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Gomti River: Water Quality Simulation For The Future Year 2030 By Using WEAP

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Abstract: There can never be enough emphasis placed on the role that water plays in the origin and growth of healthy life. We must manage water such that it benefits all living things, both now and in the future, in addition to its social, industrial, and financial value. For both plants and animals, water is a crucial resource. The Gomti River in Lucknow City, India, serves as a vital water source for numerous uses for many years. Rapid global change has made the river's current situation crucial for its environmental, scenic, and economic worth. The goal of this study is to evaluate the current situation and anticipate it in the future using a range of scenarios while taking major global trends into consideration, such as changes in temperature and population growth.

Two scenarios are utilised to simulate the quality of river water using the simulation programme Water Evaluation and Planning (WEAP). the scenario with mitigating measures versus the scenario with business as usual (BAU). A 24 km section of the Gomti River has had its water quality replicated from Gaughat to Kudiyaghat. Several aquatic species won't be able to exist by 2030 due to the water quality's rapid decline, according to simulations of water quality metrics for current and BAU conditions. In a scenario with mitigating measures, it must be given access to alternative, superior technologies as quickly as feasible in order to reach a class B level of river water quality.

Keywords: Environmental Engineering, Water Qualty, BOD, EColi,

I. INTRODUCTION

The Gomti river being tributary of the Ganges and as well as monsoon and groundwater fed river that originates from Pilibhit India. After 190 km, Gomti enters Lucknow, meandering through the town for about 12 kms and supplying it's water. The Gomti River in Lucknow City, India, was a vital source of water for the various uses few decades ago. However, due to the rapid global changes, current status of the river is extremely critical from environmental, aesthetic and commercial usage point of view. Henceforth, this research work will concentrate on assessing the present additionally as predicting its future situation using different scenarios while considering key drivers of world changes.

An evaluation and planning tool called WEAP is being utilized to model river water quality based on two scenarios: the business-as-usual scenario (BAU) as well as the mitigation scenario.

A comparison of the simulated water quality parameters with the BAU status by 2030 will signal the quality of the water by 2030, and the results from a scenario with mitigation measures will suggest current wastewater treatment plants and policies as well as future remedies. There are a number of reasons why Lucknow should be considered; Lucknow is a capital of the largest state (Uttar Pradesh), with an economic center that is among the most important in the entire country. Rapid urban expansion and high economic activity lead to unhealthy conditions around water bodies like the Gomti basin as a result of high economic activity and uncoordinated urbanization. Although it is extremely important, its current status and future management strategies are poorly documented. The purpose of this research is to create in-depth information for development of planned water resources capacity, as well as providing recommendations for how to improve river water quality.

A. Objectives of the study

The objective of this study are :

1) Water Quality Simulation including BOD, DO, EColi prediction for future (2030).
2) River Mitigation Strategies

B. Study Area

Uttar Pradesh's capital Lucknow is located between the north latitudes 26300 and 27100 and the east longitudes 80300 and 8113' (Fig.1). Located in a subtropical.climate with humid conditions, Lucknow has a cool, dry winter and a hot, humid summer.

It is a city that has experienced rapid growth over the past few years. Increasing global population has significant implications for natural resources, specifically water quality as well as quantity. Life would not exist without water, the most valuable natural resource, water overuse and exploitation has resulted in deteriorating water quality. A variety of streams cut through Lucknow. The Gomti flows through the middle of the city from North-West to South-East. This is one of the important sources of public water within the city, along with groundwater. In the city, there is a serious problem with sewage generation as well as treatment and disposal of the waste. Poorly draining sewer systems and the degrading quality of river water has been attributed to the lack of sewage treatment capacity.

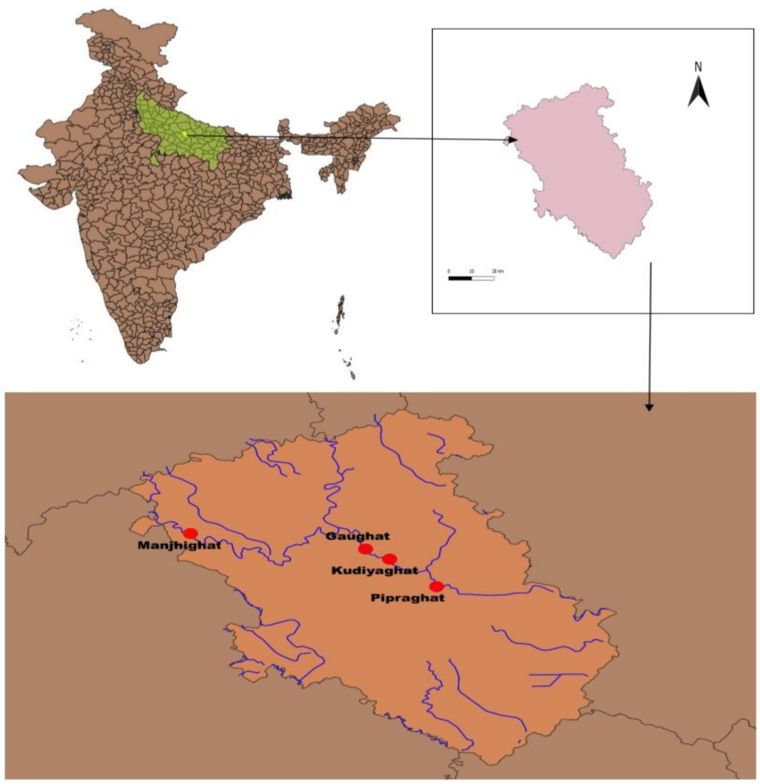


Fig.1 Sites taken into consideration for this study, as well as the Gomti River's flow course as it enters Lucknow City.

II. METHOD AND METHODOLOGY

A. Model Information

WEAP (Water Evaluation and Planning System) is a model-building tool for water resource planning and policy analysis and is distributed at no charge to non-profit, academic and governmental organizations in developing countries. People can use WEAP to create simulations of water demand, supply, runoff, evapotranspiration, infiltration, crop irrigation requirements, instream flow requirements, ecosystem services, groundwater and surface storage, reservoir operations, pollution generation, treatment, discharge and instream water quality, all under scenarios of varying policy, hydrology, climate, land use, technology and socio-economic factors. For Water quality simulation by WEAP, the entire study area must be divided into smaller catchments based on confluence points, physiographic characteristics, and climate. Water quality and hydrological simulations can both be performed within WEAP's hydraulics module. The WEAP tool includes a module for estimating pollution concentrations in water bodies, which relies on the Streeter-Phelps equation. Two processes are responsible for inducing oxygen reaeration during the simulation of oxygen balance in a river: decayed organic matter consuming oxygen and deficits causing reaeration. There has been a direct relationship between water temperature, settling velocity, and water quality in removing BOD from water.

B. Detailed Data Requirements

Using the WEAP model to simulate future water quality variables in 2030, alternative management policies within the Gomti basin were assessed. For the period 2000 to 2021, daily rainfall was collected at IMD Meteorological Station. We calibrated and validated the WEAP hydrology module simulation using daily average stream flow data collected from four stations from 2016-2021, namely Gaughat, Pipraghat, Kudiyaghat, and Manjhighat. In addition to above mentioned components for model setup, the major considerations are the eight demand sites and the two wastewater treatment plants (WWTPs) that represent the problem domain. Demand sites are used to identify domestic (population) centers with their attributes explaining water consumption and wastewater pollution loads per capita as well as water system sources and wastewater returns. Using simulated water quality results for the current situation in 2021, the model calibration and validation are completed once the model setup is completed. In the final step, numerical simulations are carried out using two major scenarios: business as usual (BAU) scenario under which it is shown that what will be the changes in future river water quality if left as it is, the way technologies and policies are going on in present time and other scenario with mitigation measures under which it is shown that after implying various measures, mitigation strategies including increased capacity of Wastewater treatment plants etc, the river water quality in future can be improved. Hence, better environment. Different dataset that were required to the model for this study and the source from where they were collected are as follows :

1) River water quality
- Daily average streamflow data at all the 4 sites from 2015-2021 (SOURCE - IMD)
- Average monthly BOD, DO, EColi data at all the 4 sites from 2012-2020 (SOURCE - UPPCB)

2) WWTP Capacitity, Sewerage collection rate (SOURCE – UPPCB)
3) Remote Sensing Data (Shape file/ vector data)
4) River cross section, etc (SOURCE – CPCB/UPPCB)

Fig.2 is an overview of the Gomti River's flow course across Lucknow along with the sites considered in this study can be found in the schematic diagram above. This has been made through QGis software by vector/rastor data , shape files of Lucknow district. The various inputs have been setup including river Gomti itself, 3 Ground Water, 8 Demand Sites, 4 Catchments, 2 Wastewater Treatment Plants, Streamflow gauge, etc to setup the model which is the first step to run the software.We can see here the Demand sites shown by red arrows which represent the population lying on either side of river Gomti in this study and gets water from GW (marked as Green) and then this water gets mixed within the river (shown as Blue line). The catchments represent the area where water is collected. The catchment of a river drains the water that is collected from the area around it. Catchments are shown by Green circle.

The study area sites are shown by Blue dots on the river flow line and are Manjhighat, Gaughat, Kudiyaghat and Pipraghat. 2 WWTP which are are currently active are shown by Red dots which are currently operational to treat the water having 345 MLD capacity (Bharwara) and 56 MLD capacity (Daulatganj). The other 2 WWTPs which have been added on both sides of river but are setup as inactive until the simulation process to take place regarding WWTP for mitigation strategies part to provide different improving facilities such as enhanced technology, capacity, etc according to future water environment.

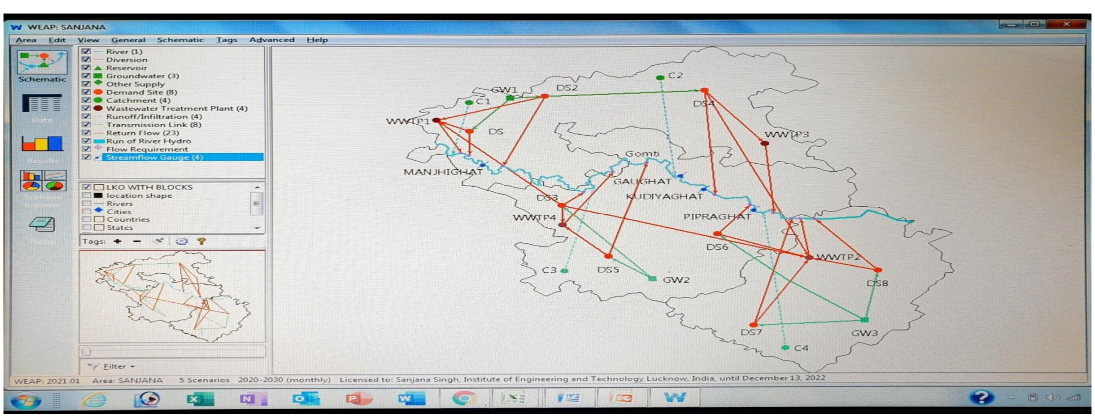


Fig. 2 An illustration of the problem domain for modeling water quality using the WEAP interface and QGis to map the Gomti River.

III.RESULTS

A. Water Quality

To run the WEAP in simulation, observed and simulated values of hydrological and water quality parameters are calibrated and validated prior to running the scenario analysis. Fig.3 represents simulation results of BOD of Gaughat used for validating the model. Similarly for other remaining sites the simulation has been done. The simulation has been done in the WEAP model by entering of BOD from 2012-2020 i.e., monthly value of BOD of 10 years and thereby simulating the BOD for future year 2030. Fig. 4(a) and (b), compares simulated and observed BOD and DO values. The observed 2021 values of BOD and DO collected from UPPCB and Simulated BOD and DO values by the model have been compared and they were found pretty much similar and have been plotted and shown for all the 4 sites namely Gaughat, Kudiyaghat, Manjhighat, and Pipraghat respectively. As a result, the Water quality simulation part is validated by comparing yearly average simulated and observed BOD and DO concentrations throughout a gradient of sites from upstream to downstream. A consistent availability of observed water quality data led to the choice of this location and year i.e. 2021. Based on the results, the model's performance is suitable for this problem domain because of a strong correlation between the two. The coefficient of correlation (R2) is found to be nearly 0.85 for which the model has been discovered to be quite practical and relatable for simulating the longer term water quality. Fig. 4 shows Simulation results of BOD and DO values used for validating the model all the chosen 4 sites during this study for validation of the model.

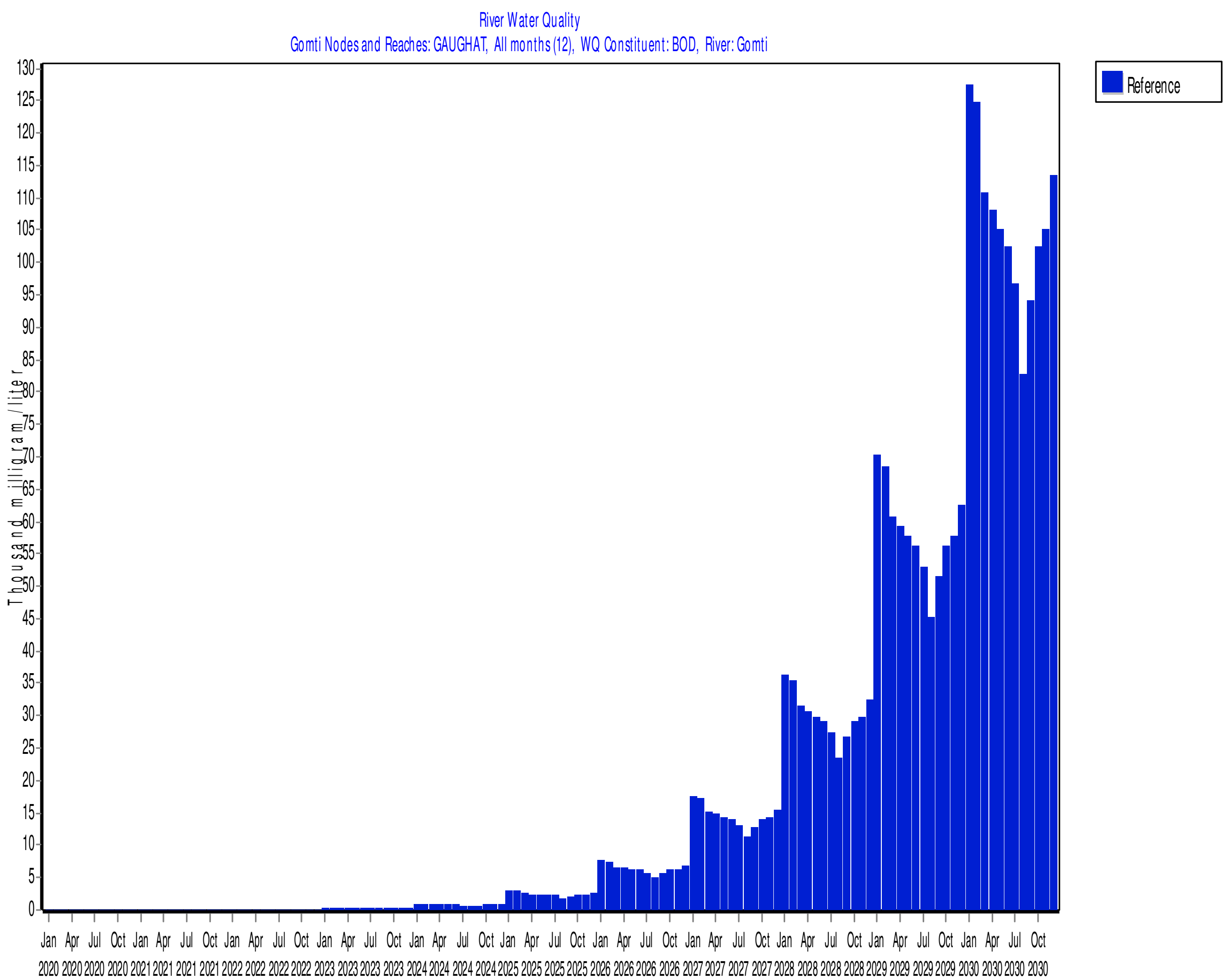
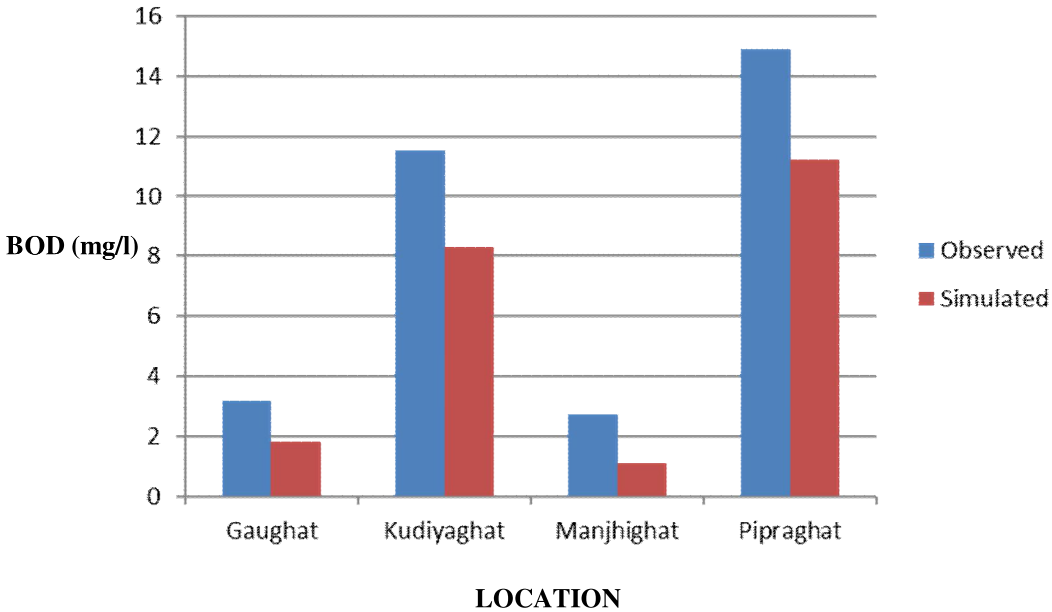
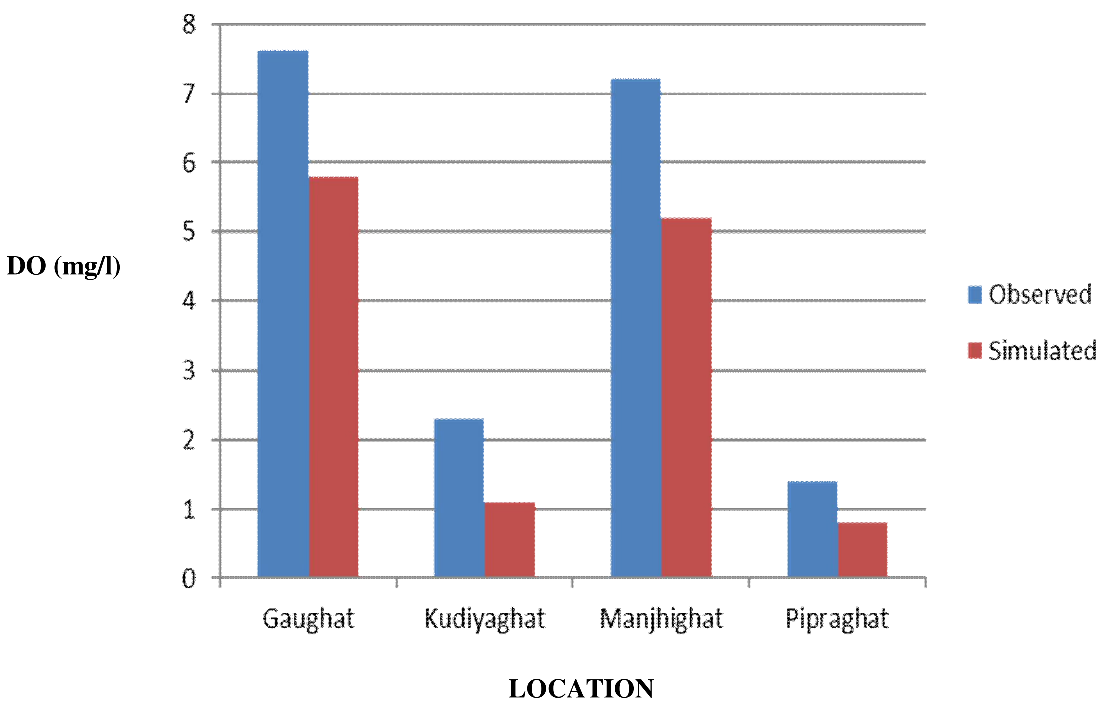


Fig. 3 Simulation results of BOD of Gaughat used for validating the model



(a)



(b)

Fig.4 The output of the model is validated by comparing simulated and observed values (a) for BOD for various locations in 2020; (b) for DO for various locations in 2020

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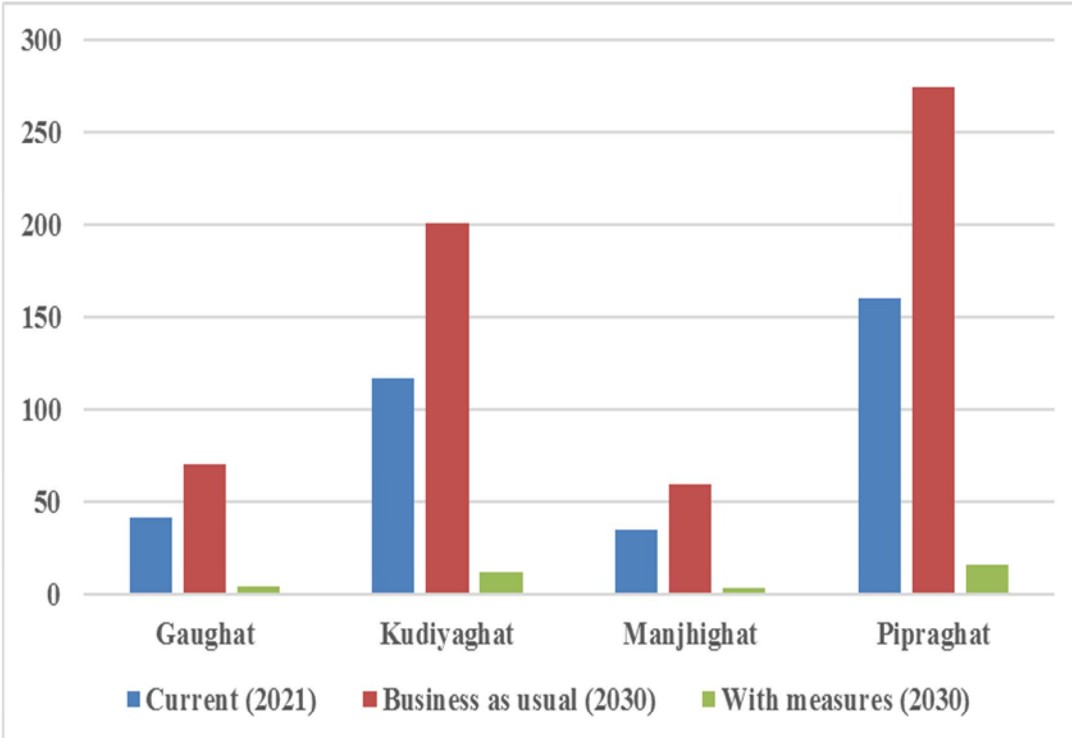
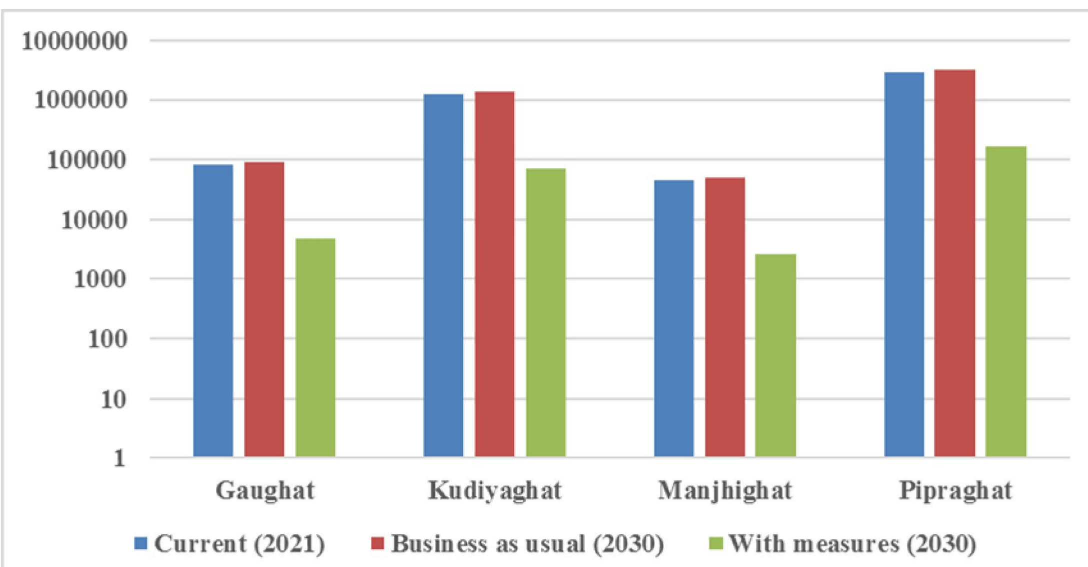
BOD (mg/L)



LOCATION

E.Coli



(CFU/100ml)
LOCATION

Fig.5 Result shows water quality parameters for the BAU scenario (2030) and With Measures Scenario (2030) (a) BOD (b) E-Coli

Fig. 5 shows results of simulated water quality parameters i.e., BOD and E-Coli under Business as usual scenario also with measures scenario for the year 2030. The BAU Scenario includes climate change + population growth + Wastewater Treatment Plant 2 WWTP (401 MLD) while With mitigation measures Scenario includes climate change + growth + 2 Wastewater Treatment Plant with increased capacity (450 MLD each = 900 MLD). A combination of anaerobic sludge blanket reactor and sequencing batch reactor (UASB-SBR) type of wastewater treatment plant is considered in this study and its treatment efficiency is estimated at 97% for BOD and 99% for fecal coliforms. Current WWTP types and specifications in Bharwara and Daulatganj is UASB (Upflow Anaerobic Sludge Blanket Digestion) Reactor and FAB (Fluidised Aerobic Bio-Reactor) Technology with capacity of 345 MLD , 56 MLD respectively, hence overall capacity of currently existing WWTPs are 401 MLD. In contrast, the WWTPs to be constructed in the future will be of UASB-SBR technology, as outlined in the current 2030 city plan. Therefore, for simplicity, UASB-SBR technology, i.e. Upflow Anaerobic Sludge Blanket and Sequential Batch Reactor technologies, are mixed up for a hybrid nature for better treatment. WWTP capacity was 401 MLD (total number 2) in the current and BAU scenarios, but 900 MLD is taken into account in the mitigation scenario for 2 WWTPs of 450 MLD each. The results of simulations using the above-mentioned two scenarios are shown in Figure 5. According to scenario 1, business as usual, climate change and population changes have a significant effect on water quality, which will deteriorate further in 2030 than now. For the year 2030 the simulated value BOD and E-Coli varies from 59.1 to 274.3 mg/L and from 51689.6 to 3241740 CFU/100Ml respectively. Consequently, due to both climate and population changes, BOD and E-Coli levels on an average will deteriorate by 71.2% and 11.4% respectively on an annual basis in 2030. Further, the effect of each individual parameter i.e. increase and global climate change is analyzed by keeping other parameters constant. The value of rainfall as a representative of climate change by year 2030 was kept constant when calculating the effect of population growth during this case. It's evident that population growth has a greater impact on both climate change and water quality degradation. The simulated water quality is significantly better compared with the scenario with measures, in which all domestic wastewater generated within the study area is collected at 100 percent sewerage collection rate, and then treated at WWTPs with 900 MLD capacity. The results shows that BOD and E-Coli varies from 3.42 to 15.85 mg/L and 2644.8 to 165870 CFU/100ml respectively. Accordingly, the concentrations of BOD and E. coli in the scenario with measures are reduced by 90.1% and 94.3%, respectively, in comparison to business-as-usual scenarios throughout the stream.

IV. CONCLUSIONS

Using different scenario analyses, this study provided a comprehensive picture of the water quality of the Gomti River in Lucknow City, India today and in the future (2030). According to simulated results, the Gomti River has moderate to severe pollution throughout the stretch when compared to the class B given by the Uttar Pradesh Pollution Control Board. Furthermore, the quality status is predicted to deteriorate by 2030 under a business as usual (BAU) scenario. In spite of this, it is expected that the standard of water quality will be significantly improved when mitigation measures are implemented as described in the local programme for water resources management. Pipraghat and Kudiyaghat in downstream areas, however, don't have desirable water quality for class B, and thus need to be addressed. In this simulation, we used two scenarios, BAU, which is Business as Usual and Mitigation measures, which tells us that the current status of water quality throughout the river is unacceptable when compared to local guidelines for class B, such as bod of 3 mg/l and E-Coli of 5000 CFU/100mm according to the UPPCB. Compared with class B water samples, BOD simulated values for 2021 (current stage) range from 34.5 to 160.2 mg/L, while E-Coli simulated values range from 46400 to 29,10000 CFU/100 mL. This clearly indicates that all water samples are surprisingly polluted. Based on the initial scenario, which is business as usual, both climate change and population change have a very significant impact on water quality. By 2030, the situation is expected to worsen even more. For the year 2030 the simulated value BOD and E-Coli varies from 59.1 to 274.3 mg/L and from 51689.6 to 3241740 CFU/100mL respectively. Here WWTP considered are 2 in no.s which are currently existing and operational with overall capacity of 401 MLD.

V. ACKNOWLEDGMENT

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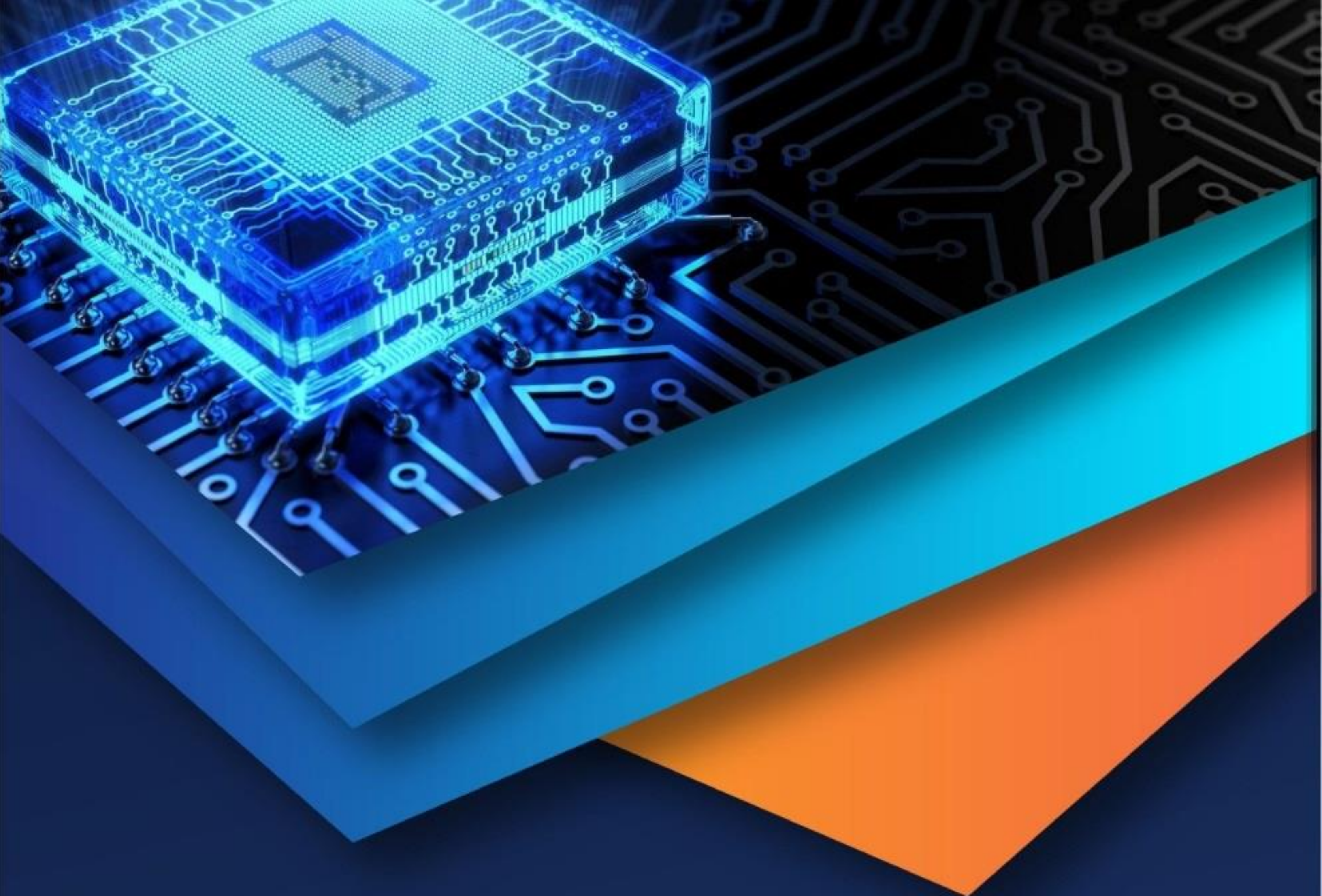

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