WASTEWATER CHARACTERIZATION

Agroindustrial Technology Department

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Outline

1. Introduction
2. Water Quality Criteria
3. Wastewater Characterization
    a. Source and flowrate
    b. Type of pollutant
    c. Measurement techniques
    d. Parameters
4. Wastewater Sampling

1. Introduction

Why Treating Wastewater?

- Domestic and industrial processes use and pollute water => wastewater
- Minimise effects of discharge on environment
- Remove pollutants for recycling and/or reuse of water

Objectives of Wastewater Treatment

- Ensure good water quality in natural environment
- Remove pollutants most efficiently and economically
- Avoid or minimise other environmental impacts like:
  - solid disposal
  - gas emission
  - odour creation
  - noise generation

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2. Water Quality Criteria

1. Traditional Approach

- Focus on point sources
- Mainly concerned with local effect
- Definition of maximum limits (BOD, SS, T, pH, nutrients etc.)
- Usually concentration limits and total flow rate limit

2. Water Quality Criteria

Modern Approach

- Classification of receiving water based on use:
  - A - drinking, environmentally sensitive
  - B - bathing, fish-life
  - C - navigation, fish-life, agricultural use
- Definition of stream quality standards for specific use

How to relate this to discharges?

- Estimating effects of non-point (diffuse) sources eg. storm water, irrigation run-off
- Set minimization targets and strategies (catchment management plans etc.)
- Focus on load (freight), not just concentrations
- Concerned with overall effects on receiving water body (creek, river, bay...)

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3. Wastewater Characterisation

What is (in) Wastewater?

1. Identify wastewater sources and flows
2. Specify likely key pollutants
3. Select suitable sampling strategies
4. Measure pollutant concentrations
5. Calculate pollutant loads
6. Identify main components to be removed

a. Sources and Flow Rates

- Essential step to identify problem area
- How to define sources & flows?
  1. Use "systems/mass balance" approach
  2. Utilize wastewater audits
  3. Anticipate future requirements
  4. **Reduce > Reuse > Recycle**
  5. Simple is better than complex
- Source reduction can drastically improve wastewater situation (tannery)

b. Types of Pollutants

- **Physical**: solids, temperature, color, turbidity, salinity, odor

- **Chemical**:
  - Organic : carbohydrates, fats, proteins, toxins…
  - Inorganic: alkalinity, N, P, S, pH, metals, salts…
  - Gaseous : H_2S, CH_4, O_2 …

- **Biological**: plants (algae, grass, etc.), microorganisms (bacteria, viruses)

c. Measurement Techniques

- Physical, chemical or biological methods
- Summary of basic methods in APHA (US): "Standard Methods for the Examination of Water and Wastewater"
- Many instrument methods in use (FIA)
- Good laboratory practice essential eg. dilution, weighing, filtration, standards

Flow Injection Analyser (FIA)

- colorimeter
- Fluorimeter
- biosensors

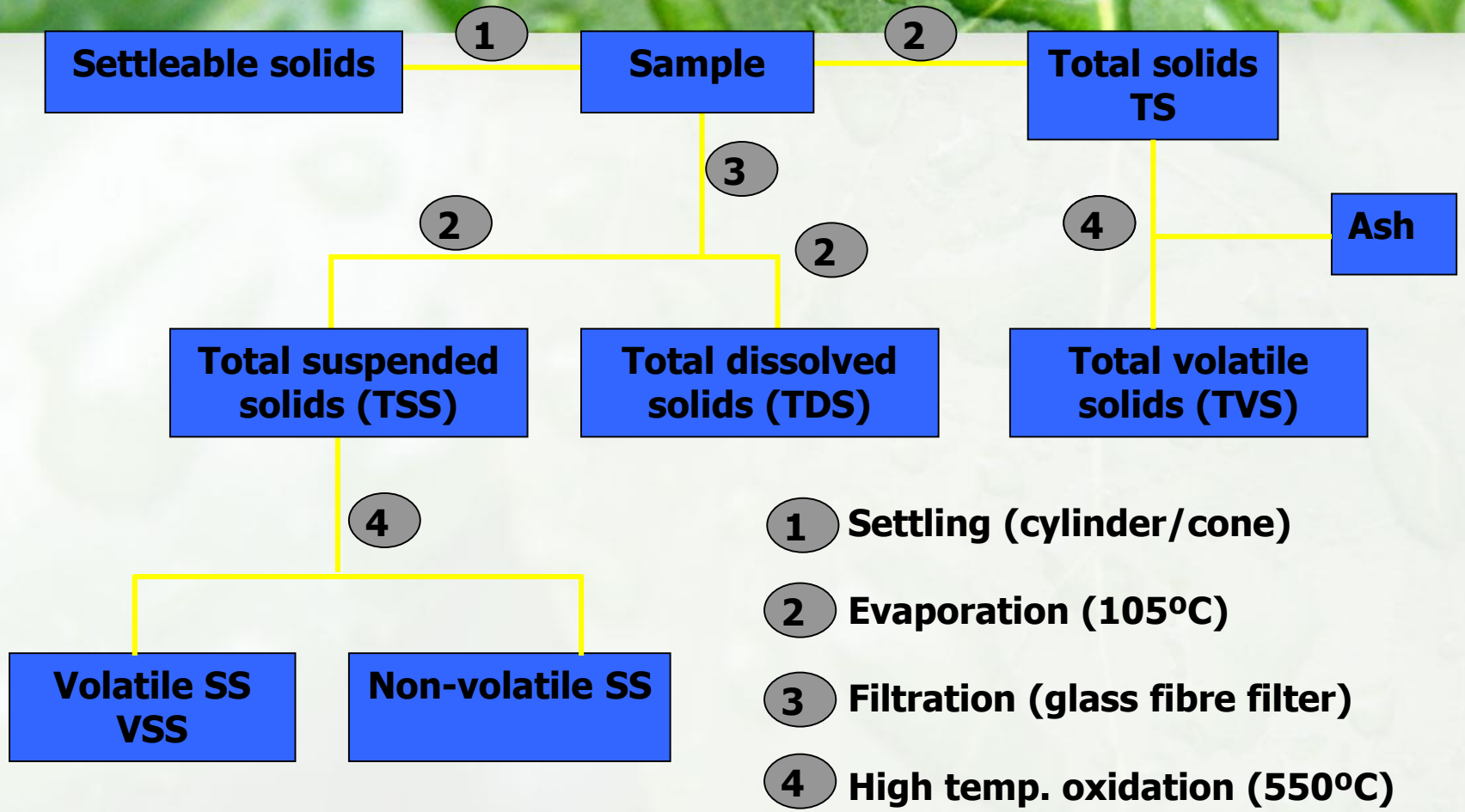
d. Measurement Parameters

1. Solids
2. Odor
3. Temperature
4. Salinity
5. Color and turbidity
6. Carbohydrate
7. Protein
8. Flow terms

1. Solids

- Solids separated by filtration into non/soluble and by high temperature oxidation into non/volatile
- Solids often form large percentage of total organic material
- Solids degradation often slow due to mass transfer limitations
- Sources: food processing, abattoirs rural industries (piggeries etc.), domestic

Solids Fractions



Practical Exercises: Solids

In solids analysis, the following measurements were obtained:

- Sample size: 50 mL
- After filtration/evaporation:

  12 mg filter cake, 2.5mg solids in filtrate
- After high temperature oxidation:

  2.0 mg filter cake

What is TSS, VSS and TS in the sample? mg/ml

Answer

TSS : 12 mg / 50 ml = 0.24 mg/ml

VSS : (12 – 2.0 mg) / 50 ml = 0.2 mg/l

TS : (12+2.5) mg /50 ml = 0.29 mg/l

2. Odour

- Often very small amounts cause nuisance (eg. H2S approx. 10 ppb)
- Physical/chemical measurement difficult
- Olfactometry uses human odor panels
- Olfactometer determines dilution necessary until no odor detected

3. Temperature

- Industrial WW often elevated temperature
- Affects treatment performance of many treatment systems
- Gas eg. O2 solubility is lower at higher temperature
- Effluent temperature usually specified in license limits

4. Salinity

- Affects ecosystems in receiving waters
- Reduces O_2 solubility
- Restricts reuse applications (eg. irrigation)
- Critical for downstream water utilization

5. Colour & Turbidity

- Colour of WW & biological treatment:
  - light brown-gray => fresh, aerob
  - dark brown-black => old, anaerob
- Soluble dyes (stains) also cause coloring, very difficult to remove (e.g textile)
- Turbidity measures light-transmission
  - Caused by colloidal or suspended matter
  - Can be correlated with suspended solids

6. Organic Matter

- Largest component group in most ww: 75 % of TSS, 40 % of TDS (domestic ww)
- Composition highly industry dependent
- Types:
  - carbohydrates
  - proteins
  - oil & grease
  - organic toxins (priority pollutants, eg.pesticides)
  - others eg. surfactants, dyes etc.
- Mostly biodegradable, some very slowly

a. Carbohydrates

- Composition: C, H, O
- Soluble: sugars, alcohols, acids (VFA) *rapidly biodegradable*
- Insoluble: starches, cellulose, fibres (*relatively) slowly biodegradable*
- Sources: sugar mills, breweries, dairy factories, canneries etc.

b. Proteins

- Composition: C, H, O, N (16%), S, P
- Solubility varies with protein type and ww conditions (eg pH, salt conc.)
- Quite *rapidly biodegradable* to amino acids except when insoluble
- Anaerobic degradation creates H_2S and other sulphur components => odor
- Sources: dairy factories, meat processing (abattoirs), food processing

c. Oil & Grease

- Composition: C, H, O
- Hydrophobic substances: grease, fat, oil
- Mostly insoluble, floating, easily adsorbed on surfaces
- *Slowly biodegradable*, even when hydrolysed to glycerol and fatty acids
- Sources: meat processing, food production, chemical factories

d. Toxics (Priority Pollutants)

- Organic toxic chemicals, pesticides, herbicides, solvents, etc.
- Inorganic substances eg. Heavy metals (Cd, Cr, Pb, Hg, Ag etc.)
- Normally very low effluent limits
- Sources: chemical factories, metal manufacturing, tanneries, agriculture, etc.

Practical Exercises: Composition

- What main components would you expect in a cheese factory wastewater?
- What are the main concerns when considering treatment of an electroplating wastewater stream?
- Why should storage of raw wastewater be avoided if at all possible?
- What precautions should be taken if storage is necessary?

Measurement of Organic Content

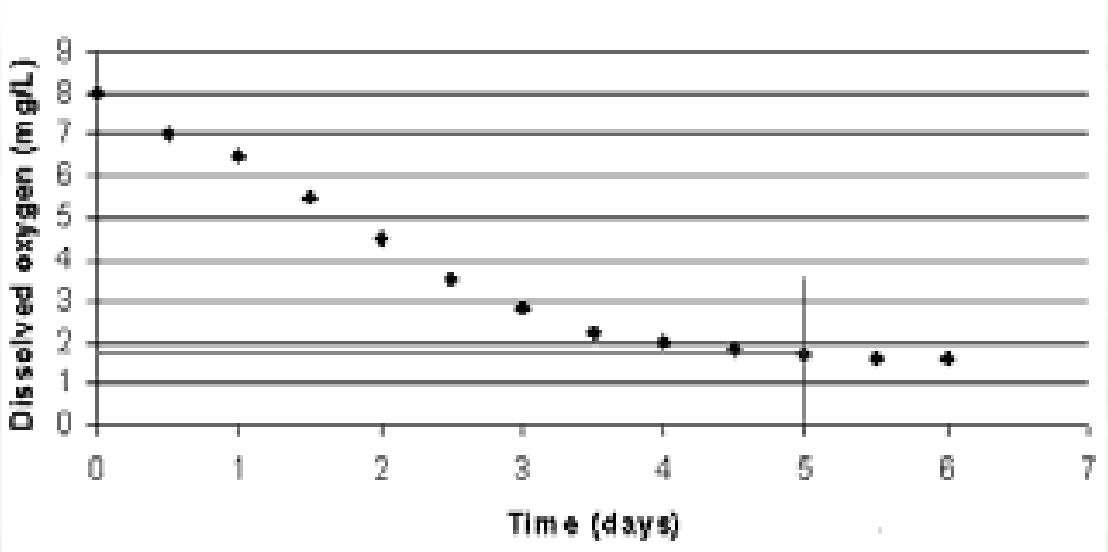
- Mostly overall content measured:
  - Total organic carbon: TOC
  - Biochemical oxygen demand: BOD
  - Chemical oxygen demand: COD
- BOD & COD most commonly used for design and effluent specifications

a. Biochemical Oxygen Demand (BOD)

- Measures **oxygen** required for biological oxidation of organics
- BOD: oxygen uptake by microorganism during aerobic growth in ww sample
- Standard BOD: 5 day incubation @ 20°C
- Samples require a series of dilutions to achieve suitable oxygen consumption

BOD Example

This result was obtained for a BOD test on a wastewater sample. The sample was diluted by a factor of 20 prior to the test.



What is the BOD5 ?

BOD5 = (8 - 1.7)*20

= **126 mg/L**

Practical Concerns with BOD Test

- Only partial degradation of organics
- Cannot be used for mass balancing
- Very high (>1000mg/L) and very low (<10mg/L) values often unreliable
- Industrial wastewater can contain inhibitors, leading to low BOD results

b. Chemical Oxygen Demand (COD)

- Also measures oxygen required, but for **chemical** oxidation of organics
- COD: chemical oxidants used for oxidation of organics to CO_2, H_2O & NH_3
- Standard COD: $K_2Cr_2O_7^{2-}$ /H_2SO_4 @ 145°C
- During oxidation dichromate is used up and remaining oxidant is measured spectrophotometrically to determine oxidant used

8. Wastewater Flow Terms

- Equivalent person (EP): average wastewater amount produced per person
- Typically 1 EP equivalent to 200-250 l/d per person for domestic households
- Average Dry Weather Flow (ADWF): average flow over 7 days without rain
- Peak Dry Weather Flow (PDWF): maximal flow during day (1.5-3 x ADWF)

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4. Sampling & Measurements

- On-line measurements where possible
- Appropriate sampling crucial to achieve relevant results
- Sampling schedule based on expected (or measured) variance over time
- Automatic sampling often essential

Composite Sampling

- Reduces analysis costs and levels out concentration fluctuations
- Composite samples should be taken proportional to flow
- Individual samples can be collected and composited later
- Ensure appropriate sample conservation/ storage from sampling time until analysis

THANK YOU