WATER QUALITY MODELING

The growing quantum of pollutant loads through point and non-point sources in streams/rivers have led to the degradation of water quality of rivers throughout the world. Water quality in rivers may be assessed by conventional sampling and subsequent analysis. Further, simulation of water quality in rivers by using mathematical models has been in vogue since the beginning of the last century. In addition to the municipal and industrial effluents which may add significant amount of biochemical oxygen demand (BOD), streams are subjected to input from agricultural lands in the form of fertilizers. Such situation may lead to dissolved oxygen (DO) depletion to such an extent that aquatic life in the stream may not be able to reproduce and survive. In addition to this, different water quality pollutants in high concentration are added to the river, which may seriously affect the health of the river.

Many rivers in India as well as abroad are receiving threats to their aquatic life. It is important and timely that a rigorous approach to the water quality modeling of such streams/rivers be undertaken. QUAL2EU (Enhanced Stream Water Quality Model with Uncertainty Analysis) is a widely used mathematical model that simulates 15 water quality constituents in branching stream systems. The studies have been undertaken by the National Institute of Hydrology, Roorkee to get an insight into the QUAL2EU model. One of the most important parameters for simulation of BOD and DO in a water quality model is the reaeration coefficient. In the Institute, a criterion has been evolved for estimating reaeration coefficient based on Froude number concept that minimizes the errors and provides better results.

TECHNOLOGY

QUAL2EU model uses a finite-difference solution of the advective-dispersive mass transport and reaction equations. A stream reach is divided into a number of computational elements, and for each computational element, a hydrologic balance in terms of stream flow, a heat balance in terms of temperature, and a material balance in terms of concentration are written. Both, advective and dispersive, transport processes are considered in the material balance. Mass is gained or lost from the computational element by transport processes, wastewater discharges, and withdrawals. Mass can also be gained or lost by internal processes such as release of mass from benthic sources or biological

transformations. The QUAL2EU model has been extensively used in developed countries but its application in Indian context is very limited.

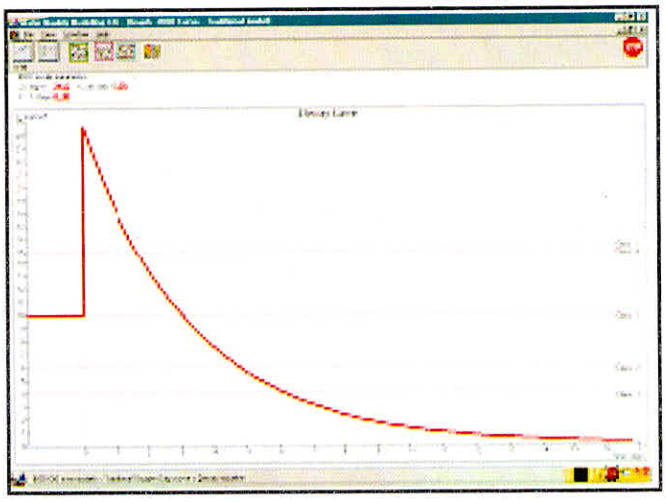

Figure – 1 Representation of BOD decay curve in QUAL2EU

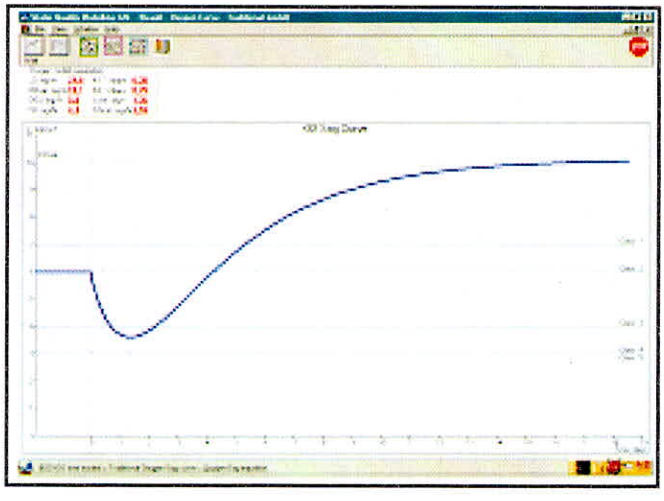

Figure – 2 Representation of Oxygen sag curve in QUAL2EU

Reaeration Coefficient

One of the major phenomena contributing to the biochemical oxidation in waters containing degradable materials is atmospheric reaeration. In the biological treatment of wastewater, aeration is an important process employed to raise the DO level to allow aerobic bacteria to reduce biochemical oxygen demand of the effluent resulting in improvement in the water quality. The oxygen supplied must be at a rate sufficient to at least balance the rate of removal of the active biomass. Reaeration is the process of oxygen exchange between the atmosphere and water body in contact with the atmosphere. Because the reaeration coefficient is one of the parameters necessary for water quality modeling, it is essential that techniques be available for measuring or predicting this coefficient with an acceptable degree of accuracy. The value of reaeration coefficient (K_2) can be evaluated using the DO balance technique and data sets of distinct terrestrial streams/channels.

The QUAL2EU program simulates the changes in flow conditions along the stream by computing a series of steady-state water surface profiles. The calculated stream flow rate, velocity, cross-sectional area, and water depth serve as a basis for determining the heat and mass fluxes into and out of each computational element due to flow. Mass balance determines the concentrations of conservative minerals, coliform bacteria, and non-conservative constituents at each computational element. In addition to material fluxes, major processes included in mass balance are transformation of nutrients, algal production, benthic and carbonaceous demand, atmospheric reaeration, and the effect of these processes on the dissolved

oxygen balance. The model also estimates the waste assimilative capacity of river, waste load allocation, minimum flow requirement, flow augmentation and uncertainty involved in various river reaches. The data of River Kali (Uttar Pradesh), River Pachin (Assam), River Krishna (Andhra Pradesh), River Yamuna (Uttar Pradesh), and River Gomti (Uttar Pradesh) were used to simulate water quality at different locations of each stream using QUAL2EU.

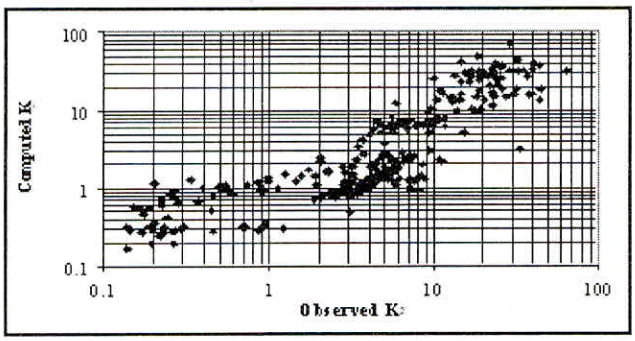

Figure – 3 Observed and computed K_2 for Froude number < 1

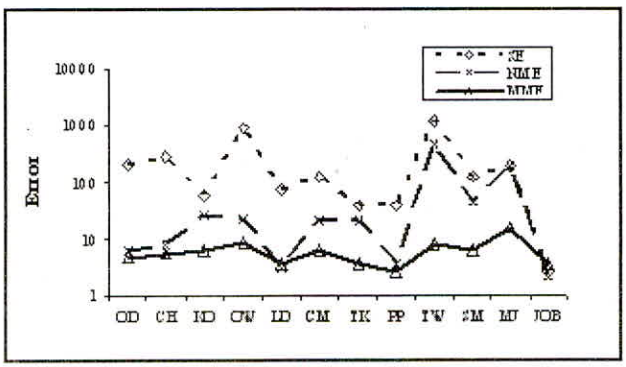

Figure – 4 Error estimates

Every stream has its own capacity to purify the organic matter disposed into the flowing water, generally known as "self purification capacity" or "waste assimilative capacity" of the stream. The most important consideration in determining the waste assimilative capacity of a stream is its ability to maintain an adequate DO concentration. DO concentrations in stream are mainly controlled by atmospheric reaeration. The developed criterion for estimation of reaeration coefficient by the Institute is helpful in accurate estimation of DO and BOD in rivers/streams for further analysis. The criteria for reaeration coefficients have been evolved using the data sets of different rivers in the world and data of the Kali, the Ganga and the Yamuna Rivers in India.

ENVIRONMENTAL IMPACT

Instead of any adverse impact, it will help in improving the environment.

ECONOMICS

As this technique provides the information on river/stream pollution status, it will have tangible and intangible benefits.

BENEFICIARIES

Central Pollution Control Board, Central Water Commission, State Pollution Control Boards, State Water Resources Departments etc. and other non-governmental organisations.

INTELLECTUAL PROPERTY RIGHTS

The mathematical model is in public domain and can be purchased from the market. However, the Institute owns the rights for the use of technique to estimate reaeration coefficients.