JECRC Foundation

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE
DEPARTMENT OF CIVIL ENGINEERING

Class – VI Semester /III Year

Subject –S&HWM

Chapter –4(Characterization of solid waste)

Presented by – Teekam Singh (Assistant Professor)

Characterization of MSW

- Physical
  - Specific weight, moisture content, particle size and size distribution, field capacity, compacted waste porosity (permeability)
- Chemical
  - Important in evaluating alternative processes and recovery options
    - Proximate analysis, fusing point of ash, ultimate analysis (major elements), energy content
- Biological
  - Important in considering organic fraction
  - Corresponding to biodegradability and production of odor

Physical Properties

- Specific weight
  - Weight of material per unit volume
    - Kg/m^3, lb/yd^3
  - Sometime referred as density
  - Often reported as
    - Loose, compacted, uncompacted, as found in containers
  - Depend on
    - Geographic location, season of the year, length of time in storage

Specific weight of MSW

Components	Condition	Specific weight (lb/yd^3)*
Aluminum cans	Loose	50-74
	Flattened	250
Corrugated cardboard	Loose	350
Fines (dirt, etc.)	Loose	540-1,600
Food waste	Loose	220-810
	Baled	1,000-1,200
Glass bottles	Whole bottles	500-700
	Crushed	1,800-2,700
Magazines	Loose	800
Newsprint	Loose	20-55
	Baled	720-1,000
Office paper	Loose	400
	Baled	700-750

Specific weight of MSW

Components	Condition	Specific weight (lb/yd^3)*
Plastics	Mixed	70-220
	PETE, whole	30-40
	Baled	400-500
	HDPE, loose	24
	Flattened	65
Plastic film and bags	Baled	500-800
	Granulated	700-750
Steel cans	Unflattened	150
	Baled	850
Textiles	Loose	70-170
Yard waste	Mixed, loose	250-500
	Leaves, loose	50-250
	Grass, loose	350-500

Moisture Content of MSW

Component	Moisture content, %	
	Range	Typical
Residential		
➢ Aluminum cans	2-4	3
➢ Cardboard	4-8	5
➢ Fines (dirt, etc.)	6-12	8
➢ Food waste	50-80	70
➢ Glass	1-4	2
➢ Grass	40-80	60
➢ Leather	8-12	10
➢ Leaves	20-40	30
➢ Paper	4-10	6
➢ Plastics	1-4	2
➢ Rubber	1-4	2
➢ Steel cans	2-4	3
➢ Textiles	6-15	10
➢ Wood	15-40	20
➢ Yard waste	30-80	60

Component	Moisture content, %	
	Range	Typical
Commercial		
➢ Food waste	50-80	70
➢ Mixed	10-25	15
➢ Wood crates and pallets	10-30	20
Construction (mixed)	2-15	8

Physical Properties

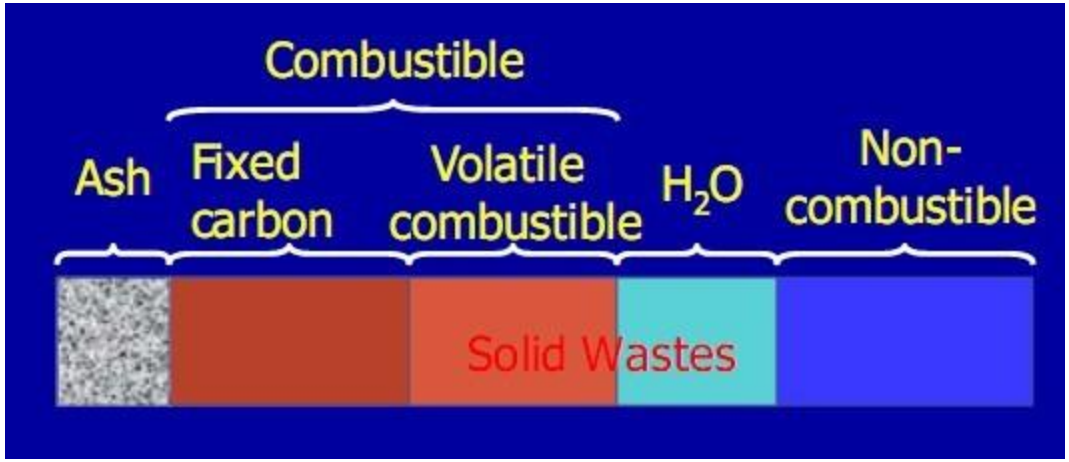
- Field capacity
  - Total amount of moisture that can be retained in a waste sample subject to downward pull of gravity
    - Determining the formation of landfill leachate
    - Water in excess will be released as leachate
  - Depend on
    - Applied pressure
    - State of decomposition of waste
- Permeability of compacted wastes
  - Or hydraulic conductivity
    - Important in governing the movement of gases and liquid in landfill site

Chemical Properties

- Used for
  - Determining alternative processing + recovery options
  - E.g: combustion, composting, etc.
  - To use MSW as fuel, it is to consider
    - Proximate analysis
    - Fusing (melting) point of ash
    - Ultimate analysis (major elements)
    - Energy content

Chemical Properties

- Proximate analysis = analysis for combustible components
  - Moisture content
  - Volatile combustible matter
  - Fixed carbon
  - Ash



Chemical Properties

Type of waste	Proximate analysis, % by weight			
	Moisture	Volatile matter	Fixed carbon	Non-combustible
Food and food products				
-Fats	2.0	95.3	2.5	0.2
-Food wastes (mixed)	70.0	21.4	3.6	5.0
-Fruit wastes	78.7	16.6	4.0	0.7
-Meat wastes	38.8	56.4	1.8	3.1
Paper products				
-Cardboard	5.2	77.5	12.3	5.0
-Magazines	4.1	66.4	7.0	22.5
-Newsprint	6.0	81.1	11.5	1.4
-Paper (mixed)	10.2	75.9	8.4	5.4
-Waxed cartons	3.4	90.9	4.5	1.2

Chemical Properties

Type of waste	Proximate analysis, % by weight			
	Moisture	Volatile matter	Fixed carbon	Non-combustible
Plastics				
-Plastics (mixed)	0.2	95.8	2.0	2.0
-Polyethylene	0.2	98.5	<0.1	1.2
-Polystyrene	0.2	98.7	0.7	0.5
-Polyurethane	0.2	87.1	8.3	4.4
-Polyvinyl chloride	0.2	86.9	10.8	2.1
Textiles, rubber, leather				
-Textiles	10.0	66.0	17.5	6.5
-Rubber	1.2	83.9	4.9	9.9
-Leather	10.0	68.5	12.5	9.0

Chemical Properties

Type of waste	Proximate analysis, % by weight			
	Moisture	Volatile matter	Fixed carbon	Non-combustible
Wood, trees, etc.				
-Yard wastes	60.0	30.0	9.5	0.5
-Wood (green timber)	50.0	42.3	7.3	0.4
-Hardwood	12.0	75.1	12.4	0.5
-Wood (mixed)	20.0	68.1	11.3	0.6
Glass, Metals, etc.				
-Glass and mineral	2.0	-	-	96-99+
-Metal, tin cans	5.0	-	-	94-99+
-Metal, ferrous	2.0	-	-	96-99+
-Metal, nonferrous	2.0	-	-	94-99+

Chemical Properties

Type of waste	Proximate analysis, % by weight			
	Moisture	Volatile matter	Fixed carbon	Non-combustible
Miscellaneous				
- Office sweepings	3.2	20.5	6.3	70.0
Residential MSW	21.0 (15-40)	52.0 (40-60)	7.0 (4-15)	20.0 (10-30)
Commercial MSW	15.0 (10-30)	-	-	
MSW	20.0 (10-30)	-	-	

Chemical Properties

- Fusing Point of Ash
  - Temp that cause ash (from burning wastes) → from a solid (clinker) by fusion and agglomeration
  - Typical range = 1,100-1,200 °C
  - May cause operational problems in incineration

Chemical Properties

- Ultimate analysis
  - To determine chemical composition
    - C, H, O, N, S and ash
    - Halogen group
      - Cl, Br, ….

- Data is used for
  - Determine C.N ratio for composting or biological conversion processes
  - Awareness of chlorinated compounds
    - Dioxin, Furan, etc

Chemical Properties – Ultimate analysis

Component	Percent by weight (dry basis)					
	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur	Ash
Organic						
- Food wastes	48.0	6.4	37.6	2.6	0.4	5.0
- Paper	43.5	6.0	44.0	0.3	0.2	6.0
- Cardboard	44.0	5.9	44.6	0.3	0.2	5.0
- Plastics	60.0	7.2	22.8	-	-	10.0
- Textiles	55.0	6.6	31.2	4.6	0.15	2.5
- Rubber	78.0	10.0	-	2.0	-	10.0
- Leather	60.0	8.0	11.6	10.0	0.4	10.0
- Yard wastes	47.8	6.0	38.0	3.4	0.3	4.5
- Wood	49.5	6.0	42.7	0.2	0.1	1.5
Inorganic						
- Glass	0.5	0.1	0.4	<0.1	-	98.9
- Metals	4.5	0.6	4.3	<0.1	-	90.5
- Dirt, ash, etc.	26.3	3.0	2.0	0.5	0.2	68.0

Chemical Properties

- Energy content

- Trace elements
  - K, Ca, Mg, Zn, Mn, Cu, Co, Ni, etc
  - Important for the production of biological conversion product as the essential nutrient

Chemical Properties – Energy contents

	Inert residue, percent		Energy, Btu/lb	
	Range	Typical	Range	Typical
Organic				
- Food wastes	2-8	5.0	1,500-3,000	2,000
- Paper	4-8	6.0	5,000-8,000	7,200
- Cardboard	3-6	5.0	6,000-7,500	7,000
- Plastics	6-20	10.0	12,000-16,000	14,000
- Textiles	2-4	2.5	6,500-8,000	7,500
- Rubber	8-20	10.0	9,000-12,000	10,000
- Leather	8-20	10.0	6,500-8,500	7,500
- Yard wastes	2-6	4.5	1,000-8,000	2,800
- Wood	0.6-2	1.5	7,500-8,500	8,000
Inorganic				
- Glass	96-99+	98.0	50-100	60
- Tin cans	96-99+	98.0	100-500	300
- Aluminum	90-99+	96.0	-	-
- Other metals	94-99+	98.0	100-500	300
- Dirt, ash, etc.	60-80	70.0	1,000-5,000	3,000
MSW			4,000-6,000	5,000

Biological Properties

- Organic fractions of MSW
  - Water soluble constituents
    - Sugars, starches, amino acid, organic acids, etc
  - Hemicellulose
  - Cellulose
  - Fats, oil, waxes
  - Lignin
  - Lignincellulose
  - Protein
- However, the important biological properties are to determine
  - Biodegradability of organic fractions

Biological Properties

- Biodegradability of organic fractions
  - Determined by volatile solid (VS) content
    - Ignition at 550 °C
  - But, may misinterpret for some components
    - Newsprint → high VS but low biodegradability
    - Food wastes → low VS but high biodegradability
- Production of odors
  - Resultant of anaerobic decomposition
    - SO_4^{2-} → reduced to sulfide $(S)^{2-}$ + combine with H → H_2S
  - Significant in a long storage and warm climate

Applications of MSW Properties& Composition

- To determine
  - Appropriate transformation processes
    - Separation, reduction, combustion, composting, etc
  - Improving efficiencies transformation processes
    - E.g. moisture content + C/N → composting reactions

- To design recovery methods
  - Reuse + recycling materials
  - Conversion products + energy