Retraction

Retraction: A Study on the Water Quality Assessment of Bhavani River in Tamil Nadu (*IOP Conf. Ser.: Mater. Sci. Eng. 1145 012068*)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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A Study on the Water Quality Assessment of Bhavani River in Tamil Nadu

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Abstract. In many parts of India, rivers and streams are the major source of water for household and irrigation purposes. Due to increased human population and industrialization, the water gets highly polluted as the sewage and household wastes, agricultural wastes, and other wastes from factories are directly discharged into the river. Pollution of river water can have harmful effects on living beings and makes water unsuitable for various needs. Thus, it is required to check the quality of water at well-ordered time intervals as the physical, chemical and biological parameters of the water will be changed. In this study, six samples from both Upper Bhavani River in Coimbatore district and Lower Bhavani River in Erode district were collected at various locations and examined for water quality parameters to know its suitability for various needs. Water samples collected were examined for water quality parameters such as electrical conductivity, alkalinity, dissolved oxygen, sulphate, chloride, hardness, turbidity and Biochemical Oxygen Demand (BOD). Based on the water quality analysis results, Water Quality Index was formulated. The overall quality of water was assessed using the WQI values and necessary solutions are suggested to improve the quality of water.

1. Introduction

Water is one of the essential resources in our day to day life. The demand for water goes on increasing due to rapid growth of population and development of industries. But due to increase in population and industrialization, the water is being polluted day by day [1]. Most of the surface water in India is being polluted and is unfit for direct consumption. All living organisms need good quality water for healthy life. So it is necessary to access the quality of surface water before using it. River In Tamil Nadu Bhavani River is the second largest River. It originates from Western Ghats in Nilgiris district and merges with Cauvery River at Erode district. It flows across three districts like Nilgiris, Coimbatore and Erode. Nearly 90% of this Bhavani water is used for agricultural purpose. Bhavani River serves as a major source of water for domestic purposes in various parts of Coimbatore, Tirupur and Erode districts. Bhavani River also serves as a source of water for many textile industries, leather factories, sugar factories and distillery units. Most of the factories which are located near the river discharge their treated or partly treated effluents into the river either directly or indirectly. In addition, most of the domestic waste from various
parts of districts also reaches the river without any treatment [2]. So the water is bacteriologically unfit for drinking due to the presence of faecal coli form, the source of which is human and animal excreta. This not only affect the human life but also agricultural products thereby causing environmental damage. Runoff from the agricultural land which is exposed to fertilizers and pesticides may reach the nearby river and make it toxic. The industrial waste contains heavy metals which may cause various health disorders. Water quality analysis determines the characteristics of water with respect to its suitability for various purposes. By analyzing the quality of water, the current condition of the river or stream can be predicted. It also provides information about natural benefit and human impact on an ecosystem [3]. Once water quality monitoring data are collected, they should be translated into easily interpreting form. For such interpretations Water Quality Index (WQI) is used. WQI compiles large amount of water quality data into basic terms. WQI grants single number which exhibits the overall water quality parameter at particular location over a particular period. WQI represents the purity of water and percentage of pollution of water. WQI is a unitless term which ranges from 0 to 100 [4]. WQI can be determined by various methods. The various parameters used to determine the quality of water are pH, electrical conductivity, sulphate, chloride, alkalinity, dissolved oxygen, turbidity, total dissolved solids, hardness and biochemical oxygen demand. In this project, an experiment has been made to calculate the Water Quality Index using the water quality parameters for determining the quality of water [5]. The objectives of this investigation are to study the geographical features of River Bhavani, conduct test the water quality parameters such as pH, alkalinity, sulphate, turbidity, TDS, chloride, electrical conductivity, DO and Hardness. Identify the overall quality of water using water quality index and also based on the physical parameters. And evaluate the water quality index based on the results obtained. Finally, suggest preventive measures based on the water quality and also based on the results obtained.

2. River Bhavani
The Bhavani River originates in the upper regions of the Nilgiris (i.e. silent valley forest of Malabar (Kerala)). It flows across the districts of Nilgiris, Coimbatore and Erode. River Bhavani flows through Coimbatore district and enters Erode district at Bhavanisagar dam. It flows through Bhavanisagar town panchayat in Sathyamangalam taluk, Gobichettipalayam taluk, Anthiyur taluk, Bhavani taluk and finally reaches Kalingarayan canal at Bhavani. River Bhavani combines with River Cauvery at Kooduthurai, Bhavani. The Tributaries of the Bhavani are Siruvani, Kundah, Conoor, Mayor. Origin of Bhavani River has latitude of 11.452434°N and longitude of 77.693253°E. It has a length of 215 kilometres and it covers around 7144 sq.km area. Totally It covers 87% of Tamil Nadu, 9% of Kerala and 4% of Karnataka. 90% of Bhavani river water is used for agriculture. But about 38000 cubic meters of effluent and waste water are dumped into the river. Many major textile units, leather preparing units, sugar factories and distillery units are located along the river bank of Bhavani. The discharge of effluents from these industries directly or indirectly in the Bhavani river causes severe pollution load leading to health problems for the peoples, plants and animals and poor strength on the water. The figure 1 show the topographical details of river Bhavani, its upper and lower region [6].
3. Selection of sampling points
To evaluate the water quality parameters of the Bhavani River, samples were assembled from six locations during two different periods (Jan 2020 and Feb 2020). Six locations (Bhavani, Appakudal, Athani, Kodiveri, Sirumugai, Mettupalayam) were selected along the study area four among them from lower Bhavani and two from upper Bhavani [7]. The significance of these six sampling points is given in the following table 1. The location of the sampling points is shown in figure 2.

| S.NO | AREA | LOCATION | GPS COORDINATES | SIGNIFICANCE OF SAMPLING POINT |
|------|------|----------|----------------|-------------------------------|
| 1    | Bhavani Kooduthurai d/s of Bhavani river | Mekkanst, Palanipuram | 11°26’27.0” N, 77°40’50.8”E | Sewage of nearby town directly confluences with river Bhavani and domestic waste are dumped into the river without treatment. |
| 2    | Appakudal d/s of Bhavani river | Near Sakthi sugars, Perundalaiyur | 11°26’57.4” N, 77°33’53.3”E | Presence of a sugar factory near the location. |
|   | Location details                                                                 | Latitude & Longitude | Activities                                                                 |
|---|----------------------------------------------------------------------------------|----------------------|---------------------------------------------------------------------------|
| 3 | Athani d/s of Bhavani river                                                       | 77°30’38.0”E        | All types of domestic waste are dumped along the river banks              |
|   | Savandapur                                                                        | 11°31’03.0”N        |                                                                           |
| 4 | Kodiveri dam of Bhavani river                                                     | 77°17’48.5”E        | Solid wastes are dumped along the river and also people bath in the river  |
|   | Periyakodiveri                                                                   | 11°28’27.6”N        | daily and wash clothes.                                                    |
| 5 | Sirumugai u/s of Bhavani river                                                    | 77°00’53.7”E        | Small drains of sirumugai municipality into the river and dumping of      |
|   | Ganeshapuram                                                                      | 11°19’36.6”N        | untreated waste                                                           |
| 6 | Mettupalayam u/s of Bhavani river                                                 | 76°55’53.5”E        | Domestic sewage in this location directly confluences with river Bhavani. |
4. Collection of water samples
Collection of water samples were carried out at the selected locations following the standard procedures of Sampling [8]. Samples were assembled during the period of January (20-01-2020) and February (25-02-2020). At six locations (Kooduthurai, Appakudal, Athani, Kodiveri, Sirumugai and Mettupalayam) were collected. Dry and clean plastic containers of 5 litre capacity were used to collect the samples from the sampling points. The container immersed into the surface of the river by hand. The sediments present in the water were not disturbed in order to...
minimize the turbulence of water. Hence water was allowed slowly run into the container. The containers were labelled with respect to the locations where samples collected. And the containers were transmitted to the laboratory for analysis.

5. Water strength parameters testing
The water strength of the river Bhavani was estimated based on the tests such as pH, chloride, dissolved oxygen, sulphate, total alkalinity, electrical conductivity, total dissolved solids, hardness, turbidity. pH is an significant parameter in assessing the water quality as it affects the biological and chemical processes of water [9]. To maintain the quality of water, adequate dissolved oxygen is required. A river stream’s ability to neutralize acidic pollution from wastewater is determined by measuring alkalinity. Hence Alkalinity is an important parameter in water strength assessment. High concentrations of sulphate in river water are toxic to the animals consuming the water and it also has long term health effects on humans [10]. High TDS concentrations can influence the taste and hardness of the water and it is also unsuitable for industrial applications. Hardness causes scaling problems in pipelines, boilers and heat exchange equipment. Electrical conductivity can be determined to detect contaminants and amount of dissolved solids in water.

5.1. pH
pH is a measure of the water to determine whether it is acidic or basic. More hydrogen ions in the water is considered as acidic and more hydroxyl ions in the water is considered as basic. pH also determines the solubility and biological availability of chemical constituents. Runoff from agricultural, household, and industrial areas may contain iron, lead, sulphate, mercury or other elements [11]. The pH of the water is affected by the toxicity of these substances. Since pH can be influenced by chemicals in the water pH is an essential indicator of the quality of water. pH of the water can be determined using two methods such as, colorimetric method and electrometric method. In Colorimetric method pH paper was dipped in the water sample and alter in colour of the paper was observed. The colour change was resembled with the standard pH scale provided along with the pH paper strip. The number on the scale which matches the colour change was taken as the pH of the water sample. In Electrometric method the electrode in pH meter was removed, washed and cleaned with soft tissue paper. Then it was dipped in the standard buffer solution and the instrument was calibrated. Once the instrument was calibrated, the electrode was again removed, washed and cleaned. Then the electrode was dipped in the water sample whose pH has to be measured.

5.2. Chloride
In plant and animal life, small amount of chloride is essential for the normal cell function. But the water used in industry or processed for any use has a very high level of chloride. Such chlorides may infect fresh water streams and lakes. Fish and aquatic communities cannot survive in such high level of chloride [12]. The amount of chloride in the water can be resolved by the following method such as, 10 ml of sodium chloride (NaCl) was pipetted out into the conical flask and few drops of potassium chromate were added, The solution was titrated against silver nitrate (AgNO₃) until the reddish brown colour appears, The titration was repeated for concordant values and normality of AgNO₃ was calculated. Then 10 ml of water sample was pipetted out into the conical flask and few drops of potassium chromate were added, The solution was titrated against AgNO₃ until the reddish brown colour appears, The titration was repeated for concordant values and the amount of chloride present in the water sample was calculated.

5.3. Dissolved oxygen
The amount of oxygen which is dissolved in the water in the gaseous state is considered as dissolved oxygen. Oxygen gets into water by diffusion from the surrounding air, by aeration and as a waste product of photosynthesis. The amount of oxygen dissolved is temperature dependent. The amount of oxygen that can dissolve in pure water is inversely proportional to the temperature of water. Decay of organic matters can also reduce dissolved oxygen concentration. Adequate dissolved oxygen is essential to maintain good water quality, for natural stream purification process and all forms of life to live. The amount of dissolved oxygen in the water can be determined by the following procedure. The sample was taken in two glass bottles, 2 ml of Manganese Sulphate and 2 ml of Alkali Iodide were added in each bottle, then 5 ml of Concentrated Sulphuric acid was added and the bottles were shaken thoroughly, 103 ml of the solution was taken in a conical flask and two drops of sodium thiosulphate and two drops of starch were added, then the solution was titrated against sodium thiosulphate until the blue colour disappears, the titration was repeated for concordant values and the amount of dissolved oxygen present in the water sample was calculated.

5.4. Sulphate
Sulphate in water comes from the discharges of the biological wastes. Naturally occurring sulphates are contracted with the water due to the breakdown of leaves in the streams and the passage of water through the rock or soil containing sulphates in the form of minerals or atmospheric deposition. Sulphates which are also comes from the runoffs from the fertilized agricultural lands into the streams. High level of sulphate in water causes diseases to all forms of life. The water used as a domestic water supply should contain sulphate below 250 mg/L. The amount of chloride in the water can be resolved by the following method. 50 l of the sample was taken in a conical flask and 10 ml of 2N HCl was added, the solution was boiled for 10 minutes, then 30 ml of barium chloride solution was added to the solution and boiled for few more minutes, after boiling, the solution was cooled and filtered, after filtration, the empty weight of silica crucible was taken and the filter paper was placed in the crucible, then the silica crucible was kept in hot muffle furnace, after 3 hours, the silica crucible was taken out and kept in dessicator for cooling, then final weight of silica crucible was taken and the amount of sulphate present in the water sample was calculated.

5.5. Turbidity
Amount of suspended particles present in the water is measured as Turbidity. Thus, it indicates the clarity of water. Suspended particles in water such as clay, silt, and algae, reduce water clarity and cause turbidity. Turbidity in water causes waterborne diseases to human life. The turbidity of water is based on the amount of light which is scattered in the water; more the turbidity means more particles are present in the water. The turbidity of water can be determined by the following method. Turbidimeter was switched on and 0 NTU and 100 NTU samples were taken in turbidimeter tube, Turbidimeter was calibrated using 0 NTU and 100 NTU solutions, then the water samples were placed in the turbidimeter and values were noted.

5.6. Alkalinity
Alkalinity is referred to as the capability of water to neutralize the acid. Alkalinity acts as a buffer if any changes are made to the water’s pH value. Alkaline water has a higher pH level than the drinking water. Alkalinity in water causes sediment deposit and also causes corrosion. The Alkalinity of water can be determined by the following method. 20 ml of sample is taken and few drops of HIn(phenolphthalein) were added in the conical flask. If the colour of the solution was changed to pink, then it should be titrated against standard acid 2N HCl until the pink colour disappears. Then few drops of methyl orange indicator were added to the solution. The solution was titrated against 2N HCl until the pink colour appears. The concordant values are measured from the titrations and the alkalinity of water sample was calculated.
5.7. Electrical conductivity and total dissolved solids:
The amount of total dissolved substances, chemicals and minerals present in the water is estimated as Electrical conductivity. It also indicates the salinity which helps to identify the purity of water. Total dissolved solids estimates the amount of inorganic materials such as calcium, magnesium, potassium, chloride, sulphate and sodium and small amount of organic matters present in water. It indicates the quality of water. The electrical conductivity and total dissolved solids in water can be resolved by the following method. The electrode in electrical conductivity meter was removed, washed and cleaned with soft tissue paper. Then it was dipped in the standard solution 0.01 KCl and the instrument was calibrated. Once the instrument was calibrated, the cell constant was found out. The electrode was again removed, washed and cleaned. Then the electrode was dipped in the water sample and electrical conductivity was obtained. The instrument was aborted and TDS in the water sample was obtained.

6. Results

6.1. Sample collected during January 2020
The following table 2 gives the results of the test conducted on the sample collected during January 2020.

| Test parameter | Bhavani | Appakuda | Athani | Kodiveri | Sirumugai | Mettupalayam | Standard value as per IS 10500-2012 |
|----------------|---------|----------|--------|----------|-----------|--------------|-----------------------------------|
| pH             | 7.61    | 8.24     | 7.71   | 8.53     | 8.69      | 8.27         | 6.5-8.5                           |
| Chloride (mg/l)| 73.74   | 64.52    | 110.60 | 73.74    | 147.47    | 46.08        | 250 mg/l                          |
| Dissolved oxygen (mg/l) | 5.83 | 6.21 | 3.88 | 5.83 | 5.44 | 6.60 | 5-8 mg/l |
| Turbidity (NTU) | 7       | 10       | 5      | 1        | 12        | 1NTU                      |                                    |
| Sulphate (mg/l) | 8       | 16       | 156    | 382      | 407       | 571          | 400 mg/l                          |
| Total Alkalinity (mg/l) | 25 | 25 | 35 | 20 | 25 | 20-200mg/l |                                    |
| Electrical conductivity | 511.8   | 355.4    | 640.8  | 326.5    | 700.1     | 731          | 300μs                             |
| TDS(ppm)       | 233.8   | 176      | 324.5  | 160.6    | 347.8     | 360.4        | 300ppm                            |

6.2. Sample collected during February 2020
The following table 3 gives the results of the tests conducted on the sample collected during February 2020.

| Test | Bhavani | Appakuda | Athani | Kodiveri | Sirumugai | Mettupalayam | Standard value as per IS 10500-2012 |
|------|---------|----------|--------|----------|-----------|--------------|-----------------------------------|
| pH   | 7.61    | 8.24     | 7.71   | 8.53     | 8.69      | 8.27         | 6.5-8.5                           |
| Chloride (mg/l) | 73.74 | 64.52 | 110.60 | 73.74 | 147.47 | 46.08 | 250 mg/l |
| Dissolved oxygen (mg/l) | 5.83 | 6.21 | 3.88 | 5.83 | 5.44 | 6.60 | 5-8 mg/l |
| Turbidity (NTU) | 7 | 10 | 5 | 1 | 12 | 1NTU |                                    |
| Sulphate (mg/l) | 8 | 16 | 156 | 382 | 407 | 571 | 400 mg/l |
| Total Alkalinity (mg/l) | 25 | 25 | 35 | 20 | 25 | 20-200mg/l |                                    |
| Electrical conductivity | 511.8 | 355.4 | 640.8 | 326.5 | 700.1 | 731 | 300μs |
| TDS(ppm) | 233.8 | 176 | 324.5 | 160.6 | 347.8 | 360.4 | 300ppm |
### Water Quality Parameters

| Parameter          | Value 1 | Value 2 | Value 3 | Value 4 | Value 5 | Value 6 | Value as per IS 10500-2012 |
|--------------------|---------|---------|---------|---------|---------|---------|---------------------------|
| pH                 | 7.67    | 7.64    | 6.96    | 8.4     | 7.32    | 6.88    | 6.5-8.5                   |
| Chloride (mg/l)    | 76.57   | 67      | 76.57   | 67      | 134     | 143     | 250 mg/l                  |
| Dissolved oxygen (mg/l) | 6.214  | 4.66    | 2.72    | 7.77    | 4.272   | Nil     | 5-8 mg/l                  |
| Turbidity (NTU)    | 1.1     | 2.7     | 3.1     | 4       | 5.2     | 6.1     | 1NTU                      |
| Sulphate (mg/l)    | 20      | 164     | 144     | 189     | 444     | 185     | 400 mg/l                  |
| Total Alkalinity (mg/l) | 15    | 25      | 25      | 25      | 35      | 30      | 20-200mg/l                |
| Electrical conductivity | 500.4 | 346.6   | 428.1   | 379.5   | 805.5   | 583     | 300μs                     |
| TDS(ppm)           | 245.6   | 179.1   | 209.9   | 186.6   | 336.4   | 284.6   | 300ppm                    |

6.3 Analysis of water quality parameters
The following are the pictorial depiction of various water quality parameters tested for the samples collected during the period of Jan-2020 and Feb-2020. Figure 3 shows the Variation of pH, Chloride, Dissolved oxygen, Sulphate at six locations. Figure 4 shows the Results of water quality parameters at various locations.
Figure 3. Variation of pH, Chloride, Dissolved oxygen, Sulphate at six locations
Figure 4. Results of water quality parameters at various locations

7. Conclusion

Based on the various criteria six locations were selected along the study area, four among them from lower Bhavani and two from upper Bhavani. Samples were collected from six locations during two different periods (Jan 2020 and Feb 2020). Water samples collected were tested for water quality parameters such as pH, electrical conductivity, TDS, alkalinity, dissolved oxygen, sulphate, chloride, hardness, turbidity and Biochemical Oxygen Demand (BOD). Based on the results it was observed certain parameters like sulphate and chloride contents were slightly above the permissible values. It was identified that almost all the sampling locations were found to source for disposal of domestic and industrial wastewater either directly or indirectly. Hence the water as such cannot be used as source of water supply without proper treatment.
Attempt has been made to formulate Water Quality Index (WQI) based on the results obtained. But as the sampling points, sampling period and parameters are less, the results of WQI may be not as accurate as anticipated. Regular monitoring of river is required to check the variations in the water quality parameters during different flow conditions. Effluent disposal standards are to be monitored for the disposal of wastewater from domestic sources and industrial sources. It is necessary to educate about water related disease in the villages near the river to stop the residents from using the untreated water for domestic purposes.

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