Water Quality Modeling and Management of Surface Water using Soft Tool

Purushottam Sarda[1], Dr. Parag Sadgir[2]

Abstract - **This study aims at examining the efficiency of current standards in Godavari River water quality in India. Godavari River receives major pollution from tributaries, the parameters are considered from Pategaon to Yelli on Godavari basin with the available data from 2001 to 2012. The monthly variation of water quality standards has been used to compare one-dimensional stream water quality model using QUAL2Kw soft tool. The model represented the field data quite well with some exceptions. The sensitivity analysis showed the model was highly sensitive for water depth and moderate to point sources flow, TN, CBOD and nitrification rate. The model was applied to simulate various water quality management strategies during critical period to maintain the targeted water quality criteria (minimum DO at or above 5 mg/L; maximum CBOD, TN, TP and temperature at or below 3, 2.5 and 0.1 mg/L and <20◦^{C}, respectively, and pH range 6.5–8.5). The results showed the local oxygenation is effective to maintain minimum DO concentrations in the river. On the basis of results, know the actual information about a particular parameter level in river and also decide which type of treatment is done on the basis of actual parameter level present in it. Results shows QUAL2Kw gives better results stimulating water quality parameter for river.**

Keywords- **Calibration, CBOD, DO, Godavari River, QUAL2Kw,**

I. INTRODUCTION

Water is one of the most indispensable resources and is the elixir of life. A big amount of agricultural, municipal and industrial wastewaters discharges to rivers around the world. These discharges of degradable wastewaters in water bodies result in decrease in water quality generally and particularly DO concentrations. According to above mentioned problems of wastewater discharges, it is important to manage the water quality of hydrological sources and predict the impact of contaminants on them. There are a lot of models available but the most appropriate is the one that meets the research objectives.

The QUAL2K model is the new version of the widely used QUAL2E. QUAL2K is distributed by USEPA (United States Environmental Protection Agency, 2007) and it is based on differential equations for one-dimensional systems and steady state flow. This model is efficient to simulate water quality and hydrological conditions of streams as well as systems with diffusive pollution loads. QUAL2K developed in order to correct the QUAL2E limitations. Therefore QUAL2K has many new elements; it is useful in data limited conditions, is freely available and is not reserved for large rivers (i.e. deep and wide).

The objective of this study is to determination the overall quality of water and its suitability for different purposes like domestic and safe for aquatic life.

Purushottam Sarda[1] *Research Scholar, Government College of Engineering Aurangabad, M.S. India, Phone: +91 9422217834;*
Dr. Parag Sadgir [2] *Associate Professor, Government College of Engineering, Aurangabad, M.S. India;*

II. LITERATURE SURVEY

The object was to define pollution level and relating to its sources of Godavari River. Due to disposal of waste water into the river it disturbs the quality of water so that we go for this project [1]. QUAL2Kw is the newest version of QUAL2K series which developed to cover limitations of previous versions. QUAL2Kw can operate either as a steady state or as a dynamic model; this software used as a tool for mathematical modeling and simulation of water quality. When operated as a steady state model, it can be used to study the impact of waste load on in-stream water quality. The sensitivity analysis showed the model was highly sensitive for water depth and moderate to point sources flow and CBOD [2].

Richa Babbar [3] has outlined the parameters and the steps required for water quality modeling. The model is an example of developing a procedure for water quality management within the constitutional framework of pollution control in India.

Kachiashvili *et al.* [4] has devoted this paper to mathematical modeling and computer simulation of diffusion and transport of chemicals in rivers. In this paper the author has presented one, two and three-dimensional models in terms of time-dependent convection–diffusion–reaction differential equations. The model has been developed for the Godavari River System that receives waste effluent from domestics and industries in its vicinity. This research provides insights into FIO source apportionment, explores a selection of pollution remediation strategies and the spatial differentiation of land use policies which could be implemented to deliver river quality improvements [5]. In-stream water-quality models provide guidance in watershed management decisions by linking pollutant loads to changes in water quality. These models are particularly useful for determining waste load allocations, developing numeric nutrient criteria, and aiding in total maximum daily load (TMDL) analyses [6].

Maryam *et al.*, [7] presented the importance of recipient environments` conditions in determining waste water

ISSN: 2278 – 7798

discharge standards, two scenarios were simulated in QUAL2Kw model. In the first one, current standards in river were simulated for 2 parameters (BOD and DO). In the second one, concentrations were suggested for these 2 parameters provided that the appropriate qualitative condition of the river (DO minimum at or above 5mg/l) is maintained due to the efficiency of current standards in Gheshlagh River- Kurdistan in Iran.

Another application of Qual2k for water quality modeling in The Bagmati River showed that, the model represented the field data pretty accurate. In this study various water quality management options taken into account to control DO, such as pollution loads modification and local oxygenation (by affixing weirs). Apparently local oxygenation is effective in raising DO levels [8].

III. METHODOLOGY

The Study area will be consider as Pategaon (D/s of Jayakwadi Dam) to Yelli having 165 km span, divided into nine reaches. Considering the hydraulic characteristics, cross sectional areas, location of the stations and basic point sources, the model presently simulates the main stem of a river as depicted in Fig.-1 tributaries are not modeled explicitly, but can be represented as point sources.

In the present study, the study reach simulated is a dendritic river that has almost steady flow condition and the transport is dominated by longitudinal changes. Thus, the assumptions of one dimensional process are reasonable. In addition, the available data for model simulation are very scarce. For these reasons, Q2K is chosen as an appropriate model of water quality simulation.

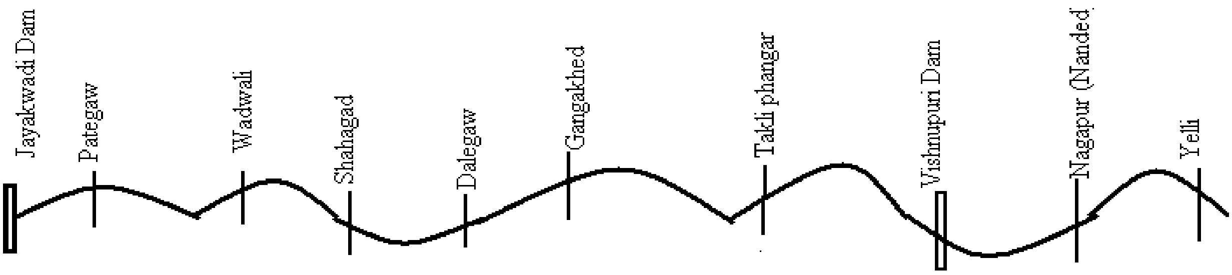

Figure 1 Reach Scheme

Table 1 Reach Hydraulic Characteristics along Godavari River

Sr. No	WQ Location	Latitude	Longitude	Elevation in (m)	Reach Dist. (km)	Bed Slope	Remark
0	Head Water (Jayakwadi Dam)	19°48’45’’	75°17’25’’	442.206	-	-	Head Water
1	Pategaon	19°27'55"	75°24'27"	439.000	12	1:3120	Reach 1
2	Wadvali	19°30'00"	75°40'00"	428.654	23	1:3983	Reach 2
3	Shahgad	19°45’10’’	75°11’23’’	413.685	49.5	1:3850	Reach 3
4	Dhalgaon	19°55’4’’	75°10’50’’	403.000	70	1:3660	Reach 4
5	Gangakhed	19°15'20"	75°27'21"	400.000	68	1:4120	Reach 5
6	Takali dhangar	19°3’8’’	75°9’34’’	388.502	65	1:4250	Reach 6
7	Vishnupuri Dam	19°3’4’’	75°8’58’’	357.450	50	1:4550	Reach 7
8	Nanded Nagapur	19°3’00’’	75°8’15’’	342.100	10.5	1:4590	Reach 8
9	Yelli	19°3’2’’	75°7’33’’	332.500	10.23	1:4600	Reach 9

3.1 The model theory

It assumes that the measure transport mechanism, advection and dispersion, are significant only along the main direction of flow. It allows for multiple waste discharges, withdrawals, tributary flows and incremental inflow and outflow. It also has the capability to compute required dilution flows for flow augmentation to meet any pre-specified dissolved oxygen level.

Hydraulically, QUAL2Kw is limited to the simulation of time periods during which both the stream flow in river basin and input waste loads are essentially constant. Following Table no.2 shows if any water quality parameter data is not available then how that parameter data will be found out.

ISSN: 2278 – 7798

Table 2 Conversion of Water Quality Parameters

Headwater water quality	**Units**	**Alternative if data is not available**
Organic Nitrogen	ugN/L	Dissolved Org. Nitrogen (DON)
Dissolved Inorg. Nitrogen (DIN)	ugN/L	NH4+NO3+NO2
Inorganic Solids	MgD/L	50% of Total Solids*
NH4-Nitrogen	ugN/L	Ammonia Nitrogen
NO3-Nitrogen	ugN/L	Nitrate Nitrogen
Organic Phosphorus	ugP/L	35% of Total Phosphorus (P-Tot) **
Inorganic Phosphorus (SRP)	ugP/L	65% of Total Phosphorus**
Phytoplankton	ugA/L	Put as zero
Detritus (POM)	MgD/L	20% of Suspended Solids **
Generic Constituent	user defined	Consider as COD

*Ref.:- By Meddcalf and Eddy as medium strength water *, By Kausha et al. 1979***

POM – Particulate Organic Matter

IV RESULT AND DISSCUSSION

As stated previous chapter, the model is run for some the water quality variables; Carbonaceous Biological oxygen demand(CBOD), Dissolved oxygen (DO), Temperature (T), Total Nitrogen (TN), Total Phosphorus (TP). The model is run with average of spring month's values of runoff and water quality. In summer most of the river basins are withering.

Table 3 QUAL2K Sheet

System ID:		
River name	**Godavari River, India**	
Saved file name	**GR 2015_1_10**	
Directory where the input/output files are saved	**C:\qual2kw51b52_xls\qual2kw\v51b52**	
Month	**1**	
Day	**10**	
Year	**2015**	
Local standard time zone relative to UTC	**5.5**	**Hours**
Daylight savings time	**Yes**	
Simulation and Iutput options:		
Calculation step	**5.625**	**Minutes**
Number of days	**30**	**Days**
Solution method (integration)	**Euler**	
Solution method (pH)	**Brent**	
Simulate hyporheic exchange and pore water quality	**Level 1**	
Display dynamic diel output	**No**	
State variables for simulation	**All**	
Simulate sediment diagenesis	**No**	
Simulate alkalinity change due to nutrient change	**Yes**	
Write dynamic output of water quality	**No**	
Program determined calc step	**5.625**	**Minutes**
Time elapsed during last model run	**0.30**	**Minutes**
Time of sunrise	**7:10 AM**	
Time of solar noon	**12:13 PM**	
Time of sunset	**5:17 PM**	
Photoperiod	**10.11**	**Hours**

Table 4 Headwater Sheet

Headwater Flow	**290**	**m^3/s**	
Prescribed downstream boundary?	**No**	**2001 to 2012**	
Headwater Water Quality	***Units***	***01/01/01***	***31/12/12***

ISSN: 2278 – 7798

Temperature	**C**	**24.00**	**26.00**
Conductivity	**Umhos**	**570.00**	**771.00**
Dissolved Oxygen	**mg/L**	**5.80**	**4.20**
CBODslow	**mgO2/L**	**2.60**	**60.00**
CBODfast	**mgO2/L**	**2.60**	**60.00**
Organic Nitrogen	**ugN/L**	**1820.00**	**2440.00**
NO3-Nitrogen	**ugN/L**	**6895.00**	**7820.00**
Generic constituent	**user defined**	**100.00**	**100.00**
Alkalinity	**mg CaCO3/L**	**200.00**	**240.00**
pH	**s.u.**	**7.70**	**8.10**

Spatial Charts QUAL2Kw *displays a series of charts that plot the model output and data versus distance (km) along the river.*

V. CONCLUSION

The aim of this study was to evaluate the water quality of the Godavari River based on the water physical and chemical variables analysis. Model QUAL2Kw was calibrated and confirmed using the data in 2000 to 2012 field data quite well with some exceptions. This model is used for small rivers with steady state flow conditions. The model was highly sensitive to depth coefficient and moderate to point sources flow, Total Nitrogen, CBOD and nitrification rate. The model was applied to simulate various water quality management strategies during the critical period to maintain stated water quality criteria, DO level present particular The QUAL2Kw model provided a satisfactory result to the calibration with the sampling data of the Godavari River. Nevertheless many parameters and applications presented in the model are assigned to tempered environments, which may compromise the calibration of some variables. Moreover some region is above 5mg/L, CBOD level in particular region in between is 1.7 to 45 mg/L, The Temperature level in particular basin in between 20^0 c to 26^0c, pH level in particular region in between 7.2 to 8.1, it's confirmation shown in above result graph.

According to graph result, Temperature, DO, and PH results are satisfactory and C-BOD result is more according to permissible limit for each parameter (as per BIS:10500-2012). So no treatment is requiring for Temperature, DO, pH and treatment is requiring for CBOD. CBOD treatment depends on CBOD concentration present in particular region.

considerations in manual program are not suitable. However, QUAL2Kw model has some limitations its use is recommended for water quality simulation in order to maintain an effective water resources management and future scenarios.

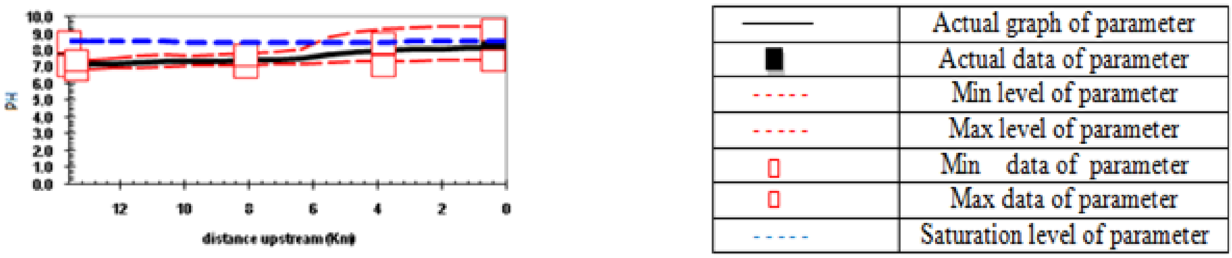

Figure 2 Data Results

RECOMMENDATIONS/REMEDIAL MEASURES

a. Domestic effluents may be treated and disinfected before discharging.

b. Effluents from non-point sources may be identified. These are required to be collected & treated

ACKNOWLEDGEMENTS

This material is based upon work supported by Office of the SDSC Manager and Superintending Engineer, Data Analysis Circle, Water Resources Department Nasik. The authors would like to thank Mr. Greg Pelletier, Washington State Department of Ecology, Olympia, WA. and Steve Chapra, Environmental Engineer, Professor and Louis Berger Chair in Computing and Engineering, Tufts University, Medford, MA, for his kindness in providing the software as well as the useful comments.

ISSN: 2278 – 7798

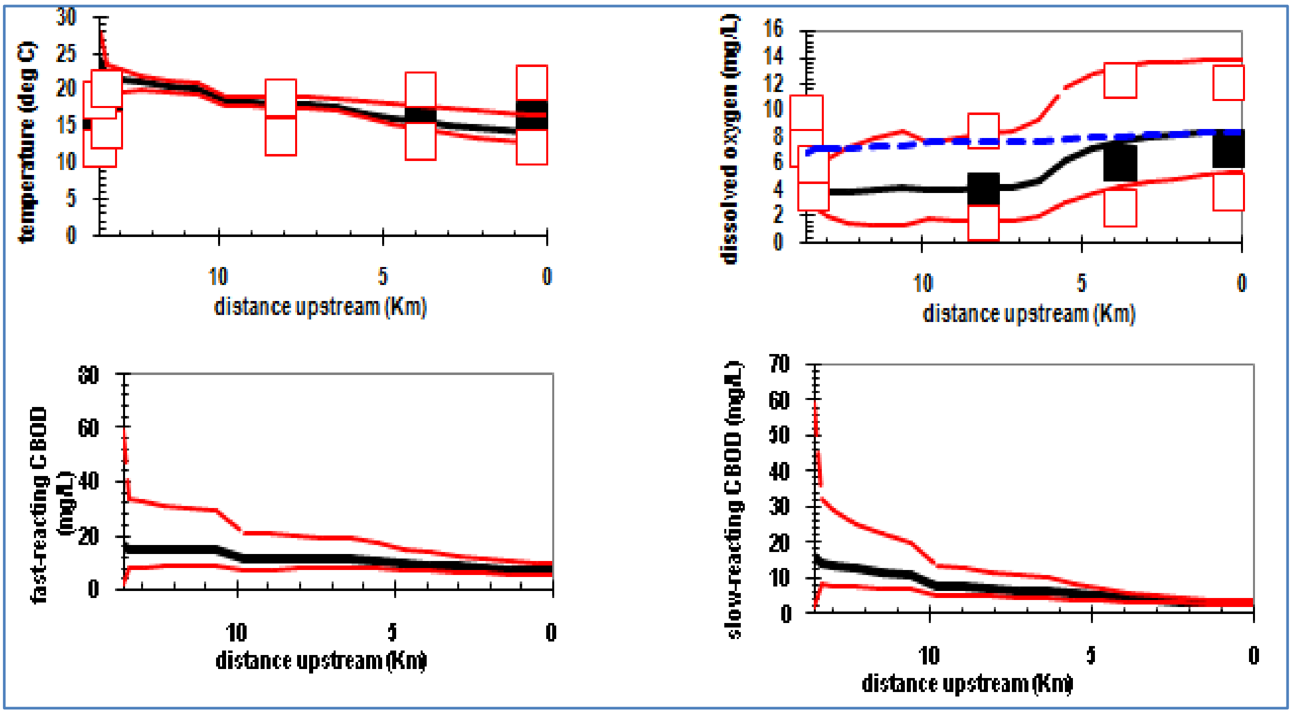

Figure 3 Graphs of upstream

REFERANCES

1. Chavan A.D., Sharma M. P. and Bhargava R., "Water Quality Assessment of the Godavari River", Hydrology, Nepal, Vol. 5, 2009, pp.31-35. DOI: 10.3126/hn.v5i0.2483
2. Pellitier G.J. and Chapra. S.C., "QUAL2Kw – framework for modeling water quality in streams and rivers using a genetic algorithm for calibration", Environmental Modeling and Software, Tufts University, Vol. 25, 2006, pp.29-35, DOI: 10.1016/j.envsoft.2005.07.002
3. Richa Babbar, "Mixed Integer Programming for Pollution Control of Indian Tropical Rivers: Case Study", Journal of Tran disciplinary Environmental Studies, Vol. 9(2), 2010, pp.1-10.
4. Kachiashvili K., Gordeziani D., Lazarov R. and Melikdzhanian D., "Modelling and Simulation of Pollutants Transport in Rivers", Applied Mathematical Modelling, Vol. 31, 2007, pp. 1371–1396, Doi:10.1016/japm.2006.02.015
5. Park S.S. and Uchrin C.G., "Water Quality Modeling of lower south Branch of the Raritan River", New Jersey, Build N.J. Academy of Science, Vol. 35 (1), 1990, pp. 17-23.
6. Hobson A. J., Neilson B.T., Stackelberg N., Shupryt M. and Chapra S.C., "Development of a Minimalistic Data Collection Strategy for QUAL2Kw," Journal of Water Resources Planning and Management, ASCE, 2013, ISSN 0733-9496/04014096(13), DOI: 10.1061/ (ASCE) WR.1943-5452.0000488
7. Moalla M.A., Mirsanjari M.M. and Zarekar A., "The Necessity of Examining Aquatic Recipient Environments of Waste Waters in Water Resources Environmental Management Utilizing Simulating Model QUAL2K," Global Journal of Medicinal Plant Research, Tehran, Iran, Vol. 1(1), 2013, pp. 157-165.
8. Kannel P.R., Lee S. and Pelletier G.J., "Application of automated QUAL2Kw for water quality modeling and management in the Bagmati River," Nepal", Journal of Ecological Modelling, Elsevier, Vol. 202, 2006, pp. 503–517. DOI: 10.1016/ j.ecolmodel.2006.12.033

ISSN: 2278 – 7798