Wastewater Characteristics

Quality

Wastewater Quality

- The degree of treatment depends on:
  - Influent characteristics
  - Effluent characteristics

- Impurities come from:
  - Domestic activities
  - Industrial activities
  - Commercial activities

- Typical characteristics are shown in the following Table
The wastewater quality characteristics may be classified according to the following:

- **Physical**
  - Turbidity, Color, Oder, Total solids, Temperature

- **Chemical**
  - COD, TOC, Nitrogen, Phosphorus, Chlorides, Sulfates, Alkalinity, pH, Heavy metals, trace elements, and Priority pollutants.

- **Biological**
  - BOD, Oxygen required for nitrification, and Microbial population.
Physical Characteristics

➢ Turbidity
   • Caused by the presence of organic suspended solids

➢ Color
   • Has a light tan color if fresh (2 to 6 hours old)
   • Grey if older than 6 hours due to biochemical oxidation in collection system
   • Dark grey or black if undergone extreme biochemical oxidation under anaerobic conditions (production of sulfides, particularly ferrous sulfide)
   • Hydrogen sulfide is produced under anaerobic condition, which reacts with ferrous ions and produce ferrous sulfide (black color)

Physical Characteristics

➢ Odor
   • Soapy or oily odor if fresh (not offensive)
   • Stale, very offensive, if undergone extreme anaerobic biochemical oxidation, due to production of compounds such as hydrogen sulfide

➢ Total solids
   • Suspended
   • dissolved
   • Volatile (evaporate at 550° C)
   • Fixed (remain after ignition)
   • settleable
**Physical Characteristics**

- **Temperature**
  - Higher than that of water supply
  - Important parameter, particularly for biological processes

Physical characteristics of industrial wastewater vary depending on the type of industry.

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**Chemical Characteristics**

- **Chemical Oxygen Demand (COD)**
  - A measure of organic materials in a wastewater in terms of the oxygen required to oxidize the organic materials chemically.

- **Total Organic Carbon (TOC)**
  - Is a measure of organic materials (based on measurement of carbon in the organic materials by combustion and measurement of CO₂ evolves)
**Chemical Characteristics**

➤ Nitrogen
   * **Organic Nitrogen**: The amount of nitrogen present in organic compounds, such as protein and urea.
   * **Ammonia nitrogen** \((\text{NH}_3/\text{NH}_4^+)\)
   * **Nitrite nitrogen** \((\text{NO}_2^-)\)
   * **Nitrate nitrogen** \((\text{NO}_3^-)\)

➤ Phosphorous
   * **Organic Phosphorous** (in protein)
   * **Inorganic phosphorous** (phosphates, \(\text{PO}_4^{3-}\))

➤ Chlorides \((\text{Cl}^-)\)

➤ Sulfates \((\text{SO}_4^{2-})\)

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**Chemical Characteristics**

➤ Grease
   * (interferes with oxygen transfer in activated sludge processes)

➤ Heavy metals such as
   * Mercury (Hg)
   * Arsenic (As)
   * Lead (Pb)
   * Zinc (Zn)
   * Cadmium (Cd)
   * Copper (Cu)
   * Nickel (Ni)
   * Chromium (Cr)
   * Silver (Ag)
Chemical Characteristics

Priority Pollutants (organic and inorganic) are:
- Carcinogenic
- Mutagenic
- High acute toxic

Biological Characteristics

Biochemical Oxygen Demand (BOD₅)
- The amount of oxygen needed to stabilize organic matter by micro-organisms
  - Time (5 days)
  - Temperature (20° C)

Nitrogenous Oxygen Demand
- The amount of oxygen needed to convert organic and ammonia nitrogen to nitrates by nitrifying bacteria
Wastewater Microbial Life

➢ Wastewater contains
  - Bacteria
  - Protozoa
  - Fungi
  - Viruses
  - Algae
  - Rotifers
  - Nematodes

➢ Sources
  - Soil (through infiltration)
  - Human intestines
Wastewater Microbial Life _ Protozoa

Wastewater Microbial Life _ rotifers
Wastewater Microbial Life _ Fungi

Wastewater Microbial Life _ Nematodes
Measurement of Waste Organic Material

The measurement of the concentration of waste organic materials in a wastewater is important in the design of the treatment plant and in the control of its operation. Following are the different tests used to measure organic waste:

- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Organic Carbon (TOC)

Biochemical Oxygen Demand (BOD)

Definition

- Microorganisms oxidize (feed on) organic material and while doing so, they consume dissolved oxygen (DO).
- BOD is a measure of the DO required for the utilization of organic matter as food by the aerobic microorganisms.
- BOD is measured by DO determination before and after an incubation period of 5 days at 20°C

BOD is conducted under aerobic conditions

\[
\text{Organics} + O_2 \xrightarrow{\text{Aerobic microbes}} CO_2 + H_2O + NH_3 + \text{new cells}
\]
Biochemical Oxygen Demand

➤ After 10 to 12 days, the NH₃ will be oxidized to nitrite and then nitrate

\[
2NH_3 + 3O_2 \rightarrow 2NO_2^- + 2H^+ + H_2O + \text{new cells}
\]

\[
2NO_2^- + O_2 + 2H^+ \rightarrow 2NO_3^- + 2H^+ + \text{new cells}
\]

➤ The next two Figures show:
- the BOD curve for both stages
- Carbonaceous stage
Carbonaceous Stage

- Removal of organic matter is a first-order reaction

\[- \frac{dC}{dt} = kC\]

- \(\frac{dC}{dt}\) = rate of removal of organic matter
- \(k\) = rate constant to the base \(e\)
- \(C\) = concentration of organic matter remaining at time \(t\)
Carbonaceous Stage

Rearrange and integrate the equation

\[
\int_{C_0}^{C} \frac{dC}{C} = -k \int_{0}^{t} dt
\]

\[
\ln \left( \frac{C}{C_0} \right) = -kt
\]

\[
\frac{C}{C_0} = e^{-kt}
\]

- \( C_0 \) = concentration of organic matter initially
- \( C \) = oxidizable organic matter remaining at time \( t \)
- \( t \) = test duration

Since the amount of organic matter oxidized is proportional to the amount of oxygen required, then:

- \( C \propto L \) (where \( L \) is the BOD remaining at time \( t \))
- Similarly, \( C_0 \propto L_0 \)

Then,

\[
\frac{L}{L_0} = e^{-k_1 t} = 10^{-K_1 t}
\]

- \( L \) = BOD remaining at time \( t \)
- \( L_0 \) = ultimate first-stage or carbonaceous BOD
- \( k_1 \) = rate constant to the base \( e \)
- \( t \) = test duration
- \( K_1 \) = rate constant to the base \( 10 \)
**Carbonaceous Stage**

Thus:

\[ L = L_0 e^{-k_t} \]

and

\[ L = L_0 10^{-K_{t'}} \]

So, BOD exerted (y) up to time (t) is:

\[ y = L_0 - L_0 e^{-k_t} = L_0 (1 - e^{-k_t}) \]

or

\[ y = L_0 - L_0 10^{-K_{t'}} = L_0 (1 - 10^{-K_{t'}}) \]

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**Example**

**Example**

A wastewater has a BOD₅ of 200 mg/l, and the k₁ value is 0.34 day⁻¹. Determine the ultimate first-state BOD, L₀.

**Solution**

\[ y = L_0 (1 - e^{-k_{t'}}) \]

\[ 200 = L_0 [1 - e^{-(0.34)(5)}] \]

Thus, \( L_0 = 245 \) mg/l