NPTEL ONLINE CERTIFICATION COURSES

Course Name: Introduction to Environmental Engineering and Science – Fundamentals and Sustainability Concepts

Faculty Name: Dr. Brajesh Kumar Dubey

Department : Civil engineering

Topic Basics of Wastewater Collection, Treatment & Resource Recovery

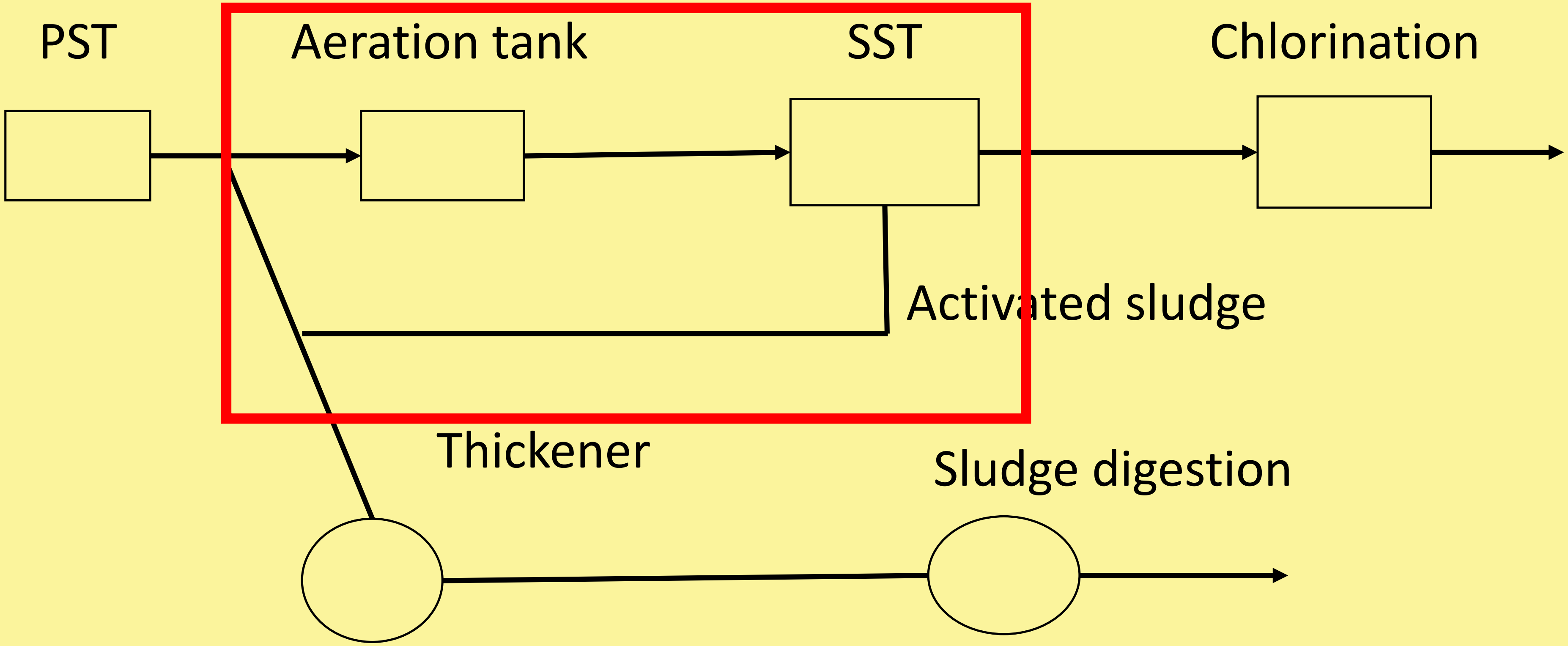
Lecture 45: Activated Sludge process and sludge disposal

Activated Sludge Process

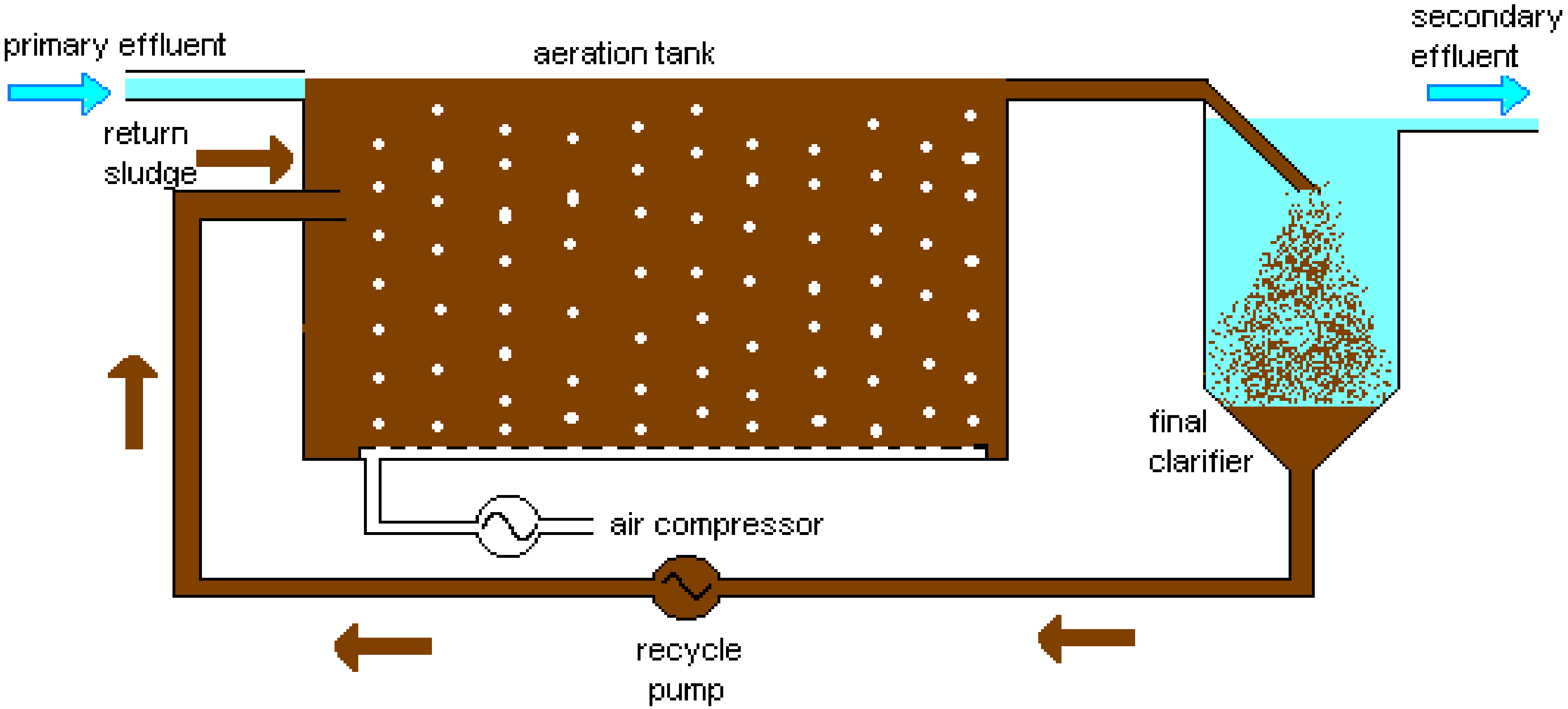
Activated Sludge : It is a sludge containing a large concentration of highly active aerobic micro organisms.

Principle: Activated sludge is mixed with raw sewage along with large quantity of air for about 4 to 8 hours in an aeration tank. The settled sludge in Secondary Sedimentation Tank is called activated sludge. It is again recycled to the head of aeration tank to be mixed with sewage being treated.

Activated sludge process



Components of ASP



Source: https://www.aboutcivil.org/activated-sludge-process-types

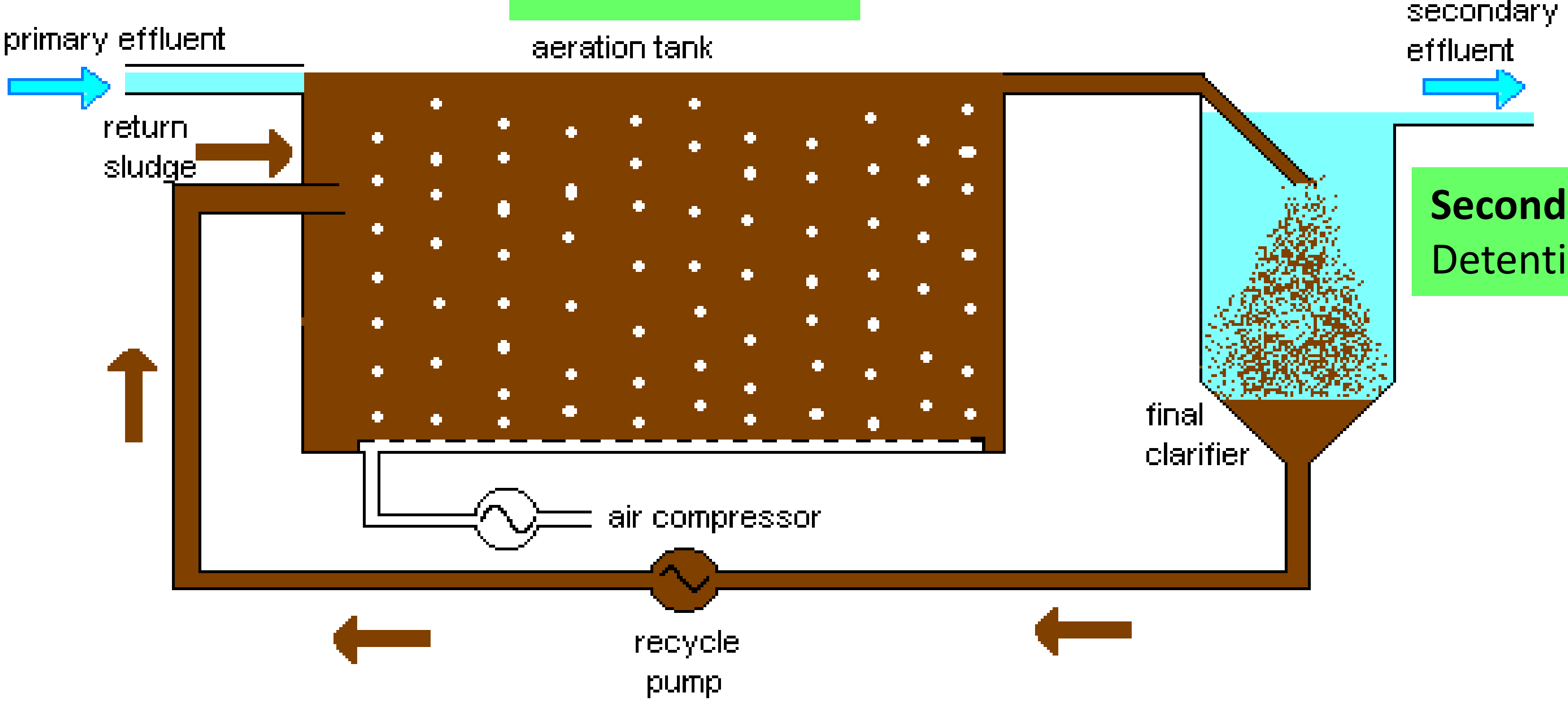
Primary settling tanks :

Lesser Detention time, i.e. , 1.5 to 2 hours

Co[...]of ASP

Aeration tank

Detention time : 4 to 8 hours



Secondary sedimentation tank :

Detention time : 1.5 to 2 hours

Source: https://www.aboutcivil.org/activated-sludge-process-types

Bulking of sludge and its control: Under sick conditions, the settled sludge may contain more moisture and thus resulting in swelling of sludge volume.
Due to sludge bulking, it remains in suspension and carried in the effluent of secondary clarifiers.

Remedial Measures:

i) Elimination of industrial wastage
ii) Chlorination of the sewage
iii) Increased aeration
iv) Raising the pH of sewage to 8 by adding lime

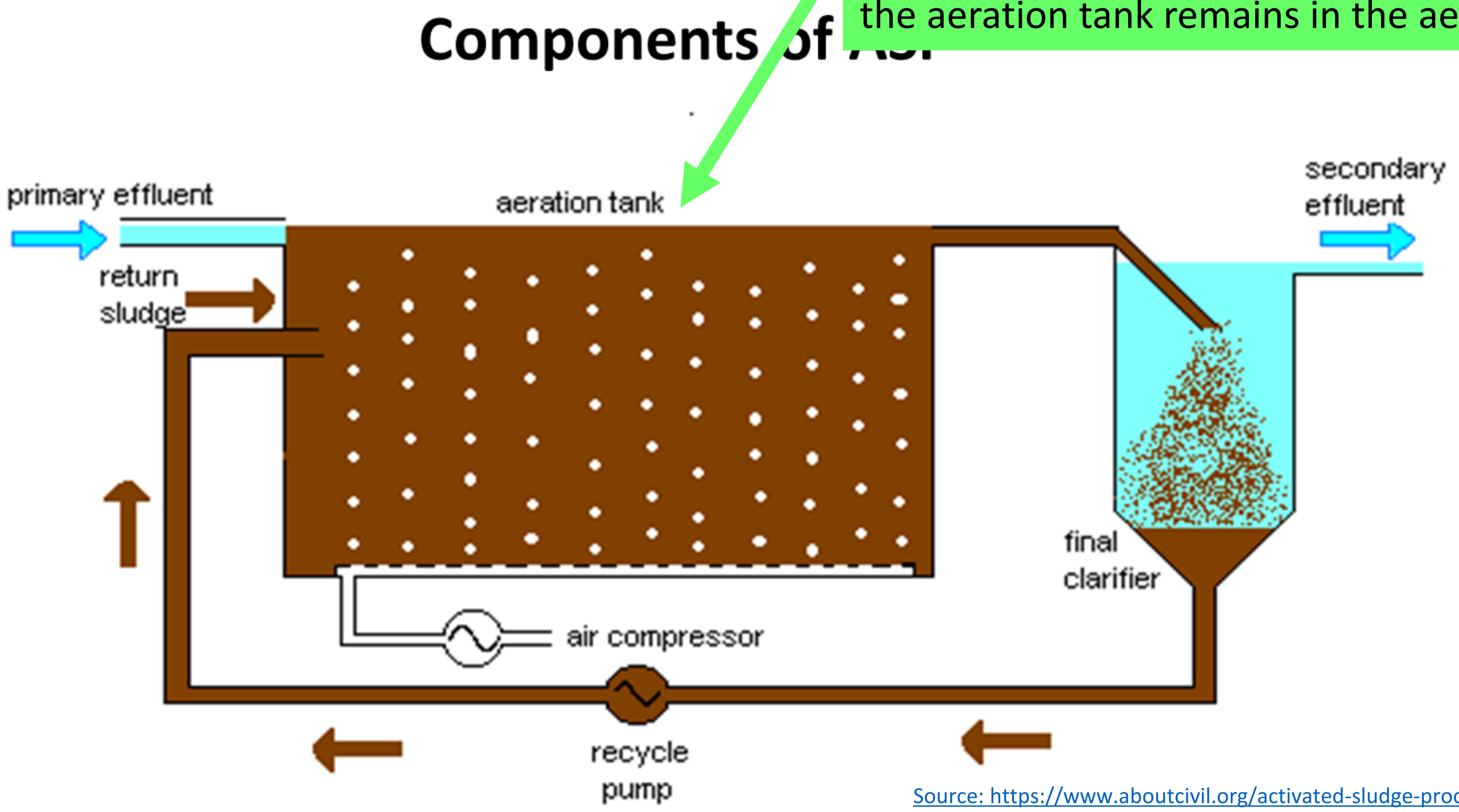
Activated Sludge process variables

Hydraulic Retention Time (HRT) = $\frac{Volume\ of\ the\ tank}{rate\ of\ sewage\ flow\ into\ the\ tank} = \frac{V}{Q}$

V = Volume of aeration tank

Q = Sewage inflow rate excluding sludge returned

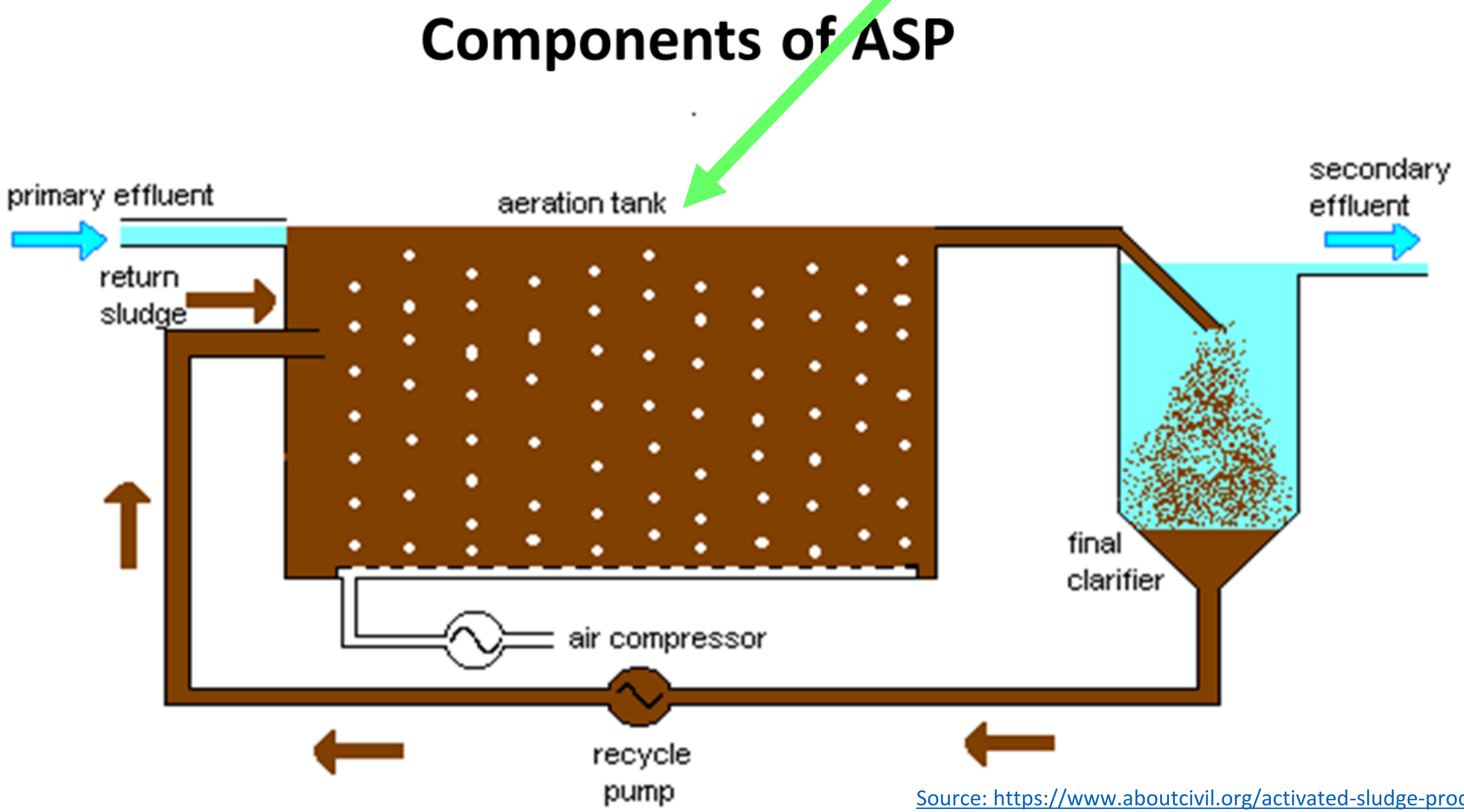
HRT is defined as an average time for which the sewage flowing into the aeration tank remains in the aeration tank.



Source: https://www.aboutcivil.org/activated-sludge-process-types

Activated Sludge process variables

Volumetric BOD loading or (Volumetric Organic loading) (u) :
It is defined as BOD load applied per unit volume of aeration tank.

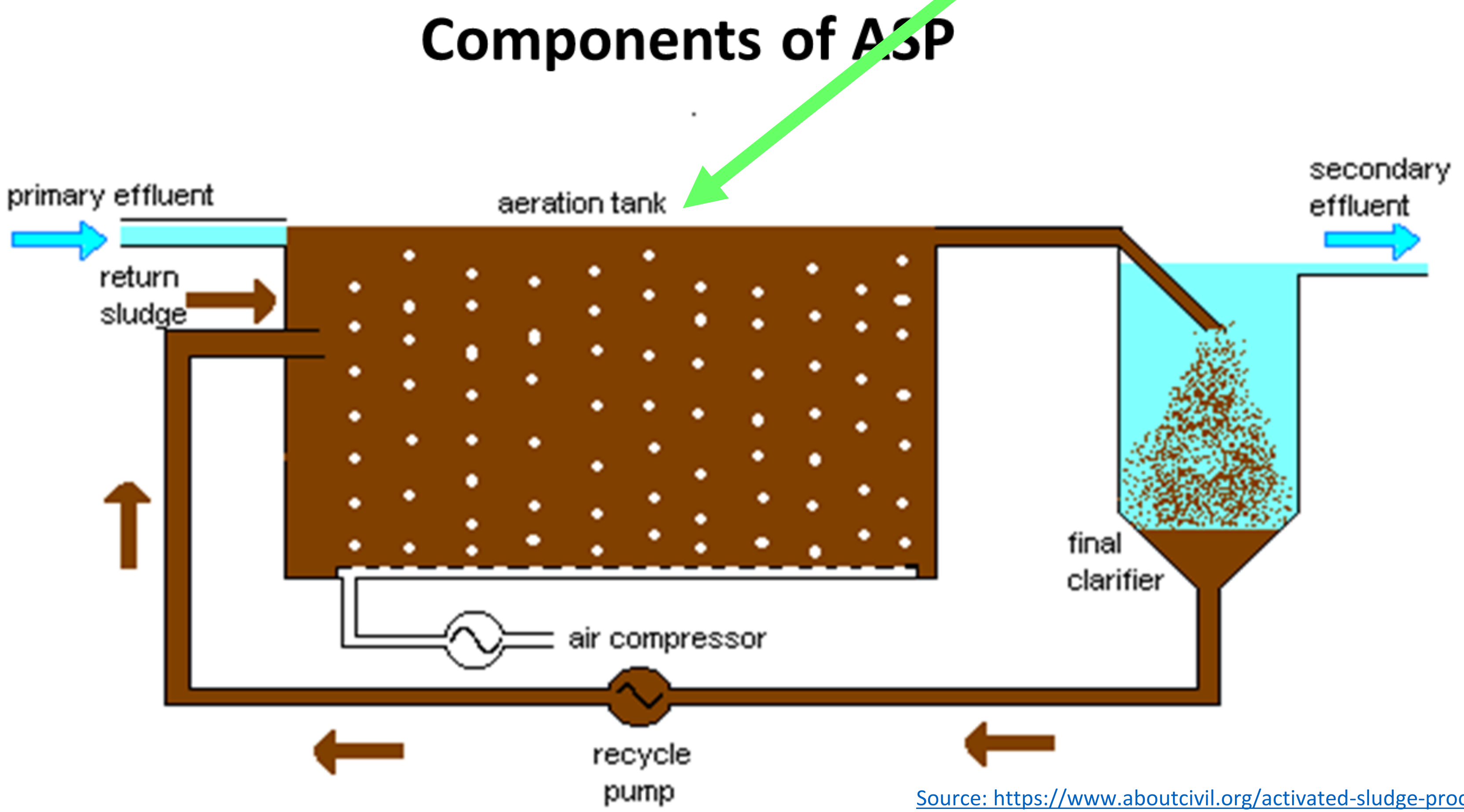


Source: https://www.aboutcivil.org/activated-sludge-process-types

Activated Sludge pro

Food (F) to Micro Organism (M) Ratio: (F/M) ratio.

It is also called Organic loading. It is defined as the ratio of kg of BOD applied per day (representing microbial feed) to kg of MLSS in an aeration tank (micro organism). F/M ratio is main factor controlling the design. Lower is the F/M ratio; higher is the BOD removal in the plant.

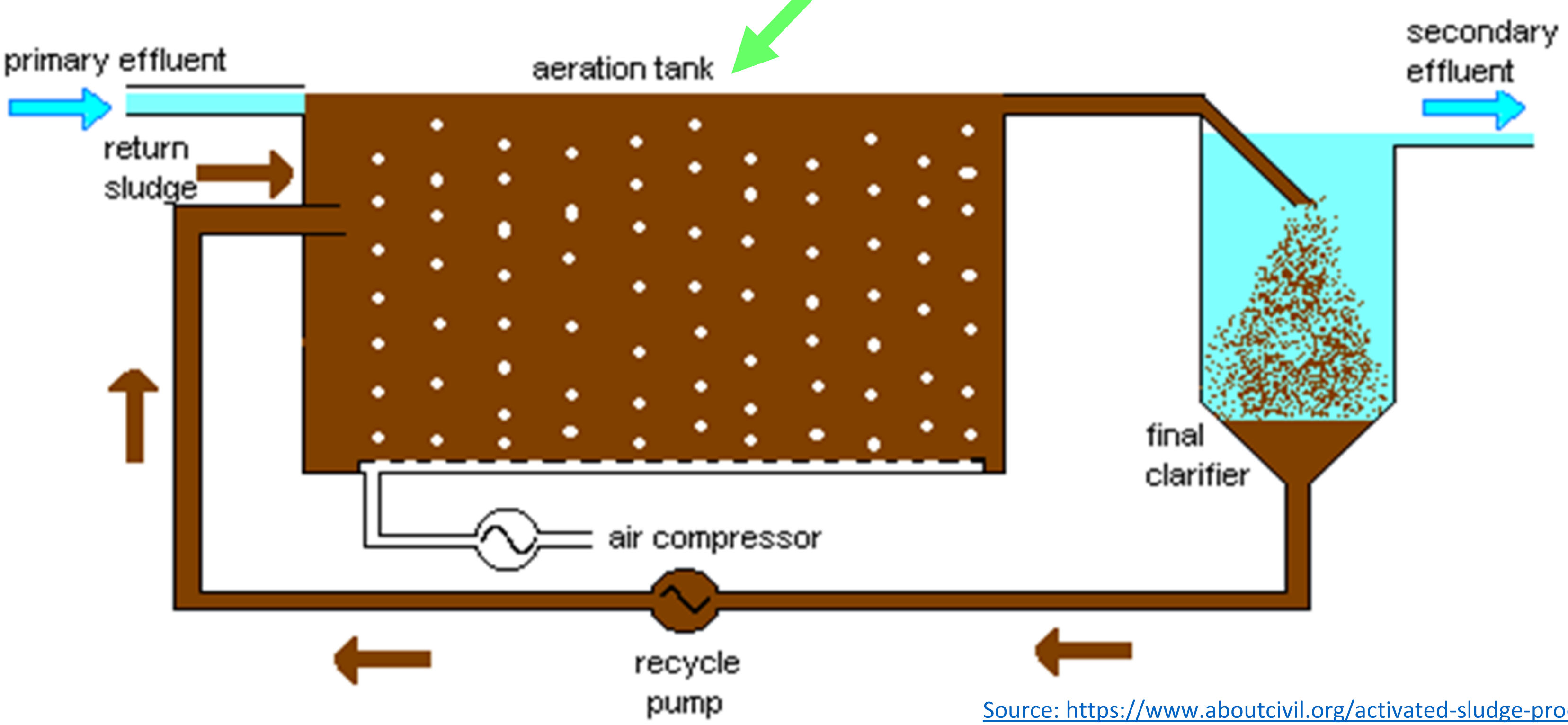


Source: https://www.aboutcivil.org/activated-sludge-process-types

Activated Sludge process variables

Sludge age or Mean cell residence time : (Φ_c) It is defined as average time for which particles of suspended solids remain under aeration

Components of ASP



Source: https://www.aboutcivil.org/activated-sludge-process-types

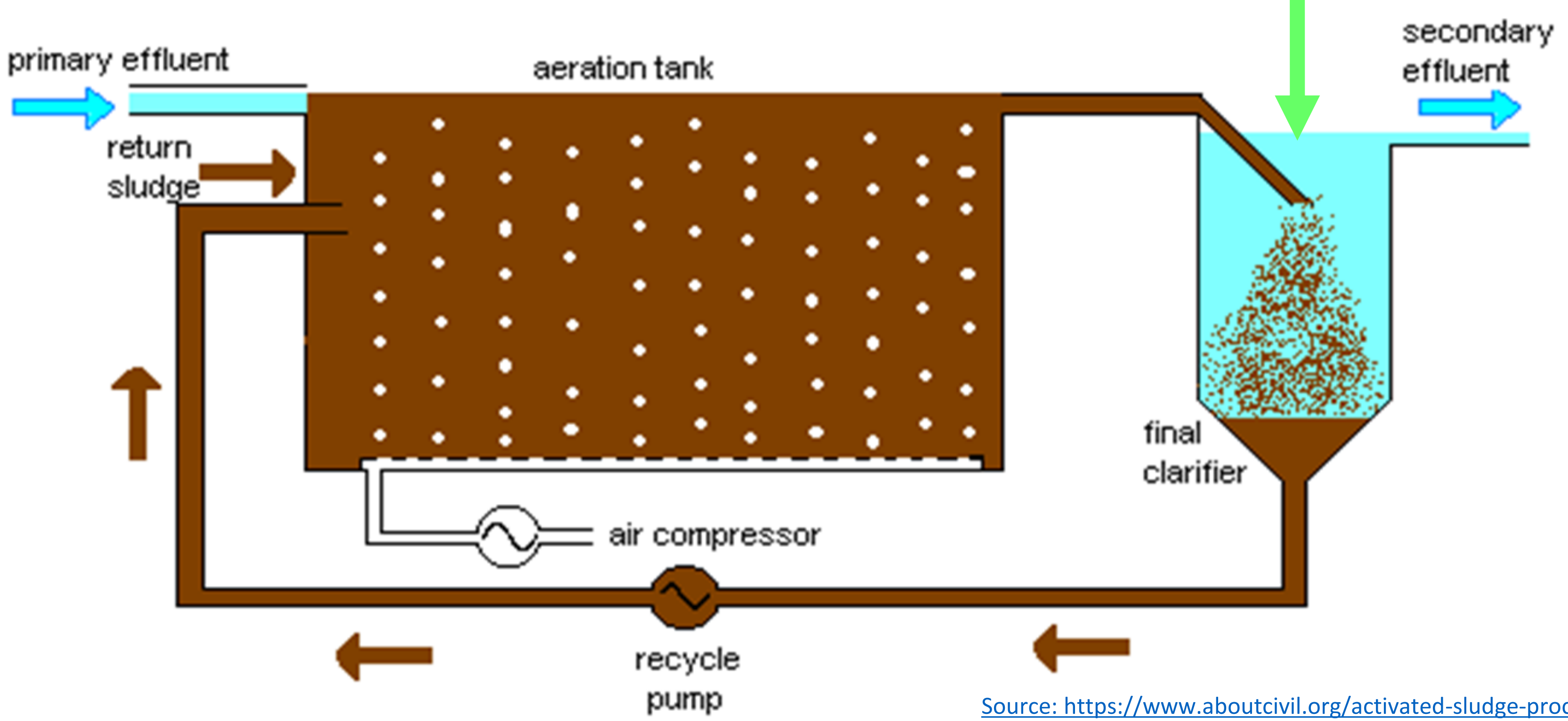
Activated Sludge pro

Sludge Volume Index (SVI) : It is the volume occupied in ml by one gm of solids in the mixed liquor after settling for 30 minutes

$$\text{SVI} = \frac{Volume\ of\ sludge\ settled\ in\ ml}{MLSS\ in\ gm}$$

Usually a SVI of 50 to 150 ml/gm is adopted.

Components of ASP



[Source: https://www.aboutcivil.org/activated-sludge-process-types](https://www.aboutcivil.org/activated-sludge-process-types)

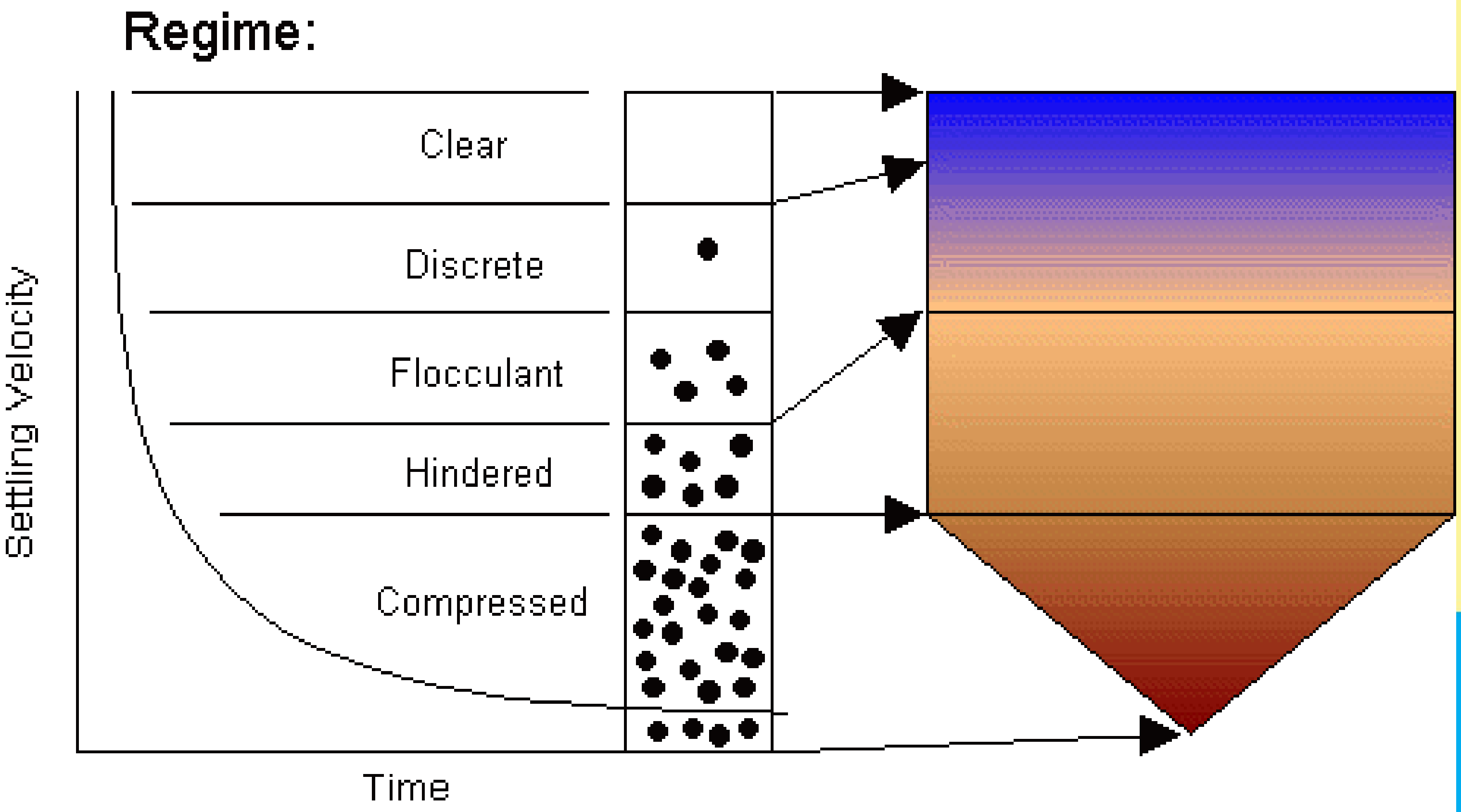
Types of Settling

Type I: Discrete particle settling - Particles settle individually without interaction with neighboring particles.

Type II: Flocculent Particle settlement

Type III: Hindered or Zone settling

Type IV: Compression settling



Sourcehttp://www.engineeringenotes.com/waste-management/sedimentation/settling-of-solids-types-and-analysis-sedimentation-waste-management/40310

A completely mixed activated sludge process is used to treat a wastewater flow of 1 million liters per day (1 MLD) having a BOD_5 of 200 mg/l. The biomass concentration in the aeration tank is 2000 mg/l and the concentration of the net biomass leaving the system is 50 mg/l. The aeration tank has a volume of 200 m^3. What is the hydraulic retention time of the wastewater in aeration tank? What is the average time for which the biomass stays in the system?

Wastewater flow rate = 1 MLD = 41.66 m^3/hr

Hydraulic retention time = $\frac{Volume\ of\ aeration\ tank}{Q} = \frac{200}{41.66}$ = 4.8 h

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Average time biomass stays in system = Mean Cell Residence Time

$$= \frac{\text{Biomass in aeration tank}}{\text{Biomass leaving the system}}$$

$$= \frac{\text{Volume of aeration tank} \times \text{MLVSS in aeration tank}}{\text{wastewater flow rate} \times \text{Concentartion of solids in the effeluent}}$$

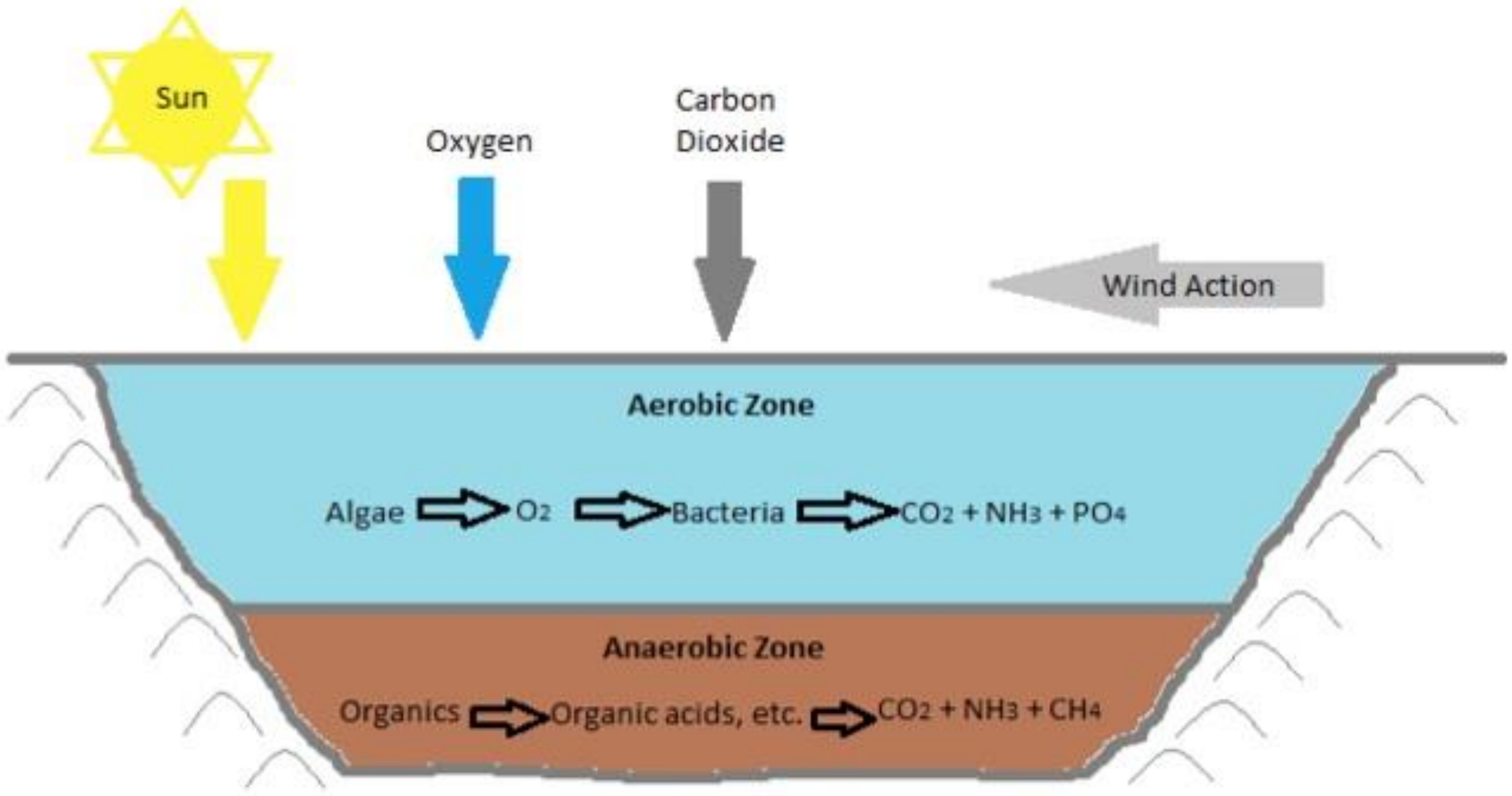
Q = 1 MLD = 1000 m^3/day, MLVSS in aeration tank = 2000 mg/l

Concentartion of solids in the effeluent = 50 mg/l

$$\text{MCRT} = \frac{200 \times 2000}{1000\ (\text{m}^3/\text{day}) \times 50} = 8 \text{ days}$$

Oxidation Pond

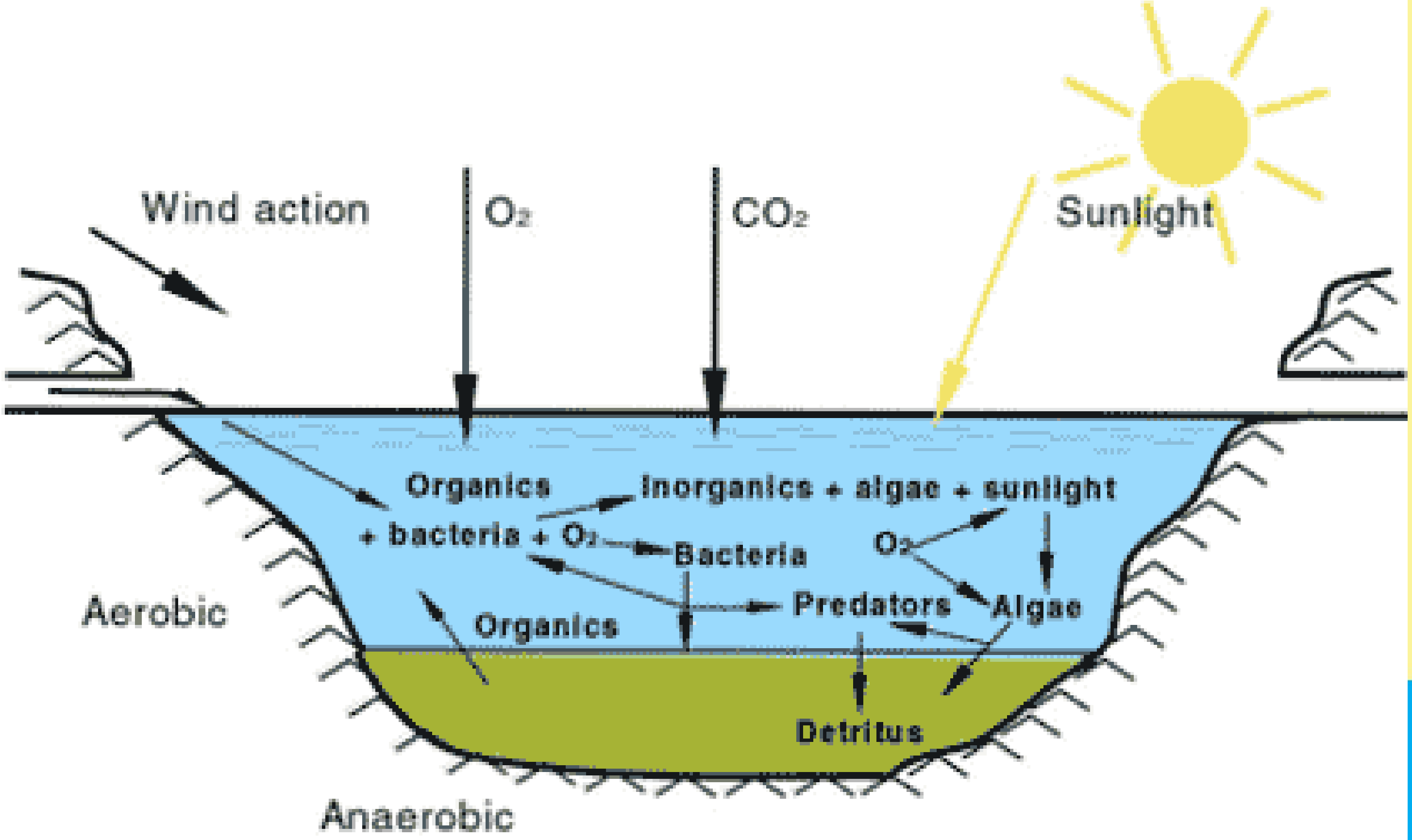
Raw sewage or primary settled sewage is allowed to be collected in the pond. Stabilization of organic matter is carried out by combined action of algae and other micro organisms by symbiotic relationship.



Source: https://www.youtube.com/watch?v=4Ch4ODvHc5w

Oxidation Pond

Symbiotic relationship exists between algae and microorganisms in the presence of sunlight. Algae produce oxygen while growing in the presence of sunlight and that oxygen is utilized by the micro organisms. End products of the process are CO_2, ammonia and phosphates. These are utilized by algae. Effluents of oxidation pond can be used for land irrigation.



Source: https://www.youtube.com/watch?v=4Ch4ODvHc5w

Design an oxidation pond for a residential colony of 5000 persons contributing sewage at 120 lit/capita/day. The 5 day BOD of sewage is 300 ppm. Take organic loading as 300 kg/ha/day. Assume L:B = 1:2. Also find detention time if depth of pond is 1 m.

Solution:

Wastewater flow rate = Q = Population X Per capita sewage flow = 5000 X 120 litres/day

= 0.6 MLD

Surface area of pond = $\frac{\text{Q x BOD loading rate}}{\text{Organic Loading Rate}} = \frac{0.6 \times 300}{300}$ = 0.6 Ha

L X B = 0.6 X 10^4 m^2, L =2B

$$B = \sqrt{\frac{0.6 \times 10^4}{2}} = 54.77 \text{ m}$$

L = 109.54 m

$$DT = \frac{\text{Volume}}{Q} = \frac{0.6 \times 10^4 \times 1}{\frac{0.6 \times 10^6}{10^3}} = 10 \text{ days}$$

Sludge Digestion

Sludge Digestion

Sludge which drawn from the sedimentation tank must be decomposed in a sludge digestion process.

Decomposing : In the decomposing process, 40 to 60% of organic solids are converted by bacteria into CO_2, CH_4(anaerobically)

Sludge digestion process

Sludge gets broken up into three following forms:

Digested sludge: Stable humus like solid matter free of pathogenic bacteria may contain cysts, eggs of bacteria etc.

Volume = 1/3 volume of undigested sludge

Dried up and used as a fertilizer.

Supernatant liquor: Finely divided solid matter and liquid with BOD about 3000 ppm.

Retreated in treatment plant along with raw sewage.

Gases of decomposition : CH_4 (65 to 70%), CO_2(30%), other gases like nitrogen, H_2S are evolved.

Stages of decomposition:

i) Acid fermentation
ii) Acid regression
iii) Alkaline fermentation

i) **Acid fermentation (or) Acid production stage :** Acidic in nature.

ii) **Acid regression :** BOD remains high during this stage. It becomes foamy and scum forms at top due to gases trapped.

iii) **Alkaline fermentation :** During this stage, liquid, digested solids and gases get separated.
Alkaline in nature
BOD falls rapidly
Large volume of Methane gas along with small amount of other gases evolved.

Factors affecting sludge digestion:

a) Temperature
b) pH value
c) Seeding with digested sludge
d) Mixing and stirring of raw sludge with digested sludge

Sludge and its moisture content (mc)

a) Sludge from sedimentation tank -- 95% mc
b) Secondary sludge from trickling filter- 96 to 98% mc
c) Secondary sludge from Activated Sludge Process - - 98 to 99%
. 95% mc means 5 lit solid matter in 100 lit sludge
. 90% mc means 10 lit solid matter in 100 lit sludge
The relation between mc content and volume of sludge

$$V_1 (100 - p_1) = V_2 (100 - p_2)$$

Where, V_1 = volume of sludge at moisture content of p_1%
V_2 = volume of sludge at moisture content of p_2%

The moisture content of a sludge is reduced from 98% to 93% in a sludge digestion tank. Find the % decrease in volume of the sludge.

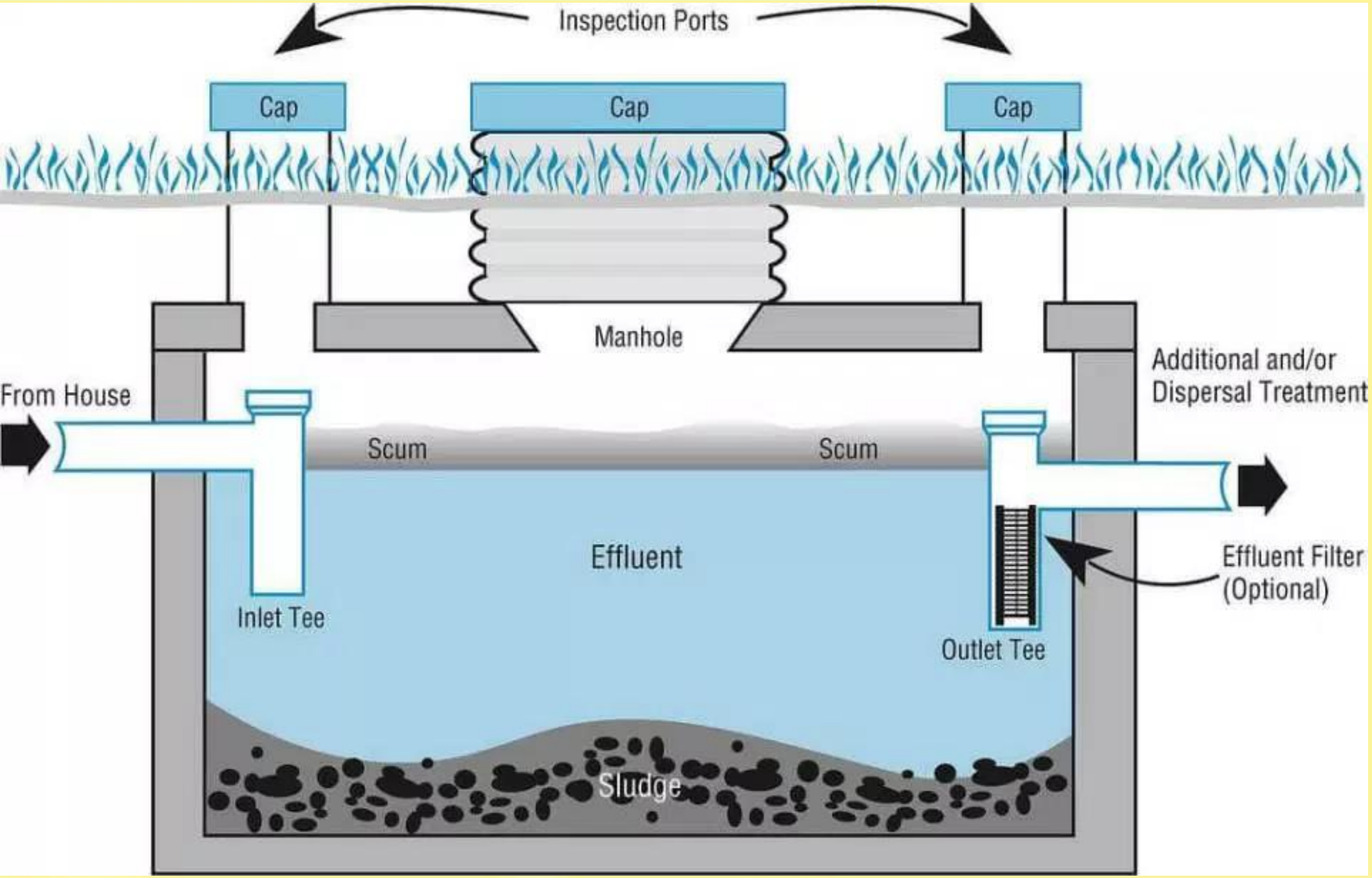
Sol : $V_2 = \frac{(100-mc)}{(100-mc)} V_1$

$$V_2 = \frac{100-98}{100-92} \times V_1 = 0.25\ V_1$$

$$\%\ \text{Decrease in volume} = \frac{V_1 - V_2}{V_1} \times 100 = \frac{V_1 - 0.25 V_1}{V_1} \times 100 = 75\%$$

Septic tank

Source: https://www.amazon.com/Septic-System-Treatment-Supply-Powder/dp/B00O2AYM9Y (Modified)



Sourcehttps://www.allstate.com/blog/buy-home-septic-system/

- Septic tank is provided in areas where sewers have not been laid and for isolated communities, schools, hospitals, other public institutions etc.
- It is a sedimentation tank with longer detention time i.e., 12 to 36 hours
- Both sedimentation and sludge digestion takes place in this tank
- Effluents should be disposed off either for sub surface irrigation or in pits or treated inlet in trickling filter before disposed off in water course
- Sludge collected at the bottom gets digested **anaerobically.**
- The digested sludge is periodically removed.

General methods of disposing of the sewage effluents:

(a) Dilution i.e. disposal in water; and

(b) Effluent Irrigation or Board Irrigation or Sewage Farming, i.e. disposal on land

Source: https://www.impatientoptimists.org/Posts/2018/08/Half-the-world-away-Fecal-sludge-and-septage-treatment-in-low-and-middle-income-countries

Disposal by Dilution:

Discharged into a river stream, or a large body of water, such as lake or sea.

It is purified by "self purification process" of natural waters.

The degree of treatment to be given to raw sewage before disposing depends on quality of raw sewage, the self purification capacity of the river stream and the intended use of the water.

The ratio of the quantity of the diluting water to that of the sewage is known as the dilution factor.

Various natural forces of self purification:

Physical forces are:

(i) Dilution and dispersion

(ii) Sedimentation

(iii) Sunlight

Chemical forces aided by biological forces

(i) Oxidation

(ii) Reduction

Dilution

Dispersion

Oxidation

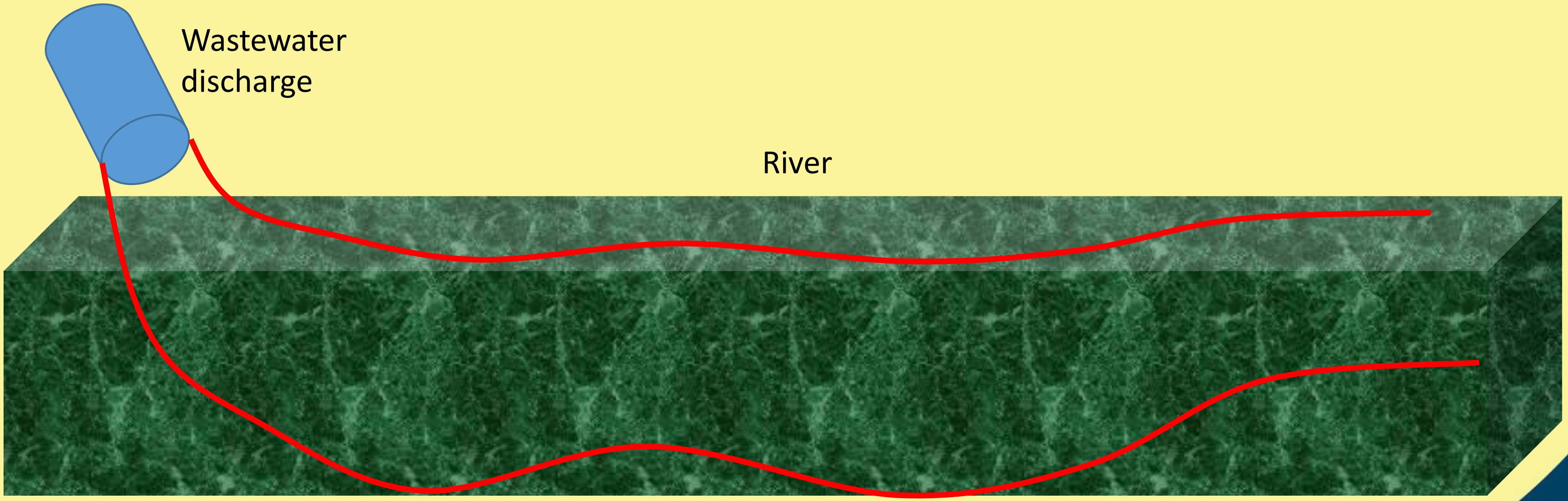
Reduction

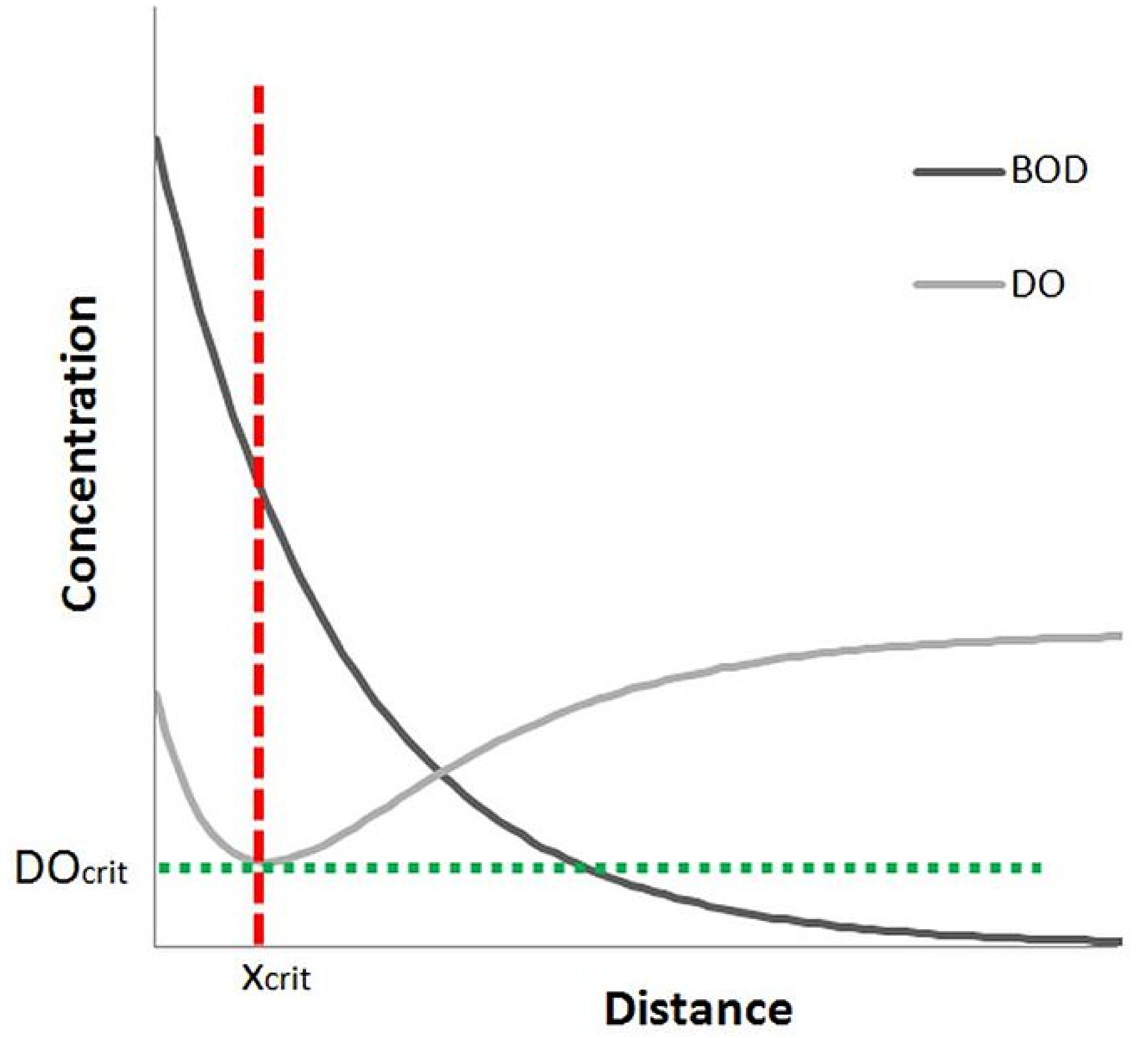
Sunlight

Sedimentation

Temperature

Source: https://www.impatientoptimists.org/Posts/2018/08/Half-the-world-away-Fecal-sludge-and-septage-treatment-in-low-and-middle-income-countries


Wastewater discharge
River



Source: https://en.wikipedia.org/wiki/Streeter%E2%80%93Phelps_equation#/media/File:DOsag_curve.jpg

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Thank you

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Introduction to Environmental Engineering and Science – Fundamentals and Sustainability Concepts

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IIT Kharagpur

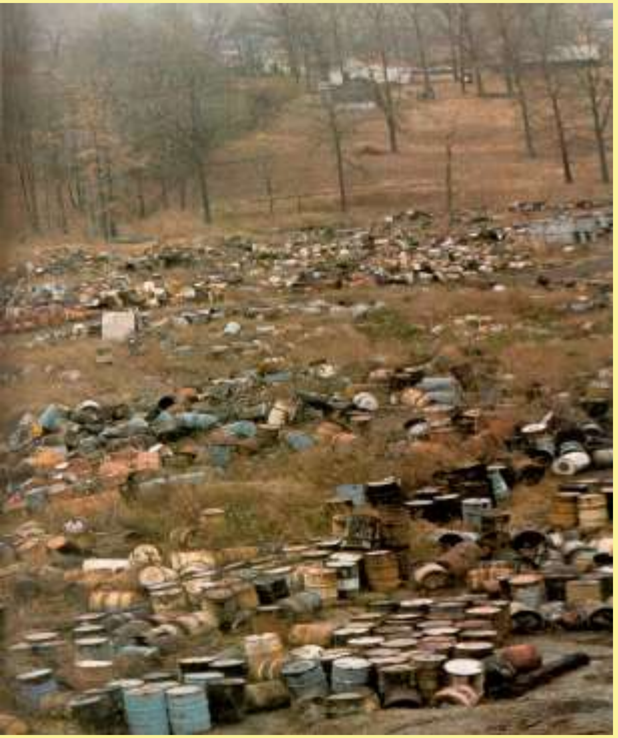
Week-10: Solid waste management Overview & Current Topics

Lecture 46 : Intro to Solid Waste Management

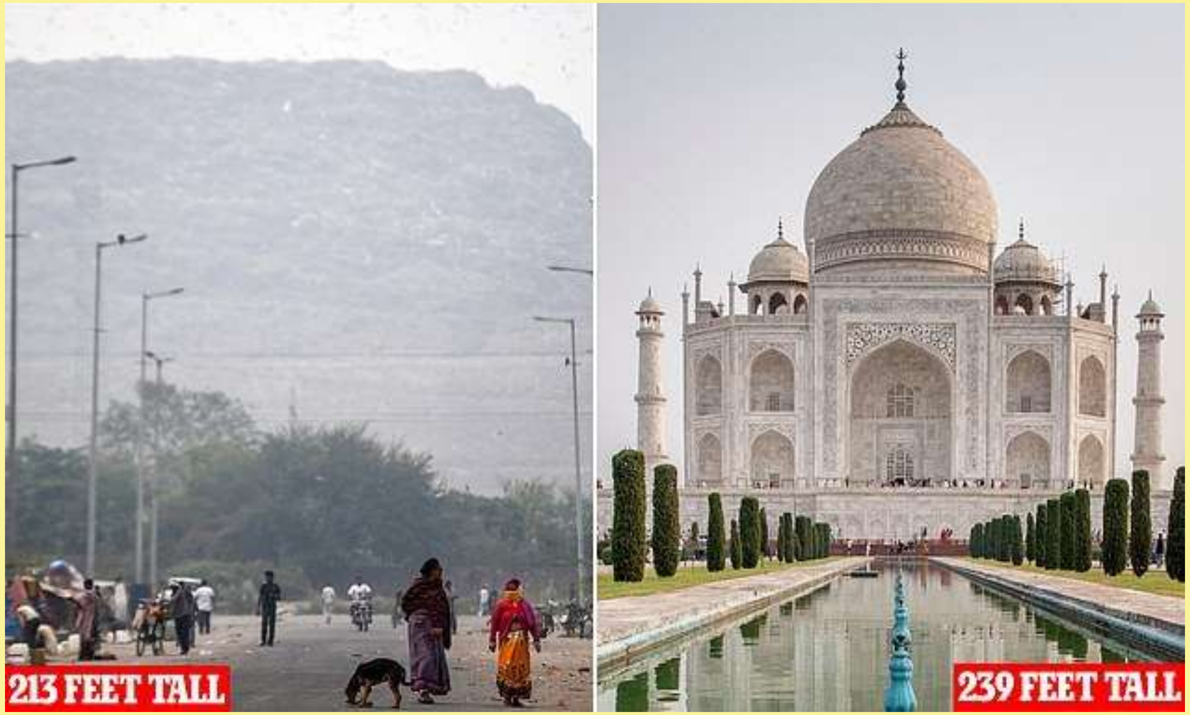
CONCEPTS COVERED

- Fundamental of solid waste management
- Resource recovery
- Current scenario

Why Do We Care How Solid Waste is Regulated/Managed?



Source: Brown, Michael, “Drums of Death”, *Audubon*, 120 July 1980.



India's largest rubbish pile is set to dwarf the 239ft Taj Mahal as it becomes a fetid symbol for the world's 'most polluted capital city (Daily Mail UK).

Ghazipur was opened in 1984 and reached its capacity in 2002 when it should have been closed

Image source; RTE, Daily Mail UK

DELHI

Waste management: Supreme Court slams Delhi householders

Krishnadas Rajagopal

NEW DELHI, AUGUST 06, 2018 19:48 IST
UPDATED: AUGUST 06, 2018 19:49 IST

SHARE ARTICLE 902 PRINT A A A

Representational image. | Photo Credit: AFP

The **Supreme Court** on Monday questioned the Delhi householder's inability to segregate the waste generated in his own home.

Source:
The Hindu: 6th August , 2018

DELHI

What happens to your garbage after you segregate it?

Sidharth Ravi

NEW DELHI , SEPTEMBER 24, 2018 01:50 IST
UPDATED: SEPTEMBER 24, 2018 01:50 IST

SHARE ARTICLE | 111 | | | | | PRINT | A | A | A

While what can go into the dry waste bin remains fairly clear, what is allowed in the wet waste bin is less apparent. | Photo Credit: V_V_KRISHNAN

Though municipalities are strongly encouraging citizens to segregate waste, chances are the segregated garbage is thrown into a mixed pile of dry and wet waste

Source:
The Hindu: 24th September, 2018

Solid Waste Management

Generation of solid waste has been around for a long time. It is an inevitable part of the human condition, and there have been problems with waste since the very beginning

There are four basic means of dealing with waste :

1. dumping
   - anywhere humans have existed
   - usually in low lying areas
2. burning
   - often uncontrolled
   - recently, we have developed incineration with some controls
   - why? It saves pace, reduces smell and pestilence
3. recycling
   - recover beneficial components
   - separation for hazardous waste
4. Waste minimization
   - reduce resource & energy usage during manufacturing

History of solid waste

Uncontrolled dumping has been the cause of many problems in society over the centuries

A good example is the Bubonic plague:

- Zoonotic disease (passed from animals to human) caused by Yersinia pestis. Transferred mainly between small rodents and their fleas, but can be transmitted to humans when they come into contact with the fleas.
- In the 14th century it killed – 50 % of the population of Europe (75 million) . In the middle ages there were uncontrolled piles of garbage in , and around, cities. This provided a great environment for rats and other disease carrying animals to prosper, providing ideal conditions for a variety of diseases to flourish :

Leptospirosis, salmonellosis, toxoplasmosis, …….

Present Day

A big component of waste management is the 3Rs

- . Reduce – at the source
  - . To make something smaller or use less.
  - . Through education and enforcement.
- . Reuse – “re-use” materials in their original from instead of throwing away
  - . Use travel mugs; have a yard sale; donate old clothes, ……

Life–cycle Assessment has been suggested as a way to help solve waste problems

- . Assess the environmental impact associated with all stages of a product’s life cycle from “cradle-to-grave ”
- . Helps avoid a narrow outlook on environmental concern.
- . Part of RCRA in the US.

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Week-10: Solid waste management Overview & Current Topics

Lecture 47 : Intro Contd...

Time Line Chart

1880 → 1900 → 1948 → 1964 → 1965

Dumping waste at sea in New York Harbor, a common practice

Early 1900s refuse collection wagon used in America

1948: Federal Water Pollution control act

1964: Post-war Period - 1964: "With prosperity again, we really need to do something. But what?"

1965: Solid Waste Disposal Act

1970: Resource Conservation Recovery Act

1976 → 1980 → 1984 → 1986 → 1989 → 2000

1976: RCRA again revised

1980: Management of Hazardous waste

1984: Hazardous and Solid waste Amendment

1986: Environmental Protection Act

1989: Hazardous Waste (Management & Handling)

2000: Municipal Solid Waste (Management & Handling)

1998 → 2001 → 2011 → 2016

1998: Bio Medical Waste (Management & Handling)

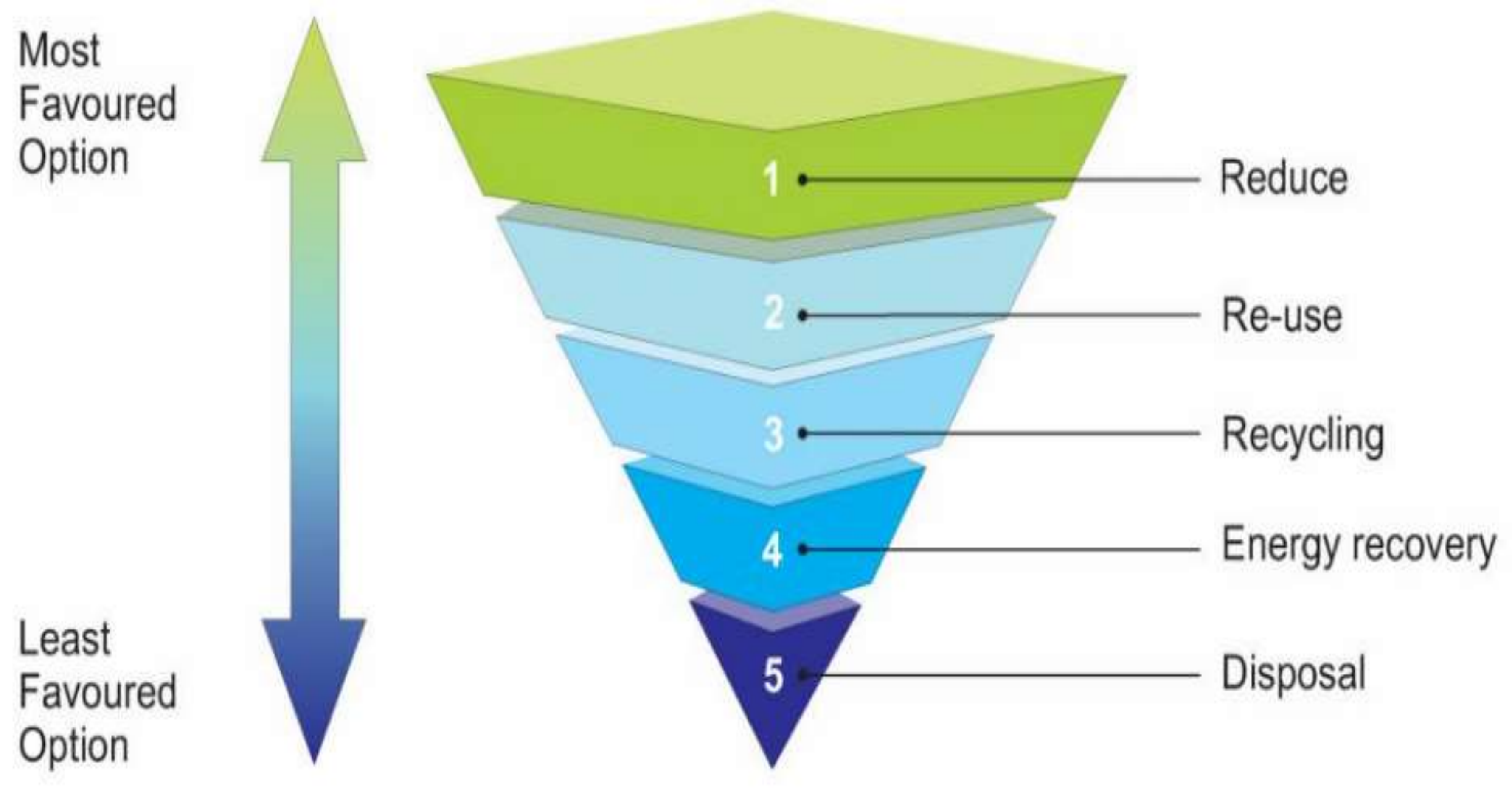
2001: Batteries (Management & Handling)

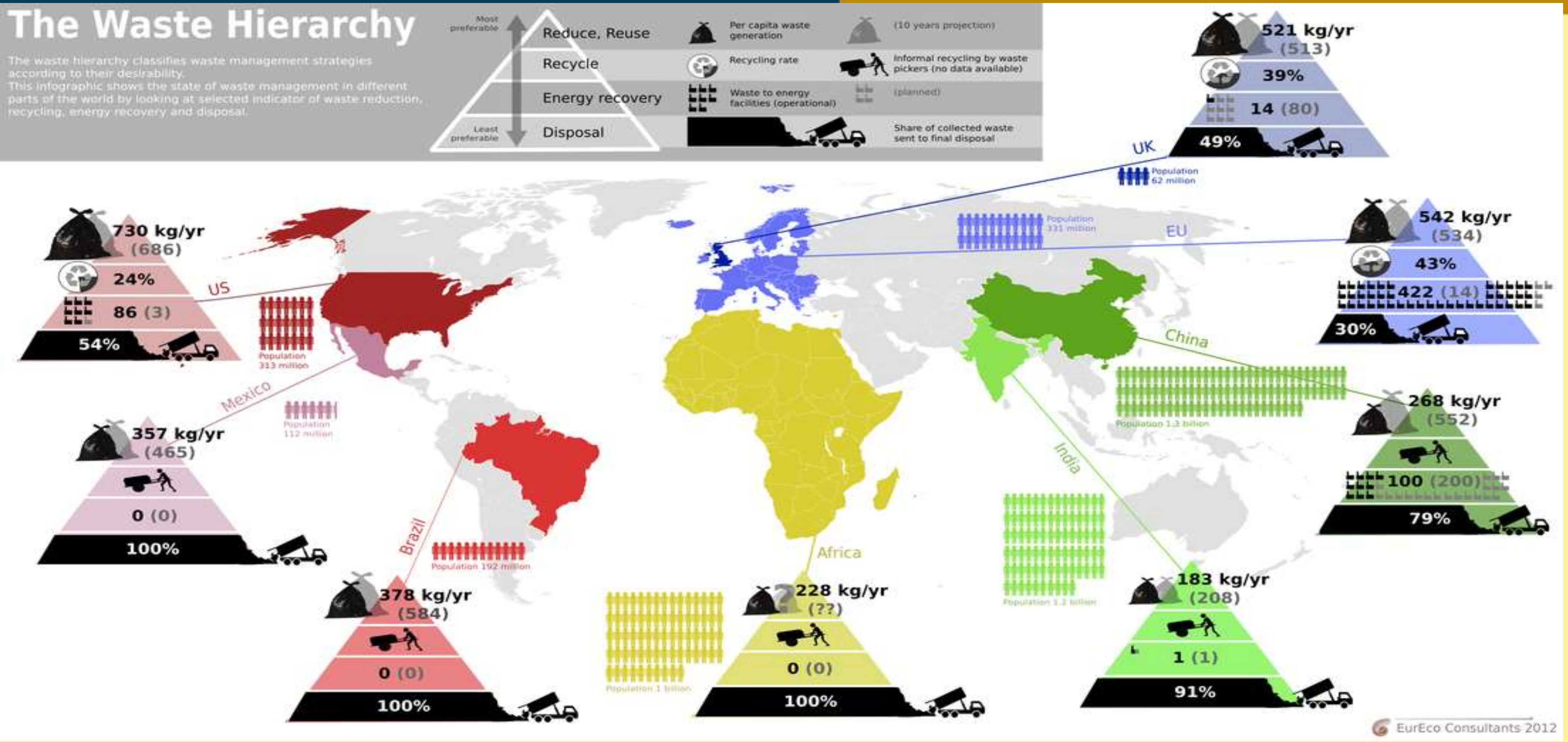
2011: E waste & Plastic waste (Management & Handling)

2016: E waste, Plastic waste, MSW, Bio Medical waste ,Construction and Demolition waste, Hazardous waste Rules (Revised)

World Scenario (grey)

India Scenario (green)


Most
Favoured
Option
Least
Favoured
Option
1
Reduce
2
Re-use
3
Recycling
4
Energy recovery
5
Disposal

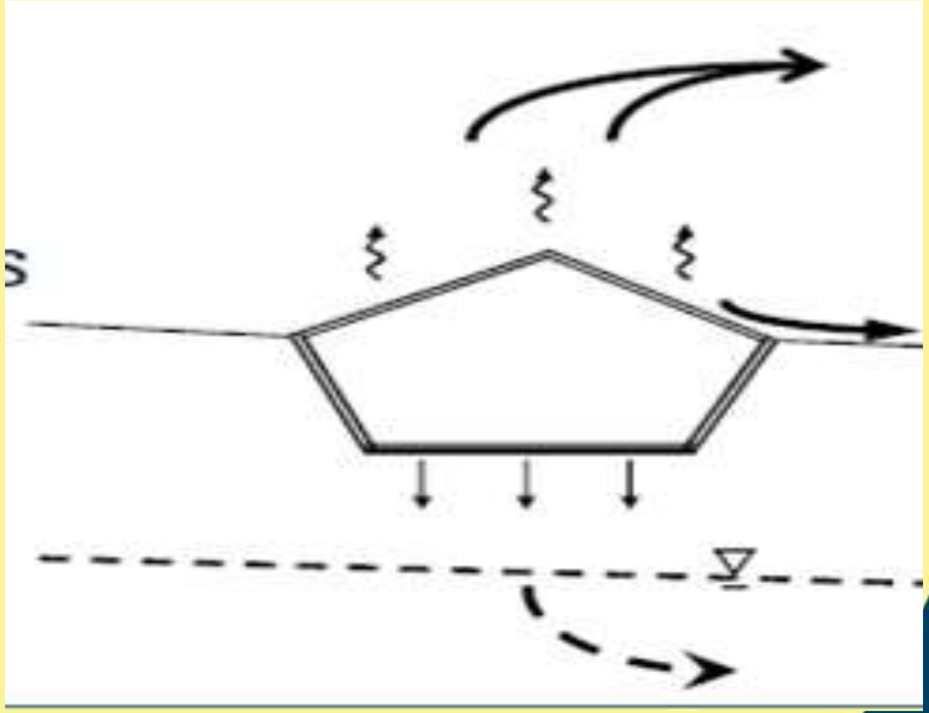


The Waste Hierarchy
The waste hierarchy classifies waste management strategies according to their desirability.
This infographic shows the state of waste management in different parts of the world by looking at selected indicator of waste reduction, recycling, energy recovery and disposal.
Most preferable
Reduce, Reuse
Recycle
Energy recovery
Disposal
Least preferable
Per capita waste generation
(10 years projection)
Recycling rate
Informal recycling by waste pickers (no data available)
Waste to energy facilities (operational)
(planned)
Share of collected waste sent to final disposal
UK
521 kg/yr
(513)
39%
14 (80)
49%
Population 62 million
EU
542 kg/yr
(534)
43%
422 (14)
30%
Population 331 million
US
730 kg/yr
(686)
24%
86 (3)
54%
Population 313 million
Mexico
357 kg/yr
(465)
0 (0)
100%
Population 112 million
Brazil
378 kg/yr
(584)
0 (0)
100%
Population 192 million
Africa
228 kg/yr
(??)
0 (0)
100%
Population 1 billion
China
268 kg/yr
(552)
100 (200)
79%
Population 1.3 billion
India
183 kg/yr
(208)
1 (1)
91%
Population 1.2 billion
EurEco Consultants 2012

Landfills

Landfills are the de-facto choice for waste management and they cause lots of problems for the environment

- . Land usage, air, surface water, ground water, posts(rats, seagulls), noise….
- . Leachate production can be a problem for groundwater
- . Residual contaminants in the waste leach out and leak out of the landfill
- . Highly toxic (- 100 times stronger than sewage) and very odorous
- . Can lead to groundwater contamination (downgradient of the landfill)
- . Methane production can be a problem of air
- . Causes odour problems around the landfill
- . 25 times more powerful than other greenhouse gas
- . Can be beneficial as a renewable energy source
- . Litter is unsightly during landfill operations
- . The area around an active landfill has to deal with lots of debris that is blown around



Alternative to Landfills

There are few, and most are used in conjunction with landfills

1. Incineration

   Positive:

   . Large volume reduction (therefore, less landfill space used, or just more time to fill up the same approved volume)

   . Potential energy recovery

   Negative:

   . Still troubled by air pollution (extensive stack gas control)

   . Some materials don't burn

   . Ash plus these non-combustibles require subsequent landfill disposal

   . Siting problems are equal to those of landfills

2. Recovery of reusable products, compost, refuse-derived fuels

   . Markets are limited

   . Short term costs > landfills, in many cases

   . Residue still remains a problem for disposal

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Week-10: Solid waste management Overview & Current Topics

Lecture 48 : Solid Waste Management Components

Solid Waste Management

So, what is solid waste management?

•It is a comprehensive program of waste prevention, recycling, composting and disposal

This includes management of:

- Waste generation,
- Storage,
- Collection,
- Transfer and transport,
- Processing,
- Disposal,

Solid Waste Management

Another important aspect of solid waste management is that you need to have an understanding of:

- Public attitudes – towards waste, recycling, landfills,…..
- An important component of landfill design is public consultation
- Administration – of the entire system
- Planning – formulating plans (tasks and schedules) to design,
- construct, operate, expand,…. Landfills and other waste management
- facilities or programs (composting, 3Rs, HHW drop-off,….)
- Legislation – all under the watchful eye of the regulatory community
- (local, regional, provincial)

Solid Waste Management

As a results, solid waste management is impacted by many different disciplines:

- Political science,
- Geography,
- Economics,
- Public health,
- Sociology,
- Communications,
- Material science,
- Archeology,
- Engineering ← just small component in the process

Solid Waste Management

And in the design and management process, takes in consideration best practices in:

- Planning,
- Public health,
- Economics,
- Engineering,
- Conversation,
- Aesthetics,
- Environmental issues,…….

6 Elements of a Waste Management System

1. waste generation – waste is material that has no further value to its owner and is thrown away

- Some has further value to others (reuse)
  . Chemical ingredients,
  . Electronic parts,
  . Compost for your garden,….
- Some is just waste (disposal)
  . Food wrapping,
  . Product containers,
  . Old computers, …..
- As technology develops, something that was previously considered waste may have renewed value:
  . Food to CH_4 for energy production

6 Elements of a Waste Management System

2. Handling, separation, storage and processing at source

- Best place is at the source!
- Placed in various containers (blue, green, white)
- Separate the valuable from the waste (paper, metals, plastics)
- Avoid contamination from hazardous waste
- Proper on-site storage for health reason
- Need the cooperation of citizens for separation for work
  - -At home and at work
  - -Houses vs. condos vs. apartments
- Much of it can be contaminated, and must be processed at a facility
- One – site processing can include composting and compaction into various containers

6 Elements of a Waste Management System

3. Collection

- Gathering waste and recyclables
- Transport to recycle, transfer or disposal facilities
- Interim disposal at transfer station
- The location is a function of distance to disposal site
- Considered the most expensive component of solid waste handling
- Industries are handled separately from municipal waste

6 Elements of a Waste Management System

4. separation, processing, transformation

- Could be as simple as opening bags
- Special facilities to separate recyclables into various streams

  -Includes shredding for easier handling

  -Compacting to reduce shipping costs

  -Screens and mechanical separators
- Incineration and composting considered transformation of the waste

6 Elements of a Waste Management System

5. Transfer and transport

- Smaller collection vehicles used to bring the waste to final destination (landfill, incinerator) or to a transfer station
- Compacted further and transported farther
  - -Truck
  - -Rail(cheapest)
  - -barge

6 Elements of a Waste Management System

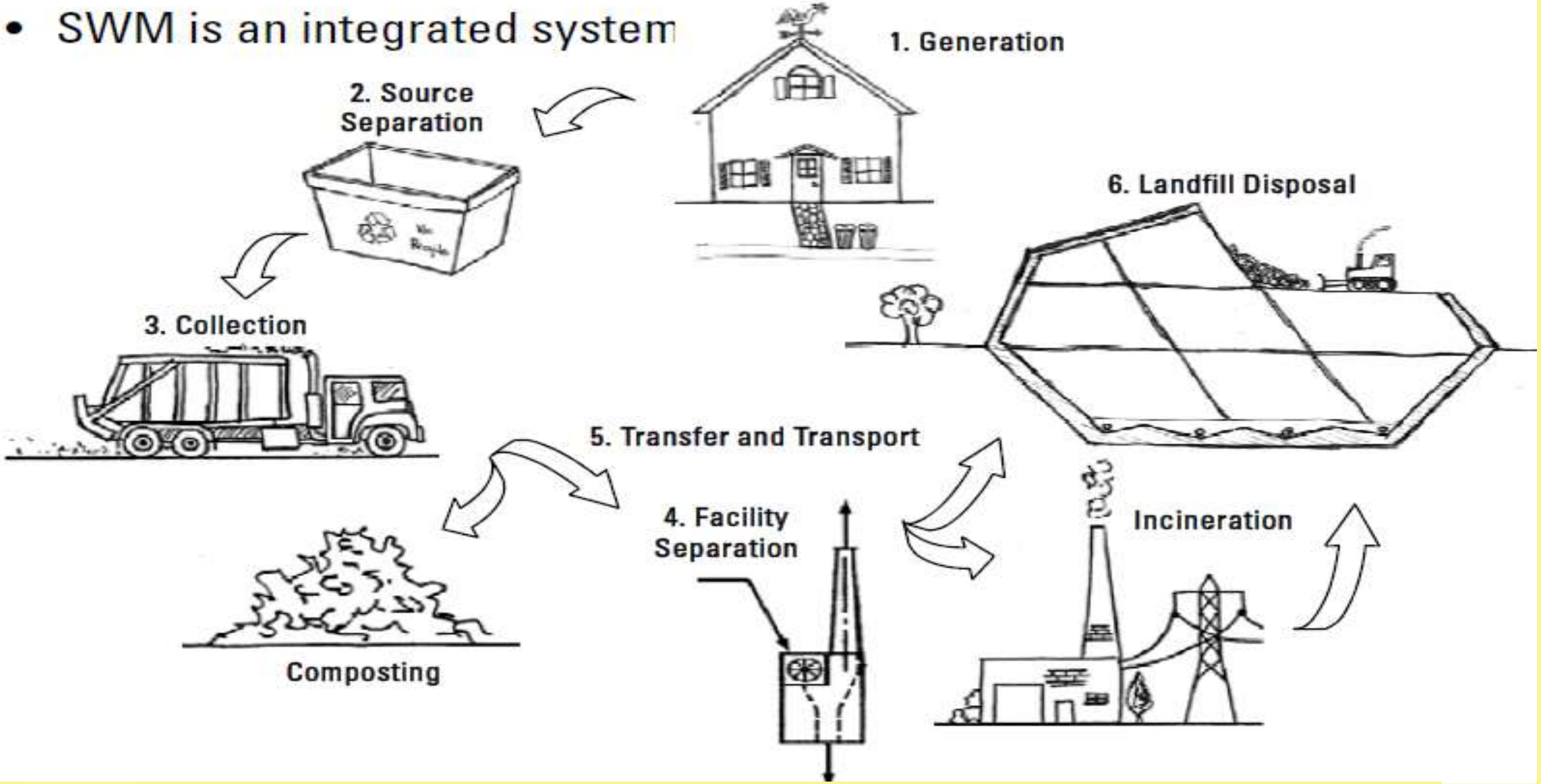
6. Disposal

- Landfill of waste or the residue of processed/transferred waste
- Considered the final destination with large liability
- A modern landfill is an engineered facility to safely contain waste
- Provides for maximum CH_4 production and minimal escape of leachate

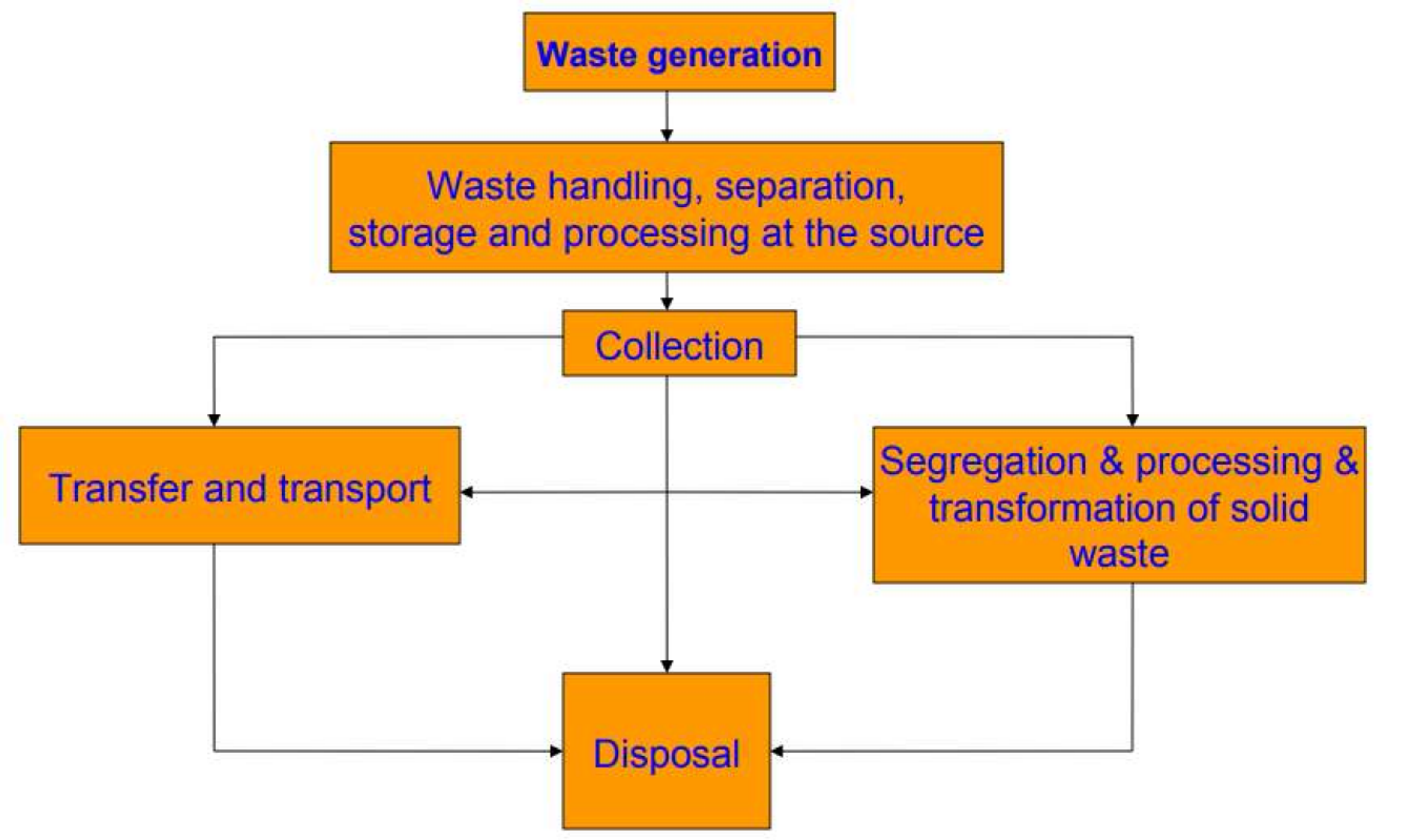
  The quicker the CH_4 is produced, the faster the landfill is stabilized, allowing the site to be "reused"
- Incinerated waste would have different characteristics

Summary

- SWM is an integrated system



Functional Elements of Solid Waste Management System



Factors Contributing to Increasing Amounts of MSW

- Increasing population
- Changing lifestyles

Waste composition

Some of the general observations associated with the composition of wastes include the following:

The major constituents are organic materials.

More often than not, metal, glass, ceramics, textile, dirt and wood form part of the composition, and their relative proportion depends on local factors.

Waste composition varies with the socio-economic status within a particular community, since income, for example, determines life style, composition pattern and cultural behaviour.

NPTEL ONLINE CERTIFICATION COURSES

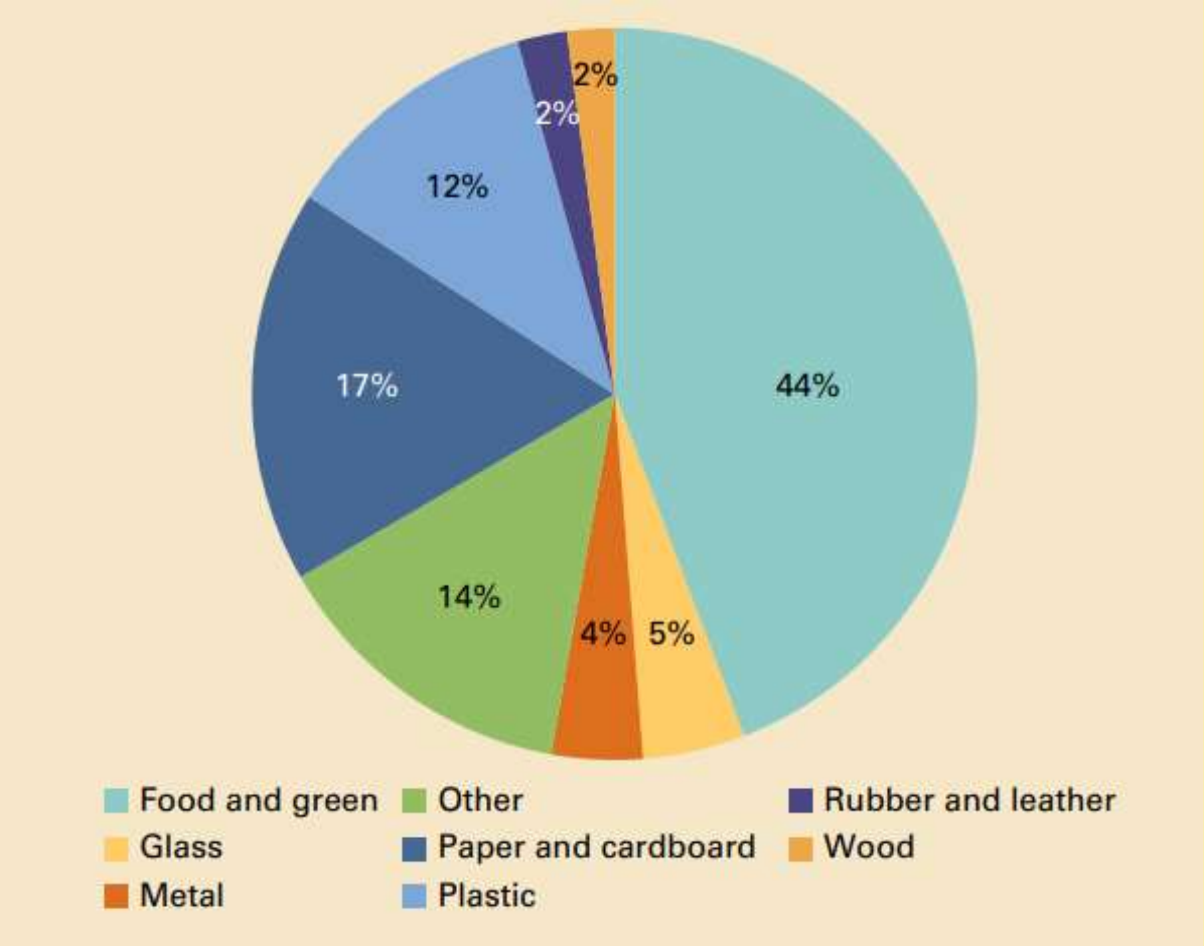
Introduction to Environmental Engineering and Science – Fundamentals and Sustainability Concepts

Dr. Brajesh Kumar Dubey
Department of Civil engineering
IIT Kharagpur

Week-10: Solid waste management Overview & Current Topics

Lecture 49 : Collection and Treatment

Global Waste Composition



What a waste 2.0 (2018)

This is an average value , this composition varies countries to country

Factors causing variation

- Geographic location
- Seasons
- Collection frequency
- Population diversity
- Extent of salvaging and recycling
- Public attitude
- Legislation

Properties of solid waste

Moisture content : It is weight of the water expressed as the percentage of water in wet or dry weight. To obtain wet weight entire sample is weighed. Then, it is dried in oven at $105^{O}C$ and dry weight is measured.

Formula : $(W_w – W_d)/W_d$

W_w =Wet weight

W_d = Dry weight

Ash content: The dried solid samples (whose moisture content is found out) is then ignited at 575 °C for 5 h in a muffle furnace to determine percentage ash (ASTM-E1755).

Volatile matter: The volatile matter of dried solid samples is measured by firing at 950 °C for 7 min (ASTM-E872).

The ash, moisture and volatile matter contents were subtracted from 100% to determine the **fixed carbon content** of the samples.

Net caloric value: It is defined at the heat produced by unit quantity of waste at constant volume and at constant pressure. It is measure using bomb calorimeter or using formula (using elemental value, Ex: Dulong formula).

$$HHV = 0.3383C + 1.422(H - 0/8).$$

(In MJ/kg)

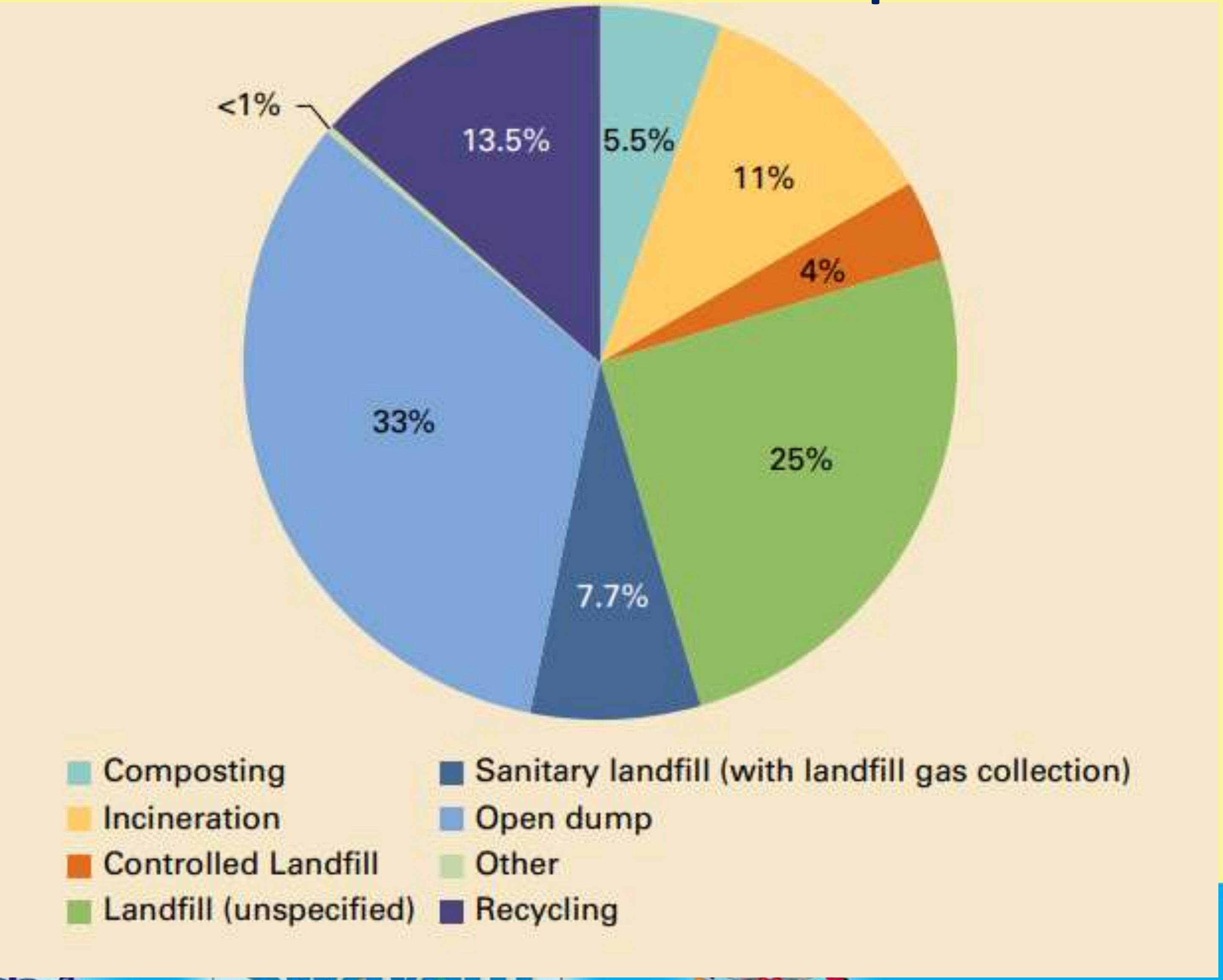
C, H and O are carbon, hydrogen and oxygen respectively

Typical MSW generation

Small towns 100g/p/day
Medium towns 300-400g/p/day
Large towns 500g/p/day

In general varies between 0.3-0.6 kg/p/day

Global Waste Treatment and Disposal



What a waste 2.0 (2018)

Various functional elements of municipal solid waste management system

Storage

- Movable bins - Type I: Bins with lid (5-20 litre), Type II: Bins of 50 litre capacity, Type III: Bins of capacity from 50-200 litres, Type IV: M.S. Bins (4.5 cum)
- Fixed bins - Masonry bins of 3.6 cum capacity (Type V)

Collection

- (H/H (house to house) collection system, Community bin system

Transportation

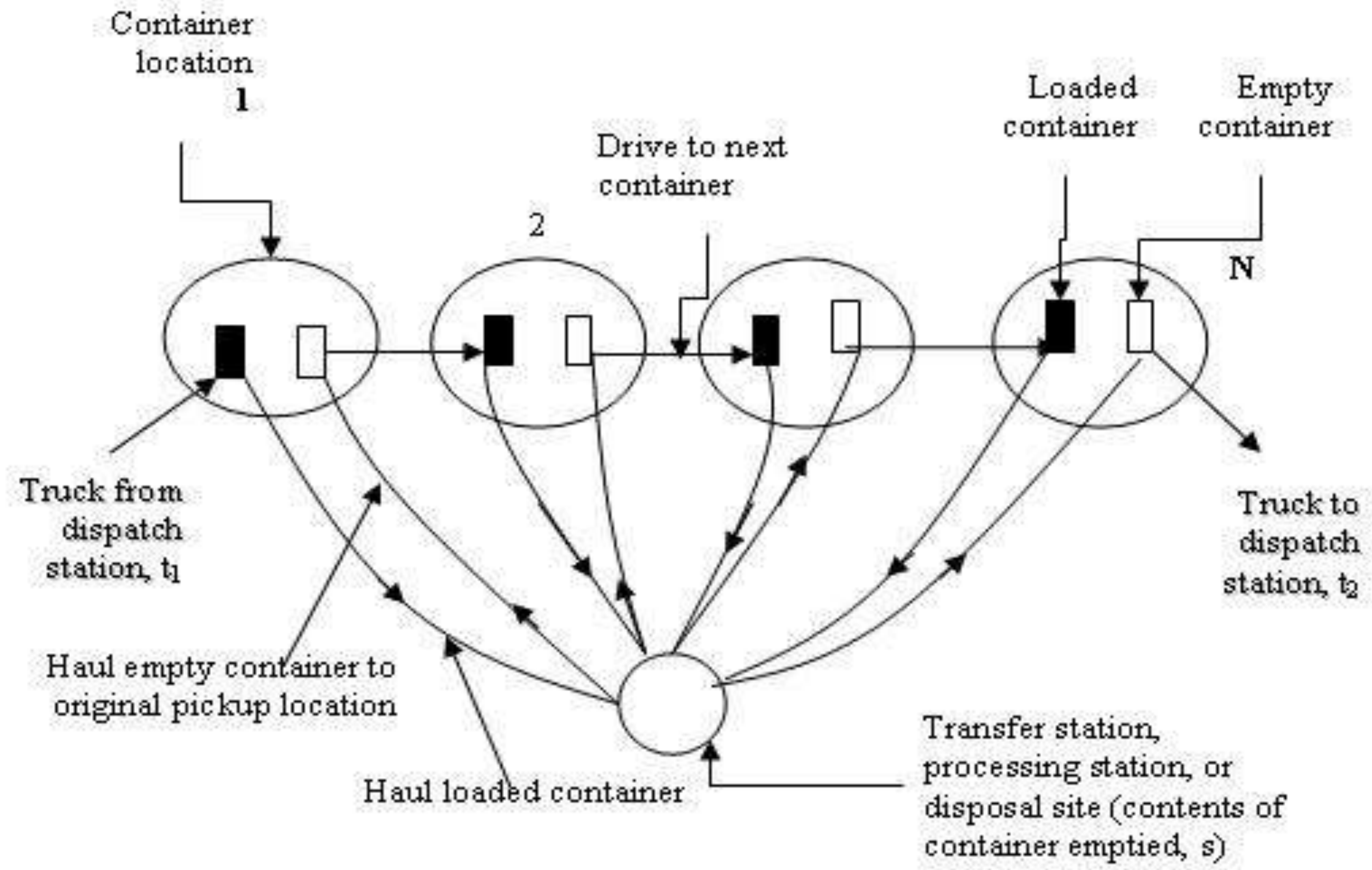
- Hand cart (Type I), Hand cart with six containers (Type II), Trycycle, Animal cart, Tipper trucks, Dumper placer, Bulk refuse carrier

Waste Transfer Stations (Relay Centre Facility)

- Transfer stations near or far off

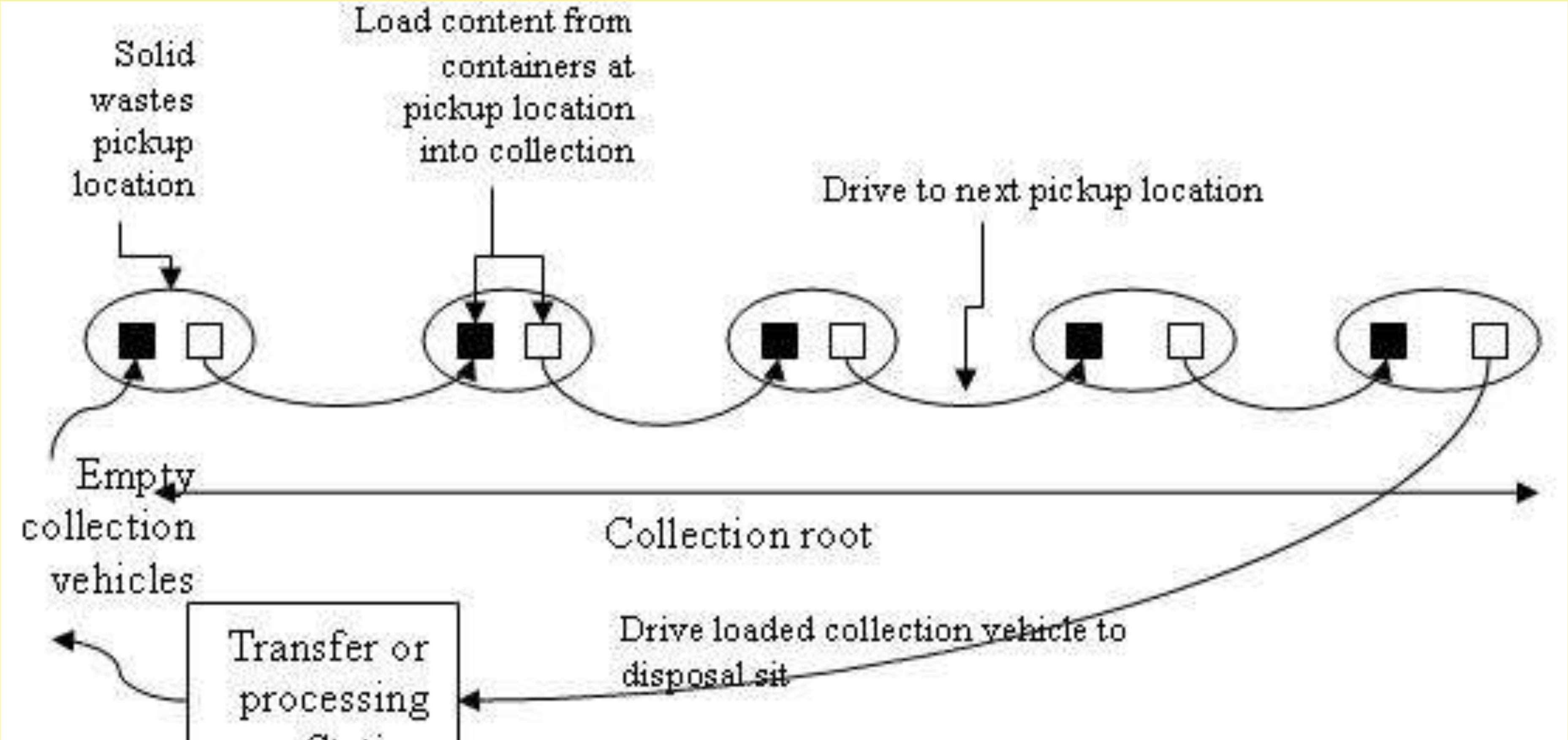
Types of Collection system

Haul container system (HCS)



(a) Hauled container.

Stationary container system (SCS)



(b) Stationary container

Properties of solid waste

Moisture content : It is weight of the water expressed as the percentage of water in wet or dry weight. To obtain wet weight entire sample is weighed. Then, it is dried in oven at $105^{O}C$ and dry weight is measured.

Formula : (Ww – Wd)/Wd

Ww =Wet weight

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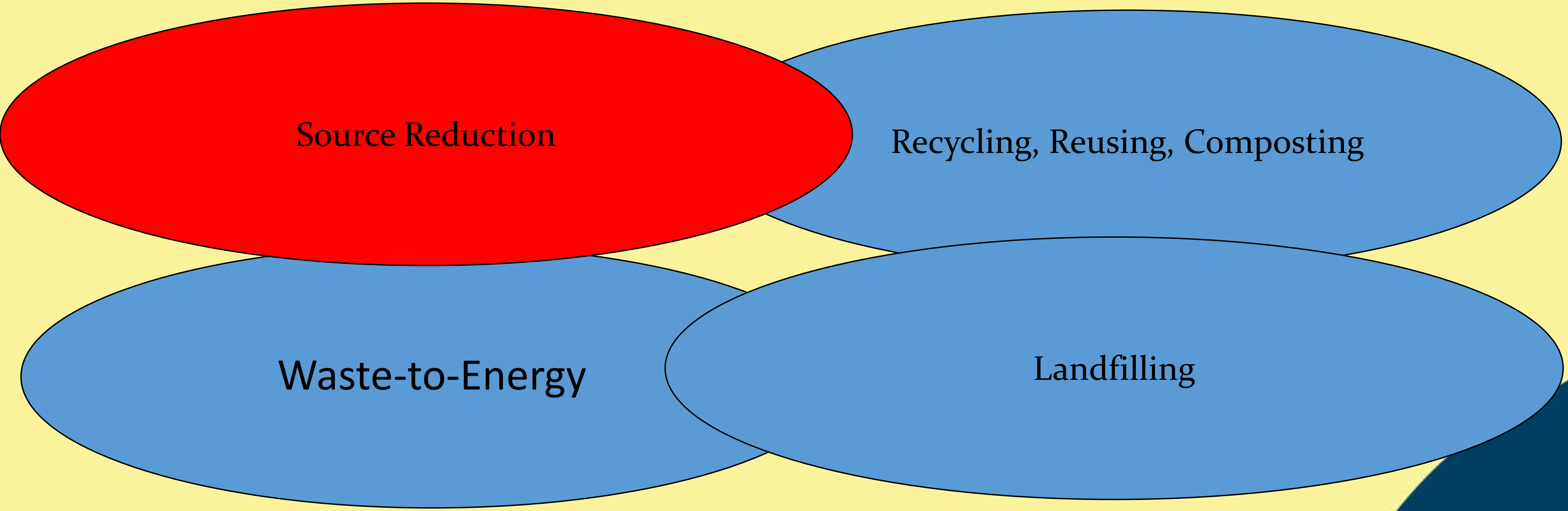
Integrated Waste Management



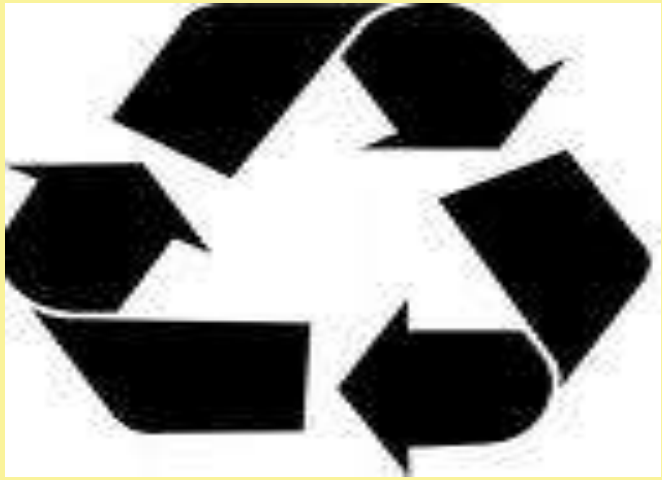
Source Reduction

- Reduce material use in product manufacture
- Increase useful life through durability and reparability
- Decrease toxicity
- Material reuse (pallets, containers, etc.)
- Efficient consumer use of materials

Source Reduction

- EPA estimates that 50% of the waste quantity can be reduced with source reduction
- Should not be a substitute of one problem for another
- Packaging is 50% of waste volume and 1/3 of waste weight
  - Paper and plastics
  - Spend more on food packaging than farmers net income
  - Replace w/smaller, lighter, degradable material

Recycling



- Returning raw material to market
- Pros:
  - Save precious resources
  - Lessens need for mining of virgin materials
  - Lowers environmental impact of mining/processing
  - Stretch landfill capacity
  - Improve efficiency of incinerators and composting facilities

Recycling

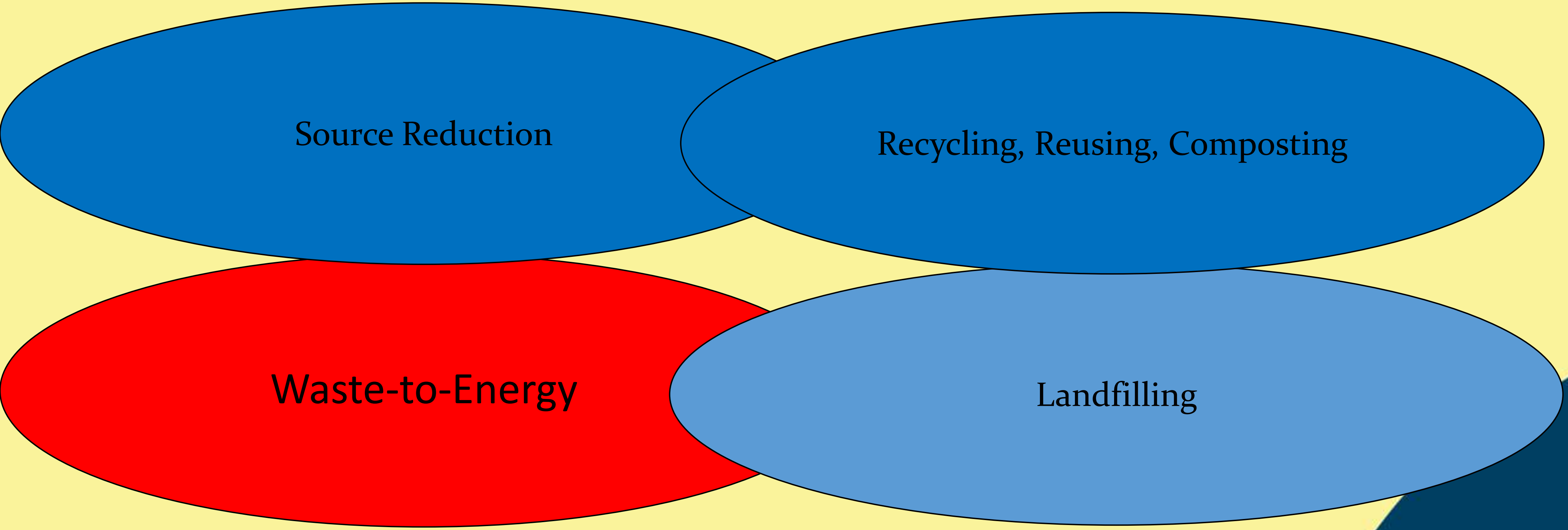
Cons:

- Poorly managed sites can result in Superfund sites
  - Waste oil recycling, newspaper de-inking, solvent and metal recycling
  - Can result in contamination of soil, groundwater, air
- Require stable market
- Only works if it is convenient
  - Curbside pick-up
  - Drop off centers
  - Mail back programs

Composting

- Natural decomposition of organic material
  - Need organic, water, oxygen
  - Not use preserved wood, human wastes, bones, meat, fat, certain weeds
- Individual
- Municipal

Integrated Waste Management



Waste to Energy (Combustion)

- There are three methods in which energy can be recovered from incineration processes;
  - Heat
  - Electricity
  - Cogeneration (harnessing of useful heat and electricity from one power plant)

Waste to Energy (Combustion)

- The two most common types of combustion that are used at these facilities are;

  - Mass Burning / Preparation
  - Combustion of Refuse Derived Fuel (RDF)

Waste to Energy (Combustion)

- Mass Burning / Preparation
  - MSW enters the facility and is inspected for the presence of non-combustible, hazardous, and explosive materials. These materials are separated from the waste stream
  - The waste stream is then fed into the combustion chamber along with forced air for "processing".
  - Some of these facilities can process 3000 tons of MSW a day. They can however be scaled down to a smaller size if necessary

Waste to Energy (Combustion)

- Combustion of RDF;
  - All hazardous, iron containing or otherwise non-combustible materials are removed from the waste stream.
  - The remainder of the waste stream is shredded
  - The material is then burned or further processed into pellets or cubes to be used as fuel in other furnaces
  - In some instanced the materials can be processed and packaged for re-sale to other facilities for use as fuel


STOP

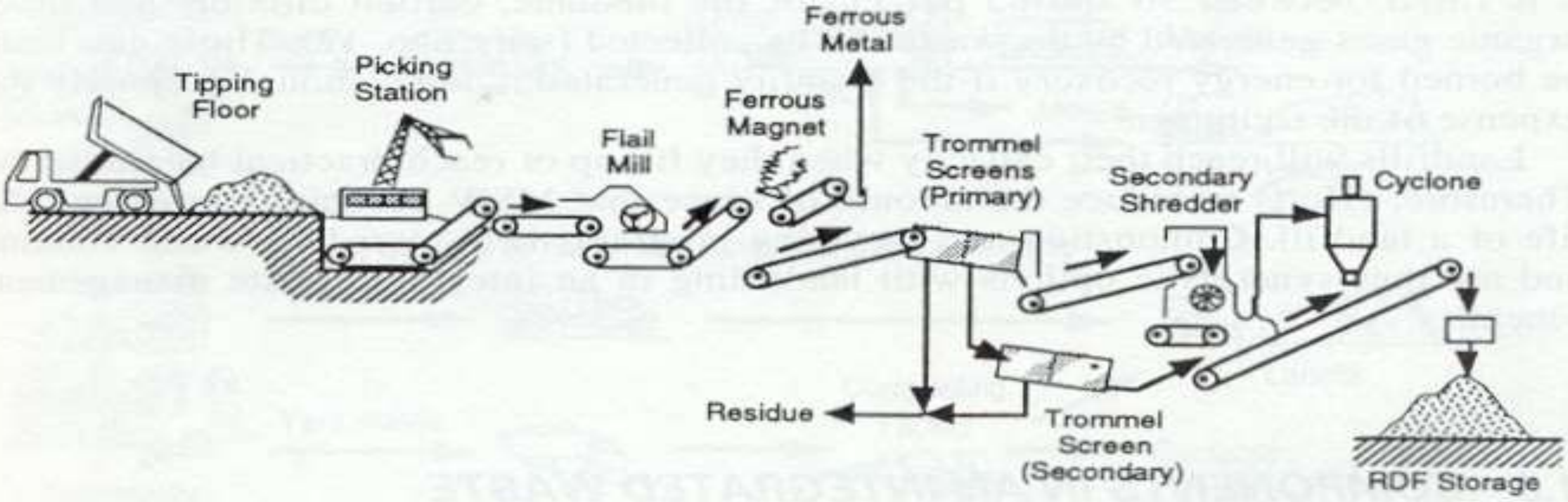
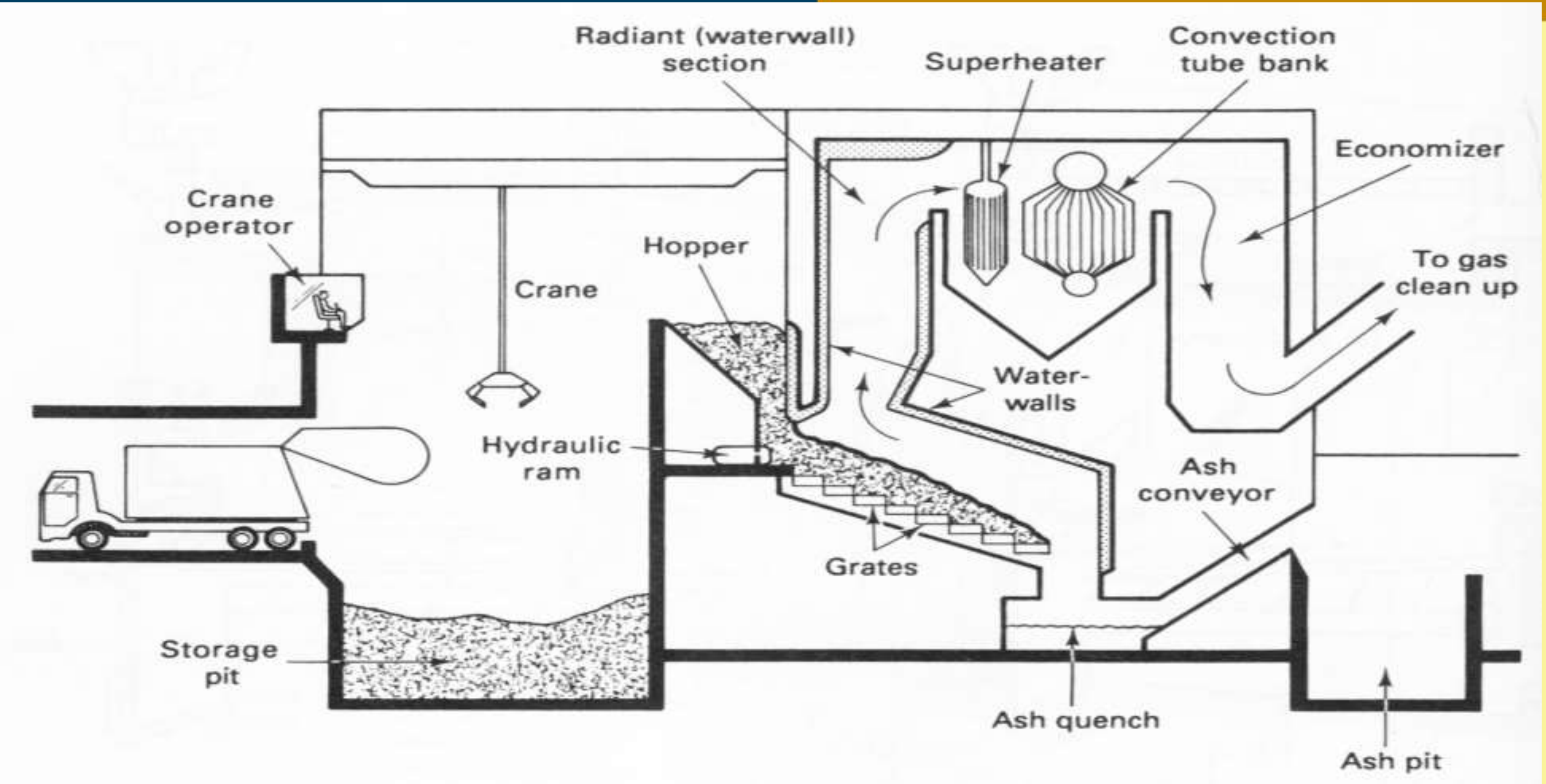
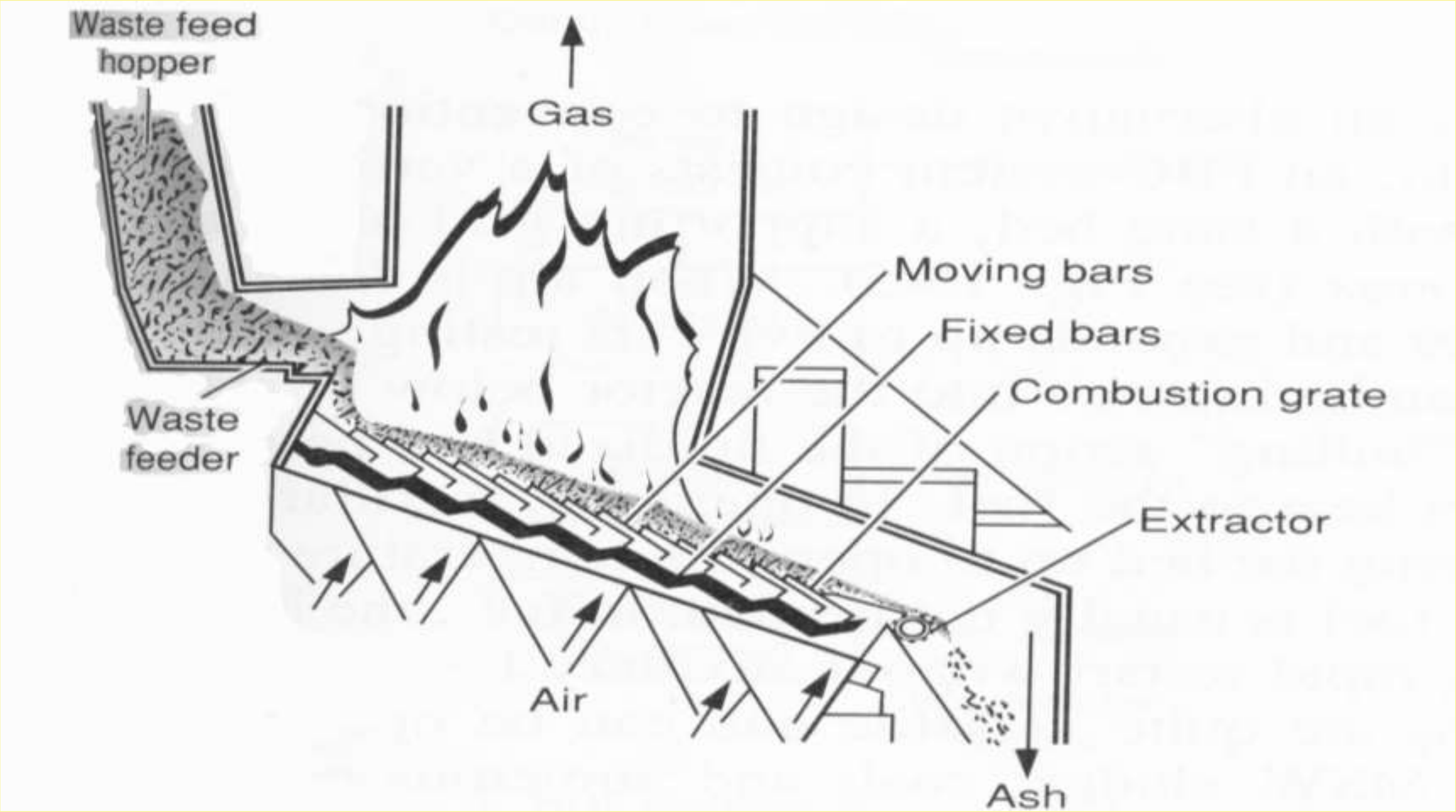
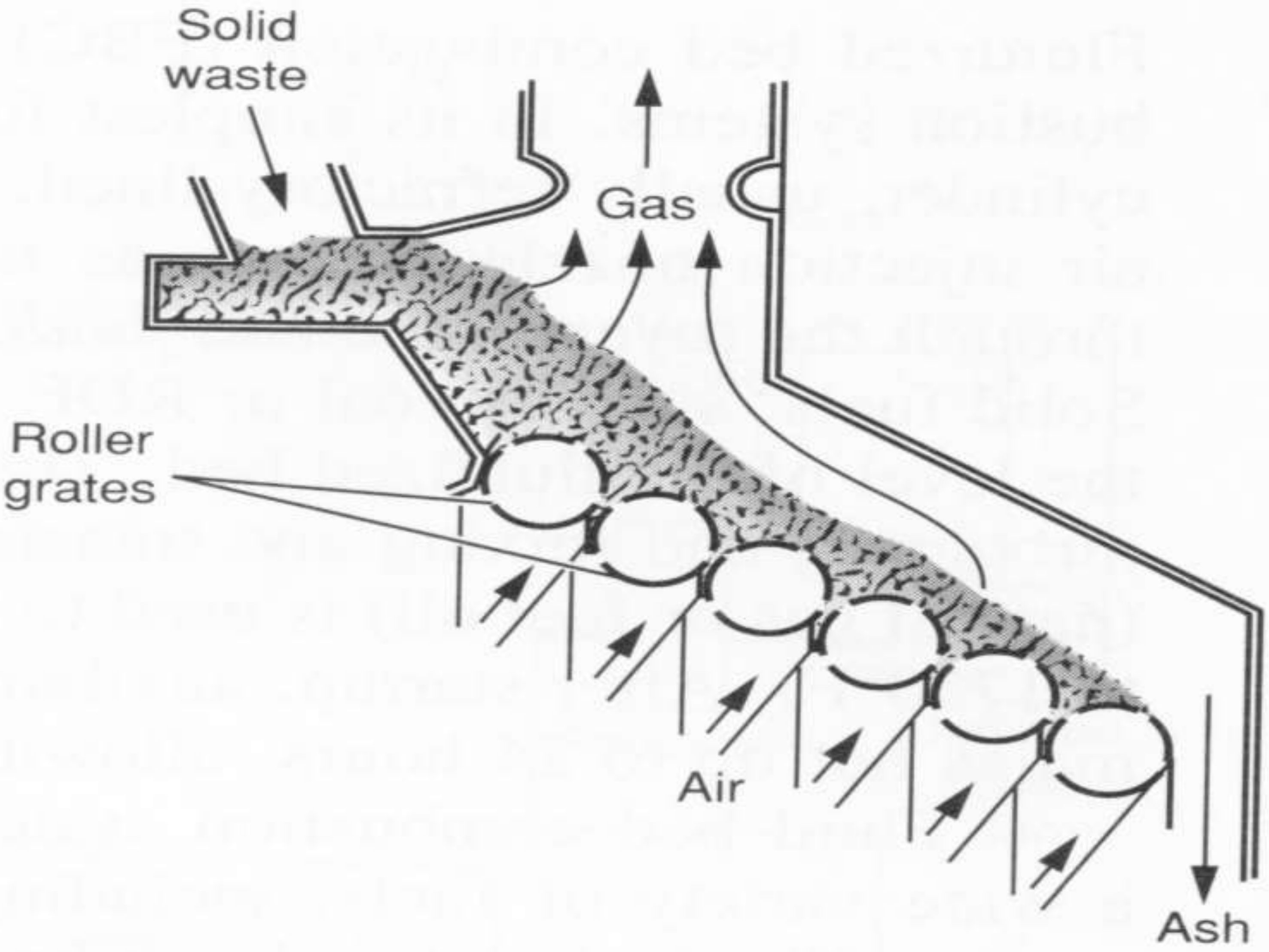


FIGURE 1.4 RDF processing system.


Radiant (waterwall) section
Superheater
Convection tube bank
Economizer
Crane operator
Hopper
Crane
To gas clean up
Water-walls
Hydraulic ram
Ash conveyor
Grates
Storage pit
Ash quench
Ash pit


Waste feed hopper
Gas
Moving bars
Fixed bars
Combustion grate
Waste feeder
Extractor
Air
Ash

Grates


Solid
waste
Gas
Roller
grates
Air
Ash

Ash Landfill

Waste to Energy (Combustion)

- What are some of the pros and cons of Combustion to Energy Operations?

- What are some of the environmental impacts of these types of facilities? (both good and bad)

Waste to Energy (Combustion)

PROS:

- Reduce volume of waste
- Recover useful energy
  - Steam
  - Waste
- Incinerator ash can be used in building material

Waste to Energy (Combustion)

CONS:

- Cost
- High degree of sophistication needed to operate safely and economically
- Public perception of safety
    - Stack emissions
    - Toxicity of ash

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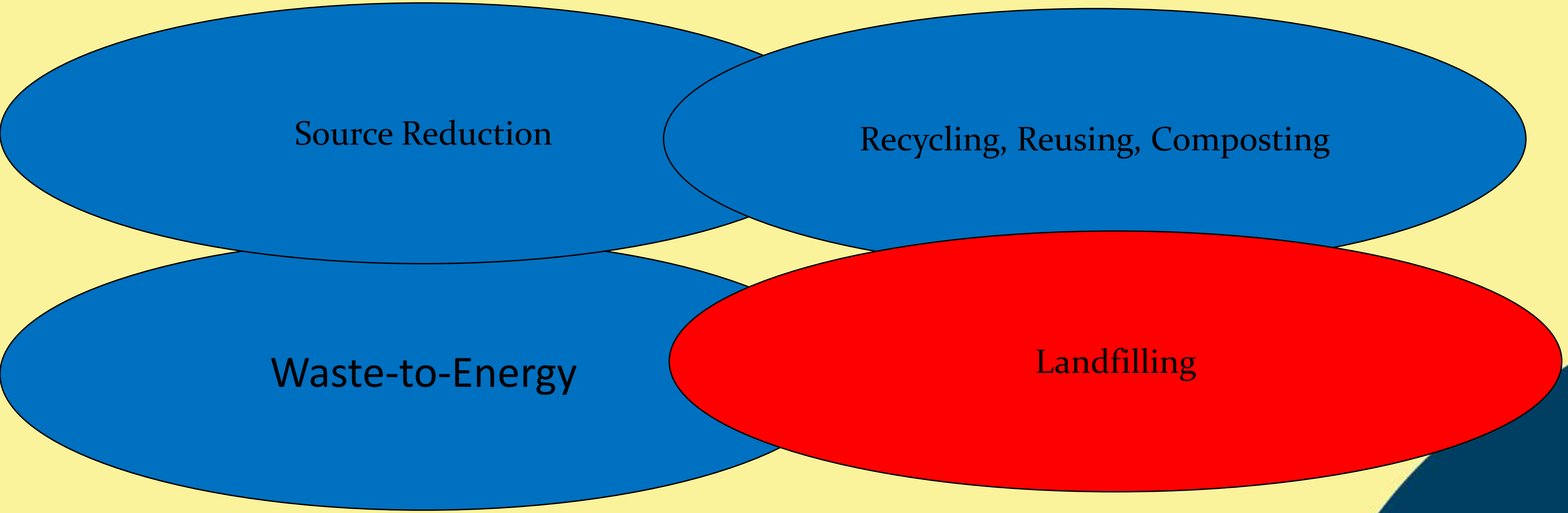
Week-10: Solid waste management Overview & Current Topics

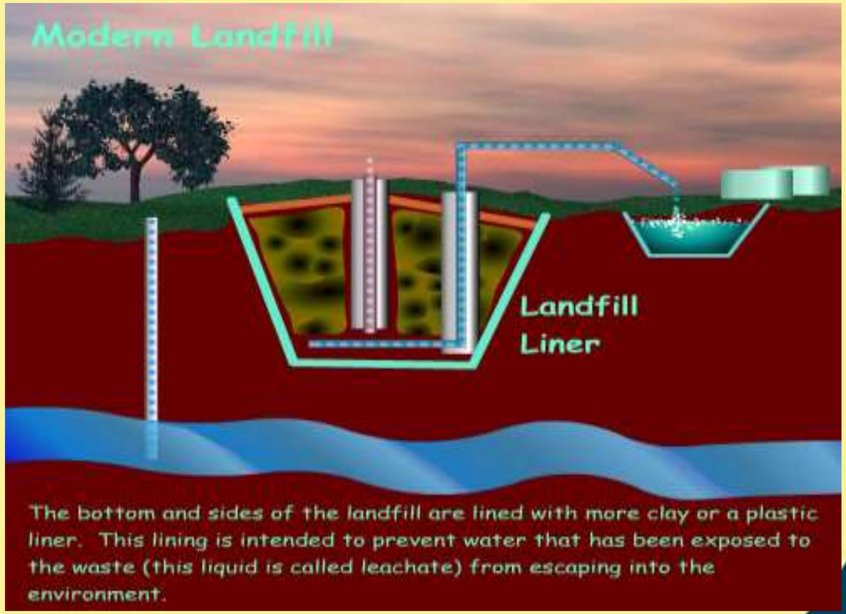
Lecture 50 : Waste Disposal & Summary

Integrated Waste Management



Landfilling

- 50-70% of municipal solid waste is landfilled
- Modern landfill vs traditional landfill
  - No longer take hazardous waste
  - Do not receive bulk liquids
  - Gas control systems
  - Liners
  - Leachate collection systems
  - Groundwater monitoring systems
  - Better sited



Landfill Problems

- Physical amount and disposal sites
- Costs to collect, handle, and dispose
- Litter
- Odor
- Insects (flies, cockroaches) & rodents
    - food
    - harborage
- Resource lost

What is a Landfill?

- Concept fostered in early 20th century
- An area of land that has solid waste deposited on it in such a quantity to noticeably change the surface elevation.

Why to use a landfill?

Potential Landfill Problems

- Landfill can present problems with respect to:
  - Spread of disease
  - Odors
  - Fires

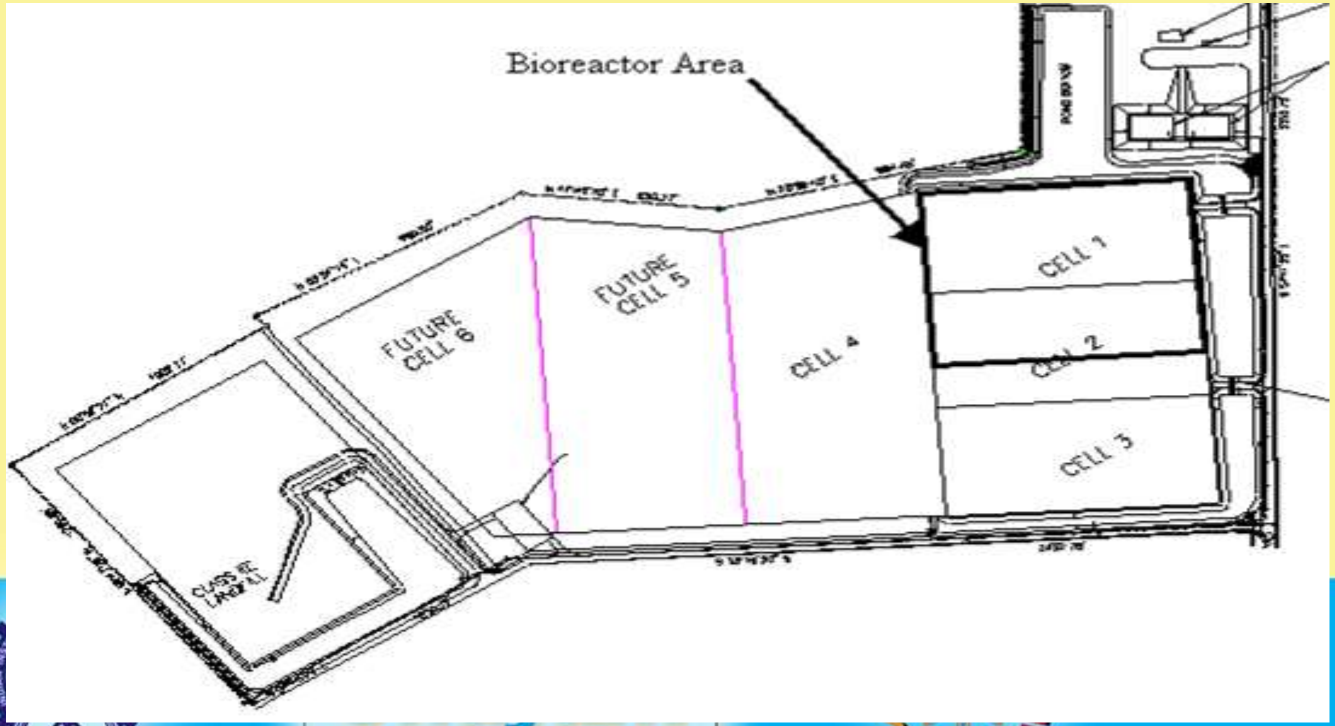
Controlled by sanitary landfill techniques

  - Contamination of groundwater
  - Gas emissions

Controlled by modern landfill design

Sanitary Landfill

- Landfills may be:
  - Excavated and filled
  - Fill existing depressions
  - Built up from the ground
  - A combination of above



- Operate landfills in a controlled safe fashion
  - Use cover soil
  - Excavate cells
  - Compact the waste
  - Control access

Modern Landfills are Engineered Structures

- Designed to Contain Leachate and Minimize Release of Pollutants from the Landfill

Leachate

- Leachate is the liquid (or wastewater) that forms when water (rainfall, groundwater) travels through solid waste
- Leachate can migrate into underlying groundwater, resulting in contamination
- Leachate can contain many different chemicals, depending on what is in the solid waste

Landfill Gas

- Landfill gas consists primarily of methane and carbon dioxide

- Results from the anaerobic decomposition of biodegradable solid wastes

Typical Regulatory Requirements

- Location restrictions
  - Airports
  - Wetlands
  - Fault lines
  - Unstable areas
  - Endangered species

Typical Regulatory Requirements

- Liners -- Low permeability barrier layers
  - Compacted soil (clay)
  - Geomembranes (plastic)
  - Composites of both
- Liner keep leachate from migrating out of the landfill
- Leachate must be collected and removed

Single Liner System

- One liner consisting of compacted soil ***or*** geomembrane

Composite Liner

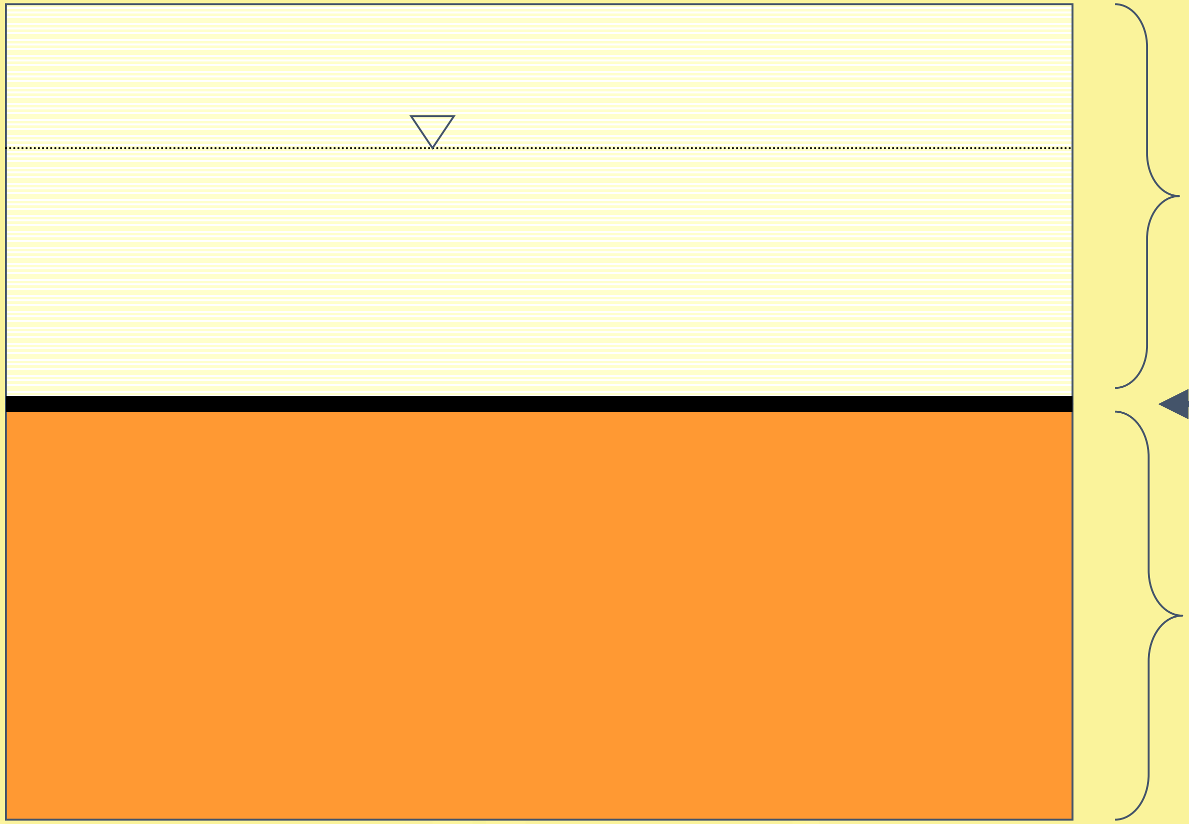
- A single liner consisting of compacted soil and geomembrane in intimate contact

Double Liner

- A liner system with low permeability barrier layers with a leak detection system layer in between. The upper and lower components are either compacted soil, geomembrane, or composite.

Typical Composite Liner

Single Composite Liner



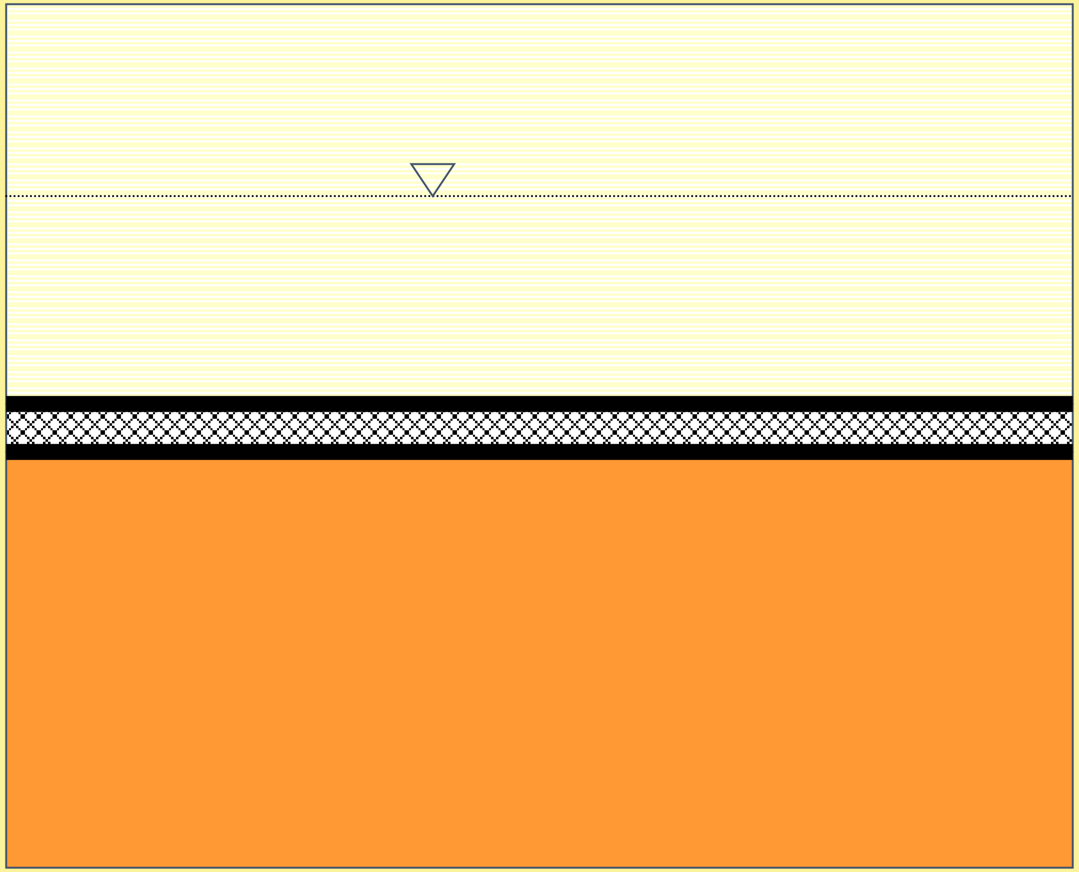
2 ft drainage material
Designed to maintain less than 1ft head on liner

60 mil HDPE Geomembrane

2 ft compacted soil
K <= 10^{-7} cm/sec

1 mil = 0.001 inch

Double Liner



2 ft drainage material

Designed to maintain

less than 1ft head on liner

HDPE Geomembrane

Geonet

HDPE Geomembrane

3 ft compacted soil

K <= 10^{-7} cm/sec

Types of Geomembrane Materials

- HDPE
- PVC
- VLDPE
- PP


CAT
CP-563D
9ZW00149


80


DEERE


544H
DEERE

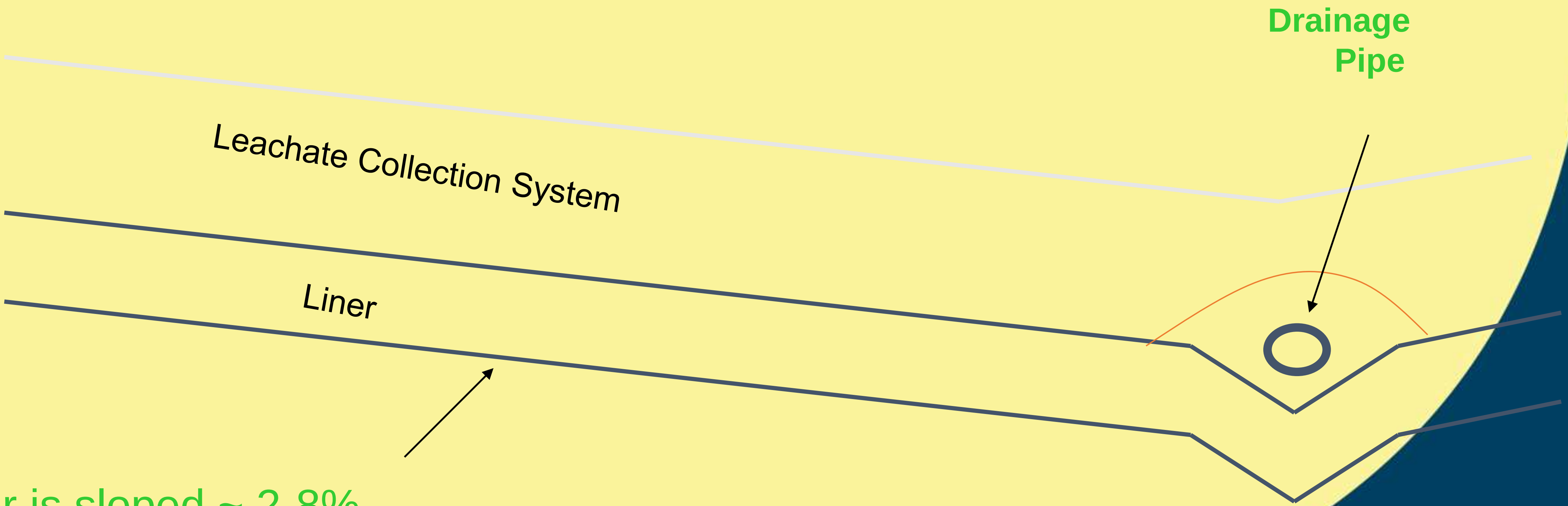
How do you Remove Leachate from the Landfill?

- Drain as much as you can by gravity (liner system and pipes)
- Pump from low points
  - Penetration through the liner
  - Pumps inside landfill

Leachate Collection System

- If leachate flow is intercepted or impeded by a liner, then it should be removed from the landfill by use of a leachate collection system. A leachate collection system is a high-permeability layer designed to transmit leachate from the liner.

How is Leachate Removed



Liner is sloped ~ 2-8%

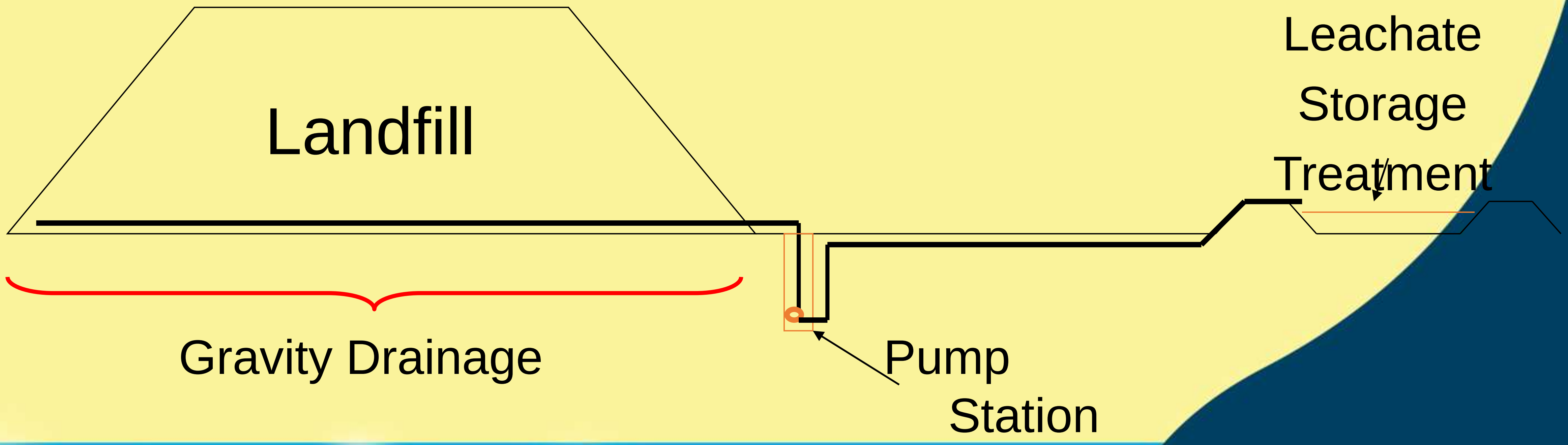
What is a Geonet?

- A synthetic (HDPE) material used for drainage of liquids. It is a has transmissivity in the later direction.

What is a Geotextile?

- A geosynthetic textile that is used in many civil engineering applications. It separates fine granular materials from coarse granular materials, plus it allows water to flow through.

Leachate is then sent to Treatment and/or Storage Facility




CAT

Leachate

- Can contain many compounds. The quality of leachate is dictated by the type waste. For MSW, leachate quality is very much dictated by the phase of landfill stabilization.

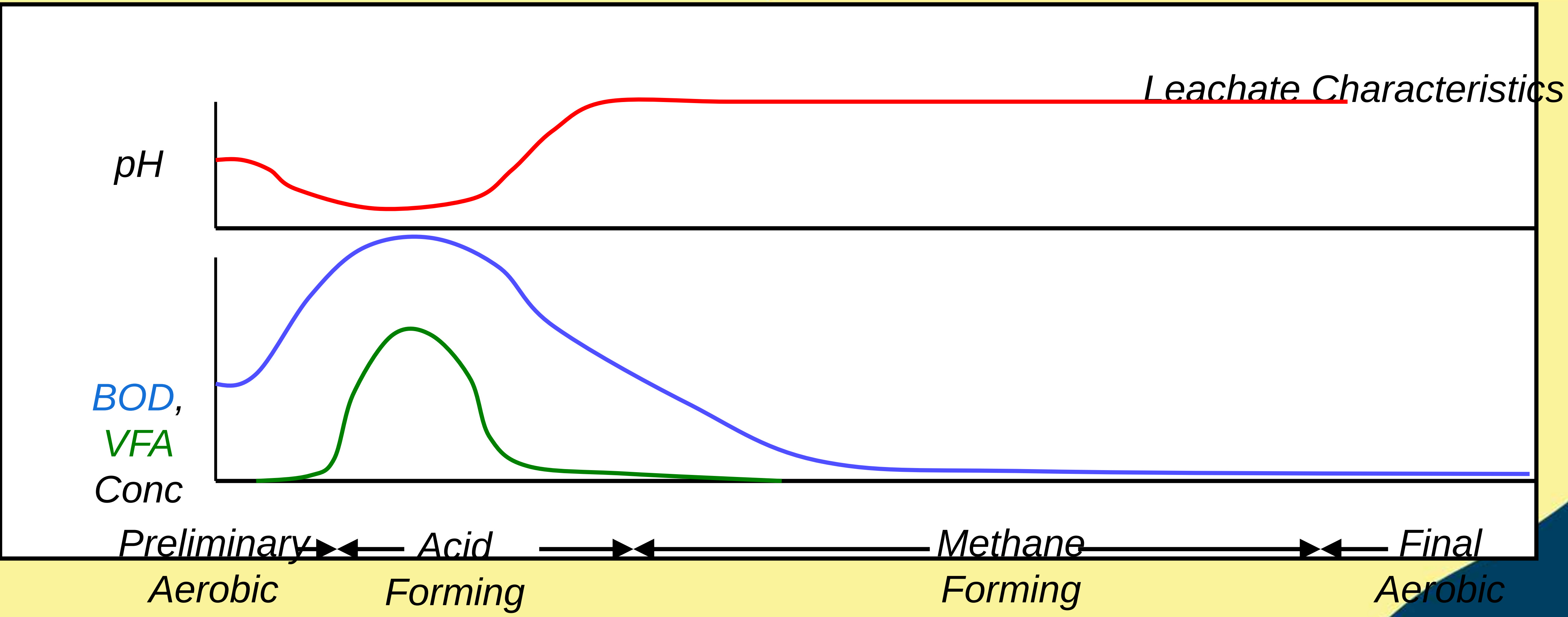
Waste Stabilization

- Phases of Landfill Stabilization
  - Previous investigators have described different phases of landfill stabilization
  - Simplified version:

Preliminary Aerobic Phase → Acid Forming Phase → Methane Forming Phase → Final Aerobic Phase

Aerobic | *Anaerobic* (Acid Forming Phase and Methane Forming Phase) | *Aerobic*

Waste Stabilization



- The phase of stabilization influences leachate and gas characteristics

Landfill Gas

- Gas wells are typically installed after the landfill has been filled up
- A vacuum is pulled on these wells to extract the gas into a pipe system
- The gas is then flared or turned to energy

Landfill Gas

- What is Landfill Gas?

$$C_6H_{10}O_5 + H_2O \rightarrow 3\,CH_4 + 3\,CO_2$$

Landfill Gas Contains

- Methane
- Carbon Dioxide
- Water Vapor
- Hydrogen Sulfide
- NMOC (non methane organic compounds)
- heavy metals??

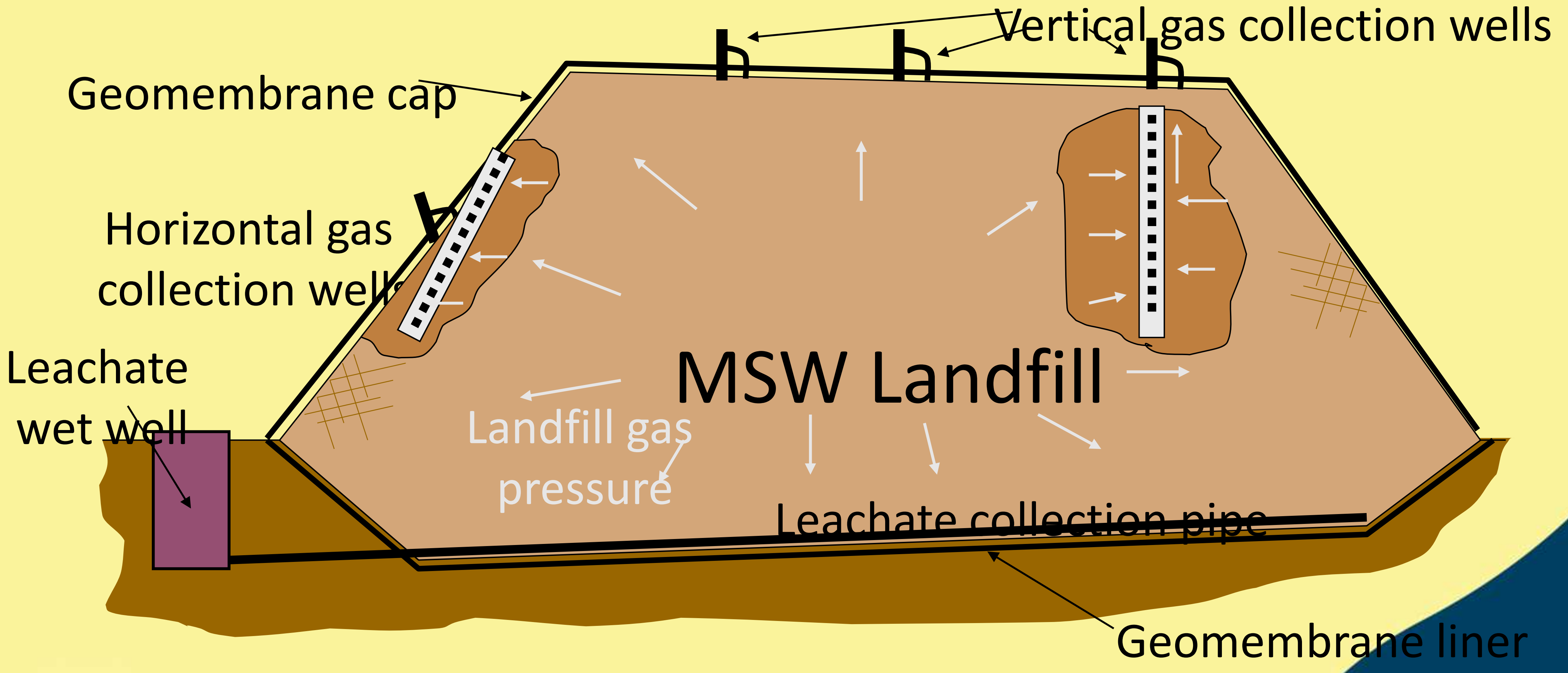
Why Bother with Landfill Gas?

- Odor
- Toxics
- Greenhouse Gas
- Explosive Gas
- Potential Energy Source

How is Gas Collected?

- Typically use vertical wells.
- Installed after landfill has reached final grade.
- Use an auger.

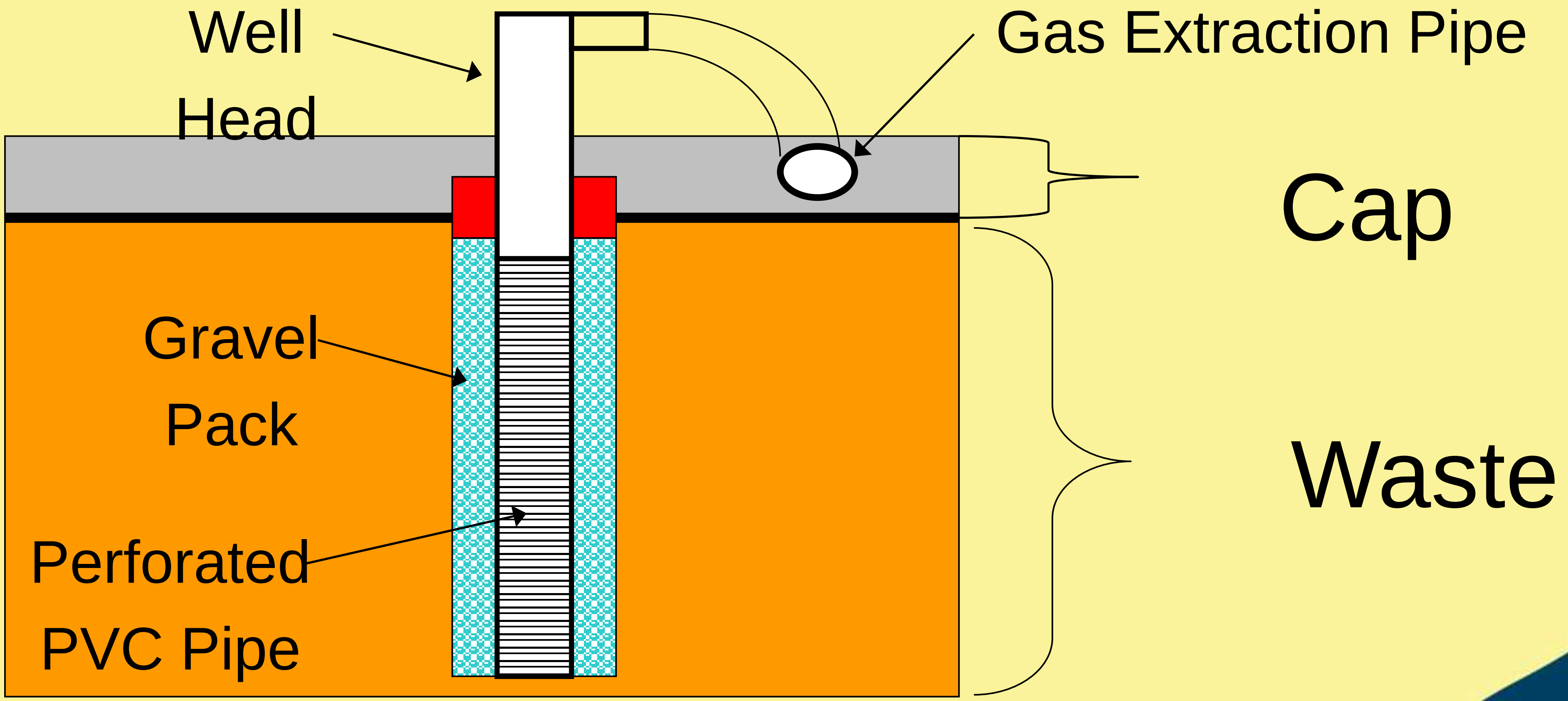
Landfill gas generation and flow



Wells

- Passive Wells (wells open to atmosphere)
- Active Wells (wells connected to a gas extraction system).

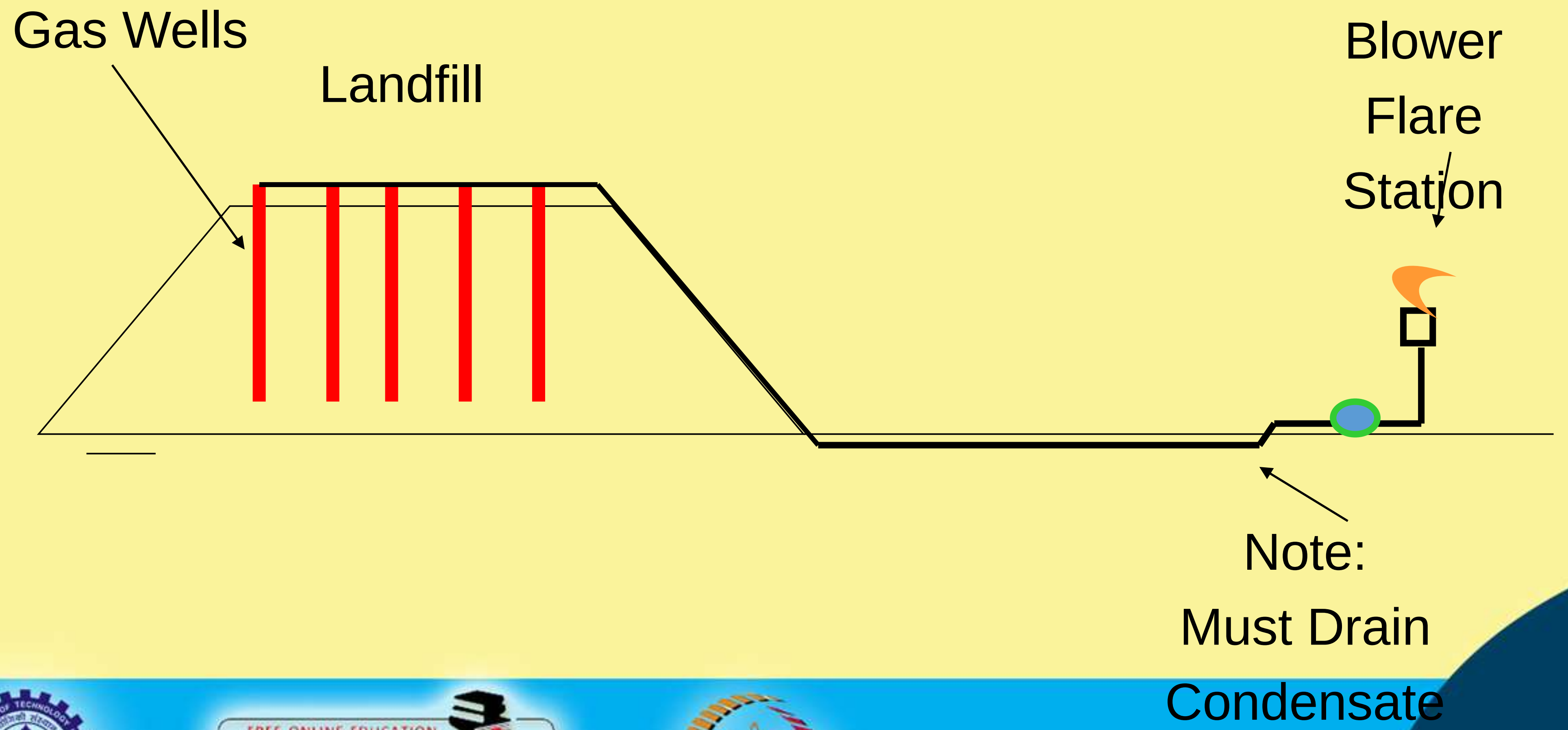
Typical Landfill Gas Well



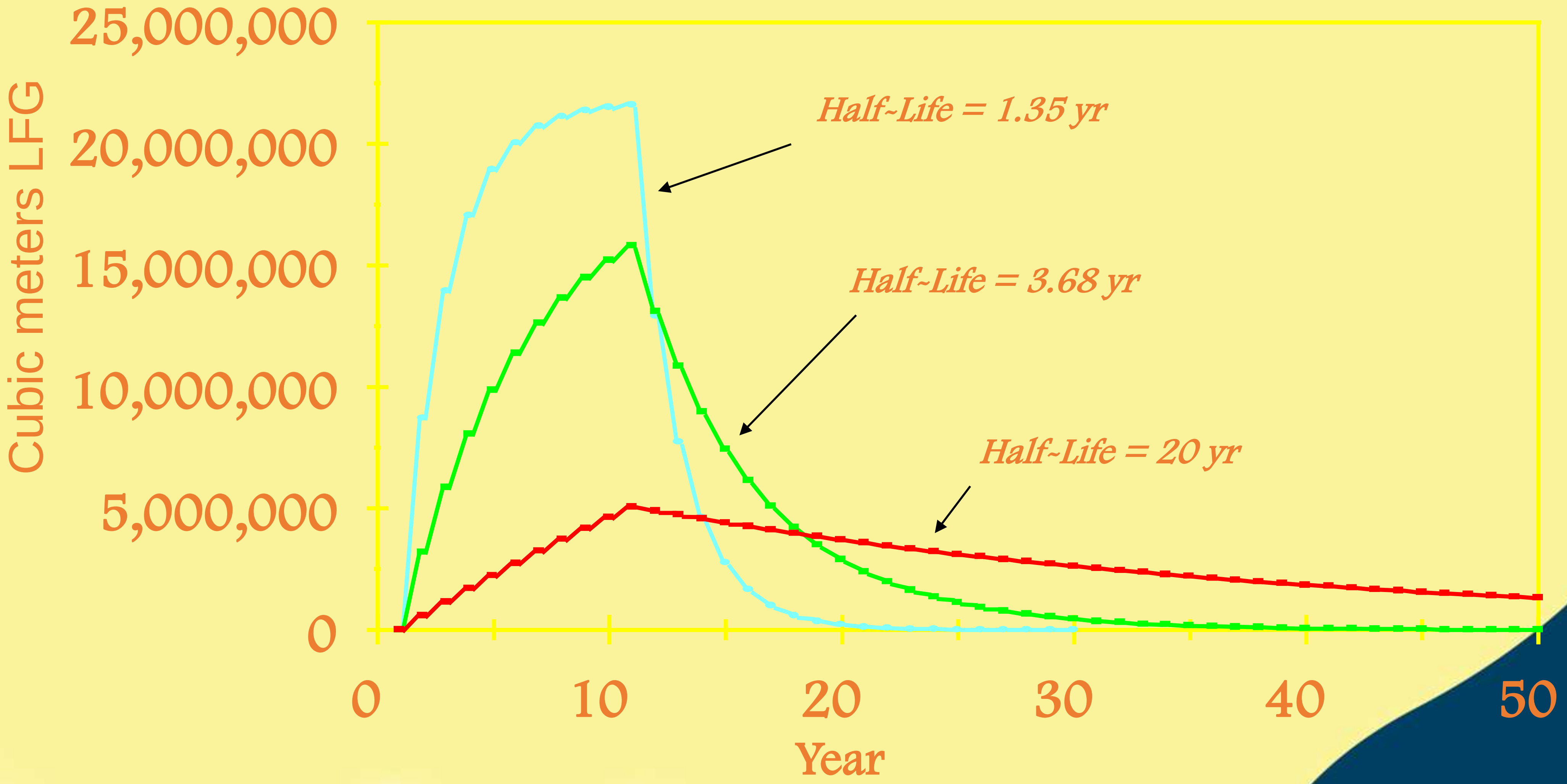
What is the Driving Force for Gas to Leave the Landfill?

- Pressure
- Without any wells, gas will find way to surface (or bottom)
- Wells provide path of escape (create pressure gradient)

Landfill Gas is Typically Extracted to a Blower-Flare Station



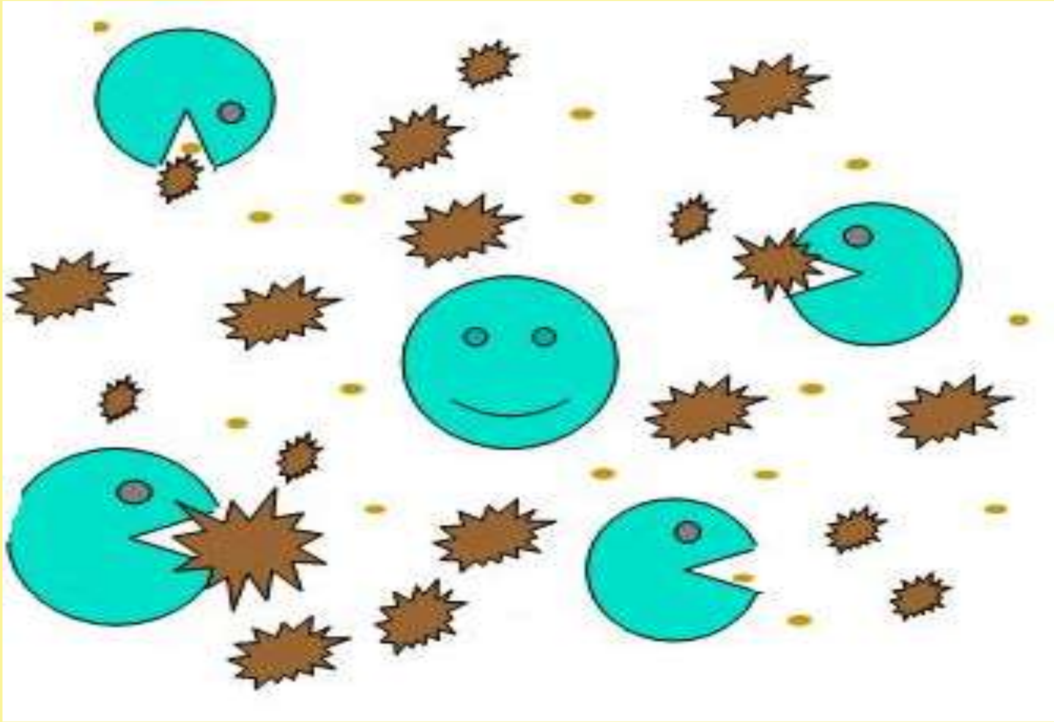
LFG Generation Curves



Biological Methods of waste treatment

- Composting

- Anaerobic digestion

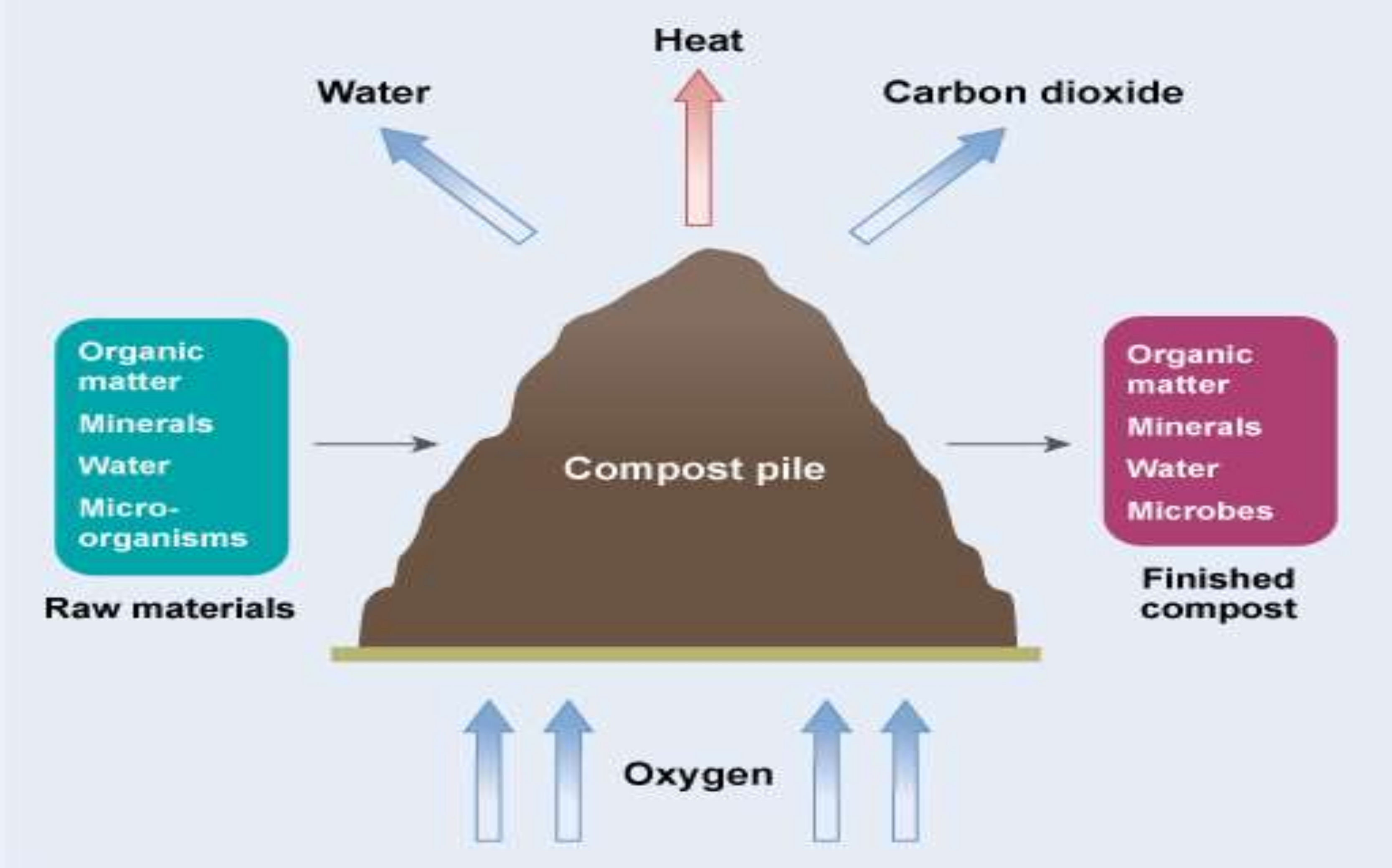


Composting (for solid waste)

https://parade.com/846018/juliebawdendavis/quick-and-easy-garden-composting/

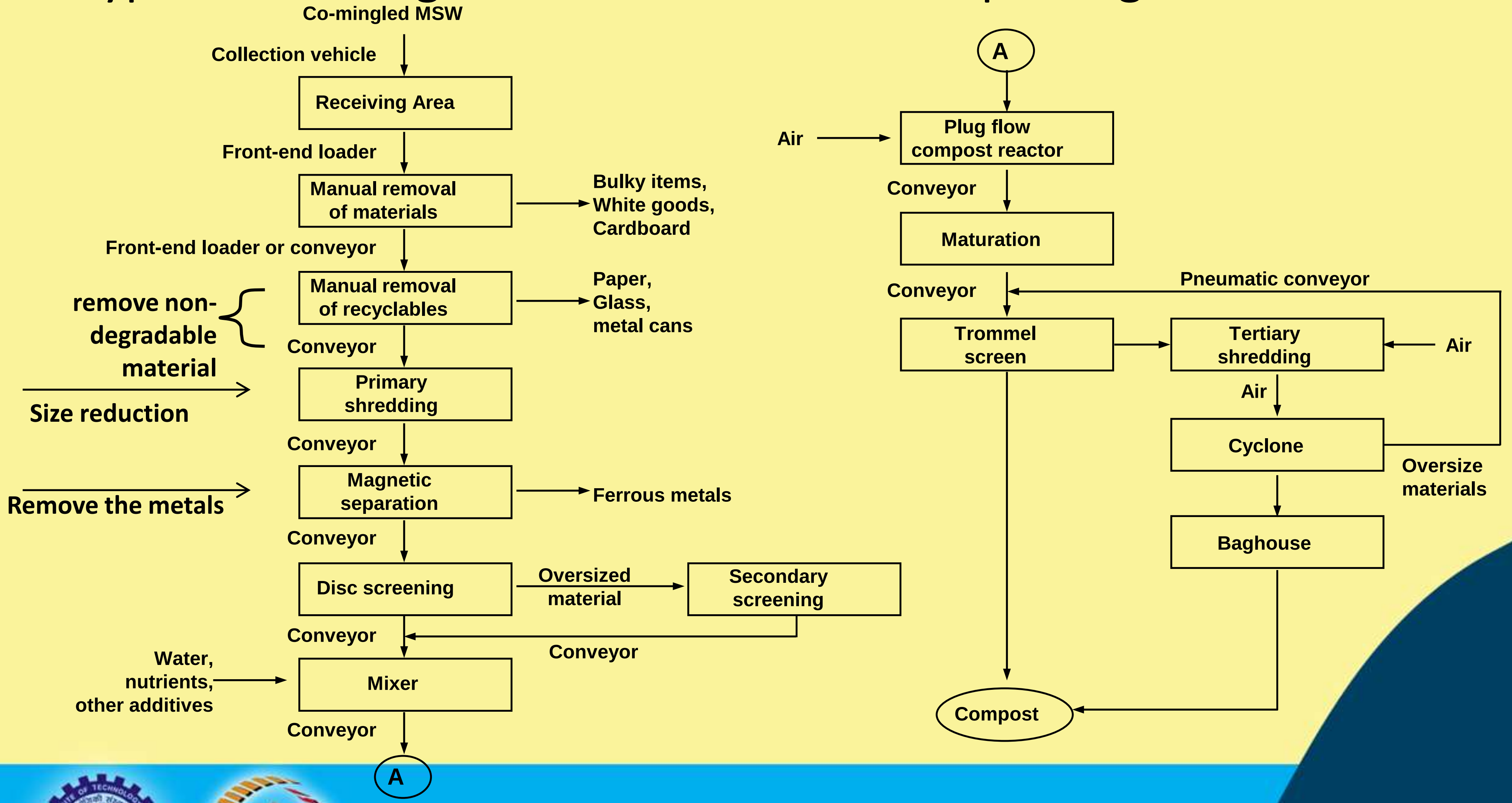
- Transformation of organic material through decomposition into a soil- like material.

- Invertebrates (insects & earthworms) & microorganisms (bacteria & fungi) help in this transformation.



https://www.open.edu/openlearncreate/pluginfile.php/170069/mod_oucontent/oucontent/13842/90723551/2f744a9c/m4_ss8_fig8.4.jpg

- a typical flow diagram for commercial composting:



Nutrients

- the most critical environmental factor for composting is the relative proportion of carbon and nitrogen (the C:N ratio)
- the optimal range is between 20:1 and 25:1
  - composting time increases with the C:N ratio above 40:1
- individual components of organic matter have different C:N ratios:
  - digested sludge has a low ratio (15:1)
  - yard waste has a high ratio (40:1 – 80:1)
  - newspaper has a very high ratio (175:1 – 800:1)
- to achieve an optimal ratio, organic waste is blended together
- for example, we might add:
  - newsprint – which is high in carbon and low in nitrogen, and
  - yard waste – which is high in nitrogen
  - and, supplement with manure (15:1) or sludge (15:1) if needed

Nutrients

- nominal C:N ratios of selected compostable materials

Material	Percent N	C/N ratio[b]
Food processing wastes		
Fruit wastes	1.52	34.8
Mixed slaughterhouse waste	7.0–10.0	2.0
Potato tops	1.5	25.0
Manures		
Cow manure	1.7	18.0
Horse manure	2.3	25.0
Pig manure	3.75	20.0
Poultry manure	6.3	15.0
Sheep manure	3.75	22.0
Sludges		
Digested activated sludge	1.88	15.7
Raw activated sludge	5.6	6.3
Wood and straw		
Lumber mill wastes	0.13	170.0
Oat straw	1.05	48.0
Sawdust	0.10	200.0–500.0
Wheat straw	0.3	128.0
Wood (pine)	0.07	723.0
Paper		
Mixed paper	0.25	173
Newsprint	0.05	983
Brown paper	0.01	4490
Trade magazines	0.07	470
Junk mail	0.17	223
Yard wastes		
Grass clippings	2.15	20.1
Leaves (freshly fallen)	0.5–1.0	40.0–80.0
Biomass		
Water hyacinth	1.96	20.9
Bermuda grass	1.96	24

Table 14-7

Temperature

- Heat is released in the composting process, and a mass of composting material will retain the heat
- The temperature rise is caused by exothermic reactions associated with microbial respiration
- High temperature is essential for destruction of pathogenic organisms
- Composting operates in 2 temperature ranges:
  - mesophilic $\rightarrow$ 30 – 35°C for the first few days
  - thermophilic $\rightarrow$ 50 – 60°C for the remainder of the time
  - 60°C for 24 hours will destroy all pathogens
  - it should be kept below 66°C or biological activity is reduced significantly
- To maintain high temperatures, compost must be aerobic
  - in static piles – temperature can be controlled by airflow
  - in windrows – temperature drops for several hours after mixing

pH Control

- pH is the measure of the acidity or alkalinity of the compost
- Initially, during the mesophilic stage, pH is between 7.0 and 7.5
- After several days, the pH will naturally drop to 5.0
  - as a result of the production of organic acids
- During thermophilic stage, pH will rise to around 8.0
- To minimize loss of N as ammonia (NH_3^+) gas, the pH should be kept below 8.5
  - this can be managed with aeration
  - the addition of lime to increase pH is discouraged – it causes nitrogen to be released as ammonia gas, which causes odour problems and a reduction in available nitrogen
- Mature compost has a pH around 7 (neutral)
- If aeration is insufficient, pH will drop to 4.5 and composting will struggle

Temperature and pH

- typical temperature and pH ranges observed during windrow composting

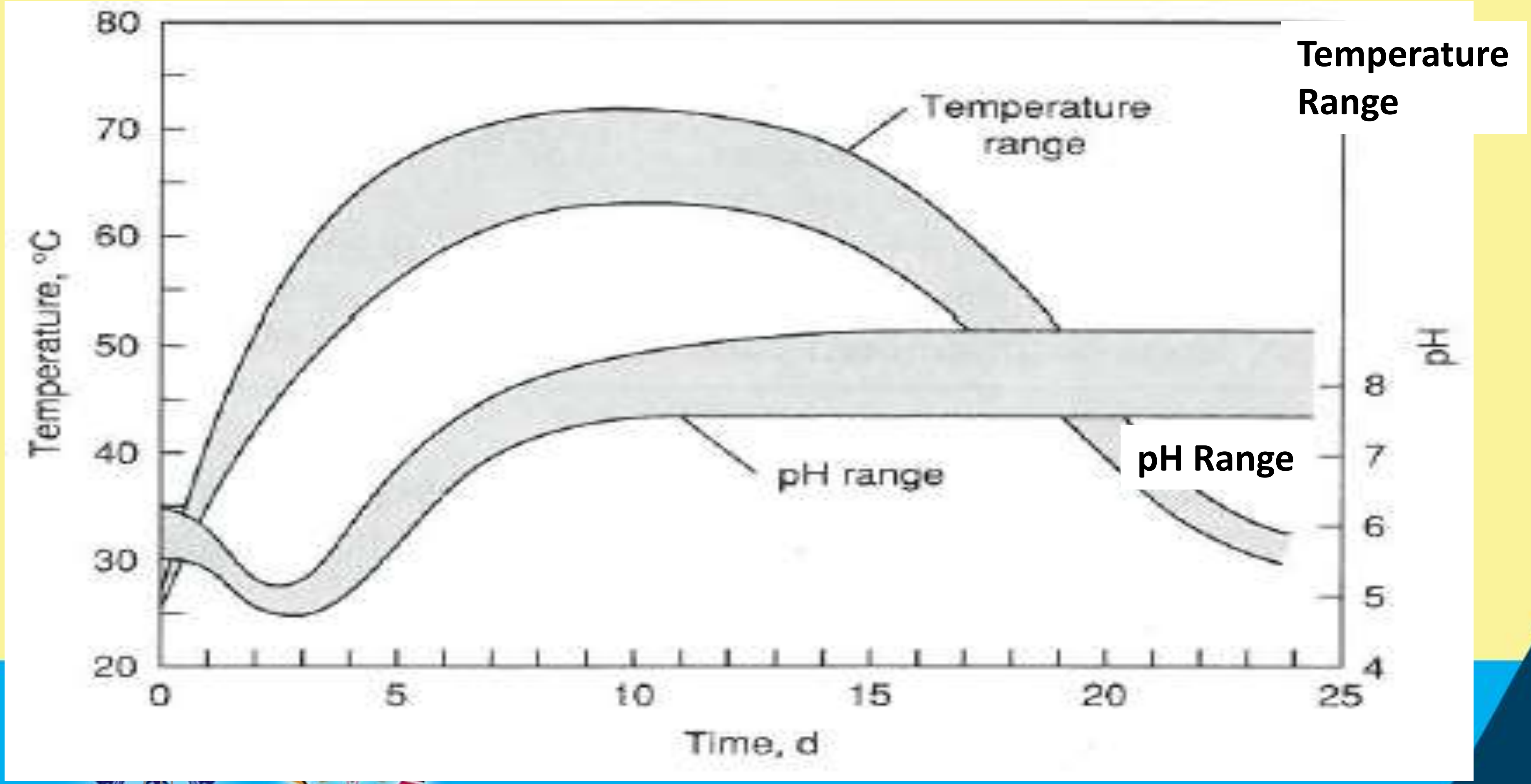


Figure 14-5

Other Environmental Factors

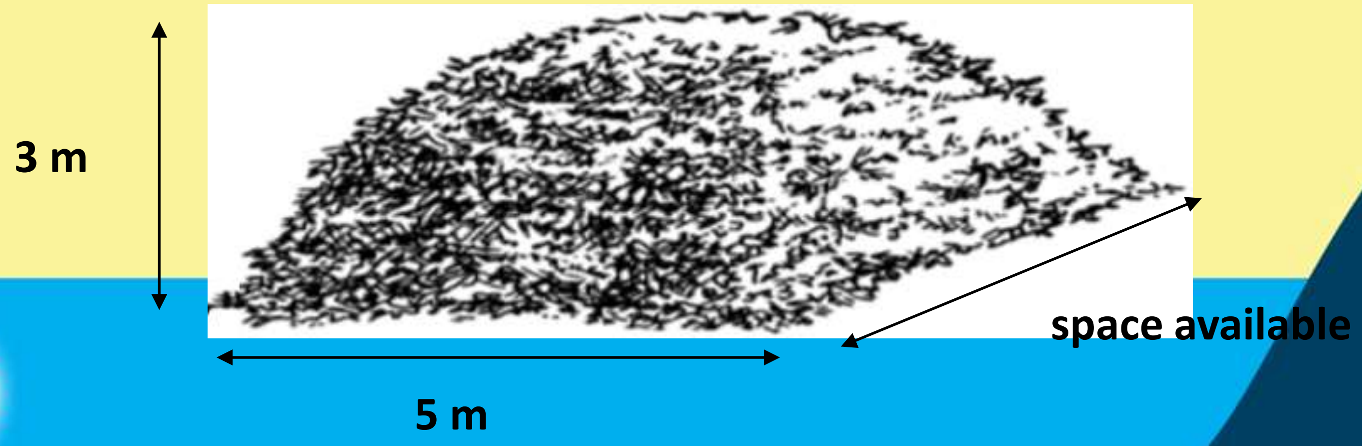
- moisture content
  - should be in the range of 50 – 60% on a wet-weight basis
  - high moisture content displaces air from the pore space
  - sludge is a good source of H_2O
- blending/seeding
  - organisms necessary for decomposition are indigenous to organic material
  - mixing with 5% partially decomposed compost speeds up the process
  - again, sludge is a good source
- particle size
  - shredded to 25 – 75 mm is beneficial
  - exposes more surface area and allows for easy air movement
- mixing/turning
  - frequency is a function of the process
  - first turning after 3 days, then every 5th day

Process and Compost Time

- The time needed to complete the process depends on the system
  - mechanical system 7 days
  - piles/windrows – turned 9 – 21 days
  - static piles/some mixing 30 – 40 days
- When is the process finished?
  - when upon turning the compost, the temperature does not rapidly rise in the pile, which means the organic fuel is gone
  - the material left over is humus-like, dark brown and smells “earthy”
  - the remaining compost is half the original volume
- The compost is then usually cured for an additional 2 – 8 weeks
  - the compost is stored outside in dry conditions and turned occasionally
  - it produces a larger, more diverse microbial population
  - provides a stable source of nitrogen for application to farm land (C:N < 25:1)
  - reduces the temperature so that seeds can survive (germination test)

Composting Techniques

- there are two principle methods of aerobic composting:
  - agitated – the material is agitated periodically to introduce air
  - static – the material remains static and air is blown through the compost
- windrow composting
  - organic material is formed into windrows (3 m high, 5 m wide)
  - the compost is turned regularly (up to 2 times per week)
    - front end loader or mixing apparatus
  - complete composting can be accomplished in 1 – 3 weeks
  - the compost is then cured (with no mixing) for an additional 3 – 4 weeks



Composting Techniques

- aerated static pile composting
  - compost is piled on top of a system of blowers
    - like corrugated steel pipe drainage
  - blower operation is typically controlled by a timer, based on temperature
  - either positive or negative pressure (negative is better)
  - material is composted for 3 – 5 weeks
  - then the compost is cured for another 4 weeks

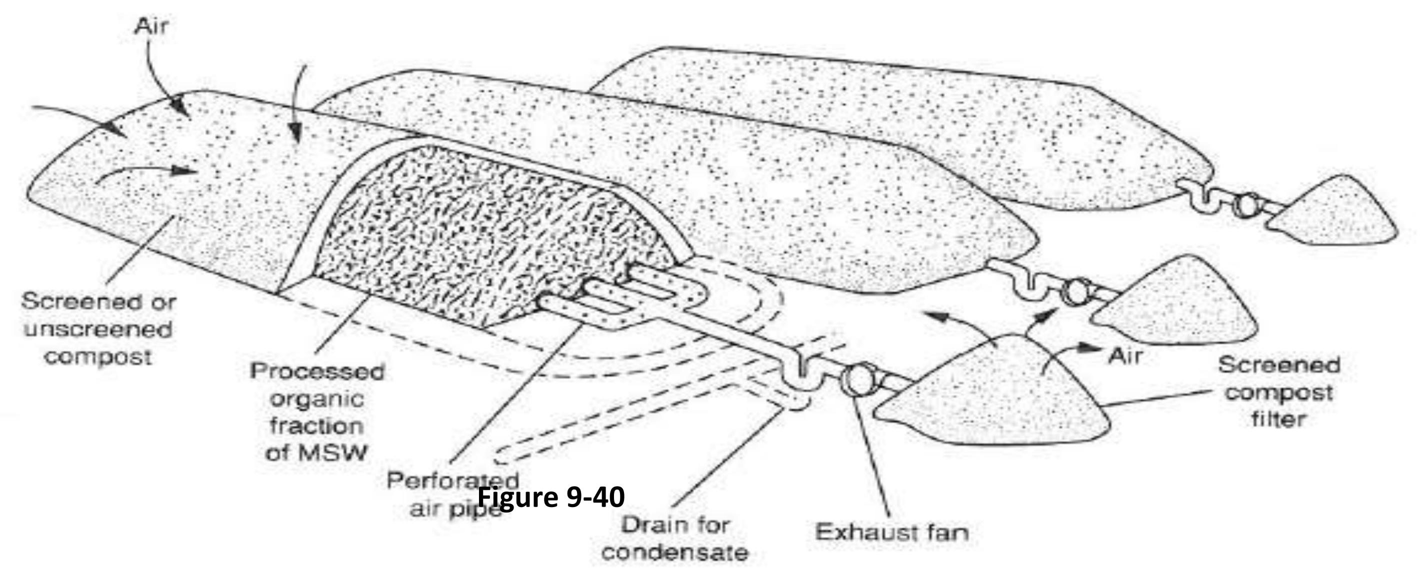
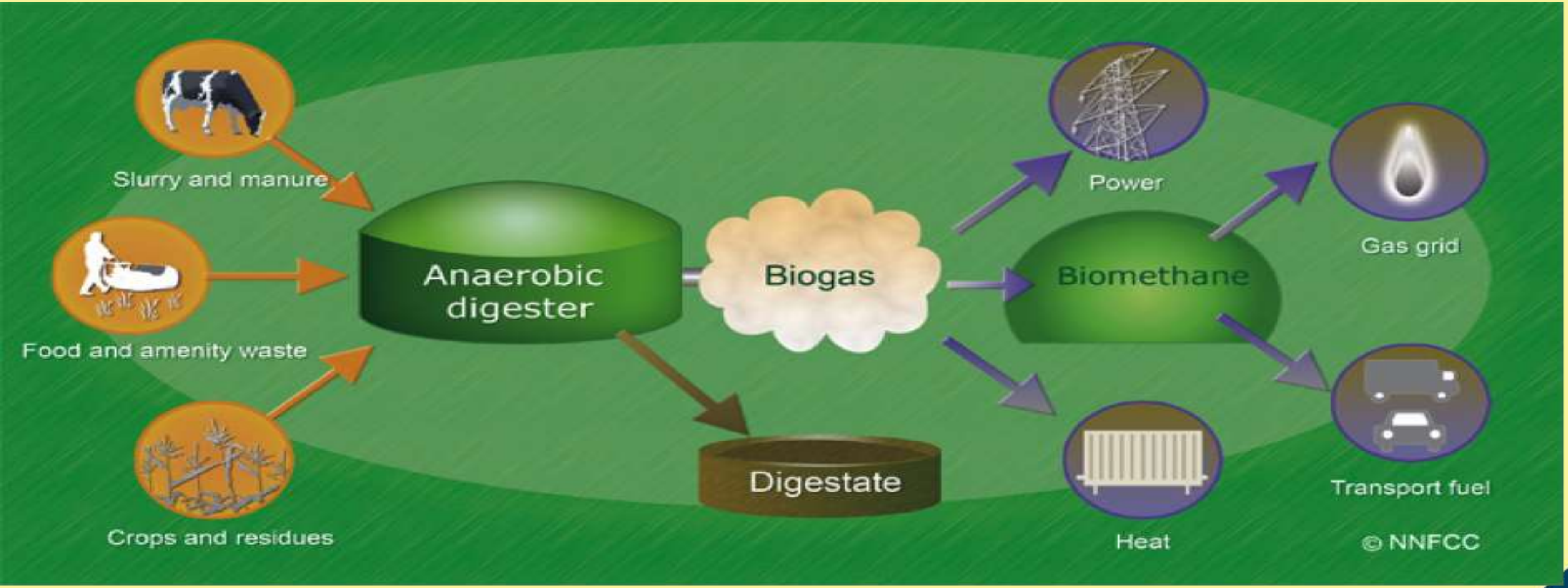


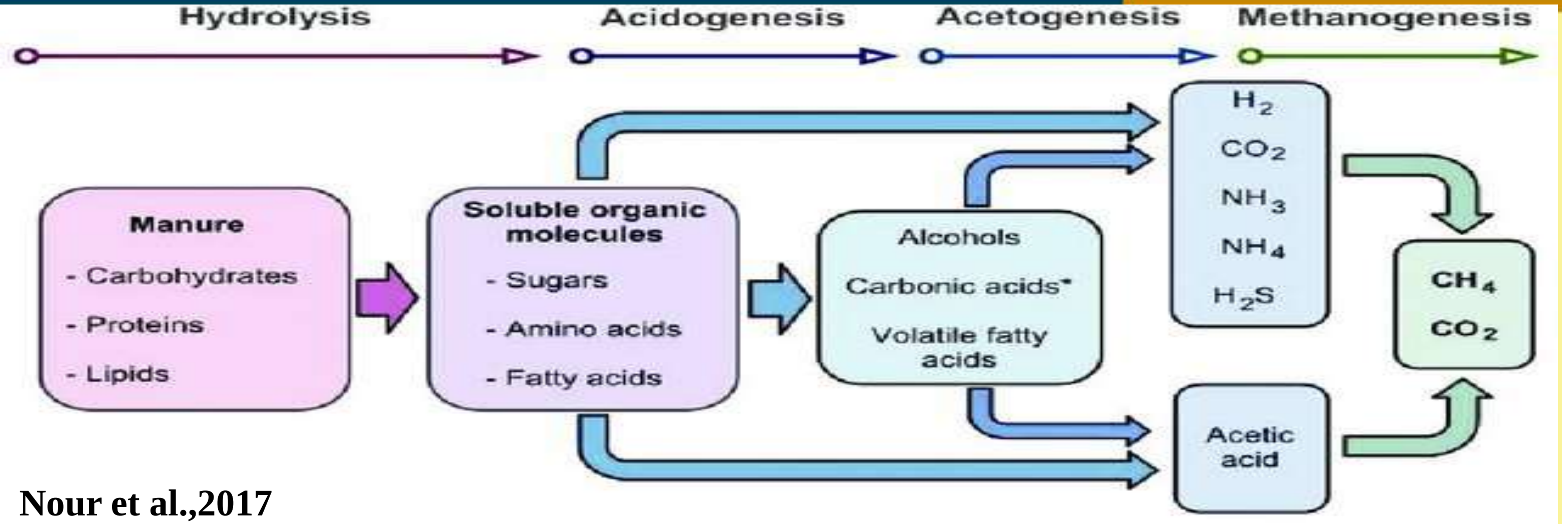
Figure 9-40

- Composting can be done by individual householders and community groups or on a commercial scale.
- On the larger scale, the waste from an entire town or city could be composted if sufficient land, labor and equipment is available.
- The benefits of composting are not only the reduction of waste, but also the production of compost which is a valuable **soil improver**.
- Soils treated with compost are better able to withstand droughts and are more fertile because plant nutrients are returned to the soil, which reduces the need for chemical fertilizers.

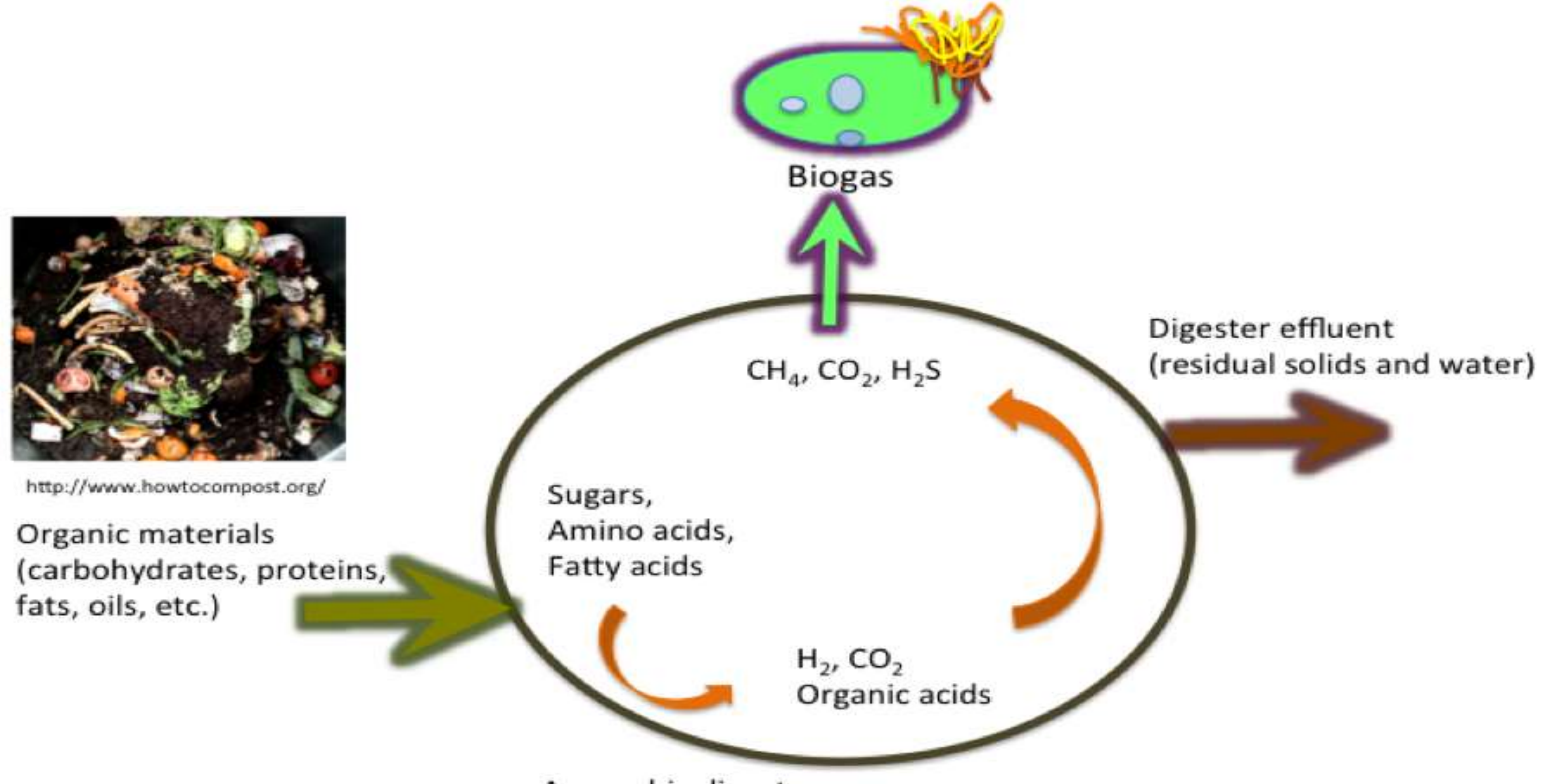
Anaerobic Digestion



http://www.biogas-info.co.uk/about/



Nour et al.,2017



Credit: Dr. Caroline E. Burgess Clifford

Anaerobic Digestion

- to maintain an anaerobic treatment system, the non-methanogenic and methanogenic bacteria must be in a state of dynamic equilibrium
- ideal conditions for digestion include:
  - pH = 6.5 – 7.5
  - need lots of alkalinity $\rightarrow$ 1,000 – 5,000 mg/L as $CaCO_3$
    - so that the pH does not drop below 6.2
    - methane bacteria can not function below this point
  - zero O_2
  - a sufficient amount of nutrients (N and P) need to be present
  - optimal temperatures are:
    - mesophilic $\rightarrow$ 30 – 38°C, and
    - thermophilic $\rightarrow$ 55 – 60°C

Anaerobic Digestion

- batch systems – need a large footprint, but low CH_4 production
  - low tech systems
  - ideal for developing countries
- two-stage system the best
  - stage 1 – provides a home for the acidogens; allows for good buffering
  - constant feed stock for stage 2 where the methanogens live
  - removal of solids from stage 2 reduces gas formation
  - but, high costs
  - can be run as a slurried system to speed things up
- in the United Kingdom
  - the first step is shredding of the organic matter
  - stage 1 operated at 37°C to break down large MWT organic material
  - stage 2 operated at 70°C to pasteurize – which is important for animal waste
  - 5000 tonnes/year @ $100/tonne → produces 880 tonnes CH_4/year
  - residue applied to land as fertilizer

Anaerobic Digestion

- Europe has done a lot of work on this over the past 15 years to stabilize the waste before land application
  - 4 million tonnes capacity
  - operating costs are high
  - lower environmental impacts than straight landfilling
  - generates a useable fuel (CH_4)
    - used to run busses
    - generate electricity
- India and Thailand have thousands of small scale facilities for low cost energy
  - reduces costs associated with transport of MSW and compost
- also think about other applications
  - agriculture – manure and crop residue
  - restaurants – food waste
  - bioremediation – composting of contaminated soil

Major Points to Consider – Compost Plant Design

1. provisions should be in-place to handle collection vehicles, surge amounts and downtime of plant
   - at least 2 days +
2. materials should be processed at a uniform rate
   - hence the need for storage capacity in the MRF
3. has the inorganic materials been separated previously, or is it to be separated by processing at the facility
   - stored and sold for money
   - placed/handled by another process
4. how specific must the refuse be
   - is flexibility allowed?
   - just MSW from the local urban areas?
   - if other waste is being allowed, are there provisions for bulking?

Major Points to Consider – Compost Plant Design

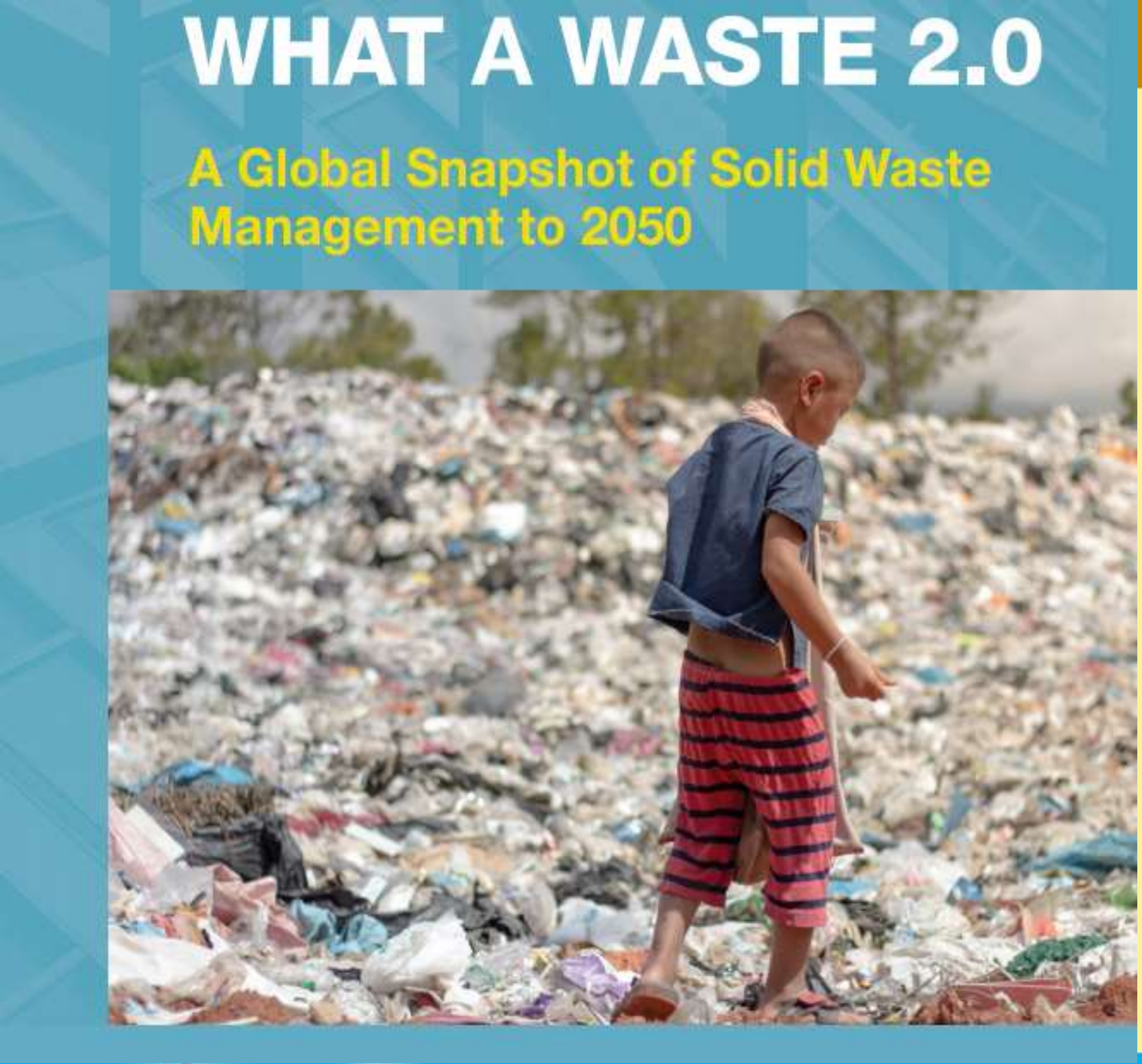
5. can other organic wastes be added to the system
   - is it accepting just municipal wet waste, or are there other sources that need to be considered (agricultural waste, WWTP sludge, …)
6. is the end produce free from pathogens/weed seeds
   - QA/QC controls on the produced compost
7. are control measures in-place for fly and odor control
   - positive pressure, HVAC control, …
8. can the facility store/handle finished compost
   - is it equipped to distribute compost to the end market
9. is a market established for the finished compost
   - homeowners – free compost days?
   - commercial landscaping firms – pay for compost?
10. are there zoning by-laws that need to be satisfied

Major Points to Consider – Compost Plant Design

11. specific design requirements
    - process design – C:N ratio, moisture content
    - composting area sizing – mass, densities, windrow length, shrinkage
    - finished compost storage area – 3 months +
    - runoff collection pond sizing – design storm events
    - land treatment design for runoff – hydraulic budget of the soil
    - costing – unit operations, equipment, personnel, …

Applications:

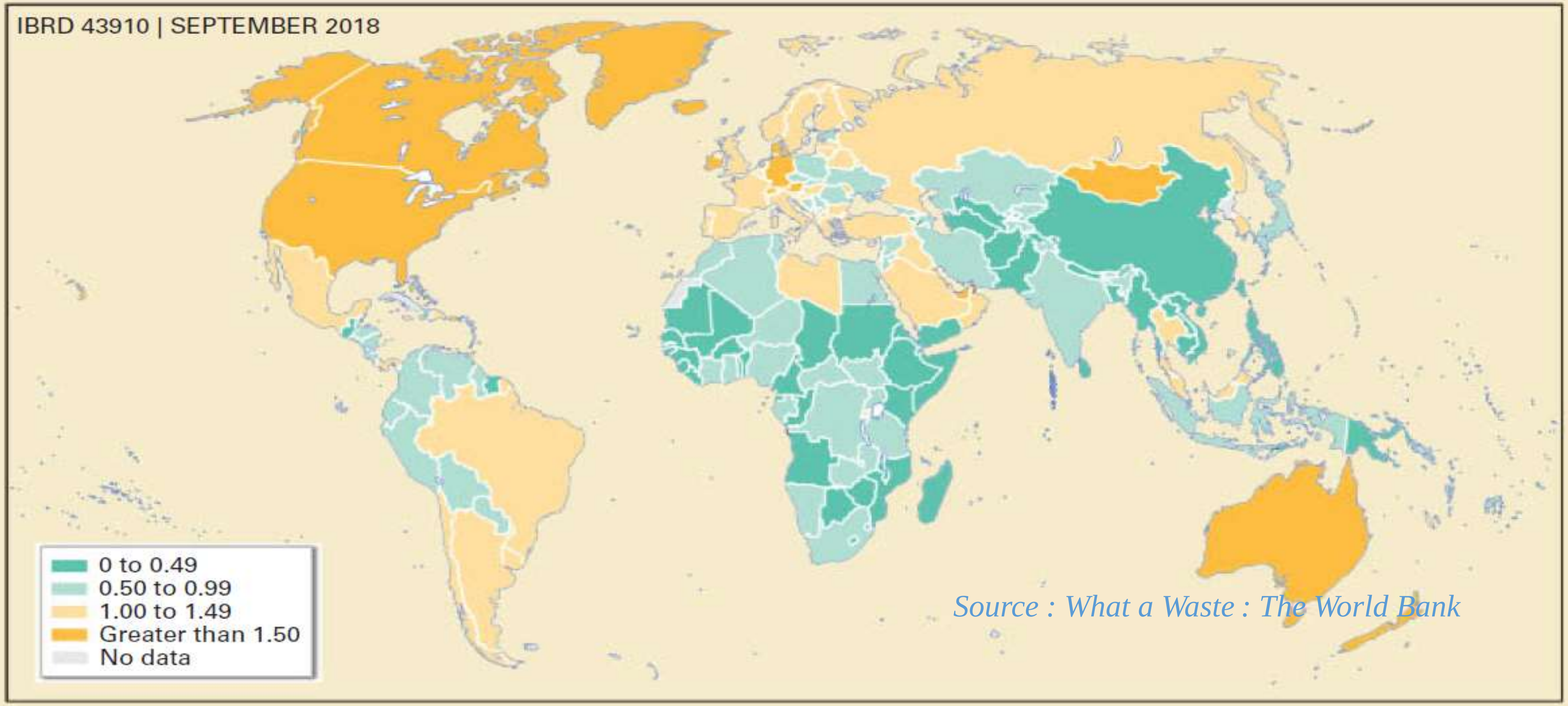
- Waste and wastewater treatment.
- Reduces the emission of landfill gas into the atmosphere.
- Power generation.
- Fertilizer and soil conditioner.
- Cooking gas.
- Vehicle fuel.



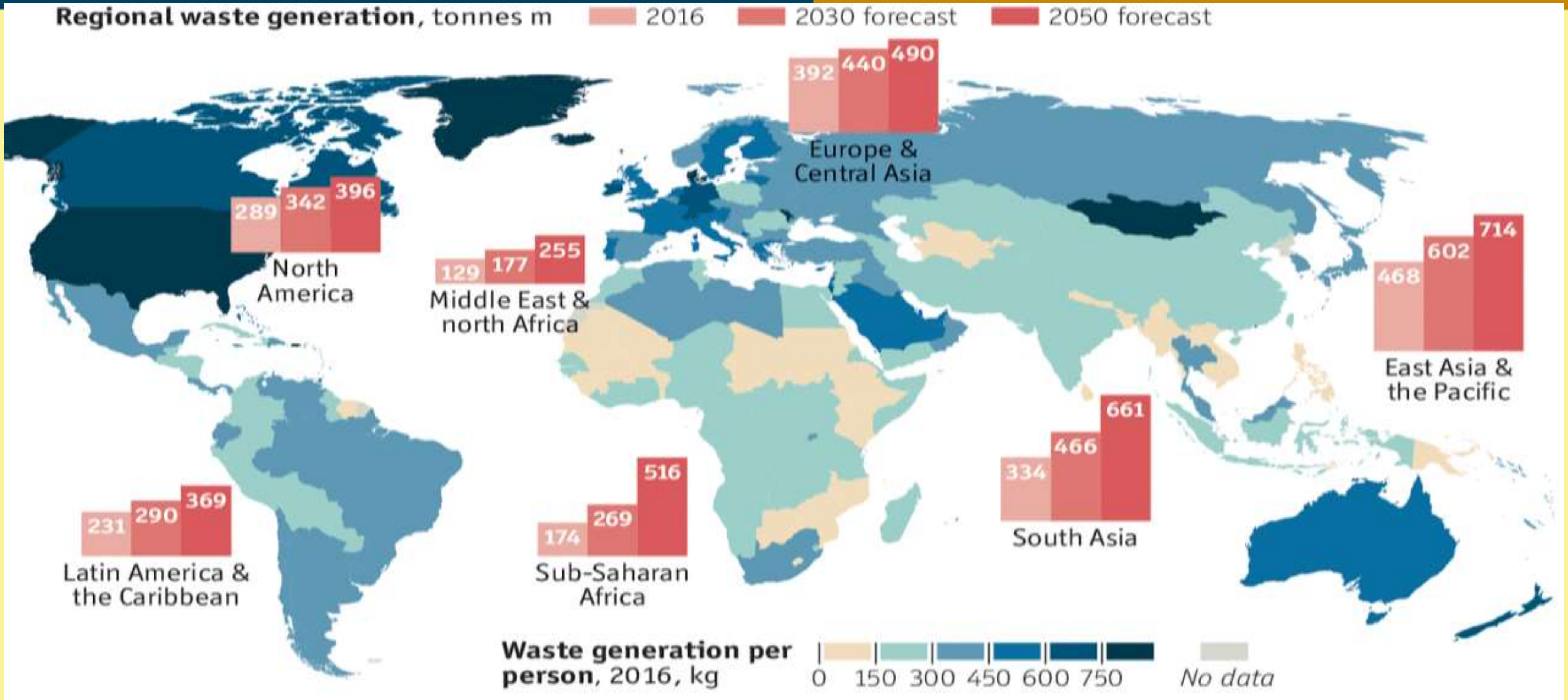
- A world bank report which replaces earlier report "what a waste".
- Funded by Japan Government in partnership with world Bank.
- Collected data on 217 countries and economies and nearly 317 cities.
- Data collected (Waste generation, collection, treatment, disposal, Operational model, financing ,Informal sector, public awareness etc.

Kaza et al., 2019

Annual Municipal Solid Waste Generated Per Capita (kilograms/capita/day)

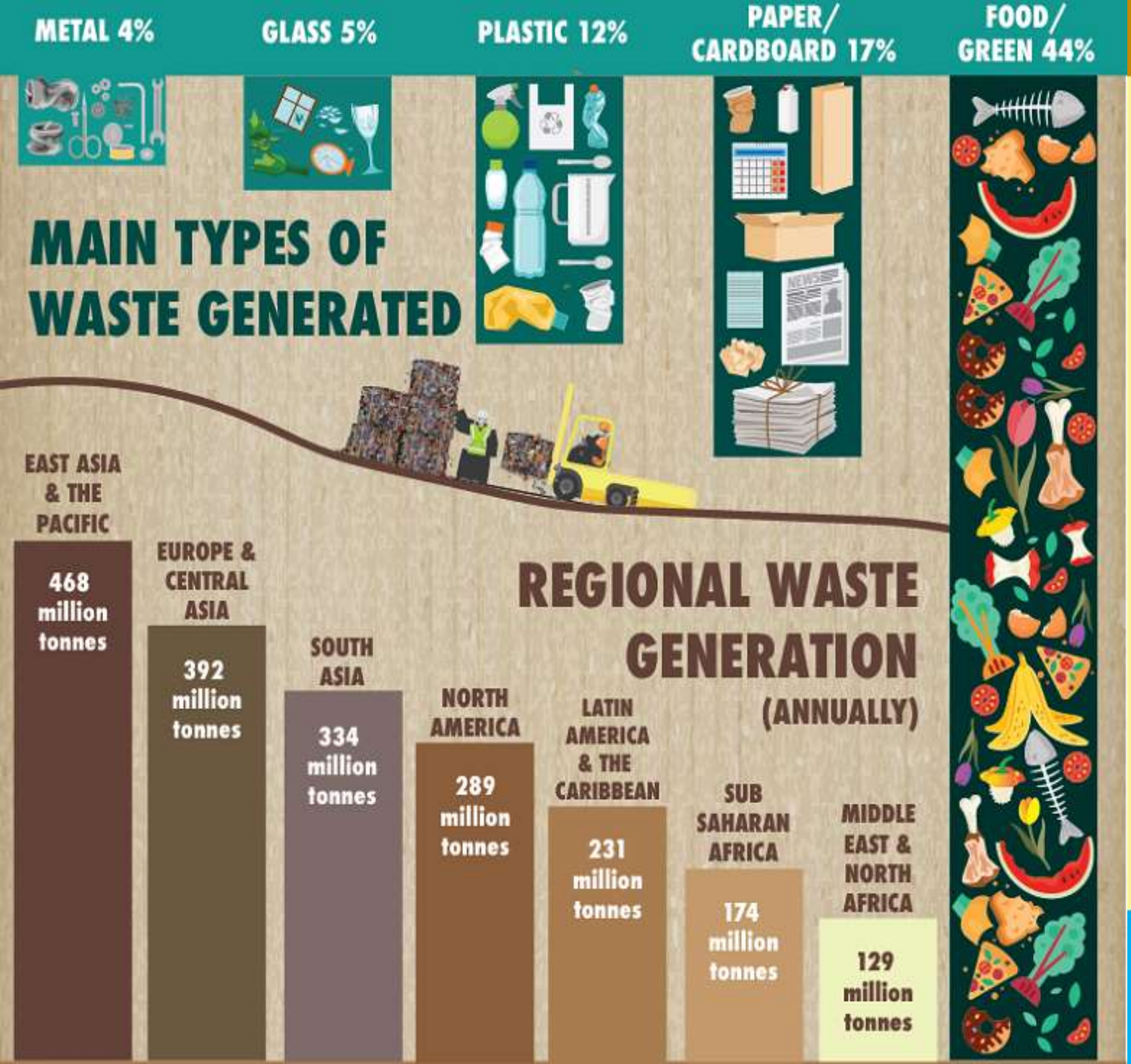


Note: kg = kilogram.



R01

Source : Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018)


METAL 4%
GLASS 5%
PLASTIC 12%
PAPER/ CARDBOARD 17%
FOOD/ GREEN 44%
MAIN TYPES OF WASTE GENERATED
REGIONAL WASTE GENERATION
(ANNUALLY)
EAST ASIA & THE PACIFIC
468 million tonnes
EUROPE & CENTRAL ASIA
392 million tonnes
SOUTH ASIA
334 million tonnes
NORTH AMERICA
289 million tonnes
LATIN AMERICA & THE CARIBBEAN
231 million tonnes
SUB SAHARAN AFRICA
174 million tonnes
MIDDLE EAST & NORTH AFRICA
129 million tonnes

•Global waste will increase by 70 percent on current levels by 2050.

•Global annual waste generation is expected to jump to 3.4 billion tonnes over the next 30 years, up from 2.01 billion tonnes in 2016.

•Driven by rapid urbanization and growing populations.

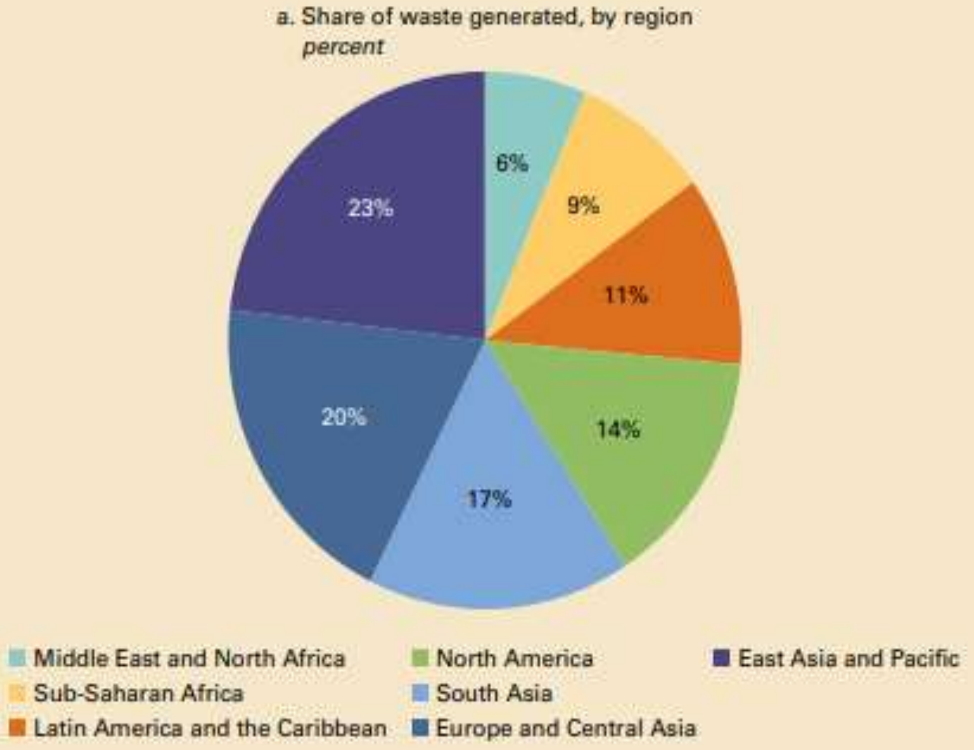
•Sub-Saharan and South Asia will have fastest growth (35% of the global waste by 2050).

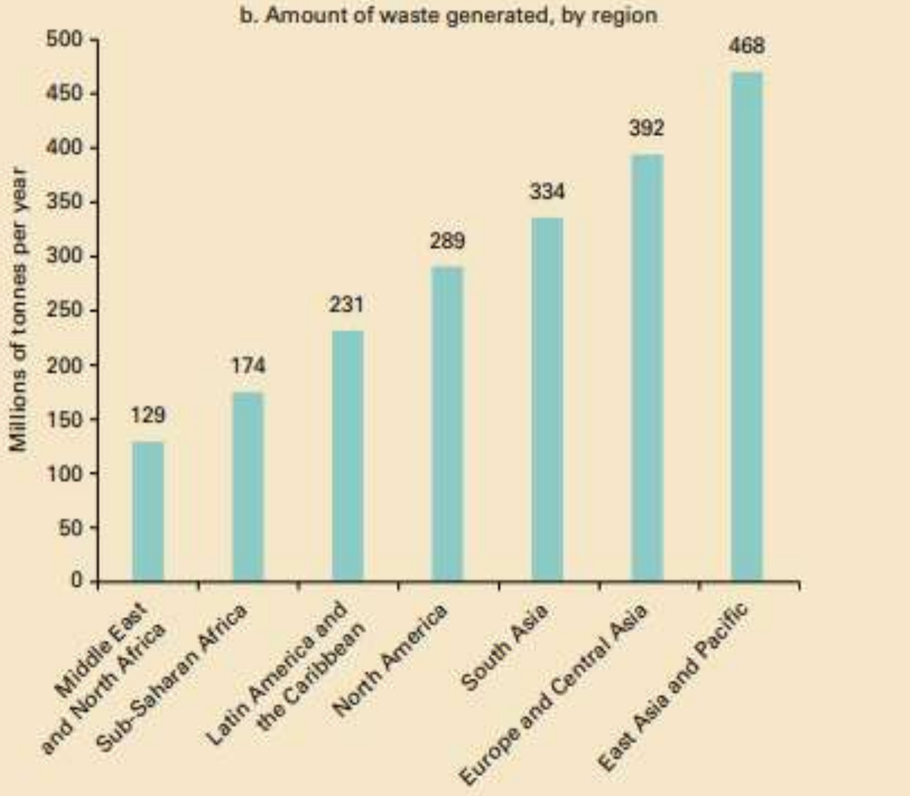
•¼ of global plastic waste is coming from east Asia and pacific with ocean waste coming from five countries in the region.

•50% solid waste management operation involves private sector and civil / non profit.

Major message from the report

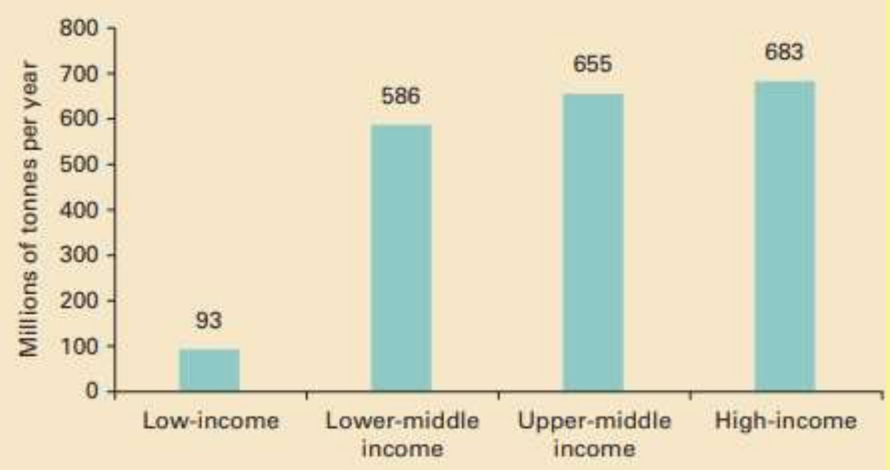
Waste Generation by Region





Projected Waste Generation by Region

Projected waste generation per capita

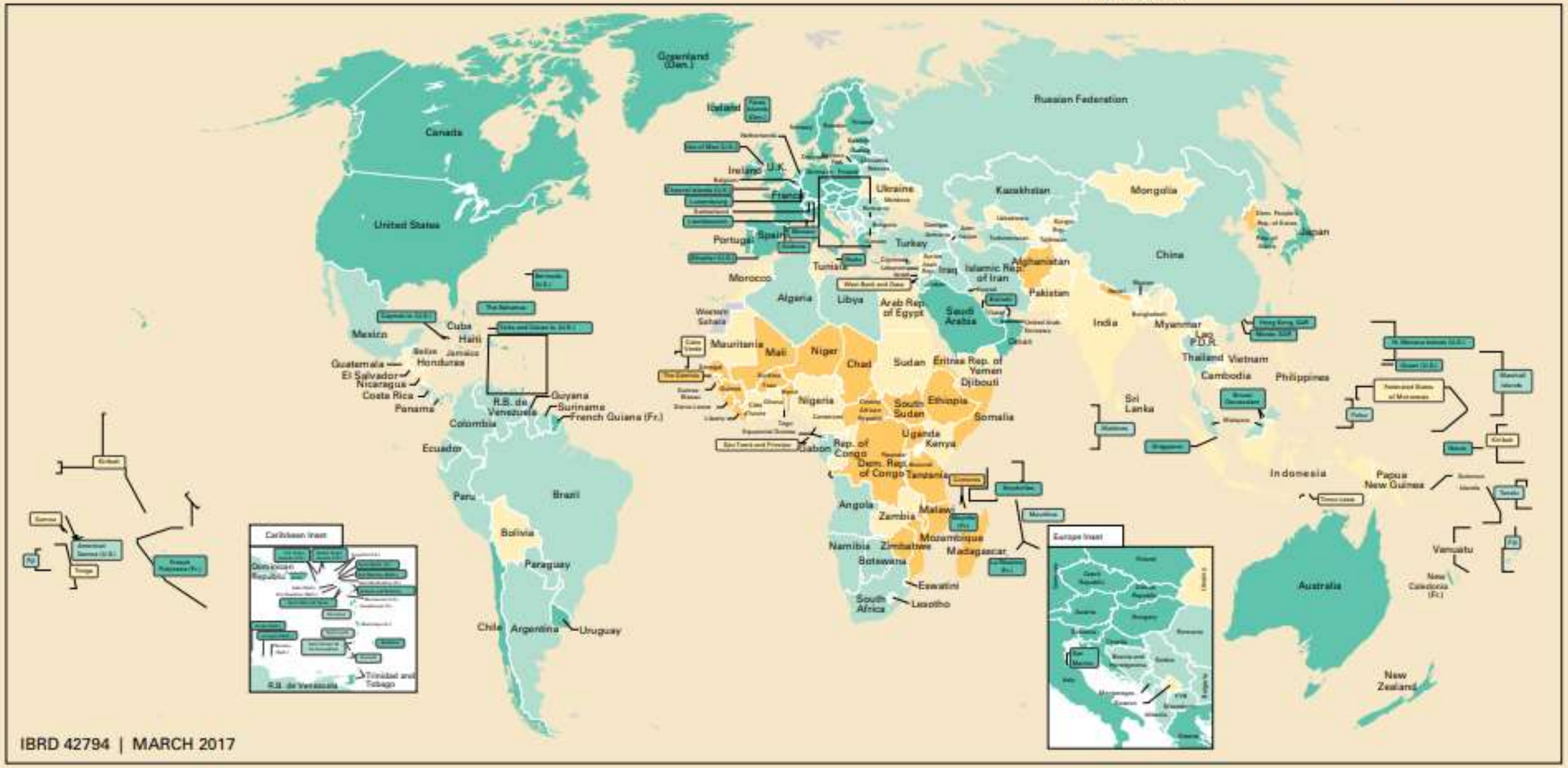


Definition of Income Levels

The world by income

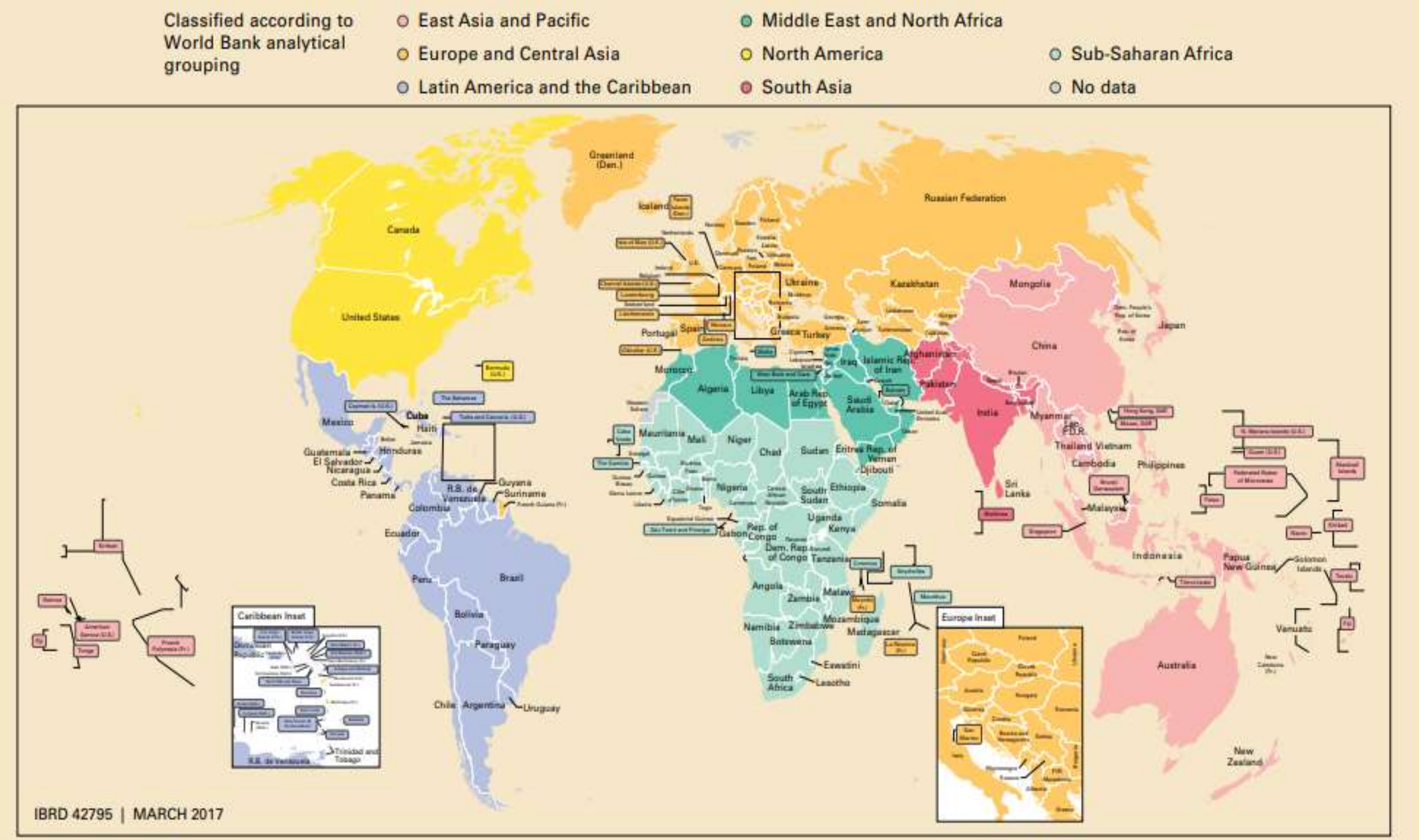
Low ($1,025 or less)
Lower middle ($1,026–$4,035)
Upper middle ($4,036–$12,475)
High ($12,476 or more)
No data

Classified according to World Bank estimates of 2015 GNI per capita

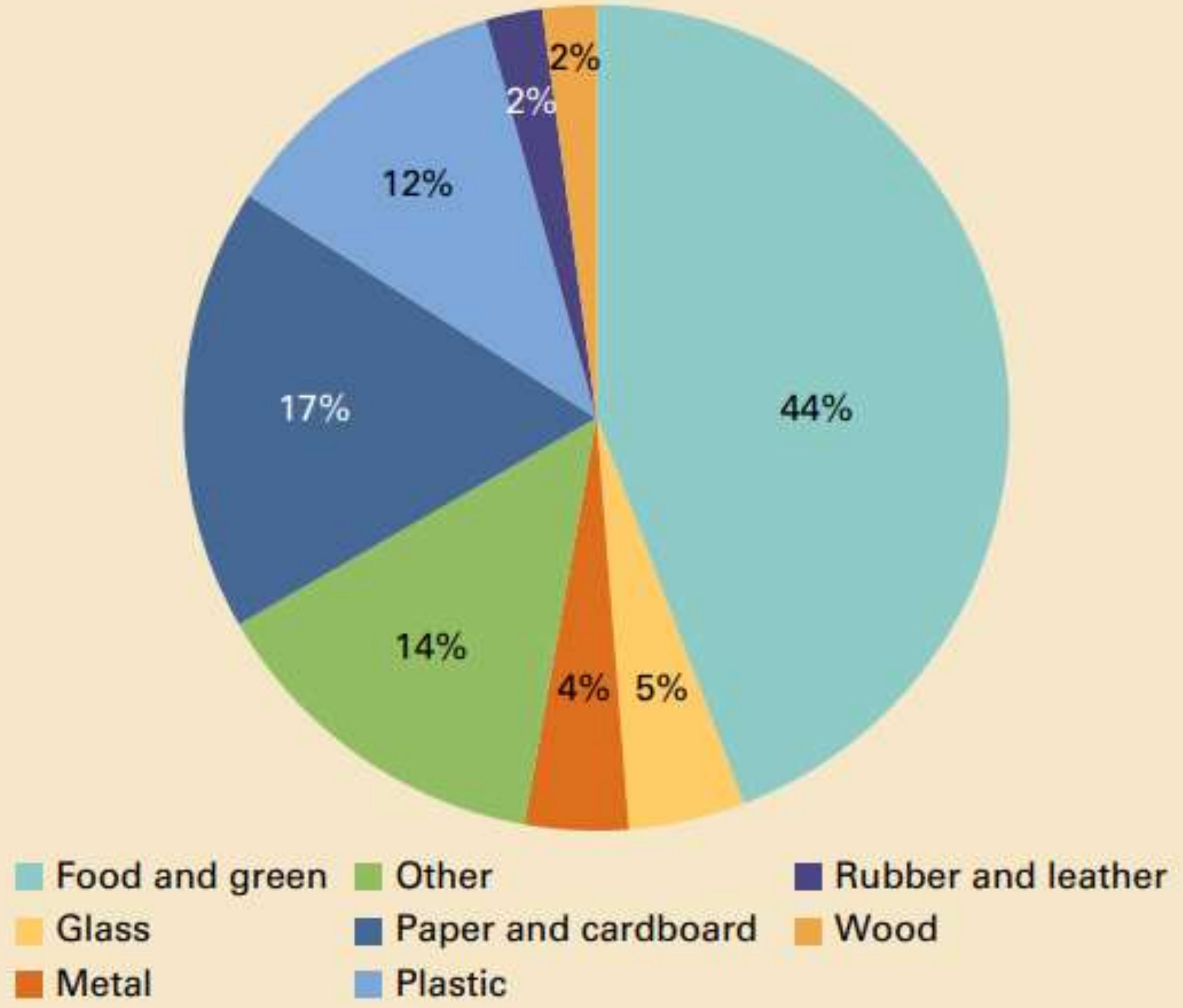


Note: GNI = gross national income.

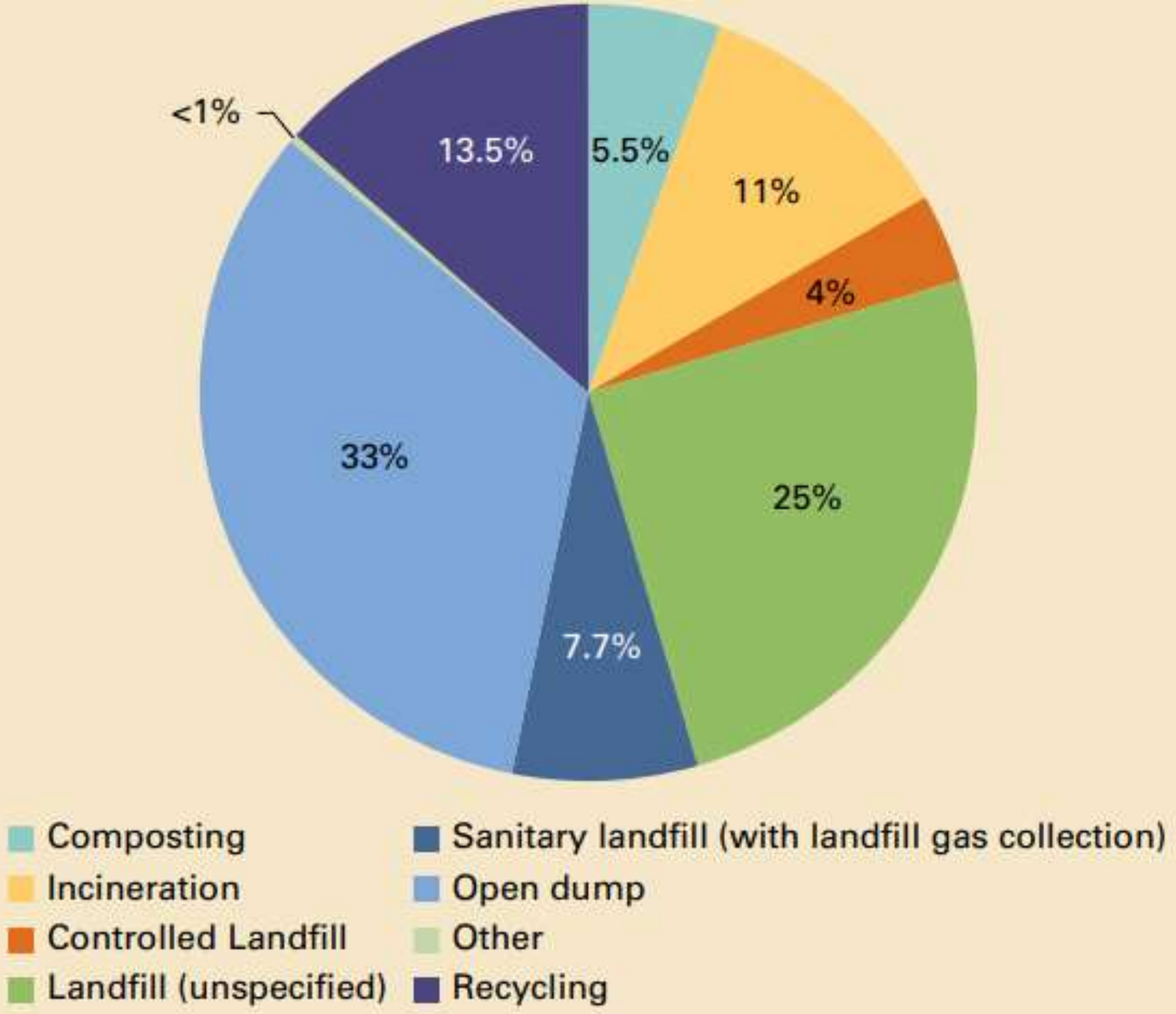
Definition of Regions



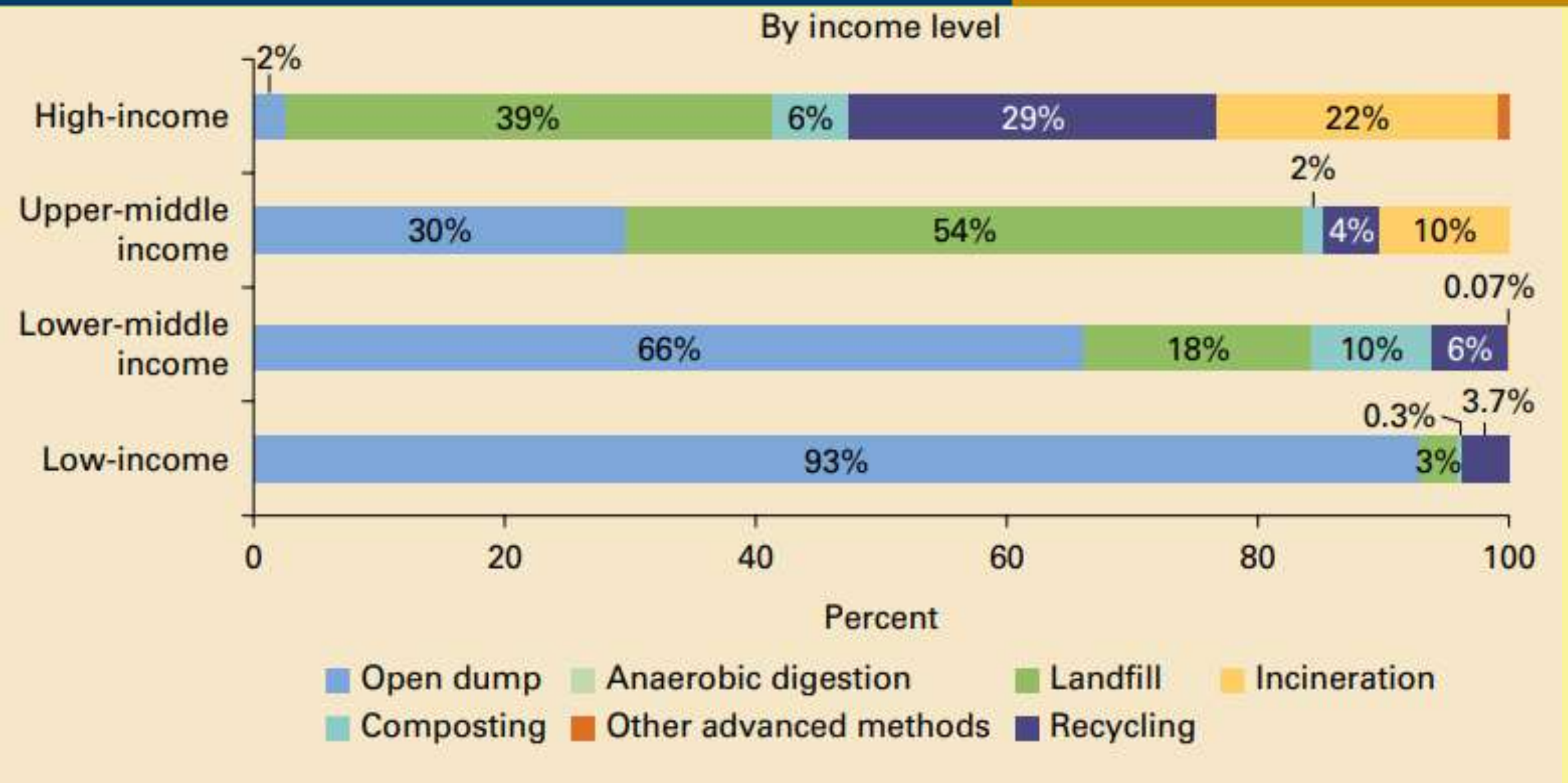
Global Waste Composition



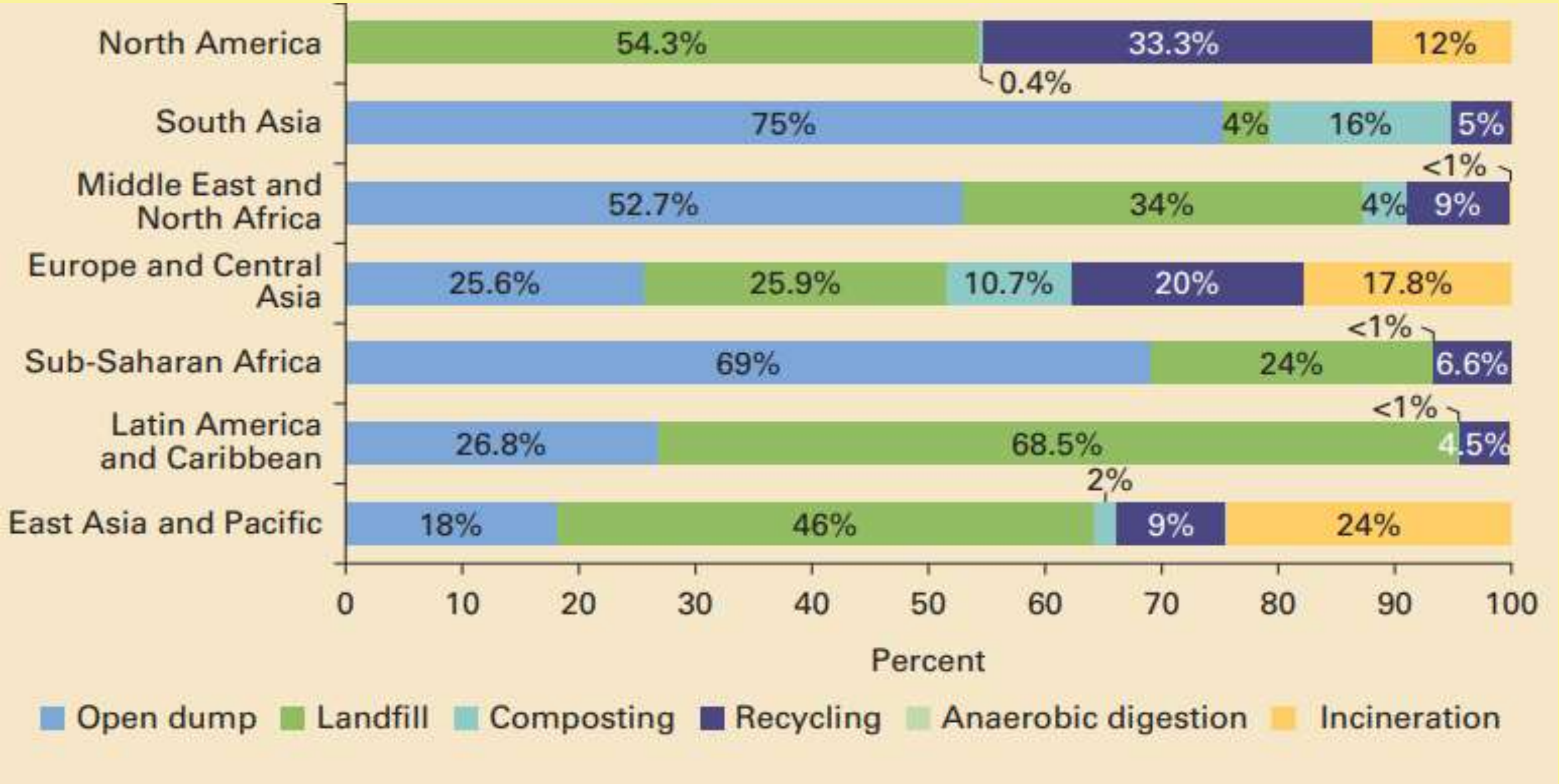
Global Waste Treatment and Disposal

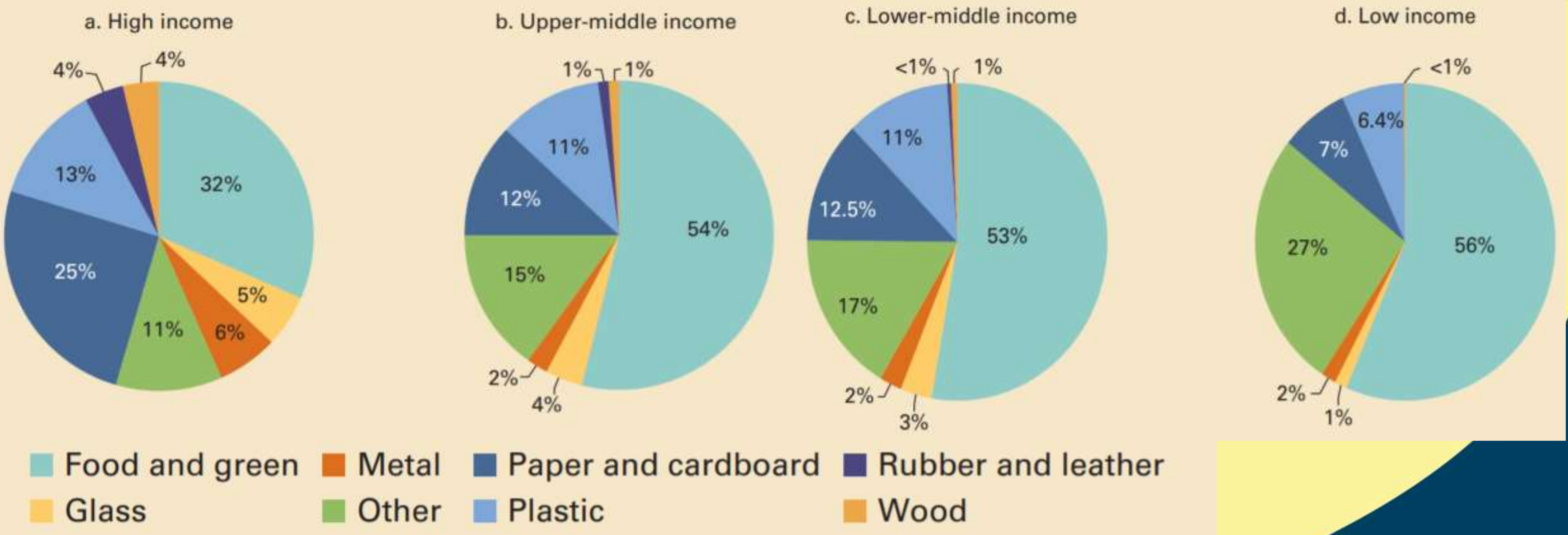


Disposal Methods by Income



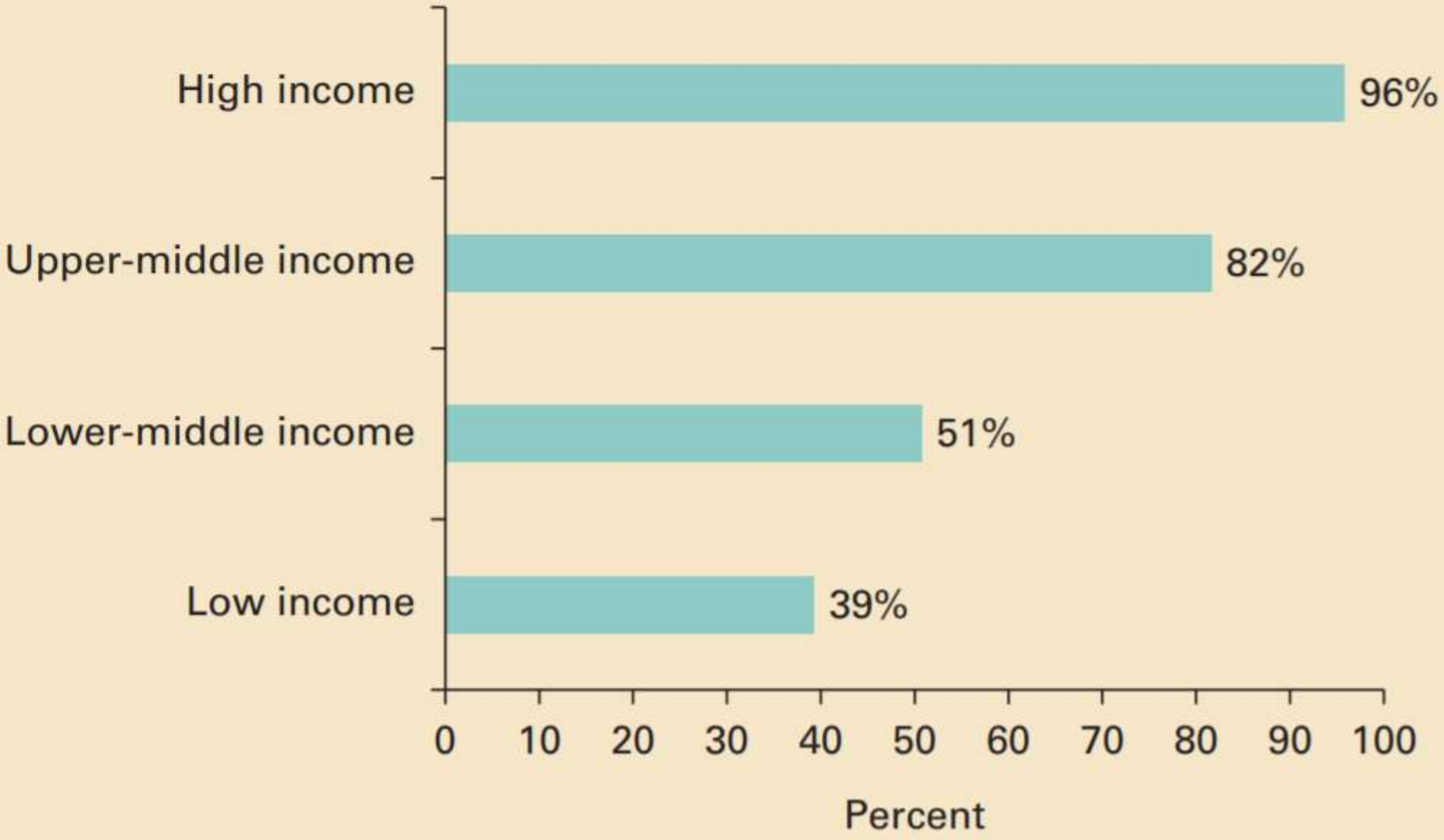
Disposal Methods by Income

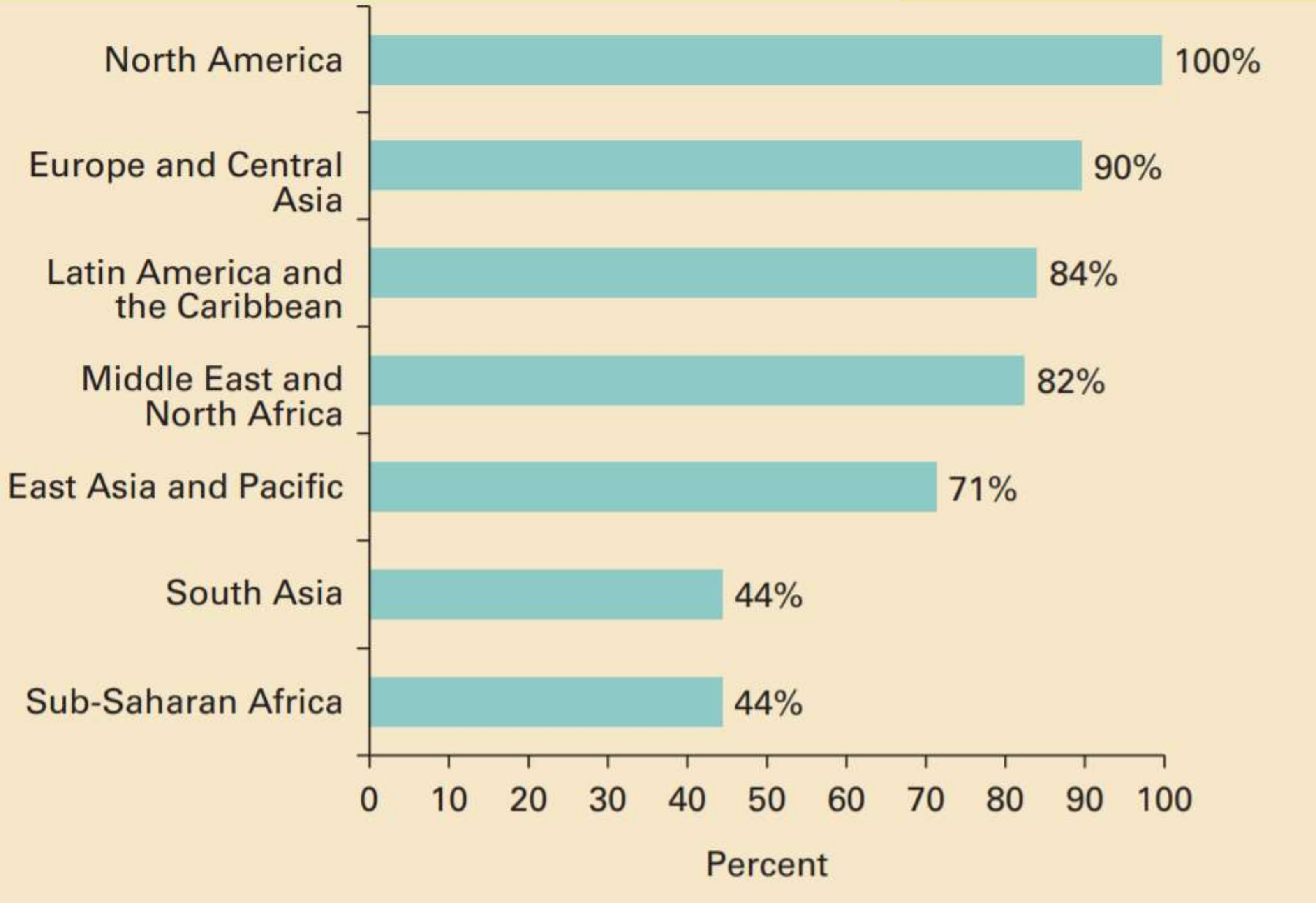




Waste Composition by Income Level

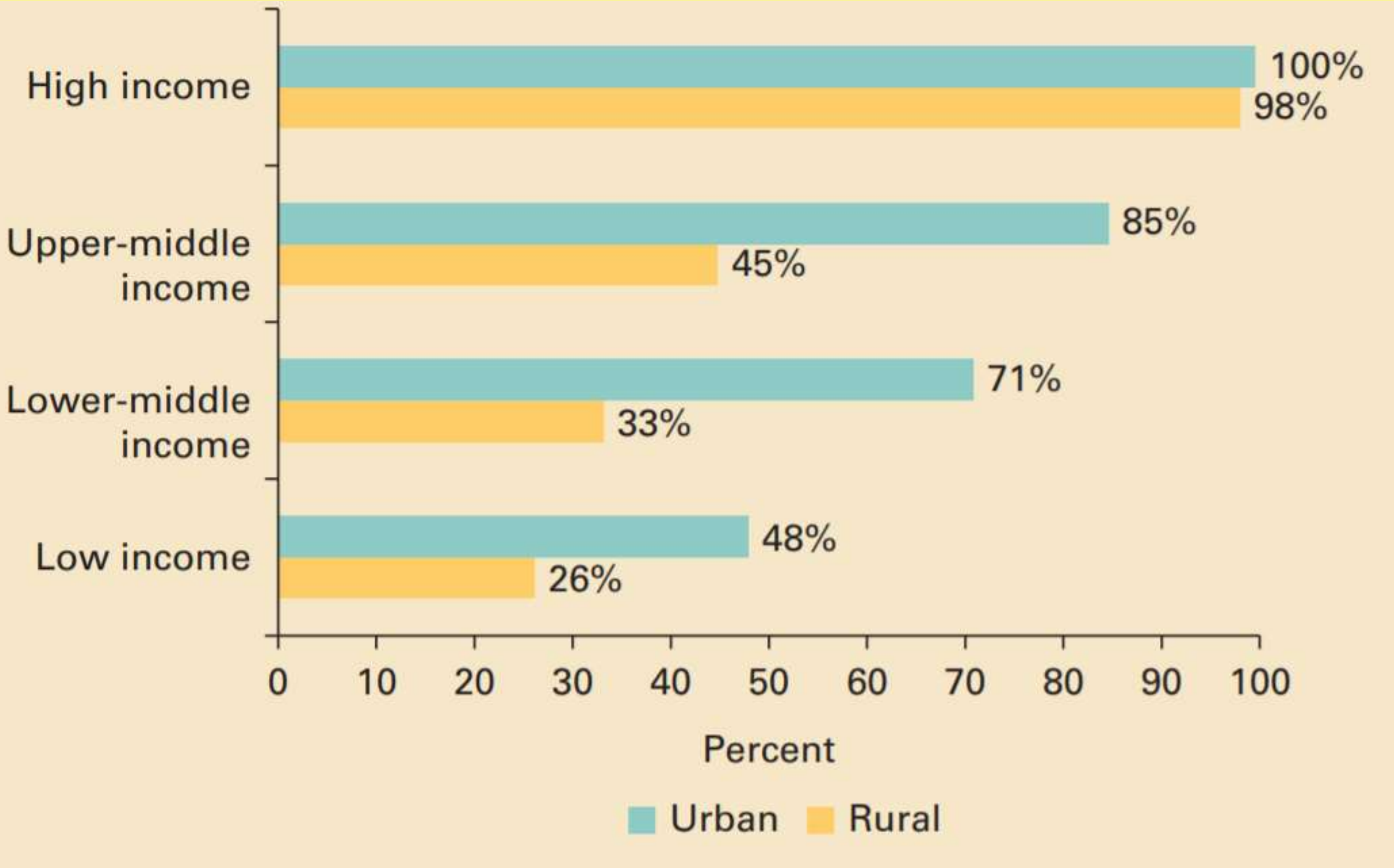
Collection rates by income level

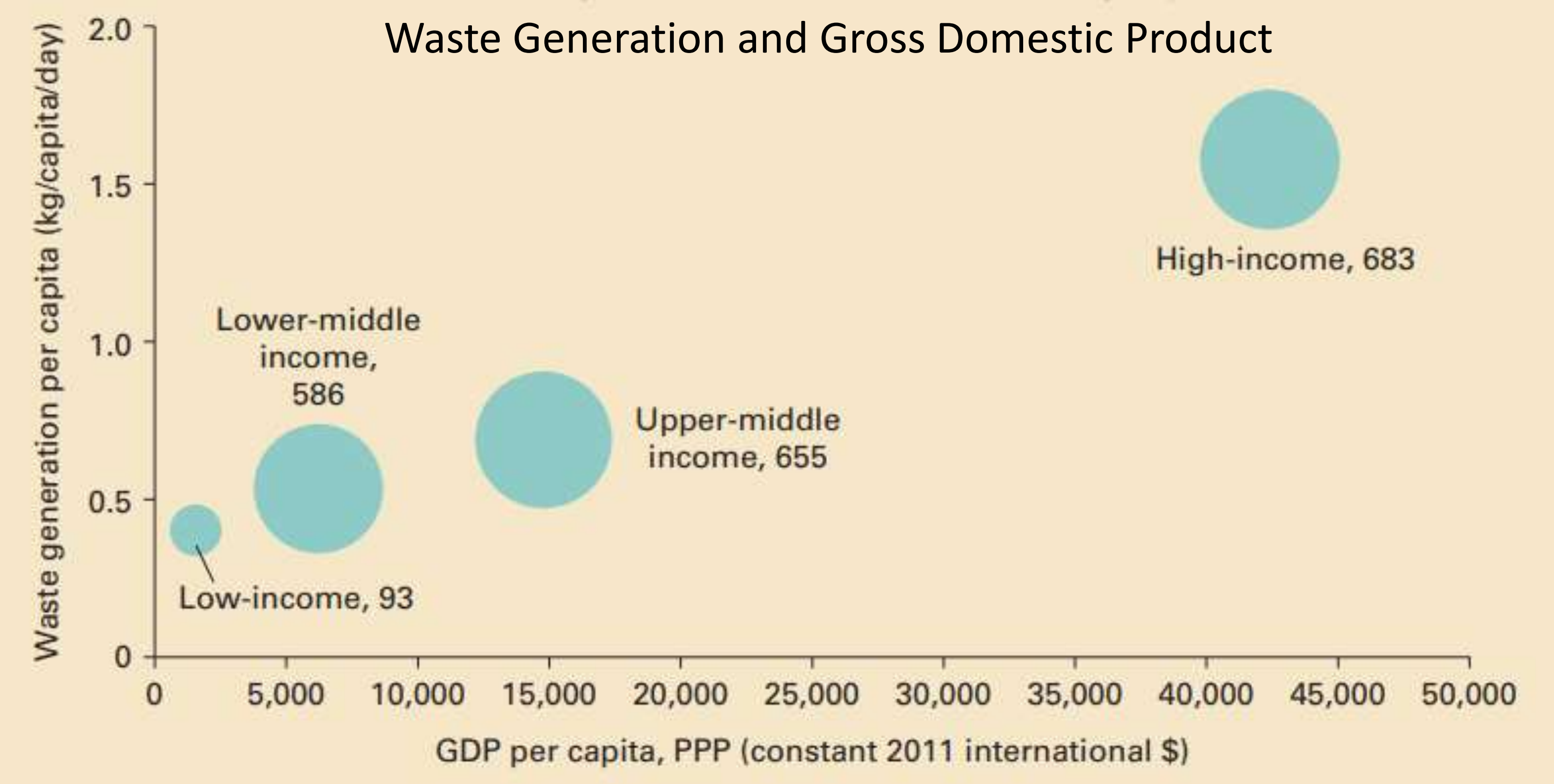




Collection rates by region

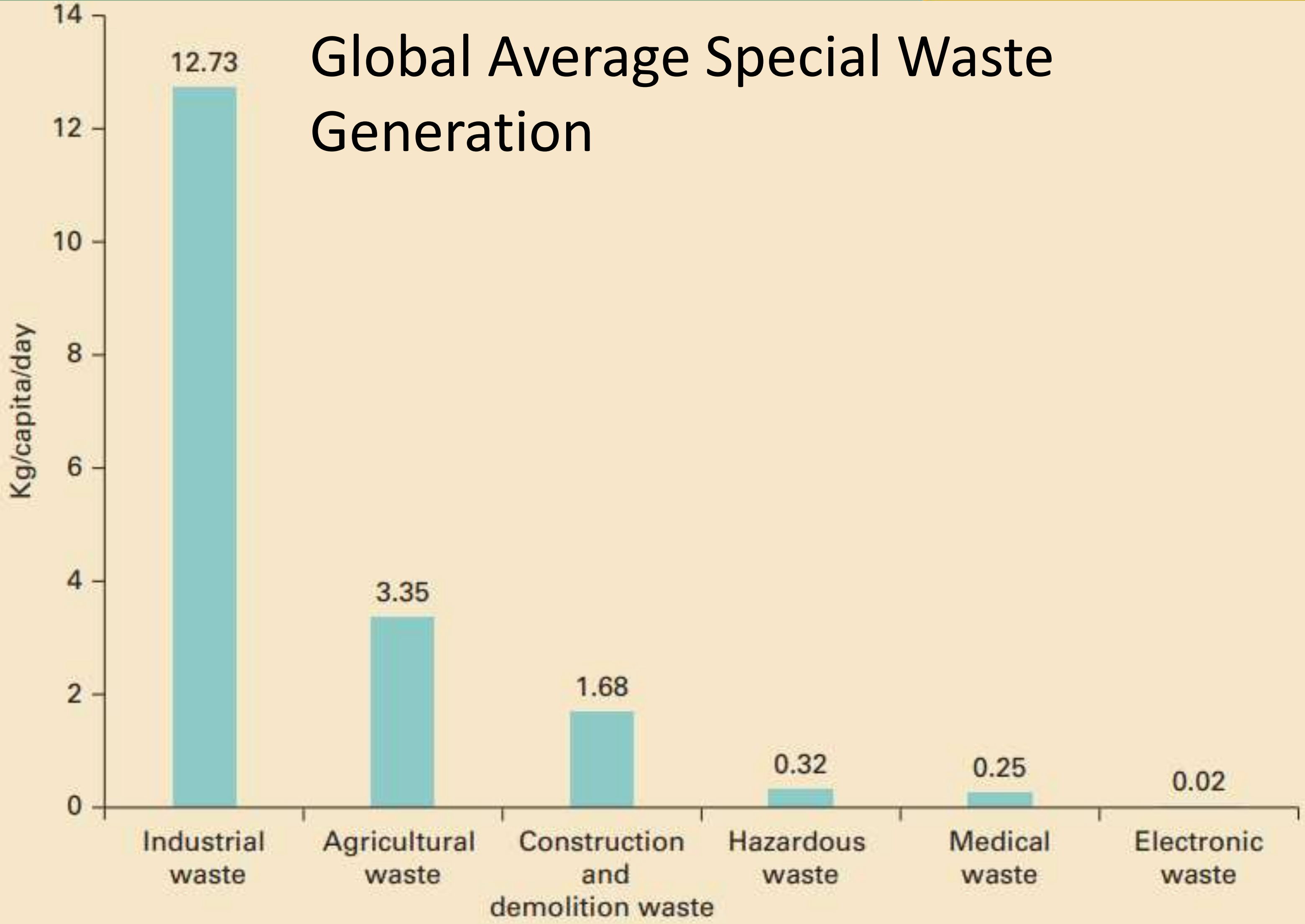
Urban and Rural Collection Rates by Income Level





- With just 16% of the world population , high income countries generates 34% of the world waste.

Global Average Special Waste Generation



Special Wastes

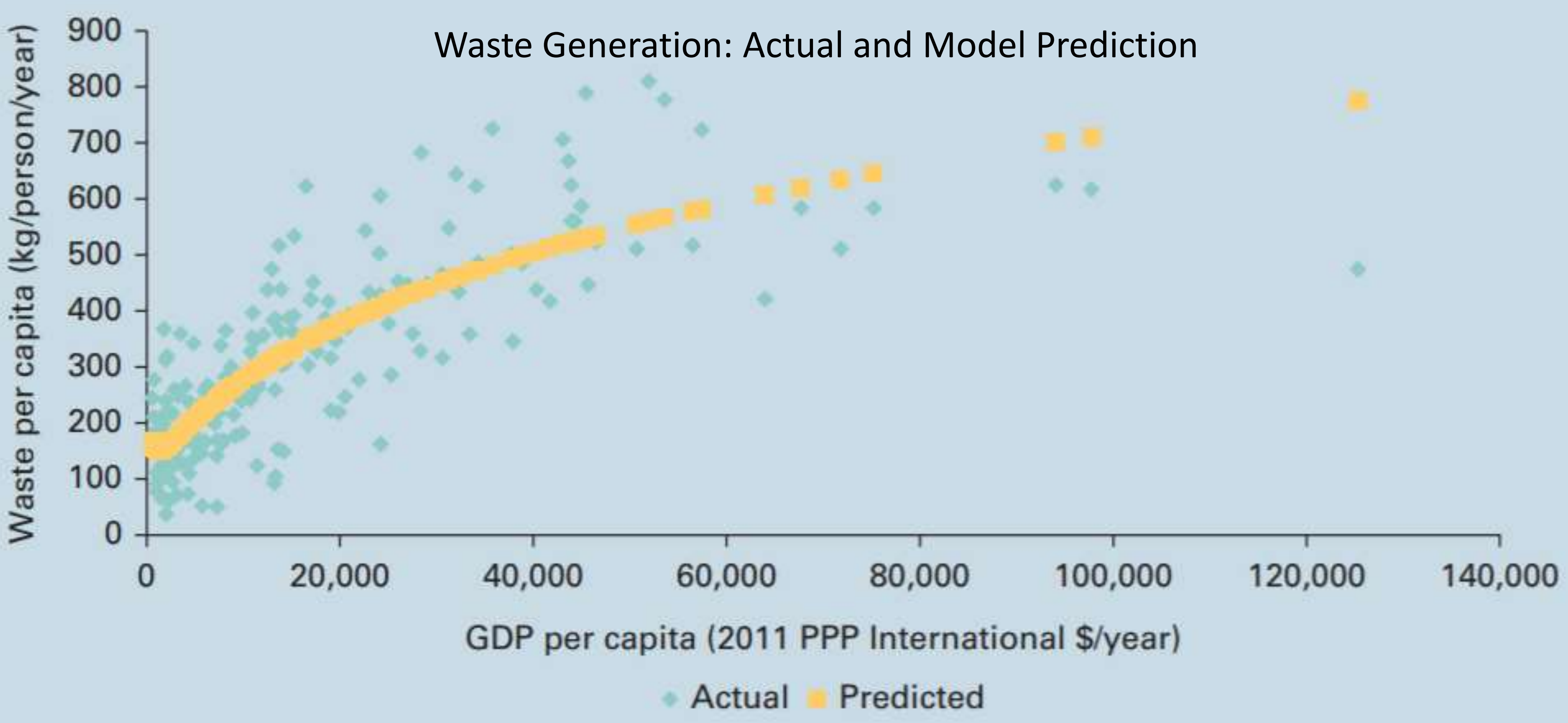
- Some waste streams, such as industrial waste, are generated in much higher quantities than municipal solid waste

	Industrial waste generation	E-waste generation
High income	42.62	0.05
Upper-middle income	5.72	0.02
Lower-middle income	0.36	0.01
Low income	No data	<0.01

Note: kg = kilogram.

Industrial and Electronic Waste Generation Rates

- Low income countries collect only 39% of the waste



- Relationship between GDP growth and waste generation rates.
- Positive correlation was found.

Waste and society

•Uncollected waste and poorly disposed of waste significantly affect public health and the environment, with the long-term economic impact of environmental recovery often resulting in multiple times the costs of developing and operating simple, adequate waste management systems

•Waste management contributes nearly 5 % of global greenhouse gas emissions, mainly driven by food waste and improper management of waste. Even basic system improvements can reduce these emissions by 25 percent and more.

•One of the major ways that solid waste contributes to climate change is its generation of greenhouse gas (GHG) emissions. The 1.6 billion tonnes of carbon dioxide–equivalent (CO2-equivalent) emissions estimated for 2016 are anticipated to increase to 2.6 billion tonnes by 2050.

- More than 15 million people globally earn a living informally in the waste sector (Medina 2010). Waste pickers—often women, children, the elderly, the unemployed, and/or migrants—are a vulnerable demographic.
- The number of female waste pickers can often exceed the number of male waste pickers. In Vientiane, Lao PDR, and Cusco, Peru, 50 percent and 80 percent of waste pickers are female, respectively (Arenas Lizana 2012; Keohanam 2017).

•80 countries have identified solid waste management as an intervention area in their Nationally Determined Contributions, which are global commitments made by each country to mitigate and adapt to climate change under the historic United Nations Framework Convention on Climate Change agreement

•Emissions from solid waste treatment and disposal, primarily driven by disposal in open dumps and landfills without landfill gas collection systems, were calculated using the CURB tool,1 and they account for about 5 percent2 of total global GHG emissions

- Methane, generated from decomposing organic waste, is the solid waste sector's largest contributor to GHG emissions. It is many times more potent than CO2

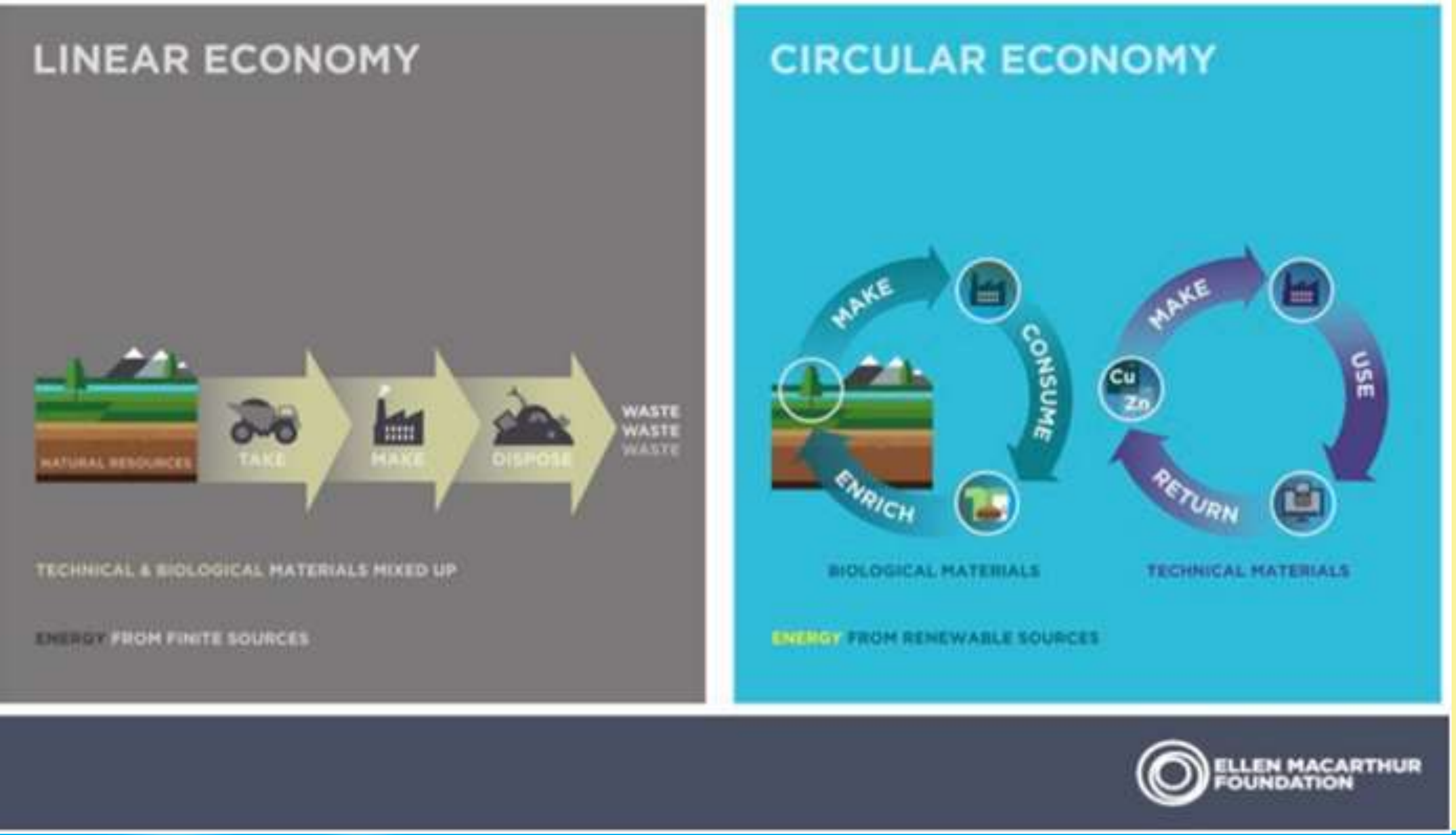
- Emissions can be mitigated through improved waste collection, waste reduction, reuse of products, recycling, organics waste management, and capture of GHGs for flaring or energy recovery.

- Reducing collection fleet lag times, improving routing efficiency such as through the use of geographic information systems, selecting cleaner fuels, and using fuel-efficient vehicles are potential approaches to reducing transportation emissions

•Composting and anaerobic digestion are organic waste treatment options that prevent the generation of methane or its release into the atmosphere. Where landfills are used, the associated methane gas can be captured and flared, converted to power, used to heat buildings, or utilized to serve as fuel for vehicles

•A World Bank study in Indonesia shows that even basic improvements, such as increasing waste collection rates to 85 percent from 65 percent and introducing controlled landfilling for waste disposal, reduces GHG emissions by 21 percent

Reports also mention about need for circular economy



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Thank you