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Assessment of Technical and Environmental Performance of Municipal Solid Waste Management in Rafah City - Palestine

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THERE are many environmental problems connected with the current collection system specially the containers system in Rafah Municipality. No separation option is available for the hazardous waste from the municipal waste. Municipality collect about 88.5% of the total generated waste from the residential and commercial areas and about 4% of population is not covered by service. Limited recycling activities are running in low quality products. Environmental health awareness unit activities running on irregular base and depend on donors.

The work analyze different stages of Solid Waste Management system in the City for the purpose of developing more efficient and effective one, which will be reflect positively on environment, health, economy and service level of the community. Consequently, the study will contribute in providing based scientific data to decrease the risks and hazards of the current system.

Keywords: Rafah City, Municipal solid waste, Solid waste management

The Palestinian territories are composed of two geographically separated areas: the West Bank and Gaza Strip. Gaza Strip (GS) has a coastline of 40 km at the eastern extreme of the Mediterranean and on the edge of the Sinai Desert and total area of 365 km2. Rafah Governorate is one of the five GS Governorates with a current population estimated at 150 thousands people of which 80% are refuges and the growth rate is estimated to be 4.32%, the average household size is 8.6 people (PCBC, 1997). Rafah city is the main link between Palestine and Egypt and the City gained the status of a municipality in 1972.

There are many major environmental problems in Gaza Strip due to long occupation period by the Israelis (Kelly & Homer-Dioxin, 1995). Thirty years of deteriorating infrastructure and negligence, over the period 1967-1994, lead to inadequate investment in the various environmental sectors, particularly water, wastewater sanitation and solid waste (Gaza Environmental Profile, 1995). Overpopulation is also a major challenge that creates more pressures, especially on the limited natural resources in the area and has a profound impact on the

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quality of health and social life of people. (Coad, 1997 and MOH, 2002). During the period some of existing infrastructure deteriorated while the population and their needs rapidly increased. This lead to environmental degradation on almost every aspect (El-Hawi, & Hamilton, 2001)

Solid waste generation and management is one of the major environmental problems in the Gaza Strip (MEnA, 2000)b. The rapid population growth rate and the increase in the generation quantities of the solid waste are the particular concern in the Gaza Strip taking in consideration the limited natural and financial resources in the area (MOH, 2002). Solid Waste management (SWM) is a major responsibility of the municipalities in Palestine. It is an essential task, which has important consequences for public health and well being the quality and sustainability of the urban environment and the efficiency and productivity of urban economy (Scheinberg, 2001). About 80 tones of solid waste are generated daily in Rafah City and the organic mater estimated between 60 to 70 percent of the total generated (Afifi, 2001). There are three stages in the solid waste management system used in Rafah, which are collection, transportation and disposal.

The city of Rafah is divided into four main collection sections which are western section, central section, eastern and camp section (Vrins, 1993). In the camp section, UNRWA is responsible for solid waste collection and transportation. Each section is divided into small squares according to the number of houses and the nature of the area. The municipality has traditionally used a container system for collection, but that system is being gradually replaced by a house-to-house collection system. The collection of waste in the residential areas is carried out in one of the several ways described accordingly.

- The people themselves carry their waste materials to the nearby containers.
- Municipality workers use small handcarts to collect waste to containers.
- Municipality workers use carriages pulled by animals to collect garbage to containers or to the transfer station.
- Small dump truck with capacity 4m3 and large compactor trucks with two workers per truck are used for collection, especially in the area of house to house collection system where the containers are removed.

The municipality vehicles transport approximately 80-90 tons daily to the dumpsite which is approximately 11 Kilometers from the city center. The operational efficiency of vehicles is generally weak, and this is strongly related to the ability of the municipality to perform proper maintenance. The outstanding problems of the transportation stage can be summarized in the following:

A. There are too many types of vehicle used in the transportation process. This has a strong effect on overall vehicle fleet maintainability.
B. Weak operation efficiency of some vehicles which results in a rise in the cost of the transportation process.
C. Transportation routes are not optimum.
D. Health and environmental problems caused by the large piles of waste in random locations.

Rafah Landfill used for waste disposal and was initially planned for dumping waste from areas under municipal jurisdiction, and due to the unstable political situation and Israelis road closure, other municipalities in the area used Rafah dumpsite as well. This lowered the expected life of the dumpsite from 7 to 5 years in addition the health department director reports that there is need for a new dumpsite within 2-3 years. This is one of the major challenges that municipality of Rafah will face in the near future. The most outstanding problems of the current dumpsite operation processes are:

A. The short chronological age of dumpsite.
B. A lack of Leachate treatment facilities.
C. The difficulty in obtaining new lands for a new landfill.
D. The dumpsite is not prepared to receive agricultural, construction and hazardous waste.

The aim of the study is to evaluate the technical and environmental aspects of existing municipal SWM status in Rafah City.

Methodology

The methodology instruments of this assessment study were focus on reviewing municipal records and field survey using questionnaire. The assessment framework addresses the following SWM dimensions:

- Technical Performance: Issues investigated are collection rate, collection coverage, solid waste container-related issues, collection frequency and consistency and collection mechanisms other than collection from containers (house-to-house collection and collection by street sweepers).
- Environmental Performance: Issues investigated are disposal rate, hazardous waste collection and disposal, solid waste recycling / reuse, environmental awareness issues and public perceptions regarding the prevalence rates of public health hazards.

The study was carried out in the residential areas of Rafah city where the municipality of Rafah is providing solid waste collection and disposal service and the field survey was conducted in the period from October to December, 2004. Five percent of the household's sample was selected through a systematic random sample from a total number of 7500 households who received the solid waste collection and disposal services in study area.

Questionnaires were numerically coded to enter the data systematically and efficiently. Data was entered using SPSS "Statistical Package for Social Sciences". Data cleaning was carried out through double check both manually and through using the computer.

Results and Discussion

The results focus on analyzing the technical and environmental performance aspects of solid waste management in Rafah.

Technical Performance

Collection coverage and collection rate

Questionnaire data show that 14 respondents out of 389 (4 %) are not currently served by any solid waste system. This means that there are about 6 thousands residents out of a population of 150 thousands residents who are not currently served by any collection system, assuming statistical (geographic) representation. Based on data provided by the Health Department on types of solid waste collected by the municipality of Rafah, the municipality at best collects 88.5% of total waste generated. This is limited mainly to residential and commercial waste, as shown in Fig. 1.

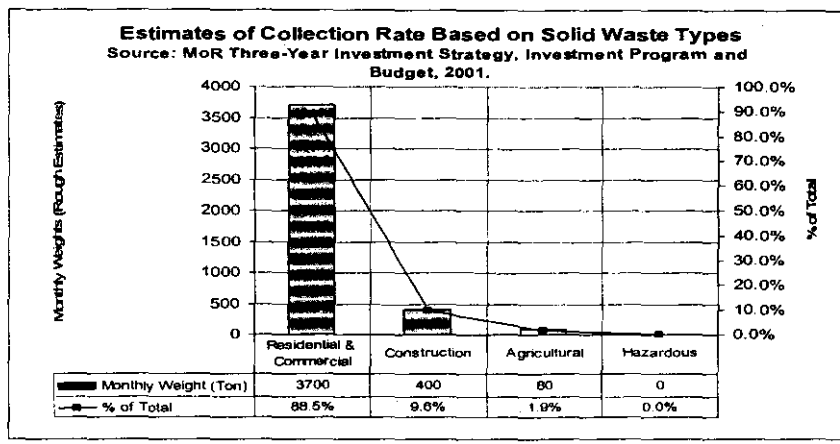

Fig. 1. Estimates of collection rate based on solid waste types.

Number of litter bins (Applies mainly to Container System)

The questionnaire data showed that respondents are more inclined towards having more containers in general, as verified in Table 1.

TABLE 1. Public's need for more containers.

Do You Need (The Need for) More Containers	Observed Public Responses Regarding the Need for More Containers	
	No.	%
Yes	117	62.6
No	70	37.4
Total	187	100

Chi-Square = 11.81, df = 1, CL = 95% ,p= 0.001

The number of litter bins to be provided in commercial and other areas is a function of the amounts of waste expected (waste accumulation) and of public perceptions regarding how close containers should be to their homes. The public sees that waste accumulates in containers, especially in the afternoons and sees that containers are not close to their homes, as shown in Table 2 and in Table 3 respectively. Both indicators explain why the public sees a need to increase the number of containers provided, as discussed in Table 1.

TABLE 2. Public's view of waste accumulation.

Does Waste Accumulate in Containers, Especially in the Afternoons?	Observed Public Responses Regarding Waste Accumulation	
	No.	%
Yes	145	78.0
No	41	22.0
Total	186	100

Chi-Square = 58.15, df = 1, CL = 95%, P= 0.000

TABLE 3. Public's view of container closeness (to Homes).

Is Container Close to You?	Observed Public Responses Regarding closeness of containers (to homes)	
	No.	%
Yes or Somewhat Close	86	46.0
No	101	54.0
Total	187	100

Container collection frequency and consistency

The public's view concerning container collection frequency is that the municipality does not perform collection from containers on a daily basis. This is verified in Table 4.

TABLE 4. Public's view of whether the municipality collects waste from containers on a daily basis.

Does the Municipality Collect Waste from Containers on a Daily Basis?	Observed Public Responses Regarding Whether Municipality Collects Waste from Containers on a Daily Basis	
	No.	%
Yes	25	13.4
No	162	86.6
Total	187	100

Chi-Square = 100.37, df = 1, CL = 95%, P= 0.000

In addition, the public sees that collection frequency from containers is not regular, whether collection is done on a daily basis or not, as verified in Table 5. This connotes low collection frequency consistency.

TABLE 5. Public's view of whether the municipality collects waste from containers on a daily basis.

Does the Municipality Collect Waste from Containers on a Daily Basis?	Observed Public Responses Regarding Municipality Collects Waste from Containers on a Daily Basis	
	No.	%
Yes	58	31.4
No	127	68.6
Total	185	100

Chi-Square = 25.74, df = 1, CL = 95%, P=0.000

Furthermore, it appears that the public values collection frequency consistency more than collection frequency per day. TABLE 6 shows that the public are not inclined to increase collection frequency from containers to more than once daily.

TABLE 6. Public's view of whether the municipality should collect waste more than once daily.

Do You Think the Municipality Should Collect Waste More Than Once Daily?	Observed Public Responses Regarding Whether Municipality Should Collect Waste from Containers More Than Once Daily	
	No.	%
Yes	73	39.5
No	112	60.5
Total	185	100

Chi-Square = 8.22, df = 1, CL = 95%, P=0.004

Weekly Frequency of House-to-House Collection

Respondents to the questionnaire point that in the House-to-House collection system, waste is collected from houses between 4 and five times a week (mean = 4.7). In addition, the respondents would like waste to be collected from houses between 5 and 6 times a week (mean = 5.9). The Paired-Samples t-test shows a significant deference between actual (observed) collection frequency and needed collection frequency, as shown in Table 7. This means that in order to satisfy public demand on this dimension, the collection frequency in House-to-House collection should be increased from 4-5 times a week to 5-6 times a week, and preferably to 6 times a week.

TABLE 7. Paired Samples T-Test on significance of difference between actual (observed) and needed weekly collection frequency in house-to-house collection system.

	Mean	t	df	P Value (Two Sided)
Actual (Observed) Collection Frequency-Needed Collection Frequency	-1.2926	-8.479	187	.000

However, and irrespective of the afore-mentioned shortcoming, the overwhelming majority of questionnaire respondents view House-to-House collection system as being better than container system, as verified in Table 8.

TABLE 8. Public's view concerning whether house-to-house collection system is better than the container system.

Is the House-to-House Collection System Better Than the Container System?	Observed Public Responses Regarding Whether There Are Street Sweepers Collecting Waste from Streets / Roads in Neighborhoods	
	No.	%
Yes	182	96.8
No	6	3.2
Total	188	100

Chi-Square = 164.77, df = 1, CL = 95%, P=0.000

The technical performance finding results show that the major strength of the SWM system at the technical level is that the newly introduced House-to-House collection system seems to results to higher satisfaction than the older container system. However the municipality records and questionnaire finding show many weakness of SW at the system level. These can be described in the following points:

1. The lack of technical and financial resources leads the municipality to ignore collection of some solid waste sources so collection is done primarily for residential and commercial waste. The construction and agricultural waste is not collected separately and is mixed with residential and commercial waste.
2. The municipality at best collects 88.5% of total waste generated and limited mainly to residential and commercial waste.
3. Residents are more inclined towards having more containers in general. This is despite the fact that they are generally more satisfied with house-to-house collection. The public sees that waste accumulates in containers, especially in the afternoons and sees that containers are not close to their home. Both indicators explain why the public sees a need to increase the number of containers provided.
4. The public's view concerning container collection frequency is that the municipality does not perform collection from containers on a daily basis. The public sees that collection frequency from containers is not regular,

whether collection is done on a daily basis or not. The public values collection frequency consistency more than collection frequency per day.

Environmental Performance

Hazardous waste collection and disposal

Based on Rafah municipality records, the current waste collection system in Rafah municipality does not show figures about the hazards waste; however the analysis of some collected data showed that the main category of the hazardous waste is the medical waste in addition to other small categories like insecticides and battery waste (Afifi, 2002). The amounts of hazardous and related waste generated in the municipality of Rafah shown in Fig. 2. The figure shows that the wound dressing used by health institutions is the most important hazardous waste in terms of weight (3177.7 kg/year) which constitutes 91.5% of the total weight of hazardous waste generated. Furthermore, the collection and disposal of this hazardous waste are being done through the municipal solid waste system without any special care or treatment.

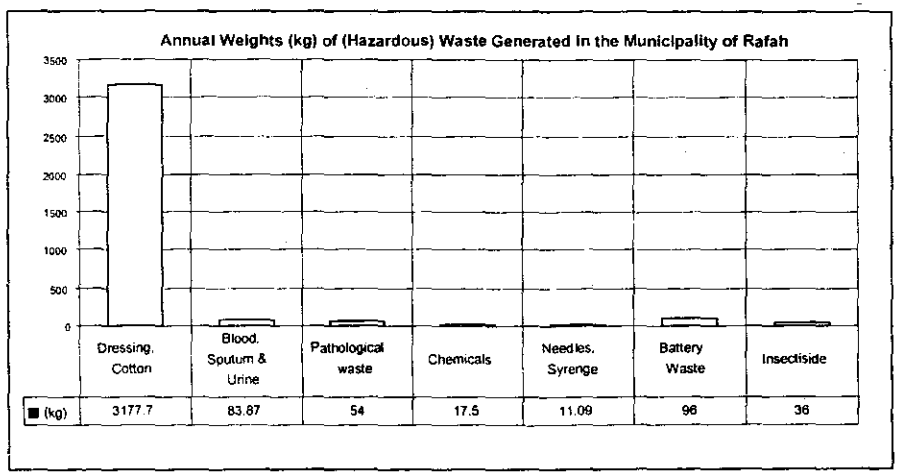

Fig. 2. Annual weights (Kg) of (Hazardous) waste degenerated in the municipality of Rafah (Afifi, 2001)

Solid Waste Recycling / Reuse

The recycled waste in Rafah is very limited due to the limitation in infrastructure, solid waste characterization and financial resources. The major constituent of municipal waste is organic waste, which could be composted. There are some activities which are running on an irregular basis for recycling the plastic and iron fraction by the private sector and they produce low quality products and they depend on collecting the plastic fraction from the landfill or from the origin. A small scale of on- Farm composting has been implemented in rural areas.

Promotion of Environmental Awareness

An environmental awareness unit was established in the municipality since ten years ago. There is no special budget line for the environmental awareness unit in the municipal budget and the activities of this unit mainly covered from the donors via different programs and projects for solid waste, water and wastewater.

Prevalence of Health Hazards of Collection Systems

In House-to-House Collection System, respondents to the questionnaire point that they are suffering from health hazards (odors, insects and rodents), as verified in Table 9. It is worth mentioning that the public are over-reporting health hazards.

TABLE 9. Public's view concerning whether they are suffering from health hazards (Odors, insects and rodents).

Are You Suffering from Health Hazards (Odors, insects and rodents)?	Observed and Expected Public Responses Regarding Whether They Are Suffering form Health Hazards (odors, insects and rodents)			
	Observed		Expected	
	No.	%	No.	%
Yes	132	70.2	94	50
No	56	29.8	94	50
Total	188	100	188	100

Chi-Square = 30.72, df = 1, CL = 95%, P=0.000

In container system, questionnaire data show that most respondents are suffering from noxious odors. Table 10 shows clearly that noxious odors constitute are a more significant problem during summer.

TABLE 10. Public's view concerning whether they are suffering from noxious odors .

Are You Suffering from Noxious Odors (Because of Containers)?	Public Responses Regarding Whether They Are Suffering form Health Hazards (odors, insects and rodents)	
	No.	%
No	7	3.7
In Summer Times	137	73.3
Always	43	23.0
Total	187	100

Chi-Square = 144.56, df = 2, CL = 95%, P=0.000

In addition, questionnaire data show that most respondents are suffering from smoke resulting from the burning of containers, as verified in Table 11.

TABLE 11. Public's view concerning whether they are suffering from container-burning smoke.

Are You Suffering from Smoke Resulting from Container Burning?	Observed and Expected Public Responses Regarding Whether They Are Suffering form Health Hazards (odors, insects and rodents)	
	No.	%
Yes	126	67.7
No	60	32.3
Total	186	100

Chi-Square = 23.42, df = 1, CL = 95%, P=0.000

Furthermore, the questionnaire data show that most respondents are suffering from rodents associated with container use, as verified in Table 12.

TABLE 12. Public's view concerning whether they are suffering from rodents (because of containers).

Are You Suffering from Rodents Because of Containers?	Public Responses Regarding Whether They Are Suffering from Rodents	
	No.	%
Yes	180	96.3
No	7	3.7
Total	187	100

Chi-Square = 160.05, df = 1, CL = 95%, P=0.00

The environmental performance finding results show that the major strength of the system connected with the new introduce collection system (House to House) in part of the Municipal area. The new system reduce the environmental and health hazards of waste. In the other hand, SWMS weaknesses as related to the environment can be described as follows:

1. The current waste collection system in Rafah municipality does not show figures about the hazards waste. The collection and disposal of this hazardous waste are being done through the municipal solid waste system without any special care or treatment
2. The waste recycling practice in Rafah is very limited due to the limited financial resources, lack of experience. However, the composting of organic fraction presented a potential recycling option.
3. There is no special budget line for the environmental awareness unit in the municipal budget and the activities of this unit are mainly covered from the donors via different programs and projects for solid waste, water and wastewater.

4. Two of the three health hazards, namely insects and rodents infestations mainly in container system are attributed to weak solid waste collection system.
5. Noxious odors from containers in container system, especially during summer, container-burning smoke and decomposing organic fraction presented a considerable environmental and health impact.

Conclusion and Recommendations

Conclusion

Municipal solid waste management in the municipality of Rafah can be significantly improved by developing new strategy for this service. The interventions among this strategy should aim to increase the strengths and in the same time reduce weaknesses among different municipal solid waste management system aspects. The following points summarizing the important issues in this regards:

1. The newly "introduced House-to-House" collection system in some residential neighborhoods in the city is a significant strength and it need to replace the container collection system in the remaining neighborhoods.
2. The municipality collect about 88.5% of the total generated waste from the residential and commercial areas, and there is part of population is not covered by this service.
3. Some recycling activities are running in very limited scale like plastic collection by the private sector for reuse it in some low quality products. There is no separate collection and disposal for the hazardous waste, they are mixed with other municipal solid waste and they are disposed together on the landfill.
4. The environmental health awareness unit activities running on irregular base because there is no separate budget line for it.

Recommendations

Based on the results of this research the recommendations are:

1. The City of Rafah is in urgent needs to prepare a comprehensive strategic plan.
2. Separate arrangements/ systems should be developed to handle special wastes (mainly medical hazardous waste) and ensure they are disposed off in full collaboration with the Palestinian Ministry of Health.
3. Its recommended to extend the new introduce House to House collection system due to it's environmental and financial advantages.
4. Strength regional planning and cooperation with neighboring municipalities is a new factor to successful environmental planning.

References

Abul Kumboz, A. (2003) Assessment of Hazardous Waste Management at Selected Sites in Gaza Strip, Master Thesis, University of Al-Quds. PNA.

Afifi, S. (2001) Palestinian Municipal Management Project phase I, Rafah Municipality, Palestinial National Authority.

Coad, A. (1997) Situation Analysis of Solid Waste Management in Palestine, EPD/MOPIC, Gaza, Palestinial National Authority.

Gaza Environmental Profile (1995) Interactions between Man and Environment – Part 2, Euroconsult- Arnhem, IWACO – Rotterdam, MOPIC- PNA.

El-Hawi, M. and Hamilton, A (2001) Public Participation in Solid Waste Management in The Gaza Strip Paper, Salford University, UK.

Kelly & Dioxin, H. (1995) Environmental Scarcity and Violent Conflict, The Case of Gaza, American Association for the Advancement of Science and The University of Toronto, Canada.

MEnA, (2000) Environmental Management, Gaza, Palestinian National Authority.

MOH, (2000) The status of Health in Palestine, Palestine 2001, Annual Report, Ministry of Health, Palestinian National Authority.

PCBC, (1997) Population, Housing and Establishment Census- 1997, Final result, Housing Report, Rafah Governorate, Palestinian Central Bureau of Statistic, Palestinian National Authority.

Scheinberg, A. (2001) Financial & Economic Issues in Integrated Sustainable Waste Management. Netherlands.

Vrins, W. (1993) Rafah Solid Waste Disposal Project, Agrovision, Holland.

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تقيم الأداء الفنى و البيئى لإدارة النفايات الصلبة لبلدية رفح بقطاع غزة فلسطين

سمير عبد الفتاح عفيفى

قسم البيئة وعلوم الأرض – كلية العلوم – الجامعة الإسلامية – غزة – فلسطين .

يعانى نظام جمع النفايات الصلبة الحالى باستخدام الحاويات فى بلدية رفح من الكثير من المشاكل الفنية والبيئية . تقوم البلدية بجمع حوالى ٨٨٫٥٪ من إجمالى النفايات المتولدة فى المناطق السكنية والتجارية ولا تغطى الخدمات حوالى ٤٪ من إجمالى عدد السكان فى المدينة ولا يوجد إمكانية لفصل النفايات الخطرة من النفايات المنزلية هذا بالإضافة إلى محدودية إعادة التدوير لبعض المكونات . لا يتم تنفيذ برامج التوعية فى مجال صحة البيئة بصورة منتظمة حيث تعتمد على تمويل الدول المانحة .

من خلال هذا البحث تم تحليل المراحل المختلفة لإدارة النفايات الصلبة لمدينة رفح بغرض تحديد نقاط القوة والضعف للنظام وإعطاء توصيات يمكن أن تنعكس ايجابيا على الجوانب الصحية والبيئية و الاقتصادية وكذلك مستوى الخدمة المقدمة . تساهم الدراسة فى تقديم معلومات علمية لتقليل المخاطر للنظام الحالى .