srbija*

(Stručni rad)

Cilj rada je da se proceni trenutna situacija u oblasti upravljanja komunalnim čvrstim otpadom u Beogradu, analizom: pravnih okvira, količine otpada koji nastaje, sistema sakupljanja, transporta, deponovanja, odvojenog sakupljanja reciklabilnih materijala, inicijative o minimizaciji količina otpada koji nastaje. Porast urbane populacije, ograničena finansijska sredstva, odsustvo savremenih tehnologija naročito u oblasti tretmana i odlaganja otpada, zakoni koji su usvojeni 2009. godine i drugi faktori, doveli su do loše situacije u oblasti upravljanja otpadom, što predstavlja ozbiljan problem u očuvanju životne sredine. Analiza je zasnovana pretežno na podacima kojima raspolaže Javno komunalno preduzeće „Gradska čistoća“, koje trenutno jedino pruža usluge sakupljanja, transporta i odlaganja komunalnog čvrstog otpada. Komunalni čvrsti otpad nastaje u domaćinstvima, poslovnim objektima, školama, drugim institucijama, maloprodajnim objektima, na javnim zelenim površinama, grobljima i slično. Dat je pregled različitih elemenata postojećeg sistema upravljanja komunalnim čvrstim otpadom u Beogradu: nastajanje otpada, način sakupljanja, transporta, odlaganja, kao i zakonodavni okvir. Dat je pregled ključnih karakteristika, problema i ciljeva sistema upravljanja komunalnim čvrstim otpadom u Beogradu. Urađena je analiza efiksnosti postojećeg sistema za odvojeno sakupljanje reciklabilnih materijala. Socijalna dimenzija jedan je od činioca koji u velikoj meri utiču na sistem upravljanja komunalnim čvrstim otpadom i koji nikako ne sme biti zanemaren. Navedene su neke smernice za naredni period, kako bi se obezbedila neophodna promena paradigme i razvio uspešan, funkcionalan sistem upravljanja komunalnim čvrstim otpadom.

*Ključne reči:* Komunalni čvrsti otpad • Sakupljanje otpada • Transport otpada • Zemlja u razvoju • Beograd • Srbija • Promena paradigme