Study of Self Depuration Capability of River Pamba

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Abstract. The natural waterbody such as rivers and lakes are able to do the purification process themselves, which has the primary dependant of absorption capacity and dissolution capacity of atmospheric oxygen from the surface of the water body. The various pollutants such as biological pollutants and chemical pollutants are broken-down into insignificant strength over a period of time by the growth of certain bacteria. This bacterial growth in the water is possible only with the absorbed and dissolved oxygen content in the water. This absorbed and dissolved oxygen content in the water bodies are based on the velocity of the stream, depth, discharge rate and temperature of the water, thus the self-depuration capacity of the water bodies are depended on the natural profiles and environmental factors of the waterbody and its location. This explains that the turbulent water will get purified by itself in much higher rate than the stagnant water, which tends to become septic because of the oxygen scarcity. The degree of self-depuration of a natural water body is based on the physiochemical and biological activities occurring in the system. Various parameters like basic physical properties, chemical properties such as pH, hardness, dissolved solids, mineral content, BOD, dissolved oxygen for the samples were taken along the Pamba River. The samples are taken from three zones of the Rivers viz. 1) Forest zone, 2) Residential zone and 3) Industrial zone. The water quality factors from the samples are validated against the desirable values as per IS 10500: 2012 and justifies the current status of the River and recommendations for its wellbeing.

Keywords: Self-depuration, Dissolved Oxygen, Contamination, Environmental degradation.

1. Introduction

The competence of a River to self-depurate is based on its current pollution stage and the available environmental factors which supports to enhance the dissolved oxygen (DO) level, where the DO is the only source to develop the bacterial content in the water that breaks down the chemical, biological pollutants and toxics in the waterbody. The DO is naturally incorporated into the waterbody through the turbulence. Even after sufficient turbulence effect, if the water quality contamination rate is uncontrollably higher, the self-depuration duration will become singularity. The desired DO content is about 2.0 mg/L to maintain the life forms in the water, but, generally when the DO drops below the 4mg/L the life forms begin to reduce below the undesired level.
Metha (2010) studied the different samples of ground water in Vadgam taluk of Gujarat state for the properties such as turbidity, electrical conductance, pH, etc. and compared with the standard drinking water parameters as per ICMR and EU (1998). He concluded with possible measures to be followed to control the ground water quality as per standards. Gabriel (2010) performed an analysis on the quality of groundwater used for drinking and irrigation in the Yola district of NE Nigeria by correlating the TDS and electrical conductivity (EC) values. Also, the salt content and heavy metal content of the water samples were studied and groundwater quality was predicted using linear regression equations. Reddy & Lakshmi (2019) developed a statistical predictive model for the quality profile of groundwater in the Prakasam district, Andra Pradesh. Biological, physical and chemical parameters as per standards were studied for the collected and compared by the correlation coefficient. The results are compared with the water quality standards as per WHO (World Health Organization). The impact of heavy metals in waste water, methods to determine and identify the various heavy metals in the waste water, such as optical plasma spectrometry, mass spectrometry, etc. and, the process and procedures to remove those heavy metals from the waste water were described (Baysal et al. (2013), Reddy et al., (2012)). The physiochemical properties of the water samples were studied at various test points and resulted with the compatibility of the water for drinking and irrigation usages as per the World Health Organization recommendations. (Yadav & Rajesh (2011), Heydari et al. (2013), Tian et al. (2011) performed research on the self-purification capacity of the Juma River in China by sampling the water and aquatic plants for analysing the pollution level. The authors conclude by recommending an aquatic plant with greater organic pollutant absorbing capacity to control the river’s pollution. Ostromov (2005) studied the basic theories of water self-purification in fresh and marine eco-system. Studies on the impact of toxic pollution in river water due to domestic, industrial and agricultural pesticide runoff, were evaluated and compared with various factors of polluted water such as BOD, total suspended solids, toxicity level, etc. with respect to the WHO standards (Raghav & Shrivastava (2016), Schulz & Peall (2001)). Jain & Shrivastava (2014) compared the localized physical and chemical properties of Katraj Lake in Pune with standard values as per authorities and sensitized the awareness among the people to save the lake from reaching the state of the septic.

Nath et al. (2018) studied the Brahmi River in Odisha by multivariate statistical method such as factor analysis, principal component of analysis for the samples taken at various places along the stream. Comparing the complex relationship among the pollutant factors and arrived the ways to improve the quality of the water of the river. Kumaraswamy & Sivanandham (2009) estimated the current level of pathogenic pollution indicators in the River Cavery of Tamilnadu by collecting samples from 16 sites along the river during various climates throughout the year. It was concluded with various reasons that causes pollution and intensity of the pollution in the river. Divahar et al. (2019) studied the impact of textile effluent pollution in the Kalingarayan canal of Erode district arrived with the water samples and compared the water quality recommendations as per BIS with the values. The author concludes that the excess discharge of the industrial effluent is the reason for the deviation of the water parameters form standards. Divahar et al. (2020) assessed the ground water quality of the areas around the Kalingarayan canal in Erode, by collecting nine samples from the downstream side of the canal in the period around the year of 2014-2016. It is suggested that the ground water has enough hardness and toxicity to make it not recommendable for edible purposes (Divahar et al. (2020)).

The scope of this study is to find out the self-depuration competence of the River Pamba. The project will estimate the ability of the river for self-purification with respect to the current polluted state. The Pamba River is the third longest river in the South Indian state of Kerala. The Pamba Originated originates at a Pulachimalai hill in the Peerumedu plateau in the Western Ghats at an altitude of 1,650 metres (5410 ft) and flows through Chittitar, Ranni, Keezhukara, Arattupuzha, Edanad, Pathencavu, Mannar, Kadapra, Melpadom, Thevery, Pallathuruthy and one of its ends is at Vembanad Lake and the other end is at Thottappally Spillway via Karuvatta district. The major length of River Pamba is flowing through the forest region, the profile of the river bed consists of lot of pebbles and stones as per the observations. Urbanization,
industrialization and population increase around the basin of Pamba are considered as the major cause for the excessive pollution. Different physicochemical and biological test on water samples collected from various zones and the test results are evaluated with respect to the Bureau of Indian Standards (IS 10500:2012).

2. Experimental Programme

2.1 Collection of Water Sample

In order to study the real characteristic of the pollution stage of the River under the scope of the study, the samples were collected along the river at various zones such as forest zone, residential zone and industrial zone. The location of the sample collection spots in the respective zones are given in Table 1.

| Sl.No. | Zone       | Station 1   | Station 2   |
|-------|------------|-------------|-------------|
| 1     | Forest     | Ranni       | Chittar     |
| 2     | Residential| Aranmula    | Kozhencherry|
| 3     | Industrial | Chengannur  | Edanad      |

2.2. Tests on samples

Water samples collected were tested for various physiochemical parameters. The characteristic values of the samples collected were compared with the respective limitations for the parameter prescribed by Indian Standard (IS) 10500. The physical properties studied were colour, odour, temperature, turbidity, taste form a batch of samples and chemical properties such as pH, total hardness, dissolved solids, dissolved oxygen (DO) and biological oxygen demand (BOD) are studied. The mineral contents such as calcium, fluorine, magnesium, copper, sulphate, nitrate and aluminium were also analysed from the water samples sorted. The recommended limits of the physical and chemical properties as per IS 10500: 2012 are shown in Table 2.

| Properties       | Desirable limit | Properties       | Desirable limit |
|------------------|-----------------|------------------|-----------------|
| Colour           | <5 u            | Fluoride         | <1 mg/l         |
| Turbidity        | 1- 5 NTU        | Chloride         | 250 mg/l        |
| pH               | 6. 5- 8. 5      | Hardness         | 200 mg/l        |
| Conductivity     | 5- 50           | Residual Chlorine| 0. 1- 0. 2 mg/l |
| Acidity          | 200 mg/l        | Dissolved oxygen | >13 mg/l        |
| Alkalinity       | 200 mg/l        |                  |                 |
2.3. Results

The physical properties such as colour, odour, taste and turbidity of the water samples collected from different zones of the river are shown in Table 3.

**Table 3. Physical Properties of Samples**

| Sl. No. | Parameter | Zone 1      | Zone 2      | Zone 3      |
|---------|-----------|-------------|-------------|-------------|
| 1       | Colour    | 1 HU unit max | 3 HU unit max | 5 HU unit max | 6 HU unit max | 7 HU unit max |
| 2       | Odour     | unobjectionable | unobjectionable | objectionable | objectionable | objectionable |
| 3       | Taste     | unobjectionable | unobjectionable | objectionable | objectionable | objectionable |
| 4       | Turbidity | 1 NTU max | 2 NTU max | 6 NTU max | 4 NTU max | 7 NTU max | 9 NTU max |

The chemical and physiochemical properties such as pH, total hardness, iron (Fe) content, Chloride (Cl) content, dissolved solids, calcium (Ca) content, Magnesium (Mg) content, copper (Cu) content, Manganese (Mn), Sulphate (as SO₄), Nitrate (as NO₃), Alkalinity (as CaCO₃), Boron (B), Arsenic (As) content, Cyanide (CN) content, Phenolic compounds, Zinc (Zn) content, Chromium (as Cr⁶⁺), Fluoride (F) content and Aluminum (A) content of the water samples collected from different zones of the river are shown in Table 4.

**Table 4. Physical Properties of Samples**

| Sl. No. | Parameters | Zone 1      | Zone 2      | Zone 3      |
|---------|------------|-------------|-------------|-------------|
| 1       | pH         | 6.5 | 6 | 7.5 | 7.9 | 7.8 | 8.2 |
| 2       | Total Hardness | 16 mg/L max | 21 mg/L max | 213 mg/L max | 220 mg/L max | 316 mg/L max | 329 mg/L max |
| 3       | Fe         | Not detected | Not detected | 0.3 mg/L max | 0.2 mg/L max | 0.5 mg/L max | 0.53 mg/L max |
| 4       | Cl         | Not detected | Not detected | 261 mg/L max | 256 mg/L max | 308 mg/L max | 316 mg/L max |
| 5       | Dissolved Solids | 16 mg/L max | 29 mg/L max | 200 mg/L max | 216 mg/L max | 425 mg/L max | 453 mg/L max |
| 6       | Ca         | Not detected | Not detected | 100 mg/L max | 108 mg/L max | 120 mg/L max | 110 mg/L max |
| 7       | Mg         | Not detected | Not detected | 36 mg/L max | 39 mg/L max | 40 mg/L max | 46 mg/L max |
| 8       | Cu         | Not detected | Not detected | 0.03 mg/L max | 0.02 mg/L max | 0.05 mg/L max | 0.04 mg/L max |
| Sl. No. | Parameters | Zone 1 | Zone 2 | Zone 3 |
|--------|------------|--------|--------|--------|
|        | Station 1  | Station 2 | Station 1 | Station 2 | Station 1 | Station 2 |
| 9      | Mn         | Ranni   | Chittar | Aranmula | Kozhencherry | Chengannur | Edanad |
|        | Not detected | Not detected | 0.08 mg/L max | 0.06 mg/L max | 0.2 mg/L max | 0.1 mg/L max |
| 10     | SO₄        | Not detected | Not detected | 190 mg/L max | 198 mg/L max | 218 mg/L max | 232 mg/L max |
| 11     | NO₃        | Not detected | Not detected | 38 mg/L max | 44 mg/L max | 48 mg/L max | 60 mg/L max |
| 12     | Alkalinity as CaCO₃ | 15 mg/L max | 22 mg/L max | 190 mg/L max | 196 mg/L max | 234 mg/L max | 256 mg/L max |
| 13     | B          | Not detected | Not detected | Not detected | Not detected | 0.8 mg/L max | 0.7 mg/L max |
| 14     | As         | Not detected | Not detected | Not detected | Not detected | 0.04 mg/L max | 0.04 mg/L max |
| 15     | CN         | Not detected | Not detected | Not detected | Not detected | Not detected | Not detected |
| 16     | Phenolic Compounds | Not detected | Not detected | 0.02 mg/L max | 0.01 mg/L max | 0.2 mg/L max | 0.4 mg/L max |
| 17     | Zn         | Not detected | Not detected | Not detected | Not detected | 4 mg/L max | Not detected |
| 18     | Cr⁶⁺       | Not detected | Not detected | Not detected | Not detected | Not detected | Not detected |
| 19     | F          | 0.3 mg/L max | 0.4 mg/L max | 1.8 mg/L max | 2 mg/L max | 1.1 mg/L max | 1.8 mg/L max |
| 20     | Al         | Not detected | Not detected | 0.01 mg/L max | 0.01 mg/L max | 0.5 mg/L max | 0.1 mg/L max |

The Biological oxygen demand and dissolved oxygen values of the samples collected from various zones and stations as classified are given in Table 5. The variation of the average BOD and DO across the zones are represented in Figure 1 and Figure 2 respectively.

**Table 5. Test Results of DO and BOD**

| Parameter | Zone 1 | Zone 2 | Zone 3 |
|-----------|--------|--------|--------|
|           | Station 1: Ranni | Station 2: Chittar | Station 1: Aranmula | Station 2: Kozhencherry | Station 1: Chengannur | Station 2: Edanad |
| DO        | 5.0 mg/L | 5.4 mg/L | 2.2 mg/L | 3.2 mg/L | 2.9 mg/L | 3.5 mg/L |
| BOD       | 124 mg/L | 102 mg/L | 193 mg/L | 147 mg/L | 242 mg/L | 158 mg/L |
3. Discussions

Based on the physical, chemical and biological characteristic analysis of the water samples of River Pamba from various zones, following discussions are arrived.

3.1. Forest zone

Compared to the residential and industrial zones, forest zone is least polluted. The water samples exhibited no bad odour and had least turbidity. The average pH value of water sample denotes that the water is slightly acidic in nature. As compared to the other two zones the DO level was higher and the BOD level was lower, this indicates that this zone contains least amount of organic matter. In this zone the river bed was characterized by a combination of course sand, fine sand and pebbles, where the impurities are held between spaces of media and also the course the of river helps in aeration of the water. Abundant fine sand content was observed in the river bed of the forest zone and the water flow was found to be vigorous with clear water.

3.2. Residential zone

This zone lies between the forest zone and industrial zone in terms of pollutant levels. The water samples gathered at this zone exhibited bad odour caused due to the dense population around the basin. The water was observed to be alkaline and consisted of chlorine, calcium and magnesium due to the anthropogenic activities and discharge of sewage from nearby sewers.
Both river stream in this zone had floating non-biodegradable wastes and debris such as plastic materials. The DO level was least in this zone because of the accumulation of various particles in the river bed. This zone is also subjected to heavy discharge from municipal sewers. The riverbed in this zone possess very small amount of broken stones and some amount of fine sand which is not sufficient for straining the impurities. The fluctuating flow rate of the river stream in this zone slows down the self-purification process.

3.3. Industrial zone

This zone is the most polluted among all the zones as per the characteristics results. The water from the zone had a foul smell of ammonia, light brown in colour and was more turbid than the water samples from other two zones. The average pH of the water in the zone was found to be 8 which indicates that the water is alkaline in nature. Despite having waste water treatment systems in the industries like brick and tiles manufacturers, the discharge consisted of chlorine, calcium, magnesium, sulphur and certain other elements. The BOD level in this zone is higher than other two zones, this indicates the presents of organic matter present in the water. The flow velocity of this region is average in nature due to the deviation of the river, also the river bed in this region possess very least amount of coarse sand and fine sand compared to the other two zones. Aquatic plants such as algae were also present in the water.

4. Conclusions

Self-purification competence of a natural stream has its ability to purify itself by removing the impurities present in the water by natural factors. After conducting the test and evaluating the results it is evident that there is self-purification process happening at a longer distance than in the expected sampling point. The flow velocity of river Pamba is varying in each zone, this velocity affects the self-purification efficiency of each zone. The forest zone has higher self-purification efficiency than residential and industrial zones, this is because in forest zone there is less inclusion of waste water and also this part of the river flows through the forest region. It is also found that quality of water is in a deteriorating condition at residential and industrial zones. Compared to industrial zone, residential zone has a high rate for self-purification because the river bed in residential zone possess broken stones, fine and course sand these act as a filter media for straining the impurities. In residential and industrial zones proper inspections should be done so as to ensure that the discharge sewage. Artificial methods can be adopted in industrial zone to enhance its purification process. Hence the self-purification process would be achieved if the river possess a moderate flow velocity, which reflects the outcome at some distance away from the station points.

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