



Sanitary Landfilling – A Key Component of Waste Management

Sanitary Landfilling – Komponen utama dari Pengelolaan Limbah

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Abstract

In many affluent countries waste management is experiencing a fast transition from landfilling to sophisticated recycling and waste to energy plants. Thus, landfilling of waste becomes less important in these countries. The present paper discusses whether a similar development will take place in transition economies, or waste management systems will mainly rely on landfilling in the near future. For this purpose, the current waste management practices and associated environmental impacts as well as the economic situation of different countries in economic transition are analyzed. Based on the status quo, scenarios for improving waste management are developed and evaluated. Criteria for evaluation are economic parameters, and indicators pointing out if the goals of waste management (protection of human health and the environment, the conservation of resources), are reached. Based on the results of selected case studies, it is shown that for regions that can afford less than 20 €/capita and year for waste management, landfilling will remain a key component of waste management, since other disposal options such as waste to energy or mechanical biological pretreatment are too expensive. In addition, the results indicate that in many of these countries waste collection still represents a main challenge.

Keywords: energy plants, environment, sanitary landfilling, waste management strategies, waste collection

Abstrak

Di beberapa negara maju, pengelolaan limbah telah mengalami proses pengolahan yang cepat dari penimbunan hingga tahap daur ulang. Sehingga tidak terjadi penimbunan limbah. Artikel ini membahas apakah sistem ini juga layak secara ekonomi. Untuk itu, dianalisis sistem pengelolaan limbah saat ini dan dampak lingkungannya serta situasi ekonomi dari beberapa negara. Sistem untuk meningkatkan pengelolaan limbah dikembangkan dan dievaluasi berdasarkan status *quo*. Kriteria untuk evaluasi adalah parameter ekonomi, dan indikator yang menunjukkan tujuan dari pengelolaan limbah ini tercapai. Hasil yang diperoleh dari studi kasus yang dipilih menunjukkan bahwa daerah yang menghasilkan kurang dari 20 €/kapita/tahun untuk pengolahan limbah, penimbunan tetap menjadi sistem yang baik untuk pengelolaan limbah, karena sistem pengelolaan lain seperti pemanfaatan limbah untuk energi atau *pretreatment* secara biologis dan mekanik terlalu mahal untuk diterapkan. Selain itu hasil menunjukkan bahwa di beberapa negara masalah penumpukan limbah masih menjadi tantangan utama

Kata kunci: lingkungan, penumpukan limbah, *sanitary landfilling*, strategi pengelolaan limbah, sumber energi

1. Introduction

The goals of waste management are firstly the protection of human beings and the environment, and secondly the conservation of resources. Under the principles of sustainability, these goals should be reached in a way that does not impair the well-being of future generations. Thus, waste management practice should not export waste related problems in space and in time,

requiring e.g. after care free landfills. Goal number one has been reached in most countries with affluent economies. Hence they are focusing on goal number two by introducing extended recycling strategies and schemes, meaning in essence that waste is increasingly redirected from landfills to recycling or thermal utilization plants (see Figure 1).

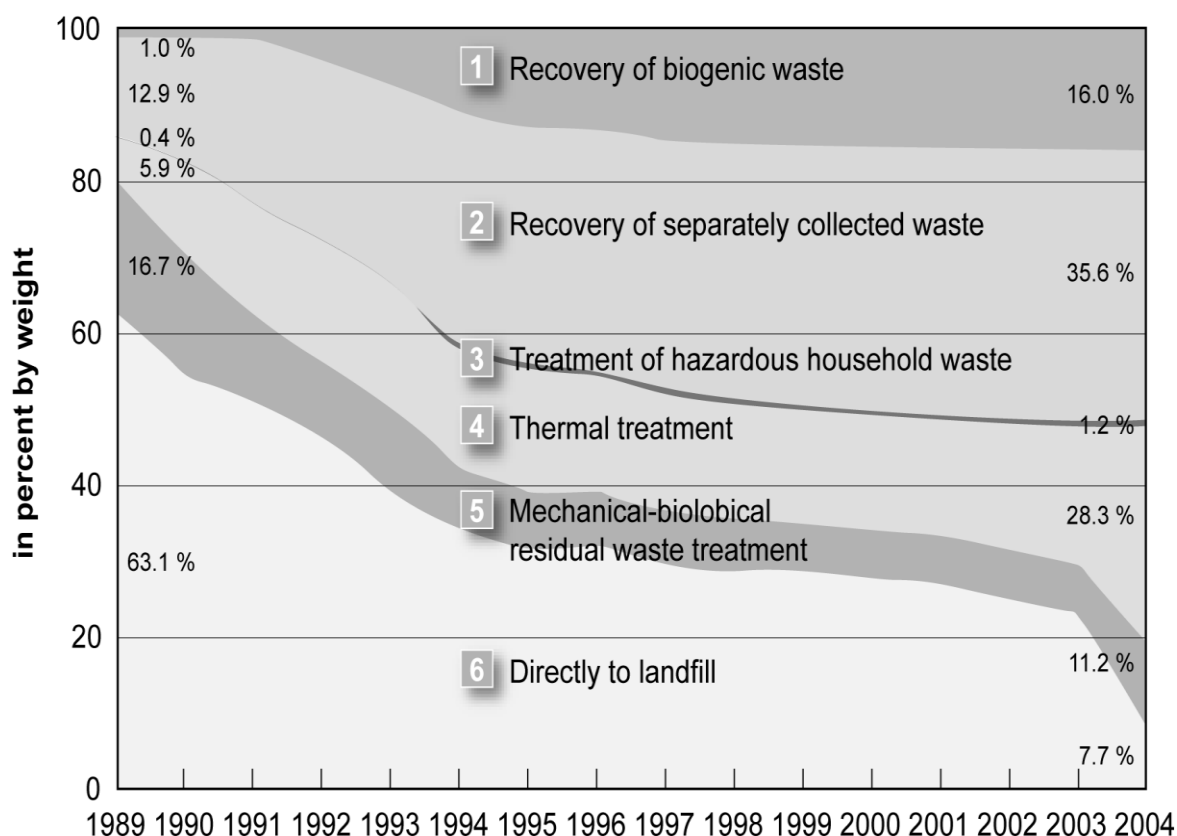


Figure 1. Disposal and recovery of MSW in Austria from 1989 – 2004 (EPA, 2009)

In less developed economies often the goal of protection of human beings is not reached yet. Thus, these countries face different challenges regarding waste and should therefore set different priorities for waste management strategies.

The objective of the present paper is to elaborate priorities of waste management in transition economies. In particular the future importance of landfilling in these regions will be investigated. Thereto the current waste management practices of four cities (Zagreb, Bucharest, Damascus, and Dhaka) are examined.

- First, the ratio "expenditures for waste management" to "Gross Domestic Product" of the four regions is determined.
- Second, current waste management practice is evaluated regarding the objectives of waste management
- Third, various scenarios such as improvement of collection, landfilling, treatment (mechanical, thermal) and waste separation are analyzed in view of their impacts on costs and on reaching waste management objectives.

- Finally, preliminary suggestions are given regarding strategies for waste management in transition economies.

2. Method

Based on the methodology of Material Flow Analysis (MFA) of Baccini and Brunner (1991) the MSW management of four cities Zagreb, Bucharest, Dhaka City, and Damascus are investigated. The investigations are based on the following system, considering wastes from households and small enterprises, only. For each of the four cities the flows of MSW within the defined systems (consisting of the processes: collection and transport, treatment and disposal)" (Figure 2) are determined. In addition to the waste flows also the costs of the single processes will be evaluated. Based on the results of the material flow analysis, the efficiency of the WM systems with respect to the overall objectives of waste management (protection of human beings and environment, conservation of resources, and sustainability) is evaluated. Analogous to the work of Brunner and Fellner (2007) the assessments are focused on a few main indicators.

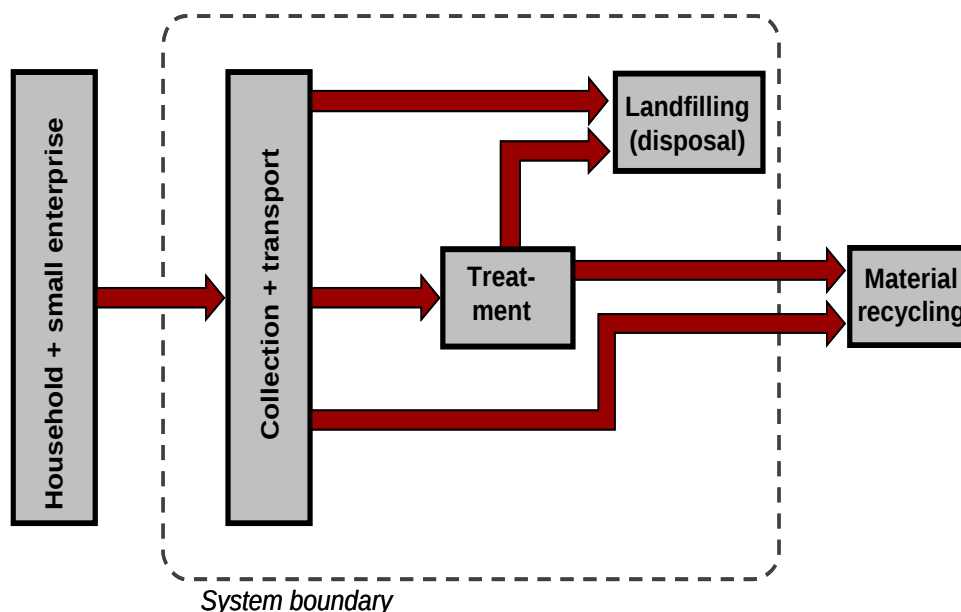


Figure 2. System definition – Municipal Solid Waste Management (MSWM) (Brunner and Fellner, 2006)

Health and environmental indicators:

- percentage of population having direct contact with waste (scavengers and habitants of residential areas without waste collection service)
- greenhouse gas emissions (expressed as CO₂-equivalents)
- nitrogen emissions to the hydrosphere
- rate of material recycling
- rate of waste landfilled
- required landfill space (volume)
- long term emissions from landfills or disposal sites (final storage quality).

Economic indicator:

- the ratio of overall expenses for solid waste management to the Gross Domestic Product (GDP) of the region.

Based on the status quo the following scenarios for upgrading waste management practice in the different regions are evaluated:

1. full coverage of waste collection service
2. upgrading of existing disposal practice to sanitary landfilling
3. mechanical biological pre-treatment of collected waste
4. incineration of collected waste
5. implementation of separate waste collection.

In the scenarios 2 to 5 the waste collection rate of the status quo is assumed. All scenarios are analyzed for their economical feasibility and their environmental impacts

using the simplified environmental indicators as listed above.

3. Results and Discussion

3.1. Dhaka City

In Dhaka city (~10 million inhabitants) less than 50% of the population is served by a formal waste collection system (Figure 3). The annual household waste generation rate is between 110 to 150 kg per capita (Zurbrugg *et al.*, 2005). Waste recovery and recycling is performed by an informal sector of more than 100,000 scavengers (Sinha, 1993).

3.2. Damascus City

In Damascus City (around 2 million inhabitants) household waste is not separated but collected together in one bin (Figure 4). The waste generation rate per capita averages around 230 kg/year (Alboukhari, 2004). More than 90% of the inhabitants are served by regular waste collection managed by the municipality. The remaining inhabitants (100,000 to 150,000) live in shanty towns of the city, which do not have any organized waste management. In addition to the formal sector organized by the municipality, an informal sector of waste collection and waste recovery exists, operated by thousands of scavengers.

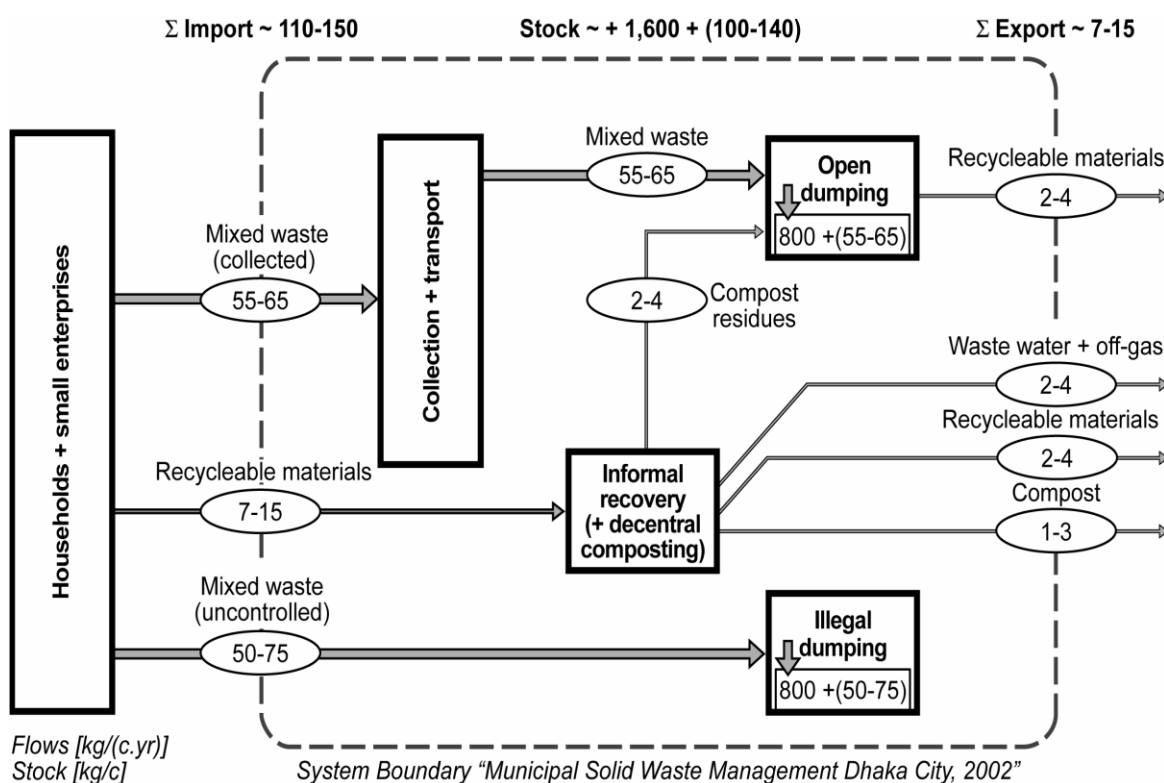


Figure 3. Municipal solid waste management – Dhaka City (2002) (Brunner and Fellner, 2006)

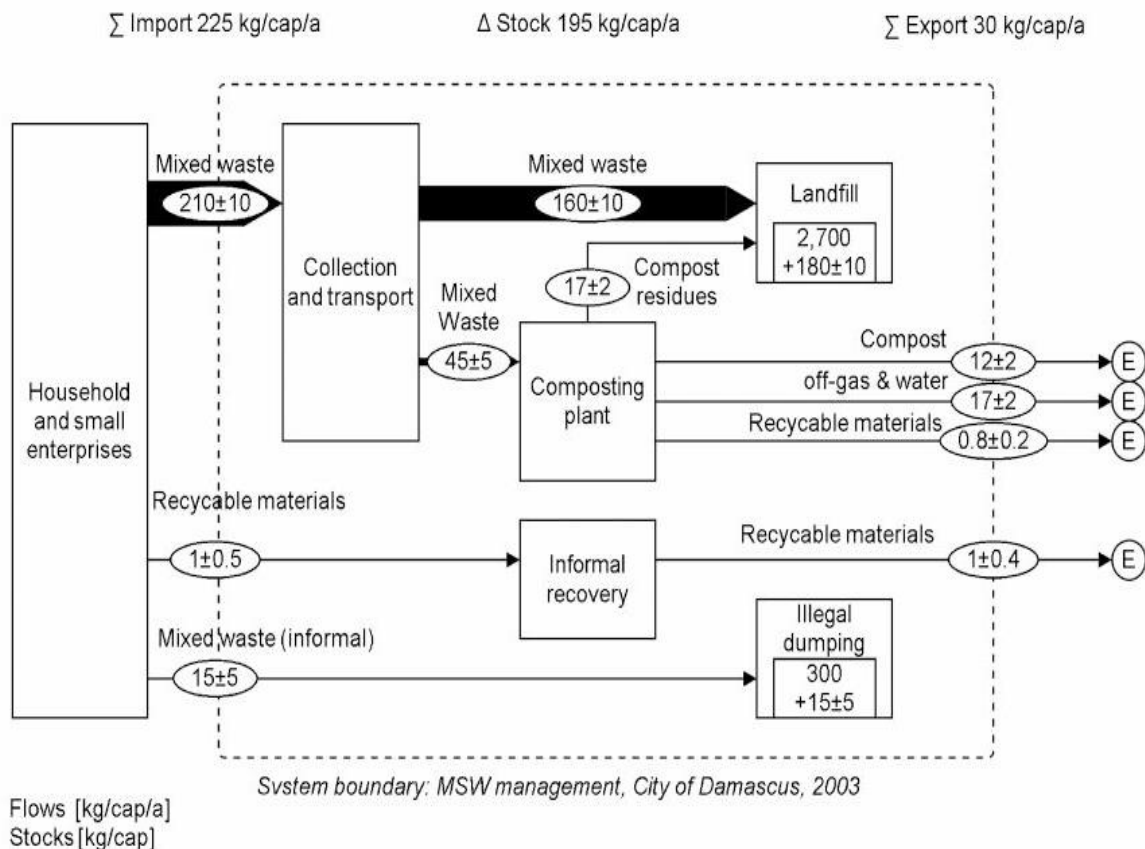


Figure 4. Municipal solid waste management (MSWM) – Damascus City (2003) (Brunner and Fellner, 2007)

Table 1. Comparison of status quo MSWM in Damascus, Dhaka City, Bucharest and Zagreb

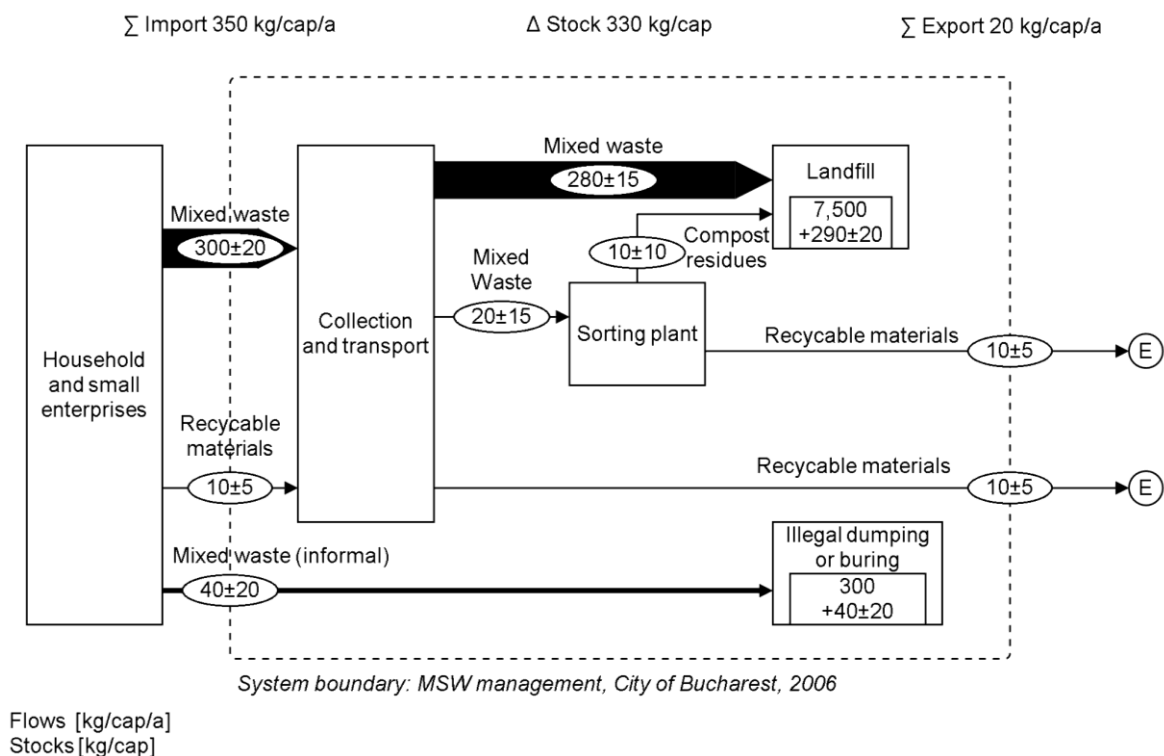
	Unit	Damascus (2003)	Dhaka City (2002)	Bucharest (2006)	Zagreb (2006)
MSW generation	[t/a]	450,000	1,400,000	700,000	300,000
Capita	[Mill.]	2	10	2	0,78
MSW/capita	[kg/capita/a]	225	140	350	380
MSW/capita/day	[kg/capita/day]	0,6	0,4	0,95	1,04
Total Costs	[Mill.Euro/a]	7,5	6,6	24	19
Costs per tone MSW collected	[€/t]	18	10	35	64
Costs per capita	[€/capita/a]	3,8	0,7	12	24
Gross Domestic Product (GDP)	(€/capita)	1,360 ¹⁾	370 ¹⁾	4600 ¹⁾	8,800 ¹⁾
Costs MSWM/GDP	[%]	0,28	0,18	0,26	0,27
Selected indicators for the Assessment of Solid Waste Management Systems					
Percentage of population having direct contact with waste	[% of total population]	5-10	40-50	15	<0.1
N-emissions	[g N/capita/a]	41	170	192	187
Greenhouse gas emissions ²⁾ (CO ₂ equivalent)	[kg CO ₂ /capita/a]	98	92	320	10
Material recycling rate ³⁾	[%]	7	6	6	7
Landfill volume required	[m ³ /capita/a]	0.23	0.21	0.41	0.44
Disposal rate	[kg/capita/a]	185	129	330	350
Final storage quality		no ⁴⁾	No	No	No

¹⁾ Source: IMF (2009)

²⁾ Methane emissions from landfills calculated IPCC (2002)

³⁾ Including compost

⁴⁾ Final storage quality could most likely be reached in Damascus due the prevailing arid climate "without" leachate generation from landfills in the long term.

**Figure 5.** Municipal solid waste management (MSWM) – Bucharest City (2006), (Atudorei, 2008; Sandulescu, 2004)

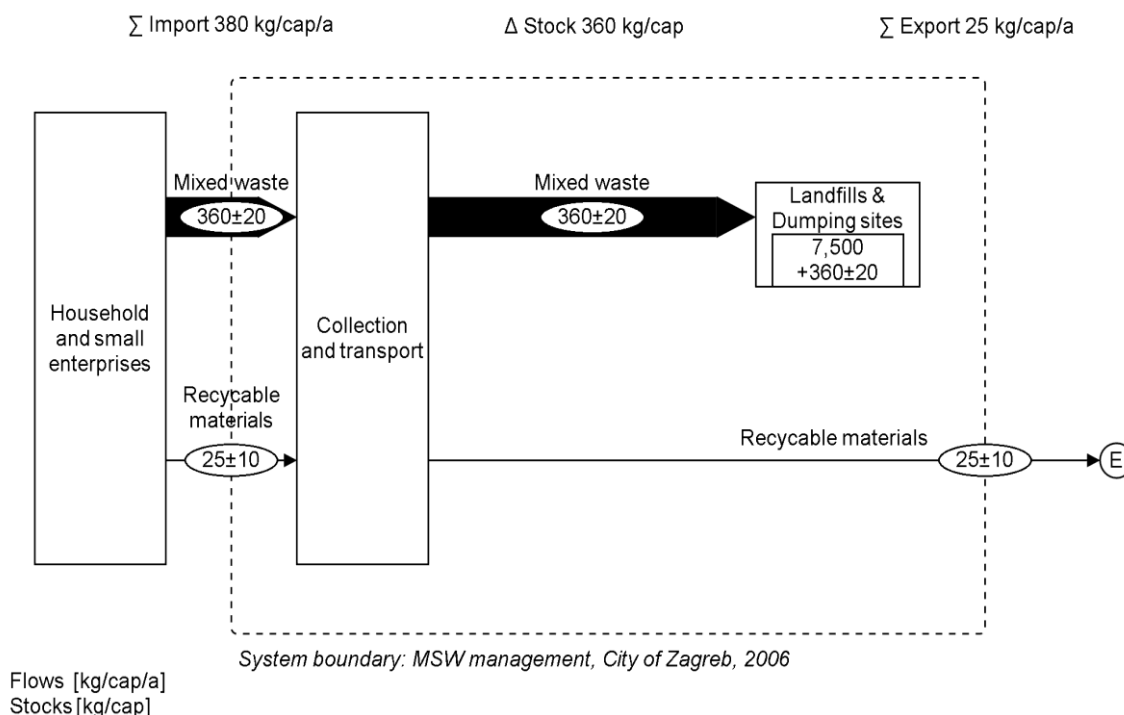


Figure 6. Municipal Solid Waste Management (MSWM) – Zagreb City (2006)

3.3. Bucharest City

In Bucharest (~2 million inhabitants), around 85% of the population benefits from a formal waste collection system (Figure 5). The annual household waste generation rate ranges between 330 to 370 kg per capita (Atudorei, 2008). Almost all the waste is collected in one bin, only packaging materials are separately collected to a small extent (less than 5% of the total MSW generated).

In addition to separately collected materials, recyclables (paper and cardboard, metals and plastics) are obtained by two sorting plants in Bucharest. Apart from the recyclable materials all waste collected is directed to the 3 landfill sites in the Bucharest region (270 to 310 kg/cap/a) (Atudorei, 2008).

3.4. Zagreb City

Zagreb has approximately 780,000 inhabitants, of which almost 100% are served by an organized system of MSW collection (Figure 6) (Source: OG No. 85/07.) In 2006 each inhabitant generated

about 380 kg waste. Out of this amount more than 90% has been disposed off at landfills or dumping sites, the remaining part has been recycled or recovered (EPA, 2009; Stanic, 2009). Countrywide less than 1% of the collected waste is composted; within the city of Zagreb, composting of bio-waste can be regarded as negligible

3.5. Evaluation of the Investigated Scenarios

All scenarios investigated have been analyzed in view of their impacts on costs and on reaching the waste management objectives, whereby the degree of fulfillment is "assessed" by single environmental indicators. Figure 7 and 8 show the "environmental and economic" consequences of the investigated scenarios, expressed as percentage of the status quo. Assumptions regarding the costs of the different MSWM practices are summarized (Brunner and Fellner, 2006; Atudorei 2008). Since Zagreb facilities have been already a full coverage of waste collection, the scenario of improved waste collection has not been investigated.

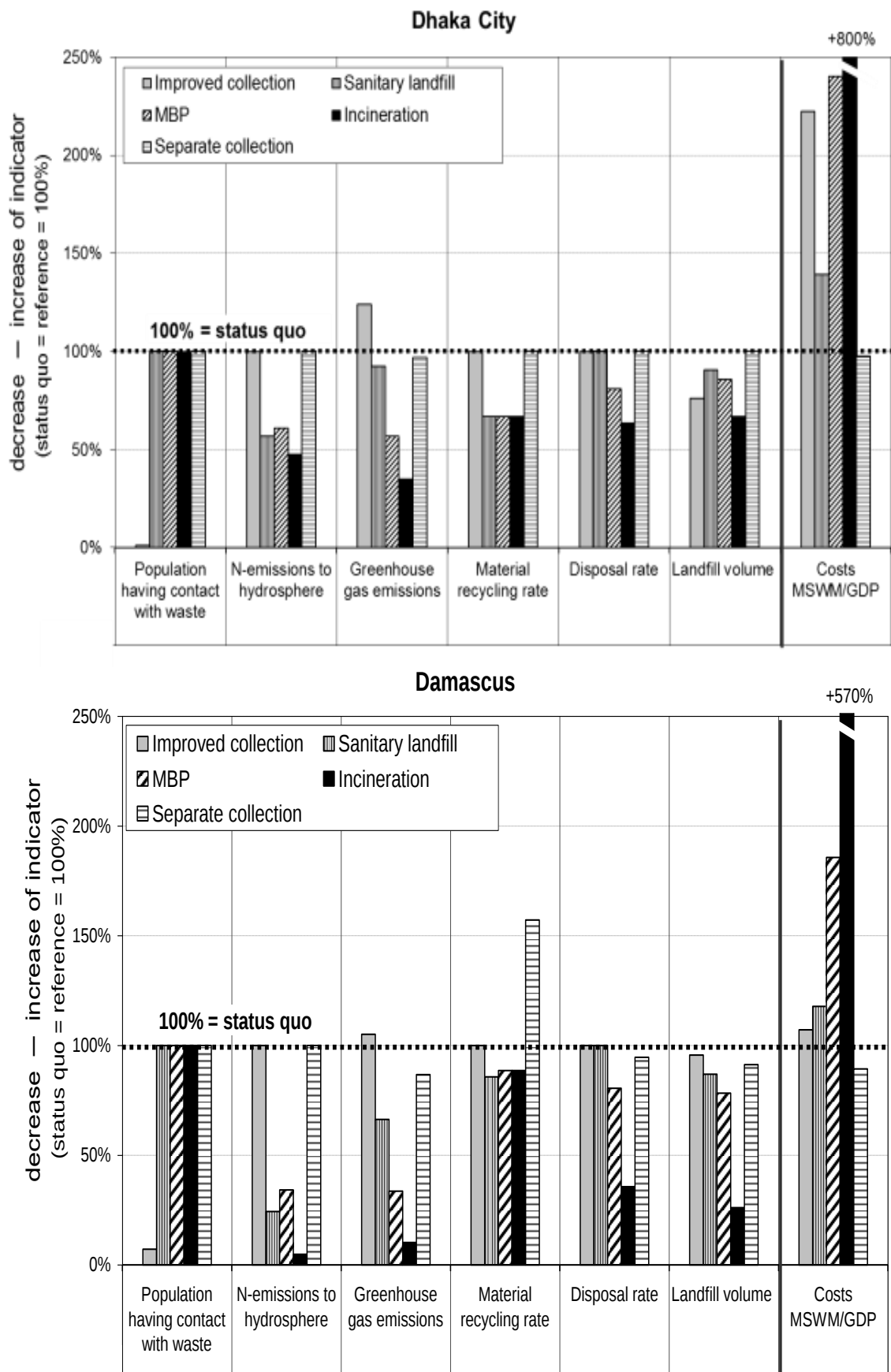


Figure 7. Changes of goal oriented parameters for different scenarios of MSWM in Dhaka and Damascus

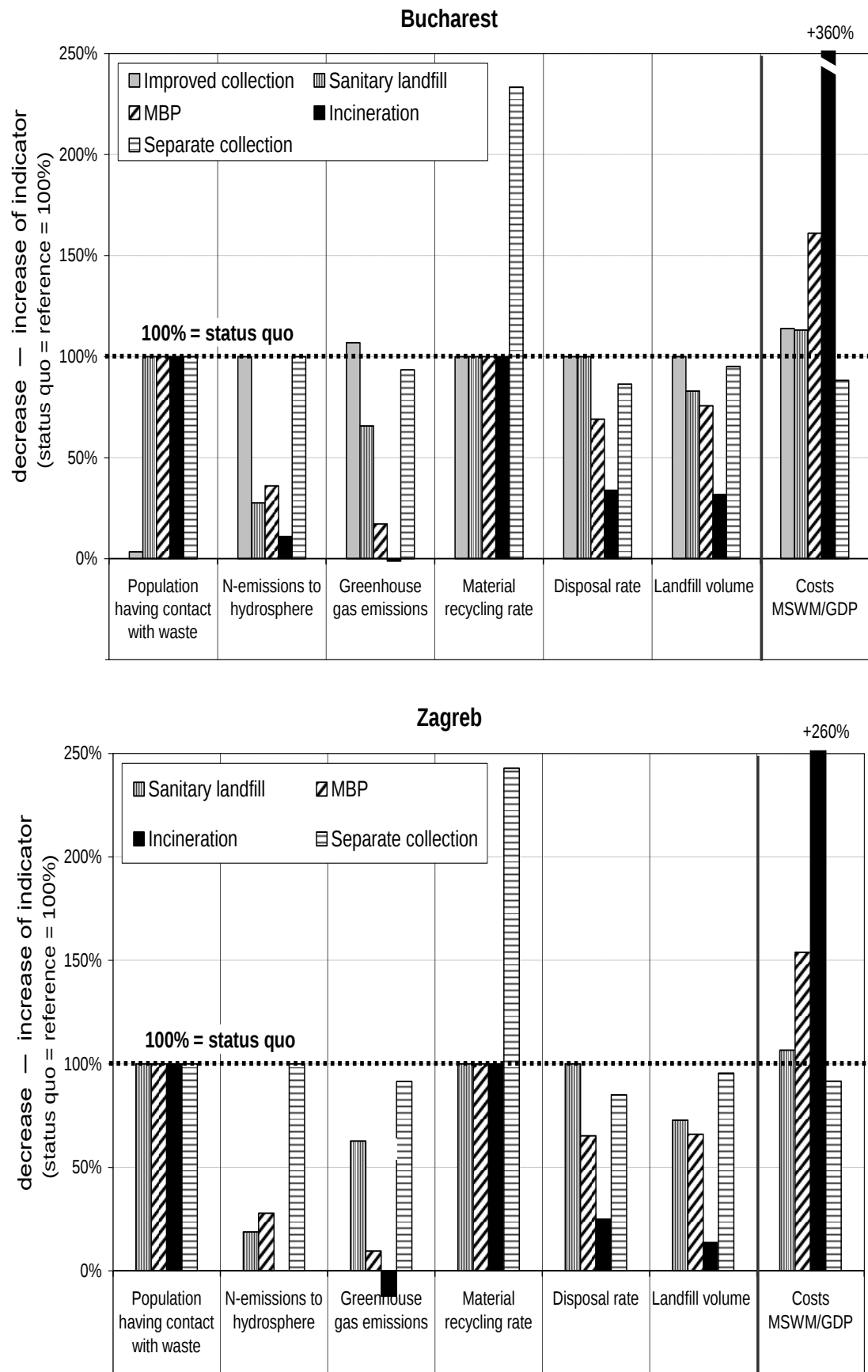


Figure 8. Changes of goal oriented parameters for different scenarios of MSWM in Bucharest and Zagreb

4. Conclusion

The results show that the hygienic hazard for inhabitants having direct contact with waste (e.g., population without waste collection service in Dhaka, Damascus, and in Bucharest) can only be reduced by the introduction of a comprehensive collection service. Other measures, such as the improvement of waste disposal sites (sanitary landfills) or biological or thermal waste pre-treatment, have an impact primarily on environmental indicators (e.g. N-emissions to hydrosphere, greenhouse gas emissions or land use for waste disposal).

In all 4 cities separate collection of recyclable materials (e.g., paper, glass, plastics and metals) would increase the conservation of resources with a simultaneous reduction of the costs of MSWM. Upgrading existing disposal practice to sanitary landfilling would be economically feasible in each region (costs would increase less than 20%), leading to lower environmental impacts. Other disposal strategies, such as mechanical-biological waste treatment prior to landfilling (increase of costs between 50 to 80% in comparison to status quo) or thermal waste pre-treatment (cost increase of up to 800%) could hardly be affordable by the municipalities without external funding (for construction) and the willingness of inhabitants to pay higher fees for their waste service (for operation). In general it can be concluded that appropriate waste solutions are regionally specific and largely dependent on the economic level of a region. In regions that cannot spend much more than 20 €/cap/year on waste management, sanitary landfilling represents a key component of MSW management. In economically more developed regions the pretreatment of waste prior to landfilling could be a feasible management option.

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