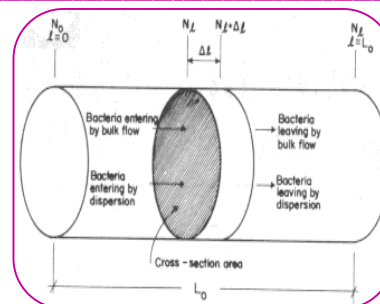_____

MATHEMATICAL MODELING OF BACTERIAL DIE-OFF, ADSORPTION AND VOLATILIZATION PROCESS

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ABSTRACT :

In this paper we have presented Bacterial Die-off, Adsorption and Volatilization process as a transformation process, these process are very important in the study water quality. We first discussed the rate of disappearance of pathogenic bacteria and viruses due to die approximately by the first-order kinetic. In adsorption the relationship between the equilibrium concentrations of a constituent in the liquid and solid phases is governed by its adsorption isotherm is discussed and we also given the equation giving the rate of decrease of the constituent concentration due to volatilization.

KEYWORDS : Pathogenic bacteria, Adsorption, volatilization.

1. INTRODUCTION:

Water quality parameters are relating to waste water discharge are dissolved oxygen, suspended solids, bacteria, nutrients, PH and toxic chemicals including volatile organics, acid/base, neutrals, metals and pesticides. Dissolved oxygen is oxygen gas molecule present in the water. Plants and animals use the dissolved oxygen in the water for respiration. So dissolved oxygen is important to aquatic life because detrimental effects can occur when DO levels drop below 4 to 5 mg/L, depending on the aquatic species. Suspended solids affect water column turbidity and ultimately settle to the bottom, leading to possible benthic enrichment, toxicity and sediment oxygen demand. Coliform bacteria are used as an indicator of other pathogenic organisms of fecal origin and as such provide a measure of the safety of the water for recreational and other uses. Nutrients can lead to eutrophication and DO depletion. The acidity of water, measured by its PH, affects the chemical and ecological balance of ambient waters. Toxic chemicals include arrange of compounds that, at different concentrations, have detrimental effects on aquatic life or on humans, upon ingestion of water and/or fish and shellfish.

The physical, chemical, and biological processes control the fate of the water quality. These processes, are several and varied. It is convenient to divide them into transport processes which affect all water quality parameters. This paper deals with Bacterial Die-Off, Adsorption and Volatilization as a transformation processes, which are constituent -specific.

Pathogenic bacteria found in sewage can adversely impact public health when the sewage is discharged to water that human comes in contact with through wading, swimming, fishing, drinking, etc. One component of this research is to study the fate and transport of these microorganisms in the environment. The die-off rates of these organisms are critical to understanding their fate in the environment.

Adsorption, in general, is the process of collecting soluble substances that are in solution on a suitable interface. The interface can be between the liquid and a gas, a solid, or another liquid. In the past,

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the adsorption process has not been used extensively in wastewater treatment, but demands for a better quality of treated wastewater effluent have led to an intensive examination and use of the process of adsorption on activated carbon [4].

The release of VOCs from wastewater surface to the atmosphere is termed volatilization. Volatile organic compounds are released because they partition between the gas and water phase until equilibrium concentrations are reached [8]. The mass transfer of a constituent between these two phases is a function of constituent concentrations in each phase relative to equilibrium concentration. Thus, the transfer of a constituent between phases is greatest when the concentration in one of the phase is far from equilibrium. Because the concentration of VOCs in the atmosphere is extremely low, the transfer of VOCs usually occurs from wastewater to the atmosphere.

2. BACTERIAL DIE-OFF:

The rate of disappearance of pathogenic bacteria and viruses due to die approximately follows first-order kinetics.

$$r_B = -K_B C_B \qquad\qquad (2.1)$$

Where

r_B= rate of bacteria die-off per unit time per unit volume of water, count /L^3T C_B=bacteria concentration, count/L^3, K_B=Die-off constant, T^{-1}

The die-off constant,K_B, depends on the bacteria or viruses and on the salinity, temperature, and light intensity. For fresh water, decay rates of 0.12 to 26 d^{-1} with a median of 1.0 d^{-1} were measured for coliform in 30 separate in-situ studies [2]. In seawater, bacterial decay is more rapid. The following average expression was derived from about 100 in-situ and laboratory measurements: K_B= [0.8 + 0.006(% seawater)] X$1.07^{(T-20°C)}$$d^{-1}$ [7]. The dependence on light intensity is more marked in sea water, with an up to 20-fold variation in K_B between daylight and night time [1]. The decay rate is sometimes expressed in terms of T_{90}, the time required for 90 percent of the initial bacteria to die. The relationship between T_{90} and K_B is

$$T_{90} = \frac{-\ln(0.1)}{K_B} = \frac{2.30}{K_B} \qquad\qquad (2.2)$$

3. ADSORPTION:

Many chemical constituents tend to attach or sorb to solid. Adsorption is relative to carbon adsorption as a treatment process. The implication for wastewater discharges is that is that a substantial fraction of some toxic chemicals is associated with the suspended solids in effluent. The relationship between the equilibrium concentrations of a constituent in the liquid and solid phases is governed by its adsorption isotherm. For environmental applications, equilibrium conditions can often be assumed, and concentrations are often small enough that the linear isotherm, a special case of the Freundlich isotherm, can be used [3].

$$F = K_d C \qquad\qquad (3.1)$$

Where
F = mass of constituent per unit mass of solid, M/M
C = Concentration of constituent in liquid, M/L^3
K_d = distribution coefficient, L^3/M

A consequence of Equation 3.1 is that the ratio of the mass of a constituent in the solid and liquid phases is equal to the distribution coefficient multiplied by the solids concentration $(Ms/Ml = K_D S)$. Distribution coefficients, K_d, can range over six orders of magnitude, depending on the chemical constituent.

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Much information on distribution coefficients is available in the groundwater contamination literature [11], where adsorption plays a paramount role (because of the high solids concentrations in groundwater). Empirical relationships are available to calculate distribution coefficients as a function of the organic content of the soil and other properties of the chemical [6]. Distribution coefficients are high for heavy metals and synthetic organics particularly high for pesticides, PCBs (polychlorinated biphenyls), and PAHs (polycyclic aromatic hydrocarbons).

Adsorption combined with solids settling results in a removal from the water column of constituents, such as metals, that might not otherwise decay. Environmental criteria usually apply to the total concentration of chemical constituents, defined as the total mass (dissolved plus adsorbed) divided by the water volume. Settling therefore leads to rate of concentration decrease per unit volume of water, r_A given by

$$r_A = -\frac{K_d w S}{H(K_d S + 1)} C \qquad (3.2)$$

4. VOLATILIZATION:

Some constituents, such as VOCs (volatile organic compounds), are subject to volatilization. The physics of this phenomenon are very similar to surface reaeration, expect that the net flux is out of the water surface. Also, for most applications, the equivalent to saturation dissolved oxygen concentration (C_s) is practically zero because the partial pressure of the chemical in the atmosphere is practically zero. The equation giving the rate of decrease of the constituent concentration due to volatilization is [5].

$$r_V = -K_V C \qquad (4.1)$$

Where
r_V = rate of volatilization per unit time per uunit volume of water, M/L^3
K_V = volatilization constant, $1/T$
C = concentration of constituent in liquid, M/L^3

Different methods have been proposed to evaluate K_V [9]. For high-volatility compounds with a Henry's law constant larger than 10^{-3} atm-m^3/mol, the vaporization constant can be related to the reaeration constant given by [4]

$$K_V = K_2 \frac{d_o}{d_c} \approx K_2 \frac{D_o}{D_c} \qquad (4.2)$$

Where d_o = molecular diameter of oxygen, L
          d_c = molecular diameter of compound, L
          D_o = diffusion coefficient of oxygen in water (see Eq. 17-10), L^2/T
          D_c = diffusion coefficient of compound in water, L^2/T

CONCLUSION:

The die-off constant, K_B, depends on the bacteria or viruses and on the salinity, temperature, and light intensity, The distribution coefficients K_d are high for heavy metals and synthetic organics particularly high for pesticides.

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