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Assessment of River Water Quality Using Weighted Arithmetic Water Quality Index in the River Kabini at Nanjangud, Karnataka, India

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Abstract Two sampling stations N1 and N4a are selected on the River Kabini stretch at Nanjangud, Karnataka, India. In this research, the assessment of the 20 year-data (2000 – 2019) indicate Water Quality Index of 75.3 and 95.3 at stations N1 and N4a respectively, which categorizes the water quality of the River Kabini at this stretch as "very poor". This assessment is useful to policymakers in deciding future course of action to protect the river from anthropogenic deterioration. Also, statistical analysis in the form of t-test for the 17 – year, 3 – year and 20 – year period indicates the 'p' value (p = 0.29, 0.21 and 0.22) respectively, which is greater than the significant value 0.05. Similarly, the critical value during the 17 – year, 3 – year and 20 – year period is 2.06, 4.30 and 2.04 respectively and is also greater than measured t statistics values of -1.08, -1.79 and -1.26 respectively. This reveals that the difference in WQI of N1 and N4a monitoring stations is insignificant.

Keywords: *water quality index, t-test, t statistics*

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1. Introduction

Rivers are an indomitable source of water for various anthropogenic and industrial developments. However, in the last few decades, there has been a stupendous demand for fresh water due to an explosion of population and accelerated growth in industrialization. The result is the excessive dumping of untreated domestic, agricultural and industrial wastes into rivers beyond the rivers' self-purification capabilities, thereby making it a hub for disease causing microbes and a dump-yard for solid and liquid wastes. Hence, it is imperative for policy makers to assess and manage water quality of rivers and protect from further deterioration and in this direction, the Water Quality Index (WQI) serves as an effective tool to communicate information on the quality of water to the concerned policy makers.

Water Quality Index is a means to summarize the large amounts of water quality data into simple terms for determining the level of water quality in a given study area. Based on the water quality index data, policy makers can be alerted about the underlying need for interventions such as installation and maintenance of wastewater treatment plant to further prevent the deterioration of surface water quality. The main objective of this study is to assess the water quality of the Kabini River at Nanjangud, Karnataka in terms of water quality index for a period of 20 years (2000 – 2019). WQI is calculated using a view to assess the degree of pollution of the river Kabini and its suitability for human, agricultural and industrial usages.

2. Materials and Methodology

2.1. Study Area

River Kabini, a lifeline to the people of Nanjangud, is a tributary of the River Cauvery and flows along Nanjangud town, situated 20 km towards the south of Mysuru city. Nanjangud is a pilgrimage town and many industries are located in the vicinity of the banks of this river. The study area is shown in the location map in Figure 1.

2.2. Monitoring Stations

To assess the pollution load from various natural and anthropogenic sources, different sampling stations have been located to monitor the water quality in the River Kabini. The monitoring stations are shown in Figure 2. Station N1 is an upstream river station located near the Karnataka Industrial Area Development Board (KIADB) water intake point. Several industries are located near this station. Station N4a is located near the bathing ghat in the River Kabini. Bathing and washing of clothes are prominent along the right bank in a stretch of about 250 to 300 m in length.

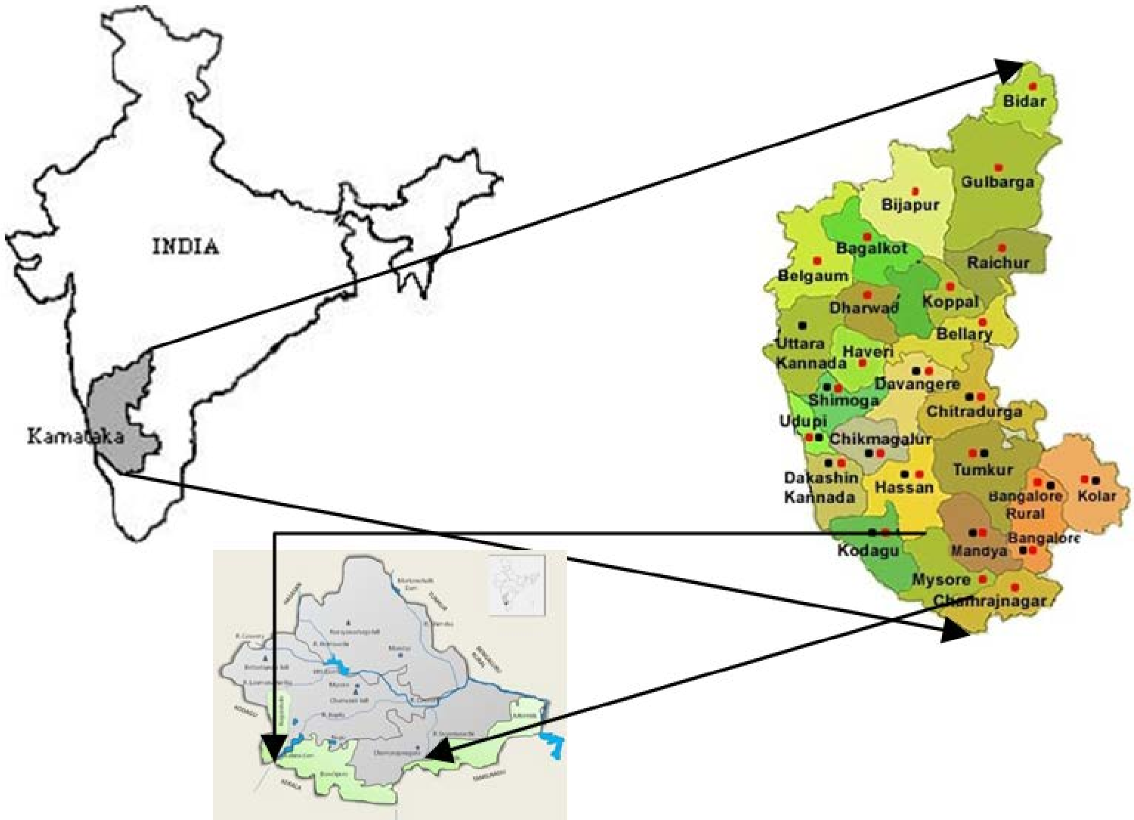

Figure 1. The River Kabini in the Study Area [1,2]

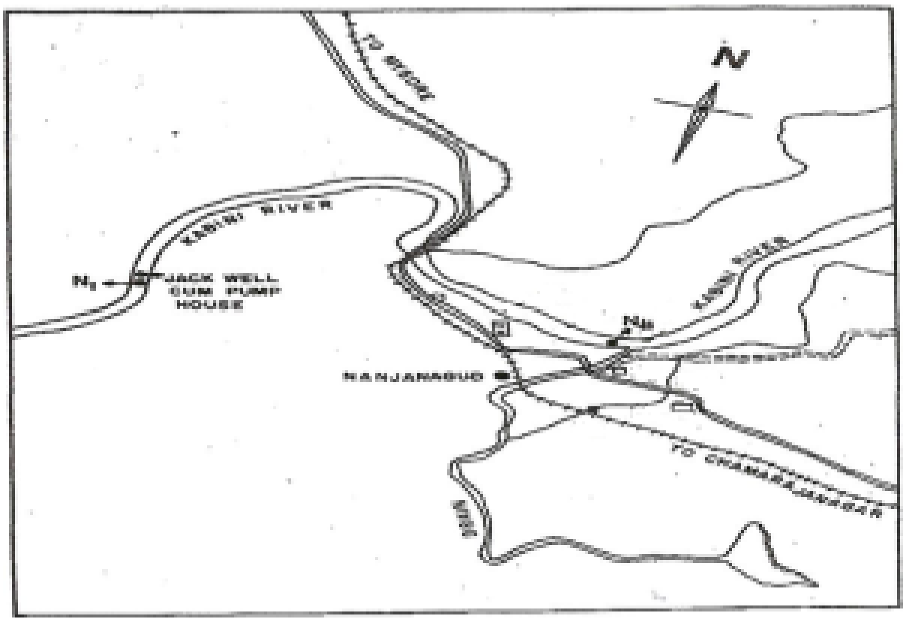

Figure 2. Location of Monitoring Stations on the River Kabini Stretch at Nanjangud [3]

2.3. Data Collection

The water quality monitoring data include the 20-year data (2000 – 2019) for the important water quality parameters such as pH, conductivity, DO, BOD, TC and FC. 13-year (2000 – 2012) data are obtained from the nationwide River Water Quality Monitoring Project, which was initiated by the National River Conservation Directorate (NRCD), Ministry of Environment and Forests, Government of India, under its National River Conservation Project (NRCP), [4] and the 7-year (2013 – 2019) data is from the Central Pollution Control Board [5].

2.4. Weighted Arithmetic Water Quality Index

The Weighted Arithmetic Water Quality Index method is a rating reflecting the composite influence of different water quality parameters [6]. It classifies water quality according to the degree of purity and provides a comprehensive picture of the quality of surface /ground water by using the most commonly measured water quality variables. Researchers [6-12] have used this technique extensively. The steps in calculating the Weighted Arithmetic Water Quality Index as given by researchers [11,12] are as follows:

- The quality rating scale (Q_i) for each parameter is calculated using the formula

$$Q_i = \left[\frac{V_a - V_i}{V_s - V_i}\right] X100 \quad (1)$$

Where V_a = Actual value of water quality parameter obtained from the data
V_i = Ideal value of water quality parameter (pH=7 and DO=14.6 mg/L, all other parameters, it is zero [12]
V_s= Recommended standard value of the parameter as given in Table 1

- The proportionality constant K is calculated as

$$K = \frac{1}{\sum\left(\frac{1}{V_s}\right)} \quad (2)$$

- The unit weight for each parameter is calculated using the equation

$$W_i = \frac{K}{V_s} \quad (3)$$

- The Water Quality Index is calculated as

$$WQI = \frac{\sum Q_i W_i}{\sum W_i} \quad (4)$$

Table 1. Standard River Water Quality Criteria [5]

Parameter	Standard Value
pH	8.5
Conductivity (μmhos/cm)	2250
DO (mg/L)	4
BOD (mg/L)	3
TC (MPN/100mL)	5000
FC (MPN/100mL)	2500

The rating of water quality according to the Weighted Arithmetic WQI as calculated in equation (4) is shown in Table 2.

Table 2. WQI Range, Status and Possible Usage of Water [11,12]

WQI Range	Water Quality Status	Possible Usage of Water
0 – 25	Excellent	Drinking, Irrigation and Industrial
26 – 50	Good	Domestic, Irrigation and Industrial
51 – 75	Poor	Irrigation and Industrial
76 – 100	Very poor	Irrigation
> 100	Unsuitable for drinking	Proper treatment required before use

2.5. Statistical Data Analysis

To determine if there are any significant differences in WQI for the two selected stations (N1 and N4a), paired t-test at 0.05 significant level and standard deviations are computed using Microsoft Excel 2019.

3. Results and Discussion

The WQI for the two monitoring stations N1 and N4a has been shown in Figure 3. It is observed that in the 17-year period (2000 – 2016), the WQI for stations N1 and N4a are 76.33 and 95.41 respectively and is categorized as very poor, used for irrigation. The worrisome factor is that the station N1 is a water intake point. Certainly, the WQI is greater at station N4a as it is located near the bathing ghat, where bathing and washing of clothes are prominent in this stretch. But the river water at both these stations is highly polluted because the domestic wastewater freely enters the river due to a lack of wastewater treatment plant and the construction of Waste Stabilization Pond has been stopped [13], which indicates there is an immediate need to have the treatment plant operational to prevent the discharge of domestic wastewater in the river. In the next 3-year period (2017 – 2019), the WQI at station N1 is 69.46 and it has marginally improved to "poor" category and water can be used for irrigation and industry. The WQI at station N4a has also improved from 95.41 to 88.03 in the 3-year period (2017 – 2019) because the wastewater treatment plant is commissioned in 2017 and is functional [14]. It clearly stresses the need for interventions in the form of wastewater treatment plants and their operation and maintenance to prevent wastewater from polluting the river water. However, the data of the total 20 year-period (2000 – 2019) indicate WQI of 75.3 and 95.3 at stations N1 and N4a respectively, which categorizes the water quality of the River Kabini at this stretch as "very poor". A marginal improvement of WQI is observed in the 20 year-period over the 17-year period as the wastewater treatment plant is functional for the last 3-year period.

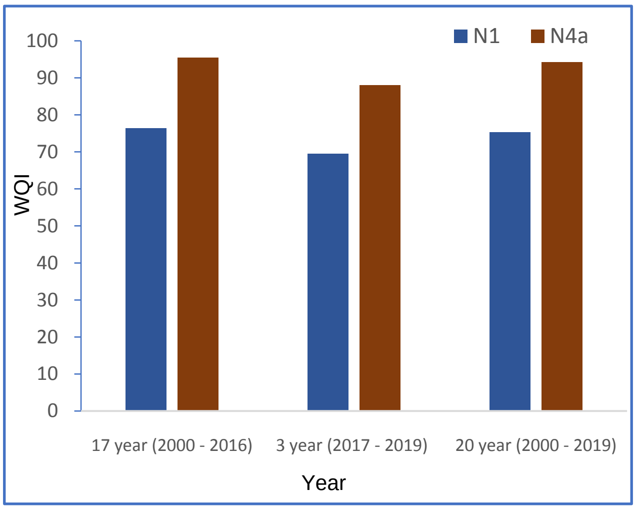

Figure 3. WQI of Monitoring Stations on the River Kabini at Nanjangud, Karnataka

The Figure 4 shows the WQI along with standard deviation error bars of the monitoring stations on the River Kabini at Nanjangud, Karnataka. From the figure, it is observed that the standard deviation errors bars overlap quite a bit in the 17-year and 20-year period, which is a clue that the difference is not statistically significant. Further in the 3-year period, standard deviation error bars do not overlap and hence the difference may be significant. However, the standard deviation is not a statistical test, but a measure of variability. To assess the statistical significance, the sample size must also be taken into account and statistical tests have to be conducted. In this connection, the data is subjected to two-sample t-test, assuming unequal variance for the 3 time periods (17-year, 3-year and 20-year).

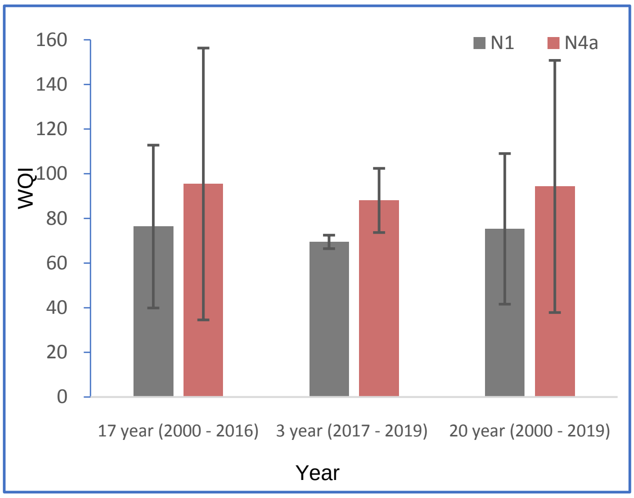

Figure 4. WQI with Standard Deviation Error Bars of Monitoring Stations on the River Kabini at Nanjangud, Karnataka

t-test is a statistical test to compare the means between two groups and in this research, it is used as a hypothesis testing to determine whether two monitoring stations are different from one another. The null and alternate hypothesis is framed accordingly:

- Null hypothesis: There is no significant difference in WQI between two monitoring stations ($p_{computed} > 0.05$)
- Alternate hypothesis: There is a significant difference in WQI between two monitoring stations ($p_{computed} < 0.05$)

Computation of paired *t*-test is shown in Table 3, Table 4, Table 5 respectively. The results show that for 17 – year, 3 – year and 20 – year period, ‘p’ values are 0.29, 0.21 and 0.22 respectively and is greater than the significant value 0.05. Similarly, the critical value during the 17 – year, 3 – year and 20 – year period is 2.06, 4.30 and 2.04 respectively and is also greater than the measured *t statistics* values of -1.08, -1.79 and -1.26 respectively. This reveals that the difference in WQI of N1 and N4a monitoring stations is insignificant and null hypothesis is accepted. Similar study of t-test on the difference in WQI of summer and winter seasons is studied by [15].

Table 3. t-Test -Two-Sample Assuming Unequal Variances for the 17-Year Period (2000-2016)

Monitoring Stations	N1	N4a
Mean	*76.33*	*95.41*
Variance	*1413.75*	*3940.18*
t Stat	*-1.08*	
P(T<=t) two-tail	*0.29*	
t Critical two-tail	*2.06*	

Table 4. t-Test -Two-Sample Assuming Unequal Variances for the 3-Year Period (2017-2019)

Monitoring Stations	*N1*	*N4a*
Mean	69.46	88.03
Variance	13.63	309.91
t Stat	-1.79	
P(T<=t) two-tail	0.21	
t Critical two-tail	4.30	

Table 5. t-Test-Two-Sample Assuming Unequal Variances for the 20-Year Period (2000-2019)

Monitoring Stations	*N1*	*N4a*
Mean	75.30	94.30
Variance	1198.29	3357.97
t Stat	-1.26	
P(T<=t) two-tail	0.22	
t Critical two-tail	2.04	

4. Conclusions

This study clearly indicates the water quality of the River Kabini at this stretch is “very poor” and can be used only for irrigation. The 20 year-data (2000 – 2019) show the WQI of 75.3 and 95.3 at stations N1 and N4a respectively. Application of Water Quality Index in this study has been found useful in assessing the overall quality of water and to get proper judgment on the quality of the water. Also, the computation of paired t-test shows the difference in WQI of N1 and N4a monitoring stations is not significant. This method is very systematic and gives comparative evaluation of the water quality of sampling stations for policy makers to take actions in the form of installation and maintenance of wastewater treatment systems.

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References

[1] http://www.districtsofindia.com/Karnataka/statedistrict.aspx.
[2] http://www.mysorenature.org/mysorenature.
[3] *NRCD Report, Department of Environmental Engineering, Sri Jayachamarajendra College of Engineering, Mysuru*. 2000 – 2012.
[4] *River Water Quality Monitoring Project Report, Department of Environmental Engineering, Sri Jayachamarajendra College of Engineering, Mysuru, Sponsored by National River Conservation Directorate, MoEF, Govt of India*, 2008.
[5] https://cpcb.nic.in/nwmp-data/.
[6] Puri P. J., Yenkie M. K. N., Rana D. B and Meshram S.U., “*Application of water quality index (WQI) for the assessment of surface water quality (Ambazari Lake)*”, *European Journal of Experimental Biology*, 5(2). 37-52. 2015
[7] Ramakrishnaiah C. R., Sadashivaiah C and Ranganna G., “*Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State, India*”, *E-Journal of Chemistry*, 6(2), 523-530. 2009.

[8] Yisa J. and Jimoh T., *"Analytical Studies on Water Quality Index of River Landzu", American Journal of Applied Sciences,* 7(4). 453-458. 2010.

[9] *Tyagi S., Sharma B., Singh P., Dobhal R., "Water Quality Assessment in Terms of Water Quality Index", American Journal of Water Resources,* 1(3). 34-38. 2013.

[10] Akter T, Jhohura F. T., Akter F., Chowdhury T. R., Mistry S. K., Dey D., Barua M. K., Islam Md A and Rahman M.., *"Water Quality Index for Measuring Drinking Water Quality in Rural Bangladesh: A Cross-sectional Study", Journal of Health, Population and Nutrition*, 35(4).1-12. 2016.

[11] Chandra D. S., Asadi S. S and Raju M. V. S., *"Estimation of Water Quality Index by Weighted Arithmetic Water Quality Index Method: A Model Study", International Journal of Civil Engineering and Technology (IJCIET),* 8(4). 1215-1222. 2017.

[12] Hossen M A., Rafiq F., Kabir M. A., Morshed M. G., *"Assessment of Water Quality Scenario of Karnaphuli River in Terms of Water Quality Index, South-Eastern Bangladesh", American Journal of Water Resources,* 7(3). 106-110. 2019.

[13] Central Pollution Control Board, Annual Report, *"Performance Evaluation of Sewage Treatment Plants in India Funded under NRCD".* 2013.

[14] Central Pollution Control Board Report, *"National Inventory of Sewage Treatment Plant"*, 2021.

[15] Bui Y and Lodhi M. S., *"Assessment of Spring Water Quality using Water Quality Index Method – Study from Upper Subansiri District, Arunachal Pradesh, India", International Journal of Science, Environment and Technology,* 9(6). 898-908. 2020.