ON SITE MUNICIPAL SOLID WASTE GENERATION OF AMMAN AREA .

By

OMAR RASHID ZEYADEH

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THESIS

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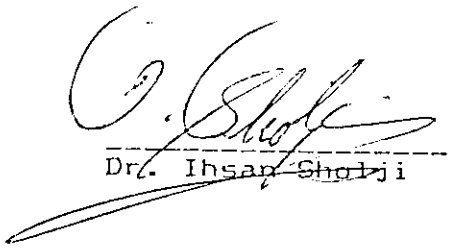

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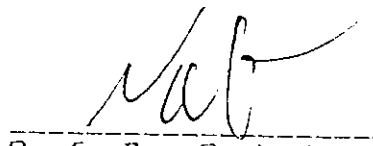

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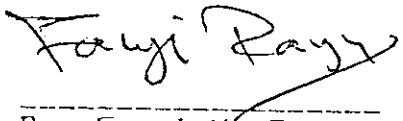

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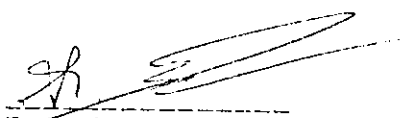

Dr. Kamel Qaisi — Department of Civil Engineering

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LIST OF ABBREVIATIONS

cal = Calorie .

C = Centigrade .

c = Capita .

d = Day .

G.A.M. = Greater Amman Municipality .

G.A.R. = Greater Amman Region .

JD = Jordanian Dinar .

Kg = Kilogram .

Kg/c/d = Kilogram per capita per day .

l = Litre .

l/c/d = Litre per capita per day .

LIST OF TABLES

ABSTRACT

The objective of this study is the determination of information about household refuse generated in Greater Amman Municipality (G.A.M) ; this information is :-

1- Generation rate as , kg/c/d and as , l/c/d .
2- Physical characteristics of household refuse (density , moisture content) .
3- Physical composition of household refuse .

Determination of the quantities , composition and physical characteristics of solid waste with great accuracy is essential to reach the most effective , healthy situation and ecnomical design for collection and disposal of refuse with least cost .

To get a nearly accurate result , twenty five houses were chosen in (G.A.M) and Five Hundred and Forty-eight samples were collected . Out of them 489 were broken down into their components and 59 samples were not broken down into their components so as to determine the effect of unsorting on the density of household refuse .

For household refuse generated in G.A.M it was found that each person produced 0.4 kg/c/d , 3.14 l/c/d , (based onsite sorting of household refuse) and 2.17 l/c/d , (based on unsorted household refuse) with a loose density of 143 kg/m , an overall moisture content of 56.4% , and

a physical composition made up as follows 61.3% food waste , 15.6% paper , 8.3% cardboard , 3.6% plastic , 2.3% leather , 1.1% wood , 3.7% glass , 3.5% tins and cans , and 0.45% garden trimming .

INTRODUCTION

Nowadays the human being enviroment is exposed to many causes of pollution which make it unsuitable for human life , therefore many of government departments in every country try to control the effect of these causes on environmental pollution .

The solid waste considered to be one of the most dangerous causes of pollution , therefore this problem has to be treated in a wise manner to protect our enviroment from any source of pollution . The determination of physical and chemical characteristics , generated quantities , and physical composition of solid waste are considered to be essential for the determination of the optimum solution to this problem .

This research was emphasized on the household refuse generated in G.A.M, and concentrated on the following:-

1- Generation rate of household refuse in G.A.M as kg/c/d , and l/c/d .

2- Physical composition of household refuse generated in G.A.M.

3- Physical characteristics of household refuse generated in G.A.M (density and moisture content) .

4- The effect of monthly income on generation rate , physical composition , and physical characteristics of household refuse generated in G.A.M.

Chapter 1

Literature Review

1.1 Solid waste , general

Solid waste can be defined <14> as any unwanted material that is not discharged to the atmosphere or via pipe , <12> solid wastes are man's unwanted material that cannot flow directly into streams or rise immediately into the air . They are non - liquid , non-gaseous residue of our manufacturing . Solid wastes are all arising from human and animal activities that are normally solid and that are discarded as useless or unwanted .

1.1.1 Main Sources of Solid waste

They are generally divided into the following :

a) Domestic solid wastes :

These wastes are the consequence of house keeping activities such as food preparation , sweeping and vacuum cleaning and they mainly contain food waste , packaging , paper, dust and worn out; broken or worn hold effects and items of clothing , they also may contain a fuel residue , empty containers, waste from repair and redecorating , reading matter , old furniture , etc.

b) Commercial Solid waste

These are mainly the wastes produced by offices and shops and consist of wood crates , paper , packaging , material carbon paper . Food waste may be included in this waste from restaurants and cafeterias, etc. Waste from hotel, schools, barracks, nurses homes and hospitals are (special waste) included in this category .

c) Street - cleaning waste

These waste vary in nature and quantity according to the habits of people and the effectiveness of refuse collection systems . They contain mainly Litter , grit , paper , small containers and food waste , etc.

d) Agricultural and Animal solid wastes :

These are made up of residues , poultry and other animal manures , certain waste arising from slaughter and from the preparation of carcasses and waste products from canning and processing of food .

e) Mining waste

The mining industry produces such large amounts of solid waste that special emphasis should be given to this material . Unplanned spoils heaps impair the land scape , threaten land slides and pollute ground water .

f) Industrial solid waste :

It consists of all factories unsaleable solid waste , i.e packaging materials , plastic , etc. Some industrial solid waste are highly toxic , so special treatment must be performed on it before disposing of it at a tip .

g) Demolition and building solid waste :

These waste consist of all waste arising from builiding demolition and building construction . The quantities produced are difficult to estimate and variable in composition but may include dirt , stones, bricks, lumber, shingles and plumbing,heating and electrical part .

h) Treatment plants semisolid and solid waste :

These waste consist of solid and semisolid wastes which result from water and waste water treatment . The specific characteristics of these materials vary, depending on the nature of the treatment process .

1.1.2 Solid waste characteristics :

The most significant charcteristics of solid waste are :-

1- Density of the solid waste :- Density is usually expressed as kg/m^3.

2- Moisture content :- The moisture content usually is expressed as the weight of moisture per unit weight of wet or dry material . In the wet weight method of measurement , the moisture in a sample is expressed as a percentage of the wet weight of the sample . In this study the moisture content is expressed as a percentage of the wet weight .

3- Chemical composition :- Information on chemical composition of solid waste is important in evaluating alternatives of processing and recovery options (i.e Energy recovery , Composting process , Waste derived fuel , etc.) .

4- Physical composition :- Information on physical composition is also necessary in evaluating alternatives processing and recovery options .

These characteristics vary widely for the major-solid waste components , such as garbage , rubbish , street sweeping, etc. These characteristics are affected by :-

1. Type of collection systems .
2. Standard of living .
3. Seasonal and local variables .
4. Extent and type of commerce and industry .
5. Prevailing climate .
6. Other considerations .

Generally we can say, the refuse of the world is increasing with time both in the amounts produced and calorific values , and is decreasing in density, moisture content and non-combustible content . This expectation is based on what occurs in United States of America (U.S.A) and Europe and because the standard of living and education is becoming higher and higher all the time <19> .

1.1.3 Classification of solid waste :

Typical classification of soild waste is that introduced by Hopkins <12> , he divided the solid waste into the following catogries :-

1- Garbage :- Putrescible (decomposable) waste from food , slaughter houses , canning and processing industries .

2- Rubbish :- Non-putrescible waste either combustible material which includes paper , cardboard , cartons , boxes barrels, wood, tree, branches, wood furniture , or non-combustible material which includes metals tins , and cans etc. In short all solid waste taken from residential or commercial establishments, excluding food waste and ashes .

3- Ashes :- The soild residues of effectively complete combustion of solid fuel heating and cooking or the incineration of solid waste by municipalities, industries and apartment houses .

4- Large waste :- Demolition and construction waste , like bricks , pipes , automobiles , furniture , etc.

5- Dead animals :- Household pets , birds , rodents , zoo animal , cows , horses , mules , hogs , etc.

6- Water and waste water treatment wastes :- Includes soild and semisoild waste which result from treatment of water and waste water .

7- Industrial waste .

8- Mining waste .

9- Agricultural and animal waste :- Includes farm animal manure and crop residue .

1.1.4 Quantities and composition of solid wastes :

Because solid wastes are generated from many different sources they naturlly contain an almost infinite variety of materials , these range in size from specks of dust to discarded automobile. The major constituents of domestic and commercial wastes are Fermentable organic matter , Glass , Wood , Metals and Plastic are often present , the relative proportion depending upon many local factors .

Quantities of solid waste discarded each day vary through the week according to whether it is the weekend , shopping days or holidays. Also it varies with the season depending on the availability of fresh fruit and

vegetables . Solid waste composition and quantities vary over the year with changes in diet , packaging , fuel , literacy , etc. Residents of large towns also seem to throw away more than people in small twons . In short <20> "the general rule is that as one goes from a small poor traditional , illiterate community to a large , rich , modern, literate one , the refuse weight becomes more , the density less (and therefore the volume more) , the food preparation waste becomes less , the paper and packaging fraction increases and the average particle size increases" .

Solid waste characteristics vary greatly with time and space , even the variety within a sample of solid waste is great . The wide variation in values for the domestic solid wastes over the world is demonstrated in table 1.1 <19> .

Table (1.1)

Range of values, excluding industrial waste .

per capita weight, (kg/day)	0.2 - 3
Density, kg/m^3	100 - 500
Putrescible matter, %	5 - 90
Paper , %	0.25 - 55
Plastic, %	0.1 - 7

Where the solid waste production is low the density tends to be high and vice versa , which means the daily per capita volume has a very large range <19> 1-80 l/c/d which affects collection and disposal cost , therefore the collection of local data is essential for effective economical design of collection and disposal systems .

1.2 International and Local studies performed to determine the composition , Quantities and characteristics of solid waste .

Determination of the quantities , composition and different characteristics of solid waste with complete accuracy is essential to reach the most healthy situation with the Least cost . Therefore developing countries try to obtain accurate information about its solid waste to facilitate the planning of an efficient system of collecting and disposing of solid waste with the appropriate cost , because most of the available information is about solid waste generated in industrialized countries such as United States of America (U.S.A) or United Kingdom (U.K) .

1.2.1 Study performed by Qasir in Baghdad-Iraq in 1978 <12>.

The main objectives of this study were :

1. To determine the quantities of household refuse generated in Baghdad city at that time .
2. To determine the physical composition of household refuse generated in Baghdad city .
3. To determine the density , moisture content of household refuse generated in Baghdad city .

Work done in this study :-

1. Three representative houses from each district of Baghdad's ten districts were chosen , thus 30 houses were chosen in Baghdad city .
2. The refuse generated by chosen houses (30 houses) were collected twice a week for the months July , August and September of 1977 .
3. From each house was taken one plastic bucket of volume 0.137 m^3 and three to four polythene sacks . The garbage produced was dumped in the bucket ; paper wrapper , carton boxes , and other paper products were placed in the first polythene sack , in the seconed sack , plastic , leather and rubber products were , collected in the third glass products were collected and in the fourth water melon shells were collected .

4. The total volume , weight of the different components of domestic refuse were determined after collection of household refuse .

5. For each of the Baghdad districts one sample was taken , the weight of sample taken was between 50-200 gm of the fresh refuse to determine moisture content of refuse , that operation being run once per month table 1.2 shows the results of this study .

Table (1.2) : Density , moisture content , and physical composion of household refuse generated in Baghdad city <12> .

Average density, kg/m^3	73.9
Average Generation rate, kg/c/d	0.354
Average moisture content, %	78.7
Physical composition of house hold refuse generated in Baghdad city, percentage by weight.	
Food waste	62.89
Water melon shells	29.85
Paper	4.53
Plastic	0.96
Leather	0.3
Textiles	0.33
Glass	1.59
Tins	1.12

1.2.2 Study performed in Amman City - Jordan

This was performed by WATSON HAWKSELY-ERL, U.K in 1978 in association with MIDDLE EAST ENGINEERING SERVICE <15> .

the senior guard requested information from each house concerning date of the last refuse collection , and the number of persones living there . After the collection of generated refuse , the gross weight , volume and weight of each different component of refuse was determined .

Six such tests and analyses were carried out and the results are summarized in table 1.4 (taken from WATSON <15>) .

It was found that the largest constituent of refuse was the vegetable and putrescible mater 63.5- 77.9% by weight while ,paper and paper products varied from 10.4 - 24% by weight .

3. The Moisture and Calorfic values of particular constituents of Amman city refuse were determined by the Royal Scientific Society (RSS.) at the request of WATSON <15> . Their results are summarized in table 1.5 .

It was found that refuse generated in Amman city had a low calorific value 700 - 1700 cal/gm because the moisture content of refuse was high .

4. Estimation of solid waste generated by Domestic , commercial , Industrial and Demolition waste in Amman city :-

Load - Account Analysis was used to determine the solid waste arising in the Amman Municipality area . The number of individual loads and the corresponding vehicle characteristics are noted at Marka tip over the time period 15 - 29 March 1979 .

To estimate the waste arising , the following assumptions were made , these are :-

1. An average weight of 5 tonnes per load for Amman municipal waste collection vehicles .
2. An average weight of 2.5 tonnes per load for institutionl , commercial and industrial vehicles .
3. An average weight of 6 tonnes per load for demolitions and building waste .

Table (1.4) : City Of Amman - Summary of Household Refuse Analyses , Ref. <15> .

Income Croup Classification.	Proportion of constituent in waste % by weight					
	A		B		C	
Category of Waste.	Dates of Analyses					
	19.3.79	10.4.79	22.3.79	28.3.79	25.3.79	3.4.79
Paper and paper products.	22.2	24.0	12.2	16.0	14.0	10.4
Vegetable & putrescible.	65.5	63.5	76.6	71.2	64.0	77.9
Rags and textiles.	0.2	0.3	2.6	1.9	8.0	3.1
Ferrous metals.	2.5	3.0	1.0	1.4	2.4	3.3
Non-ferrous metals.	0.2	0.1	-	-	-	-
Glass.	3.0	4.5	0.8	1.9	1.8	0.2
Plastic.	6.0	4.0	5.2	6.2	4.0	4.2
Unclassified						
- combustible.	0.3	0.1	1.5	1.2	5.5	0.6
- incombustible.	0.1	0.1	0.1	0.2	0.3	0.3

	A			B			C		
	19.3	10.4	mean	22.3	28.3	mean	25.3	3.4	mean
Avg. density of refuse kg/m^3	291	268	280	239	307	273	280	224	252
No. persons per dwelling.	5.14	3.31	4.22	7.25	7.1	7.18	7.21	6.39	6.80
kg/person/ day.	0.63	0.67	0.65	0.43	0.36	0.40	0.53	0.27	0.40

Weighted average for the City .

Average density of refuse = 259 Kg/m^3 .
No. of persons per dwelling = 6.5
Kg refuse per person per day = 0.43

Table (1.5) Moisture content and Calorfic value .

	Moisture content (wet basis) % by wet weight		Calorfic value on dry basis cal/gm	
	1st test	2nd test	1st test	2nd test
Paper	8.33	15.44	4,330	4,133
Textile (carpet man made fiber)	-	18.37	-	-
Food waste	64.59	84.89	3,763	4,133

. The tip records <15> are summarized in table (1.6). To determine the amount of waste produced by the Amman Municipality at the time of analysis - the following were taken into consideration .

1. House hold refuse generated in Amman city (Weight average) was = 0.43 kg/c/d
2. Population of Amman city was = 731,145
   Total tonnage = 314 tonne
3. They assumed that Amman city produced 40% of industrial , commercial , and institutional waste . = 36 tonne .
4. They assumed the street sweeping = 10 tonne

Table (1.6) : Summary of Amman Tip record over time of (15-19 March 1987) , Ref. <15> .

Loads from	No. of loads recorded	Period of record (d)	Ave. number of loads per day (d)	Estimated weight per load (tonne)	Total weight per day (tonne)
Amman Municipality	1044	15	70	5	350
Private Source (Institutional, commercial industrial)	535	15	36	2.5	90
Total (excluding Building waste)					440

Table (1.7) shows the estimated quantitues of solid waste generated in Amman Municipality .

Table (1.7) estimated quantities of solid waste generated in Amman (Excluding building waste), Ref.<15>.

Gategory of waste	Estimating arising (tonne/day)
household	314
Institutional, commercial and industrial	62
Street sweeping	10
Total	386 ton

1.2.3 The study performed in the Municipality of Amman 1984 , Ref <13> .

Objective of the study :- Determination of generated solid waste quantities and composition of solid waste in the Amman Municipality .

Date of the study :- The date of data collection was Feb. and Jun. of 1984 .

How the study was performed :- To determine the generated quantities of solid waste , Weight-Volume Analysis was used . The vehicles which entered the tip gate during Feb. and June 1984 were weighed to determine the weight of load and since Amman Municipality is divided into nine districts , the weight of waste generated by the same district were added together . To determine the solid waste composition , two samples were analyzed , first from Basman district and the second from Al Abdali district representing Lower and middle income group , middle , upper income group respectively .

Results of the study :-

1. Generated quantities of solid waste during June (Ramadan) was greater than that during Feb. by 11.58% .
2. Daily generation rate varied from 0.5 upto 1.4 kg/c/d with an average of 0.721 kg/c/d .
3. Composition of solid waste is shown in table (1.8) .

Table (1.8) : Results of refuse compostion analysis performed by Amman Municipality in 1984 , Ref. <13> .

Refuse generation district	Basman		Abdali		
	Refuse composition % by weight.				
Food waste	Rags,Paper Plastic	Glass Cans&Tins	Food waste	Rags,Paper Plastic	Glass Cans&Tins
72.08	21.49	6.4	69.49	21.46	9.04

2. To determine the composition of solid waste , random samples from all Amman districts were taken .
3. To determine the constituents of organic material and paper and cardboard a sample from six districts was taken and it was analyzed to their components .

Result of the study :-

1. It was found that generation rate during July-1986 is 0.864 kg/c/d .
2. It was found that compacted density of solid waste is 434 kg/m^3 .
3. Composition of solid waste shown in table (1.9) .
4. Breakdown of organic material shown in table (1.10) .
5. Breakdown of paper and cardboard shown in table (1.11) .
6. Cost of collection , transport and disposal of solid waste is 14.57 JD/tonne .
7. Average weight of refuse in Mercedes collection vehicles is 6.4 tonne/load .
8. Average weight of refuse in Hoist truck collection vehicles 3 tonne/load .

Table: (1.9) Pysical composition of solid waste generated in Amman Municipality , Ref.<22> .

Component	Percent by weight , %
Organic waste	49.48
Paper and cardboard	25.91
Plastic	12.31
Glass	3.29
Metals	2.46
Others	6.5

Table (1.10) Breakdown of organic material, Ref.<22> .

Component	Percent by weight, %
Food waste	49.79
Vegetable waste	7.12
Fruit waste	31.5
Bread	5.87
Bones	1.42
Egg's shell	0.2
Raw meats	0.63
Others	3.48

Table (1.11) Breakdown of paper and cardboard, Ref. <22>.

Component	Percent by weight, %
News paper	33.75
Cardboard	17.77
Sanitary paper	31.47
Offices paper	4.19
Normal paper	10.78
School paper	1.44
Magazine	0.62

1.2.5 Study performed in Al-Kuwait City in 1980 by Natoure , R.M, Ref. <9> .

Objective of the study :-

1. Twenty-one samples were collected , each of them composed of number of bags between 50 and 101 bags , each sample was sorted into the following components: food waste , paper cartons , plastic metals , glass and ceramic , Textile , bones , wood , shoes , and miscellaneous the percentage of each components was was determined .
2. The kitchen waste , excluding the paper and plastic and paper and cartons was brokendown into its component, and the percentage of each components was determined .

Results of the study :-

1- Composition of household solid waste reproduced in Table (1.12) , breakdown of putercible fraction of household refuse was reproduced in Table (1.13) and a breakdown of papers and cardboard reproduced Table (1.14) .

table (1.14)

Table : (1.14) Breakdown of paper and cartons , Ref <9>.

Component	Percent by weight, %
News paper	36.6
Cartons	25.5
Warpping paper	16.1
Napkins	12.2
School paper	5.4
Magazine	3.2
Office paper	0.7

Table (1.12) : Composition of Household Soild Wastes (Weight % as recived) , Ref. <9> .

Component	Percent by weight	
	Range %	Typical %
Food waste	41.7-60.5	53.3
Paper & cartons	11.4-29.4	22.2
Plastic	3.2-13.0	8.4
Metal	1.3- 8.2	4.4
Glass & ceramics	0.1- 5.3	2.6
Miscellaneous	0.6- 8.6	3.3
Texitles	0.7- 3.8	2.1
Bones	0.4- 2.9	1.4
Wood	0.1- 6.1	1.5
Shoes	0.0- 1.9	0.6

Table (1.13) : Breakdown of Kitchen Waste , Excluding Paper and Plastics , Ref. <9> .

Component	Percent by weight	
	Range %	Typical %
Cooked food	27.5-46.8	36.1
Fruit waste	2.3- 7.7	4.1
Vegetable waste	7.6-14.8	11.9
Bread	7.7-13.6	10.1
Components Fibrous shells & peelings	19.0-28.8	23.5
Egg-shells	0.2- 1.3	0.5
Bones	1.9- 4.6	3.2
Raw meat & fat	0.8- 8.7	3.2
Unsortable waste	2.6-13.7	7.3

1.2.6 Summary of some studies performed in Asian , American and European countries .

The cost of collection , transport and disposal of solid waste depends on the following factors .

1. Generation rate as weight and volume per captia per day .
2. Physical charactristics of solid waste .
3. Chemical characteristics of solid waste .
4. Physical composition of the waste .

Therefore determination of the mentioned factors are considered to be essential to minimize the cost of the collection - disposal process of solid waste , therefore many countries realised the importance of the existence of data about the previous factors mentioned above , i.e U.S.A or most of the European countries have their own data about their solid waste . Table 1.15 shows the refuse composition of U.S.A , European countries , Israel and Japan . Table (1.16) shows the refuse composition refuse characterisitics of U.K , U.S.A and some of Asian countries . If you look carefully at these tables you may notices the followings :-

Table (1.15) : A Summary of International Refuse Composition (weight percent-mixed refuse) Ref. (17) .

	Ash	Paper	Organic matter	Metals	Glass	Misc.
United States (1959)[a]	43.0	21.9	17.0	6.8	5.5	5.8
United States (1970)[b]	~0	44.0	26.5	8.6	8.8	12.1
Canada	5	70	10	5	5	5
United Kingdom	30-40	25-30	10-15	5-8	5-8	5-10
France[c]	24.3	29.6	24	4.2	3.9	14
West Germany[d]	30	18.7	21.2	5.1	9.8	15.2
Sweden	0	55	17	6	15	12
Spain[e]	22	21	45	3	4	5
Switzerland	20	40-50	15-25	5	5	–
Netherlands[f]	9.1	45.2	14	4.8	4.9	22
Norway (summer)	0	56.6	34.7	3.2	2.1	8.4
Norway (winter)	12.4	24.2	55.7	2.6	5.1	0
Israel	1.9	23.9	71.3	1.1	0.9	1.9
Belgium[g]	48	20.5	23	2.5	3	3
Czechoslovakia[h] (summer)	6	14	39	2	11	28
Czechoslovakia[h] (winter)	65	7	22	1	3	2
Finland	–	65	10	5	5	15
Poland	10-21	2.7-6.2	35.3-43.8	0.8-0.9	0.8-2.4	–
Japan (1963)	19.3	24.8	36.9	2.8	3.3	12.9

[a] Ref. 00.
[b] From Tables 2.5, 2.6 above (organic matter = yard and food waste; Misc. = plastics, leather and rubber, wood, textiles, and miscellaneous).
[c] Paris (considered representative of national average).
[d] West Berlin.
[e] Madrid.
[f] The Hague.
[g] Brussels.
[h] Prague.

Source: Refs. 29, 30, 31.

Table (1.16) : Composition of town refuse

Ref. (6) .

Place		World range	Bangkok, Thailand		Calcutta, India		Deshapara India	Delhi, India	Dubai	Enugu, Nigeria	Ibadan, Nigeria		Madras, India	Nagpur, India		Poona, India	UK	USA
Date		1971	1957	1970	1970	1964	1970	1974	1973	1973	1972	1972	1970?			1970?	1968	1972
Note (see below)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fruit and vegetable	% by weight (generally wet weight)	5–90	47·5	2·6–5·1	16·0	14	20	20·3	40				57	3·8	4–6	68	1706	
Leaves, grass, straw																		
wood, coconut shells				6–75	18·0		21			83	80·7	9·6		12·9	4–6			9
Food wastes			0 7							9·1	9·1	70·3						14
Paper and cardboard		0·25–55	4	7–13	3·2			5·9	25·5		3·4	10·0	4·8	2·0	3–6	8·7	36.9	55
Rags			5·4	0·3–0·6	3·6	2	1	3·6	8·0	4·1	4·1	1·6	3·8	0·6	3–7	1·6	2·4	3
Glass, crockery, bones			1·9	1·6–6·9	7·4	4	1	0·6	5·0		0·5	2·5	0·5	0·2	0·3–0·8	0·6	9·1	9
Metal, tins			2·3	0·8–1·3	0·7	4		0·6	12·5	2·3	2·3	5·9					8·9	9
Plastics		0·1–7		2–7	0·6			0·5	4·5				0·6	0·3	0–2	0·7	1·1	1
Dust, ash, cinder			24·1		41·6	69	57	6·0									21·9	
Miscellaneous			14·1			7			4·5	1·0							2·1	
Moisture content					41			14·7			43–65			42	10–32			
Weight per person kg/d		0·2–3			0·51	0·39	0·32	0·31			0·4–0·6		0·56			0·3	0·80	2·6
Density	kg/l	0·1–0·5		0·163 –0·335	0·52– 0·57	0·46	0·38	0·47			0·28		0·435			0·298	0·157	
Volume per person l/d					1·08	0·8	0·85	0·66			1·4		1·29			1·0	5·1	
Calorific value kJ/kg					6300		1400	6600					6700	5300	4600	7100	8000– 10 500	

1. WHO Expert Committee (1971).
2. Surveyor (1958).
3. Information from Professor M. B. Pescod.
4. Central Public Health Engineering Research Institute (1970).
5. Ghosh *et. al.* (1964).
6. Rao *et. al.* (1970).
7. Bijlani *et. al.* (1974).
8. Information from J. D. and D. M. Watson.
9. Information from Enugu Municipal Council.
10. Ibadan Old Town. Oluyemi (1972) and Oluwande (1974).
11. Ibadan reservation. Oluyemi (1972).
12. Information from CHERI.
13. Bhide and Muley.
14. Bide, Mottghave, Patel and Gautam.
15. Information from CPHERI.
16. Department of the Environment (1971).
17. Davoll (1972).

A- For countries which are considered as industrialized countries , the following are correct :-

1. Paper and cardboard has a high percentage .
2. Density is low .
3. Puterscible matter has a low percentage .
4. Generation rate (kg/cap./day, liter/cap./day) is high .
5. Calorific value is high since the perentage of paper and cardboard is high and the moisture content is low .

B- For countries which are considered as poor developing countries , the following are correct :-

1. Paper and cardboard percentage is less than that of industrialized countries , ranging between 2-25% roughly .
2. Density of solid waste is high > 200 kg/m^3.
3. Generation rate (kg/cap./d, litre/cap/day) is low (0.2-0.6) kg/c/d .
4. Calorific value is low because :-
    1. Moisture content of solid waste is high.
    2. Precentage of putrescible material is high.
    3. Percentage of paper and cardboard is low.

2.1 General information about Amman Municipality (G.A.M)

G.A.M. is the capital of the Hashemite Kingdom of Jordan and has an estimatded population of 1001186 inhabitant in 1987 with an expected annual rate of increasing of 4.2% , the average size of family being 6.7 persons <23> . G.A.M consists of nineteen districts some of them shown in figure (2.1). Table (2.1) shows the estimated number of population and estimated number of families of G.A.M in 1987 , the base year of estimation is 1979 .

2.1.1 Present status of onsite generation of refuse and collection

Some of the main duties of G.A.M are :-

A- Collection , transport and disposal of solid waste generated by :-

1. Residential areas :-

   a- Development residential area .
   b- Small under developed and middle class residential area .
   c- Refugee camps.

2. Public yards and streets sweeping .

3. Commercial areas .

B. Disposal of the solid waste generated by :-

1. Industrial .

2. Special activities i.e University , Institution , Hospitals , etc .

3. Building construction and demolition activities .

Fig. (2.1) : Some districts of G.A.M.

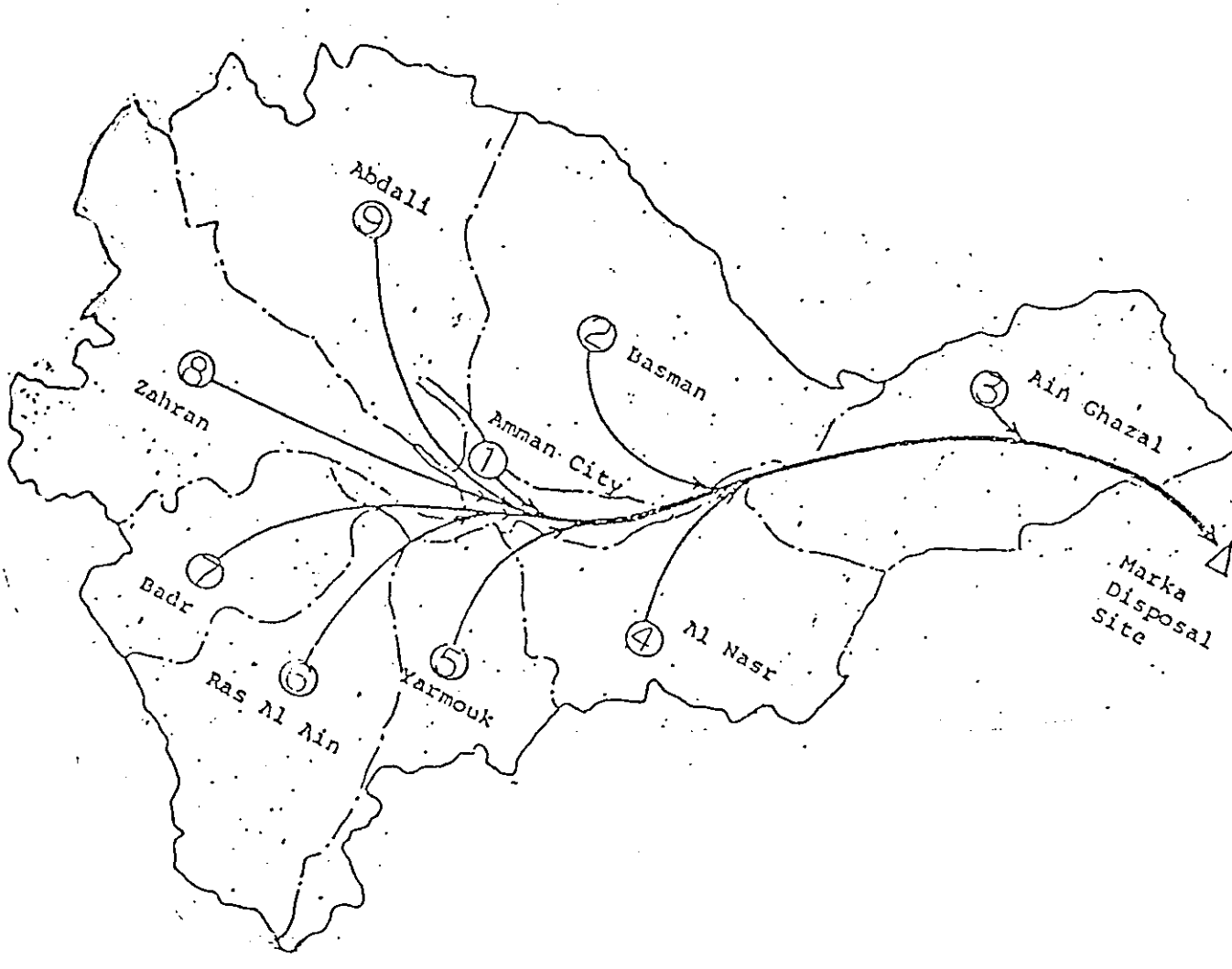


Table (2.1) : Estimated population number of Greater Amman Municipality's districts. Assumed annual growth rate is 4.2% and size of family is 6.7 person per dwelling Ref. <23> .

District Name	Estimated populaion in 1985	Estimated population in 1987	Estimated No. of family in 1987
Central	44,000	47,000	7,130
Basman	178,000	193,266	28,846
Ain Ghazal	50,000	54,288	8,103
Al-Nasser	111,000	120,520	17,988
Al-Yarmouk	131,000	142,235	21,229
Ras-Al-Ein	74,000	80,347	11,992
Bader	62,000	67,317	10,047
Zahran	54,000	58,631	8,750
Abdali	96,000	104,233	15,557
Tarik	3,600	3,909	583
Quweisma	18,990	20,619	3,077
Sweileh	30,160	32,747	4,888
Jubeiha	9,820	10,622	1,591
Tala-El-Ali, Khilda and Um-Sumak	7,930	8,610	1,285
Shafa Badran	2,500	2,714	405
Khribat El Suq.	10,390	11,281	1,684
Wadi-ser	30,900	33,550	5,007
New Bader	2,570	2,790	416
Abu Allanda	5,280	5,733	856
Total	922,140	100,1186	149,434

In short we can say that service introduced by G.A.M for part A is a service which is similar to the set-out set-back collection service . For this service the G.A.M employs about 2000 worker to collect the solid waste from different houses and transfer it to the pick-up points found on the main street. The wages of those workers cost the G.A.M. 2.26 milion JD ayear <22> then the collection vehicles collect the refuse and transfer it to the tip at Marka , where the method of disposal is open dump , inspite of a recommendation introduced in 1979 by consultant <15> this site must be closed , another site chosen and the disposal must be changed to land fill method because the present site leads to :

1. Pollution of ground water .
2. Pollution surrounding residential area , Marka , Resifia and Zarka .

But the Greater Amman Municipality (G.A.M) realized this fact and the director of general cleansing department said "Another site was chosen at Al Resuifia , in phosphate mines , and Land fill as a method of disposal will be used" with respect to the solid waste generated by activities mentioned in part (B) the G.A.M duty is confined to the disposal of generated solid waste only . G.A.M used a fleet of collection vehicles to collect solid waste generated by the activities mentioned in part (A) , table (2.2) shows the Number and type of collections vehicles .

Table (2.2)

Type and number of collection vehicles used in G.A.M.

Type of vehicles	Number of vehicles
Compaction shredding collection vehicles	66
Hoist-truck collection vehicles	11
Compaction collection vehicles	6
Flat-truck collection vehicles	19

With respect to the onsite storage , two systems were used :

1- Dustbin plastic containers of capacities , 120 l , 140 l and 1100 l galvanized steel were used in :-

   a. Centeral district .

   b. Developed residential areas .

   These containers unloading in collection vehicles is automatic with the help of the two workers who accompanied each collection vehicle .

2- Plastic bags and other small containers used by the household in middle and underdeveleped residential areas and refugee camps . (it is valuable to note that the UNRWA is responsible for collection of the solid waste generated by the refugee camps from household and put it at a pickup and G.A.M is responsible to transfer and dispose of these waste) . Schedule of collection is not defined clearly but it seems that all solid waste generated was collected by G.A.M .

2.1.2 Estimated population of greater Amman Municipality (1987-2000)

Before 1/1/1987 the Municipality of Amman consisted of nine districts , but through the decision of the Minsters council , G.A.M now consists of nineteen districts , these are :-

1- Centeral district
2- Basman district
3- Ain-Ghazal district
4- Al-Nasser district
5- Yarmouk district
6- Ras Al-Ain district
7- Bader district
8- Zahran district
9- Abdali district
10- Tarik district
11- Jubeiha district
12- Sweileh district
13- Tala El-Ali, Khilda and Um-Sumak district
14- Wadi-Ser district
15- Quweisam and district
16- Khribate El-Suq. district
17- New Bader district
18- Shafa Badran district
19- Abu-Allanda district

Estimation of Population of G.A.M (1987) .

"The size of family is increasing and the annual increasing rate is decreasing in the now current days (the head of population departmert in the general statistics department said) that trend may be as a result of the national economic recession in Jordan" . Therefore he recommends the use of the following parameter to make population and number of families forecasts for the

period from 1987 to 2000 . The parameters are :-

1- Annual increasing rate is 4.2% .

2- Size of family is 6.7 person/family .

Table (2.3) contains the estimated population , estimated number of families over a period of (1987-2000) of G.A.M.

2.2 Quantities of Domestic Refuse in G.A.M.

To determine suitable methods of collection , transport, disposal, recycling recovery of the refuse the following must be determined :-

1- Generated quantities of G.A.M , generation rate as kg/c/d , as litre/c/d .

2- Physical characteristics of the solid waste (i.e density , mositure content) .

3- Physical composition of the refuse .

4- Chemical composition of the refuse .

Hence the household refuse constitutes more than 80% of refuse of G.A.M which G.A.M is responsible for collection , transport and disposing of it . Therefore it may be necessary to perform this study - which will be illustrated later-taking into our consideration the follwoing objectives :-

1- Determination of physical composition of household refuse .

2- Determination of average generation rate of household refuse as kg/c/d & l/c/d .

Table (2.3) : Estimated Population of Greater Amman Municipality through (1987 - 2000) .

Year Of Estimation	Estimated No. Of Population	Estimated No. Of Families
1987	1,001,186	149,434
1988	1,043,236	155,707
1989	1,087,052	162,247
1990	1,132,708	169,061
1991	1,180,282	176,161
1992	1,229,854	183,560
1993	1,281,508	191,270
1994	1,335,331	199,303
1995	1,391,415	207,674
1996	1,449,854	216,396
1997	1,510,748	225,485
1998	1,574,200	234,955
1999	1,640,316	244,823
2000	1,709,209	255,106

* Assumed annual growth rate of population is 4.2 % .
* Assumed average size of family is 6.7 person per dwelling .
* Compounded annual growth rate is considered to estimte pouplation .

3- Determination of physical charcteristics of household refuse (loose density, moisture content) .

4- Determination of the effect of monthly income per person , season , educational level and literacy , social factors on the generation , physical composition and physical characteristics of household refuse .

2.2.1 Data collection** :-

To get an accurate result , twenty five houses were chosen ; three houses from each district which represent the high , middle , and lower income groups , Table (2.4) shows significant informations related to the twenty five houses . The refuse generated by those houses was collected approximately 1.5 times a week , each house was given three plastic bags each time and a gentleman's agreement was accepted by each house , first not to throug away any part of their refuse , seconed to sort their refuse in the follwoing manner :-

1- Storage of food waste in the first bag .

2- Storage of papers , cardboard , plastic & leather in the seconed bag .

3- Storage of wood , glass , tins & cans , and garden trimming in the third bag .

** This study was performed in October, November, December 1985 and January & February of 1986 . At that time Amman Municipality consisted of nine districts only .

To recognize the refuse generated by each house , a symbol for each house was used , the explanation sympol , each sympol consisted of two digits the first one from left denotes the district number as used by Amman Muncipality , the second digit from left denotes the house number (i.e 23 this mean house number 3 from district number 2 , Basman) .

When the collection was finished , the collected refuse was transported to sanitary laboratory in the Jordan University , then the following analyses were performed :-

1- Determination of generation period of refuse for each house ,

Generation period = Date of collection of plastic bags - Date of distribution of plastic bags

2- Resorting of components of each house refuse , weigh each components and determine its volume , also this information was recorded .

3- Calculation of generated volume of refuse = Sum of volume of each component .

4- Calculation of generated quantities of refuse = Sum of weight of each component of refuse .

5- Calculation of generation rate :-

a- As kg/c/d = $\frac{\text{Generated Quantities of refuse (kg)}}{\text{Generation period} * \text{size of family}}$

Table (2.4) : Monthly income, per person monthly income, size of family and No. of infants of the chosen 25 houses .

District Name	Center			Basman			Ain Ghazal			Nasser		
House Number	11	12	13	21	22	23	31	32	33	41	42	43
Size of family	2	6	12	10	7	11	7	10	7	10	4	7
Monthly income JD	180	250	200	700	300	200	700	250	150	500	350	220
Income per person per month.(JD/month/ person) .	90	42	17	70	43	18	100	25	21	50	88	31
Number of in-fants.	-	1	-	1	-	-	-	-	1	1	1	-

Cont. Table (2.4) :

District Name	Yarmouk			Ras-El-Ain			Bader			Zahran	Abdali		
House Number	51	52	53	61	62	63	71	72	73	81	91	92	93
Size of family	11	9	8	10	20	8	5	15	15	5	8	4	6
Monthly income (JD)	500	200	150	800	500	200	250	350	500	1000	650	100	700
Income per person per month.(JD/month/ person) .	46	22	19	80	25	20	50	23	33	200	81	25	83
Number of in-fants.	1	-	1	-	5	2	-	3	1		-	-	-

Table (2.30)

Number of running moisture tests .

Refuse components	Number of running moisture tests
Food waste	70
Paper	69
Cardboard	65
Leather	22
Glass	41
Tins & Cans	39

Method of determing moisture content of the X-component.

1- Determine the weight of the empty container W0 .

2- Choose a representative sample of X-component .

3- Determine the weight of wet sample plus weight of container W* .

4- Put the sample in the oven at 75 $^{\circ}$C for food waste component and at 100, $^{\circ}$C for any other components<12>.

5- After 24 hr of keeping the sample in the oven , the sample was weighted , W2* .

Then moisture content can be calculated as following :-

$$\text{Wet weight} = W^* - W0 = W1$$

$$\text{Dry weight} = W2^* - W0 = W2$$

$$\text{Moisture content, \%} = \frac{W1 - W2}{W1} * 100$$

Table (2.31) up to table (2.37) contains the net wet weight and net dry weight (in wet weight and dry weight the weight of container was discarded) the moisture con-

tent of the moisture content tests which were conducted in the data collection period , the weights are expressed in gm .

Note :- To determine the effect of unsorting of household refuse into its components , a 59 sample out of the 548 collected samples were not sorted into its components .

Table (2.31) : Food waste moisture content of household refuse generated in Greater Amman Municipality (1985-1986) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample(excluding container weight) (gm)	Moisture content (%)
18/11/85	11	219	54	75.3
16/12/85	11	181	26	85.6
27/11/85	12	163	36	77.9
25/12/85	12	196	25	87.2
15/01/86	12	181	28	84.5
07/12/85	13	308	22	92.3
04/01/86	13	234	42	82.1
23/11/85	21	229	44	80.7
16/12/85	21	168	19	88.7
11/01/86	21	178	26	85.4
03/12/85	22	203	28	86.2
25/12/85	22	236	43	81.8
07/12/85	23	210	42	80.0
30/12/85	23	155	17	89.0
18/11/85	31	205	64	68.8
20/12/85	31	208	23	88.9
11/01/86	31	230	42	81.7
27/11/85	32	179	39	78.2
25/12/85	32	157	17	89.2
23/11/85	33	206	44	78.6
16/12/85	33	230	32	86.1
18/11/85	41	207	58	72.0
11/01/86	41	230	51	77.8
27/11/85	42	288	84	70.8
16/12/85	42	303	28	90.8
04/01/86	42	205	37	82.0
23/11/85	43	178	48	73.0
11/12/85	43	154	58	62.3
30/12/85	43	198	22	88.9
23/11/85	51	229	76	66.8
16/12/85	51	154	31	79.9
11/01/86	51	204	15	92.6
03/12/85	52	207	25	87.9
25/12/85	52	184	18	90.2
20/01/86	52	230	58	74.8
07/12/85	53	232	74	68.1
30/12/85	53	165	25	84.8
20/11/85	61	205	31	84.9
14/12/85	61	157	61	61.1
01/01/86	61	179	17	90.5
30/11/85	62	182	30	83.5
08/01/86	62	158	44	72.2

Continued of Table (2.31) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture* content (%)
09/12/85	63	238	45	81.1
06/01/86	63	241	28	88.4
20/11/85	71	238	67	71.8
14/12/85	71	216	84	61.1
27/11/85	72	174	54	69.0
07/12/85	72	231	58	74.9
25/12/85	72	255	22	91.4
06/01/86	72	204	30	85.3
20/01/86	72	218	25	88.5
09/12/85	73	228	57	75.0
01/01/86	73	155	22	85.8
22/01/86	73	231	27	88.3
20/11/85	81	206	31	85.0
24/11/85	81	174	18	89.7
04/12/85	81	279	59	78.9
14/12/85	81	297	34	88.6
25/12/85	81	280	70	75.0
04/01/86	81	237	43	81.9
06/01/86	81	216	31	85.6
18/01/86	81	238	57	76.1
23/11/85	91	187	73	61.0
25/12/85	91	162	21	87.0
04/01/86	91	228	41	82.0
27/01/86	92	205	29	85.8
30/12/85	92	300	24	92.0
04/11/85	93	230	51	77.8
03/12/85	93	245	44	82.0
25/12/85	93	204	23	88.7

* Moisture content, % = $\frac{W1 - W2}{W1} \times 100$.

Table (2.32) : Papers moisture content of household refuse generated in greater Amman Municipality (1985-1986) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture* content (%)
18/11/85	11	43	36	16.3
16/12/85	11	58	46	20.7
27/11/85	12	43	35	18.6
25/12/85	12	39	27	30.8
15/01/86	12	56	44	21.4
07/12/85	13	58	42	27.6
04/01/86	31	62	49	26.5
23/11/85	21	59	46	22.0
16/12/85	21	60	44	26.7
11/01/86	21	64	54	15.6
03/12/85	22	63	45	28.6
25/12/85	22	59	45	23.7
07/12/85	23	59	48	18.6
30/12/85	23	64	51	20.3
18/11/85	31	59	38	35.6
20/12/85	31	59	43	27.1
11/01/86	31	60	48	20.0
27/11/85	32	41	35	14.6
25/12/85	33	48	35	27.1
23/11/85	33	41	33	19.5
16/12/85	33	34	25	26.5
18/11/85	41	43	28	34.9
11/01/86	41	39	33	15.4
27/11/85	42	41	29	29.3
16/12/85	42	47	39	17.2
04/01/86	42	49	38	22.4
23/11/85	43	46	38	17.2
11/12/85	43	43	32	26.1
30/12/85	43	57	46	19.3
23/11/85	51	75	59	21.3
16/12/85	51	105	88	16.2
11/01/86	51	75	69	8.0
25/12/85	52	85	72	15.3
09/01/86	52	62	49	22.6
07/12/85	53	75	60	20.0
30/12/85	53	52	36	30.8
20/11/85	61	41	33	19.5
14/12/85	61	38	28	26.3
01/01/86	61	46	41	10.9
30/11/85	62	43	30	30.2
08/01/86	62	36	32	11.1

Continued of Table (2.32) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture* content (%)
09/12/86	63	57	47	17.5
06/01/86	63	48	42	12.5
20/11/85	71	59	41	30.5
14/12/85	71	45	35	22.2
27/11/85	72	55	40	27.3
07/12/85	72	56	46	17.9
25/12/85	72	41	37	9.8
06/01/86	72	46	40	13.0
20/01/86	72	44	39	11.4
09/12/85	73	34	26	23.5
01/01/86	73	58	45	22.4
22/01/86	73	95	89	6.3
20/11/85	81	56	49	12.5
24/11/85	81	53	49	7.5
04/12/85	81	43	32	25.6
14/12/85	81	36	31	13.9
25/12/85	81	48	37	22.9
04/01/86	81	55	48	12.7
06/01/86	81	31	26	16.1
18/01/86	81	57	44	22.8
23/11/85	91	58	43	25.9
25/12/85	91	59	38	35.6
04/01/85	91	105	89	15.2
27/01/86	92	105	75	28.6
30/12/85	92	116	96	17.2
04/11/85	93	63	43	31.7
03/12/85	93	59	47	20.3
25/12/85	93	105	87	17.1

* Moisture content, % = $\frac{W1 - W2}{W1}$ X 100 .

Table (2.33) : Carboard moisture content of household refuse generated in greater Amman Municipality (1985-1986) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture content (%)
18/11/85	11	51	38	25.5
16/12/85	11	46	38	17.4
27/11/85	12	33	24	37.5
25/12/85	12	45	39	13.3
15/01/86	12	50	45	10.0
07/12/85	13	58	53	8.6
04/01/86	13	46	37	19.6
23/11/85	21	41	36	12.2
16/12/85	21	38	32	15.8
11/01/86	21	39	29	25.6
03/12/85	22	60	51	15.0
25/12/85	22	59	52	11.9
07/12/85	23	59	45	23.7
30/12/85	23	46	31	32.6
18/11/85	31	46	42	8.7
20/12/85	31	48	44	8.3
11/01/86	31	55	47	14.5
27/11/85	32	59	49	16.9
25/12/85	32	41	33	19.5
23/11/85	33	48	42	12.5
16/12/85	33	41	34	17.1
18/11/85	41	58	43	25.9
11/01/86	41	60	52	13.3
27/11/85	42	46	39	15.2
16/12/85	42	49	45	8.2
04/01/86	42	55	48	12.7
23/11/85	43	46	41	10.9
11/12/85	43	49	39	20.4
30/12/85	43	46	42	8.7
23/11/85	51	50	37	26.0
16/12/85	51	46	38	17.4
11/01/86	51	29	23	20.7
25/12/85	52	59	50	15.3
20/01/86	52	71	66	7.0
29/01/86	52	92	76	17.4
07/12/85	53	82	66	19.5
30/12/85	53	51	45	11.8
20/11/85	61	43	37	14.0
14/12/85	61	33	26	21.2
01/01/86	61	35	31	11.4
30/11/85	62	41	36	12.2

Continued of Table (2.33) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture* content (%)
08/01/86	62	65	59	9.2
09/12/85	63	71	60	15.5
06/01/86	63	43	38	11.6
20/11/85	71	30	25	16.7
14/12/85	71	41	36	12.2
27/11/85	72	32	27	15.6
25/12/85	72	48	40	16.7
06/01/86	72	31	23	25.9
09/12/85	73	27	23	14.8
01/01/86	73	36	34	5.6
22/01/86	73	38	34	10.5
20/11/85	81	41	35	14.6
24/11/85	81	36	31	16.1
04/12/85	81	46	42	8.7
14/12/85	81	48	44	8.3
25/12/85	81	65	54	16.9
04/01/86	81	71	65	8.5
06/01/86	81	65	56	13.8
18/01/86	81	46	35	23.9
23/11/85	91	33	27	18.2
25/12/85	91	39	36	7.7
04/01/86	91	48	42	12.5
27/01/86	92	26	24	7.7
30/12/85	92	34	29	14.7
04/11/85	93	46	37	19.6
03/12/85	93	26	21	19.2
25/12/85	93	39	36	7.7

* Moisture content, % = $\frac{W1 - W2}{W1} \times 100$.

Table (2.34) : Plastic moisture content of household refuse generated in greater Amman Municipality (1985-1986) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture* content (%)
18/11/85	11	45	42	6.7
16/12/85	11	46	42	8.7
27/11/85	12	43	40	7.0
25/12/85	12	36	35	2.8
15/01/86	12	26	25	3.8
07/12/85	13	29	26	10.3
04/01/86	13	25	22	12.0
23/11/85	21	46	44	4.3
16/12/85	21	33	28	15.2
11/01/86	21	56	54	3.6
03/12/85	22	65	62	4.6
07/12/85	23	60	55	8.3
30/12/85	23	77	75	2.6
18/11/85	31	46	43	6.5
20/12/85	31	52	46	11.5
11/01/86	31	59	56	5.1
27/11/85	32	46	44	4.3
25/12/85	32	47	43	8.5
16/12/85	33	43	39	9.3
18/11/85	41	43	39	9.3
11/01/86	41	58	51	12.1
27/11/85	42	59	50	15.3
16/12/85	42	46	45	2.2
04/01/86	42	36	33	8.3
23/11/85	43	43	40	7.0
11/12/85	43	39	37	5.1
30/12/85	43	49	48	2.0
23/11/85	51	45	41	8.9
16/12/85	51	46	41	10.9
11/01/86	51	56	54	3.6
25/12/85	52	55	51	7.3
07/12/85	52	41	36	12.2
30/12/85	53	48	42	12.5
20/11/85	61	48	46	4.2
14/12/85	61	40	35	12.5
01/01/86	61	55	50	9.1
30/11/85	62	43	36	16.3
08/01/86	62	58	53	8.6
09/12/85	63	59	54	8.5
06/01/86	63	46	43	6.5
20/11/85	71	55	53	3.6
14/12/85	71	46	42	8.7

Continued of Table (2.34) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture* content (%)
27/11/85	72	44	40	9.1
07/12/85	72	46	43	6.5
25/12/85	72	26	25	3.8
06/01/86	72	33	32	3.0
20/01/86	73	38	35	7.9
09/12/85	73	41	36	12.2
01/01/86	73	35	33	5.7
22/01/86	73	46	45	2.2
20/11/85	81	67	63	6.0
24/11/85	81	48	45	6.3
04/12/85	81	72	66	8.3
14/12/85	81	86	83	3.5
25/12/85	81	62	57	8.1
04/01/86	81	53	50	5.7
06/01/86	81	48	45	6.3
18/01/86	81	48	46	4.2
23/11/85	91	23	21	8.7
25/12/85	91	31	27	14.8
04/01/86	91	29	27	6.9
27/01/86	92	30	28	6.7
30/12/85	92	24	21	12.5
04/11/85	93	38	35	7.9
03/12/85	93	29	27	6.9
25/12/85	93	50	48	4.0

* Moisture content, $\% = \frac{W1 - W2}{W1} \times 100$.

Table (2.35) : Leather moisture content of household refuse generated in greater Amman Municipality (1985-1986) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture* content (%)
16/12/85	21	57	51	10.5
03/12/85	22	67	56	16.4
25/12/85	22	89	81	9.0
30/12/85	23	52	43	17.3
25/12/85	32	87	74	14.9
11/01/86	41	75	62	17.3
27/11/85	42	89	70	21.3
04/01/86	42	58	53	8.6
23/11/85	43	62	53	14.5
11/12/85	43	75	63	16.0
16/12/85	51	89	73	18.0
20/11/85	61	62	50	19.4
30/11/85	62	72	53	26.4
06/01/86	63	52	47	9.6
06/01/86	72	92	79	14.1
09/12/85	73	54	41	24.1
20/11/85	81	57	42	26.3
14/12/85	81	92	79	14.1
06/01/86	81	87	69	20.7
18/01/86	81	72	63	12.5
23/11/85	91	86	66	23.3
25/12/85	93	46	38	17.4

* Moisture content, % = $\frac{W1 - W2}{W1} \times 100$.

Table (2.36) : Glass moisture content of household refuse generated in greater Amman Municipality (1985-1986) .

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture* content (%)
07/12/85	13	96	90	6.3
16/12/85	21	65	58	10.8
03/12/85	22	75	66	12.0
25/12/85	22	82	78	4.9
30/12/85	23	91	84	7.7
18/11/85	31	58	56	3.4
20/12/85	31	71	62	12.7
11/01/86	31	86	80	7.0
27/11/85	32	92	87	5.4
23/11/85	33	82	75	8.5
18/11/85	41	86	81	5.8
11/01/86	41	71	65	8.5
27/11/85	42	65	63	3.1
04/01/86	42	52	47	9.6
30/12/85	43	71	67	5.6
23/11/85	51	87	84	3.4
16/12/85	51	92	85	7.6
11/01/86	51	92	85	7.6
25/12/85	52	81	77	4.9
20/01/86	52	78	68	12.8
30/12/85	53	95	89	6.3
01/01/86	61	88	77	12.5
30/11/85	62	91	86	5.5
08/01/86	62	65	59	9.2
09/12/85	63	76	71	6.6
06/01/86	63	81	78	3.7
27/11/85	72	52	48	7.7
07/12/85	72	92	87	5.4
25/12/85	72	82	75	8.5
06/01/86	72	71	64	9.9
01/01/86	73	62	55	11.3
20/11/85	81	82	79	3.7
24/11/85	81	62	59	4.8
04/01/86	81	86	80	7.0
06/01/86	81	57	51	10.5
18/01/86	81	71	66	7.0
04/01/86	91	57	55	3.5
27/01/86	92	62	57	8.1
04/11/85	93	82	78	4.9
03/12/85	93	115	107	7.0
25/12/85	93	65	57	12.3

* Moisture content, % = $\frac{W1 - W2}{W1} \times 100$.

Table (2.37) : Tins and Cans moisture content of household refuse generated in greater Amman Municipality (1985-1986).

Date of sample	Source of sample (house number)	W1 Wet weight of sample (excluding container weight) (gm)	W2 Dry weight of sample (excluding container weight) (gm)	Moisture * content (%)
18/11/85	11	95	91	4.2
16/12/85	11	51	48	5.9
15/01/86	12	86	79	8.1
07/12/85	13	88	79	10.2
23/11/85	21	71	67	5.6
16/12/85	21	82	75	8.5
03/12/85	22	91	81	11.0
07/12/85	23	86	74	14.0
30/12/85	23	71	66	7.0
18/11/85	31	65	60	7.7
20/12/85	31	71	68	4.2
11/01/86	31	87	80	8.0
27/11/85	32	32	29	9.4
23/11/85	33	81	77	4.9
18/11/85	41	51	45	11.8
11/01/86	41	48	46	4.3
27/11/85	42	52	50	4.0
16/12/85	42	62	59	4.8
04/02/86	42	78	73	6.4
23/11/85	43	68	65	4.4
11/12/85	43	58	57	1.7
30/12/85	43	77	68	11.7
23/11/85	51	45	43	4.4
11/01/86	51	52	49	5.8
07/12/85	53	82	76	7.3
30/12/85	53	48	46	4.2
14/12/85	61	69	61	11.6
01/01/86	61	72	68	5.6
30/11/85	62	82	78	4.9
09/12/85	63	71	66	7.0
14/12/85	71	57	55	3.5
07/12/85	72	67	63	6.0
09/12/85	73	48	45	6.3
22/01/86	73	72	66	8.3
23/11/85	91	46	43	6.5
25/12/85	91	56	51	8.9
27/01/86	92	78	75	3.8
04/11/85	93	51	47	7.8
25/12/85	93	41	37	9.8

* Moisture content, % = $\frac{W1 - W2}{W1} \times 100$.

3.1 General

As mentioned previously the main objectives of this study are :-

A- Determinations of :-

1- Physical components of household refuse in the Amman area .

2- Physical characteristics of household refuse in the Amman area .

3- Generation rate represented as :-

a) kg/c/d .
b) l/c/d .

B- Determination of the effect of the following factors on those mentioned in part A , these factors are :-

1. Economic status (Monthly income per person) .
2. Geographic location .
3. Season of the year .
4. Frequency of collection .
5. Use of home grinder .
6. Characteristic of population .
7. Legislation .
8. Public atitude .

To achieve those objectives of part A descriptive statistics must be used , and to achieve objective of part B linear regression must be used .

3.1.1 Descriptive statistics :-

Descriptive statistics introduce many measures . These are :-

1- Relative frequency :- The relative frequency of occurrence represnts the numer of times a given value occurs in 100 observations .

2- Mean :- The mean is the arthmetic average of a number of individual measurements and is given by :-

$$\text{Mean } \bar{X} = \frac{\sum_{i=1}^{N} Xi}{N}$$

Where

Xi = The ith observation .

N = Number of observation .

$\bar{X}$ = Mean .

and mean for grouped observation given by :-

$$\bar{X} = \frac{\sum_{i=1}^{n} Fi * Xi}{N}$$

Where

Fi = Frequency number in the ith interval .

Xi = Centre of the ith interval .

N = Number of observation .

$\bar{X}$ = Mean .

n = No. of intervals .

3- Median :- If a series of observation are arranged in order of increasing or decreasing, the term which its arrangement is $\frac{N+1}{2}$ is the median .

4- Mode :- The mode is the occurring with the greatest frequency in a set of observation .

5- Standard deviation :- It is one of the dispersion measures , it is given by the following relation .

$$\text{Standard deviation} = \left(\frac{\sum_{i=1}^{N} (Xi - X)^2}{N} \right)^{\frac{1}{2}}$$

Where

N = The number of observation .

Xi = The ith observation .

X = Mean .

and grouped obsevation given by :-

$$\text{Standard deviation} = \left(\frac{\sum_{i=1}^{n} Fi * (Xi - X)^2}{N} \right)^{\frac{1}{2}}$$

Where

Fi = Frequency in the ith interval .

Xi = Center of ith interval .

X = Means .

n = Numbers of intervals .

N = Number of observations .

If you refer to tables 2.5 2.29 and tables 2.31 2.37 you will find a numbers of observations related to different components of household refuse , that number of observation are illustrated in Table 3.1 and Table 3.2 .

Table (3.1)

Number of individual observations .

	Number of observation
Density, kg/m^3	548
Generation rate, kg/c/d	548
Generation rate, l/c/d	548
Food waste, %	489
Paper, %	489
Cardboard, %	489
Plastic, %	489
Wood, %	489
Glass, %	489
Tin&cans, %	489

Table (3.2)

Number of individual observations of moisture content .

	Number of observation
Food waste, %	70
Paper, %	69
Cardboard, %	68
Plastic, %	66
Leather, %	22
Glass, %	41
Tins & cans, %	39

First , as mentioned , descriptive statistical analysis will be performed on the available observations. Two types of analysis in this stage will be performed . These are :-

A- Dealing with the observation as it is, its mean value was calculated .

B- Dealing with the observation after grouping it into intervals and the frequency of each interval was determined then relative was calculated and standard deviation was calculated also , this standard deviation is considered to be an aproximate value of the exact standard deviation which can be calculated from individual observations .

Type A analysis

Here one measure of the central tendency will be determined, that the mean of individual observation , for each component of household refuse , generation rate kg/m^3 , l/c/d , and loose density we have 489 different observation , for productivity (kg/c/d) , we have 548 individual observations . With respect to the moisture content , we have 70, 69, 68, 66, 22, 41, 39 observations for moisture content of food waste, paper, cardboard, plastic, leather, glass, tins & cans respectively as shown in Table (3.1) and Table (3.2) .

First if you refer to Table (2.5) up to (2.29) you will find that we can calculate the mean of the following (for each house) :-

1- Density for household solid waste, kg/m^3 .

2- Generation rate , as (kg/c/d) .

3- Generation rate , as (litre/c/d) .

4- Precentage of different composition of household refuse , these are :-

1. Food waste .
2. Paper .
3. Cardboard .
4. Plastic .
5. Leather .
6. Wood .
7. Glass .
8. Tins & cans .
9. Garden trimming .

Table (3.3) contains means of all items mentioned for each house but Table (3.4) contains overall means for the Amman area .

Table (3.4)

Overall means of household refuse characteristics , generation rate and physical composition .

Density kg/m^3	153
Generation rate kg/c/d	0.40
Generation rate l/c/d	3.03
Food waste, %	61.3
Paper, %	15.6
Cardboard, %	8.3
Plastic, %	3.6
Leather, %	2.3
Wood, %	1.1
Glass, %	3.7
Tins & cans, %	3.5
Garden trimming, %	0.45

Table (3.3) : Arithematic mean of generation rate (kg/c/d, l/c/d), solid waste characteristics (loose density), and physical composition of household refuse.

	District Name	Central			Basman			Ain-Ghazal			Al-Nasser		
	House number	11	12	13	21	22	23	31	32	33	41	42	43
refuse generation rate.	Generation rate, kg/c/d.	1.02	0.36	0.3	0.28	0.32	0.29	0.42	0.29	0.29	0.41	0.39	0.25
	Generation rate, L/c/d.	5.4	2.4	2.5	1.5	1.9	2.2	3.4	2.7	2.6	2.7	3.2	2.4
refuse characteristics	Loose density kg/m^3	207	161	129	206	181	159	141	126	119	166	134	122
Refuse composition percent by weight	Food waste	61.6	62.6	57.2	62.8	69.4	52.9	61.1	63.4	64.6	56.6	46.9	47.8
	Paper, %	7.3	13.9	15.7	22.2	12.8	12	16.7	16.7	16.5	15	27	24.8
	Cardboard, %	7.7	8.1	10.5	3.5	4.5	8.7	7.3	6.4	6.3	8.2	14.1	12.9
	Plastic, %	4.7	5.9	5.1	2.6	3.6	4.6	4.2	2.9	3.3	3.2	2.7	2.8
	Leather, %	7.9	2.6	1.9	2.2	2.0	1.7	2.5	3.0	2.4	3.6	1.5	2.3
	Wood, %	0.0	0.1	0.0	0.4	0.0	2.7	2.2	0.9	0.5	1.3	0.8	2.5
	Glass, %	4.8	2.9	5.1	4.1	5.1	5.8	2.2	2.4	2.5	3.8	4.2	3.5
	Tins and Cans, %	5.9	4.5	4.6	2.3	2.5	4.1	3.5	4.3	4.1	4.8	2.8	3.4
	Garden, % trimming	0.0	0.0	0.0	0.0	0.2	4.8	0.4	0.0	0.0	3.3	0.0	0.0
Income per person per month, (JD/month/person) .		90	42	17	70	13	18	100	25	21	50	88	31

Cont. Table (3.3) :

	District Name	Yarmouk			Ras-ElAin			Bader			Zahran	Abdali			Over all average
	House Number	51	52	53	61	62	63	71	72	73	81	91	92	93	
refuse Generation rate.	Generating rate, L/c/d.	0.47	0.29	0.27	0.58	0.28	0.32	0.31	0.43	0.23	0.96	0.32	0.43	0.44	0.40
	Generation rate, L/c/d.	2.3	1.9	2.1	4.1	1.9	2.4	2.1	2.7	1.5	12.1	2.6	3.1	4.1	3.03
refuse character-stics .	Loose density kg/m^3	206	172	129	162	160	167	158	169	161	88	129	157	120	153
Refuse composition percent by weight .	Food wast, %	73.3	72.2	62.7	66.9	64.9	66.7	66.7	63.8	58.2	53	60.8	68.3	49.3	61.3
	Paper, %	9.2	9.3	16.7	14.9	13.1	15.4	11.9	14.2	14.9	19.1	17.7	12.2	19.9	15.6
	Cardboard, %	5.9	6.0	9.3	7.6	7.6	6.7	7.6	10.5	8.2	9.7	9.7	7.5	14.2	8.3
	Plastic, %	2.2	1.6	3.5	2.6	3.8	2.6	3.5	2.6	1.8	6.6	3.2	4.2	5.5	3.6
	Leather, %	1.0	2.0	1.2	1.1	1.3	1.3	2.9	1.3	4.4	2.4	1.2	1.8	2.1	2.3
	Wood, %	1.6	0.3	0.9	0.3	1.8	0.7	1.8	1.5	0.9	1.7	1.2	1.0	1.5	1.1
	Galss, %	4.2	4.5	2.7	3.5	3.5	2.7	2.4	3.4	8.7	3.7	2.2	1.4	2.4	3.7
	Tins and Cans, %	2.5	3.7	3.0	3.0	4.1	2.9	1.6	2.7	2.8	3.6	3.1	3.7	4.8	3.5
	Garden & trimming	0.0	0.0	0.0	0.6	0.0	0.8	1.4	0.0	0.2	0.0	0.0	0.0	0.0	0.45
Income per person per month. (JD/month/person) .		46	22	19	80	25	25	50	23	33	200	81	25	82	

Table (3.5) contains overall mean of moisture content for each compononts of household refuse .

Table (3.5)

Overall means of moisture content of household refuse.

	Overall average moisture content
Food waste, %	81.2
Paper, %	20.7
Cardboard, %	15.3
Plastic, %	7.4
Leather, %	16.1
Glass, %	7.3
Tins & cans, %	6.9

Type B analysis

The main idea of this analysis is the formation of frequency distribution tables by using individual observations found in Table (2.5) to (2.29) and Table (2.31) (2.37) . Each frequency distribution table represents the individual observation related to one of the following items :-

1- Density of household refuse .

2- Productivity of household refuse as kg/c/d .

3- Productivity of household refuse as litre/c/d .

4- Percentage of different components of household refuse .

5- Moisture content of each component of household refuse .

After forming frequency distribution tables , these are conducted :-

1- Calculation of relative frequency .

2- Calculation of centre of each interval and consider each centre to be equivalent to the interval .

3- Calculation of the mean and standard deviation of each set of group data by Eq. (3.1) , (3.2) respectively .

$$\bar{X} = \frac{\sum_{i=1}^{n} Fi * Xi}{N} \quad \text{.....Eq.(3.1)}$$

$$\text{Standard deviation, } = \left(\frac{\sum_{i=1}^{n} Fi * (Xi - \bar{X})}{N} \right)^{\frac{1}{2}} \text{.Eq.(3.2)}$$

$\bar{X}$ = Mean of grouped data .

Xi = Centre of ith interval .

N = Number of individual observation .

Fi = Frequency of ith interval .

n = Number of intervals .

4- Drawing of relative frequency curve for each set of grouped data .

Example :- Form the relative frequency distribution table for density , using the observation found in Table (2.5) to Table (2.29) .

Steps of solution :-

1- Divide the space into the following intervals :-
40-80, 81-99, 100-119, 121-139, 140-160, 161-179, 180-200, 201-219, 220-240, 241-259, 260-280, 281-299, 300-500 .

2- Refer to tables (from 2.5 to 2.29) and determine the frequency of observation in each interval .

3- Refer to Table (2.5) - Table (2.29) you will find 489 observations of loose density and 59 observation of density of unsorted household refuse , Table (3.6) shows the results of loose density .

Table (3.6)

Relative freguency analysis (example) .

Interval	Centre of interval kg/m^3	Frequency	Relative frequency
40 - 80	60	46	9.41
81 - 99	90	61	12.47
100 - 120	110	83	16.97
121 - 139	130	76	15.54
140 - 160	150	76	15.54
161 - 179	170	47	9.61
180 - 200	190	38	7.77
201 - 219	210	14	2.86
220 - 240	230	17	3.98
241 - 259	250	9	1.84
260 - 280	270	11	2.25
281 - 299	290	3	0.61
300 - 500	400	8	0.64

4- Relative frequency calculated by this relation :-

$$\text{Relative frequency} = \frac{\text{Frequency}}{\text{Sum of individual reading}} * 100$$

5- Mean and standard deviation are calculated by using eq.(3.1) and eq.(3.2) respectively, mean = 143 kg/m^3 and standard deviation = 61.2 kg/m^3 .

6- Relative frequency curve of loose density is drawn in Fig. (3.1) .

In the same way Table (3.7) to Table (3.13) are constructed and relative frequency curves for generation rate , physical composition, and physical characteristics of household refuse are drawn these are in Fig. (3.1) to Fig. (3.11) .

Table (3.14) contains a summary of Table (3.6) up to Table (3.13) . It may be appropriate to note that the mean and standard deviation of the grouped data are an estimation of the means and standard deviations of of individual observations of the grouped observations approximately equal to the standard deviaton of individual observations , this assumption is used in section 3.2 .

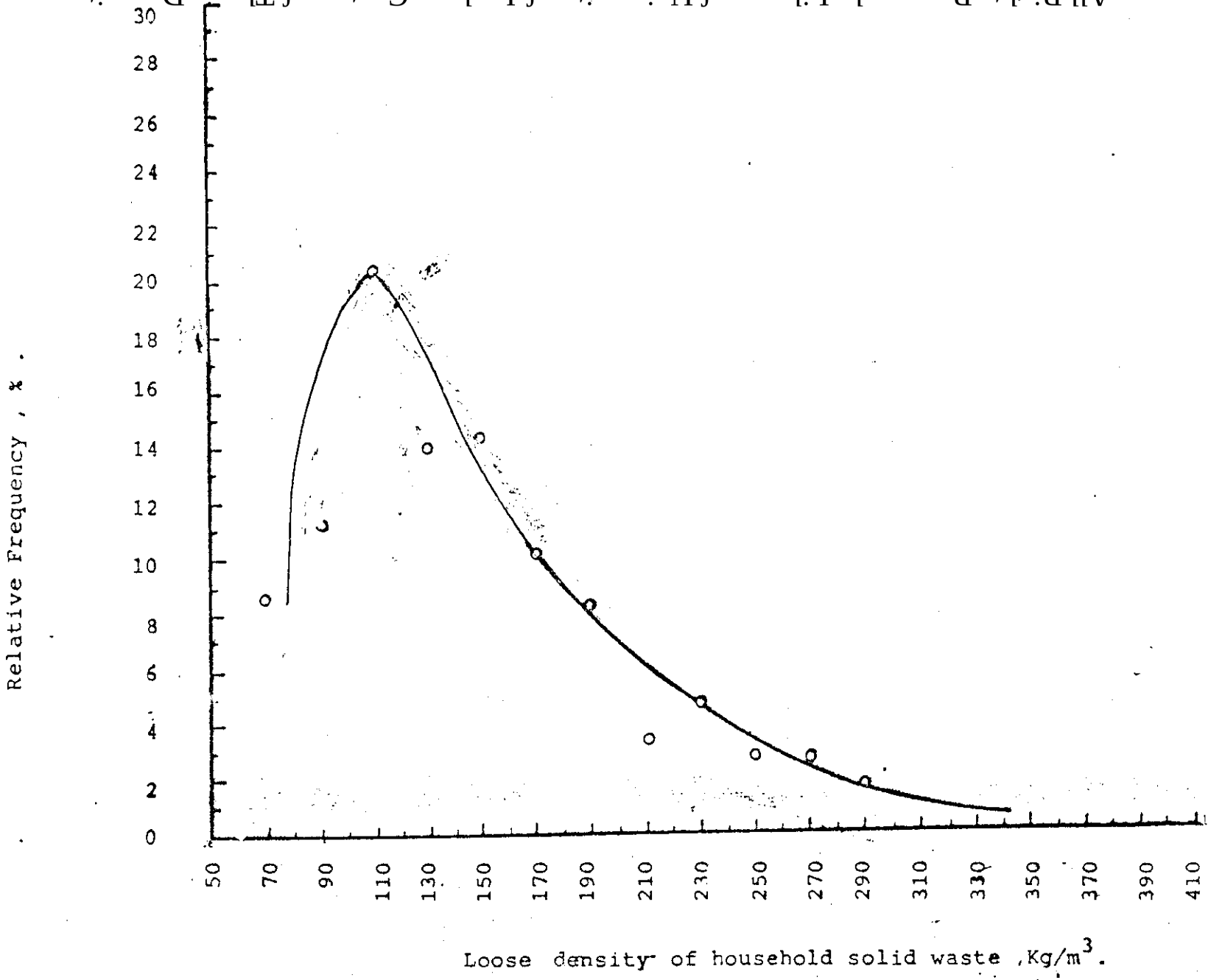


Figure (3.1) : Relative frequency distribution curve for loose density of household solid waste generated in Greater Amman Municipality .

Figure (3.2) : Relative frequency distribution curve for household solid waste generation rate in Greater Amman Municipality .

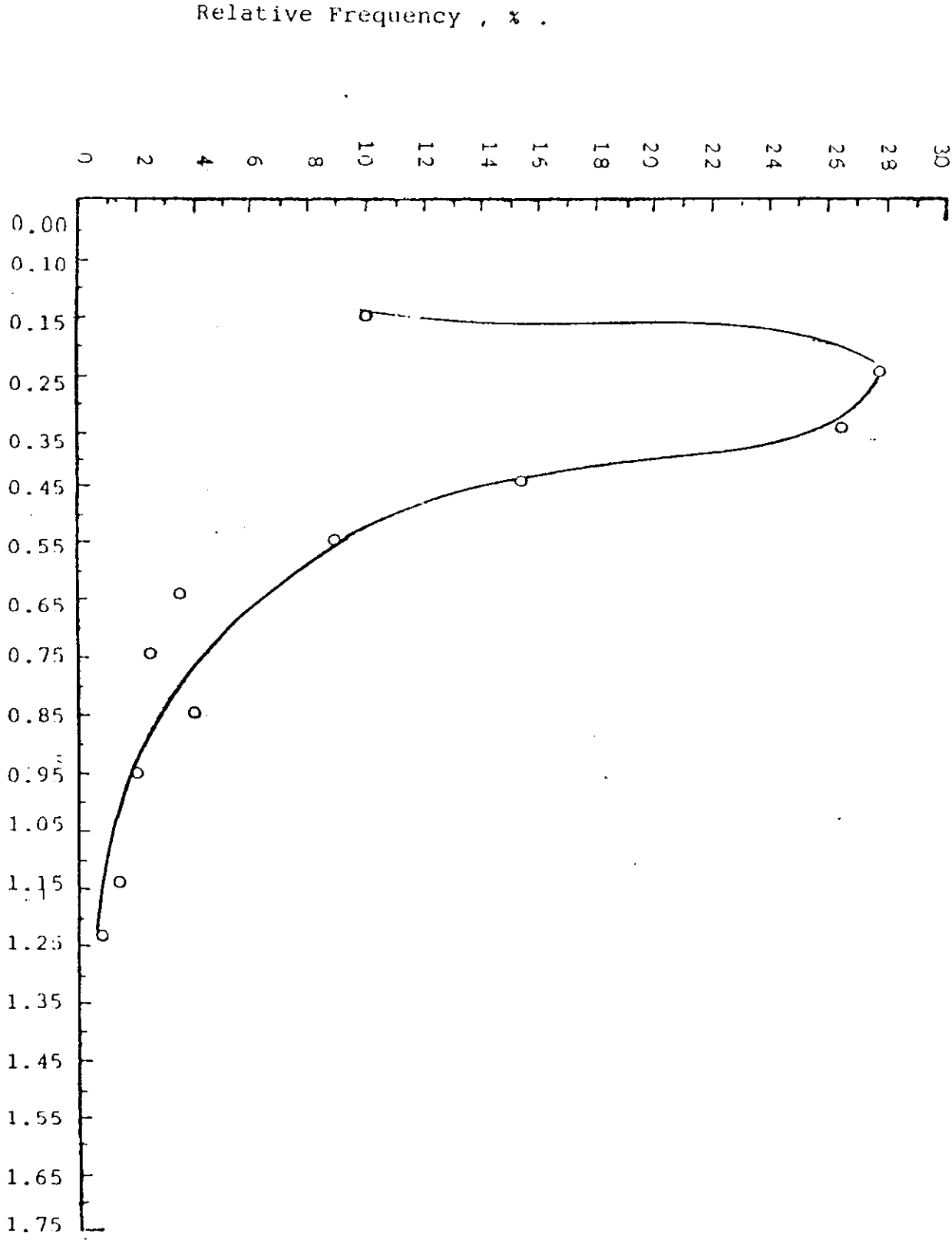


Figure (3.3) : Relative frequency distribution curve household solid waste generation rate in Greater Amman Mnuicipality .

Figure (3.4) : Relative frequency distribution curve for Food waste percentage in household solid waste generated in Greater Amman Municipality.

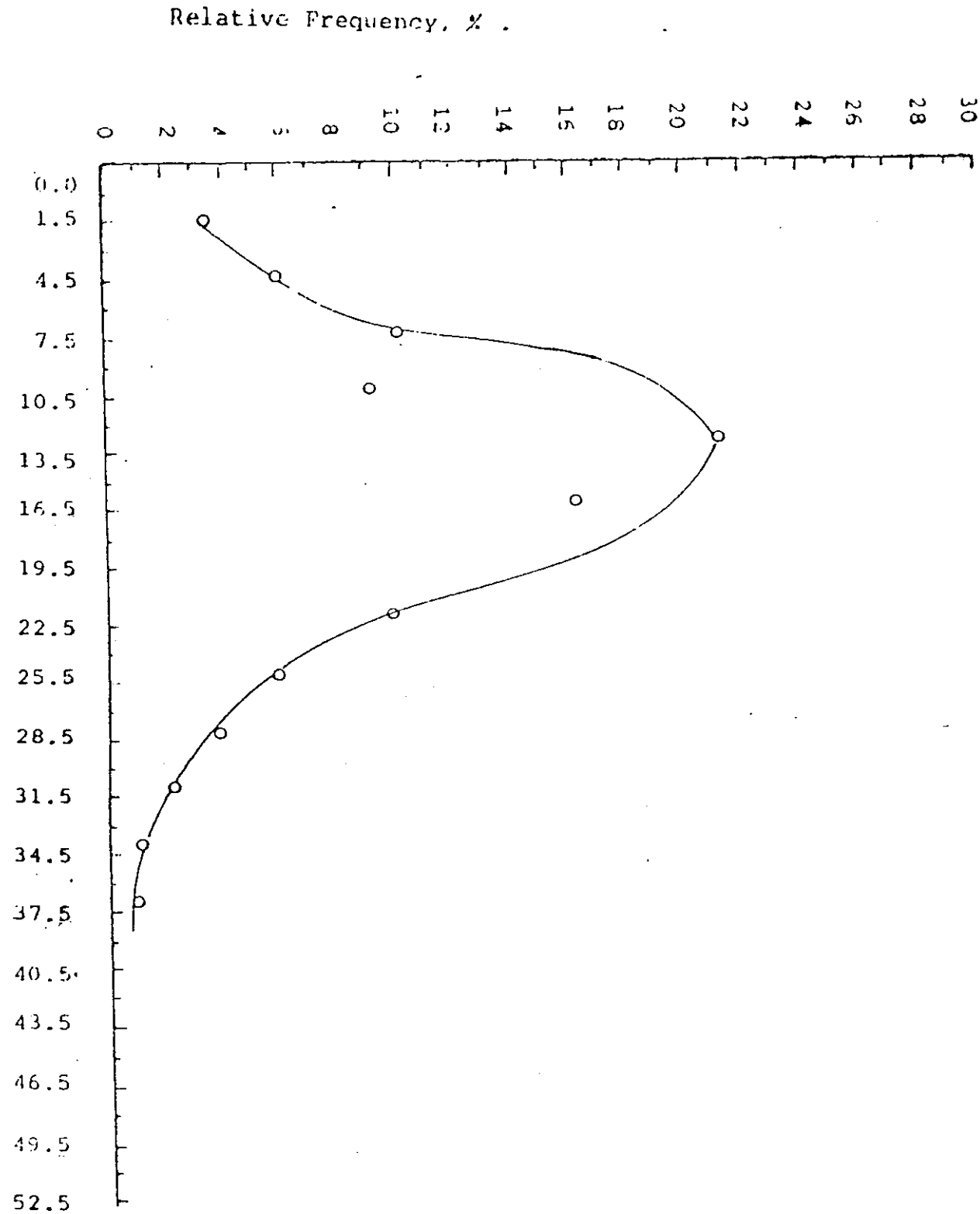


Figure (3.5) : Relative frequency distribution curve for Paper percentage in household solid waste generated in Greater Amman Municipality .

Figure (3.6) : Relative frequency distribution curve for Cardboard percentage in household solid waste

Figure (3.7) : Relative frequency distribution curve for Plastic percentage in household solid waste generated in Greater Amman Municipality .

Figure (3.8) : Relative frequency distribution for curve Leather percentage in household solid waste generated in Greater Amman Municipality .

Figure (3.9) : Relative frequency distribution curve for Wood precentage in household solid waste generated in Greater Amman Municipality .

Figure (3.10) : Relative frequency distribution curve for Glass precentage in household solid waste generated in Greater Amman Mnuicipality .

Figure (3.11) : Relative frequency distribution curve for Tins and cans percentage in household solid waste generated in Greater Amman Municipality .

3.1.2 Linear regression :-

Linear regression is used to determine the parameter of the best linear equation between two variables the first one is independent , X and the second is dependent , Y . Thus linear reqression gives us the most suitable values of A,B in equation 3.3 .

$$Y = A + BX \quad \text{.....Eq.(3.3)}$$

The value A, B, and corelation coefficient can be calculated by using eq. (3.4) , eq. (3.5) and equation (3.6)

$$B = \frac{n \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{n \cdot \Sigma x^2 - (\Sigma x)^2} \quad \text{.....Eq.(3.4)}$$

$$A = \frac{\Sigma y - B \cdot \Sigma x}{n} \quad \text{.....Eq.(3.5)}$$

$$r = \frac{n \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{\sqrt{[n \cdot \Sigma x^2 - (\Sigma x)^2][n \cdot \Sigma y^2 - (\Sigma y)^2]}} \quad \text{..Eq.(3.6)}$$

Where

X = Independent variables .

Y = Depednent variables .

n = No. of individual observations .

r = Correlation coefficient .

Table (3.7)

Loose Density , kg/m^3.

Density, kg/m^3 frequency intrval	Centre of density interval, kg/m^3 .	Frequency Number (N)	Relative Frequency, %
40- 80	60	46	9.41
81- 99	90	61	12.47
100-120	110	83	16.97
121-139	130	76	15.54
140-160	150	76	15.54
161-179	170	47	9.61
180-200	190	38	7.77
201-219	210	14	2.86
220-240	230	17	3.48
241-259	250	9	1.84
260-280	270	11	2.25
281-299	290	3	0.61
300-500	400	8	1.64

Table (3.8)

Generation rate , kg/c/d .

Generations rate, kg/c/d, Frequency interval	Centre of Frequency interval, kg/c/d.	Frequency Number (N)	Relative Frequency%
0.10-0.20	0.15	54	9.85
0.21-0.29	0.25	150	27.37
0.30-0.40	0.35	143	26.09
0.41-0.49	0.45	84	15.33
0.50-0.60	0.55	48	8.76
0.61-0.69	0.65	17	3.10
0.70-0.80	0.75	14	2.55
0.81-0.89	0.85	8	1.46
0.90-1.00	0.95	11	2.01
1.01-1.09	1.05	2	0.36
1.10-1.20	1.15	4	0.73
1.21-1.29	1.25	8	1.46
1.30-2.00	1.65	4	0.73
2.01-4.00	3.00	1	0.18

Table (3.9)

Generation rate , Litre/c/d* .

Generation rate, L/c/d, frequency interval	Centre of frequency interval, L/c/d	Frequency Number (N)	Relative Frequency,%
0.50- 1.00	0.75	31	6.3
1.01- 1.49	1.25	53	10.84
1.50- 2.00	1.75	69	14.11
2.01- 2.49	2.25	100	20.44
2.50- 3.50	3	99	20.24
3.51- 4.99	4.25	82	16.76
5.00- 6.50	5.75	27	5.52
7.00- 8.00	7.75	11	2.25
8.01- 9.99	9	3	0.61
10.00-12.00	11	3	0.61
12.01-15.99	14	8	1.64
25.00-27.00	26	2	0.41
42.00-43.00	42.5	1	0.20

*Based on onsite sorting of household refuse samples .

Table (3.10) : Relative frequency analyses

Percent interval, % total weight of household refuse .	Centre of interval, % by total weight .	Some of household refuse components											
		Cardboard		Plastic		Leather		Wood		Glass		Tins and cans	
		Fregency Number (N)	Relative frequency%	Freqency Number (N)	Relative frequency%	Frequency Number (N)	Relative frequency%	Frequency Number (N)	Relative freqency%	Frequency Number (N)	Relative frequency%	Frequency Number (N)	Relative frequency%
0 -2	1	37	7.6	120	24.5	331	67.7	405	82.8	218	44.6	183	37.4
2.01-3.99	3	62	12.7	205	41.9	56	11.5	33	6.7	79	16.2	100	20.4
4 -6	5	76	15.5	102	20.9	36	7.4	16	3.3	85	17.4	116	23.7
6.01-7.99	7	70	16.2	30	6.1	19	3.9	15	3.1	41	8.4	49	10.0
8 -10	9	85	17.4	22	4.5	23	4.7	10	2.0	33	6.7	25	5.1
10.01-11.99	11	33	6.7	3	0.6	2	0.41	2	0.41	8	1.6	1	0.2
12 -14	13	52	10.6	3		10	2.0	6	1.2	10	2.0	10	2.0
19.01-15.99	15	25	5.1	2	0.4	6	1.2	2	0.41	2	0.4	2	0.41
16 -18	17	16	3.1			1	0.2			3	0.6	1	0.2
18.01-19.99	19	13	2.7	1	0.2					5	1.0		
20 -22	21	7	1.4			4	0.8			1	0.2		
22.01-23.99	23	1	0.2	1	0.2								
24 -26	25	3	0.61			1	0.2			4	0.8	2	0.41
Total		489		489		489		489		489		489	

Table (3.11) .

Percent interval, % by weight of household refuse .	Center of interval, % by weight .	some of household refuse components					
		Food waste		Percent interval, % by total weight of household refuse .	Center of interval, % by weight .	Paper	
		Frequency Number (N)	Relative frequency, %			Frequency Number (N)	Relative frequency, %
30 -35	32.5	13	2.7	0 -3	1.5	16	3.3
35.01-39.99	37.5	11	2.2	3.01-5.99	4.5	28	5.7
40 -45	42.5	32	6.5	6 -9	7.5	48	9.8
45.01-49.99	47.5	50	10.2	9.01-11.99	10.5	43	8.8
50 -55	52.5	50	10.2	12 -15	13.5	101	20.7
55.01-59.99	57.5	63	12.9	15.01-17.99	16.5	74	15.1
60 -65	62.5	80	16.4	18 -21	19.5	72	14.7
65.01-69.99	67.5	70	14.3	21.01-23.99	22.5	46	9.4
70 -75	72.5	66	13.5	24 -27	25.5	27	5.5
75.01-79.99	77.5	23	4.7	27.01-29.99	28.5	17	3.5
80 -85	82.5	19	3.9	30 -33	31.5	10	2.
85.01-89.99	87.5	8	1.6	33.01-35.99	34.5	4	0.8
90 -95	92.5	4	0.8	36 -39	37.5	3	0.6

Table (3.12)

Tins and cans

Moisture content interval, percent by wet weight	Centre of interval (moisture content,%)	Frequency number (N)	Relative frequency
0.00- 2.00	1	1	2.6
2.01- 3.99	3	2	5.1
4.00- 6.00	5	15	38.5
6.01- 7.99	7	8	20.5
8.00-10.00	9	7	17.9
10.01-11.99	11	5	12.8
12.00-14.00	13	1	2.6

Table (3.14) : Summary of results of type A and type B analysis . Household Refuse Generated in Greater Amman Municapility.

		Results of ungrouped observation, type A analysis		Results of grouped observation, type B analysis	
		Mean	Standard deviation	Mean	Standard deviation
moisture content,%	Food waste	81.2		81.5	5.1
	Paper	20.7		20.9	7.1
	Cardboard	15.3		15.1	6.8
	Plastic	7.4		7.7	2.2
	Leather	16.9		15.9	5.3
	Glass	7.4		7.2	2.8
	Tins and cans	6.9		6.9	2.8
	Loose density kg/m^3	143		143	61.2
	density, kg/m^3 *	240	67.9	247	81.7
	Food waste	61.3		60.8	12.7
	Paper	15.6		15.8	7.2
	Cardboard	8.3		8.4	5
	Plastic	3.6		3.7	2.8
	Leather	2.3		2.8	3.7
	Wood	1.1		1.9	2.3
	Glass	3.7		4.0	4.2
	Tins and cans	3.5		3.72	2.9
	Garden trimming	0.45		-	-
	Weight per capita perday (kg/c/d)	0.4		0.41	0.26
	liter/c/d	3.14		3.24	3.1
	liter/c/d*	2.17	1.7	2.24	1.4

*Based on unsorted household refuse samples .

Table (3.13) : Moisture content frequency table .

Food wast.			Paper.			Cardboard.		
Moisture content intervals,percent by wet weight.	Center of interval, (moisture conten,%)	Frequency Number (N)	Relative frequency %	Moisture content intervals,percent by wet wight.	Center of interval (moisture contents, %	Frequency Number (N)	Relative frequency %	Moisture content intervals,percent by wet weight.	Center of interval (moisture content,%)	Frequency Number (N)	Relative frequency %
60 -63	61.5	4	5.7	3.01-9.99	6 .5	4	5.8	3.01-9.99	6.5	14	20.6
66 -69	67.5	4	5.7	10 -13	11.5	6	8.7	10 -13	11.5	14	20.6
69.01-71.99	70.5	2	2.9	13.01-15.99	14.5	7	10.1	13.01-15.99	14.5	13	19.1
72 -72	73.5	7	10.0	16 -19	17.5	11	15.9	16.0 -19	17.5	10	14.7
75.01-77.99	76.5	5	7.1	19.01-21.99	20.5	10	14.5	19.01-21.99	20.5	8	11.8
78 -81	79.5	6	8.6	22 -25	23.5	9	13.0	22 -25	22.5	2	2.9
81.01-83.99	82.5	9	12.9	25.01-27.99	26.5	11	15.9	25.01-27.99	26.5	5	7.4
84 -87	85.5	12	17.1	28 -31	29.5	7	10.1	31.01-33.99	32.5	1	1.5
87.01-88.99	88.5	12	17.1	31.01-33.99	32.5	1	1.4	37.01-39.99	38.5	1	1.5
90 -93	91.5	7	11.4	34 -37	35.5	3	4.3				
Total		70				69				68	

Cont. Table (3.13) :

Plastic			Leather			Glass		
Moisture content intervals, percent by wet weight.	Centre of interval (moisture contant, %)	Frequency Number (N)	Relative frequency %	Moisture content intervals, percent by wet weight.	Centre of interval (moisture content, %)	Frequency Number (N)	Relative frequency %	Moisture content intervals, percent by wet weight.	Centre of interval (moisture content, %)	Frequency Number (N)	Relative frequency %
0 - 2	1	1	1.5	6 - 9	7.5	1	4.5	2.01- 3.99	3	6	14.6
2.01- 3.99	3	11	16.7	9.01-11.99	10.5	3	13.6	4 - 6	5	10	24.4
4 - 6	5	11	16.7	12 -15	13.5	5	22.7	6.01- 7.99	7	10	24.4
6.01- 7.99	7	14	21.2	15.01-17.99	16.5	5	22.7	8 -10	9	8	19.5
8 -10	9	15	22.7	18 -21	19.5	3	13.6	10.01-11.99	11	2	4.9
10.01-11.99	11	3	4.5	21.01-23.99	22.5	2	9.1	12 -14	13	5	12.2
12 -14	13	7	10.6	24 -27	25.5	3	13.6				
14.01-15.99	15	3	4.5								
16 -18	17	1	1.5								
Total		66				22				41	

Table (3.15) : Raw data required for linear regression analysis.

Independent variable (X) monthly income Per captia in JD.	Generated Quantity		Dependent Variables (Y) .								
	Kg/c/d.	L/c/d.	Kg/m³ Loose density	Physical household refuse composition .							
				Food Waste	Paper	Cardboard	Plastic	Leather	Wood	Glass	Tinsand cans	Garden trimming
200	0.96	12.1	088	53	19.1	9.7	6.6	2.4	1.7	3.7	3.6	0.00
100	0.42	3.4	141	61.1	16.7	7.3	4.2	2.5	2.2	2.2	3.5	0.38
90	1.02	5.4	207	61.6	7.3	7.7	4.7	7.9	0-0	4.8	5.9	0.00
88	0.39	3.2	134	46.9	27	14.0	2.7	1.5	0.8	4.2	2.8	0.00
82	0.44	4.1	120	49.3	19.9	14.2	5.5	2.1	1.5	2.4	4.8	0.00
81	0.32	2.6	129	60.8	17.7	9.7	3.2	1.2	1.2	2.2	3.1	0.00
80	0.58	4.1	162	66.9	14.9	7.6	2.6	1.1	0.3	3.5	3.0	0.00
70	0.28	1.5	206	62.8	22.2	3.5	2.6	2.2	0.4	4.1	2.3	0.00
50	0.36	2.4	162	61.7	13.5	7.9	3.3	3.2	1.5	3.1	3.3	0.36
46	0.48	3.2	206	73.3	9.2	5.9	2.2	1.0	1.6	4.2	2.5	0.00
43	0.32	1.9	181	69.4	12.8	4.5	3.6	2.0	0.0	5.1	2.5	0.22
42	0.36	2.4	161	62.6	13.9	8.1	5.9	2.62	0.1	2.9	4.5	0.00
33	0.23	1.5	161	58.2	14.9	8.2	1.8	4.4	0.9	8.7	2.8	0.20
31	0.26	2.4	122	47.8	24.8	2.9	2.8	2.3	2.5	3.5	3.4	0.00
25	0.33	2.5	153	65.7	14.4	7.8	3.5	1.4	1.1	2.6	3.3	0.30
23	0.41	2.6	183	63.8	14.2	10.5	2.6	1.3	1.5	3.4	2.7	0.00
22	0.29	1.8	172	72.2	9.3	6.0	1.6	2	0.3	4.5	3.7	0.00
21	0.27	2.6	119	64.6	16.5	6.3	3.3	2.4	0.5	2.5	4.1	0.00
19	0.25	2.1	129	62.7	16.7	9.3	3.5	1.2	0.9	2.7	3	0.00
18	0.29	2.2	159	52.9	12.0	8.7	4.6	1.7	2.7	5.8	4.1	4.8
17	0.30	2.5	120	57.2	15.7	10.5	5.1	1.9	0.0	5.1	4.6	0.00

The value of (r) must be > - 1 or <+1 . If r=+1 this means the xy-point lie exactly on the straight line given by Eq. (3.3) and since that rarely occurs in actual life, an error term (u) must be added to the Eq. (3.3) , the error term is due to the effect of factors other than independent variable (X) the effect of which on dependent variable (y) was calculated . Thus to determine the degree of correlation between dependent and independent variables the correlation coefficient is used (i.e if r = 0.70 , this means that 70% of change in dependent variable (y) is caused by change in independent variable (X) but 30% of change in (y) is due to other factors) and thus the use of correlation coefficient clears the effect of change of independent variable on dependent varaible .

The sign of correlation coefficient is explained as:-

1- If r is (+) this means that there is linear relation between X and Y .

2- If r is (-) this means that there is an inverse relation between X and y .

For the purpose of analysis we divided the factors which affect the generation , physical characteristics ,

physical composition of household refuse into two factors :-

1- Monthly Income per person (JD/person) .

2- Other factors :-

a) Season of the year .
b) Frequency of collection .
c) Charactristic of population .
d) Geographic location .
e) Public atitude .
f) Legislation .

By using the linear regression, we want to know, how much monthly income per person and other factors affects the follwoing :-

1- Productivity as kg/c/d .

2- Productivity as l/c/d .

3- Density as kg/m .

4- Physical composition of household refuse :-

- Percentage of food waste .
- Percentage of paper .
- Percentage of cardboard .
- Percentage of plastic .
- Percentage of leather .
- Percentage of wood .
- Percentage of glass .
- Percentage of tins & cans .

Analysis by using linear regression :-

Assume the following :-

X : Is the independent variable and it represents monthly income (JD/month) . Person .

Yi = Is the dependent variable of ith item, and it is defined clearly below .

Dependent variable	Symbol of dependent variable	Unit of dependent variable
1- Productivity of household refuse	Y1	kg/c/d
2- Productivity of household refuse	Y2	litre/c/d
3- Density of household refuse	Y3	kg/m^3
4- Food waste percentage in household refuse	Y4	%
5- Paper percentage in household refuse	Y5	%
6- Cardboard percentage in household refuse	Y6	%
7- Plastic percentage in household refuse	Y7	%
8- Leather percentage in household refuse	Y8	%
9- Wood percentage in household refuse	Y9	%
10- Glass percentage in household refuse	Y10	%
11- Tins&cans percentage in household refuse	Y11	%

u = Is the error term , it is included to explain the effect of other factors (i.e season, literacy, size of family etc.) .

Yi = A + BX + u ..... Eq. (3.7) , i = 1,2,.....11.

The constants A, B in Eq. (3.7) must be determined for ith item shown in Table (3.15) , Table (3.16) shows value of A and B for item and also the correlation coefficient (r) relevant to each item .

Table (3.16)

Shows values of A, B, and r to each dependent variable , the independent variable is monthly income per person for all dependent variables .

Dependent variables	Unit of dependent variables	(A)	($B*10^3$)	Correlation coefficient (r)
Y1	kg/c/d	0.2	3.65	+0.75
Y2	l/c/d	0.6	45.2	+0.87
Y3	kg/m^3	165.7	-220	-0.29
Y4	%	63.6	52	-0.30
Y5	%	14.1	31	+0.27
Y6	%	7.2	15.9	+0.24
Y7	%	2.8	14	+0.46
Y8	%	1.95	6.2	+0.18
Y9	%	0.9	2.33	+0.12
Y10	%	4.2	-6.5	-0.18
Y11	%	3.4	1.5	+0.07

The values of correlation coefficient was found to vary between -0.30 and +0.87 , this effect of per person monthly income and other factore (season ,.....etc) , may be defined as shown in Table (3.17) .

Table (3.17)

Shows the effect of per person monthly income and other factors (size of family, literacy.....etc.) on household refuse charcteristic, composition and generation rate .

Dependent variable, Yi and its unit	Range of effect of per capita monthly income on dependent variable	Range of effect of other factor (size of family,..etc.) on dependent variable	Nature of relationship between per capita monthly income an dependent variable
Generation rate, kg/c/d	+0.75	+0.25	linear prop.
Generation rate, l/c/d	+0.87	+0.13	linear prop.
Density, kg/m^3	-0.29	-0.71	Inversely prop.
Food waste, %	-0.30	-0.70	Inversely prop.
Paper, %	+0.27	+0.73	Linear prop.
Cardboard, %	+0.24	+0.76	Linear prop.
Plastic, %	+0.46	+0.56	Linear prop.
Leather, %	+0.18	+0.82	Linear prop.
Wood, %	+0.12	+0.88	Linear prop.
Glass, %	-0.18	-0.82	Inversely prop.
Tins & cans, %	+0.07	+0.93	Linear prop.

It is clear that :-

1- Generation rate as kg/c/d and l/c/d , percentage of paper, cardboard, plastic, leather, wood, and tins & cans are linearl y proportional to the per capita monthly income .

2- Percentage of food waste, glass and density of household refuse are inversely proportional to the per person monthly income .

3- The effect of per capita monthly income on generation rate, as kg/c/d or l/c/d is high since 75%, and 87% of change in generation rate (kg/c/d , l/c/d) is caused by per person monthly income , this behaviour is expected because as the per person monthly income incearsed the purchasing power increased and the generation rate (in the two forms as kg/c/d , litre/c/d) is increased also .

4- relation between density of household refuse and per person monthly income is inversely proportional , this phenomena is expected , since as the per person monthly income increased precentage of food waste is decreased and percentage of paper , cardboard , plastic, and leather increased thus density decreased as per person monthly income increased .

5- From Table (3.17) it was found that the relation between per person monthly income and percent of glass is inversely porportional and the effect of per person monthly income on percentage of tins and cans was small , 7% only .

3.1.3 Assumption of analysis :-

Here we have the following random variables :-

1- Generation rate as , kg/c/d .

2- Generation rate as , litre/c/d .

3- Density as , kg/m^3 .

4- Physical components of household refuse .

Figure (3.12) shows a normal distribution curve with mean = 0 , and standard deviation equal to 1.0 , where the X-axis represents the units of random variables and the Y-axis represents the probabilitys of occurrence of random variable values , the main characteristics of normal distribution curve are :-

1- Area under the curve = 1.0 .

2- Probability of occurrence of single value of random variable = 0.0 (Zero) .

3- Probability $(X - \sigma < X < X + \sigma) = 68.27\%$.

Assumption :-

1- Assume the distribution of defined random variables are normal distribution .

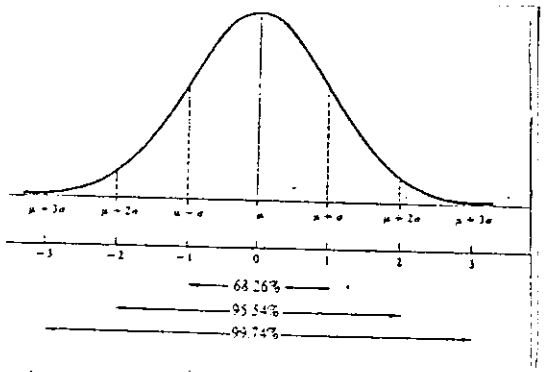
2- Assume the standard deviation of grouped observations is (that standard deviation which was calculated by using type "B" analysis in sec. 3.1.1) equivalent to the standard deviation of ungrouped observations. Therefore , for defined random variables two measure

were calculated for each random variable these are :-

i) Mean of random variables calculated by type "A" anaylsis in section (3.1.1) .

ii) Standard deviation of random variables calculated by type "B" analysis in section (3.1.1) .

iii) Assume the points of generation of this study are considered to be a representative sample of G.A.M.



X, unit of random variable .

Fig. (3.12) Normal distribution curve , Ref. <21>.

3.2 Results of analysis

This study was performed during October, November, December, 1985, January and February 1986, by using the collected data during that time and the assumption in section (3.1.3) . It is appropriate to determine the parameters mentioned with a confidence degree of 68.27%.

3.2.1 Household refuse composition in G.A.M.

By using the data avialable in Table (3.14) , with a degree of confidence of 68.27% , the average of the physical composition of household refuse is shown in Table (3.18) .

Table (3.18)

Typical physical composition of household refuse generated in G.A.M.

Component	Percent by weight, % Range	Typical
Food waste	48.6 - 74	61.3
Paper	8.4 - 22.8	15.6
Cardboard	3.3 - 13.3	8.3
Plastic	0.8 - 6.4	3.6
Leather	0 - 6	2.3
Wood	0 - 3.4	1.1
Glass	0 - 7.9	3.7
Tins & cans	0.6 - 6.4	3.5
Garden + trimming	-	0.45

* Leather : Include leather textile and dust .

3.2.2 Household refuse characteristics in G.A.M.

Main refuse characteristics investigated in this study are :-

- Loose density of household refuse .
- Density of unsorted household refuse .
- Moisture content of each component of household refuse .

By using the data shown in Table (3.14) with a degree of confidence of 68.27% , the range and typical values of household refuse loose density , density of unsorted household refuse , and the range and typical values of moisture content of each component of household refuse are shown in Table (3.19) and Table (3.20) respectively .

Table (3.19)

Typical density of household refuse in G.A.M.

	Range (kg/m^3)	Typical (kg/m^3)
Loose density	81.8 - 204.2	143
Density of unsorted refuse	158.3 - 321.7	240

* Loose density based on loose volume ; loose volume is the sum of the volumes of each component of refuse after sorting .

Table (3.20)

Typical data on moisture content of household refuse in G.A.M.

Component	Moisture contnent, percent by wet weight, %	
	Range	Typical
Food waste	76.1 - 86.3	81.2
Paper	13.6 - 27.8	20.7
Cardboard	8.5 - 22.1	15.3
Plastic	5.2 - 9.6	7.4
Leather	11.6 - 22.2	16.9
Glass	4.6 - 10.2	7.4
Tins & cans	4.1 - 9.7	6.9

3.2.3 Household refuse quantities in G.A.M.

Volume and weight of the generated refuse greatly influence the system of collection , transport and disposal . Therefore a determination of quantity and volume generation rate are essential . By using data shown in Table (3.14) the range and typical generation rate in the form of kg/c/d and l/c/d are shown in Table (3.21A) (3.21B) respectively the degree of conif-dence of these values is 68.27% .

Table (3.21A)

Typical generation rate per capita of household refuse .

	Unit rate, kg/c/d	
	Range	Typical
Household refuse .	0.14 - 0.66	0.4

Table (3.21B)

Typical generation rate per capita of household refuse .

	Range (l/c/d)	Typical (l/c/d)
Generation rate of unsorted household refuse	0.37 - 3.97	2.17
Generation rate of sorted household refuse	0.04 - 6.24	3.14

3.3 Discussion of the obtained results .

3.3.1 Physical Composition of household refuse in G.A.M.

The study reveales that food waste , paper and cardboard were the most predominant components of household refuse , comprising average of 85.2% of the whole waste . The food waste was the largest of all item and had an average of 61.3% . These results are similar to the results obtained , HAWKSELY <15>, Rashaideyh <13>, Hani <22> and Natoure <9> .

The study revealed that household contains a very small fraction of garden trimming with an average value of 0.45% .

These results are within the known ranges . see Table (1.16) .

3.3.2 Characteristics of household refuse in G.A.M.

The present investigation revealed that the loose density of onsite sorting of household refuse was 143 kg/m while the density of unsorted household refuse was 240 kg/m , the later value was approximately equal to that obtained by HAWKSELY <15> , and Rashaideyh <13> and it agrees with the known information related to Asian countries , Table (1.16) . It is obvious that

the loose density was less than the density of unsorting household refuse , this difference may refer to the reduction of total volume of refuse which was caused by unsorting of refuse components due to :-

1- The effect of moisture of food waste fraction on volume of paper, cardboard, leather and textile .

2- The effect of increased compaction due to transportation of refuse from generation site to laboratory .

Therefore the density of unsorted refuse will be greater than loose density . For the purpose of computing the capacity of the onsite storage container and the fleet of collection vehicles required , the effect of transport on density of unsorted refuse has to be removed . The author recommends a value of 200 kg/m^3 to be used in computation of onsite storage container capacity and the number of collection vehicles required .

The calculated moisture content of food waste , paper, cardboard, leather, glass and tins & cans was 81.2% , 20.7% , 15.3% , 7.4% , 16.9% , 7.4% , 6.9% , (by wet weight) respectively . The approximate over all moisture contnent is within the known range of Asian countries , Table (1.16) , but it is greater than the

moisture content of refuse in U.S.A and U.K , this rise in value is justified because G.A.M household refuse has a greater food waste fraction and smaller paper, plastic, and cardboard than that of U.S.A refuse and U.K refuse.

The moisture content of the compostable protion of G.A.M household refuse (food waste, paper, and cardboard) was 63.7% . The typical moisture content for the composting process is 50 - 60% by wet weight . Therefore the moisture content of the compostable portion of G.A.M household refuse seem to be suitable for the composting process but there is a lack of information of G.A.M household refuse to determine the suitablity of it for the composting process .

3.3.3 Quantities of household refuse :-

The study reveales that the generation rate of household refuse in G.A.M was 0.4 kg/c/d , which agrees with known generation rate of Asian countries , Table (1.16), and the value determined by HAWKSELY <15> . However it is samller than the value obtained by Rashideyh <13> and Hani <22> . This situation may be explained as follows :-

1- Reshaideyh performed his study during the Ramadam period of 1984 which was in June while Hani performed

his study during the summer month of July 1986 . The generation rate would be maximized during the summer months becasue .

a) During summer the Jordanians working abroad usually come back for a holiday visit and thus a rise in the generated quantities of refuse is expected due to the increased number of people in Amman . However in the two studies mentioned above the effect of Jordanians who work abroad and visit Jordan , espically Amman , in the summer wasn't taken into consideration when the generation rate was calculated .

b) Indiginous vegetable and fruit produce available during the summer season (like water melon , oranges , ...etc.) .

c) The generation rate was expected to rise during the fasting month of Ramadan , Rashaideyh <13> .

2- Rashaideyh and Hani determined the generation rate per captia as they take into account refuse generated by :-

a) Household activities .

b) Commercial activities .

c) Street sweeping .

The present investigation considers the household activity during the winter time falling at the end of the 1985 and the beginning of 1986 .

4 Conclusion :-

This study revealed the following results :-

1- The average generation rate of household refuse was 0.4 kg/c/d . Therefore , about 400 tonne/day of household refuse was generated per day in G.A.M . The value of 0.4 kg/c/d would be considered to be reasonable for spring and winter seasons for the G.A.M.

2- The overall moisture content of household refuse generated in the G.A.M was 56.4% which is equivlent to 224 tonne of water/day , but the moisture content of the compostable portion (food waste, paper, and cardboard) was 63.7% which seems to be very close to the suitable range of moisture content . This range of moisture content is considered to be suitable for the composting process .

3- Calorific value of household refuse generation in G.A.M was expected to be low because of the relativ-ely high moisture content .

4- Physical components of household refuse generated in G.A.M are food waste, paper, cardboard, plastic, leather, glass, tins & cans and garden trimming , where their percentages are 61.3%, 15.6%, 8.3%, 3.6%, 2.3%, 1.1%, 3.7%, 3.5% and 0.45 respectively .

5- It was found that the highest fraction was food waste fraction 61.3%by weight . There are many alternative

ways of benefiting commercially from this food waste fraction by utilising one of the following alternatives :-

a) Converting it into compost .

b) Converting it into animal feed .

c) Using it as an enviornment for unicell or mush-room cultivation .

d) Converting it into a recovered type of energy like gasification or liquification or waste derived fuel .

It is worth mentioning that Jordan import <23> was 18 millon JD for the year 1985 of animal feed . Therefore , it is worth mentioning that further research into this area of its effectiveness and commercial viability could prove to be important .

6- A density of 200 kg/m^3 was recommended to calculate the capacity of on the onsite storage container , temporary storage container (glavanised container) and number of collection vehicles .

7- A linear relationship was found relating the per person monthly income and generation rate , paper fraction , cardbaord fraction , plastic fraction , leather fraction , wood fraction and tins & cans fraction and an inversely proportional relationship was found between the per person monthly income and the loose density , food waste and glass fraction .

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ملخص

يهدف هذا البحث الى الوصول لمعلومات حول انتاجية النفايات المنزلية المقذوفه من قبل سكان عمان، وعلى وجه التحديد يهدف الى معرفة ما يلي :-

١- معدل انتاجية الفرد وزنا (كغم/فرد/يوم) وحجما (ليتر/فرد/يوم) من النفايات المنزلية.
٢- الخواص الفيزيائية للنفايات المنزلية (الكثافه، نسبة الرطوبة).
٣- نسب المكونات الفيزيائية للنفايات المنزلية (مخلفات الطعام، الورق....الخ).

ومما يجدر ذكره ان الوصول الى الاهداف المذكوره أعلاه يسهل الوصول الى أنسب نظام لجمع ونقل النفايات المنزلية والتخلص منها.

ولتحقيق الاهداف المذكوره أعلاه فلقد تم جمع ٥٤٨ عينة منتجه من قبل ٢٥ منزلا تم اختيارها في مناطق مختلفه من امانة عمان الكبرى وتم فرز ٤٨٩ عينة منها الى مكوناتها الفيزيائية فيما ابقيت ٥٩ عينة بدون فرزها الى مكوناتها الفيزيائية (وذلك لتحديد اثر عدم الفرز على كثافة النفايات الصلبة المنزلية) وتم اجراء الاختبارات اللازمه على هذه العينات.

ولقد توصل هذا البحث للنتائج التالية وأهمها ان معدل انتاج الفرد من النفايات المنزلية بلغ ٤٠٠ غم/فرد/يوم ، ٣,١٤ ليتر/فرد/يوم (للنفايات المنزلية المفروزه) ٢,١٧ ليتر/فرد/يوم (للنفايات الغير مفروزه) فيما بلغ معدل نسبة الرطوبة ٥٦,٤٪ ، أما المكونات الفيزيائية للنفايات المنزلية فكانت مخلفات الطعام ،

الـــورق، الكرتـــون، البلاستيك، الجلـــود، الاخشـــاب، الزجـاج، المعادن وتشذيـــب الحدائـــق فيمـا بلغـــت نسبتهـا ٦١,٣٪ ، ١٥,٦٪ ، ٨,٣٪ ، ٣,٦٪ ، ٢,٣٪ ، ١,١٪ ، ٣,٧٪ ، ٣,٥٪ ، ٠,٤٥٪ على الترتيب.