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## Waste Management

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## Solid waste treatment opportunities in the Palestinian authority areas

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## ABSTRACT

Municipal services in the Palestinian Authority (PA) areas, including the West Bank and Gaza Strip (WBGS), are facing serious difficulties that have been intensified following the outbreak of the Palestinian uprising in late September 2000. The solid waste management services, being the most essential services provided by the municipalities and village councils, are mostly affected by the ongoing harsh situation and hence proper solutions that take into account the actual amount of generated municipal solid waste and its composition is a pre-requisite for planning proper treatment. Hence, a study was carried out to identify the actual status of solid waste in eight West Bank districts. A social survey was also conducted to collect information concerning the level of public awareness among communities surveyed to the perception of solid waste recycling and reuse. The results of the survey conducted in 2001–2002 were later reviewed during July–October 2008 to assess if the trend of domestic solid waste generation had changed. Based on the survey and post-assessment, it is found that political and economic conditions have both significantly impacted the trend of generated municipal solid waste and since no improvements in either condition are forthcoming, it is concluded that survey results could be used in a planning study. A possible handling of the generated wastes may entail transferring the recyclable waste to Israeli recycling industries, and in constructing three composting plants in different accessible locations in the West Bank.

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## 1. Purpose of the study

The 3.7 million Palestinians (PCBS, 2008) living in the West Bank and Gaza Strip (WBGS) of the Palestinian Authority are facing serious developmental challenges due to the fact that they are living in a relatively small land area of 6192 km<sup>2</sup> over which the population increases steadily at a rate that exceeds 3% per year. In West Bank (WB) areas the population is 2,761,646 and grows at an annual rate of about 3%. The average family size is 5.8 and the average population density exceeds 500 cap/km<sup>2</sup>. The challenges are becoming more difficult as the economic outputs since the second Intifada are facing turbulent conditions driving the WBGS in 2006 and 2007 to almost all-out social and institutional breakdown. The poverty rate jumped in 2007 to almost 56% in WB and 19% in East Jerusalem (UNDP, 2007). In particular the service providing institutions such as the municipalities or village councils are mostly affected by the conditions and as a result cannot provide proper services to communities, especially solid waste management services.

Solid waste management services are usually the responsibility of the municipalities and village councils in Palestinian urban and rural areas. In the refugee camps, the United Nations Relief and

Works Agency for the Palestinian Refugees in the Near East (UNRWA) is the body responsible for providing solid waste management services. In addition to political conditions that significantly affect providing the services, the lack of proper funds and infrastructure are making solid waste management services one of the most expensive services. Although municipalities and councils have assigned fees for the collection and transportation of wastes, few people have been able to pay for the services and hence the revenue actually collected from the fees has contributed to less than 20% of the money needed to run the services (UNEP, 2003).

Studies conducted in the mid-1990s estimated that the amount of solid waste generated daily ranges from 0.9 to 1.2 kg/cap in the Palestinian urban area and 0.5 to 0.8 kg/cap in rural areas; the total annual amount of solid waste produced in WB alone exceeds 500,000 tons (Al-Hmaid, 2002). The Ministry of Environmental Affairs (MEnA), which was later named the Environmental Quality Authority (EQA), is the PA's regulatory institution mandated to propose a strategy and action plan for tackling environmental issues within the PA jurisdiction. The EQA, with direct help and funds from the Netherlands, drafted in 2000 the Palestinian National Environmental Strategy and Action Plan (MEnA, 2000a,b) that proposed short-, mid- and long-term actions. In addition to the strategy and action plan, the EQA drafted the Palestinian Environmental Law and the Environmental Impact Assessment Policy

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(MEnA, 1999; MEnA, 2000c). These documents addressed issues related to the improper handling of solid waste, as it is a major cause of the deterioration of the quality of ground water, degradation of land, pollution of air and shoreline, aesthetic distortion of the visual environment and adverse consequences on public health.

With regard to solid waste treatment and reuse, EQA suggested that separation and composting of organic waste, incineration, separation and recycling of certain waste streams were considered alternatives that depend on the effectiveness of the proposed collection and landfill measures. Hence, in order to investigate the feasibility of such alternatives, a national survey on the composition of solid waste was deemed essential. The results of a field survey should provide a clear picture of the quantity and composition of solid waste and form a basis for future projections. In early 2001 funding was provided by the United States Agency for International Development (USAID) through its Middle East Regional Cooperation (MERC) Program to carry out a survey on the generated solid waste in PA areas, aiming to assess the opportunities for regional recycling of solid waste components and to measure the public awareness of the subject. The survey study outcomes are presented in the following sections.

## 2. The approach

The study, which was executed between July 1, 2001 and June 30, 2002, sought to evaluate the feasibility of building a regional recycling infrastructure based on two elements:

1. The establishment of joint industrial zones where businesses within each zone would use the waste products produced by each other in their own manufacturing processes; and
2. The potential for establishing regional waste treatment and recycling facilities that would take advantage of economies of scale to make recycling more economically attractive.

This approach reflected increased interest in regional cooperation, particularly the establishment of joint industrial zones, following the 1993 Oslo Accords up until the outbreak of Intifada in September 2000. In addition the study sought to execute detailed surveys of local waste generation patterns and attitudes towards recycling in the domestic and industrial sectors, complete an economic analysis of the feasibility of recycling different materials based on the data gathered in the surveys, and evaluate the local socio-political/economic situation so as to identify various options and make recommendations that would enable the implementation of steps leading to the establishment of such an infrastructure. The turbulent situation that pervaded the study period encumbered efforts to realize all these goals; however, the study nevertheless succeeded in executing the planned surveys which have significantly strengthened technical knowledge in the environmental field in general and waste treatment options in particular, in addition to having created a very valuable dataset.

The methodology of the research surveys was prepared over the course of several meetings between the different co-principals and institutions. Several changes were made to the original research methodology in order to increase the feasibility and relevance of this research. It was decided to conduct three surveys, namely: domestic solid waste composition survey, industrial solid waste survey and social related survey. In order to accomplish the surveys, 13 university students were recruited, trained in conducting the surveys and provided with proper manuals and questionnaires. The three planned surveys were finalized by October 2002, and data and information collected were analyzed afterwards and included in the project final report.

In a recent attempt to assess the results obtained during the 2001–2002 survey, a small-scale survey was conducted during the period July–October 2008 on several families who already had been surveyed. The same approach was applied to the domestic solid waste survey; no other surveys (i.e., industrial or social) were carried out.

## 3. Domestic solid waste composition survey

The recruited students began their fieldwork for the domestic waste composition analysis in November 2001. The collection of data ended at the end of October 2002. The survey was conducted in eight WB districts; namely, Bethlehem, Nablus, Ramallah, Jenin, Tulkarem, Jericho, and Hebron. The other three WB districts of Tubas, Qalqilia and Salfit were excluded as data could be assessed based on the conditions of northern districts of Nablus, Jenin and Tulkarem. The surveyed communities live in urban, rural and refugee camps. In addition to WB districts, the survey was also conducted in East Jerusalem. A total of 64 sites were surveyed in 2001–2002, and in 2008 6 urban sites were surveyed for the domestic waste assessment. Table 1 shows the number of surveyed sites in the West Bank and the places where the 2008 survey assessment was carried out.

The surveyed households were chosen randomly, and families that participated in this survey showed willingness and cooperation. The collection and analysis of domestic waste composition data was carried out on a weekly basis. However, even though the participating families varied in the way they dispose of their waste; all of them agreed to dispose of glass, plastic, writing paper, metal and other waste on weekly basis. While disposal patterns of the organic and toilet papers were varied between families; most of them collected the materials it for the last 48 hours of the week while others collected it for all the week. The data, in the end, was standardized to represent a weekly disposal basis. This methodology was based on a 12-month cycle that allowed for seasonal variation. During the domestic waste composition survey, regular bi-weekly follow-up meetings were conducted with the students to ensure proper implementation. The domestic solid waste data was then entered into a database and analyzed. In order to check whether domestic waste generation trends changed in 2008 compared to that of 2002, six urban sites were surveyed.

## 4. The social survey

The social survey covered 109 families; 52 of them were the families that participated in the domestic waste composition survey. The distribution of families among the surveyed districts is shown in Table 2.

The students were randomly assigned the families they would be covering as part of this survey. A questionnaire that covers information concerning the families' knowledge, practices and attitudes towards reuse, recycling and separation at source of solid waste was used in the survey. The background information collected from the surveyed families reflects to a major extent the diverse socio-economic characteristics of the Palestinian communities as listed in Table 3.

## 5. Industrial sector survey

The questionnaire used in the industrial survey addresses the general information about the raw materials, final products, types and quantities of generated industrial waste, means of waste disposal, recycled and/or reused products and the level of knowledge about reuse and/or recycling of products and by-products. Ten categories of industries were identified based on major types of

**Table 1**  
Distribution of surveyed families in the West Bank areas.

District	Place of living				Total
	Urban – City <sup>a</sup>	Urban – City assessment <sup>b</sup>	Rural – Country	Refugee camp	
Bethlehem	8	1	–	–	8
Jerusalem	6	1	–	–	6
Hebron	8	2	5	–	13
Ramallah	3	1	3	1	7
Jericho	2	–	1	1	4
Nablus	3	1	4	1	8
Tulkarem	6	–	3	–	9
Jenin	9	–	–	–	9
Total	45	(6)	16	3	64

<sup>a</sup> 2001–2002 solid waste survey.<sup>b</sup> July–October 2008 small-scale assessment survey.

industries that characterize the Palestinian industrial sector, namely: metal, food, stone and glass, leather, wood and furniture fabrication, paper, chemical, textile, plastic and electrical equipment industries. A total of 154 industrial premises were surveyed. These are geographically located as indicated in Table 2, covering the entire West Bank area.

## 6. Research outcomes

A total of 64 families were surveyed, comprised of 393 persons. The average number of persons in a family is approximately six. The six families surveyed during the recent assessment had 29 persons. The analysis carried out on the composition of the domestic waste, demonstrated the following:

1. The average domestic solid waste generated did not vary considerably when comparing the data collected during the 2001–2002 survey and the data from the recent assessment survey. This could be due to the economic and political conditions that did not improve much from the intervening time period. Since the outbreak of the second Intifada in 2001 up until 2008, the conflict intensified as internal political division has adversely impacted any reforms that might bring better conditions for Palestinian communities in WB. In addition the policy of the donor countries implemented after the Palestinian elections in 2006 has significantly impacted the already shaking economy and increased the poverty among families.
2. Based on the 2001–2002 survey and the assessment survey, the average solid waste generated is 426.91 g/cap/day, or 155.82 kg/cap/yr.
3. Organic solid waste is the most abundant type of waste that families produce, as it forms 74% by weight of the solid waste generated. Fig. 1 shows the average solid waste weight generated per capita per year for each waste item.

**Table 2**  
Geographic distribution of families and factories surveyed.

District	Place of living			Total (families)	Total (factories)
	Urban (City)	Rural (Country)	Refugee camp		
Hebron	11	14	1	26	29
Bethlehem	6	2	1	9	32
East Jerusalem	6	2	2	10	19
Ramallah	10	3	2	15	27
Jericho	1	2	6	9	–
Nablus	5	4	1	10	9
Tulkarem	7	6	–	13	8
Jenin	14	2	1	17	19
Total	60	35	14	109	154

**Table 3**  
Information about the surveyed families.

Background information	(%)	
Place of living	Urban (City)	55.0
	Rural (Country)	31.2
	Refugee camp	12.8
Geographic nature of living areas	Mountains	59.6
	Plains	25.7
	Valley	5.5
	Al-Ghor	8.3
	Arid area	0.9
Education of family supporter	Illiterate	6.4
	Elementary level	11.9
	Secondary level	22.0
	Higher Educ. level	59.7
Number of workers at family	No workers	2.6
	One worker	54.2
	Two workers	33.8
	More than two workers	9.4
Monthly family income	<US\$ 200	6.4
	US\$ 200–500	33.0
	>US\$ 500	60.6
Responsibility of solid waste collection	Municipality or village Council	93.6
	Others	6.4

4. Per capita solid waste generation for communities of the northern districts is less than those of other districts. This is due to the fact that communities living in the northern districts are experiencing more difficult political situations, less accessibilities, and worse infrastructure. Of all eight districts surveyed, only Jericho district enjoys better conditions as it has not been re-occupied and it depends mainly on agriculture and internal national tourism. Table 4 shows the distribution of generated solid waste by each district and for each type of domestic waste generated.

The population of each district was taken from the PCBS 2007 census (PCBS, 2008). It should be noted here that in order to assess the size of the generated domestic wastes for the whole WB area of the PA, the remaining unsurveyed districts (Qalqilia, Salfit and Tubas) were included in Table 4 and the average solid waste per capita per day was taken as the average of those for the northern West Bank districts, i.e., Nablus, Tulkarem and Jenin.

Outcomes of the social survey showed a poor level of knowledge concerning reuse and recycling. For example, answers to question: “Do you have knowledge or information about waste recycling and reuse?” were as follows:

1. Of respondents, 49.5% said they do not have knowledge about reuse while the rest said yes they know what reuse is and gave a short explanation about it. These explanations varied as follows:

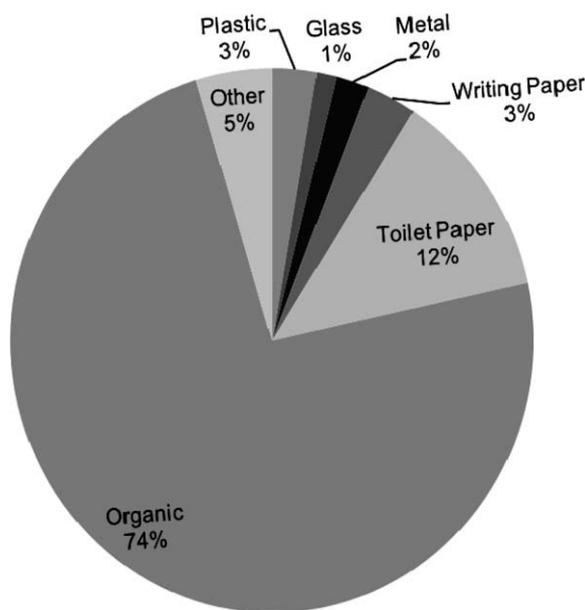


Fig. 1. Composition of generated solid waste for the surveyed communities.

- 13.9% of yes answers said reuse is converting organic waste into composting.
  - The rest of the yes answer were about reusing glass, plastic, bottles, cola cans, food containers, metal containers, plastic bags and so on.
2. Of respondents, 51.4% said they do not have knowledge about recycling while the rest said they do know and gave a brief explanation that recycling relates to paper, toilet paper, plastic, cola cans and glass, metal and so on.
  3. Of the answers to the question regarding if they know what organic fertilizer is, 77.8% were positive; of them 31.8% said it is composed of animal waste, 7.1% said it is composed of organic waste and 16.7% said it is composed of animal and organic waste.
  4. More than half of the participants (55%) have no knowledge about countries that recycling solid waste. However the participants who said they do know of countries that recycle mentioned European countries, Japan and the USA.
  5. The answers to question: "Would you agree to do waste separation?" were encouraging since 80.7% of them said yes. On the other hand, the ones who said no gave reasons such as: no

Table 5  
Community perception regarding recycling.

Products	Frequency	(%)
All	28	29.2
Glass	13	13.5
Glass, metal	2	2.1
Glass plastic	5	5.2
Glass, plastic, metal	5	5.2
Metal	3	3.1
Paper	13	13.5
Paper, glass	3	3.1
Paper, glass, metal	1	1.1
Paper, metal	4	4.2
Paper, plastic	5	5.2
Paper, plastic, metal	1	1.1
Plastic	3	3.1
Plastic, metal	2	2.1
Other	3	3.1
No answer	5	5.2
Total	96	100

containers and/or industries for such things; no space at home; can't do it; it requires too much effort; or there is no need for doing it.

6. Of the 96 cases, 88.07% said that they would agree to use recycled or reused products; of them 29.2% said that they agree to use all kind of products, e.g., glass, metal, plastic, and paper. In Table 5, reused and recyclable waste products that surveyed participants agree to use are shown by type.
7. Answers to the question asking for clarification as to why recyclable products should be used show that protecting the environment was the most important reason for using recyclable products (33%) followed by the need to decrease the amount of waste generated (14.7%). The percentage of those surveyed that stated both of these reasons was 13.8%. Table 6 shows the answers to the question "What factors encourage you to use recyclable products?"

The outcomes of the domestic and social surveys clearly highlight the impact of the political conditions that Palestinian communities are experiencing. This is shown in the variation of the average solid weight per capita per day among the eight surveyed districts. In addition, the outcomes on the composition of generated domestic solid wastes showed that the largest component of the generated domestic waste is the organic waste (74%), which means a rich organic domestic solid waste. This agrees well with the trend found in other developing countries (El-Edghiri, 2002). This rich organic domestic waste suggests a solid waste management strategy

Table 4  
Total average domestic solid waste generated by each district.

District	Average solid waste (g/cap/day)	Population (2007) <sup>b</sup>	Total average generated waste (Ton/yr)					
			All	Plastics	Glass	Metal	Papers <sup>c</sup>	Organic
Hebron	556	551130	111846	3065	1376	2304	17403	82442
Bethlehem	394	176515	25385	696	312	523	3950	18711
East Jerusalem	434	362521	57427	1573	706	1183	8936	42329
Ramallah	418	278018	42417	1162	521	874	6600	31266
Jericho	842	41724	12823	351	158	264	1995	9452
Nablus	321	321493	37668	1032	463	776	5861	27765
Tulkarem	336	158213	19403	532	239	400	3019	14302
Jenin	369	256212	34508	946	424	711	5369	25436
Qalqilia	342 <sup>a</sup>	91046	11365	311	140	234	1768	8377
Salfit	342 <sup>a</sup>	59464	7423	203	91	153	1155	5471
Tubas	342 <sup>a</sup>	48771	6088	166	75	125	947	4487
Totals (West Bank)		2345107	366353	10038	4506	7547	57005	270039

<sup>a</sup> The value was taken as the average of the average per capita generated solid waste for the northern districts, i.e. Nablus, Tulkarem and Jenin.

<sup>b</sup> PCBS (2008).

<sup>c</sup> This is the sum of writing and toilet paper generated domestic wastes.

**Table 6**  
Community perception regarding the use of recyclable products.

Responses	Frequency	(%)
No answer	3	2.8
Decrease amount of waste generated ("waste size")	16	14.7
Decrease waste size and save money	1	0.9
Protect environ	36	33.0
Protect environ, decrease waste size	15	13.8
Protect environ, save money	2	1.8
Protect source	6	5.5
Protect source and environ	2	1.8
Protect source and environ, decrease waste size	1	0.9
Protect source and environ, decrease waste, save money	7	6.4
Save money	20	18.3
Total	109	100.0

by which a composting plant could be erected in the WB areas. Three composting plants serving the northern (Nablus, Jenin, Tulkerem, Tubas and Salfit), middle (east Jerusalem, and Ramallah) and southern districts (Hebron and Bethlehem) could be constructed to mitigate accessibility problems. The suggested composting plant could also be used for recovering methane through the anaerobic decomposition of organic waste. The results of the social survey support the suggested handling of organic wastes as it showed that 78% of all surveyed communities have knowledge about the values of composting. It is worth mentioning that 55% of the surveyed participants are living in agricultural areas and most of them are directly or indirectly working in the agriculture sector.

With regard to other recyclable generated wastes, a cost-benefit analysis should be performed to assess the feasibility of dumping recyclable solid waste in existing landfills versus separating solid waste items and transferring them to the existing large recycling facilities in Israel. The social survey results showed that 88% of those surveyed would use products produced by recycling solid waste. In addition some 63% of them are aware that recycling of their waste will protect the environment and reduce the amount of waste generated. The idea of separating domestic waste items at the household seems promising as around 81% of the surveyed people expressed a willingness to separate waste at their houses.

## 7. Conclusion

The ongoing political conflict has it adverse impact on the domestic solid waste generation trends in the WB areas,

although the weight composition of domestic waste items agree well with other developing countries. As generated domestic solid waste is rich with organic waste, it is suggested to plan for constructing three composting facilities serving communities in the northern, middle and southern parts of the WB. This plan is supported by the results of the social survey. The remaining recyclable items may be either dumped in the existing landfills or transferred to Israeli recycling industries. A cost-benefit analysis is needed to determine the feasibility of any suggested plan.

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