UNIT - IV

DISINFECTION:

The filtered water may normally contain some harmful disease producing bacteria in it. These bacteria must be killed in order to make the water safe for drinking. The process of killing these bacteria is known as Disinfection or Sterilization.

Disinfection Kinetics

When a single unit of microorganisms is exposed to a single unit of disinfectant, the reduction in microorganisms follows a first-order reaction.

$$dN/dt = -kN \qquad N=N_0e^{-kt}$$

This equation is known as Chick‟s Law:-

N = number of microorganism (N_0 is initial number)

k = disinfection constant

t = contact time

METHODS OF DISINFECTION:

1. **Boiling:** The bacteria present in water can be destroyed by boiling it for a long time. However it is not practically possible to boil huge amounts of water. Moreover it cannot take care of future possible contaminations.

2. **Treatment with Excess Lime:** Lime is used in water treatment plant for softening. But if excess lime is added to the water, it can in addition, kill the bacteria also. Lime when added raises the pH value of water making it extremely alkaline.

This extreme alkalinity has been found detrimental to the survival of bacteria. This method needs the removal of excess lime from the water before it can be supplied to the general public. Treatment like re-carbonation for lime removal should be used after disinfection.

3. **Treatment with Ozone:** Ozone readily breaks down into normal oxygen, and releases nascent oxygen. The nascent oxygen is a powerful oxidising agent and removes the organic matter as well as the bacteria from the water.

4. **Chlorination:** The germicidal action of chlorine is explained by the recent theory of Enzymatic hypothesis, according to which the chlorine enters the cell walls of bacteria and kill the enzymes which are essential for the metabolic processes of living organisms.

Chlorine Chemistry:

Chlorine is added to the water supply in two ways. It is most often added as a gas, $Cl_2(g)$. However, it also can be added as a salt, such as sodium hypochlorite (NaOCl) or bleach. Chlorine gas dissolves in water following Henry's Law.

$$Cl_2(g) \longrightarrow Cl_2(aq) \qquad K_H = 6.2 \times 10^{-2}$$

Once dissolved, the following reaction occurs forming hypochlorous acid (HOCl):

$$Cl_2(aq) + H_2O \longrightarrow HOCl + H^+ + Cl^-$$

Hypochlorous acid is a weak acid that dissociates to form hypochlorite ion (OCl^-).

$$HOCl \longrightarrow OCl^- + H^+ \qquad K_a = 3.2 \times 10^{-8}$$

- All forms of chlorine are measured as mg/L of Cl_2 (MW = 2 x 35.45 = 70.9 g/mol) Hypochlorous acid and hypochlorite ion compose what is called the free chlorine residual.
- These free chlorine compounds can react with many organic and inorganic compounds to form chlorinated compounds. If the products of these reactions possess oxidizing potential, they are considered the combined chlorine residual.
- A common compound in drinking water systems that reacts with chlorine to form combined residual is ammonia. Reactions between ammonia and chlorine form chloramines, which is mainly mono-chloramine (NH_2Cl), although some di-chloramine ($NHCl_2$) and tri-chloramine (NCl_3) also can form.
- Many drinking water utilities use mono-chloramine as a disinfectant. If excess free chlorine exits once all ammonia nitrogen has been converted to mono-chloramine, chloramine species are oxidized through what is termed the breakpoint reactions. The overall reactions of free chlorine and nitrogen can be represented by two simplified reactions as follows:

Monochloramine Formation Reaction. This reaction occurs rapidly when ammonia nitrogen is combined with free chlorine up to a molar ratio of 1:1.

$$HOCl + NH_3 \longrightarrow NH_2Cl + HOCl$$

Breakpoint chlorination: When excess free chlorine is added beyond the 1:1 initial molar ratio, mono-chloramine is removed as follows:

$$2NH_2Cl + HOCl \longrightarrow N_2(g) + 3H^+ + 3Cl^- + H_2O$$

The formation of chloramines and the breakpoint reaction create a unique relationship between chlorine dose and the amount and form of chlorine as illustrated below.

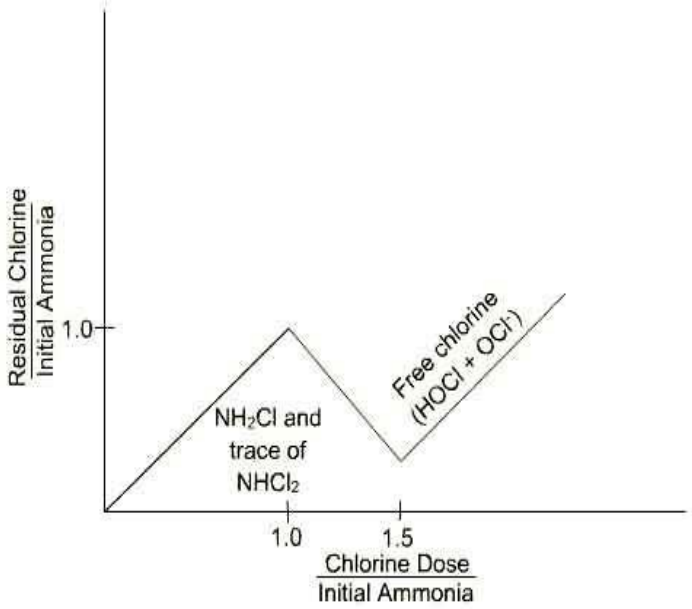

Fig: Break Point reaction

TYPES OF DISINFECTANTS:

Most commonly used disinfectants are:

1. Bleaching Powder or hypochlorite
2. Chloramines
3. Free chlorine gas
4. Chlorine dioxide.