NATURAL PURIFICATION PROCESSES

DILUTION

Dilution is a process whereby the concentration of pollutants is reduced due to mixing of a small volume of polluted water with a large body of water, e.g. a stream or river. This usually happens when wastewater is discharged into a stream. If the stream has a low or negligible amount of pollutants, and its volume flow rate is much greater than the wastewater, dilution will take place and is reflected in downstream water characteristics. Low pollutant concentrations, adequate mixing, temperature, and hydraulic characteristics will dictate the success of dilution.

The *principles of continuity* and *mass balance* can be used to calculate the dilution capacity of a stream. Consider the following example, as illustrated in ***Figure 1***.

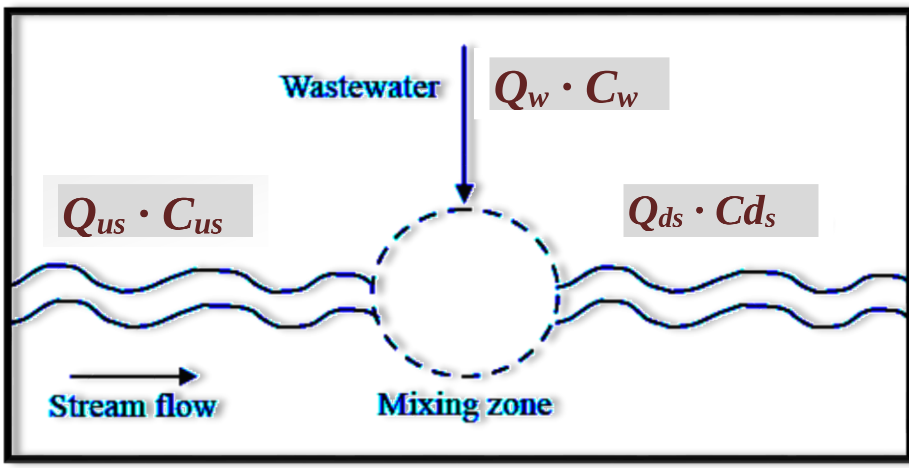


Figure1: **Stream flow with wastewater discharge.**

Wastewater is discharged into a stream at a *flow rate* Q_w with a *concentration* C_w of a pollutant. Prior to **discharge**, the *stream flow rate* was Q_{us} with a *concentration* C_{us} of the pollutant. Assuming complete mixing at the point of discharge and no accumulation or chemical conversion, we can calculate the downstream flow rate Q_{ds} and concentration C_{ds} of the mix after discharge.

From the ***principle of continuity***,

$$Q_w + Q_{us} = Q_{ds} \qquad \text{...}(1)$$

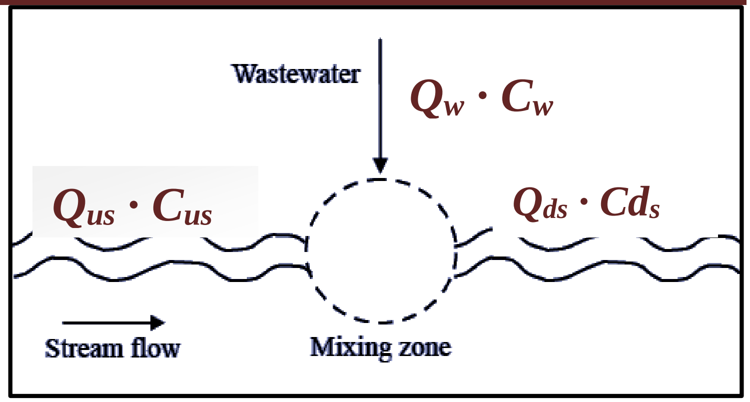
From the ***principle of mass balance***,

$$(\text{Mass flow rate of pollutants})_{in} = (\text{Mass flow rate of pollutants})_{out} \qquad \text{............................ } (2)$$

$$Q_w \cdot C_w + Q_{us} \cdot C_{us} = Q_{ds} \cdot Cd_s \qquad \text{...} (3)$$

EXAMPLE 1

A tanning industry discharges wastewater with ammonia into a stream as illustrated in the following *Figure*. Prior to discharge, the flow rate of the stream is 30 m^3/s with an ammonia concentration of *0.2 mg/L*. The flow rate of the industrial discharge is *1.3 m^3/s* with an ammonia concentration of *50 mg/L.* Calculate the resultant flow rate and ammonia concentration downstream from the point of discharge.



SOLUTION

Calculate resultant flow rate using equation of continuity (***equation 1***).

$$Q_{ds} = 30\ m^3/s + 1.3\ m^3/s$$

$$Q_{ds} = 31.3\ m^3/s$$

Write a mass balance between upstream and downstream points (equation 2).

$$(\text{Mass flow rate of ammonia})_{in} = (\text{Mass flow rate of ammonia})_{out}$$

$$(30\ m^3/s \times 0.2\ mg/L) + (1.3\ m^3/s \times 50\ mg/L) = 31.3\ m^3/s \times C_{ds}$$

$$C_{ds} = 2.27\ mg/L$$

SEDIMENTATION

Sedimentation is a process that involves the removal of suspended solids from a water body by settling them out. The size of the solid particles plays a major role in the efficiency of sedimentation. Larger particles settle out quickly, whereas smaller particles may remain suspended for longer periods and eventually settle out. Stream characteristics, such as flow rates, bed depth, and roughness, also affect the rates of sedimentation. Excessive turbulence or flooding can cause resuspension of deposited solids. This can transfer solids deposits from one location to another.

MICROBIAL DEGRADATION

Wastewater discharged from municipal sources contains a large amount of organic matter. When untreated wastewater is discharged into streams and rivers, the organic matter is used as food by bacteria, protozoa, and other microorganisms in the water bodies. Aerobic microorganisms use oxygen during aerobic oxidation of organic matter. This creates a substantial oxygen demand in the water body and can lower the dissolved oxygen concentrations significantly. The oxygen in water bodies is replenished by transfer from the atmosphere.