



SHORT COURSE ON SOLID WASTES
COLLECTION AND DISPOSAL

Damascus, 20-30 May 1968

EMRO 134

Lecture No. 1

Description of Solid Wastes

Definitions - these definitions are taken from the second edition of the publication, Municipal Refuse Disposal, prepared by the American Public Works Association, Chicago, Illinois, 1966.

- A. Waste
 - 1. Solids
 - 2. Liquids
 - 3. Gases
- B. Solids - Refuse; Classification by Point of Origin
 - 1. Domestic
 - 2. Institutional
 - 3. Commercial
 - 4. Industrial
 - 5. Street
 - 6. Construction and Demolition
 - 7. Agricultural
- C. Solids - Refuse; comprises all the solid wastes of the community; classification by kind or composition
 - 1. Garbage - defined as wastes from preparation, cooking and serving of food. It is comprised largely of putrescible organic matter; its natural moisture containing substance will consist largely of cellulosic-type materials, except for a certain amount of protein matter, fats, lipids and carbohydrates. Moisture content is approximately 72%. Largely the source of fly and insect problems and the cause of odors, rat and rodent attraction.

Market wastes - made up of the waste derived from wholesale-retail stores, markets, result of handling and storage and selling of food. Contains great quantities of putrescible garbage and some rubbish. Due to its putrescible nature, requires very frequent collection and proper storage.

2. Rubbish

- a. Combustible - in general, consists of miscellaneous burnable materials. Contains the high Btu components of refuse, provides the main source of heat for self-sustained incineration.

Organic components of rubbish are: paper, rags, cartons, boxes, barrels, wood, excelsior, tree branches, yard trimmings, wood furniture, rubber, leather, etc.

Inorganic combustible components of rubbish are:

plastics, in general not considered highly putrescible.

- b. Non-Combustible - consists of miscellaneous refuse materials that are unburnable at ordinary incinerator operating temperatures in a range of 1300^oF - 2000^oF; inorganic for the most part - tin cans, metals, dirt, ceramics, glass, etc. Relatively non-putrescible, but esthetically objectionable. May, however, contain in its cans and bottles food particles which will putrefy, causing odors, fly attraction and harborage and food for rodents. Rubbish contains lawn clippings, brush and other fibers, some of which may have quite a high moisture content, such as grass, which has 65% moisture. Grass, when dry, will burn very well but with such highbound moisture, it is very difficult to incinerate. Tends to mat together, results in bad odors when stored.

3. Ashes - residue from fires used for cooking and heating and from on-site incineration; residue from burning solid fuel, coal, wood, etc. May contain small portions of partially burned, or unburned fuel, some metal, glass and other non-combustible materials; are found in the ashes as presented for collection. Constitute a fire hazard due to the possibility of hot coals. Mixture is mostly inorganic. May be used in some instances as cover material, where low in organic content, and with enough binder to prevent dust.

4. Bulky Wastes - constitute such items as boxes and crates, large auto parts, trees and branches, stumps, driftwood, stoves, refrigerators and other large appliances, which in many cases, require special collections due to the size or weight of the object; it is impossible for normal collecting forces to handle them in their collecting containers or on their collecting vehicles.

5. Street Refuse - street and sidewalk sweepings, dirt, leaves, catch-basin dirt, contents of litter receptacles.
6. Dead Animals - cats, dogs, horses, cows; the animals that are killed or die naturally in the streets or on public property. Larger animals may be valuable from the standpoint of rendering and for their hides; small animals have to be removed quickly to avoid attraction of vermin, flies and development of odors and unsightly conditions.
7. Abandoned vehicles - unwanted cars and trucks left on public property; comprised mainly of passenger automobiles, trucks and trailers which have been abandoned, stripped in the street; must be removed and disposed of.
8. Industrial Wastes - food processing wastes, boiler house cinders, various process wastes. This is as varied as the industry from which it is derived. Since some may be hazardous in many respects, it should come under the general control of some regulatory agency for the protection of the public health and may best be disposed of by the industry itself.
9. Construction and Demolition Wastes - the debris from building and destroying buildings, mainly broken masonry, rubble, brick, plaster, roofing, pipe, scrap lumber and other construction materials, apt to be very bulky, heavy, difficult to dispose of, occupying large volumes in disposal sites and being made up of a good percentage of unburnable materials.
10. Special Wastes - hazardous solids, explosives, pathological wastes, radioactive materials, toxic materials. They require very careful handling and disposal to assure no human or animal contact for an adequate period of time, to assure that they become innocuous and do not represent a hazard in the environment. In general, it might be stated that these wastes are best disposed of by the institution or industry generating them since they are more aware of the potential danger; but they must be generally disposed of in an acceptable manner to assure the safety of the populace.
11. Sewage Treatment Residue - solids from coarse screenings and of grit chambers, dewatered sludge and septic tank and cesspool solids. Generally quite a hazard from the bacteriological standpoint; may be offensive odor-wise, and must be handled with a great deal of caution. The material should be as thoroughly dewatered as possible before being turned over to the solid wastes handling facilities, due to the increased hazard of contamination of ground and surface water by the high moisture content of the wastes.

12. Agricultural Wastes and Animal Wastes - principally the manures and crop residues from various agricultural activities, including dairying, livestock and poultry raising. These wastes are largely organic and very decomposable, so that they must be disposed of in a sanitary manner. They do, in many instances, lend themselves to conversion to a safe and useful by-product which may be of benefit to the surrounding area, either as a material to return to the soil, or in some other by-product.
13. Problem Wastes - defined in various ways; perhaps the most universal definition is a solid waste which does not fit any of the previous definitions or is a particular problem to a particular community under some particular circumstances. It may be anything from a littering problem beside the highway to a particular type of industrial or commercial refuse that presents peculiar problem to the community involved.
- B. Physical Characteristics - municipal refuse consists of various amounts of the several classes of refuse,

Table 1 *

Physical Components of Combined Refuse
in New York City, 1939, and Chicago, 1956-1958

		Per Cent by Weight									
		Organic					Inorganic				
Month	Year	Garbage	Paper	Wood	Grass	Misc.	Total	Metal	Glass	Ashes	Total
New York City, New York ¹											
Jan.	1939	5.7	12.4	0.3		1.0	19.4	4.3	4.0	72.3	80.6
Feb.		9.0	12.6	0.7		1.7	24.0	6.6	4.9	64.5	76.0
Mar.		9.7	20.6	0.3		2.1	32.7	7.4	7.3	52.6	67.3
Apr.		18.1	21.6	2.0		2.8	44.5	7.4	6.9	41.2	55.5
May		26.7	23.0	3.1		3.3	56.1	7.1	6.8	30.0	43.9
June		35.1	24.3	4.6		3.8	67.8	6.4	6.8	19.0	32.2
July		43.8	25.5	5.9		4.1	79.3	6.6	6.3	7.8	20.7
Aug.		23.1	37.6	3.8		7.4	71.9	11.6	5.1	11.4	28.1
Sept.		12.6	26.7	4.9		5.6	49.8	8.2	9.1	32.9	50.2
Oct.		10.1	31.0	2.6		3.8	47.5	8.9	4.0	39.6	52.5
Nov.		6.6	18.0	2.1		1.9	28.6	3.8	2.9	64.7	71.4
Dec.		3.5	9.0	0.8		0.8	14.1	3.1	1.9	80.9	85.9
Avg.		17.0	21.9	2.6		3.2	44.7	6.8	5.5	43.0	55.3

¹ from: Casimir A. Rogus, "Refuse Quantities and Characteristics," APWA Proc. National Conference on Solid Waste Research, 17-27 December 1963

* from: Refuse Collection Practice, APWA, 3rd Edition, 1966, p.38

Month	Year	Garbage	Paper	Wood	Grass	Misc.	Total	Metal	Glass	Ashes	Total
Chicago, Illinois ²											
Mar.	1956	6.4	50.1		o		56.5	18.5		25.0	43.5
Apr.		7.4	64.0		o		71.4	13.9		14.7	28.6
May		5.6	57.3		11.9		74.8	14.0		11.2	25.2
June		2.5	60.7		6.5		69.7	13.6		16.7	30.3
Oct.		3.5	56.0		4.5		64.0	11.9		24.1	36.0
Feb.											
Mar.	1957	6.1	49.2		o		55.3	17.5		27.2	44.7
Apr.		3.2	53.3		19.7		76.2	(9.3)	5.9	8.6	23.8
Sept.		3.6	42.0		23.0		68.6	(7.4)	5.4	18.6	31.4
Nov.		2.3	59.3		3.7		65.3	(5.2)	6.5	23.0	34.7
Feb.	1958	5.7	57.6		o		63.3	(11.6)	9.3	15.8	36.7
Feb.		1.5	56.3		o		57.8	(7.5)	6.0	28.7	42.2
Feb.		2.6	70.4		o		73.0	(8.0)	6.9	12.1	27.0
Apr.		1.5	63.7		o		65.2	(8.1)	5.8	20.9	34.8
June		0.8	54.7		34.4		89.9	(6.2)	3.5	0.4	10.1
Avg.		4.8	56.5		9.6		70.9	14.8		18.7	33.5

o. Analysis not performed; grass included with paper. () Not included in avg.

Note: Chicago - Each sample consists of one truck load of refuse (approximately three tons); March 1956 - March 1957 represents analysis of 4 to 10 loads each, April 1957 - June 1958 represents analysis of 1 to 3 loads each.

² from: Municipal Refuse Disposal, APWA, 1961

Physical characteristics obtained by segregating representative loads of refuse and weighing each component.

E. Chemical Composition of Components of Refuse.

Table 2 *

Composition and Analysis of an Average Municipal Refuse
From Studies made by Purdue University

Component	Per cent of All Refuse by Wt.	Moist- ure % by Wt.	Analysis in Per cent of Dry Weight							Calorific Value Btu Per Lb.
			Volatile Matter	Carb (C)	Hydr (H)	Oxyg (O)	Nitr (N)	Sulf (S)	Non- Comb. ¹	
			Rubbish, 61%							
Paper	42.0	10.2	84.6	43.4	5.8	44.3	0.3	0.20	6.0	7572
Wood	2.4	20.0	84.9	50.5	6.0	42.4	0.2	0.05	1.0	8613
Grass	4.0	65.0	--	43.3	6.0	41.7	2.2	0.05	6.8	7693
Brush	1.5	40.0	--	42.5	5.9	41.2	2.0	0.05	8.3	7900
Greens	1.5	62.0	70.3	40.3	5.6	39.0	2.0	0.05	13.0	7077
Leaves	5.0	50.0	--	40.5	6.0	45.1	0.2	0.05	8.2	7096
Leather	0.3	10.0	76.2	60.0	8.0	11.5	10.0	0.40	10.1	8850
Rubber	0.6	1.2	85.0	77.7	10.4	--	--	2.0	10.0	11330
Plastics	0.7	2.0	--	60.0	7.2	22.6	--	--	10.2	11368
Oils, paints	0.8	0.0	--	66.9	9.7	5.2	2.0	--	16.3	13400
Linoleum	0.1	2.1	65.8	48.1	5.3	18.7	0.1	0.40	27.4	8310
Rags	0.6	10.0	93.6	55.0	6.6	31.2	4.6	0.13	2.5	7652
Street										
Sweepings	3.0	20.0	67.4	34.7	4.8	35.2	0.1	0.20	25.0	6000
Dirt	1.0	3.2	21.2	20.6	2.6	4.0	0.5	0.01	72.3	3790
Unclass.	0.5	4.0	--	16.6	2.5	18.4	0.05	0.05	62.5	3000
Food Wastes, 12%										
Garbage	10.0	72.0	53.3	45.0	6.4	28.8	3.3	0.52	16.0	8484
Fats	2.0	0.0	--	76.7	12.1	11.2	0	0	0	16700
Noncombustibles, 24%										
Metals	8.0	3.0	0.5	0.8	0.04	0.2	--	--	99.0	124
Glass and Ceramics	6.0	2.0	0.4	0.6	0.03	0.1	--	--	99.3	65
Ashes	10.0	10.0	3.0	28.0	0.5	0.8	--	0.5	70.2	4172
Composite Refuse as Received										
All Refuse	100	20.7	--	28.0	3.5	22.4	0.33	0.16	24.9	6203

¹ Noncombustibles - ash, metal, glass and ceramics

* From Refuse Collection Practice, APWA, 3rd Edition, 1966, p.39

Chemical Analysis

1. Moisture - by drying at 75°C, note loss of weight
2. Volatiles - burn at 600-650°C, loss in weight
3. Carbon - burn in O₂, generate CO₂ collect and measure
(Approx. % of carbon - $\frac{\% \text{ volatile solids}}{1.8}$)

(Research at Purdue recommends 2.08, U.S.P.H.S. 1.85, range of 1.63 to 2.05.)
4. Nitrogen - Kjeldahl-Wilfarth-Gunning
Method of digestion and distillation of the NH₃ measures organic and ammoniacal nitrogen
5. Sulfur - Calorimeter - extract in the form of barium sulfate
6. Hydrogen - Combustion train
from Purdue studies $\% H = \frac{\text{vol. matter}}{15.0}$
7. Calorific Value - Calorimeter - gross value (HHV)

F. Characteristic Changes

1. More paper
2. Less garbage
3. Less ashes
4. Moisture content (Range low 15-20%, high 50-60%)
 - a. Seasonal
 - b. Garbage
5. Calorific value
 - a. Increases with more paper, less moisture
 - b. Avg. approx. 5000 Btu/lb. as received
(Value from Table 1 - 6203 Btu/lb. - dry weight basis;
20.7% moisture 6203 x 79.3 = 4920 Btu - wet weight basis,
as received.
On a dry weight, ash free (MAF) basis
(20.7% moisture, 24.9% non-combustible)
$$\frac{4920}{(1 - .207 + .249)} = 9060 \text{ Btu/lb. MAF}$$

- c. High calorific value from fats, oils, some plastics, rubber
(as high as 16,000 Btu/lb.)
- 6. Nutrient value (plant)
 - a. Nitrogen (.33%) largely from garbage
 - b. Phosphorous and potash - low (.5% to .1% or less)
- 7. Non-combustible
 - a. Small amount of combustible matter attached, i.e., paper, plastic. Btu content neglected.
 - b. Ashes - considered to neither add nor deplete Btu value

Some rather general expressions of refuse characteristics are:

Density	200-700 lb./cu. yd.
Total moisture	15-35%
% combustibles	50-75%
Calorific value	3000-5500 Btu/lb. as collected
% putrescibles	5-25%
% compostibles	30-60%
Fines (under 3/4 in.)	10-20%