Chapter – 5

Modeling Aspects of Waste Water Treatment

5.0: Modeling Aspects of waste water Treatment:

In wastewater treatment tank, ponds and lagoon, there is a tendency of developing algae and it is a well-known fact that all plants extract nutrients, including metals, from their soil and water environments. Some plants like hyper accumulators have the ability to store large amounts of metals; even some metals are basically not required for the functioning of the plant. Further to this the plants can also take up a variety of organic chemicals from the ecological medium and degrade or else process them for the further use in their physiological processes. To improve the natural capabilities of plants to perform remediation functions & to investigate other plants with potential phytoremediation applications, an additional research, including genetic engineering, is being conducted. For the physical & chemical means of the wastewater treatment, mathematical models have also been developed. In this present paper, an effort has been made to build up a mathematical model for the calculation of the pollution load removal from one of the deadliest wastewater of Steel industry employing phytoremediation by water hyacinth.

5.1 Mathematical Model:

Mathematical modeling is the process of representing symbolically the systems through mathematical languages. As in natural sciences like physics, biology, earth science, Metrology and like engineering discipline such as mechanical, civil etc & computer sciences, the mathematical models are also used in social sciences like economics, psychology, sociology, geography & political sciences. The mathematical models are now a day's used very extensively by the mathematicians, physicists, engineers, statisticians, economists and the operations research analysts. There are different forms of mathematical models like linear & non linear models, deterministic & probabilistic models, static & dynamic models, discrete & continuous models.

The mathematical models have included a variety of factors like contact, vertical, horizontal & vector transmissions for the perspective view of transmission mechanism. The incubation, isolation, vaccination& infection within or between groups and different population dynamics are incorporated in mathematical models. The more complex models with time delay, structure of age, structure of infection age, spatial structure are also studied in mathematical models.

5.1.1 Assumptions:

The variation in the parameters is understood & assumed because of phytoremediation by the waste matter of steel industry, which contains heavy load of organic & inorganic compounds. It has been assumed here in this study that with the increase in time, the concentration & effectiveness of the contaminants reduces by the aquatic weed which may scavenge inorganic & some organic compounds from the wastewater. Though, beyond the accomplishment of the equilibrium position, the plants take hold to contribute towards contamination removal. The difference in the parameters caused by the phytoremediation of the industrial waste matters should not go beyond the finite limit and beyond the maximum limit at the first day of the experiment.

5.1.2 Phytoremediation Model:

The phytoremediation model is the process of direct use of living green plants for in place, taking away, deprivation or control of contaminants in soil, sludge, deposit, surface water & groundwater.

Let "p" be the phytoremediation potential of the water hyacinth at time "t" from the initial day of the experiment. Then the rate of change in p, with respect to t, from the initial day of the experiment till the time, at which the plants attain the equilibrium, is directly proportional to p, at that time.

$$\frac{dP}{dt} \propto P \Rightarrow \frac{dP}{dt} = \alpha P \qquad (1)$$

Where, α is the constant of proportional.

Integrating equation (1), we get,

$$\ln P = \alpha t + C \qquad (2)$$

Where, *C* is the constant of integration.

To get the value of C, put the initial condition in Eq. (2) as at the starting day of the experiment, i.e. t = 0;

P will be maximum, let it be P_0. Then,

$$\ln P_0 = \alpha.0 + C \Rightarrow C = \ln P_0$$

Putting the value of *C* in Eq. (2),

$$\ln P = \alpha t + \ln P_0$$

$$\Rightarrow \ln P - \ln P_0 = \alpha t$$

$$\Rightarrow \ln \frac{P}{P_0} = \alpha t$$

$$\Rightarrow \frac{P}{P_0} = e^{\alpha t}$$

$$\Rightarrow P = P_0 e^{\alpha t} \qquad (3)$$

Now when plant attains equilibrium after 46 days, the change in P with respect to t tends to zero,

$$\frac{dP}{dt} = 0$$

$$\Rightarrow P = b \qquad (4)$$

Where, b is a constant. Now combining Eqs (3) and (4),

$$\Rightarrow P = \begin{cases} P_0 e^{\alpha t}, & before \quad attaining \quad equilibrium \\ b, & after \quad attaining \quad equilibrium \end{cases}$$

The young water (aquatic) plants collected from the sludge pond at Tata Steel, Jamshedpur were thoroughly washed with the running tap water to keep away from any surface contagion & kept in a tank filled with the tap water. This testing was performed with five replicate in different tubs of plastic having dimensions of depth 16 cm, diameter 45 cm & of capacity 9 L. Here the industrial water having concentration 25% collected from the waste water of the steel industry was used. For this experiment, in each tub, one (01) plant was permitted to grow for 61 days. To find out the declination in waste matter distinctiveness because of the factors which are other than the phytoremediator plants, the elimination of the corresponding control treatment of the plants was as well maintained. The mechanical aeration is given by a air pump at the rate of 10 min/tub at an interval of three (03) days throughout the experimental duration for providing the dissolved oxygen in a proper manner to the roots. By using standard methods the analysis of pH, EC (electrical conductivity), BOD (biochemical oxygen demand),COD (chemical oxygen demand), TSS (total suspended solids), TDS(total dissolved solids), Na & K of the waste matter drained from the treatments during experiments is done at an interval of 0, 15, 30, 45 & 60 days from the day of start of the experiment. On each & every day of observation the plant growth parameter like leaf area, content of chlorophyll & biomass surrender were recorded.

The methods discussed in the above section were used for the application of the representation to the experimental data. After three equidistant time intervals the observations corresponded to 0, 15, 30 & 45 days, the phytoremediator plant attains fatigue for the appropriate nutrients from the industrial throw away after 45 days of phytoremediation, hence therefore the data collected after 45 days is not considered for the calculation of α. On the basis of these explanation the value of α is calculated & the expected value of P is compared with the experiential value.

Results and Discussion:

All the parameters exhibits an exponential decrease in P of water hyacinth, from the start date of the experiment up to the 45^{th} days of the experiment & thereafter showed negligible decrease till the end of the experiment. Such type of behavior of plant up to 45 days of absorption of the nutrients from the industrial throw away may be credited to the achievement of the stability up to carrying ability of the phytoremediator plants, due to the commitment of all the compulsory sites in the zone of source, as also reported prior. Besides, this might be also Due to the negative force exerted by the high essential absorption in plant body which gives comparatively poor plant growth considered in the leaf area, content of chlorophyll & biomass yield after the 45^{th} day of the testing. Such a weak growth of the plant may have been stopped up the amalgamation of the organic & inorganic stuffing from the waste water.

With the increase in the phytoremediation duration may be beyond 40^{th} day of the experiment the observed value of pH exceeds estimated value.