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CONTEMPORARY ASPECTS OF SOLID WASTE MANAGEMENT

Abstract: *The main objective of the solid waste management is to protect the public health and safety of the community by providing quality municipal solid waste services and environmental programs that are safe, efficient, cost effective and environmentally responsible. A comprehensive strategy framework is needed at the national and provincial level to connect public health, environmental concerns, decentralization, obligatory legal limitations and economic interests. This framework should motivate municipal authorities to deliver better services, recover more costs from users, and cooperate with neighboring municipalities. Demands to solid waste management system are often highly opposed. Furthermore, acting mechanisms of internal and external influential factors to the system are highly complex. This papers deals with contemporary aspects of solid waste management in correlation to society demands and influential factors. The basis hypotheses, in this paper, are analysis of the current solid waste management systems. Through the analysis of current solid waste management systems the influential factors are defined. The acting mechanisms of each influential factor are considered. Identification of demands and its ranking was done. The objective state of solid waste management systems is determined. Upon the analysis of the influential factors and its acting mechanisms the proposals for the efficient solid waste management systems optimization was given.*

Keywords: *solid waste, influential factors, society demands, public health, environmental concerns*

1. INTRODUCTION

Solid waste management is a sophisticated expression for garbage manipulation. From the first human settled communities generation of waste has been a problem. In everyday life in modern community several kilograms of solid waste per community member can be generate. Solid waste management is integrated system of actions for manipulation and handling of garbage, which enclosed municipal waste collection so as the recycling programs, dumps, and incinerators.

Continuous society growth, urbanization and industrialization as side effect have rapid increase in waste quantity and its diversification, so as increase in quantity, severe and types of hazardous waste. As a result solid waste is becoming a very important topic. According to

reference, it is estimated that in 2006 the total quantity of community solid waste generated globally reached aboat 2.02 billion tones with 7% annual increase since 2003 (Global Waste Management Market Report 2007). Between 2007 and 2011, it is further estimated that global generation of community waste will increase by 37.3%, which it equivalent to approximately 8% increase per year. According to data given in the reference [1] it is estimated that about 318 and 338 million tons of hazardous and other toxic waste were generated in 2000 and 2001. Medical waste is classified as a special sub-category of hazardous wastes in many countries. Corresponding to World Health Organization estimations, the total medical waste per person for year in the majority of low-income countries is between 0.5 kg to 3 kg. The estimation of global industrial wastes generation is not adequately done yet because of several different types of reasons. The 25 member states of EU produced about 700 million tons of agricultural waste per year. In consistent to data given in the reference [1] electrical and electronic equipment waste or E-waste is one of the rapid growing waste streams and it is equal to 1% of total average quantity of solid waste in developing countries. It is expected to rise to 2% and even more. The main objective of solid waste data collection, so as quantification and characterization of various waste is to develop an integrated solid waste management system. The evaluation of data obtained from the analysis of the existing waste management systems is to overcome the difficulties and to optimize the procedures of solid waste management such as collection, transportation, treatment, disposal, recycling and recovery.

Total waste generation in the 15 countries of EU in 2004 was estimated at 1.93 billion tones and it had reached an estimated 2.01 billion tones in 2006 (increase of 4%). In 2008 estimated total waste generation decrease the level reached in 2004. In the 27 member countries of EU it was estimated that total waste generation was 2.91 billion tones in 2004 according to data given in the reference [2]. In correspondence to data given in reference [2] it is estimated that it had risen to 2.95 billion tones in 2006 with increase of just over 1% in two years but decrease to around 2.6 billion tones in 2008 (Figure 1). Nevertheless, total waste generation in most member states of EU stabilize or increase.

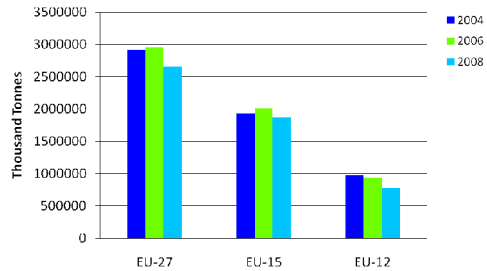

Figure 1. Total generation of solid waste (in 1000 tones) [2]

The diagram shown in the Fig. 2 summarizes the data given in the reference [2] by the three main treatment types: disposal, incineration and recovery for member countries of EU. About 5.5 % of solid waste was incinerated, 46 % recovered and 48.5 % disposed in 2008 in EU [2].

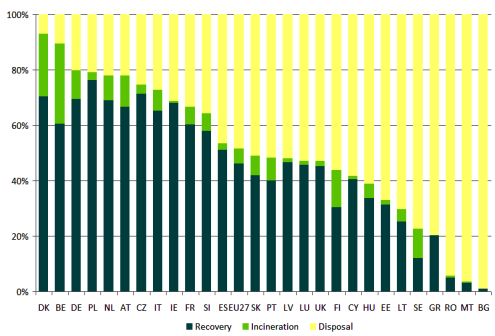

Figure 2. Major types of waste treatment in EU member countries for 2008 [2]

Solid waste management topics are at

the focus of environmental concerns, especially because constant growth of population and the development of economic activities stimulate higher consumption of resources and a bigger generation of waste. In these conditions major improvements in solid waste management efficiency are required. Primarily, it is important to decouple the environmental degradation from growth of population and economic development. The real challenge is converting solid waste into reusable resources. This can be done through development of clean technologies, by replacing dumps with final waste disposal centers and by responsible and sustainable local government solid waste management policy.

2. PRESENT FRAMEWORK OF SOLID WASTE MANAGEMENT

Present solid waste management in Republic of Serbia is quit out of date. According to the data from the year 2003 only 50% of solid waste was collected. The worst situation was in the rural area, where the solid waste was burned or deposed on inadequate dumps. Among about 170 city dumps in Serbia, there is no one which fulfills the contemporary sanitary requirements. Those dumps do not fulfill the basic ecological criteria. The 4650 improperly dumps were registered in the year of 2009. National strategy for solid waste management is in correlation with obligatory laws related to this area [3, 4, 5]. Present national strategy for solid waste management proposes 26 regional centers for solid waste management in Republic of Serbia. Sporadically foundation of private recycling companies established the system of collecting and classification of solid waste. Situation in the area shows the slow improvement, but with out of global implementation of national strategy for solid waste management.

There is no solution, which completely fulfill the global requirements of solid waste management. Every community has its own unique set of requirements for solid waste management. Depending on influential variables as urbanization, commercial enterprises, manufacturing, and service sector activities, composition of the waste varies. The manner of people in different regions varies about waste management practices. This is often connect with the waste management ethic and includes the recycling ethic and litter ethic of a community as its subcategories. Diversity of population and diversity of waste are main reasons why no single method to solid waste management has been pointed as the best solution. This paper deals with contemporary aspects of solid waste management obtaining from the analysis of the present state in this area in the City of Kragujevac. The dominant processes in present solid waste management in Kragujevac are collecting, transport and deposing to landfill. The part of the process of solid waste management, which can be seen in the everyday life on the streets of Kragujevac is shown in Figure 3.

Figure 3. Solid waste colecting and transport in Kragujevac

The City of Kragujevac is situated in the central part of the Republic of Serbia. It is one of four biggest cities and macro regional centers of the Serbia. The City it

is at 173 meters above the sea level and takes up 835 km^2. The farming land is 54.093 ha and is composed of: 48.487 ha cultivated land, 34.025 ha ploughed land and gardens, 23.704 ha forestry land, 420 ha vineyards and 7.089 ha meadows. The farming land covers 64.8% of the total land, of which cultivated land covers 89.6%. Kragujevac is the largest in Šumadija Region and the fourth biggest in the Republic of Serbia with around 180.252 inhabitants. The City territory involves 57 settlements with 76 local communities. The urban area has 147.473 inhabitants, while the rural area has 32.779. The population of working age makes 65.2% of total population, which is more encouraging that the average on the Republic level. Educational structure: Majority of population has secondary school education completed (38.2%), unskilled workers with primary education completed account for 26.8%; higher education 4.1% and University degree 5.3%. The illiterate population (6.261) account for 3.5%. Population Social Structure: 48.6% active population, 11.2% people with incomes. 38.2% supported and 2.0% work abroad.

Solid waste management in the city of Kragujevac is based on City regulation for maintaining public area clean, which regulates the conditions for cleaning and waste management in the City of Kragujevac. These City regulations provide also regulations on other subject in the area of public service and usage of the public service for solid waste management [6, 7, 8]. The main objective of the City regulation is to address the obligation and responsibility of the factors involved in solid waste management.

3. STATE OF PRESENT SOLID WASTE MANAGMENT

Solid waste collecting, transport and final disposal is given to public company in the City of Kragujevac. The company has 232 employs and 75 of them are in direct contact to waste. By the public service for solid waste management in the City of Kragujevac 75 local communities is enclosed for 365 days in the year through three shifts. Organized collecting of solid waste cover 43214 homes, 415 companies and service sector, so as 3226 small businesses [6, 7, 8].

Figure 4. Solid waste collection vehicle with rear loadings and compactor in Kragujevac

The major quantity of solid waste which is collected and disposed daily (averagely about 160 tons) comes from houses, public services and profit or nonprofit type of companies. For collecting and transport of solid municipality waste following machinery is used:

- 19 waste collection vehicle with rear loadings and compactors (Fig.4)
- 3 tipper trucks
- 1 truck with hydraulic loading system for industrial non hazardous waste transport
- 1 heavy duty damp tipper trucks

Average age of the used machinery is 15 years, while optimal exploitation period is 7 years. In the May of 2010 the public service company handle with following vessels for waste collecting:

- containers of 5 m^3 – 115 pieces
- containers of 1,1 m^3 – 4000 pieces
- trash cans with volume of 140 l – around 4000 pieces

Some suburb settlements of the city are not supplied with waste collecting vessels and are not involved in public

service of collecting and transport of solid waste (about 10 000 homes). Final disposal of community solid waste is on the landfill in Jovanovac, about 2 km from the center of the city. The landfill has the area of 14.3 ha, on the 164 m above sea level, while maximum allowed limit is 178 m. Till now, about 1 900 000 m^3 of solid waste were disposed in last 42 years. About 160 tons of solid waste is disposed daily and about 4 500 tons per month. On the existing landfill about 52 311.77 tons is disposed per year. According to projections and calculations landfill can be used for maximum two or three years before reaching limit of 178 m above sea level. The truck scale was set on the landfill entrance on 01.10.2008. and from then measuring of weight deposed daily is conducted. From the whole quantity of solid waste per month recyclable used paper makes about 30 tons, used tires makes 20 tons and PET packaging makes about 15 tons. On the basis of the given data it is estimated that only 1.44 % of solid waste is recycled and reused. Environmental impact of solid waste is not properly monitored on the landfill [8].

4. DEVELOPMENT STRATEGIES IN SOLID WASTE MANAGMENT

Municipal solid waste analysis and projections are based on existing trends and correlations between generation of municipal solid waste and influencing factors such as family consumption, number of people per family, growth of population and its development. According to a model developed by the European Environmental Agency and its European Topic Centre on Sustainable Consumption and Production, which is presented in reference [9], the generation of municipal solid waste can be expected to rise to quantity level of about 280 million tons in 2020 in the EU. This predicted situation is done on the basis of projections of economic development, taking into account the economic depression in the years 2008/2009. The uncertainty of the economic projections also introduces uncertainties in the projection of municipal solid waste generation. This predicted situation does not take into account effects of specific policies on waste prevention because of its uncertainty. If the existing trends in the development of recycling and composting, incineration and landfill shares are used to predict solid waste management till 2020 the following situation can be expected: recycling of municipal solid waste would increase from 40% in 2008 to 49%. The predicted situation of solid waste generation and tree major types of waste reduction treatment in EU according to data and modeling presented in reference [9] is graphically presented in Figure 6. The predicted situation point out the importance of implementation the solid waste management policies and strategies for development in the area of waste management. Strategies implicated in suitable solid waste management procedures ensure minimal environmental impacts, effectiveness and sustainable solid waste management with decrease of total costs, so as economical positive effects.

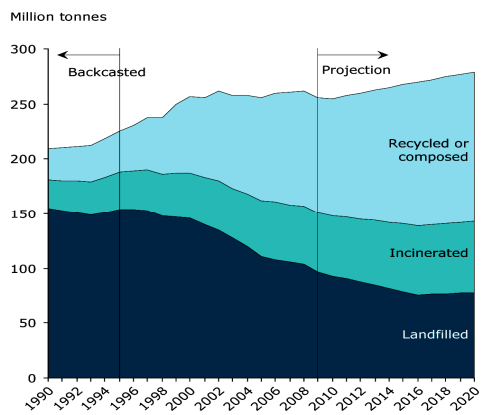

Figure 5. Trends of municipal solid waste generation and shares of major waste treatments in Europe Union [9]

Hierarchy of procedures integrated in solid waste management process is graphically presented in Fig. 6.

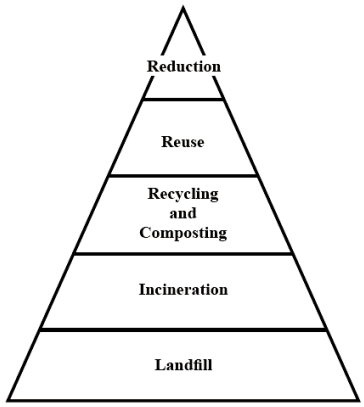

Figure 6. Hierarchy of procedures in solid waste management

Implementing and developing of the integrated process for solid waste management requires complete data on present and expected waste circumstances, highly supportive framework policy, knowledge and capacity to develop the systems, proper use of environmentally friendly technologies, and appropriate financial instruments for supporting [10, 11, 12 and 13].

4.1. Reduction Strategies

Reduction methodology includes various types of strategies that can be used by a community to lower the quantity of waste being produced. Reduction of waste production may be done as simple activities in everyday life of community, such as supplement on bags, containers, or home refuse. Reduction strategies involved, also, the motivation programs for reduction efforts. Reduction activities that individuals within a community can do are crucial but very simple such as two-sided copying on paper. Public education and involvement are essential in any of the development strategies (reduction, reuse, and recovery). Reduction strategies suppose the dedication and involvement of all society. Reduction strategies have many positive environmental impacts, including reducing greenhouse effect, energy saving and resources conserving.

4.2. Reuse actions

Using the same product more than once, either for the main purpose or for alternate purposes is reuse action. Reuse does not require reprocessing of object and, by that, it has lower energy requirements than recycling. Reuse actions include reuse of packaging (for example boxes and bags, using empty jars for food storage and etc.), charity donations and participating reuse programs.

4.3. Recycling, materials recovery and composting

Recycling is the process in which waste materials are processed industrially and then reformed into new or similar products. Recycling can be done on pre consumer waste, such as factory cuttings or shavings, as well as post consumer waste, including cardboard, newspapers, plastic bottles, and aluminum cans. Recycling processes offer great benefit in energy savings, so as resource conservation.

Figure 7. Sorting plastic waste for recycling at source in Kragujevac

Addition positive effect of reducing processes is reducing the necessity for setting and constructing new landfills and

incinerators, so as reducing greenhouse gas emissions and other pollutants. Many combustibles in solid waste are recyclable, but there is often a higher total value in burning the waste for energy than in recycling due to processing costs.

The first steps in recycling in Kragujevac have been done by sorting recyclable materials at source in special vessels for plastic waste (Fig. 7). Development of incineration program with a materials recovery component, incinerator and processing equipment exploitation life is extended because glass, ferrous and non-ferrous metals are removed during material recovery before incineration. Incineration reduces the quantity of refuse waste up to 90 percent, leaving behind only ash. The objective of recycling, materials recovery and composting processes is also less need for landfill surface.

4.4. Final disposal to landfill

The last option in integrated solid waste management is final disposal of waste to landfill. The residuals from the previous processes and some materials that are not recoverable must be disposed to landfill. The continuous development of requirements set for landfills obtained this option of disposal less environmentally offensive, but more costly. The increasing ability to produce methane from landfills provides a positive commercial effect to procedure which has been, till now, a non-commercial method. Bioreactor technology has the potential to reduce the landfills' environmental impact and to maximize methane production on landfills. From the society environmental concerns and economic aspect the final disposal of solid waste to landfill have rising importance. The final procedure in process of integrated solid waste management has the biggest unwonted effects so precise analysis of generation of solid waste, waste streams and opportunities to reduce the quantity of final disposal of residuals is crucial.

5. CONCLUSION

Integrated system of solid waste management requires demanding use of environmentally friendly technology. Some of procedures in the process are very simple, but effective such as containers for primary collection and sorting recyclable materials at source, while other are complicated as incinerators, bioreactor or disposal of hazardous and toxic waste. The potential technological interventions within solid waste management system are as follows:

1. Primary collection and transfer centre must manage the waste collection bins for segregated municipal solid waste and special containers for special sub categories of waste such as toxic and hazardous waste. Design and material, labeling and storage so as hygiene of the collection containers are important. Similarly, location, construction and functionality of transfer station is also crucial to avoid effects due to odor, breeding of diseases carriers such as flies and mosquitoes, and entrance of birds or cats and dogs. The transfer centers should be located and constructed in such a way that it is convenient for small trucks and cars to discharge solid waste and for bigger vehicles to collect and transport that waste.

2. Efficient transportation of waste implies usage of different types of vehicles to transport solid waste from its generation point to the transfer station, and further from there to the treatment and disposal location. The used transportation vehicles in function should be listed out with precise tasks including small manually driven carts to sophisticated transportation vehicles and special vehicles for special wastes - hazardous, large and recyclable wastes. The transportation system must be highly flexible and task oriented.

3. Treatment of waste incorporate sorting and separation of different types of waste. The widely used approach is sorting and separation at source point. This approach implies separate waste streams and complicate transport and handling. The other approach is sorting and separation at transfer point, mostly manually. The technology for separation the various types of materials for recovery and recycling before final disposal is still very expensive. In some countries, incineration is done at the level before sorting and separation due to economic reasons. The ash from it is sent to landfill for final disposal, but incineration as high-tech process has the negative impact to public health as well as the environment.

4. Final disposal to landfill is, still, the most commonly used technology in solid waste management. Also, the conventional and environmentally dangerous methods as open-burning, open-dumping and disposal to non-sanitary landfill are still widely used. However, these methods are officially forbidden and only sanitary landfill for final disposal is allowed. Sanitary landfills operate as fully aerobic, semi-aerobic or anaerobic. The landfill may be used for co-disposal of special wastes. The landfills for hazardous wastes are known as "secure landfill" and are more complicated.

Share of recycling and recovery, so as other reduction activities like recycling of reusable materials, recycling of materials for industrial production, converting waste into energy, and converting waste into a resource must be risen. Hence, the technology at this level of solid waste management must be developed rapidly.

REFERENCES:

[1] United Nations Environmental Programme Division of Technology (2009) Developing Integrated Solid Waste Management Plan, Industry and Economics International Environmental Technology Centre, Japan

[2] European Commission (2011) Thematic Strategy on the Prevention and Recycling of Waste, Commission staff working document, Brussels

[3] National Assembly of the Republic Serbia (2004) Law on environmental protection, Official Republic Gazette (in Serbian)

[4] National Assembly of the Republic Serbia (2009) Law on public health protection, Official Republic Gazette (in Serbian)

[5] National Assembly of the Republic Serbia (2009) Law on solid waste management, Official Republic Gazette (in Serbian)

[6] Commission staff for City authority of Kragujevac (2010) Local Ecological Action Plan 2010 - 2014, City authority of Kragujevac (in Serbian)

[7] Public company "Clean" (2011) Internal company data, City authority of Kragujevac (in Serbian)

[8] City authority of Kragujevac (2010) City regulation for maintaining public area clean, Official City Gazette (in Serbian)

[9] European Environmental Agency (2010) Thematic Assessment – Material Resources and Waste, The European Environment, State and Outlook

[10] Nicholas P Cheremisinoff, Dr Nicholas P. Cheremisinoff (2002) Handbook of Solid Waste Management and Waste Minimization Technologies, Elsevier Science ISBN: 0750675071

[11] Frank Kreith, George Tchobanoglous (2002) Handbook of Solid Waste Management, McGraw-Hill Professional; 2 edition, ISBN: 0071356231

[12] Basaling B. Hosetti (2006) Prospects and Perspectives of Solid Waste Management, New Age International
[13] Joe E. Heimlich, Kerry L. Hughes, and Ann D. Christy (2005) Integrated Solid Waste Management, Ohio State University
[14] Peter Schübeler (1996) Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries, UNDP/UNCHS/WORLD BANK-UMP
[15] Eurostat (2010) Environmental Data Centre on Waste, Overall Waste Generation
[16] European Environmental Agency (2009) Working paper 'EU as a Recycling Society: Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU'

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