DETERMINING WATER QUALITY INDEX FOR THE EVALUATION OF WATER QUALITY OF KALI RIVER, KARNATAKA

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Abstract: The systematic study has been a carry over to assess the water quality index (WQI) of Kali River in and around the Uttara Kannada district. Water samples are collected from six stations along the stretch of Kali river. Considering the physical, chemical and biological parameters like Temperature, pH, Turbidity, Total Hardness (TH), Total Dissolved Solids (TDS), Total Alkalinity (TA), Total Acidity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Calcium (Ca), Magnesium (Mg), Chloride (Cl), Nitrates (NO_3), Sulphate (SO_4), Iron (Fe). The observed values of the parameters were compared with the standard values recommended by the World Health Organization (WHO) and Bureau of Indian Standards (BIS).

Keywords : Kali river , River pollution, Physico-chemical parameters, Water quality index.

I. INTRODUCTION

Water pollution caused by increased industrialization and urbanization is considered to be the major problem which is faced by the mankind in India. The increase of water pollution in rivers results in decrease of DO concentration and increase of toxic chemicals concentration which ends up in death of aquatic animals like fishes which are further consumed by humans, animals their health. Hence it becomes important to determine the status of Rivers water quality before actual utilization for different purpose. Many rivers, both east-flowing and west-flowing are found within the boundaries of Karnataka. Most of the rivers originate in the Western Ghats and runs towards the Eastern side of the state. These are some of the largest rivers in the state and drain towards the Bay of Bengal. Therefore almost all the major east-flowing rivers are inter-state rivers. The rivers in the Western Ghats that generally flow westward meet the Arabian Sea after a short run varying from 50 kilometres to 300 kilometers. These rivers are very steep in the middle. As it reaches the sea, they have relatively flat gradients and a mild floodplain.

The River Kali which is flowing through Uttara Kannada district in the state of Karnataka in the country of India. Its birthplace is near Diggi, a small village in Uttara Kannada district. The river flows 184 kilometres before joining the Arabian Sea. The river is the lifeline to some 4,00,000 people in the Uttara Kannada district and it supports the livelihoods of ten thousands of people including fishermen on the coast of Kara. There are many dams built across the river for the generation of power. One of the important dams build across Kali River is the ‘Supa dam at Ganeshgudi’. The length of the river is 184 kilometres. The average discharge of the river is 152m^3/sec. This river flows through Dandeli, Joida, and Karwar taluks.

II. LETERATURE SURVEY

a) **Rajkumar V. Raikar, Sneha, M.K,** May **2012**, studied the **"Water quality analysis of Badravathi taluk using GIS – a case study". :** The paper presents a case study on the water quality analysis carried out at the Bhadravathi Taluk, Karnataka, India. The physico-chemical parameters were considered in the analysis. Geographic information system (GIS) is used to represent the spatial distribution of the parameters and raster maps were created. The analysis was carried for pre-monsoon and post-monsoon seasons. The water samples were collected by grab and composite sampling method during pre and post-mansoon season of the year 2010-2011 and GPS survey was done.

b) **Prabhavathi K., Ramana C. V., Rami Reddy N., 2015,** studied the **"Physico-chemical analysis of Thunga Bhadra river in and around Kurnool town".** : Water samples from five sampling stations were collected during premonsoon and post-monsoon seasons in the year April 2013and March-2014 and analyzed for physicochemical parameters like pH, temperature, conductivity, turbidity, total hardness, total alkalinity, Dissolved Oxygen, Calcium, Magnesium, Chloride, Nitrates, Sulphate, fluoride. The observed values of different physicochemical parameters were compared with standard values recommended by world health organization(WHO). The study revealed that due to discharge of untreated sewage into the Tungabhadra, the water quality of Tungabhadra has been severely deteriorated and the portable nature of water is being lost.

c) **Rajnee Naithani, Dr. I. P. Pande,** December **2015**, studied the **"Comparative analysis of the trends in river water quality parameters: A case study of Yamuna River".**: The Delhi segment is the most polluted as the river gets severely affected by the impediments of industrialization, urbanization and agricultural advances. In view of the social, economic, religious and cultural significance of the Yamuna River and progressive degradation of its water quality, numerous conservation campaigns and the major cleaning up projects like the Yamuna Action Plan (YAP) I, II and III were undertaken for its restoration and conservation.

d) **Suresh B., June 2015,** studied the **"Appraisal of distinctiveness of physico-chemical parameters in Tungabhadra river near Harihar, Karnataka (India)".:** Tungabhadra has a drainage basin of 71,417 sq. km out of which 57,671 sq. km lies in the Karnataka state. Tungabhadra covers a distance of 293km in the state. This river can be considered as lifeline of this area, which fulfills the needs of hundreds of villages, situated along the banks of the river. Due to anthropogenic activities, rapid industrial growth, domestic and agricultural activities of the region, the river water is being polluted, which is the case with almost all major rivers of the country. The study revealed that there is an indication of pollution in the river and hence preventive measures are required to avoid further deterioration of the river water quality.

III. STUDY AREA

The Kali River origins in the village of Diggi of Joida Taluka, 15°14′56″N 74°17′58″E, in the Western Ghats to join the Arabian Sea 14°50'32"N 74°7'23"E near the town of Karwar. The river flows entirely through the district of Uttara Kannada. The River is about 184 kilometres long. There were six sampling stations such as Ganeshgudi, Dandeli, Shivapura Bridge, Kaiga, Kadra, Kerwadi. Those stations are described below Table 3.1.

Table 1. List of areas were selected for this present study

SL No.	Sites	Sample	Location	Latitude (N)	Longitude (E)
1	Station-1	S1	Ganeshgudi, down stream of Supa dam	15º 16' 35.49"	74º 32' 9.10"
2	Station-2	S2	Dandeli, Dandelappa temple	15º 14' 31.56"	74º 37' 26.52"
3	Station-3	S3	Shivapura Bridge, up stream of Kodasalli dam	14º 58' 58.39"	74º 34' 17.56"
4	Station-4	S4	Kaiga Nuclear power plant, Downstream side	14º 51' 44.88"	74º 24' 31.48"
5	Station-5	S5	Kadra , Bus stand	14º 54' 14.91"	74º 20' 4.86"
6	Station-6	S6	Ulga – Kerwadi	14º 52' 57.10"	74º 15' 9.32"

Figure 1: Sampling stations of Kali river selected for the present study

International Journal in IT & Engineering (IJITE)
Volume 7 Issue 7, July 2019 ISSN: 2321-1776 Impact Factor: 6.493
Journal Homepage: http://ijmr.net.in, Email: irjmss@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal

IV. METHODOLOGY

4.1 Sampling: Water samples from different sampling points were collected for pre-mansoon season of 2019. Water samples were collected in each station at 15cm depth in the river. Using grab sampling method in clean and dry polythene bottles. To avoid the direct sun light all collected samples are kept in black bag. Temperature was measured in the sampling sites by Thermometer. Samples were filtered before chemical testing by filter paper. Distilled water used for testing. All laboratory analysis is done using the standard methods.

4.2 Some standad methods of testing

a) Determination of pH of river water by electrometric method (Using Digital pH meter), According to IS 3025 Part-11.
b) Determination of turbidity of river water by Nephlometry (According to IS 3025Part 10)
c) Determination of Alkalinity, Acidity, Hardness, Calcium, Magnesium, Chlorides of river water by titrimetric method (According to IS 10500:1991).
d) Determination of TDS, Sulphates, DO, BOD, Iron of river water (According to IS 3025 Part- 16, 24, 38, 44, 53).
e) Determination of COD by APHA 23rd Edition, 5220- B.
f) Determination of Nitrates by APHA 23rd Edition 4500, NO3 B.

4.3 **Drinking Water Quality Standards:** The observed values of the collected samples after laboratory testing, results of the parameters were compared with the standard values recommended by the World Health Organization (WHO) and Beaurau of Indian Standards (BIS).

4.4 Water Quality Index (WQI): Water quality index (WQI) provides information about water quality in a single value. WQI is commonly used for the detection and evaluation of water pollution and may be defined as a reflection of the composite influence of different quality parameters on the overall quality of water. WQI indices are broadly classified into two types, they are physicochemical and biological indices. The physicochemical indices are based on the values of various physicochemical parameters in a water sample, while biological indices are derived from the biological information. Here an attempt has been made to calculate the water quality index of the study area based on hydrochemical data.

WQI Calculation: Calculation of WQI was carried out in this work by Horton's method. The WQI is calculated by using the expression given in Equation (1).

$$WQI = \Sigma q_n W_n / \Sigma W_n \quad \text{.....(1)}$$

Where, q_n = Quality rating of nth water quality parameter.
W_n= Unit weight of nth water quality parameter.

Quality rating (q_n): The quality rating (q_n) is calculated using the expression given in Equation (2).

$$q_n = [(V_n - V_{id}) / (S_n - V_{id})] \times 100 \quad \text{.....(2)}$$

Where,
V_n = Estimated value of nth water quality parameter at a given sample location.
V_{id} = Ideal value for an nth parameter in pure water.
(V_{id} for pH = 7 and 0 for all other parameters)
S_n = Standard permissible value of nth water quality parameter.

Unit weight: The unit weight (W_n) is calculated using the expression given in Equation (3).

$$W_n = k / S_n \quad \text{.....(3)}$$

Where,

S_n = Standard permissible value of n th water quality parameter.
k = Constant of proportionality and it is calculated by using the expression given Equation (4).
$k = [1 / (\Sigma 1/ S_{n=1,2,..n})]$
….. (4).

Status of Water Quality Index : The ranges of water quality index, the corresponding status of water quality and their possible use are listed in below Table 4.2.

Table 2. WQI and corresponding water quality status

Sl. No	WQI	Status	Possible usages
1	0 – 25	Excellent	Drinking, Irrigation and Industrial
2	25 – 50	Good	Domestic, Irrigation and Industrial
3	51 – 75	Fair	Irrigation and Industrial
4	76 – 100	Poor	Irrigation
5	101 – 150	Very Poor	Restricted use for Irrigation
6	Above 150	Unfit for Drinking	Proper treatment required before use.

V. RESULTS

5.1 Physico-Chemical pameters results of sample stations

All parameter results with laboratary tested results of six samples with the standard permissible limit values recommended for drinking water by the BIS.

International Journal in IT & Engineering (IJITE)
Volume 7 Issue 7, July 2019 ISSN: 2321-1776 Impact Factor: 6.493
Journal Homepage: http://ijmr.net.in, Email: irjmss@gmail.com
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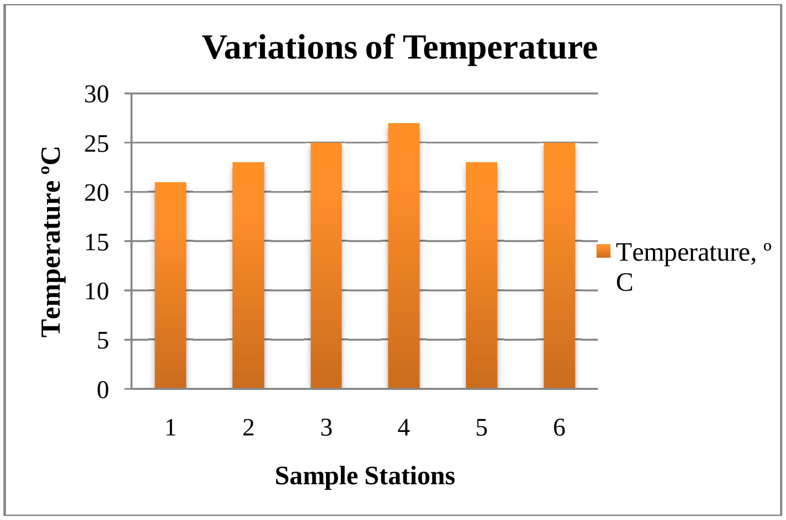
Table 3
Physico-Chemical parameters of Kali river water for six stations with BIS permissible limit of drinking water standards

Sl No	Parameters	Sample Stations 1	2	3	4	5	6	BIS Permissible Limit
1	Temperature, ºC	21	23	25	27	23	25	-
2	pH	5.36	6	5.7	5.5	5.3	5.38	6.5 - 8.5
3	Turbidity, NTU	3.39	11.32	4.4	7.11	4.27	4.38	5
4	Total Dissolved Solids, mg/l	32	207	60	31	32	32	500
5	Dissolved Oxygen, mg/l	5.9	5.8	8.8	8	7.4	8.3	5
6	Biological Oxygen Demand, mg/l	0.2	21	1.1	0.5	0.1	1.3	6
7	Chemical Oxygen Demand, mg/l	8.03	112.45	4.03	3.92	15.68	3.92	10
8	Nitrates as NO_3 , mg/l	0.72	8.22	0.95	1.33	1.53	1.35	45
9	Chlorides as Cl , mg/l	15.4	50.2	11.4	21.4	14.8	28.2	250
10	Sulphates as SO_4 , mg/l	1.82	15.61	3.12	5.72	5.99	5.99	200
11	Total Alkalinity, mg/l	57.2	41.2	52	73.2	57.2	56	200
12	Total Acidity, mg/l	10	12	10.8	25.2	13.2	41.2	-
13	Total Hardness as $CaCO_3$, mg/l	48	85.2	40	27	35	34	200
14	Calcium as Ca, mg/l	14.4	21.3	7	8	9.2	9.2	75
15	Magnesium as Mg, mg/l	3	7.7	5.52	2	3	2.64	30
16	Iron as Fe, mg/l	0.02	0.17	0.01	0.04	0.01	0.02	0.3

5.2 Variations of different parameters

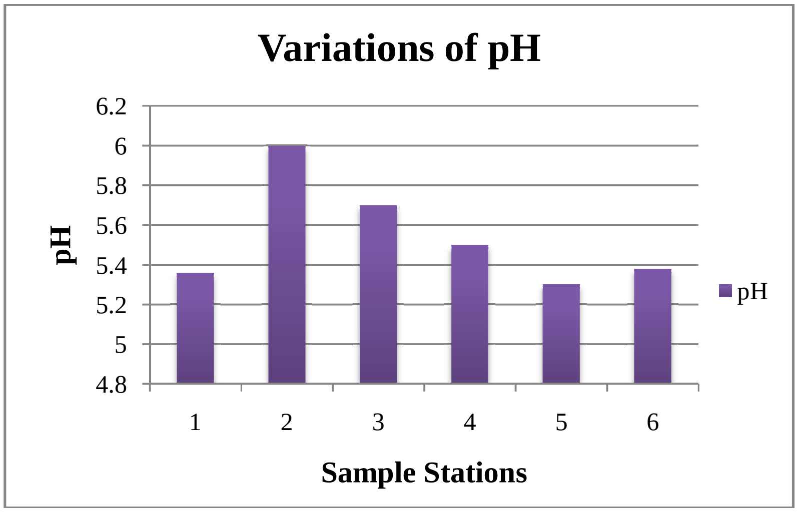
Temperature: As per BIS the temperature in water should be 27^0c.

Figure 2: Variations of Temperature



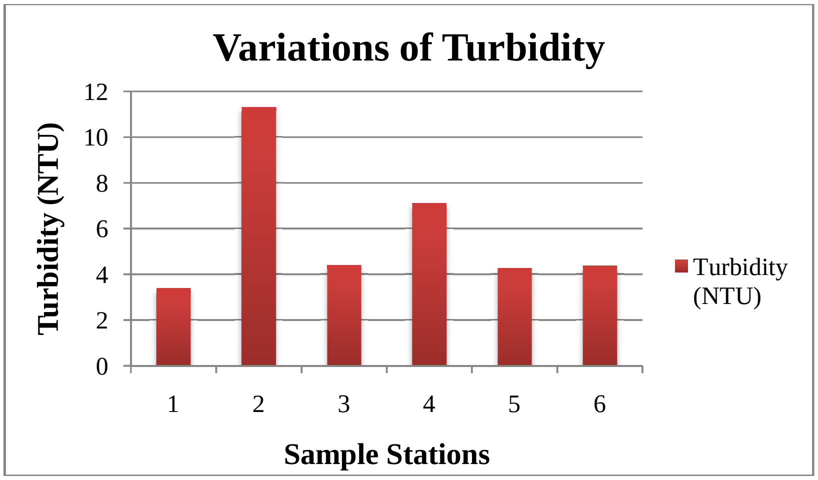
pH: A pH value is a number from 1 to 14, with 7 as a middle (neutral) point. Values below 7 indicate acidity and above 7 indicate alkalinity. The analysis of the water sample collected from the study area indicated that the average value of pH ranges from 5.3 to 6 in the pre-monsoon season. As per BIS 6.5 to 8.5 pH is suitable for drinking water.

Figure 3: Variations of pH



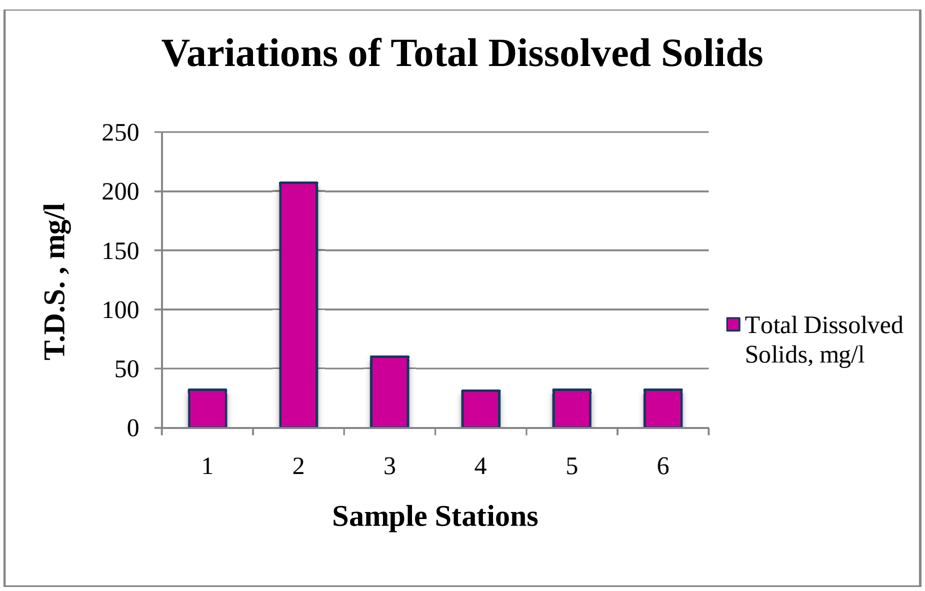
Turbidity: The analysis of the water sample collected from the study area indicated that the average value of turbidity ranges from 3.39 to 11.32 in the pre-monsoon season. As per BIS, the standard value of turbidity is 5. it should be less than 10 in river water if it's more than 10 it caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky.

Figure 4: Variations of Turbidity



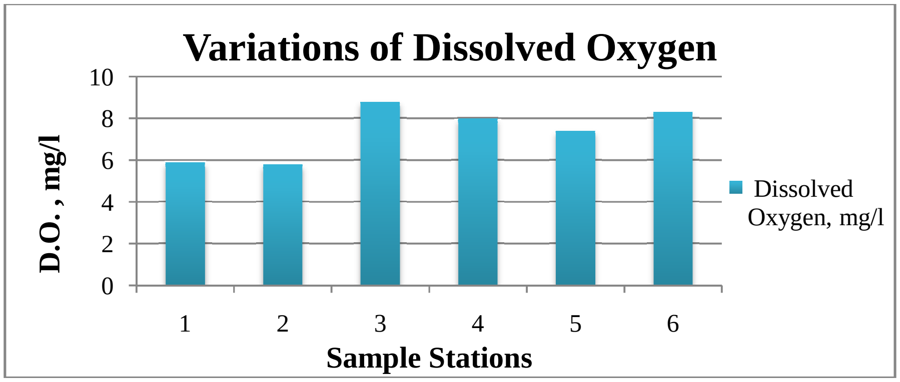
Total Dissolved Solids (TDS): The analysis of the water sample collected from the study area indicated that the average value of TDS ranges from 31 mg/l to 207 mg/l in the pre-monsoon season. As per BIS, the standard value of total dissolved solids is 500(ppm or mg/l). If it is less than 100 mg/l it is caused to hair fall, heart diseases. If it is more than 500 mg/l it may be very bad for kidneys and unacceptable for use. High level of TDS in surface water may be due to several factors such as sedimentation, mining and storm water runoff.

Figure 5: Variations of Total Dissolved Solids



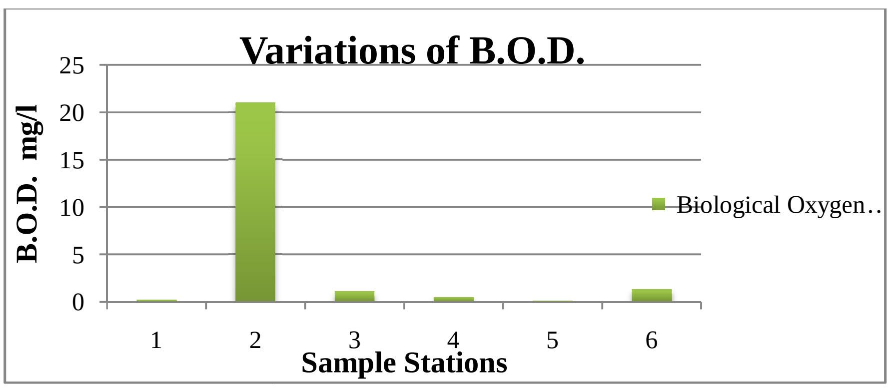
Dissolved Oxygen (DO): Dissolved Oxygen (DO) test measures the amount of life-sustaining oxygen dissolved in the water. Low level of dissolved oxygen is a sign of possible pollution. In the present study, it varied from 5.8 mg/l to 8.8 mg/l. AS per WORLD HEALTH ORGANISATION; the standard value of dissolved oxygen in water is below 5 mg/l. If it is more than 5 mg/l is present in the river water causes undesirable for aquatic life.

Figure 6: Variations of Dissolved Oxygen



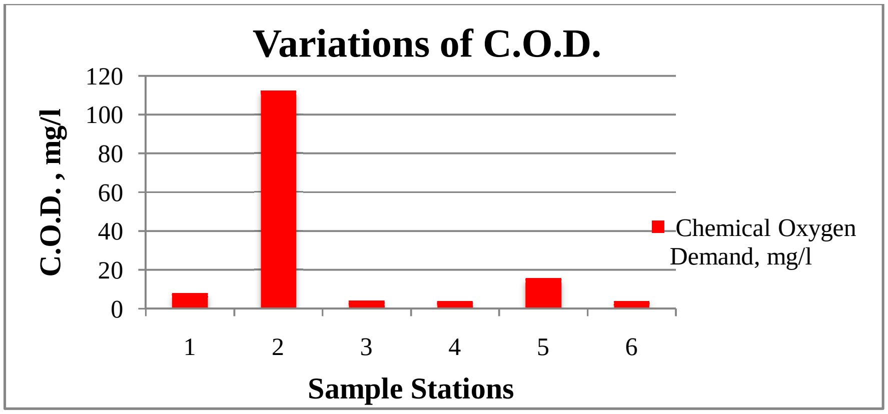
Biochemical Oxygen Demand (BOD): Biochemical Oxygen Demand (BOD) is a measure of the amount of biological pollutions. The BOD test provides an estimate of how much biodegradable waste is present in the water. Here, BOD varied from 0.1 mg/l to 21 mg/l. As per the WORLD HEALTH ORGANISATION, the value of biochemical oxygen demand is 6 mg/l.

Figure 7: Variations of Biochemical Oxygen Demand



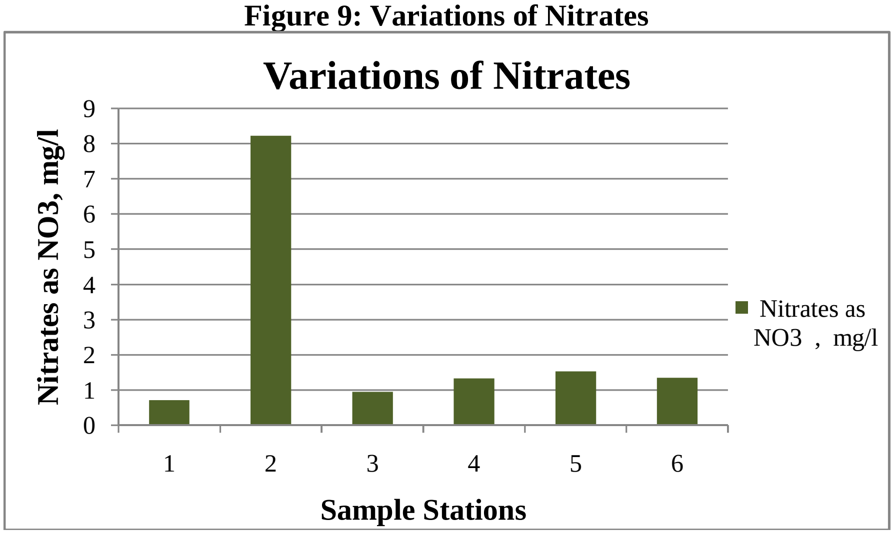
Chemical Oxygen Demand (COD): The chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. A COD test can be used to easily quantify the amount of organics in water. Here, COD varied from 3.92 mg/l to 112.45 mg/l. As per BIS 10500, the limit of Chemical oxygen demand in water is should be 250 mg/l.

Figure 8: Variations of Chemical Oxygen Demand



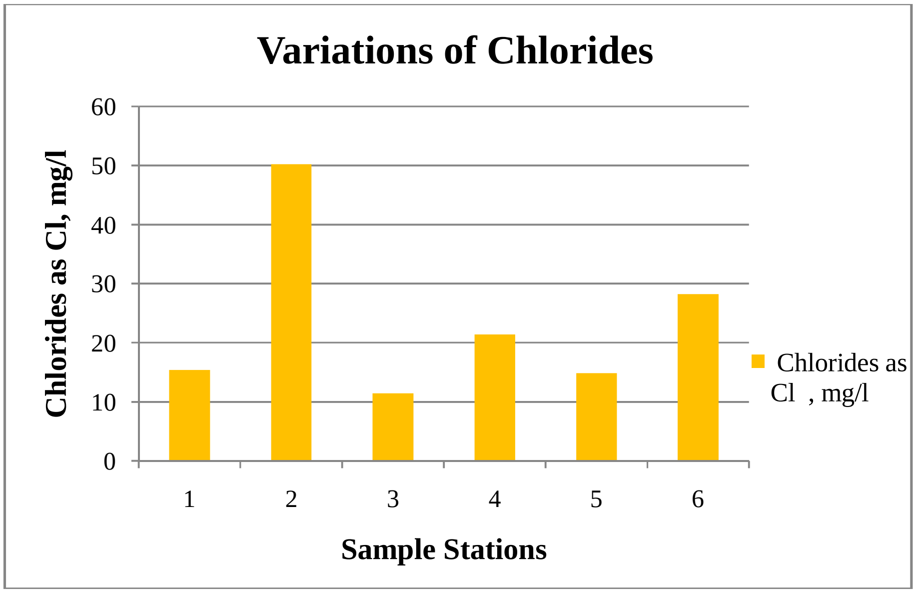
Nitrates (NO_3): Nitrate is added by common sources such as fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plant debris. In the present study, nitrate ranged from 0.72 mg/l to 8.22 mg/l. As per the BIS, the value of nitrate (NO_3) is 45 mg/l. If it is more than 45 mg/l in the water. The blue baby flue will occur.

Figure 9: Variations of Nitrates



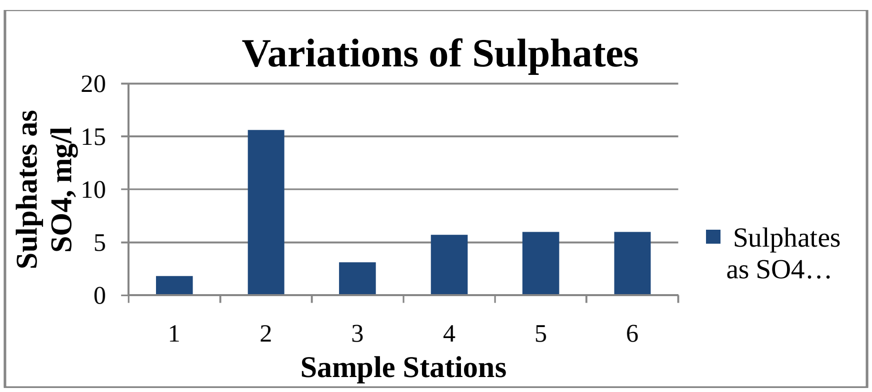
Chlorides (Cl) : Chloride level of water indicates the pollution degrading of water. A higher concentration of chloride is hazardous to human consumption and creates health problems. As per the BIS, the value of chloride is 250 mg/l. In the present study, it varied from 11.4 mg/l to 50.2 mg/l.

Figure 10: Variations of Chlorides



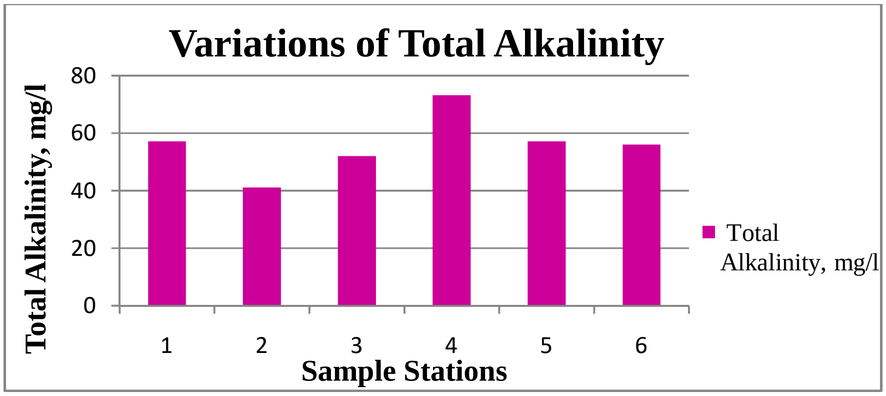
Sulphates (SO_4): Sulphates (SO4) were analysed in the water samples which indicated that it was present in the range of 1.82 mg/l to 15.61 mg/l. As per BIS 10500:1991 the limit of sulphate is 200 mg/l. If it is more than the limit effects on eye, skin, or scalp etc.

Figure 11: Variations of Sulphates



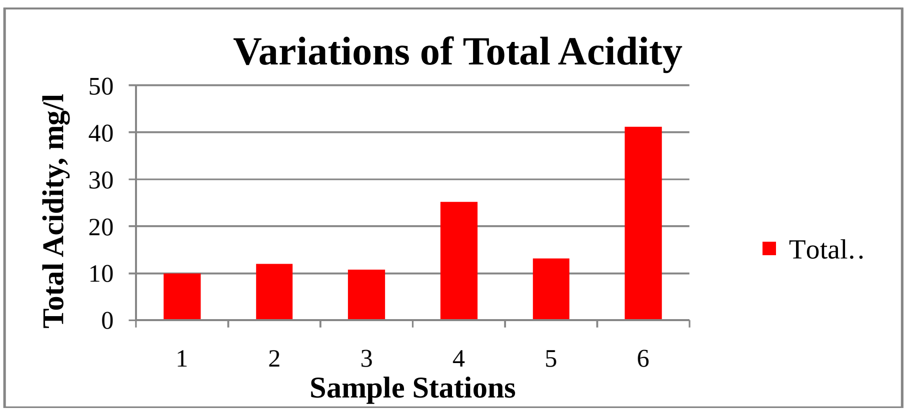
Total Alkalinity (TA): Total alkalinity in natural water is generally imparted by the hydrolysis of salts such as carbonates, bicarbonates, phosphates and nitrates. Lower values of alkalinity indicate that anions and cations are not concentrated. Higher values of alkalinity cause problem like inscrutability in water pipelines. The average value of total alkalinity in the different stations of water samples of the present study ranges from 41.2 mg/l to 73.2 mg/l. As per BIS the limit of total alkalinity is 200 mg/l. This beyond the limit taste becomes unpleasant.

Figure 12: Variations of Total Alkalinity



Total Acidity : The present study indicated that the total acidity of the water samples ranges from 10 mg/l to 4102 mg/l. As per BIS to a determination of acidity in drinking water or wastewater the applicable range is 0.5 to 500 mg/l.

Figure 13: Variations of Total Acidity



Total Hardness (TH): Total hardness (T++) is determined as $CaCO_3$ mg/l. Mainly TH causes from cations of calcium, magnesium, iron and strontium. The present study indicated that the total hardness of the water samples ranges from 27 mg/l to 85.2 mg/l. As per BIS the limit of total hardness is 300 mg/l. If it exceeds the 300mg/l it causes the Encrustation in water supply structure and adverse effect on domestic use.

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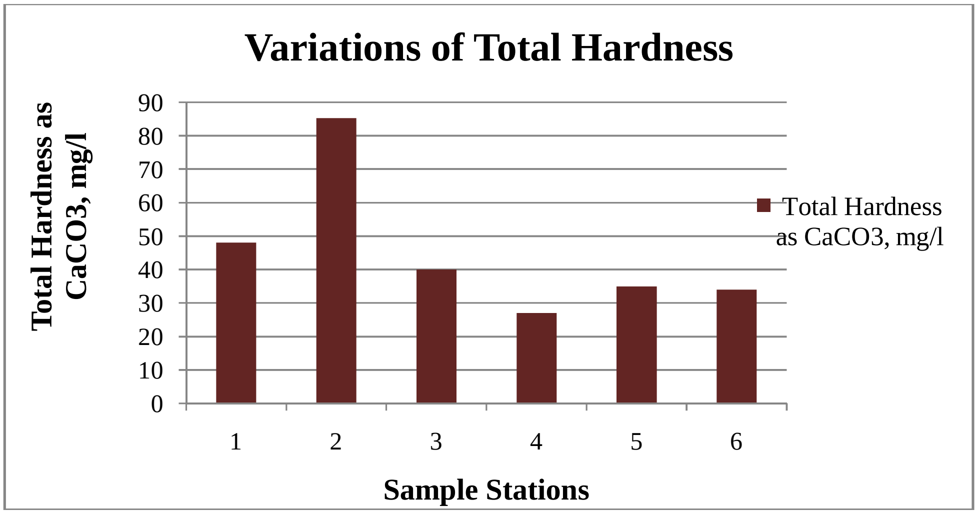
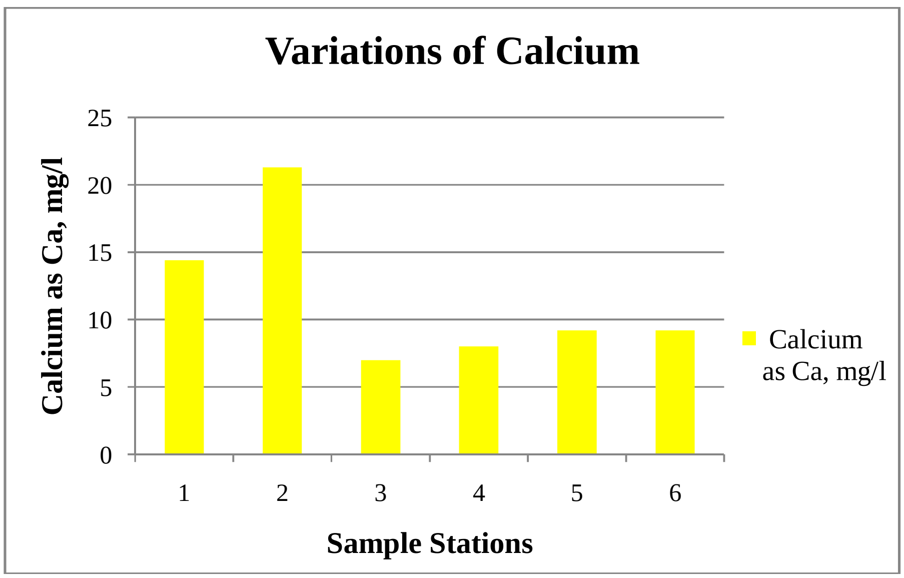
Figure 14: Variations of Total Hardness



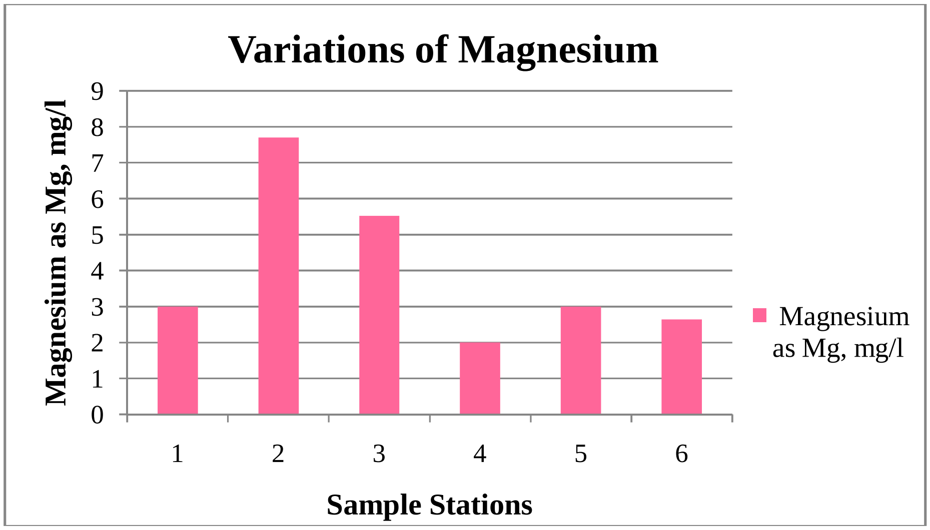
Calcium (Ca) : The water samples collected from the study zone indicated the magnitude of the calcium ranging from 7 mg/l to 21.3 mg/l. As per BIS the limit of calcium is 75 mg/l. If it exceeds the 75 mg/l it causes an adverse effect on domestic use.

Figure 15: Variations of Calcium



Magnesium (Mg) : The value of magnesium in the water samples ranges from 2 mg/l to 7.7 mg/l. As per BIS the limit of magnesium is 30mg/l. If it exceeds the 30mg/l it causes an adverse effect on domestic use.

Figure 16: Variations of Magnesium



Iron (Fe): In the study area, the iron of the water samples is found to range from 0.01 mg/l to .17 mg/l. As per BIS the limit of iron content in water should be 0.3 mg/l. Beyond this limit, its effects on taste/ appearance on the water. It has adverse effects on domestic uses and water supply structures and promotes iron in bacteria.

Figure 17: Variations of Iron

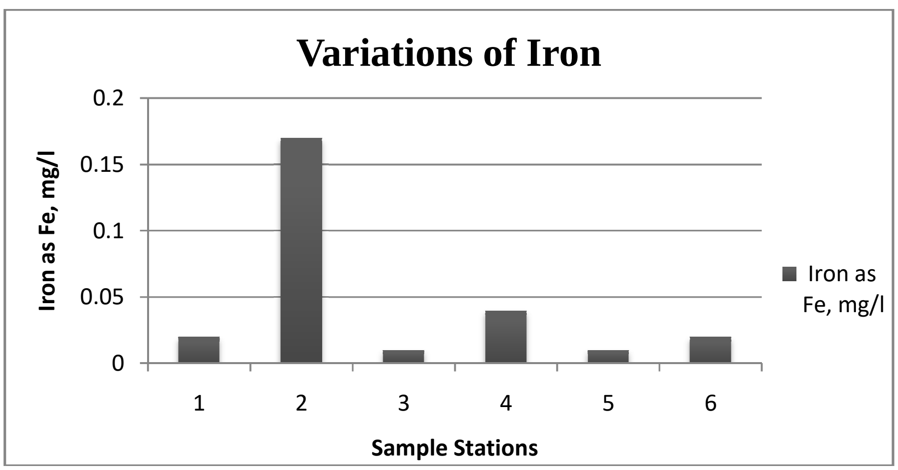


Table 4. Water Quality Index for Kali river samples

International Journal in IT & Engineering (IJITE)
Volume 7 Issue 7, July 2019 ISSN: 2321-1776 Impact Factor: 6.493
Journal Homepage: http://ijmr.net.in, Email: irjmss@gmail.com
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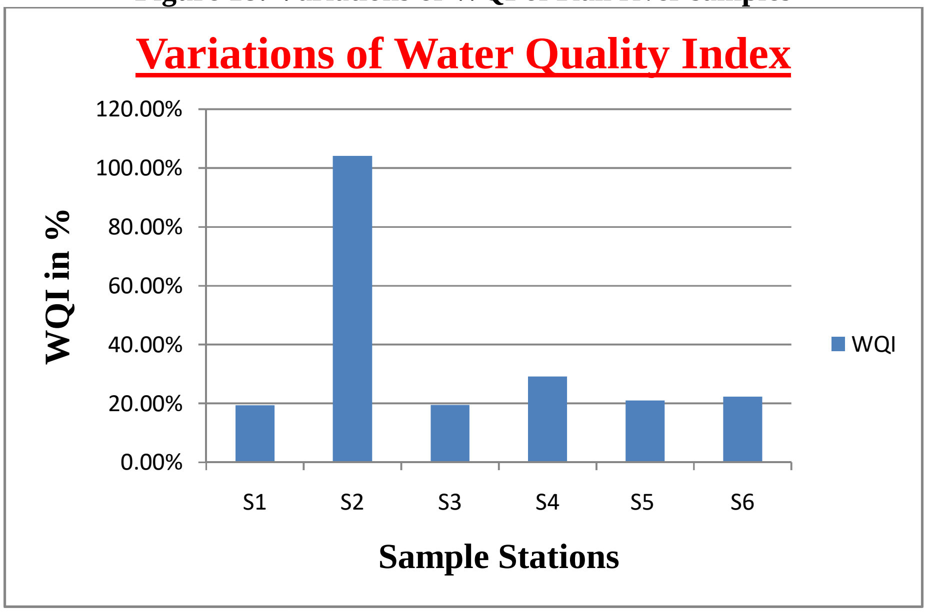
Sample Stations	WQI	Sample Stations	WQI
Sample 1	19.43%	Sample 4	29.16%
Sample 2	104.14%	Sample 5	21%
Sample 3	19.55%	Sample 6	22.34%

Water Quality Index developed for the river water samples indicated that there is a wide variation from station to station. The WQI of all the locations is given in Table 5.9. In the present study area, the WQI of the water samples is found to range from 19.43% to 104.14%.

Figure 18: Variations of WQI of Kali river samples



WQI is commonly used for the detection and evaluation of water pollution and it may be defined as the reflection of the composite influence of different quality parameters on the overall quality of water. The WQI of the study area during the pre-monsoon season is analyzed here. The overall water qualities during the pre-monsoon season with representing samples are presented in Table 5.10.

Table 5. WQI of premonsoon samples of Kali river

Sl. No.	WQI	Status	Representing premonsoon samples
1	0 – 25	Excellent	S1, S3, S5, S6
2	25 – 50	Good	S4
3	51 – 75	Fair	Nil
4	76 – 100	Poor	Nil
5	101 – 150	Very Poor	S2
6	Above 150	Unfit for Drinking	Nil

The WQI of premonsoon samples states that 66.67 % of the total collected samples are excellent, 16.67 % is good, 16.66 % is very poor.

VI. CONCLUSION

From the present study we conclude that Kali river water is most probably is not fit for drinking at Sample collection sites (Station-2 & Station-4) and it needs to treated to reduce contamination especially the pH, turbidity, BOD, COD.

The present revels that the water quality of Kali river (station1, station3, station5 and station6) is quite safe as compared to the physicochemical parameter point of view at present however due to increased human activities along its bank constant monitoring of the water quality of the river is a must to maintain the river water quality.

The present study reveals the values of BOD of the Kali river for five stations various from 0.1mg/l to 1.1mg/l except station-2 which is the highest values of 21mg/l, thus indicating considerable deterioration in water quality in the stretch due to discharge of sewage and industrial effluents and is far below the bathing standards. Comparatively all stations the station-2 is more polluted from BOD point of view.

The estimation of COD is of great importance for water having unfavourable conditions for the growth of microorganisms, such as the presence of toxic chemicals. The WHO's recommended permissible limit is 10mg/l. According to this study, the sample is unsafe because station-2 and station-5 having higher values of 112.45mg/l and 15.68mg/l.

The turbidity water interfaces with self-purification of streams by reducing the photosynthetic activity of aquatic plants. The permissible limit 5NTU is prescribed by Who and BIS for drinking water standards. The higher values are shows in station-2 and station-4 having a higher value of 11.32NTU and 7.11NTU.

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