International Journal of Future Generation Communication and Networking
Vol. 13, No. 4, (2020), pp. 3121–3129

Water Quality Analysis And Scientific Remediation Of River Arkavathi, Karnataka, India

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Abstract

Deteriorating water quality is becoming a major problem nationwide making it unlikely to meet the demand for fresh water for its growing population unless drastic measures are adopted. The river considered in this study is the Arkavathi an important mountain river in Karnataka originating at Nandi Hills of Chikkaballapur District. The river is used by the Bangalore Water Supply and Sewerage Board to provide 135 million litres of drinking water per day to the city of Bengaluru, or about 20% of all the city's water, it aims to determine the polluting sources responsible for the poor water quality of the Arkavathi River and to suggest a scientific water remediation plan to rectify the same. Due to rapid urban-industrialization and domestic needs of the people which are responsible for polluting Arkavathi river by direct disposal of untreated effluents into the Arkavathi river. In this study, the water samples are collected from 8 selected sampling stations of Arkavathi River during the study period of post monsoon month in February 2020 for physio-chemical analysis and the Water quality index developed for the water samples. According to the NSF, surface water quality of overall Arkavathi River, was mainly assessed as bad quality since the value was between 35 to 45. This research analyzed the current situation of Arkavathi river pollution, and summarized the researches on river pollution control and remediation. The remediation aims to better the quality of river by enabling it to be used for domestic and agricultural purposes. After comparing and analyzing different techniques and clarifying the concepts of remediation technology, based on the advances of river remediation, and its approaches to alleviate the river pollution problem that plagues the Arkavathi River.

Keywords: *Water quality, River pollution control and remediation.*

Introduction

ISSN: 2233-7857 IJFGCN

Water is the Elixir of life. Its an inorganic, transparent, tasteless, odorless, and nearly colorless chemical substance, which is the main constituent of Earth's hydrosphere and the fluids of most living organisms. Notice how of the world's total water supply of about 332.5 million cubic miles of water, over 96 percent is saline. In addition, of the total freshwater, over 68 percent is locked up in ice and glaciers. Another 30 percent of freshwater is in the ground. Fresh surface-water sources, such as rivers and lakes, only constitute about 22,300 cubic miles (93,100 cubic kilometers), which is about 1/150th of one percent of total water. Yet, rivers and lakes are the sources of most of the water people use every day. Karnataka possesses about six percent of the country's total surface water resources of about 17 lakh million cubic meters (Mcum). Karnataka is blessed with seven river basins. Karnataka receives mean annual rainfall of around 1,355 millimeters. Though Karnataka enjoys a substantial amount of rainfall and has a significant quantity of water resources, it is not enough to meet the ever-increasing water requirement of the state. Karnataka suffers repetitive droughts. In spite of the availability of water from the river systems and tanks, Karnataka faces the serious issue of 67 percent of its land marked for irrigation falling under dry tracts. With a rapidly increasing population and improved living standards, the pressure on the water resources is constantly on the rise. Water pollution is the contamination of water bodies, usually because of human activities. Water pollution results when contaminants are introduced into the natural environment. Water pollution is the leading worldwide cause of death and disease, e.g. due to water-borne diseases. The per capita availability of water resources is reducing day by day. In order to distribute the water requirement for the increased growth of population, the available water resources should be conserved and avoid further depletion and degradation. Proper scientific and economic use of water resources for agricultural, industrial and domestic purposes can help in solving the problem to a large extent.

Study Area

Arkavathi River is one of the peninsular rivers; it is a tributary of the River Cauvery, originated at the foot of Nandi hills to the north of Bengaluru and located between 12°15'13.24"N, 77°12'77.41"E flows in the west part of Bengaluru city in the southern part of Karnataka state. It covers an area of 4,253km2. It flows for 190 kilometers and joins the River Cauvery at Sangama in Kanakapura district. The sub-basin covers parts of eight taluks – Chikkabalapur, Doddaballapur, Nelamangala, Magadi, Bengaluru Rural, Bengaluru North, Ramanagara and Kanakapura.

The Arkavathi River is an main river in Karnataka state, India, which runs 193 km, originate at Nandi hills of Chikkaballapur district. It is a tributary of Cauvery, which it joins at 34 km south of Kanakapura, Ramanagara District called Sangama in Kannada, after flowing through Ramanagara and Kanakapura. The river drains into the Chikkarayappanahalli Lake near Kanivenarayanapura, Kumudavathi and Vrishabhavathi Rivers are tributaries to this river. It forms Chunchi falls near Haroshivanahalli. It joins Cauvery River as a tributary near Mekedatu.

The river is used by the Bangalore water supply and sewage board to provide 135 million liters of drinking water per day to the city of Bangalore. As it is filtered in the nearby mountain aquifer, the water is fresh and crystal clear. The water is taken from two reservoirs built on the river, Hesaraghatta, which was built in 1894, and the Thippagondanahalli reservoir, which was built in 1933. There is Manchanbele dam that is across the river further downstream located in Ramanagara district.

Materials and Methodology

The type of investigation, purpose of the study, and anticipated variation in chemical quality determine to a large degree the location of the surface- or ground-water sampling site and the frequency of sample collection. The dry season is very important because pollution has the highest impact on a receiving river due to its dry weather flow. 8 sampling stations were chosen based on the basis of point source pollution. The samples collected using the grab sampling method of collection. The location details of sampling stations are described in Table. 1.

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Table 1: Water sample codes of sampling stations along River Arkavathi

Code	Description of Site	Longitude	Latitude
S1	Manchenahalli Dam, Tavarekere Village Bridge	12.869882	77.336536
S2	Rampura Village Bridge	12.838819	77.32885
S3	Sugganahalli Bridge	12.799942	77.31758
S4	Ramanagar-Mysore Road, Bridge of NH-275	12.729972	77.282063
S5	Bridge Between Krishnadoddapuram and Kunagal Village Near Kailancha	12.68498	77.315403
S6	Borewell near Halesandra Bus Stop (300 Meters from River)	12.587283	77.403052
S7	Bridge Between Bandehosappanahalli And Halesandra Village	12.585631	77.406128
S8	Bridge in Tiyagarahalli Near Kanakapura	12.573895	77.406796

During the present study the physical, chemical and biological parameters of water analyzed. Parameters of the sample were analyzed in the laboratory using the guidelines from the standard methods for the examination of water and wastewater, published by the American Public Health Association (Inc). Some of the parameters were measured in the field by using portable kits, at the time of sample collection. The Methodology adopted in this study is shown in Figure 1.

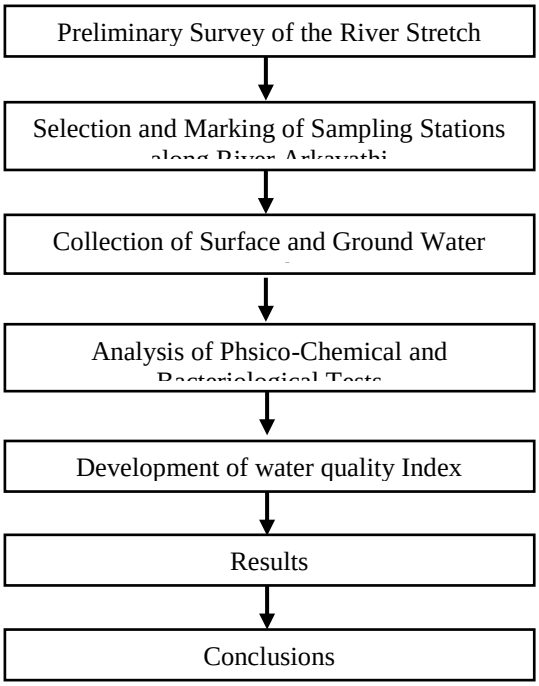

Figure 2: Flowchart of Methodology adopted in the study

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Results

Results reported on physico-chemical factors are influenced by change in rainfall and seasonal variations in hydrology. It was found that inflow of freshwater altering water quality frequently in this zone with continuous discharge of pollutants into river basin. The table 2 shows the water quality parameters for surface water of river Arkavathi. surface water of river Arkavathi.

Table 2: Water Quality Parameters of the Samples collected at the Study Area

Parameters	**S1**	**S2**	**S3**	**S4**
	SW	**SW**	**SW**	**GW**
pH	6	7	7	5
Temp ° C	23	23	24	19
EC, µS/cm	111.2	111.4	115.9	514
TDS, mg/L,	125.9	95.1	79.2	438.4
T. Acidity, mg/L,	35.6	49.2	45.6	82.6
T. Alkanity, mg/L,	36.4	35.6	59.2	132.4
Chloride, mg/L,	10.2	12.3	17.2	15.4
T. Hardness, mg/L,	111.92	105.24	123.52	248.5
Sodium(Na), mg/L,	26.2	31.3	31.2	85.08
Potassium(K), mg/L,	2.4	3.8	1.9	5.94
Sulphate(SO_4), mg/L,	24.5	28.9	22.2	26.3
Phosphate(PO_4), mg/L,	1.78	2.1	2.32	6.3
Nitrate (NO_3), mg/L,	0.66	0.71	0.54	1.03
Fluoride, mg/L,	0.20	0.22	0.28	2.8
Iron, Fe, mg/L	0.57	0.41	0.39	0.82
D.O, mg/L,	6.7	6.9	6.5	4.4
BOD_5, mg/L,	3.8	3.7	3.9	4.9
E.coli	<100	<100	<100	<100
Parameters	**S5**	**S6**	**S7**	**S8**
	SW	**GW**	**SW**	**SW**
pH	9	7	8	8
Temp ° C	24	18	25	25
EC, µS/cm	112.5	558	113.2	124.1
TDS, mg/L,	85.2	462.1	85.2	92.1
T. Acidity, mg/L,	59.6	93.4	44.0	38.4
T. Alkanity, mg/L,	48.4	163.2	47.6	51.2
Chloride, mg/L,	14.2	13.6	18.2	15.8
T. Hardness, mg/L,	81.8	222.2	95.92	132.04
Sodium(Na), mg/L,	39.8	76.4	21.2	20.6
Potassium(K), mg/L,	4.6	7.8	6.7	6.1
Sulphate(SO_4), mg/L,	38.7	36.6	31.1	30.99
Phosphate(PO_4), mg/L,	3.23	5.65	2.22	2.77
Nitrate (NO_3), mg/L,	0.69	0.89	0.74	0.61
Fluoride, mg/L,	0.26	3.4	0.31	0.32
Iron, Fe, mg/L	0.56	0.94	0.53	0.51
D.O, mg/L,	6.7	3.2	5.6	5.8
BOD_5, mg/L,	4.8	5.0	7.2	6.9
E.coli	<100	<100	<100	<100

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Discussions

Water Quality Analysis

pH

The pH value represents the acidic and alkalinity value of the water. The surface water maximum value (9) is observed in the Ramanagar district (S4), and the minimum value (6) is observed in manchenahalli dam tavarekere bridge (S1). The pH values show that water is suitable for drinking except in Ramanagar district (S4), because of sewage water from the residential area.

Temperature

The Temperature of river water is considered as important factor in quality analysis of water. The surface water maximum value (25) is observed in both stations point 7 and 8, and the minimum value (23) in both station point 1 and 2. The temperature value is inversely proportional to dissolved oxygen, as the temperature increase the dissolved oxygen decreases.

Electrical Conductivity (EC)

In surface water maximum value (124.1 μS/cm) is observed in station Bridge in Tiyagarahalli near Kanakapura (S8), and minimum value (111.2 μS/cm) observed in station Manchenahalli dam, Tavarekere village bridge (S1). Electrical Conductivity of surface water shows that water is suitable for both drinking and irrigation purposes. It has been observed that in ground water samples electrical conductivity is more than 500 μS/cm shows that the sources of high electrical conductivity are due to the presence of high amount of dissolved salts limit of 300mg/L at station S5 the stations S1, S2, S3 and S4 which is more than the permissible limit.

Total Dissolved Solids (TDS)

The TDS content in the study area observed in the surface water varied from 79.2 mg/L to 125.9 mg/L and 462.1 mg/L in groundwater indicating the suitability of water for all purposes.

Total Acidity

Acidity is important because acid contributes to corrosiveness and influences certain chemical and biological processes. Dissolved CO2 is usually the major acidity component of unpolluted surface water. In surface water Total acidity ranged from 35.6 mg/L in Manchenahalli dam, Tavarekere village bridge (S1) to 59.6 mg/L in bridge between Krishnadoddapuram and Kunagal village near Kailancha (S5) and 93.4 mg/L in groundwater.

Total Alkalinity

Alkalinity is ability of water to neutralize acids. The primary source of carbonate and bicarbonate ion in water is the dissolved carbon dioxide in rain, which as it enters the soil, dissolves more carbon dioxide. Water charged with carbon dioxide dissolves carbonate minerals, as it passes through soil and rocks, to give bicarbonates. In river water, Total alkalinity ranged from 35.6 mg/L in Rampura village bridge (S2) to 59.2 mg/L in Sugganahalli Bridge near post office (S3). In Ground water TA was observed 163.2 mg/L. The desirable limit for alkalinity in drinking water is 200 mg/L, beyond this limit, taste becomes unpleasant. This indicates that water is within the desirable ranges of Alkalinity.

Chloride (Cl)

The most important source of chloride in natural water is due to the discharge of sewage and it plays a vital role in photo phosphorylation reaction in autotrophs. The chloride concentration between 4-10 ppm indicates purity of water. High chloride concentration indicates the impact by human activities such as road salting, agricultural runoff, and sewage effluent. Chlorides in river water ranged from 10.2 mg/L in Manchenahalli dam, Tavarekere village bridge (S1) to 18.2 mg/L in bridge between Bandehosappanahalli and Halesandra village (S7). In Ground water, chloride values observed is 15.4 mg/L. The desirable limit for chloride is 250 mg/L. The chloride values are found to be well within desirable limits.

Total Hardness (TH)

Drinking water suitability can be measured by determining the hardness of water, domestic and many industrial purposes. The total hardness in surface water ranged from minimum 81.8 mg/L in bridge between Krishnadoddapuram and Kunagal village near Kailancha (S5) to maximum of 132.04 mg/L in bridge in Tiyagarahalli near Kanakapura (S8). In groundwater TH range is higher as 248.5 mg/L. The sources of hardness in the current research study may be due weathering of limestone,

ISSN: 2233-7857 IJFGCN

sedimentary rock and calcium bearing minerals and groundwater quality is affected by chemical and industry effluents.

Sodium

All groundwater contains some sodium because most rocks and soil contain sodium compounds from which sodium is easily dissolved. In surface, water the concentration of sodium ranges from 20.6 mg/L in bridge in Tiyagarahalli near Kanakapura (S8) to 31.7 mg/L in Rampura village bridge (S2) and recorded 85.08 mg/L in groundwater. Sources of sodium levels in the current research investigation could be due to erosion of salt deposits and sodium bearing rock minerals, Infiltration of contaminated surface water or even pollution by sewage effluents.

Potassium

Potassium is an essential element in humans and is seldom, if ever, found in drinking water at levels that could be a concern for healthy humans. In surface water the concentration of potassium ranges from 1.9 mg/L in Sugganahalli bridge near post office (S3) to 6.7 mg/l in bridge between Bandehosappanahalli and Halesandra village (S7) and recorded 7.8 in groundwater. The higher potassium concentration is observed in the study area is due to the application of excessive fertilizers.

Sulphate

Sulphate concentration is attributed to the wide application of soil conditioners. In view of the stability of the dissociate sulphate ion in most environments where it occurs, and due to high solubility of the sulphates of the common cations such as calcium, magnesium and sodium, high concentration of sulphate may be expected. In the study area Concentration of sulphate in surface water ranged from 22.2 mg/L in Sugganahalli bridge near post office (S3) to 38.7 mg/L in bridge between Krishnadoddapuram and Kunagal village near Kailancha (S5), and in groundwater it is 36.6 mg/L. The main sources of sulphates in groundwater samples may generate from the dissolution of minerals, such as gypsum and anhydrites.

Phosphate

Phosphates in natural water does not cause any threats to human life. Phosphates are also used as primary volume in fertilizers. Phosphates act as nutrient for plant growth and high concentration of it is also an indication of eutrophy. In surface water it varies from 1.78 mg/L in Manchenahalli dam, Tavarekere village bridge (S1) to maximum of 2.23 mg/L in Sugganahalli bridge near post office (S3) and in ground water it is 6.3 mg/L. The sources may be due to anthropogenic activities mainly input of fertilizers and decomposition of organic matter during the study period.

Nitrate

Nitrate (NO3) is a naturally occurring form of nitrogen found in soil. Nitrogen is essential to all life. In surface water it ranged from 0.54 mg/L in Sugganahalli bridge near post office (S3) to 0.74 mg/L in bridge between Bandehosappanahalli and Halesandra village (S7) and in groundwater it is 1.03 mg/L. Most crop plants require large quantities of nitrates to sustain high yields. The desirable limit for nitrate in drinking water is 45 mg/l. The values for nitrate are well within the desirable limits.

Fluoride

Fluorides are only found in ground water source. As per the Indian standard drinking water specification the maximum permissible limit of fluoride in drinking water is 1.5 mg/L, and the desirable limit is 1.0 mg/L. Fluoride concentrations above 1.5 ppm in drinking water cause dental fluorosis and much higher concentration skeletal fluorosis. In surface water the fluoride concentration varies from 0.20 mg/L in Manchenahalli dam, Tavarekere village bridge (S1), to 0.32mg/L in bridge in Tiyagarahalli near Kanakapura (S8) and in groundwater it ranged to maximum of 3.4 mg/L. The groundwater sample results recorded above the desirable limit of 1mg/L.

Iron

Iron is reddish color to water when found in high concentration. High content of manganese is found when purple to brown color in water. When exposed to air in the pressure tank or atmosphere, the water turns cloudy and a reddish-brown substance begins to accumulate. In surface water concentration of iron varies from 0.39 mg/L in Sugganahalli bridge near post office (S3) to 0.57 mg/L in Manchenahalli dam, Tavarekere village bridge (S1) and in groundwater it ranged to maximum of 0.94 mg/L The permissible concentration of iron is 0.3 mg/l and therefore the above values are beyond the desirable ranges.

Dissolved Oxygen

ISSN: 2233-7857 IJFGCN

Dissolved oxygen keeps water fresh for long period. High Dissolved oxygen can cause corrosion. Dissolved oxygen improves taste of water. As the temperature is inversely proportional to Dissolved oxygen. D.O Increases with decrease in temperature. In surface water the concentration of DO varies from 5.6 mg/L in bridge between Bandehosappanahalli and Halesandra village (S7) to 6.1mg/L in Rampura village bridge (S2) and in groundwater it ranged to minimum of 3.2 mg/L.

BOD

Biochemical Oxygen Demand (BOD) is an index of organic pollution to measure the amount of DO required by microbial community in decomposing the organic matter present in a water sample by aerobic biochemical action. The high BOD is an indication of organic pollution. In the present study BOD value was minimum in RAMPURA VILLAGE BRIDGE (S2) with 3.7 mg/l and maximum in bridge between Bandehosappanahalli and Halesandra village (S7) with 7.2 mg/L, and in groundwater it ranged to maximum of 5.0 mg/L indicating the traces of organic pollution.

Escherichia coli (E.coli)

E.coli comes from human and animal waste. Bacteriological water quality data of River Arkavathi were observed and E.coli in river water and in groundwater were observed and were recorded is <100 MPN/100 ml in all the samples and is harmful. Heavy precipitation may cause these organisms to be washed into river, or ground water.

Water Quality Index

It provides a convenient means of summarizing complete water quality data. Water quality index developed for the surface water samples does not indicate a wide variation from station to station.

The objective of the study was to determine the WQI in order to assess the water quality of the area for domestic use, irrigation and other purposes. According to the NSF, surface water quality of overall Arkavathi river, was mainly assessed as bad quality since the value was between 35 to 45 and shown in table 3.

Table 3: WQI of samples in the study area

Code	**Description of Site**	WQI	Quality
S1	Manchenahalli Dam, Tavarekere Village Bridge	41	Bad
S2	Rampura Village Bridge	45	Bad
S3	Sugganahalli Bridge	43	Bad
S4	Ramanagar-Mysore Road, Bridge of NH-275	35	Bad
S5	Bridge Between Krishnadoddapuram and Kunagal Village Near Kailancha	39	Bad
S6	Borewell near Halesandra Bus Stop (300 Meters from River)	43	Bad
S7	Bridge Between Bandehosappanahalli And Halesandra Village	42	Bad
S8	Bridge in Tiyagarahalli Near Kanakapura	42	Bad

Scientific Remediation Of River Arkavathi

As the results of Water Quality Index shows the overall quality of the river Arkavathi is bad. It is due to rapid urbanization and the continuous gradual increase in the river pollution levels of the river, also

ISSN: 2233-7857 IJFGCN

generous amount of domestic and industrial waste contaminants have depleted the quality of Arkavathi river considerably. Hence designed an effective technique to regulate and control the quality of river water. Physical remediation, chemical remediation and bioremediation technologies, can be adopted to develop a cost-effective technique to improve the Arkavathi river water quality.

Conclusion

The assessment and management by water quality index plays a very important role in quality of water. The current analysis serve as the first assessment on the Arkavathi River. The present study delivers valuable ideas into the status of overall suitability of the Arkavathi River water based on WQI values. The salient features of various important physico-chemical parameters of water quality of the river are highlighted. The variations in the WQI values were evaluated depending upon on the water quality analysis data of eight sampling sites distributed along the length of river channel. The baseline data obtained in these analysis and approximate interpretation will fetch a long way in improving our basic knowledge on the status of water quality of a socio-economically important system, i.e., the Arkavathi River and the factors affecting the overall quality of the river water. The objective of this study has both academic weightage and practical importance. The immediate requirement is to implement effective treatment measures to assess and augment the river water quality by defining water quality management plan, which impacts sustainable river restoration system successfully. Water quality of the river needs to be restored by implementing various parameters like restriction of inflows of raw sewerage from Industries and residential structures, narrowing of storm water drains discharge into the river body and prevention of solid wastes disposal by residential communities throughout the river channel. Apart from these, to increase the river potential certain desilting techniques should be implemented and avoid major encroahments for urban infrastrure developments.

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ISSN: 2233-7857 IJFGCN