Pakistan J. Sci. Ind. Res., Vo. 28, No. 3, June 1985

ENVIRONMENTAL PROBLEMS OF PAKISTAN
Part I Composition of Solid Wastes of Karachi

M. Arshad Ali Beg, S. Naeem Mahmood, and Sitwat Naeem

PCSIR Laboratories, Karachi-39

(Received February 20, 1985)

The quality of the Karachi city garbage has been evaluated in terms of its ingredients and chemical analysis by collecting samples from twenty refuse dumps located in various areas of Karachi. The data so collected classifies the refuse into three types, viz. from opulent localities, middle class areas and slums.

The garbage samples have been examined with regard to their utilization as a composting material. The carbon: nitrogen ratio, which determines compostibility, ranges between 8 and 44 and on an average it is about 16 which is below the optimum value of 30. These values have been taken to suggest that the average city garbage may be supplemented with wastes containing higher amounts of organic matter, viz. vegetable market dumpings, slaughterhouse wastes, food processing wastes etc. for composting. Sludge from the city has also been analysed and the same is recommended for being utilized to raise the C:N ratio.

INTRODUCTION

Solid wastes constitute an important facet of the environment aesthetics but seem to be unmanageable in Pakistan. Their indiscriminate dumping, accumulation and failure of removal system for two or three weeks is a common feature of the city life and the consequent problems of odour, unsightly scenes, flies, mosquitoes, rodents and similar undesirables are quite painful. In order to dispose them of the wastes are burnt, which is quite a usual sight, but this gives rise to air pollution. However, they cannot be left alone because they create health hazard. It is known that flies breed in the refuse and garbage dumps and even cans [1] and the rodents and rats abound mostly near such dumping sites.

Storage, collection, treatment and disposal of city garbage are different aspects of a waste management programme which civic bodies have to integrate into their total environment planning. Thickly populated cities, the world over produce unmanageable amounts of solid wastes and Karachi is no exception. The waste is generated at a rate of 1.0 to 2.5 kg per caput per diem and it has to be efficiently disposed of.

It is generally realised by civic bodies of the country that treatment and disposal of solid wastes generated in large quantities require a sound management programme. The important factors to be determined for implementing such a project are volume, composition and economics. So far there is no information available on any of the three factors. Collection of the wastes is effected as one of the municipal responsibilities in Karachi, but due to the small fleet of collection vans, refuse removal is not effected within the desirable time frame. The composition of garbage has not been reported for this city except for a brief report prepared by the authors in 1981 and another in 1983 [2]. The data generated for these reports form the subject matter of this paper.

The economics of the disposal system has not so far received active consideration in Pakistan but for a feasibility report prepared for Karachi in 1981 [3]. As mentioned earlier, the disposal has been undertaken more as a municipal activity than an economic proposition and therefore the metropolitan corporation has been maintaining a small fleet of vans for collection. Indiscriminate dumping on waste lands or dry river beds followed by burning has so far been the only mode of its disposal in Karachi. An attempt has been made here to examine the compostability of the city refuse to help establish disposal as an economic proposition.

The present population of Karachi is over six million and it generates more than 5,500 tons of garbage daily or approximately 1 kg/capita/day. This does not include industrial wastes. It is estimated that by the year 2000 A.D. the population of the city would be over 12 million and about 17,000 tons of solid wastes will be generated per day. It is also estimated that only one-third of the total solid waste produced in the city is being removed, and the uncollected garbage lies in unofficial dumping areas in the city creating environmental problems. Very little information is available on the quality of solid wastes, although it is needed for a sound environmental planning. Karachi Laboratories have carried out a fair amount of data collection to quantify the quality of the deteriorating environment of Karachi and the present paper is intended to provide some data on solid wastes.

METHODOLOGY

Samples of 50 to 100 kg size were collected between 10 and 1 p.m. in a mini truck with the help of appropriate tools and implements. Sampling was performed from 20 refuse dumps of different localities of the city, covering a major portion of residential areas. The description of sampling points and their locations is as follows:

Sampling point	Location
1.	Near KMC Treatment Plant, Mahmoodabad
2.	Block B, Sindhi Muslim Society
3.	Opp. Society Complaints Centre, Shahrah-e-Qaideen.
4.	Market, Dhorajee Colony
5.	Near Market, Delhi Saudagran Society
6.	Near Dhorajee Chowrangi
7.	Tariq Road, PECHS
8.	Brazil Primary School, PECHS
9.	Mohammad Ali Society
10.	Kokan Society, Off Shaheed-e-Millat Road
11.	Amber Cinema, Bahadarabad Chowrangi
12.	Khudadad Colony
13.	Lal Market, New Karachi
14.	Child Care Centre, Pir Colony
15.	Shomaila Apartments, Gulshan-e-Iqbal
16.	Aliabad, F.B. Area
17.	Nursrat Bhutto Colony, North Nazimabad
18.	Market, Liaquatabad
19.	New Chali
20.	Kharadar

Care was taken to ensure that the samples were well mixed and representative of the spot. They were then immediately brought to the laboratories for their physical and chemical analysis.

Moisture content was determined as soon as the samples reached the Laboratories. About 500 g. of each sample were weighed and heated in an oven at 100° for 24 hr. The moisture content was then calculated as the percentage of total weight.

Physical analysis was carried out on wet weight basis. Various ingredients viz. paper, plastics, rubber, leather and non-ferrous materials were hand-picked while stones, gravel, glass and ceramic pieces were separated by judicious sieving, and small ferrous metals pieces were removed by a magnet. The weights of the individual components were then expressed in percentgage terms with regard to the original sample.

For chemical analysis, the total sample used for physical analysis was reduced, by using the method of quartering to about 10 kg. The reduced samples were spread in stainless steel trays, placed in an industrial oven at 75 ± 5° for 12 hr. The samples were turned over several times to ensure complete drying. They were then removed, allowed to cool and ground in a ball-mill until converted to a homogeneous powder, which was passed through a sieve having a mesh size 0.45 mm and the fractions passing through were taken for chemical analysis.

pH of the samples was obtained by pH meter after making their pastes as is done in case of soils. Losses at 600°C (total volatile matter) and at 1000°C (ash) were obtained by usual methods of igniting the dried samples in a muffle furnace. Organic matter was determined by the dichromate method, while nitrogen was estimated by Kjeldahl's method. Carbonate was determined by reacting with standard hydrochloric acid. Organic carbon was calculated from the organic matter of the samples using a factor of 1/1.724 [4]

RESULTS AND DISCUSSION

Composition. Table 1 lists the composition of the refuse in the form of fines, stone, blocks, earthenware, marble pieces, paper and cardboard, textile pieces and ropes, bones, poultry wastes, metals, glass, plastics, leather and rubber, fruit-peels and vegetables, wood shavings, straws, leaves etc.

The data listed show that there is a great variability in the nature and quantity of the Karachi refuse varying according to its location. The localities from where these samples were collected can be categorised into three types, A, B. and C. Type A includes the prosperous localities, e.g. Sindhi Muslim Society, Dhoraji Colony, Delhi Saudagran Society, PECHS, Muhammad Ali Society and Kokan Society. Type B represents residences belonging to middle class families, viz. Pir Colony, Federal 'B' Area, Gulshan-e-Iqbal,

Table 1. Composition of Karachi city refuse (% by weight)

Sample No.	Moisture	Fines	Stones, blocks, earthen-ware	Paper and card-board	Textile pieces, ropes, and clothes	Bones, poultry wastes etc.	Metals, tins etc.	Glass pcs	Plastics, rubber and leather	Vegetables, peels of fruits, etc.	Wood, baskets grass, leaves etc.
1.	46.32	12.46	8.42	6.35	8.0	1.25	0.34	0.5	2.96	2.51	10.77
2.	29.8	18.78	2.89	6.09	5.59	1.09	0.136	0.04	2.99	2.09	30.72
3.	45.02	1.96	0.87	7.15	10.21	0.41	0.15	0.07	3.3	2.74	28.00
4.	58.21	7.15	3.27	2.62	2.72	0.65	Nil	Nil	0.65	1.05	23.63
5.	70.5	0.14	4.27	2.82	2.84	0.71	0.04	0.12	1.04	3.78	13.71
6.	22.09	38.83	16.35	2.23	3.88	0.71	0.08	0.26	0.98	4.55	9.94
7.	39.91	13.08	18.29	2.02	6.39	0.14	0.07	0.33	1.37	3.59	14.69
8..	35.95	15.17	3.97	3.42	7.94	0.46	0.23	Nil	1.55	6.23	25.08
9.	79.34	7.36	2.74	1.55	1.08	0.47	0.07	Nil	0.27	4.66	2.41
10.	54.62	8.2	5.09	2.09	4.91	0.54	0.09	0.4	1.4	8.38	14.2
11.	42.73	18.43	2.82	4.19	13.94	0.09	0.53	0.48	0.39	2.04	14.24
12.	16.29	23.1	7.55	4.17	14.99	0.67	0.18	0.12	8.71	16.59	7.54
13.	23.77	28.24	14.08	4.68	14.38	0.93	0.2	0.2	1.87	0.93	10.72
14.	46.14	24.01	6.2	3.78	8.93	0.31	0.37	0.37	4.4	0.86	4.55
15.	62.88	14.29	2.01	2.25	3.45	0.56	0.22	0.86	1.72	4.58	7.08
16.	24.79	32.87	18.18	0.55	4.33	2.09	0.23	0.25	0.193	0.14	16.22
17.	30.41	44.31	5.2	1.13	9.43	0.69	0.3	0.2	0.96	0.2	7.21
18.	49.48	17.76	7.59	5.63	7.48	0.44	0.81	Nil	2.89	0.72	7.15
19.	42.9	18.21	5.31	6.5	8.53	0.2	0.56	1.78	2.8	2.76	10.36
20.	49.1	20.85	8.1	3.96	2.94	0.59	0.27	0.46	1.69	3.28	8.71

Bahadurabad, Tariq Road etc., while category C represents houses owned by lower class families or slum dwellers, viz. New Karachi, Nusrat Bhutto Colony, Liaquatabad Market, New Chali, Kharadar etc. Samples No. 2, 4, 5, 8, 9 and 10 were collected from type A localities, samples No. 3, 7, 11, 14, 15, and 16 from type B localities and samples No. 1, 6, 12, 13, 17, 18, 19 and 20 from type C localities. The composition of waste from type A locality is different from that of type B and C localities and is in line with the general observation that domestic wastes increase with prosperity. Fines and stone pieces, textile and rope pieces are lower while moisture, peels of fruits and vegetables are in higher proportion in the garbage from prosperous localities as compared with middle-class and slum areas.

The differences are also to be noted among residential and commercial areas. Table 1 lists samples collected from residential areas, viz. samples No. 1, 2, 3, 5, 6, 8, 10, 12, 14, 15, 16, 17, and 20 and commercial areas and market places viz. samples No. 4, 7, 9, 11, 13, 18 and 19. These samples fairly represent the different areas since collections from residential areas, hotels, restaurants etc. suggest their being domestic in nature, whereas those from commercial areas have been found to consist of refuse such as paper, cardboard and packing material. Wastes from market places are, on the other hand, largely due to vegetables, straws, leaves etc. It may be observed that there is not much variation as regards the quantity of paper and cardboard. Furthermore, these materials as also tins, metals, glasses and bones are quite low in the collected samples. The main reason for the low values is perhaps, the practice of manual collection of the above mentioned constitutents by scavengers who earn their living by selling them to small industries or their agents.

The main constituents of the collected garbage samples are moisture, 16 to 79%; dust, 1 to 24%: leaves and straws, 2 to 30%; textiles, 1 to 14%; stones, 0.5 to 17%; and peels of fruits, 0.2 to 16%. The overall average composition of the Karachi city garbage, listed in Table 3 is: paper, 3.6%; glass, 2.5%; metals, 0.2%; rags, 7.1%; plastics, 2.1%; fines, 18.2%; moisture, 43.5%; and compostable matter, 52.0%.

These average values suggest that the garbage is a typical city refuse, comparable with those of the cities of developing countries, as would be apparent from Table 3 which lists the refuse composition of the various large cities. It is also quite significant from Table 3 (10, 12) that the refuse of developed countries is different from that of under developed or developing countries. For example, the quantity of plastics, glass, waste paper, cardboard, metals and tins is quite low, while the compostable matter and fine sized material is quite high in Indonesia, Pakistan and India as compared with USA., and UK. As the corresponding quantities of paper, plastics, glass, metals, rays etc. increase, the proportion of compostable matter decreases. The content of paper amounts to half the refuse, while compostable matter is less than 20% in United States.

Suitability for Composting. Composting is the aerobic biochemical degradation of the organic fraction of refuse under controlled conditions, converting the garbage into an end-product which is useful as an agricultural humus or fertilizer. Composts can be used with artificial fertilizers for agricultural purposes to increase soil fertility and reduce soil erosion by water, wind etc. Being a microbial process, it depends mainly upon the presence of certain microbes and nutrients in the refuse, hence the composition of the matter being composted plays a vital role in the process of composting.

The main factor affecting composting is moisture content which should be about 50 to 60% [6]. If the material is too dry, nitrogen losses may occur and the process of composting is slowed down giving an inferior product. However, if it has more than 60% moisture [5], anaerobic conditions are created and thereby retard decomposition resulting in the release of unpleasant odours. As seen from Table 1, the moisture content of the samples analysed ranges between 16.29 and 79.34% but on an average, it is about 43% which seems reasonable for composting.

The organic matter listed in Table 2 varies from 12 to 37% and the organic matter: nitrogen ratio varies from 12:1 to 75:1, which, on an average, amounts to approximately 25:1. In order to attain ideal humification, the organic matter/nitrogen ratio is commonly assumed to be 20:1. Analysis of the samples therefore suggests that the garbage in the form collected,is suitable in attaining good humification and there would be little need to supplement it with organic matter.

C:N ratio is another factor which plays a vital role in the process of composting. An initial C:N ratio of 27 to 30 [6] is best for micro-organisms, it is reduced during composting and a ratio of about 20 is obtained in the end product. In general, composting will not take place if the C:N ratio is more than 80 [6]. Vegetable matter with a high C:N ratio decomposes more rapidly than those with low C:N values under both aerobic and anaerobic conditions [7].

It can well be observed from *Table 2* that the C:N ratio of the garbage samples analysed ranges between 8 and 44 and on an average it is about 16 which is below the optimum value of 30 [6] : the speed of fermentation would therefore

Table 2. Chemical characteristics of refuse samples (% on dry weight basis).

Sample No.	pH	Loss at 600°C (%)	Loss at 1000°C (%)	Ash (%)	Organic matter (%)	Organic Carbon (%)	Carbonate (%)	Nitrogen (%)	C/N ratio	OM/N ratio
1.	7.7	34.05	50.1	49.9	13.71	8.06	3.9	0.63	12.79	21.76
2.	7.9	29.76	48.28	51.72	17.09	10.05	4.3	0.53	18.96	32.24
3.	7.8	46.12	60.32	39.68	20.75	12.20	4.5	0.76	16.05	27.3
4.	7.8	32.84	51.92	48.08	16.67	9.80	4.7	0.71	13.80	23.4
5.	7.7	49.78	66.32	33.68	24.0	14.11	4.6	0.32	44.09	75.0
6.	7.6	30.52	45.51	54.49	17.37	10.21	4.5	0.44	23.2	39.47
7.	7.0	39.26	50.22	49.78	18.75	11.02	4.4	0.90	12.24	20.8
8.	7.8	28.50	38.85	61.15	15.41	9.06	4.8	0.80	11.32	19.25
9.	7.7	23.81	37.31	62.69	17.77	10.45	4.5	1.23	8.49	14.44
10.	7.7	34.99	44.31	55.69	18.22	10.71	4.2	0.91	11.76	20.02
11.	6.6	32.15	46.94	53.06	12.28	7.22	5.1	0.6	12.0	20.46
12.	6.9	20.76	39.08	60.92	14.61	8.59	4.6	0.61	14.08	23.95
13.	6.7	31.59	51.46	48.54	15.84	9.31	4.3	1.28	7.27	12.37
14.	7.1	17.11	34.39	65.61	14.23	8.37	4.5	0.62	13.5	22.95
15.	6.2	36.94	51.63	48.37	37.45	22.02	3.9	1.24	17.75	30.2
16.	7.1	19.83	36.91	63.09	13.69	8.05	4.5	0.47	17.12	29.12
17.	6.1	26.69	43.78	56.22	22.18	13.04	4.9	0.74	17.62	29.97
18.	7.3	16.91	33.22	66.78	14.14	8.31	4.6	0.59	14.08	23.96
19.	7.0	20.08	37.14	62.86	17.26	10.15	5.1	0.57	17.8	30.28
20.	6.6	25.06	40.97	59.03	16.67	9.80	4.8	0.48	20.4	34.72

Table 3. Physical characteristics of city refuse (% by weight)

Place	Bangkok (Thailand)	Jakarta (Indonesia)	Calcutta (India)	Madras (India)	Paris (France)	London (U.K.)	New York (U.S.A.)	Karachi (Pakistan)
Paper	24.6	2.0	3.18	7.85	34	38	50	3.6
Plastics	7.0	2.0	0.65	0.88	4	2.5	3	2.1
Rags	0.6	–	3.6	4.8	4	3	2	7.1
Metals	1.0	2.0	0.66	0.95	8	9	8	0.2
Glass pieces	1.0	2.0	3.8	0.95	8	9	8	2.5
Fines*	8.3	25.0	34.0	28.0	20	11	7	18.2
Compostable matter	44.0	60.0	47.0	48.0	15.0	24.0	18.0	52.0
Moisture	–	–	41.11	36.63	35	25	30	43.5

* includes fine sized material, i.e. dust, ash etc.

be slow. The C:N ratio is quite wide and if used as such it would imply the immobilisation of nitrogen [4]. However, the average ratio is about 16 and this suggests that there would be mineralisation of nitrogen in the soils.

pH value of the material being composted is essential in evaluating the microbial environment [6]. The pH should not be too low since microbial population is restricted and the larger soil organisms die out [9]. It is reported [8] that the initial pH of a three-day old refuse is between 5 and 7; it drops during the first two or three days of composting, then begins to rise and ultimately stabilizes at about 8.5. The pH of the analysed samples is between 6.1 and 7.9, which shows that it is a mixture of fresh and old refuse and is suitable for the growth of microbial population.

Temperature also has a marked effect on the process of composting. High temperature during composting destroys most of the parasitic organisms. The higher the maximum temperature attained, the more is the destruction of parasitic organisms and consequently the better would be the quality of the compost produced [9]. In addition, higher temperatures also destroy and decompose the weeds and seeds of the material being composted. Temperature in the range of 30 – 45^{o}C does not effect the loss of organic matter; however, it increases the organic nitrogen of the compost [9]. The temperature of Karachi during most part of the year ranges between 25 to 35^{o}C which is quite suitable for the process of composting. Wind velocity and humidity of Karachi also provide better environmental conditions for composting, since decomposition takes place under good aeration and adequate moisture supply.

The garbage available from different areas of Karachi Metropolitan Corporation may, by the above observations, not be classified as excellent composting material. However, an average of the city garbage can be used for composting and may produce the desired results, if supplemented with organic matter from vegetable market dumping, animal manure, meat and food processing wastes, crop residues, slaughter house wastes, etc. In addition, sludge from the sewage treatment plant could be utilized. Since the composition of refuse varies from one load to another, the

Table 4. Average chemical characteristics (% on dry weight basis*)

Characteristics		Sludge from treatment plant		Averge garbage from Karachi City
pH	–	7.4	–	7.2
Moisture	–	5.8	–	43.5
Ash	–	52.2	–	54.5
Organic matter	–	45.2	–	17.5
Nitrogen	–	2.4	–	0.7
Phosphate	–	0.5	–	–
Calcium oxide	–	8.3	–	3.6
Carbon	–	22.5	–	10.5
C/N ratio	–	9.1	–	15

* excepting the pH and C/N ratio

moisture and carbon to nitrogen ratio would require some adjustment before composting to 50% and below 30% respectively. Sludge from the city sewage treatment plant having the analysis listed in Table 4 would most efficiently adjust the moisture and nutrient contents. It would increase the manurial value of compost and would provide a sanitary disposal of the sludge itself.

REFERENCES

1. D.G. Wilson, Problems of solid waste pollution in "Industrial Pollution", ed. N.I. Sax, Van Nostrand Reinhold Company, New York, 1974.
2. M.A.A. Beg, S.N. Mahmood and S. Naeem, Karachi City Garbage and its Evaluation, Tech. Rep. Karachi, June 1983.
3. Pakistan Industrial Development Corporation, "Refuse Compost Project, Feasibility Study", Karachi, May 1981.
4. L. M. Thompson, Soils and Soil Fertility, McGraw – Hill Book Company Inc., 1952, pp. 47-135.
5. J. Pickford, Solid Wastes in Hot Climates, in "Water, Wastes and Health in Hot Climates", John Wiley and Sons Ltd., New York, 1977, pp. 322-40.
6. J.L. Pavoni, J.E. Heer, Jr. and D.J. Hagerty, Handbook of Solid Waste Disposal, Van Nostrand Reinhold Company, New York, 1975, pp. 9-16.
7. S.K. Saxena and S.V. Patwardhan, Univ. Roorki Res. J. India, **8**, 63-67, 1965.
8. A.W. Breidenbach, Composting of Municipal Solid Wastes in the United States, U.S. Environ. Prot. Agen. Publ. No. SW-47r, Govt. Printing Office, 1971.
9. E.W. Russel, Soil Conditions and Plant Growth, ELBS London, 1975, pp. 265-72.
10. C. Rogus, Refuse Collection and Disposal in Western Europe: Parts I, II and III, Public Works, **93**, Nos. 4, 5 and 6, 1962.
11. CPHERI Report "Solid Waste in India", Final Rep., 1973.
12. B.N. Lohani and N.C. Thanh, "Special Problem of Solid Waste Management in Asia", Proc. Sem. Solid Waste Management held at Asian Institute of Technology, Bangkok, pp. 3-14, September 1978.