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Simulated and observed DO (Dissolved Oxygen) values for selected major stations of spring-fed Kosi River stretch through model WASP (Water Quality Analysis Simulation Program)

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ABSTRACT

The river Kosi is a spring fed river of Indian Himalayan region which quenches the thirst of major population of Kumaon region. The model WASP (Water quality analysis simulation program) is a widely used model suggested by EPA that can help simulate the water quality processes in diverse water bodies as reservoirs, ponds, lakes river like surface water bodies. The analysis in the 4 major selected stations of the stretch for Dissolved Oxygen was found to be 4-11mg/l as measured value whereas simulated values ranged from 1 mg/l to 10mg/l at the origin of the river, whereas at the end point of the river the simulated and measured value ranged from 4mg/l-8mg/l , 6mg/l. The Dissolved oxygen in the water is very essential to estimate the water quality as it directly affects the aquatic life and also signifies the presence of organic matter as well as microorganisms in the water. The continuous variations in the DO levels are observed in the entire stretch. The probable reason is uneven rainfall, scattered population and terrain complexities of the region. The continuous and frequent merging of various springs into the main course river results in frequent fluctuations in the physicochemical parameters of the river. This study is an attempt to comparatively analyse the water quality of the only river of the region with the simulated values from model WASP and observed water quality from daily sampling from the water body.

Keywords: *WASP, Simulation, Dissolved Oxygen, Water quality, Aquatic life*

1. INTRODUCTION

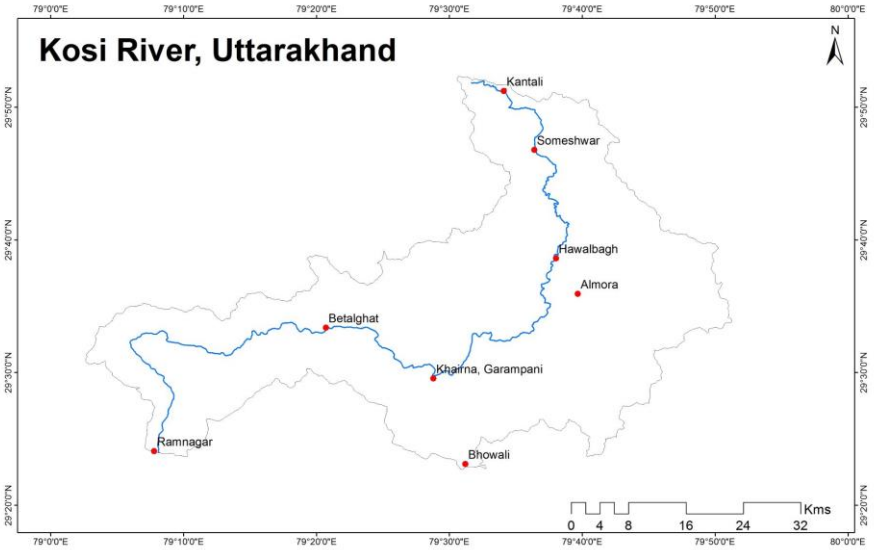
Himalayas is source of generation of various rivers and is quenching the thirst of people of India as well as neighboring countries. Amongst many other Himalayan river system Kosi is the river that originates in the middle Himalayas of Kumaun, Uttarakhand. This river is being used for many purposes as drinking, washing, bathing, fishing, irrigation other than that it is also used for power generation industrial uses as well as for waste dumping like solid waste, domestic waste effluent, industrial waste effluent, cremation waste etc. Such activities contribute towards the pollution load in Kosi River water and thus influencing its ecosystem. Semwal, N., Akolkar, P. (2006). In the consideration to this the current study was carried out to analyze the water quality of Kosi River at district Almora, Uttarakhand, India for evaluating and seeing the future aspect of the water quality the selected points in the stretch for the suitability for drinking and irrigation purposes (Richa Seth, Prashant Singh et.al 2015) Dissolved oxygen (DO) is one of the most significant variables participating in water quality analysis. The low concentrations of DO directly affect fish and may alter a healthy ecological balance. Because DO is affected by many other water quality parameters, it serves to be susceptible indicator of the health of the aquatic system. This water quality DO has been modeled for many past years. The most key steady-state equations were developed and used by Streeter and Phelps (1925). Consequent expansions and applications have added provisions to their basic equation and offered for time-variable analysis. The equations implemented here are fairly standard. We may implement some or all of the processes that are described with terms in the standard equations. Dissolved oxygen and associated variables are simulated using the EUTRO program. Several physical-chemical processes can pose impact in the transport and interaction within the various nutrients, the phytoplankton present, the carbonaceous material, and also the dissolved oxygen in the aquatic environment. The EUTRO and TOXIC are the two major components of the model to operate and find the various components and its concentration in the water body. In order to identify DO in the water body, the model can be driven at various levels of complexity to simulate variables and interactions between various parameters. To simulate only

carbonaceous biochemical oxygen demand (BOD) and DO, we may bypass calculations of other parameters as for the phytoplanktons, nitrogen and phosphorus, APHA (2001) The sediment oxygen demand may be specified, as well as photosynthesis and respiration rates. Major EUTRO state variables that can participate directly in the DO balance are phytoplankton carbon, ammonia, nitrate, carbonaceous biochemical oxygen demand, and dissolved oxygen. In the present study only those concentration were considered in model that were significant in the water body Since concentration of ammonia is not found in the water body of the region hence is considered to be insignificant in the data input of the model. The decrease of dissolved oxygen is outcome of the aerobic respiratory processes in the water body and also might be due to the anaerobic processes in the underlying sediments. Although the underlying segments in river Kosi was not traceable until the river reaches Ramnagar barrage.

2.STUDY AREA

The river Kosi has total catchment of 3,420 sq km and is a major tributary of river Ramganga. Where most of the rivers in our country are glacier fed rivers, the river Kosi is a spring fed river originating from Penath (Rudradhari) near Kausani in Almora district Uttrakhand. In the course of flowing from its originating point till the river merges into Ramganga there merges various other perennial and non perennial springs contributing to the volume of the river. (Er. Kireet Kumar, D.S Rawat). This river flows in the central part of Almora district. The four major stations selected for analysis were:

1.) Kantli: The origin of river Kosi.
2.) Kosi: Before the river crosses Almora (This station was selected to see the parametric study before the river crosses the most populated town of the watershed
3.) Kwarab: After river crosses Almora. (This station was selected to see the contamination levels of the river after the river crosess Almora)
4.) Ramnagar: The end point of river Kosi where it merges to Ramganga (Ramanagar is the point where the river engulfs most pollution as solid waste debris,dometic effluents etc.)



3. MATERIALS AND METHODS

With the help of observed data 4 major stations for daily sampling of the river water for analysing the water quality fluctuations in the region. The major four stations selected was selected on the basis of population topography, water quality sensitiveness, availability of hydrometeorological data and various other model required constraints. Dissolved Oxygen is considered as an essential parameter to analyse the presence of organic compound in the water. The greater is the amount of the organic compound in the water greater will be the demand for oxygen that is required to decompose the organic matter by the microorganisms. Accordingly, the demand for oxygen increases or decreases with the increase or decrease in the organic matter. The DO was measured and calculated according to the norms of APHA from all the four selected stations. With the rapidly the changing environment and its complexities arising with the environmental constraints, water quality models play a vital and atheistic role in predicting assessing and analysing the water quality of the region. WASP is the model proposed by EPA and has simulated the field values well and is going well with the observed values.

3.1 Input parameters of the model

The model WASP requires a huge set of parameters which is broadly divided into two major sections as pre and post processor. The pre processor consists of various constraints that includes various meteorological, environmental and hydrological inputs These inputs fed into the model WASP model. The output of the two sections merges as a BMD file and WRDB graph which results in simulated as well as observed graph of the values observed. The various other constraints demanded with the model are for hydrodynamic constraints, meteorological constraints, and hydrological values as depth, width, and length of the stream segment. The time function is the segment which describes the time period of the simulation for the model

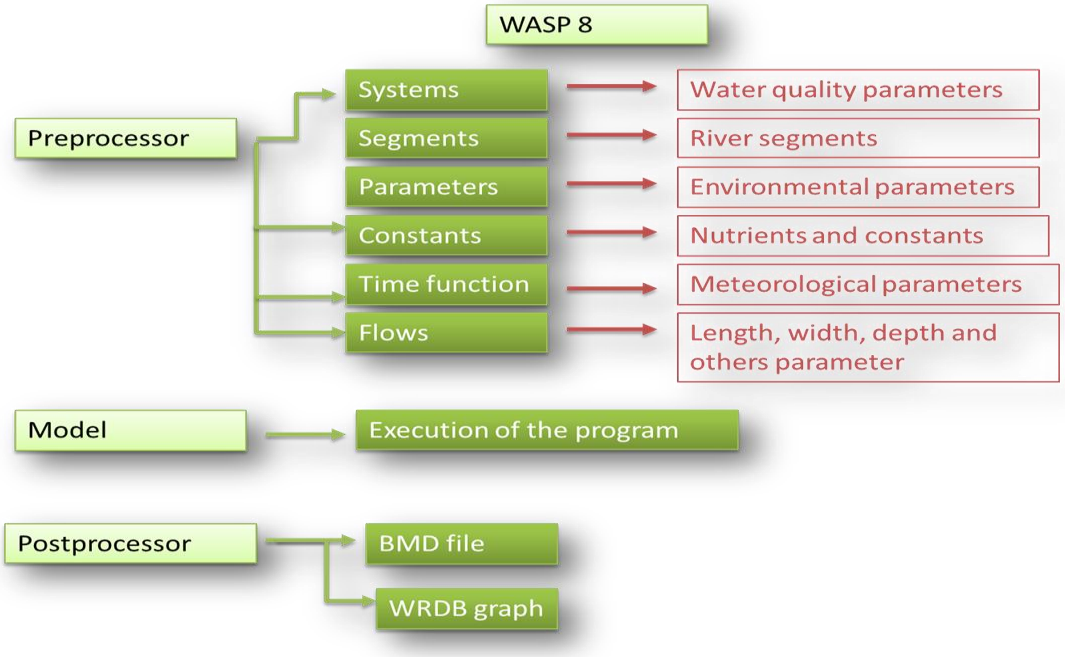


Chart 1: Flow Chart specifying the constraints required in the model

The water surface elevation, flow rate, the wetted width, wetted cross sectional area, the time, distance along the channel, conveyance of the channel, gravitational acceleration and the discharge per unit channel length respectively Mahmudian Shushtari, M. (2008). The collaborative approach of the pre processor and the post processor results in generation of BMD file and ultimately the WRDB graph which eventually helps in calibration and validation of the model.

Table 1: Model state variable activation constraint for model execution

Model State Variable Activation

	System Type	System Name	Particulate Transport	Mass Balance	Density	Dispersion Bypass	Flow Bypass
1	PH-SU	PH-SU 1	Solids 1	☑	1	☐	☐
2	CBODU	CBODU 1	Solids 1	☑	1	☐	☐
3	NO3O2	NO3O2 1	Solids 1	☑	1	☐	☐
4	WTEMP	WTEMP 1	Solids 1	☑	1	☐	☐
5	DISOX	DISOX 1	Solids 1	☑	1	☐	☐

3.2 Segment Selection

Selection of the segment is a vital parametric step for the model execution. The segment definition screen is where the user provides segment specific geometry information. It is important that the user has a good understanding of the segment to be selected in the entire stretch.

Table 2: The depiction of segment characteristic and transport mode of the model

Segments

Segment Definition | Initial Conditions | Fraction Dissolved

	Segment Name	Segment Type	Transport Mode	Segment Below
1	Kantli	Surface	Kinematic Wave	Kosi_bridge
2	Kosi_bridge	Surface	Kinematic Wave	Kwarab
3	Kwarab	Surface	Kinematic Wave	Ramnagar
4	Ramnagar	Surface	Kinematic Wave	None

Insert | Delete

OK | Cancel

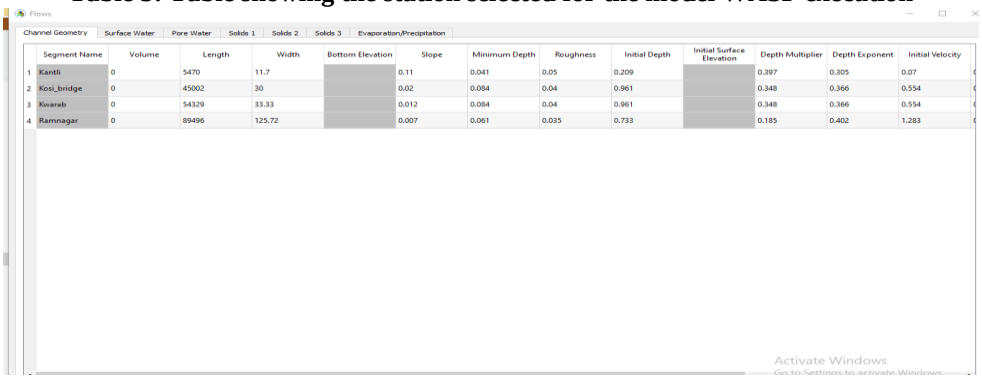
The boundary concentrations needs to be specified for any segment that are receiving flow inputs, outputs, or exchanges from the outside the model network. The boundary segments are automatically determined by WASP 8 when the user defines the transport patterns. Hence, the user generally cannot enter the boundary information until and unless the transport information has been entered.

3.3 Hydrological Parameters

There are several options for specifying water velocity and depth to WASP 8. Depth and velocity can be held constant by entering their values in the Depth and Velocity multiplier field and setting the exponent to zero. The user may also allow depth and

velocity to vary as a function of flow. The velocity, depth of the selected stations were calculated and remained constant for that particular point. Since the river is a spring fed river and the water quality parameter was the analytical parameter hence the dry weather flow was taken into consideration for hydrological constraints and variables.

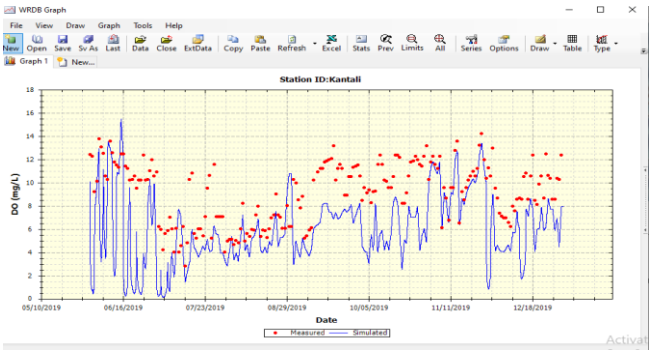
Table 3: Table showing the station selected for the model WASP execution



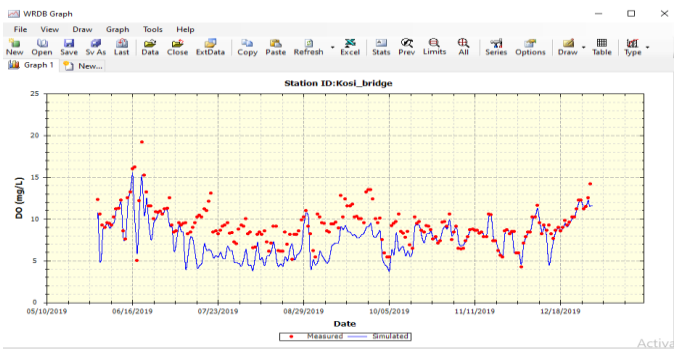
	Segment Name	Volume	Length	Width	Bottom Elevation	Slope	Minimum Depth	Roughness	Initial Depth	Initial Surface Elevation	Depth Multiplier	Depth Exponent	Initial Velocity
1	Kantli	0	5470	11.7		0.11	0.041	0.05	0.209		0.397	0.305	0.07
2	Kosi_bridge	0	45002	30		0.02	0.084	0.04	0.961		0.348	0.366	0.554
3	Kwarab	0	54329	33.33		0.012	0.084	0.04	0.961		0.348	0.366	0.554
4	Ramnagar	0	89496	125.72		0.007	0.061	0.035	0.733		0.185	0.402	1.283

The river Kosi has varied depth in the entire course of the flow because of the certain reasons as one hand where it is a summation of seasonal springs with uneven rocky bed. The depression of the bed and geological formation results in depth variation in the entire bed range of the river hence flow and velocity too varies.

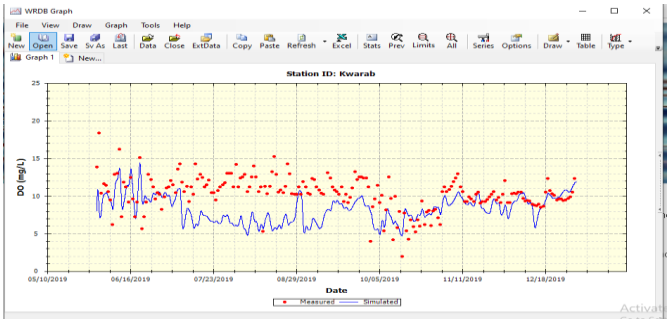
4. RESULTS AND DISCUSSION



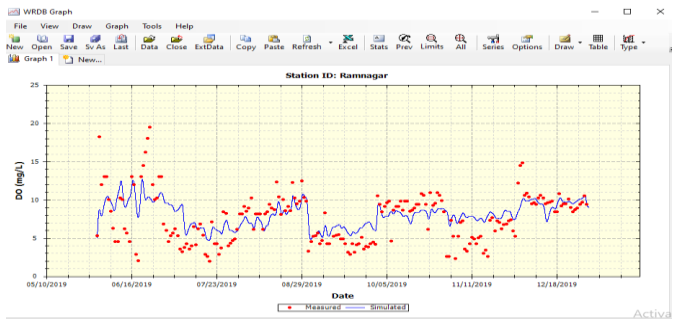
DO of river Kosi at Kantli station



DO of river Kosi at Kosi barrage



DO of river Kosi at Kwarab station



DO of river Kosi at Ramnagar station

Chart 2: Model execution results for the selected station

The execution of WASP model produced a vast quantity of data. The output data read the output files created by the model and displayed the results in x/y plots. The graph configuration menu for creating x/y plot was obtained with x/y plot icon with the data being plotted in x/y window for any file. The predicted value for dissolved oxygen as parameter from may 2019 to December 2019 in all segments presented in x/y plot. The simulated and predicted values showed a continuous fluctuation in the dissolved oxygen values in the entire stretch and major difference was seen between Kantli and Ramnagar station.

Table 4: Simulated model generated values

Station Codes	Mean	Median	5%	95%
Kantli	9.178	10.230	4.960	12.632
Kosi barrage	9.286	9.235	5.900	13.125
Kawarb	10.359	10.560	5.901	13.650
Ramnagar	7.609	8.450	2.851	13.00

Table 5: Measured model generated statistical values

Station Codes	Mean	Median	5%	95%
Kantli	6.110	6.058	1.015	11.810
Kosi barrage	7.662	8.080	4.446	11.398
Kwarb	8.242	8.593	5.598	10.841
Ramnagar	8.058	8.341	5.520	10.503

Table 6: Simulated –Measure model generated statistical values

Station Codes	R2	Mean error	RMS	Normal RMS	Index of agreement
Kantli	.25	3.275	4.154	.537	.60
Kosi barrage	.46	1.719	2.377	.276	.74
Kwarb	.03	2.616	3.364	.363	.47
Ramnagar	.43	1.935	2.555	.318	.70

The comparative study of the values of dissolved oxygen showed that the minimum value was expressed at Ramnagar station of 3mg/l and also the lowest simulated value as 5mg/l respectively. Kantli station observes highest measured value till 14mg/l for the month of June 2019.Results indicate that Ramnagar have more pollution as disposing of waste sewage and biodegration organisms. Alireza Aliverdi Hossein Eslami(2014).

The statistical analysis of the observed and simulated data generated by the model clearly specifies the degree of agreement between the two values. Both the observed and simulated values showing the degree of agreement close to 1 shows that the values go true with each other.

5. CONCLUSION

The river Kosi being spring fed river strongly manifests the dilution of contamination. Most of the springs in the most populated stretch are contaminated with nitrate, high BOD and also have high colonies of microorganisms. These springs along with other springs which feed the river get diluted with many perennial and non-perennial springs. (Pooja Rani Sinha et.al(2021)) The continuous monitoring of the springs of Almora which is highly and densely populated town of the watershed shows, that the springs are highly contaminated with nitrate, sulphate and showing high values of microbiological colonies.

Along with the phenomenal changes and increase in other physicochemical properties. However, the physicochemical analysis of the river Kosi from the period of May 2019-December 2019 shows decreased contamination. This could be probably manifesting the merging of various other perennial and non perennial springs into the river. Model WASP predicts the contamination of the river at 4 different stations in the entire stretch for the nitrate as contaminant.

Daily variations analysed during the entire period and is represented in an x/y plot. The results of the present study revealed that WASP model is best suited for predicting nitrate and many other parameters as dissolved oxygen, phosphate and DO. The graphically representation of the daily water quality variations provides a clear picture of nitrate values of the river at a glance. The present study reveals the precipitation, flow, river bed topography along with various hydrometeorological parameters poses and defines the water quality of the river. Since the region doesn't have any precise summer season and increase of temperature in summers ranges between 20-32 degree centigrade. The region all the year round receives frequent and scattered rainfall.

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