The University of Zambia
School of Engineering
Dept. of Civil & Environmental Engineering

CEE 4412: Environmental Engineering I

WASTEWATER/FAECAL SLUDGE MANAGEMENT

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Objectives

The aim of this topic is to introduce students to the aspects of wastewater management. Specific objectives include to:

- Introduce students to wastewater and its characteristics
- Highlight environmental and public health implications of Wastewater
- Explain some of the amelioration measures for addressing the environmental and public health impacts associated with wastewater

Sanitation

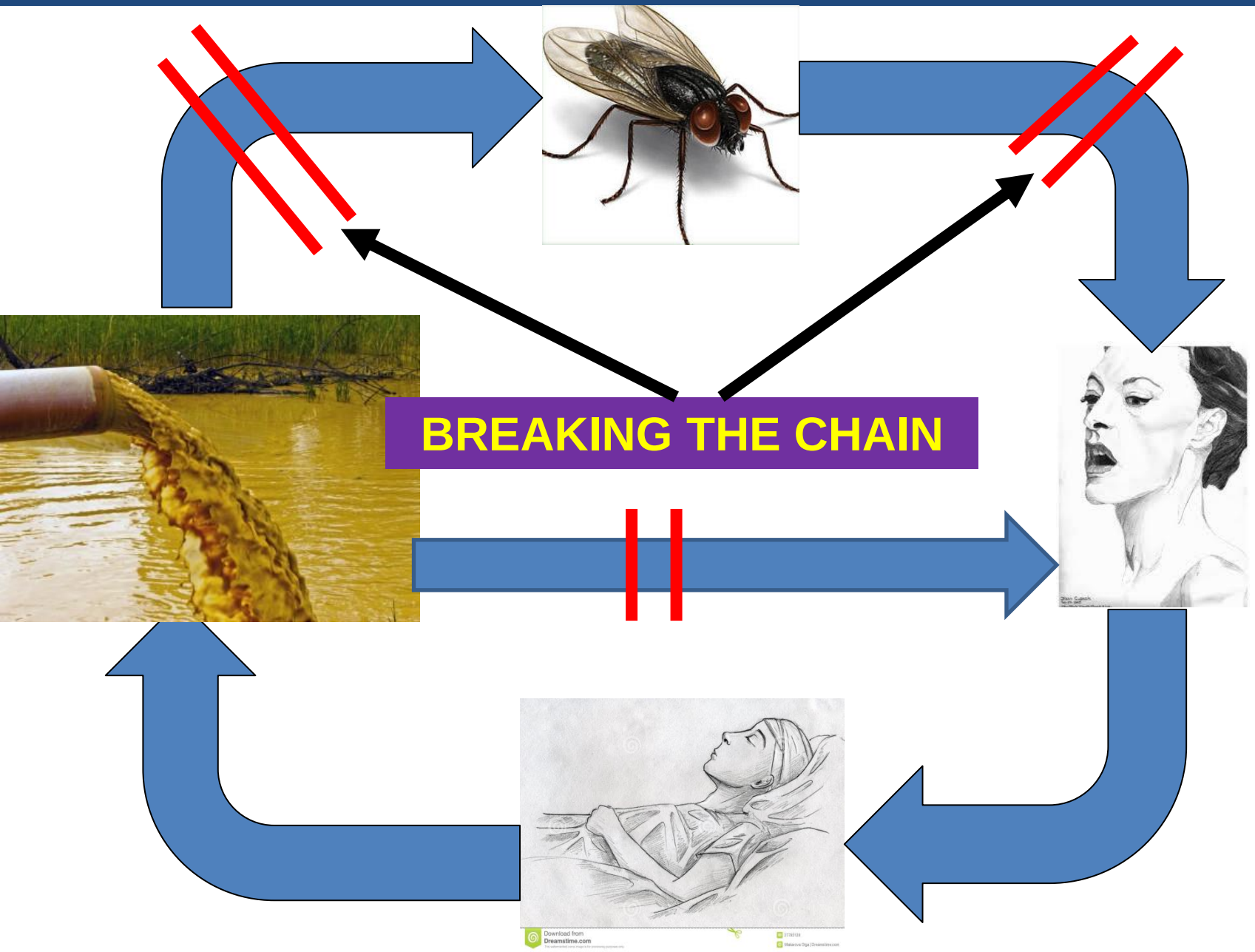
Before we delve into wastewater management, we firstly look at sanitation which means:

- Making Healthy

  or

- Removal and safe disposal of wastes that can be hazardous to health

Sanitation – Why??



Sanitation - What does it consist of?

1. Wastewater Management
2. Faecal sludge or Excreta management (faeces, urine)
3. Greywater management
4. Solid waste management
5. Drainage (for rainwater / stormwater)

Sanitation - What does it consist of?

Solid waste management

Sanitation - What does it consist of?

Drainage for storm water

Sanitation - What does it consist of?

Faecal Sludge management

Sanitation - What does it consist of?

wastewater management

Wastewater

What is wastewater?

- Water that is no longer needed – mostly which has served the intended purpose and in the process has been loaded with various pollutants in form of *suspended, colloidal* and *dissolved constituents*.

Or

- Any water that has been adversely affected in quality by anthropogenic activities and needs to be disposed of.

Types

- Domestic sewage or pure sewage (Excreta + Sullage)
- Trade effluents
- Industrial
- *Sewage + Trade = Municipal Wastewater*

Faeces +
Urine (Black Water)

- Cleaning of food; Food left-overs
- Dish washing; Body washing; Washing of clothes
- Washing of floors (Grey Water)

Characteristics

Organic Matter (CHNOP)

- High content of organic matter mainly in form of:-
  - Carbohydrates
  - Fats and Grease
  - Protein

Raw Sewage Strength (BOD)

Characterisation of wastewater is usually through the organic matter content as follows:

WEAK	MEDIUM	STRONG
>200	<200 to >350	>350

Determination of strength is either through Chemical Oxygen Demand or Biochemical Oxygen Demand.

Measurement of Organic Matter (Strength)

Chemical Oxygen Demand (COD)

H_2SO_4+SAMPLE+$K_2Cr_2O_7$→ H_2O+CO_2+NO_3

This test will give the oxygen required to oxidise both the organic and non organic component of the wastewater

Biochemical Oxygen Demand (BOD)

- Simulating Natural process

- Organic matter +DO + Saprophytic bacteria = More Bacteria +H_2O+CO_2 + Energy

- For domestic wastewater COD/BOD = 1.5 – 1.8

- COD vs BOD importance of relationship

Suspended Solids

- Wasterwater usually has a lot of SS most of which form part of the COD-BOD.

- COD-BOD can be in form of dissolved, colloidal or suspended matter

- NOTE: Suspended matter that settles in 1 hour =Settleable solids

Dissolved Gases

- DO – Low to absent (measure of degree of treatment)
- NH_3 – high due to biodegradation of protein
- CO_2 – high due to biodegradation process of organic matter
- H_2S – High due to anaerobic decomposition of Sulphur containing substances
- CH_4 – where anaerobic digestion has been allowed to go on for some time (Bio-gas)

Microbiological characteristics

- Contains all microorganisms being excreted by the population

- Faecal Coliform concentrations = $1X10^{6-8}$FC/100ml

Industrial Wastewater

- Differs from domestic as each is different (e.g. acidic from mines and alkaline from textile and tannery).
- Significance: Can inhibit growth of microorganisms required in the treatment process

Types of industrial wastewater

- Cooling water (biggest volume; least polluted)
- Rinse water (from food packaging companies – not so polluted)
- Process water (small volumes with high concentration of pollutants)

Process Water

- High organic content
- Extreme pH
- toxic

Process Water - Types

- With high organic content
  - High COD; High BOD e.g. breweries
  - High COD; Low BOD

With extreme pH

- ❖ e.g. acidic from mines and alkaline from textile and tannery.
- ✓ Significance: Can inhibit growth of microorganisms required in the treatment process

With Toxic Substances

Like heavy metals and chemicals which will be:-

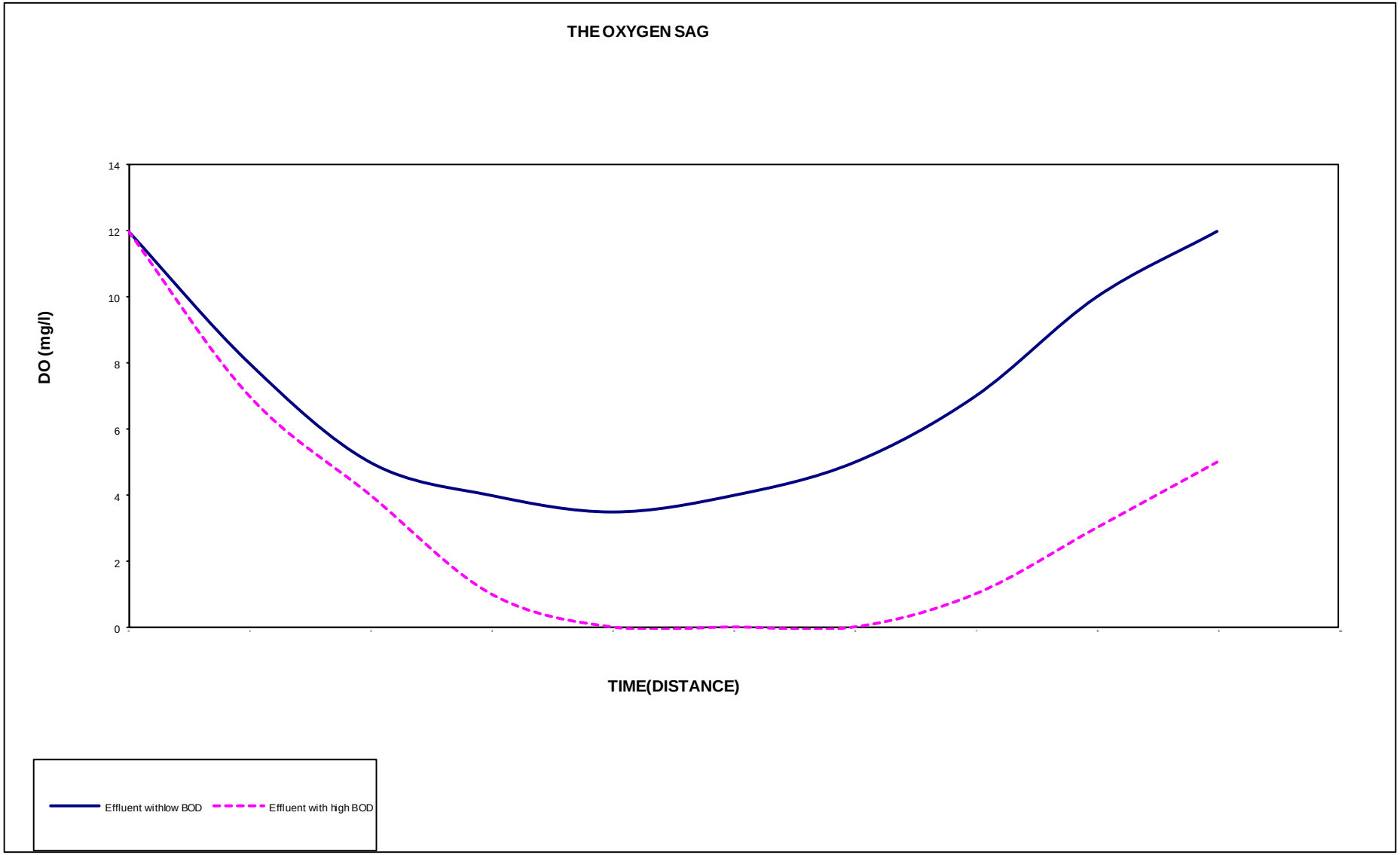
- Harzadous to human health
- Dangerous to fish
- Impair functioning of microorganisms in natural water bodies and treatment plants

Reasons for wastewater treatment

Prevent Depletion of O_2

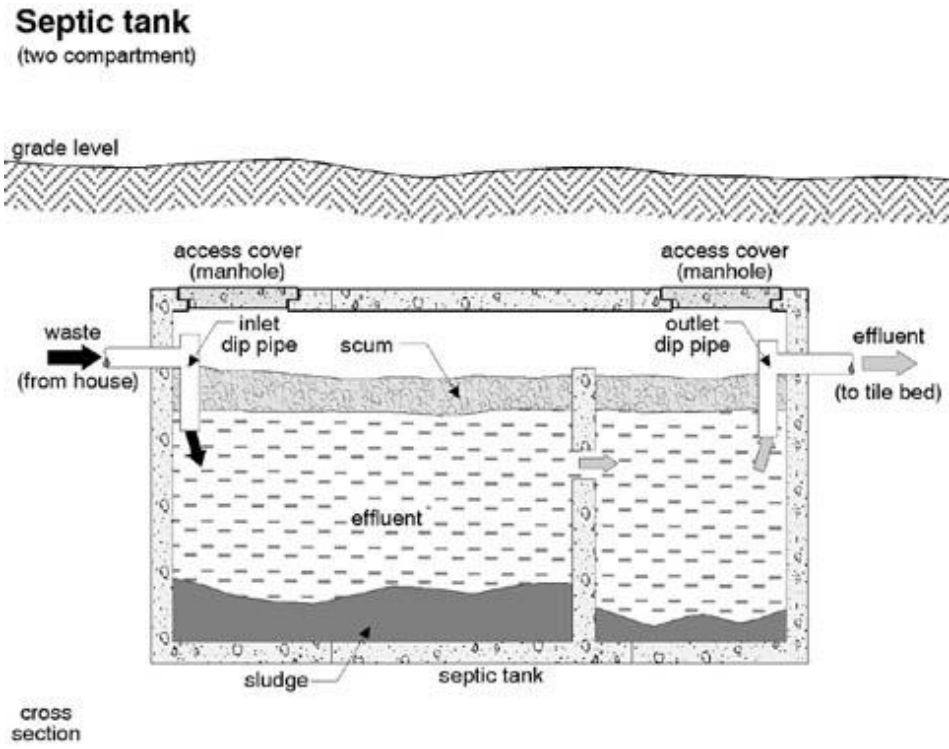
- Aquatic creatures (fish etc) need DO
- Untreated wastewater discharged into a river introduces organic matter
- Bacteria metabolise organic matter using DO
- Bacteria increase in no. using up more DO
- Depletion of O_2 occurs
- Death of the aquatic lif

Oxygen sag versus BOD concentration



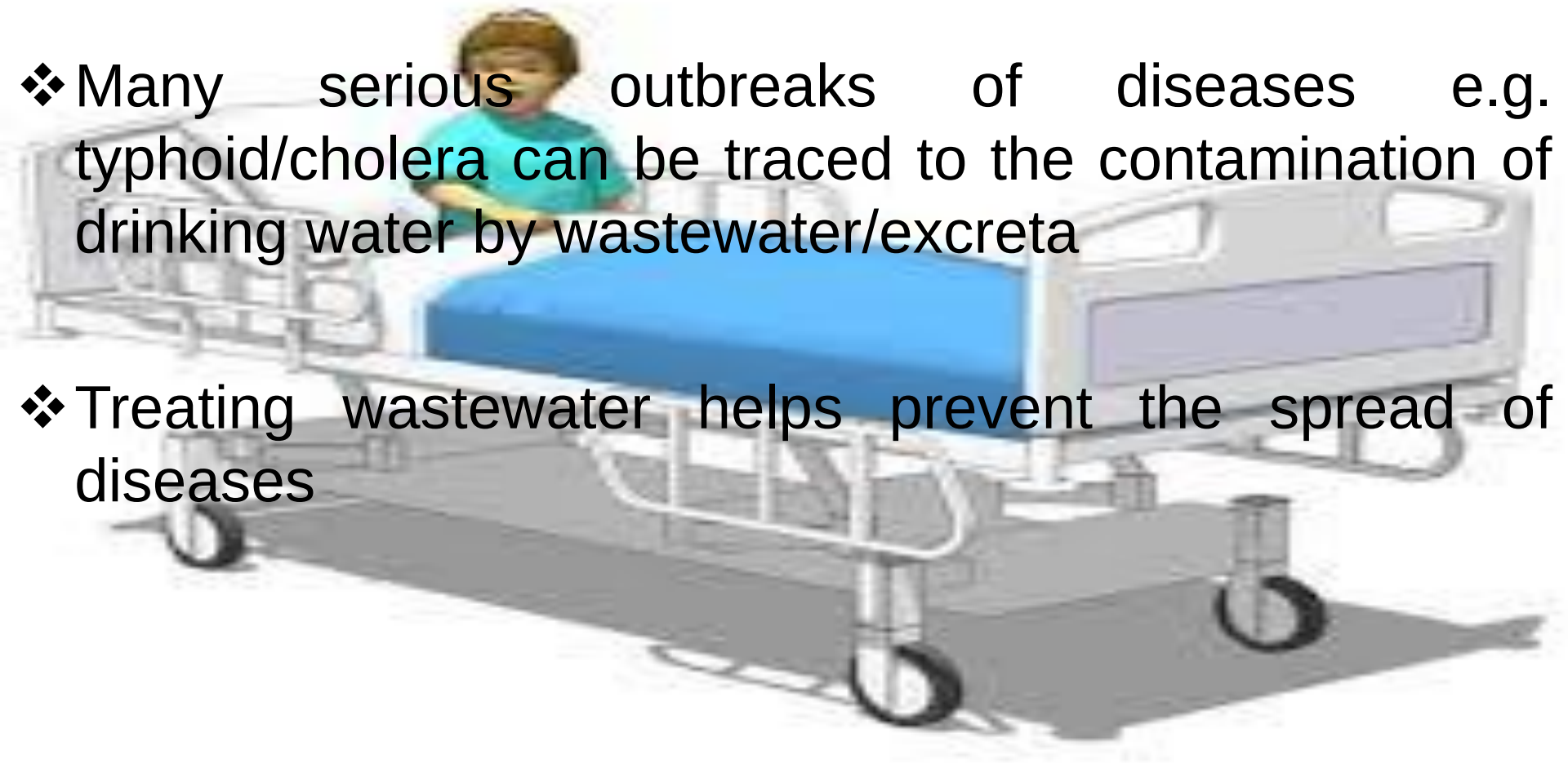
Reasons for wastewater treatment cont'

- REDUCING SLUDGE AND SCUM
  - Avoid formation of sludge banks
  - Avoid sludge deposits at the bottom of the receiving water body
  - Avoid formation of scum in the receiving water body
  - Avoid unsightliness and odour problems and
  - Avoid oxygen depletion that may arise from scum and sludge.



Prevent Ill-effects on Human Health

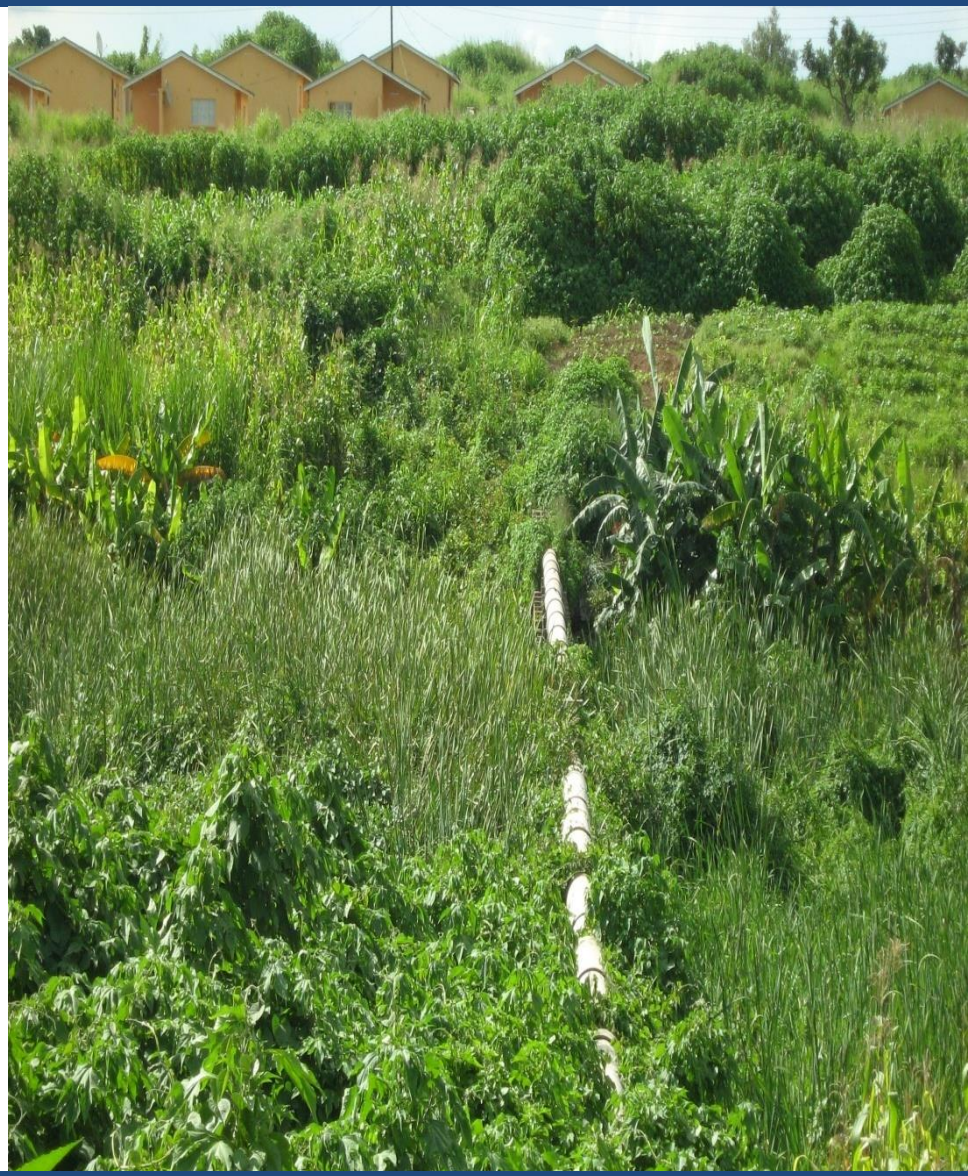
- Wastewater contains disease causing bacteria (pathogens), viruses and worm eggs.
- Many serious outbreaks of diseases e.g. typhoid/cholera can be traced to the contamination of drinking water by wastewater/excreta
- Treating wastewater helps prevent the spread of diseases



Prevent nutrient loading to the river

- Increased growth of algae in river water due to nutrients in the water might occur (eutrophication).

E.G effects of ww on veg.-Mindolo kitwe (2012)



WW reuse in agriculture and horticulture

Aesthetic Reasons

- The clarity and colour of the water may be affected
- Taste and odour problems

Cost Implications

- Untreated wastewater will introduce pathogens into receiving water bodies
- Additional treatment especially wrt chlorination at water treatment plant will be required (Chongwe, Kafubu, Pre-Chlorination, activated carbon)
- In communities drawing directly from river, this can lead to outbreaks (Medicines and morbidity/Mortality)
- Resulting nutrient loading will lead to algal blooms leading to increased treatment requirements at water treatment plant (Organic,clogging, odour)

Example- Chongwe Plant (2011)

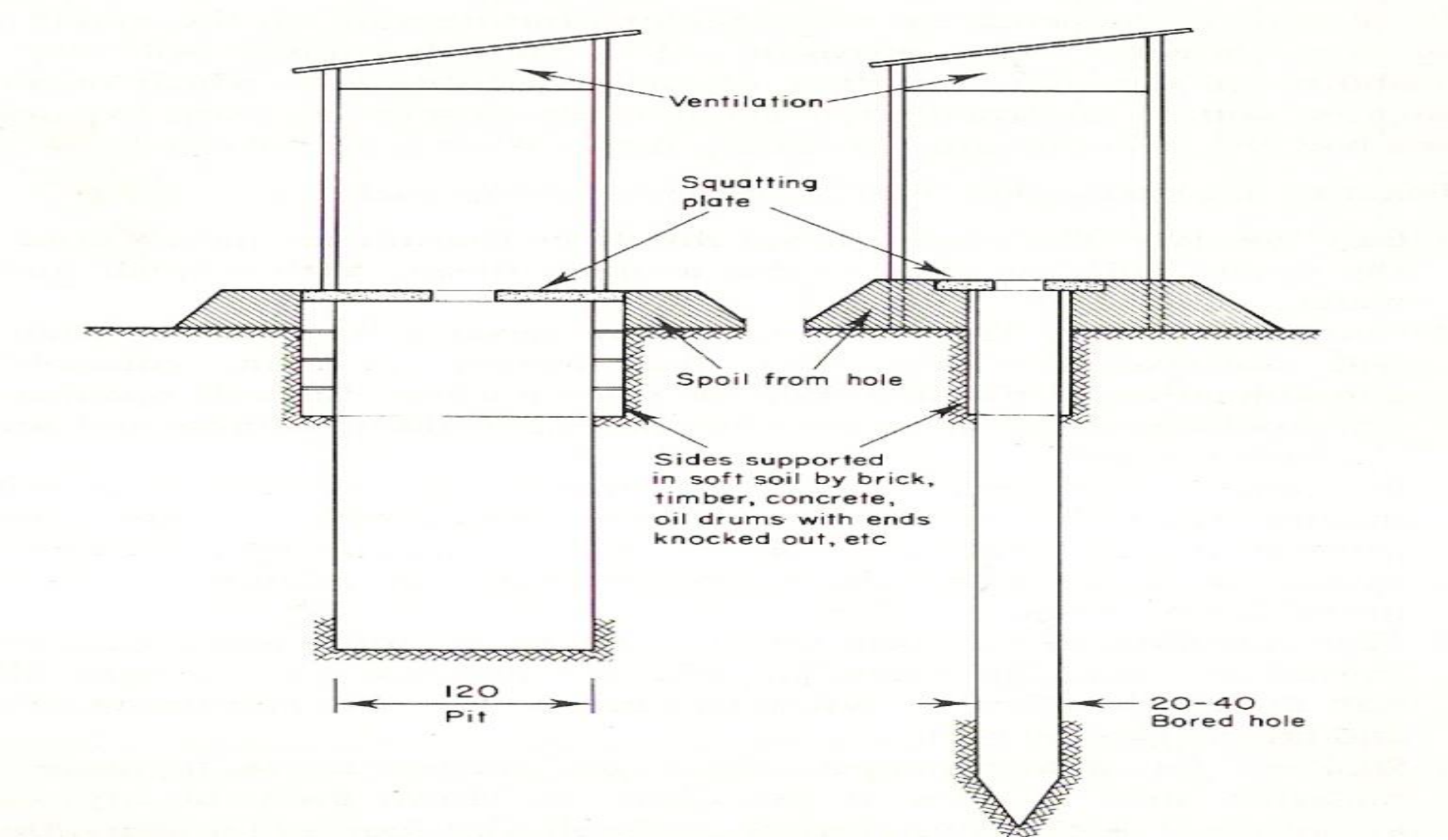
Effluent Standards

- BOD =<50mg/l
- COD =< 90mg/l
- Settleable Solids in 2hrs =< 0.5mg/l
- DO => 5mg/l
- Temp =< 40deg cel
- Nitrate =< 50mg/l
- Total Phosphates =< 6mg/l

Types of Sanitation Systems

- On-site
- Off–site

On-site/Drop-and-Store



Off-site/Flush-and-Forget