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Potential of Solid Waste Composting in the Gaza Strip-Palestine

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

The land in the Gaza strip is limited and there is no more space for solid waste dumping. The current situation with regard to handling of waste in the Gaza Strip poses serious threats to the environment and public health. The paper discussed the potential of solid waste composting in the Gaza Strip. More than 60% of Gaza solid waste is organic as 360,000 tons of domestic organic waste is generated yearly in addition to 440,000 tons of organic agriculture waste. Composting municipal and agriculture waste in the Gaza Strip is expected around 800,000 tons/year while the local market demand is only 160,000 tons/year (20%). To avail a higher quantum it would be required to also look at the potential of compost markets in the West Bank and Egypt. By mixing the compost with manure, the organic matter content can be increased further and the compost can be enriched with nitrogen and phosphorus. The marketing potential may be enhanced by the mixing because farmers then only have to use one soil improver for both organic matter and nutrients.

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1. INTRODUCTION

Waste management services in Gaza are under great stress, as most other public services, due to the political and economic restrictions imposed on Gaza [1]. Primary collection of waste is done through the use of containers located along the streets, most of which have been manufactured locally in Gaza [2]. If there is a delay in collection, the people tend to burn the waste in the containers to provide more space [3,4]. One of the related problems is that most of the vehicles and equipment used for primary and secondary collection have become old and rickety which leads to high maintenance cost, and reliance on donkey carts for primary waste collection [4,5].

Due to the limited access to the three overloaded central dump sites a substantial part of the waste is dumped temporally at transfer sites throughout Gaza without control or protection [6].

The current situation with regard to handling of waste in the Gaza Strip poses serious threats to the environment and public health. One major threat relates to mixing of hazardous and untreated health care waste with the main stream domestic solid waste [7]. Both waste collectors as well as the general public are directly exposed to these threats, specifically near public containers along the streets where the waste is mixed and near dump sites [8]. A particular vulnerable group is the waste pickers (often children), who collect valuables from either waste containers along the streets, from open transfer sites in the cities, or from the three central dump sites [9].

Another risk in terms of public health is attributed to the habit of burning waste in containers whenever they are overloaded, causing smoke emission and smell nuisance [8]. Farther, the open dump sites and scattered of waste around the containers contain high fractions of organic matter. This attracts harmful insects and causes related contagious impacts [10].

Environmental risks are directly connected to the large and smaller waste dumps in Gaza, which do not have particular environmental protection facilities [11]. Leachate directly infiltrates into the subsurface, causing pollution of soil and threats for groundwater pollution. Sometimes leachate is concentrated around the dumpsites, causing direct human exposure risks [12]. Taking the already harrowing groundwater situation in Gaza into account, these additional groundwater threats are particularly poignant.

Organic waste constitutes the major part of solid waste and composting such quantities could minimize the problem of limited area of landfilling. In the same time, farmers in Gaza import huge amounts of compost material to improve the soil conditions [13]. The research aims to study the potential of composting the solid waste in Gaza which could minimize environmental health hazards problems and could be considered as a model for poor densely populated areas.

2. MATERIALS AND METHODS

To study the potential of composting solid waste in Gaza, the author collected data on quantities and qualities of solid waste and agriculture land in the Gaza Strip. Further data on quality of compost imported and produced locally in Gaza Strip is collected. Based on the available data, the researcher studied quantities of local market needs and potential of producing compost locally.

2.1 Population

The Gaza Strip consists of five governorates, including a total of 33 villages and municipalities with a total surface area of 365 km^2 [14]. Table 1 presents the population of the Gaza Strip based on location type.

2.2 Solid Waste Composition

A study conducted by United Nations Development Program (UNDP) in 2012 covered the main three dumping sites in Gaza strip (North, Middle and South) to have a comprehensive view of the solid waste composition in the area. Three waste sampling teams were selected and trained to perform the sorting and analysis based on the standard definition; the sampling was performed according to the international ASTM D 5231-92 sampling methodology [16]. This methodology prescribes that the desired precision of the results depends on the number and volumes of the individual waste samples. Table 2 shows the waste components used in this sampling.

Table 1. Gaza strip population in 2007

Governorate	Number of households	Population 2007			
		Urban	Rural	Camps	Total
North Gaza	40,262	225,502	2,811	41,933	270,246
Gaza City	76,809	448,221	12,542	34,648	496,411
Middle Area	32,082	129,050	1,873	74,612	205,535
Khan younis	43,203	218,061	15,213	37,705	270,979
Rafah	26,864	132,506	6,308	34,558	173,372
Total	219,220	1,154,340	38,747	223,456	1,416,543

Source: [15]

Table 2. Waste categorization

Waste component	Description
Paper	Newspaper, office paper, computer paper, magazine, glossy paper and corrugates
Plastic	All types of plastic
Yard Waste (non wood)	All organic waste coming from yards except wood
Organic Food Waste	All organic food waste, excepts bones
Wood	Wood waste
Textile	Textile waste
Diapers	Baby diapers
Other Organic Waste	Yard waste, agriculture waste, wood, textile, rubber, leather and other organic burnable waste
Ferrous	Iron, steel, tin, cans, and bi-metal materials
Aluminum	Pieces cans and foils
Glass	All types of glass
Sand/Fine Material	Inorganic materials with grain size less than 1 cm
Other Inorganic	Rocks, ceramics, plaster, bones, etc.

Source: [16]

Total 116 samples were composed from 40 various locations cover all over Gaza strip; North, Middle and south. Waste loads of at least 450 kg were offloaded along stretch on the sampling area. Next the waste was mixed, coned and separated in four equal parts. One quarter of around 100 kg was next selected for further analysis. Next, the waste was segregated manually and the different waste components were put in plastic bags which were weighed and recorded.

2.3 Compost Process

It is estimated that less than 1% of the total solid waste flow is actually being composted in Gaza and the major amount is imported from Israel [17]. In Gaza, they use windrows active pile systems for composting. The piles are allocated as shown in Fig. 1 Size, shape and spacing of piles are determined based on waste composition, aeration equipment and size of the site. For turning the windrows, they use shovels, rakes, or with equipment such as a bulldozer and tractor. Currently in Gaza they use Static pile systems beside active pile system.

Compost samples from both imported and locally produced were analyzed by Palestinian Environmental Friends Association for many parameters mainly organic matter, nitrogen content, pathogens, pH and impurities.

3. RESULTS

Solid waste in the Gaza Strip is normally composed of paper, plastic, organic waste, metals, among others. Table 3 shows the composition of solid waste in the Gaza Strip based on analyses conducted by UNDP in 2012 and the Environmental Quality Authority (EQA) & Ministry of Planning (MoP) in 2007 and 2010 respectively.

In the Gaza Strip, organic waste is the most dominant component in solid waste generated accounting for more than 60 percent of total domestic waste.

Within the Gaza Strip, many types of fruits, vegetables and other plants are cultivated. For some vegetables, the farmers use greenhouses, which means that more than one crop can be raised each year. The Ministry of Agriculture (MoA) compiles yearly statistics for the crops and areas under cultivation in each district in the area. Table 4 summarizes data on the agricultural land use for the main crops grown.

Table 3. Solid waste composition in the Gaza Strip (% per weight)

Component	EQA 2007	MoP 2010	UNDP 2012
Paper	8.0	10.0	8.4
Plastic	8.0	12.0	16.1
Organic Waste	40.0	65.0	65.4
Metals	3.0	5.0	2.8
Glass	6.0	3.0	2.3
Other Inorganic	5.0	5.0	5.0
Total	100	100	100

Sources [7,9,13]

A cursory look at Table 4 reveals that field crops (cereals) are occupied a large area of land with nearly 53,000 dunums under cultivation. Other major crops are citrus fruits (approx. 32,000 dunums), vegetables (approx. 31,000 dunums), olives (approx. 27,000 dunums) and greenhouses vegetables (approx. 15,000 dunums). Less than 5,000 dunums are used for cultivation of each of the other crops grown within the Gaza Strip.

In the Gaza Strip, compost is used for agriculture. Some of this compost is produced locally, while majority is imported from outside the Gaza Strip. Table 5 presents the quality of three imported and two locally produced compost samples.

4. DISCUSSION

4.1 Compost Quality and Quantities

The compost produced locally has a low organic matter and nutrient content compared with imported compost. Table 6 presents recommended compost quality according to Ohio State University. Comparing locally produced compost with quality mentioned in Table 6 shows that Gaza compost has TKN less than 1% while the recommended values are 1-2%. In terms of pH and electrical conductivity, Gaza compost is within the recommended values.

The organic matter and moisture content in Gaza compost is low. This is due to high percent of inorganic substances in solid waste. Biologically, the compost is free of pathogens which make it safe for use as Gaza farmers have direct contact with compost. The Ministry of Agriculture has indicated that farmers will accept compost as soil improver and will accept the idea that compost application is better than using artificial fertilizers. This will also require an increase of the quality of the compost in terms of organic matter and nutrients. This can partly be done by carefully selecting the base material for the compost, increasing the organic matter content.

The total population in Gaza is approximately 1.7 million people who generate domestic waste amounting to 600,000 tons per year. With an organic waste percentage of approximately 60 % this corresponds to 360,000 tons of organic waste in the domestic waste. By 2040, the population is estimated to grow to 3.2 millions [15], which will result in 1.3 million tons of waste and thus approximately 800,000 tons of organic waste.

Furthermore based on the Ministry of Agriculture figures, an additional 440,000 tons of organic agricultural waste is generated in Gaza each year. The major part of the waste (Appr. 90%) is burned at the farms (and partly transported to landfills without being registered [18]. Approximately 10% is collected by the Ministry and used as fuel or as fodder for animals. Only a small amount (Appr. 2%) is currently being composted in the pilot composting plants [18,21].

The quantities of organic waste from both municipal and agriculture waste in Gaza will be 800,000 tons by 2015 and will increase up to 1,240,000 tons by 2040. Composting all quantities will produce around 480,000 tons by 2015 and will reach up to 744,000 tons by 2040.

4.2 Compost Market Potential

The potential market for compost application in Gaza is relatively small due to the high population density resulting in a high waste generation and therefore high potential compost production per surface area. About 29 % of the Gaza surface area consists of arable land (crops replanted after each harvest) and another 21 % is cultivated for permanent crops [22,23]. With a total surface area of Gaza of approximately 36,000 ha [24], this results in a total surface area for the potential compost market of 18,000 ha.

Table 4. Agricultural land areas in the gaza strip in Dunums (10 dunums = 1 hectare)

Crop type	North area	Gaza	Middle area	Khan younis	Rafah	Total
Citrus	11847	11950	5917	955	1400	32070
Olive	1022	9500	5400	7920	3050	26892
Date Palm	0	150	1650	645	190	2635
Almonds	37	150	1000	1665	1650	4502
Guava	330	0	500	3170	500	4500
Grapes	400	2600	934	4	20	3958
Other fruits	621	600	88	158	360	1827
Vegetables in green houses	1029	531	3338	3491	6584	14973
Vegetables	4498	5895	6769	5302	8351.5	30815.5
Strawberries	1611	0	0	24	31	1666
Field Crops (cereals)	4605	4010	5530	28970	9850	52965
Total	26000	35386	31126	52304	31987	**176803**

Source: [18]

Table 5. Quality of compost used in Gaza (% per weight)

Parameter	Imported				Locally produced		
	S1	S2	S3	Average	S1	S2	Average
TNK %	1.5	0.76	1.5	1.25	0.9	0.69	0.8
Total organic matter %	48.2	15	47.6	36.9	16	33	24.5
pH	7.8	6.9	7.5	7.4	7.1	6.6	6.85
Electrical conductivity dS/m	0.36	0.3	.4	0.35	0.21	.28	0.24
Moisture %	32	23	42	32.3	20	17	18.5

Source: [19]

The Ministry of Agriculture has indicated that the total surface area, which is actually used as agricultural land is approximately 16,000 ha. On average, about 10 tons of compost can be used on each ha of agricultural land per year. This results in a potential maximum compost application of 160,000 tons of compost per year. This amount constitutes around 20% of potential compost production by 2015 and less than 13% of potential production in 2040.

In general the best market conditions are in the spring or autumn. Currently approximately 5,000 tons of compost is produced in Gaza [18]. The compost is sold to some international financiers, who further distribute the waste to farmers. The compost is often given to the farmers for free. Attempts to have farmers directly pay for the compost have failed so far, due to questions about the compost quality and the poor economic circumstances under which the farmers operate.

In Gaza, the compost is sold for 10NIS/20 kg bag (about 3 USD/20 kg bag) which corresponds to 500 NIS/ton, while in the West Bank, about 50 USD/ton is being paid [20,25]. At this moment it is difficult to get people to pay for the compost partly as a result of the poor economic situation. However, compost in bags is imported from Israel with a current price of 250 USD/ton. The costs for compost production in Gaza are calculated on approximately 68 USD/ton of compost [19]. It should therefore be possible to create a sustainable compost market if good quality compost can be produced in Gaza and if the farmers can be convinced of the quality of the compost produced. An overview of this comparison between costs and profits is given in Table 7.

Table 6. Typical ranges of test parameters in quality compost

Test parameter	Range
pH	6.8-7.3
Soluble Salts	0.35-0.64 dS/m
Nitrogen	1.0-2.0%
Phosphorus	0.6-0.9%
Potassium	0.2-0.5%
Moisture Content	45-50%
Organic Matter	35-45%
Particle Size	passes 3/8" screen
Bulk Density	900-1,000 lbs/yd^3

Source: [20]

Fig. 1. Compost process

Table 7. Costs of compost production compared with the price currently paid for compost

Compost Prices	TNK content %	USD/ton compost	Cost//ton TNK (USD)
Price paid in Gaza for locally produced compost	0.8	150	18,750
Price paid for Israeli produced compost	1.5	250	16,666

Due to its low TKN, the locally produced compost will cost 18,750 USD per ton TNK while imported will cost less (16,666 USD/ton TNK). This makes imported compost more attractive to the farmers.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

- Composting municipal and agriculture waste in the Gaza Strip will produce around 800,000 ton/year and the agriculture demand is only 160,000 ton/year (20%).
- The main barriers to market development for organic “waste”-derived compost in Gaza are the deficit of high quality compost and limited information on compost usage and its benefits

5.2 Recommendations

- Separation at source of the organic waste is essential for development of the good compost market
- To be able to make a higher percentage possible, it would be required to also look at the potential of compost markets in the West Bank and Egypt in the future.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Morris-Iveson G. Disaster waste recovery - gaza analysis mission. Mission report. The Gaza Strip, Palestine; 2009. Available:http://www.ochaopt.org/documents/ocha_opt_wash_cluster_assessment_waste_management_dwr_0904-20090603-124235.pdf
2. El-Hawi M, Hamilton A, Tarshawi A. Recycling of municipal solid waste in the gaza strip. Proceeding 28th WEDC Conference Kolkata (Calcutta), India; 2002.
3. United Nations Relief and Works Agency (UNRWA). Assessment of solid waste in the gaza strip. UNRWA Gaza Field Office, Gaza City, the Gaza Strip, Palestine; 2000.
4. United Nations Environment Programme (UNEP), desk study on the environment in the occupied Palestinian Territory. UNEP Office, Palestine; 2003.
5. Abdelqader A. Landfills needs assessment in the gaza strip and site selection using GIS. M.Sc thesis, IUG Library. The Islamic University of Gaza. The Gaza Strip, Palestine; 2011.
6. Coastal Municipal Water Utility CMWU. Sheikh ejleen wastewater treatment plant rehabilitation report. CMWU Library, Gaza City, the Gaza Strip, Palestine; 2010.
7. Ministry of Planning MoP, Sectoral planning for solid waste. Gaza Strip: MoP library, the Gaza Strip, Palestine; 2010.

8. Nassar A, Jaber A. Assessment of solid waste dumpsites in gaza strip. EQA Library, the Gaza Strip, Palestine; 2007.
9. United Nations Development Program (UNDO). Feasibility study and detail design of solid waste management in the Gaza Strip. UNDP library, UNDP Office, the Gaza Strip, Palestine; 2012.
10. Applied Research Institute-Jerusalem ARIJ. Status of the environment in the occupied Palestinian Territory. ARIJ Library, the West Bank, Palestine; 2007.
11. Barod N. Solid Waste Management in Northern Governorate. Aqsa University Journal. 2009;13:59-93.
12. Ministry of Planning (MoP). National Strategy for solid waste management in the Palestinian Territory 2010-2014. MoP library, Ramallah, Palestine; 2010.
13. Environmental Quality authority (EQA). Overview of solid waste management in the Gaza Strip. EQA library, Gaza City, the Gaza Strip; 2007.
14. Nassar A, Hamdan SM. Socio economic aspects of rooftop rainwater harvesting in the gaza strip. International Journal of Emerging Technology and Advanced Engineering. 2013;3(10):316–324.
15. Palestinian Central Bureau of Statistics PCBS. PCBS Annual reports. Current and future demography in Gaza Strip, The Gaza Strip, Palestine; 2013.
16. ASTM D5231-92, Standard test method for determination of the composition of unprocessed municipal solid waste, ASTM International, West Conshohocken, PA; 1992/2003. Available: www.astm.org
17. Nassar A, Tubail K, Afifi S. Attitudes of farmers toward sludge use in the Gaza Strip. Int. J. Environmental Technology and Management. 2009;10(1):89–101.
18. Ministry of Agriculture. Annual Report. MoA library, Gaza, the Gaza Strip, Palestine; 2013.
19. Palestinian environment friends association (PEF). Compost quality in the gaza strip. PEF library, Rafa City, the Gaza Strip, Palestine; 2011.
20. Maurice E. Watson. Ohio State University fact sheet -agriculture and natural resources. 2120 Fyffe Road, Columbus, Ohio 43210-1084. Available:http://ohioline.osu.edu/anr-fact/0015.html
21. Mahamid I, Thawaba S. Multi Criteria and Landfill Site Selection Using GIS: A Case Study from Palestine. The Open Environmental Engineering Journal. 2010;3(1):33-41. DOI: 10.2174/1874829501003010033
22. D'Haeyer T. Net Irrigation Requirement for the Major Field Crops in the Gaza Strip. M.Sc Thesis. Katholieke University Leuven, Belgium; 2000.
23. Palestinian Water Authority PWA. Irrigation water demand for cultivated area in the Gaza Strip. Gaza. PWA library, the Gaza Strip, Palestine; 2013.
24. Khalaf A; H Al-Najar; J Hamad. Assessment of rainwater runoff due to the proposed regional plan for Gaza Governorates. J. Applied Sci. 2006;6(13): 2693-2704.
25. Hargreaves JC, Adl MS, Warman PR. A Review of the Use of Composted Municipal Solid Waste in Agriculture. Agriculture, Ecosystems and Environment. 2008;123:1–14.

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