Modeling And Simulation Of Rivers- A Review

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***Abstract*—Simulation programming techniques are used in all sectors like engineering education and research for model based and virtual based experimentation with the help of collected data from field. The river water quality is degraded from tremendous discharge of highly polluted effluents. The simulation environment of river includes several programming techniques, interactive graphic displays and user friendly interface. There are several softwares available in market for the prediction of river water quality but MATLAB provides easy and convenient user interface in the form of MATLAB GUI (Graphical User Interface) in environmental research that helps for understanding research problem and find out remedial measures on that. In the current review article, different works based on simulation techniques using softwares have been reviewed.**

***Keywords*— simulation, programming techniques, softwares, water quality prediction**

I. INTRODUCTION

The history of human civilization states that water supply and civilization are almost synonymous. Many cities and civilizations have developed near the water sources or on banks of rivers. Larger rivers are the principle source of water supply for many cities and towns. Rivers play an important role for the human development as well as helps in rapid industrialization, urbanization but in this development negative impact like direct discharge of effluent from sewage treatment plants and effluent treatment plant contributed for increase in pollution level of river body [1]. Increasing consumption of natural resources for fulfilling demands of world population has manipulated natural hydrological cycle both quantitatively and qualitatively. The concentration of pollutants is affected by river water flow and its discharge which is main factor for determination of level of pollution in river stretch. Increased pollution level in rivers affects not only environment but also human beings [2].

The mathematical models helps in the understanding of dynamics of water flow and pollutant transport in planning long term measures of river water use and reduction of pollutant from all sources, future impact assessment of pollutant on river water, development of various water pollution controlling methods and monitoring systems as well as prediction of water quality management[3]. Studies of water quality models help for understanding the water quality, saving time, labour cost for extra samplings and continuous monitoring and also find out remedial measures for control the water pollution [5]. It is worldwide accepted that urbanization and industrialization are main causes for water quality degradation so that assessment of point source on river stretch need to be carried out, which includes identification, evaluation and modeling [4]. The success of model depends upon its convenience for its use and quality of software used for the simulation purpose. Simulation programs are used widely in model based problem solving and virtual experimentation. In current scenario QUAL2KW, QUAL2K, CalHidra 3.0, SIMCAT, TOMCAT, QUAL2E, HEC-RAS and MATLAB software are used for the simulation of river water quality.

II. LITERATURE REVIEW

Prakash Raj Kannela et al (2007) [6], studied Bagmati River water pollution from modeling point of view. He states that Bagmati River receives large amount of pollution. Decrease in DO concentrations in river stretch because of untreated discharges of wastewater containing degradable organics and nutrients into river stream. He developed one-dimensional stream water quality model QUAL2KW which represented and confirmed data from 18 sites sampling. During results sensitivity analysis showed model was highly sensitive for water depth and moderate to point sources flow, TN, CBOD and nitrification rate. He applied model to simulate various water quality management strategies during critical period to maintain the targeted water quality criteria and he considered pollution loads modification, flow augmentation, local oxygenation during his study. He concluded that local oxygenation is effective to keep DO concentration well above minimum levels with the help of QUAL2KW Model.

C.M. Cardona et al (2011)[7], studied new software CalHidra 3.0 which is mostly developed for dynamic simulation based on the Component Object Model (COM) programming with windows graphical tools for water quality in river stretch paradigm. The author states that this software combines1-D hydrodynamic model which is based on Saint Venant equations and transport sub-model that incorporates advection dispersion terms and simplified version of (RWQM1) for the biochemical transformations which allows dynamic simulation of bacterial populations in rivers, making possible simulation of the river acclimatization to changes of pollutant load or environmental conditions. Author concluded that biochemical sub-model, hydrodynamic model and assessment of parameter uncertainty can be effectively done with these models.

Letensie Tseggai Hadgu et al (2011)[8], studied Ndarugu River in Kenya, which is highly polluted from point and non-point sources from untreated industrial, domestic and agricultural waste and during its course through different agricultural and industrial areas from coffee and tea factories of point source discharges. Author states that such river pollution also contributed by runoff carrying soil, fertilizer and pesticide residues from catchment area. Author used water quality model QUAL2K for prediction of water quality of river which reflected field data quite with minor exceptions. Author

calibrated this model for 6 months by data collected and sample analysis with flow discharge (Q), temperature (T), flow velocity (V), biochemical oxygen demand (BOD), dissolved oxygen (DO) and nitrate (NO3-N). Author used model for simulation and he evaluated performance using statistical criteria based on correlation coefficient. This Model helped author for prediction of pollution level in river and develop strategy for controlling the river pollution.

Jinal Y. Patel et al (2011) [12], focused on Par River to study water pollution. She collected samples from eight locations for 6 months on monthly basis for assessment of water quality of monsoon and post monsoon season. Author analysed water sample for Temperature, pH, electrical conductivity (EC), Turbidity, Total dissolve solids (TDS), Dissolve oxygen (DO), Biochemical oxygen demand (BOD), chemical oxygen demand (COD), chloride, Total hardness and Sulphate. Author determined Pearson's correlation coefficient (r) value, p-value with the help of correlation matrix for identification of highly correlated and interrelated water quality parameters by regular water quality monitoring. Author states that correlation study and correlation coefficient values helps in selecting few parameters which helps in determination of status water quality. Author concluded that negative relationship with DO and other parameter shows high degree of pollution in river stretch. Correlation study and correlation coefficient values helps for determination of status of water quality.

Ruibin Zhang et al (2012) [13], studied Taihu Lake Basin in China for study of water pollution. He states that primary sources of pollution in Taihu Lake are rivers inflow and their tributaries. For the sustainable development author applied QUAL2K model which was used for calculate water environmental capacity of the Hongqi River for water quality. He calibrated model parameters by trial and error until simulated results agreed with observed data by satisfied water quality objectives and helps for environmental management. Author concluded that QUAL2K helps and give confirmation about simulation of water environmental capacity of the Hongqi River.

Yang LI et al (2009)[14], performed Multivariate statistical Technique, which include cluster analysis (CA), principal component analysis (PCA), factor analysis (FA) and discriminant analysis (DA) with temporal and spatial variations for evaluation of water quality of Songhua River Basin. Monitoring program was carried out at different sites. Author selected 3 significant sampling locations (less polluted sites, moderately polluted sites and highly polluted sites) which were detected by CA method. Further he found that five latent factors (organic, inorganic, petrochemical, physiochemical, and heavy metals) were identified by PCA and FA methods, domestic and industrial wastewater disposal taken into the consideration during this study. Author concluded that PCA and FA help to identify parameters responsible for water quality variations. Domestic wastewater and industrial discharges control helps to improve Water quality and spatial variations in water quality analysis of pollution levels and design of monitoring strategy helps for effective river water quality management.

Antonio A.L.S. Duarte et al (2008) [15], selected mathematical models to mitigate prediction uncertainty. For calibration and validation he studied river water systems dispersion modeling which is based on tracer experiments data. For determination of in situ river water dispersion behavior he used racer injection (rhodamine WT) and for simulation of mathematical models applied to different water quality management scenarios of 3 rivers. Author calibrated Models for producing operational tools to estimate probabilistic arrival, peak, recession times, and reminiscent substance concentrations. He gives good correlation between experimental data and simulation results with applied models having good accuracy for describing as well as predicting conservative pollutant transport under different hydrodynamic scenarios. Author concluded that to solve pollutant transport problems in river, mathematical models is a powerful tool like DUFLOW package, which develop accurate river models and simulate pollutants transport in water bodies with different dispersive characteristics. Mathematical models show satisfactory results for impact assessment of different pollutant river and help to improve river water quality.

M K Yetik et al (2010)[9], studied how research and development on water quality model helps for model calibration and verification techniques recognizing current degree of pollution in rivers and importance of the sustainable water resources management. GIS system effectively implemented with MATLAB as an integrated platform on Arc Map which works in user friendly manner and software allows user to enter data collected from river, runs dynamic model in MATLAB environment, predicts values of pollution constituents along river, extracts results and displays water quality on the map in different forms. It also provides a considerable ease in future real time application for onsite river monitoring and environmental pollution assessment.

Sarah Khan et al (2013) [10], carried out study for entire stretch of Yamuna river for pollution study. High amount of organic matter originates from domestic sources, depletion of dissolved oxygen in river water affect the biotic community as well as self-purification capacity of river like river Chambal. In Delhi stretch, load of organic matter is so high that consumes entire dissolved oxygen available in river water and results in BOD level increase in water. To predict water quality of river Yamuna, MATLAB is used with the help of DO-BOD modeling of river Yamuna for Delhi stretch.

Elena Skorzinki et al (2009) [11], studied how simulation program can be used for numerical, virtual model based on virtual experimentation and visualisation of challenging concept. Pollution dispersion programme is carried out to solve environmental problems with simulations based on MATLAB platform. He developed models for three type of simulation like oxygen sag model for predicting oxygen deficit, Gaussian dispersion model for prediction of air quality and Model for pollution dispersion in ground water. Such simulations are carried out to solve environmental, chemical and biotechnological problems. MATLAB GUI user helps to predict the water and air quality of source. DO simulations of two main curves i.e. de-oxygenation and Re-oxygenation curve shows inter-relation with time with study of BOD at dilution point, oxygen and concentration deficit at dilution point, temperature effect on constant and oxygen saturation parameters. For study of pollutant dispersion in ground water, radioactive radiation and absorption such two cases were studied.

III. SIMULATION SOFTWARES

- HEC-RAS model used for study hydraulics of water flow through natural River and other channel. This program is one dimensional which is developed by US department of Defence but it has problems while doing highly dynamic river study.
- MATLAB is the mostly advance language used for mathematical modeling and simulation that provides native support for solving problems with built in graphics, mathematical functions, developmental tools for improving software performance and helps with custom graphical interfaces. MATLAB based algorithms also include tools such as C, Java, .NET and Microsoft Excel. MATLAB provides easy and convenient user interface in the form of MATLAB GUI (Graphical User Interface) in environmental research that helps for understanding research problem and to find out remedial measures on that. The simulation programs learning by discovery instead of traditional learning techniques. MATLAB GUI helps for rapid introduction and effective use of simulation.
- SIMCAT, TOMCAT, QUAL2E are steady state models used for estimation of dilution of pollutant loads in river stretch.
- CalHidra 3.0 includes hydrodynamic model and water quality model for simulation. This is based on 1-D full Saint Venant non-linear partial differential equations.

IV. SUMMARY OF LITERATURE

After throughout evaluation of related literature, it can be revealed that most of the works for water prediction model were carried out by using softwares like QUAL2KW, QUAL2K, CalHidra 3.0, SIMCAT, TOMCAT, QUAL2E, HEC-RAS and MATLAB. All these softwares needs primary field data for the simulation of river which helps for design strategies for controlling pollution in river, study the behavior of pollutant transfer in river as well as for prediction of water quality in river in future with the help of simulation and observed data . The paper has revealed the current simulation and modeling work for study pollution effect on river. The review empowers researchers to choose available technologies and mathematical, visual simulation and programming which will not only improve the water quality prediction efficiency but also will help for easy, convenient, accurate and effective programming with minimum data input for river water quality prediction.

CONCLUSION

Above mentioned literature summarised that QUAL2KW, QUAL2K, CalHidra 3.0, HEC-RAS and MATLAB gives easy and accurate simulation and modeling with effective user friendly interface.

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