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Comparative Water Quality Indexing of Three Different Water Bodies in Siwan City, Bihar

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Abstract* – An effective way to gauge surface water quality is to use the Water Quality Index (WQI) model. It makes use of methods like as aggregation to reduce a large amount of water quality data to a single number. Using local water quality criteria, the WQI model has been used throughout the world to assess water quality (surface and groundwater). It's been a popular tool since the 1960s when it was first developed because of its basic structure and simplicity of use. This paper presents a comparative discussion of the most commonly used WQI models, including the different model structures. The focus of this study is on analysis of physiochemical parameters and WQI value of different type of lakes in siwan. The findings obtained from the quality analysis confirm that the water quality of Gargatwa canal Lake may not be acceptable for household uses. Disposing industrial wastewater into lake system has raised the possibilities of severe localized pollution and danger to the environment.

***Keywords* – Water Quality, Physiochemical Parameters, WQI, Siwan**

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1. INTRODUCTION

Surface and groundwater quality have been degrading for a long time as a result of natural and human-related activities. In addition to hydrological and atmospheric influences on water quality, there are also topographical and lithological variables that have a role. Land use change, increased sediment run-off, and heavy metal contamination are all examples of human activities that have a negative impact on water quality. Examples of mining and animal husbandry are also included. Recent years have seen major challenges for developing nations when it comes to improving water supply and sanitation while also preserving water quality. When faced with issues like nutrient enrichment, eutrophication, and providing water and wastewater services to an ever-increasing population, even wealthy countries have fought to preserve or enhance their water quality. Data collection and analysis are challenging tasks for managing water quality because of the sheer size of the datasets involved. The Water Quality Index (WQI) model is one of several methods available for evaluating water quality data. Aggregation functions in WQI models enable the analysis of vast, geographically and temporally changing water quality datasets to generate a single value, which is the water quality index, which reflects the level of a water body's quality. Because they are simple to use and transform complicated water quality information into a single value measure of water quality that is straightforward to comprehend, they are appealing to water management and supply organizations. For the most part, a WQI has four steps or components. To begin, the characteristics of water quality that should be studied are chosen. Second, the data on water quality are read and concentrations are transformed to a single-value dimensionless sub-index for each water quality indicator (Trikoilidou). The weighting factor for each water quality parameter is established in the third step, and the final single value water quality index is produced in the fourth step using an aggregation function using all of the sub-indices and weighting factors. WQI models vary widely in terms of model structure, parameters included and their weightings, and the techniques used for sub-indexing and aggregation. Many of these models have been created. Due to expert opinions and local standards, several WQI model components were created and are as a result, regionally unique. WQI models have uncertainty issues, as several scholars have noted. All four phases of the WQI may contribute to model uncertainty, which cannot be avoided in any mathematical model (Gikas, G.D.).

1.1 WQI model structure

The general structure of WQI models is illustrated and shows that most WQIs contain four main steps.

1) **Selection of the water quality parameters**: The evaluation will include one or more measurements of water quality.

2) **Generation of the parameter sub-indices:** The parameter concentrations are divided by

the number of sub-indices to get the final result.

3) **Assignment of the parameter weight values:** based on the importance of the characteristic to the evaluation, weights are given to it.

4) **Computation of the water quality index using an aggregation function**: Using weightings, a single overall index is derived from the sub-indices of the various parameter values. To categorize/classify water quality, a rating system based on the total index value is often employed.

Parameter selection

Selecting parameters is a crucial first stage in the WQI process, and there was wide diversity in the types and numbers of parameters used by models, as well as the rationale behind those choices. There were a number of characteristics that were frequently included, including: temperature, clarity, turbidity, pH, suspended particles, faecal coliforms (FC), dissolved oxygen (DO), biochemical oxygen demand (BOD), and nitrate nitrogen (NH3-N). The majority of the models made use of eight to eleven different variables related to water quality. The CCME index, the Roos index, and the Said index models all utilised just four user-selected parameters, whereas the Bascaron model suggested as many as twenty-six (26) parameters.

Sub-indexing

With the sub-index process, the main objective is the unitless value conversion of parameter concentrations into the parameter sub-indices. Several WQI models based their subindices on established guideline values for water quality. The CCME model and the Dojildo model removed this step and used the parameter concentrations directly rather than sub-indices to conduct the final aggregation function instead.

Parameter weighting

The parameter weight value is typically calculated using the relative significance of the water quality parameter and/or applicable water quality standards. When calculating parameter weights, most WQI models used uneven weighing methods, which resulted in a total weight of 1. They all employed uneven weighting but it was an integer and the sum was higher than one for the weights used in Horton and Bascaron/Ameida. All parameters were given same weight in the Oregon model, which employed an equal-weighting method. The CCME, Smith, and Dojildo index models, on the other hand, don't use weights to estimate the final score.

2. LITERATURE REVIEW

Dohare et al. (2014) researchers in Indore, India, examined the quality of groundwater in several wards and concluded that regular assessments of water quality parameters and water quality management techniques are needed in this region to ensure the sustainability of water resources. After conducting an analysis, it was found that most water quality indicators were greater during the rainy season.

Eugene et al. (2014) The water quality index was used to evaluate the ground water quality of dug wells in the west Jaintia Hills district of Meghalaya, India, and the results showed that, despite being acidic and high in iron content, the water samples fell under good water characteristics when other parameters are taken into account.

Gyampo et al. (2014) studied Ghana's Bunpkurugu-Yunyo district's drinking water quality and found that water quality varies dramatically depending on the weather, with 94.7 percent of samples falling into the "Excellent" and "Good" categories during the rainy season and about 89.5 percent falling into the "Poor" and "Unsuitable" categories during the dry season.

Umar et al. (2014) Pakistan's semi-arid Quetta and Sorange Intermontane Valleys were studied for surface and subsurface water quality. They propose scientific study in the hard rock formations exposed in the region, such as the Chiltan, Parh, Dungan, Dhok Pathan, and Soan formations, to meet future water demands. Modern sewage systems are also required to minimise human impacts, particularly in Quetta's densely populated core district.

Sharma et al. (2013) Studied surface and subsurface water statistics in Rajasthan's Alwar district of Rajgarh. They calculated the mean, standard deviation, mode, median, and correlation coefficients to determine the quality of the surface and subterranean water. Hand pump water, they claim, had greater levels of nitrate, total hardness, calcium hardness, magnesium hardness, and alkalinity than acceptable limits, whereas in pond water, only BOD & COD were found to be higher.

Chowdhury et. al. (2012) It was determined that, in Bangladesh, along the Faridpur-Barisal route, the WQI values are generally low and extremely poor in condition, with just a few being considered decent. Of the water stations in Bangladesh, only one has an exceptional WQI value for human consumption and other purposes. Results showed that even though most water bodies had WQI levels that were unacceptable, they could still be utilised for domestic and household purposes after they were purified.

Dandwate (2012). The physico-chemical characteristics of ground water in Kopargaon Area, Maharastra State, India were examined before and during the monsoon season and discovered that water quality parameters differed significantly across samples. All of the water samples were alkaline, with TDS levels that were somewhat higher than ideal. Some water samples were deemed unsuitable for drinking due to excessive levels of EC (WHO criteria 11), TH, and chloride. After appropriate purification, it was suggested that you utilise the water from these locations.

3. MATERIAL AND METHODS

Sampling and Analysis

Three distinct sites in Siwan were used to collect samples, including Manir Gadha Lake, Gargatwa Canal Lake, and Pokhra Lake. It was necessary to use the usual sample method, and the results included the evaluation of parameters such as pH and E Coli as well as BOD, COD, TDS, TP, and TN. Table-1 displays the different parameters' analysis techniques.

Table 1: Different parameters with their different values

S. No.	Parameters	Technique used	Indian	WHO	EPA
1	pH	pH meter	6.5 – 9.5	6.5 – 9.5	6.5 – 9.5
2	BOD mg/l	Incubation followed by titration	3	6	5
3	COD mg/l	COD digester	-	10	40
4	TN mg/l	UV Spectrophoto meter	45	3	.5
5	TP mg/l	Digestion and colorimeter	-	-	.124
6	TDS mg/l	Gravimetric method	500	500	-
7	E coli N/100 ml	Membrane filtration technique	-	-	1000

RESULTS AND DISCUSSION

Table 2 provides an overview of lake water quality parameter values. The greater the parameter values, the more pollution there is in the watershed and lake around that parameter. Figures 1 to 7 illustrate the concentration levels of the seven different parameters in the lakes that were studied.

Table 2: Water Quality Parameters of Different Lakes

Parameters	Manir Gadha	Gargatwa canal	Pokhra
pH pH	7	6	6.2
BOD mg/l	14	20	12
COD mg/l	19	58	34
TDS mg/l	350	386	568
TN mg/l	1.14	1.6	1.4
TP mg/lmg/l	0.02	0.02	0.03
Ecoli,N/100ml/100ml	300	136	900

pH

The pH readings in the chosen lakes are shown in a graph along with the maximum pH that may be tolerated. This figure (1) displays the pH levels in three lakes.

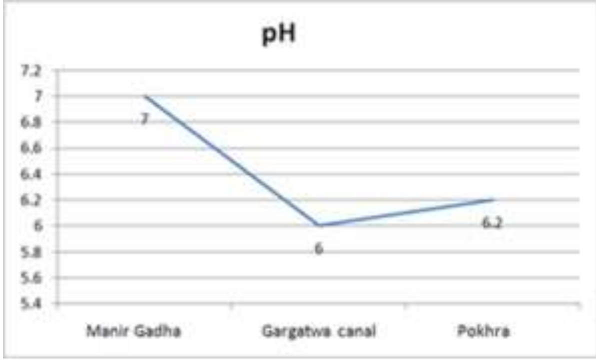

Figure 1: Variation of pH in three Lakes

Bio-Chemical Oxygen Demand (BOD)

BOD is a measure of the water's organic contamination level, and it has an impact on the level of dissolved oxygen in the solution. The amount of dissolved oxygen in water has a significant impact on aquatic creature development. Some fish species can withstand 3mg/l, but according to recent research, it is the minimal need for tropical freshwater fish. The maximum allowable BOD concentration in Indian surface water is three milligrammes per litre (mg/l). According to the findings of this research, the BOD concentrations in all lakes are higher than the allowable level, indicating that water should only be utilised for agriculture or industrial purposes. The presence of BOD in various lakes is shown in the Figure 2.

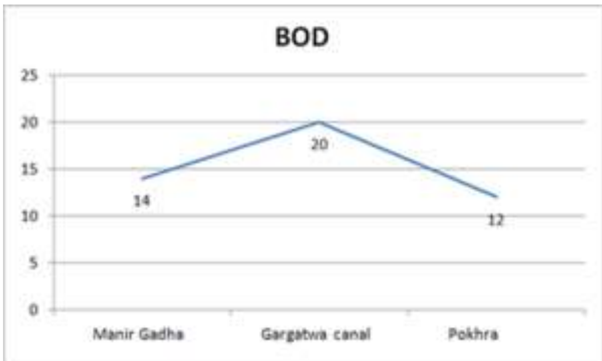

Figure 2: The Values of BOD in the Lakes

Chemical Oxygen Demand (COD)

When it comes to organic matter in water, the COD test evaluates how easily it may be oxidised. A healthy lake environment is also indicated by Chemical Oxygen Demand (COD), which is similar to BOD. The concentrations of COD in the three lakes are shown in the Figure 3.

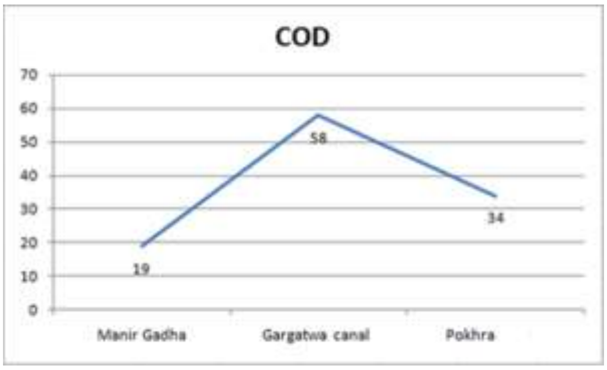

Figure 3: Variation of COD in three Lakes

Total Dissolved Solids (TDS)

Total dissolved solids in the lake have risen as a result of runoff, sewage discharge, and industrial effluents. According to the results of this investigation, the TDS concentration varies from 350 to 568 mg/l. Presence of TDS in various lakes is shown in the Figure 4.

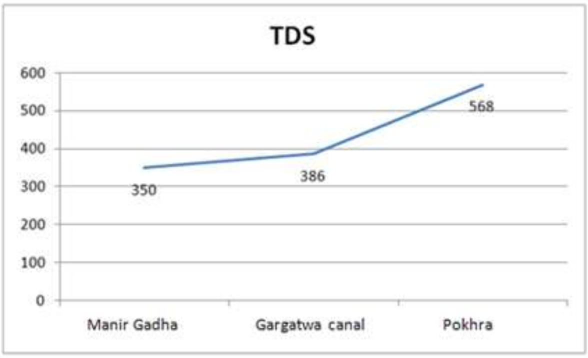

Figure 4: Values of TDS in the Lakes

Total Nitrogen (TN)

Lake water nitrogen has been shown to be one of the most important elements that contribute to eutrophication. Sewage treatment plant effluents, urban storm water runoff, and sediments are all sources of nitrogen that may make their way into lakes. The US EPA established recommendations to help identify at-risk water bodies and minimize eutrophication's impact. These guidelines suggest a nitrogen acceptable limit of 0.3 mg/l for streams and 0.1 mg/l for lakes. In the current research, the lowest TN value was found to be 1.14 mg/l in Manir Gadha Lake, while the highest was found to be 1.6 mg/l in Gargatwa Lake. It makes sense, therefore, that some of the lake waters being studied are more suited for industrial and agricultural use than for human consumption in the conventional sense. The concentrations of total Nitrogen in the selected three lakes are shown in the Figure 5.

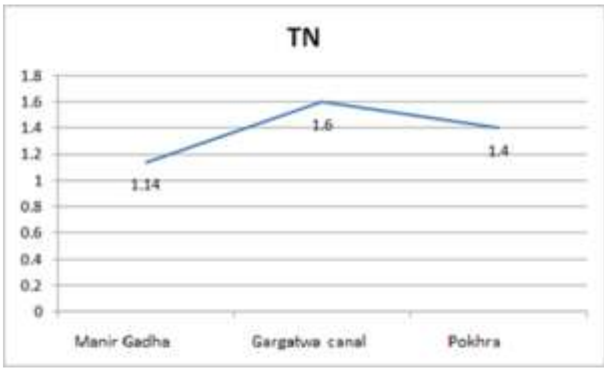

Figure 5: Concentration of Total Nitrogen in the Lakes

Total Phosphorus (TP)

There is a limit to the development of algae in lakes due to phosphorus availability. Phosphorus is found in fertilisers, animal and human waste, and detergents. When it comes to phosphorus, reducing the amount of phosphorus that gets into lakes is a common goal. SRP is a kind of dissolved phosphorus that algae may easily use. Dissolved phosphorus and particulate phosphorus are both terms that describe the same thing. Lake eutrophication may occur when total phosphorus concentrations (TP) reach 0.03 mg/l. According to the results, the toxic concentration (TP) ranged from 0.02 to 0.03 mg/l. The total phosphorus in various lake water samples is determined in the laboratory and the values are shown in the figure 6.

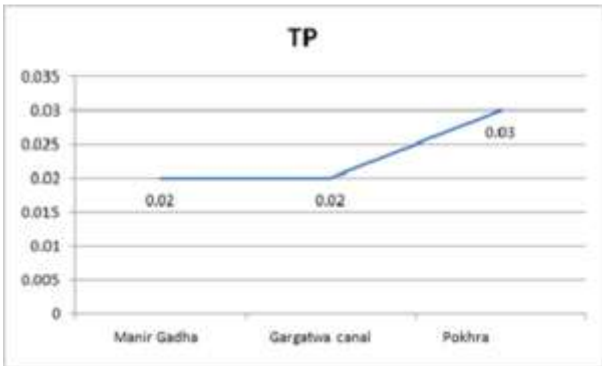

Figure 6: Concentration of Total phosphorus in the Lakes

E. coli

There is an abundance of E. coli (Escherichia coli) in the water, which suggests recent, heavy contamination from human and animal feces. These bacteria are found in high concentrations in excrement, both human and animal. This E-coli finding confirms the presence of pathogens. Presence of E coli in various lakes is shown in the Figure 7.

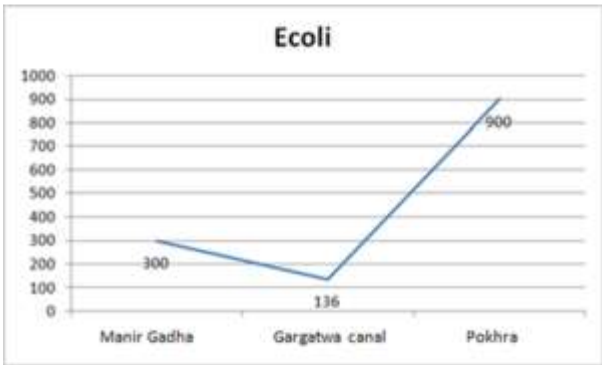

Figure 7: Concentration of e coli in the Lakes

WATER QUALITY INDEX (WQI)

According to this research, the World Health Organization (WHO), Bureau of Indian Criteria (BIS), and Environmental Protection Agency (EPA) suggested surface water quality standards for calculating WQI.

Table 3 displays the index status of the lakes. For each of the chosen lakes, an index of water quality was calculated, and the lakes' conditions were evaluated. Table-4 displays the findings. The Manir Gadha lake's condition has been determined to be good. It has been determined that the condition of Gargatwa Canal Lake and Pokhra Lake are satisfactory.

Table 3: Water Quality Index (WQI) and status of water quality

Water Quality Index	Water quality status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
>100	Unsuitable for drinking

Table 4: WQI Value and the Status of the Lakes under Study

Lakes	WQI	Status
Manir Gadha lake	21.0521.05	Excellent
Gargatwa canal	26.87 26.87	Good
Pokhra	21.0721.07	Excellent

4. CONCLUSION

A water quality assessment has shown that Gargatwa canal Lake's water isn't appropriate for household use, according to the findings. Wastewater disposal into lakes has raised the likelihood of localised contamination and environmental hazard. The current investigation of the health of the lakes in the Siwan area will aid in determining the level of treatment necessary for future water treatment facilities. The Gargatwa canal Lake's pH, COD, and TDS concentrations are all well over the recommended standards. The lake's pollution level is rising rapidly and may become a major issue if it is not closely monitored and managed. Although certain criteria are within acceptable ranges, the results of this research show that surface water quality in Siwan's main lakes poses a danger to the environment. Rapid urbanisation and industrialisation may cause water contamination to worsen in the not too distant future, according to scientists. Wasteful consumption and pollution have a negative impact on human well-being.

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