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# THE WATER QUALITY OF ULHAS RIVER AT RAYATE - THREE YEARS CASE STUDY

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***Abstract:*** The paper presents a case study involving the physico-chemical analysis of Ulhas River water at Rayate village. The analysis was done for a span of thirty-six months from January 2016- December 2018. The Ulhas River passes through various villages on its course, including Rayate village. This river acts as a source of 60% of the potable water provided to these villages. The river water also sustains aquatic life like fishes. The local residents at Rayate village utilize this river water for drinking purposes, agricultural activity and animal husbandry. The anthropogenic activities affect the quality of water. Thus affecting the aquatic ecosystem. Therefore, it is important to check the levels of contamination. The water quality needs to be monitored for a longer period of time on a monthly basis. Hence, such study was undertaken to determine the extent to which the water quality deteriorated. The parameters studied include Temperature, pH, Conductance, BOD, COD, Acidity, Alkalinity, TSS, TDS and Total Hardness. Parameters like temperature and pH were monitored on-site whereas Conductance, BOD, COD, Acidity, Alkalinity, TSS, TDS and Total Hardness were monitored in lab. The results obtained on performing the tests were further compared with the standard values provided by BIS, EPA and WHO. The values of Conductance, BOD, COD, TDS and Total Hardness are higher than the acceptable standards, thus indicating the dire state of the river water at this sampling site. The effect of one parameter affecting another was deduced by conducting statistical analysis using Karl Pearson's coefficient of correlation.

***Index Terms* - *Ulhas* River, BOD, COD, Karl Pearson's coefficient of correlation, physico-chemical analysis, anthropogenic activities**

## I. INTRODUCTION

Water plays an important role in sustaining life on Earth, hence water bodies must be well maintained. It is timely proven that anthropogenic activities lead to detrimental effects on the water bodies (Lal 2000). Further, these polluted water bodies lose their aesthetic appeal and cannot be used for recreational activities as well. In the 'Mumbai Metropolitan Region' (MMR), the Ulhas River and Patalganga River is used as a source of potable water in the upper reaches while using it for effluent discharge in its lower reaches (INDIRA GANDHI INSTITUTE OF DEVELOPMENT RESEARCH, MUMBAI (2005). When a river gets contaminated by domestic and industrial waste, it eventually contaminates the sea. Contaminated waters, due to reduced levels of Dissolved Oxygen (DO), threaten aquatic life and also spread water borne diseases (Jadhav & Singare, 2015). Hence, pollution levels of such water bodies need to be regularly monitored.

Water analysis is analyzing the chemical, physical, biological, and radiological characteristics of water. It helps to deduce the quality of water and categorize it according to the requirements while comparing it with respective standards used for reference. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and water potability. Such tests include determination of physico-chemical parameters (Midhun et. Al. 2016).

Temperature of water needs to be optimum to support life as water forms a vital component in any biological medium in which a reaction occurs. Thus, the drastic temperature changes due to thermal pollution can be fatal to aquatic beings (Patil et. Al. 2012). The temperature of a water body influences the rate of metabolism of aquatic organisms, thereby influencing the DO in water (Pal & Chakraborty, 2014). High temperatures reduce the amount of DO, creating anoxic environment leading to the death of aerobic organisms in water.

Likewise, pH levels need to be optimum for the good health of the biodiversity of an aquatic ecosystem. Lower the pH value higher is the corrosive nature of water (Pal & Chakraborty, 2014). While a high pH increases the toxicity of other substances. For example, ammonia becomes ten times more toxic at a pH of 8 than it is at pH 7. Hence, discharges containing low concentration of ammonia are generally permitted.

Conductivity indicates the amounts of ionic salts present in water. It is affected by presence of dissolved inorganic solids having anions like chlorides, nitrates, sulphates, phosphates, and cations like sodium, magnesium, calcium, iron, aluminum. Sewage water has high amounts of chlorides, phosphates and nitrates which are present in the form of dissolved solids (Kumar & Sinha, 2010).
The amount of dissolved solids present in water determines its suitability for domestic use. The Total Dissolves Substances (TDS) present in water are majorly carbonates, bicarbonates, chlorides, phosphates, calcium and magnesium, among others. The high content of dissolved solid increases the density, turbidity, hardness, salinity, etc. and also decreases the solubility of oxygen in water. High TDS causes respiratory ailments in fishes and may prove to be fatal (Bhateria & Jain, 2016).

The Total Suspended Solids (TSS) include organic materials like algae and inorganic materials like silt and sediment that get easily suspended due to seasonal flow of water (EPA, 2012). High TSS levels absorbs sunlight, increasing the surface water temperatures thus decreasing DO of the water body (EPA, 2012). The dissolved metals and pathogens when get attached to these suspended solids, they enter into the water body and contaminate it (Perlman, 2014). It is difficult to disinfect turbid water as the suspended solids "hide" these pathogens (http://www.who.int/water_sanitation_health/hygiene/emergencies/fs2_33.pdf). The prediction of TSS levels and set standards is not easy. According to The National Academy of Sciences "TSS should not reduce light penetration by more than 10%" (http://ky.gov/nrepc/water/ramp/rmtss.htm). The European Protection Agency (EPA) has created guidelines for discharge of the effluent, but considering the technology used rather than the final impact on the local water body (EPA, 2014). The unintentional discharge of the runoff from farms carry the fertilizer and animal waste, which is detrimental to the water body that receives it (NOAA, 2008). Animal wastes increases pathogen concentrations in the water, while fertilizer is responsible for eutrophication. High TSS and TDS values reduce the visibility, affects feeding behaviors and cause physical damage to the aquatic life.

Biological Oxygen Demand (BOD) measures the organic pollutants in the water sample (Premlata, 2009). High BOD levels represent that water is under anoxic pressure which does not support aquatic life. Chemical Oxygen Demand (COD) is always higher than BOD for a water sample as it oxidizes organic as well as inorganic contaminants. Higher BOD than COD indicates extreme levels of organic waste and high organic Nitrogen or Ammonium ions in the wastewater. The high levels of Nitrogen are responsible for algal blooms leading to eutrophication of the water body (Zhu et. Al., 2013).

Alkalinity acts as a stabilizer for pH. Alkalinity, pH and Total hardness affect the toxicity of many substances in the water. Alkalinity value less than 100 mg/L is desirable for domestic use. Alkalinity if very high, fails to buffer the pH and risks the life of marine creatures. It is contributed by carbonates and bicarbonates present in the river bed naturally (Patil et. Al. 2012).

The organic acids in combination with catchment sources of sulphates are the responsible for increasing acidity levels in water body (Clair et. Al., 2007). Nitrogen and sulphur oxide emissions come from microbial process and anthropogenic sources. These compounds when mix with water vapor at unusual proportions, acid deposition occurs. The high levels of Acidity in water affects the reproductive cycles in fish, also affects the larval development (Singh & Agrawal, 2007).

Discharge of sewage, effluents may elevate levels of hardness. The high amount of hydroxide ions can lead to algal bloom causing eutrophication. The total hardness is the sum of hardness contributed by carbonate hardness and non-carbonate hardness. The carbonate hardness is responsible for alkalinity in water which is due to presence of carbonates, bicarbonates and hydroxides of Calcium and Magnesium. Whereas non-carbonate hardness is due to presence of chlorides, sulphates and nitrates of Calcium and Magnesium ions (Singare & Dhabarde 2017).

The statistical correlation within these parameters were studied by applying Karl Pearson's Coefficient of Correlation.
Karl Pearson's Coefficient of Correlation is a mathematical method used to calculate the degree and direction of the relationship between linear related variables. The 'Coefficient of Correlation' is denoted by "r". If the relation between two variables A and B is to be ascertained, then the following formula is used:

$$r = \frac{\sum(A-\bar{A})(B-\bar{B})}{\sqrt{\sum(A-\bar{A})^2}\sqrt{\sum(B-\bar{B})^2}}$$

Where, $\bar{A}$ = mean of A variable
$\bar{B}$ = mean of B variable

i. The value of the Coefficient of Correlation (r) lies between ±1. Viz.:

   r = +1, perfect positive correlation

   r = -1, perfect negative correlation

   r = 0, no correlation

ii. The coefficient of correlation do not depend on the origin and scale. By origin, it means subtracting any non-zero constant from the given value of A and B the value of "r" remains unchanged. By scale it means, there is no effect on the value of "r" if the value of A and B is divided or multiplied by any constant.

iii. The Coefficient of Correlation is a geometric mean of two regression coefficient. It is represented as: $r = \sqrt{c_{ab} + c_{ba}}$

iv. The coefficient of correlation is 'zero' when the variables A and B are independent but the converse is not true.

***Study area***

The water from the Ulhas River near village Rayate, Kalyan is majorly used by the local residents for drinking and agricultural activities. In addition, cattle shed near the site also utilizes this water. Ulhas River from the point of origin (Rajmachi hills, Western Ghats, Maharashtra) flows north turning left where it is joined by River Salpe. The 60% of potable water provided to the villages it passes is provided by this river that finally flows into the Vasai Creek. The Ulhas basin lies between North latitudes of 18º 44’ to 19º 42’ and East longitudes of 72º 45’ to 73º 48’. The study was carried out using Ulhas river water sample collected from village Rayate (latitude - 19.247287 and longitude - 73.117547) (ESRMMR, 2015). There is a difference of 1100-1200 mm of precipitation between the driest and wettest months. The variation in annual temperatures is around 8°-9°C (https://en.climate-data.org).

For this study secondary data has been collected. From the website of KSE the monthly stock prices for the sample firms are obtained from Jan 2010 to Dec 2014. And from the website of SBP the data for the macroeconomic variables are collected for the period of five years. The time series monthly data is collected on stock prices for sample firms and relative macroeconomic variables for the period of 5 years. The data collection period is ranging from January 2010 to Dec 2014. Monthly prices of KSE -100 Index is taken from yahoo finance.

## II. Materials and Methods

The samples were analyzed by Standard procedures of Bureau of Indian Standards (BIS) and the results were compared with standards given by BIS. The presence of different radicals in the water samples were qualitatively analyzed as per Vogel’s handbook. The various methods used to study the different parameters are tabulated in Table number 1.

| Sr. No. | Parameter Studied | Method used |
|---|---|---|
| 01 | Sampling method | Grab method |
| 02 | Acidity | Acid Base Titration |
| 03 | Alkalinity | Acid Base Titration |
| 04 | Biological Oxygen Demand | Wrinkler’s method |
| 05 | Chemical Oxygen Demand | Closed Reflux method |
| 06 | Conductance | Conductivity meter |
| 07 | pH | On site - pH meter |
| 08 | Temperature | On site - Thermometer |
| 09 | Total Dissolved Solids | Gravimetric method |
| 10 | Total Suspended Solids | Gravimetric method |
| 11 | Total Hardness | Complexometric Titration |

Analytical grade chemicals and reagents of Merck Limited and Loba Chemie Pvt. Ltd. were used without any further purification. All the parameters were analyzed on a monthly basis for the period January 2016 – December 2018.

***Sample Planning, Collection & Preservation***

Sampling from the Ulhas River near Rayate area was done using grab sampling technique. Samples were collected and analyzed on a monthly basis for thirty six months. Cleaned polyethylene cans were used for sample collection, which after filling completely were sealed air tight.

## III. Results and Discussion

The experimental data on physico-chemical properties of samples collected from along the Ulhas River of Maharashtra are presented in Table 2.

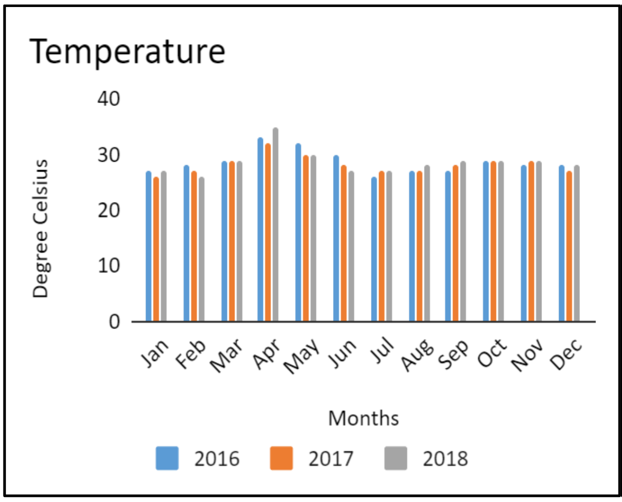
**Table. No. 2 - Physico-Chemical Properties of water sample collected from Ulhas River at Sampling point.**

| Year | Month | Temperature (°C) | pH | Conductance (µS/cm) | B.O.D (ppm of $O_2$) | C.O.D (ppm of $O_2$) | Acidity (ppm of $CaCO_3$) | Alkalinity (ppm of $CaCO_3$) | TSS (mg/L) | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | **Jan** | 27 | 7.4 | 146.8 | 3.5 | 6.8 | 9.5 | 71.9 | 148.9 | 223.0 |
| | **Feb** | 28 | 7.9 | 203.3 | 6.7 | 9.0 | 1.8 | 78.0 | 158.0 | 645.0 |
| | **Mar** | 29 | 7.7 | 270.0 | 3.0 | 12.0 | 8.0 | 100.0 | 176.2 | 13466.0 |
| | **Apr** | 33 | 8.3 | 12140.0 | 2.1 | 18.0 | 2.0 | 67.7 | 97.8 | 1190.0 |
| | **May** | 32 | 7.7 | 2060.0 | 1.3 | 18.4 | 4.0 | 59.8 | 63.8 | 146.0 |
| | **Jun** | 30 | 7.4 | 1531.5 | 0.4 | 42.0 | 2.0 | 63.6 | 425.0 | 613.4 |
| | **Jul** | 26 | 7.7 | 750.0 | 0.9 | 35.0 | 2.4 | 59.4 | 310.0 | 360.0 |
| | **Aug** | 27 | 7.6 | 720.0 | 2.9 | 16.4 | 5.1 | 112.0 | 380.0 | 573.3 |
| | **Sept** | 27 | 7.5 | 202.0 | 0.2 | 10.0 | 11.0 | 110.6 | 240.0 | 506.7 |
| | **Oct** | 29 | 7.5 | 1050.0 | 0.6 | 9.5 | 9.0 | 158.9 | 291.2 | 7186.7 |
| | **Nov** | 28 | 7.6 | 144.0 | 0.3 | 9.4 | 8.0 | 30.6 | 130.0 | 13866.7 |
| | **Dec** | 28 | 7.5 | 136.0 | 0.3 | 12.0 | 13.2 | 62.7 | 140.0 | 150.0 |
| 2017 | **Jan** | 26 | 7.6 | 150.0 | 1.2 | 7.2 | 10.8 | 60.0 | 175.0 | 245.0 |
| | **Feb** | 27 | 7.5 | 252.5 | 6.5 | 8.9 | 2.0 | 80.0 | 182.0 | 510.0 |
| | **Mar** | 29 | 8.2 | 355.0 | 3.5 | 14.0 | 1.9 | 95.7 | 193.2 | 600.0 |
| | **Apr** | 32 | 8.4 | 24000.0 | 1.3 | 19.0 | 1.6 | 90.2 | 170.0 | 1240.0 |
| | **May** | 28 | 7.9 | 4000.0 | 0.4 | 16.7 | 3.4 | 63.9 | 150.0 | 574.6 |
| | **Jun** | 28 | 8.4 | 2900.0 | 0.8 | 53.6 | 1.9 | 70.5 | 300.0 | 40.0 |
| | **Jul** | 27 | 8.0 | 34000.0 | 1.3 | 38.4 | 1.9 | 81.3 | 470.0 | 626.7 |
| | **Aug** | 27 | 7.9 | 19000.0 | 2.2 | 17.0 | 1.6 | 33.0 | 430.0 | 133.3 |
| | **Sept** | 28 | 8.1 | 27000.0 | 0.2 | 14.0 | 2.0 | 31.8 | 220.0 | 93.3 |
| | **Oct** | 29 | 7.7 | 2000.0 | 0.4 | 3.1 | 2.0 | 33.6 | 280.0 | 173.3 |
| | **Nov** | 29 | 8.0 | 90.0 | 0.4 | 4.9 | 1.8 | 31.6 | 100.0 | 613.3 |
| | **Dec** | 27 | 8.1 | 130.0 | 0.9 | 11.9 | 2.0 | 35.2 | 220.0 | 0.5 |
| 2018 | **Jan** | 27 | 7.8 | 143.5 | 4.1 | 7.9 | 11.0 | 35.0 | 172.3 | 340.0 |
| | **Feb** | 26 | 8.4 | 154.0 | 6.8 | 9.3 | 1.6 | 33.2 | 160.0 | 547.0 |
| | **Mar** | 29 | 8.3 | 440.0 | 3.3 | 16.0 | 2.0 | 38.5 | 187.2 | 100.0 |
| | **Apr** | 35 | 7.9 | 280.0 | 2.9 | 20.0 | 2.0 | 57.5 | 193.4 | 1300.0 |
| | **May** | 30 | 7.5 | 120.0 | 2.2 | 30.0 | 4.4 | 62.4 | 200.0 | 160.0 |
| | **Jun** | 27 | 7.4 | 163.0 | 0.5 | 68.5 | 2.2 | 68.0 | 550.0 | 1186.7 |
| | **Jul** | 27 | 7.5 | 9731.5 | 0.5 | 52.4 | 2.8 | 71.9 | 1,520 | 493.4 |
| | **Aug** | 28 | 7.2 | 19300.0 | 0.9 | 36.3 | 1.4 | 85.1 | 2,640 | 23333.3 |
| | **Sept** | 29 | 7.2 | 2100.0 | 0.8 | 22.1 | 3.5 | 77.5 | 1,240 | 1853.3 |
| | **Oct** | 29 | 7.5 | 100.0 | 0.8 | 11.5 | 1.7 | 32.8 | 300.0 | 133.3 |
| | **Nov** | 29 | 7.8 | 117.0 | 0.8 | 7.2 | 4.9 | 44.6 | 320.3 | 724.0 |
| | **Dec** | 28 | 7.8 | 133.0 | 1.4 | 14.0 | 7.6 | 48.9 | 225.4 | 0.3 |

**Table. No. 3 - Total Hardness studied during the period January 2018 - December 2018**

| Month | Total Hardness (ppm of $CaCO_3$) | Month | Total Hardness (ppm of $CaCO_3$) | Month | Total Hardness (ppm of $CaCO_3$) | Month | Total Hardness (ppm of $CaCO_3$) |
|---|---|---|---|---|---|---|---|
| **Jan** | 130 | **Apr** | 32.7 | **Jul** | 532 | **Oct** | 173.6 |
| **Feb** | 154 | **May** | 19.1 | **Aug** | 550 | **Nov** | 125 |
| **March** | 46.2 | **Jun** | 78.4 | **Sept** | 393.6 | **Dec** | 140 |

***Temperature*** - Temperature of the river water was measured on site and was found as per expectations with seasonal changes. The maximum temperature was observed to be 35℃ (April 2018) while minimum was 26℃ (July-2016, Jan-2017, Feb-2018).



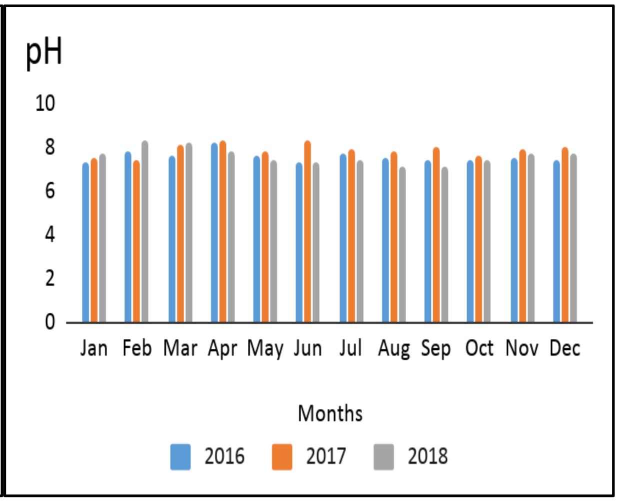




**Figure 1** **Figure 2**

**Figs.1&2: Figure 1 describes the variations in temperature while figure 2 describes the variations in the pH of the water body for the year 2016-18.**

***pH*** - The river water pH ranges from a minimum of 7.2 and the maximum pH of 8.4 is. The river water has naturally high pH. The acceptable range of pH for river water is 6.5 to 8.5. The results observed throughout the span of thirty-six months lie between these acceptable values. The variations in pH follows a routine seasonal trend. The year 2017 observed high rainfall as compared to 2016 and 2018 and the runoff is responsible for high pH for the monsoon. In June 2016, sample collection was done immediately after heavy showers, hence the reason for low pH.

***Conductance*** - The conductance values of river water ranges from a minimum of 90 µS/cm (November 2017) to a maximum of 34000 µS/cm (July 2017). As the rainfall received during 2017 is more than 2016 and 2018, the values are affected as well. The summer months show low conductance levels except for April 2016 and 2017 due to the pollution of the sampling site by the local activities. During the rainy season, the conductance values increase due to the runoff water. The post-monsoon months show low conductance as per expectations. The correlation Conductance with TDS (r = +0.14), TSS (r = +0.33), Alkalinity (r = +0.01) is weakly positive and with Total Hardness (r = +0.85) is strongly positive [Refer Table No.4].

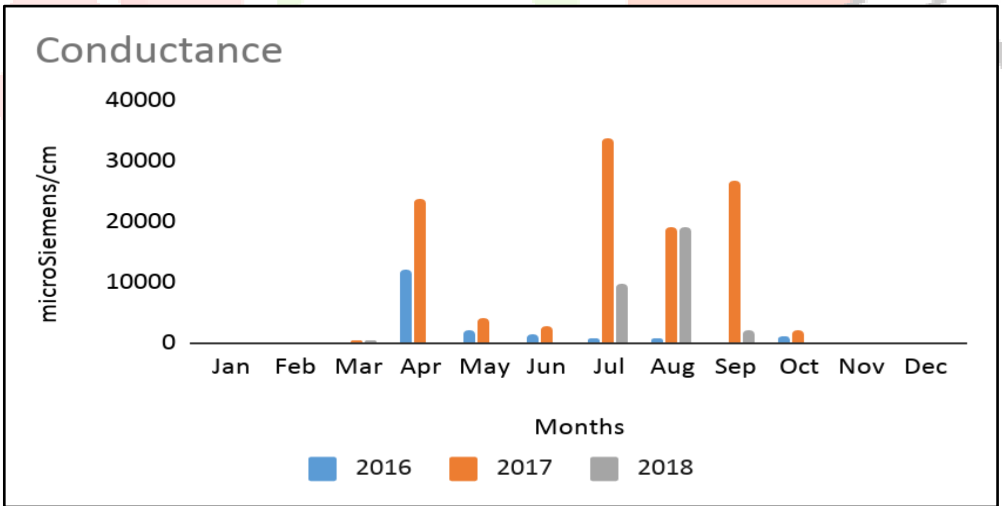
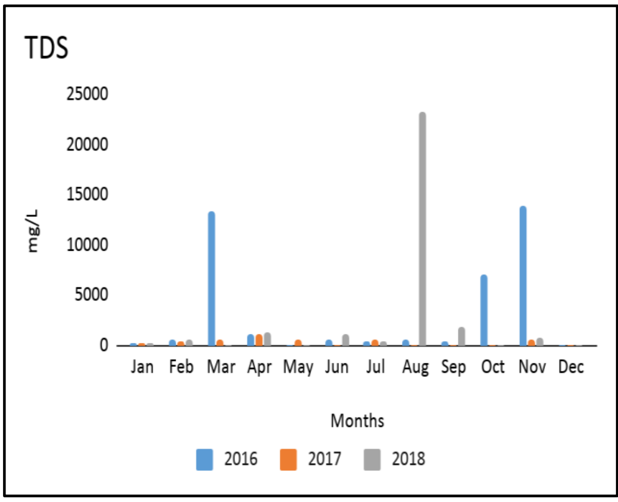



**Fig. 3: Summary of specific conductance of the samples of three years.**

***TDS*** - The maximum value for TDS is 23333.3 mg/L (August 2018) as the sample was collected during heavy showers that created flood-like situations. TDS is generally low during winter months and summer months. The March 2016 shows high TDS due to the pollution of the sampling site. As in the year 2016, the scanty rainfall was received; the ritual of immersing of Lord Ganesh's idol in the river at the end of the festival in September has affected TDS values of October and November 2016. The correlation TDS with Conductance (r = +0.14) and Alkalinity (r = +0.25) is weakly positive, with TSS (r = +0.55) and Total Hardness (r = +0.61) is strongly positive. [Refer Table No.4]



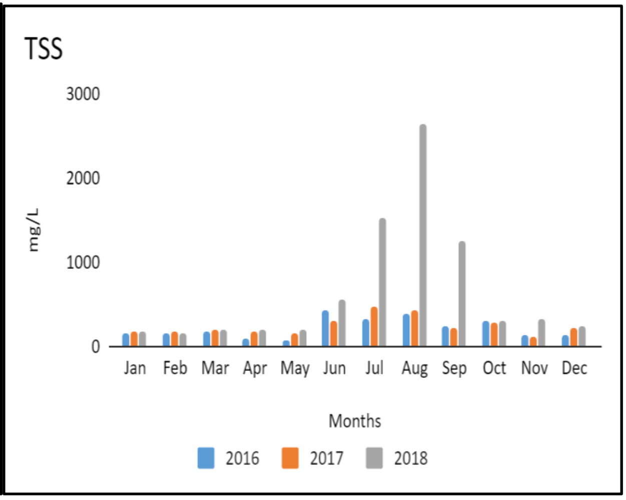
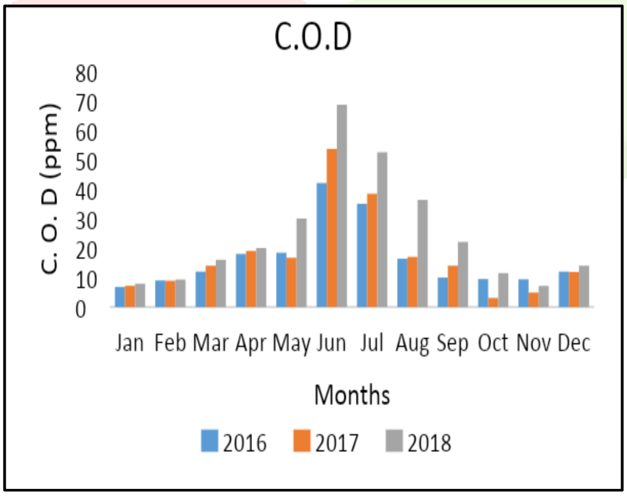




**Figure 4** **Figure 5**

**Figs. 4&5: Figure 4 indicates the TDS level and figure 5 indicates TSS level**

***TSS*** - TSS values are low throughout the year for 2016 and 2017 during the winter months and summer months. Lowest TSS is observed as 63.8 mg/L (May 2016) while highest as 2640 mg/L (August 2018). The sampling was done immediately after heavy showers causing flood like situations. Along with the runoff water that is responsible for the increase of TSS during monsoons, the resurfacing of the soil sediments during heavy downpour leads to high values of TSS. Due to the same reason, TSS of July 2018 is higher than 2016 and 2017. The correlation TSS with Conductance (r = +0.33) is weakly positive with TDS (r = +0.55) and Alkalinity (r = +0.18) whereas with Total Hardness (r = +0.92) is strongly positive. [Refer Table No.4]

***COD*** - The COD value of the river ranges from a minimum of 3.1 ppm of $O_2$ (October 2017) to a maximum of 68.5 ppm of $O_2$ (June 2018). With the increase in temperature from January to May, the COD values also increase due to the evaporation that causes concentration of the chemical pollutants in the water body. The months of June, July, August and September are evidence of the increase in pollution with population when comparing COD values in 2016, 2017 and 2018. As the rain commences in June, high levels of COD are obtained in it, with the increased flow of the water body during the monsoon, the dilution leading to decrease in the COD values is observed across June till September. Due to high rainfall in 2017 as compared to 2016 and 2018, the river floods and the flows away contents produce high COD, hence October and November 2017 are found to have lower COD than 2016 and 2018. From December, the COD levels are almost the same till February.



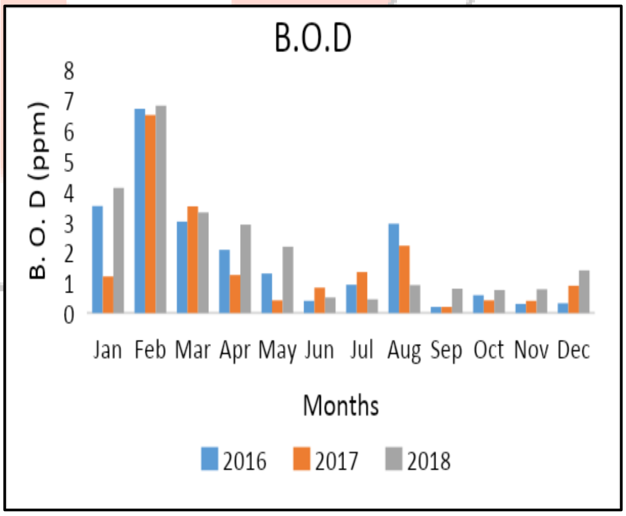




**Figure 6** **Figure 7**

**Figs. 6&7: Figure 6 represents the variation in the COD level while figure 7 represents the variation in BOD level.**

***BOD*** - The BOD value of the river ranges from a minimum of 0.2 ppm of $O_2$ (September 2016 and 2017), to a maximum of 6.8 ppm of $O_2$ (February 2018). From September to December, low temperatures are observed near the point of collection (night temperature 10° - 15°C) which results in sluggish growth rate of microbes indicated by low BOD values. The BOD values in January and February were expected to be low. Only the BOD values of Jan 2017 produce the expected results. The possibility of high BOD during Jan (2016 and 2018), February (2016, 2017 and 2018) is the contamination of the water body at sampling site with high amounts of organic wastes from the cattle shed.

The spike observed in the month of August 2016 is due to the accumulation of nitrogenous substances in the water caused by pouring of land surface washings as the amount of rainfall received in 2016 was less. BOD levels decrease during June-July as the river water flows out.

***BOD vs COD-*** BOD is usually lower than COD. This phenomenon is observed for the Ulhas River water sampled at Rayate village. Hence indicating the presence of organic waste degradable by microbes is less than the chemical waste polluting the river.

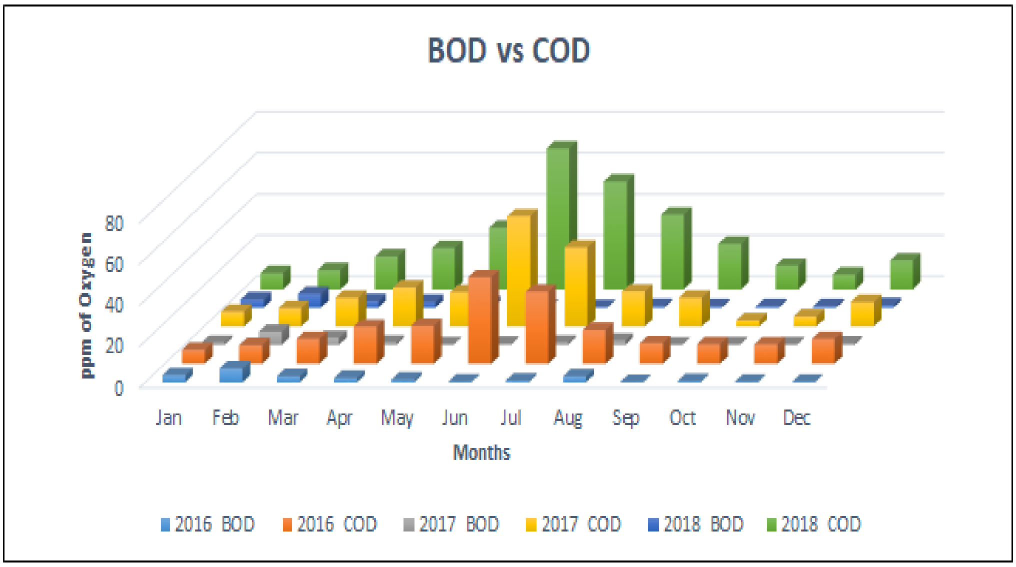



**Figure 8**

**Fig. 8: Indicates a comparison between BOD and COD levels during the project period.**

Another study on the water samples indicated that BOD went on increasing till the fourth day of collection of samples with a sudden drop on the fifth day, when preserved in an air tight container. This was due to the increase in microbial counts followed by anoxia. This study suggests that, the potability of the water increases on storing for five days but with the debris of the microbes.

***Acidity***- Maximum acidity is 13.2 ppm of $CaCO_3$ (December 2016) while minimum is 1.4 ppm of $CaCO_3$ (August 2018). An overall observation is made that 2016 had higher acidity levels in water as compared to 2017 and 2018. The peaks observed in Acidity are due to the transient STP discharges into the river.

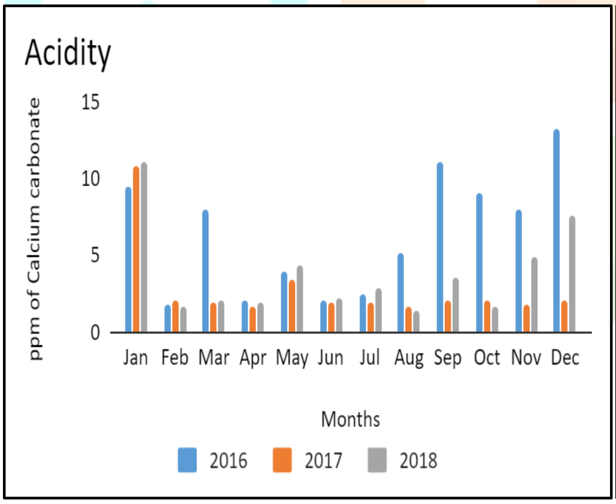



**Figure 9**

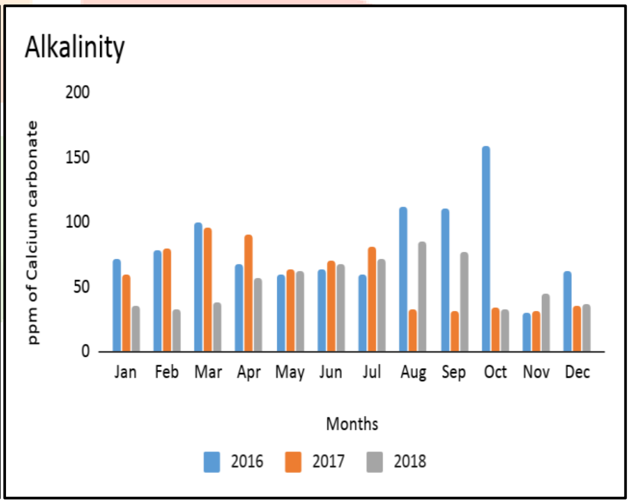



**Figure 10**

**Figs. 9 & 10: Figure 9 indicates the Acidity level while figure 10 indicates the alkalinity level.**

***Alkalinity***- The minimum alkalinity was found to be 30.6 ppm of $CaCO_3$ (November 2016) while maximum was 158.9 ppm of $CaCO_3$ (October 2016). The levels of Alkalinity level lie with the range of acceptable limits. Alkalinity increases due to the presence of salts of Calcium, Magnesium and Phosphate. Phosphates enter the water body through human sewage, chemical manufacturing industries. Iron and Manganese used by bacteria act as electron acceptors during the anaerobic decomposition of organic waste. The year 2016 observed scanty rainfall and in the month of September, post-celebration of Ganesh Festival involves the idol immersion ritual that increases the contaminants in water. The high temperatures cause accumulation of pollutants in the river as well as increase in metabolic rates of the microbes. This could possibly be the reason for the increase in Alkalinity during October 2016. With the commencement of the rainy season, the alkalinity levels increase gradually from June to September in 2016 and 2018. Whereas 2017 shows low alkalinity due to the high amount of rainfall received that has caused dilution of these pollutants in the river water. As the pollutants flow away, the alkalinity levels decrease at the sampling site of this River. Any aberrations in values during these winter months is because of the local factors contributing to pollution of the water body. The correlation of Alkalinity with Conductance ($r = +0.01$), Total Hardness ($r = +0.002$), TDS ($r = +0.25$) and TSS ($r = +0.18$) is weakly positive. [Refer Table No.4]

***Total Hardness*** - This parameter was analyzed for the period January 2018 - December 2018. The minimum Total Hardness was found to be 19.1 ppm of $CaCO_3$ (May 2018), while maximum was found to be 550 ppm of $CaCO_3$ (August 2018). The rise in Total Hardness in August 2018 is due to the high alkalinity contributed by the bicarbonates, carbonates and hydroxides of Calcium and Magnesium carried by the runoff water into the river during rains. Lord Ganesh's Idol immersion in the river water in September, led to an increase in the permanent hardness of water which is caused by Plaster of Paris. Hence, the Total Hardness measured in September is a result of aggregation of temporary hardness and permanent hardness, therefore high levels observed in this month. With the Lord Ganesh's idol immersion, devotees also immerse the floral tributes along with curd rice (A ritual) is decomposed by the bacteria via an ammonification process. The decomposers consume organic matter and the nitrogen contained in these dead organisms is converted to ammonium ions. The nitrifying bacteria take up these ammonium ions and convert it to nitrates. Thus increasing the non-carbonate hardness in water along with temporary and permanent hardness previously present in water. Therefore a spike observed in September 2018. The winter months show less Total Hardness levels as expected. The correlation of Total Hardness with TSS (r = +0.92), Conductance (r = +0.85), TDS (r = +0.61) is strongly positive and with Alkalinity (r = +0.002) is weakly positive. The Total Hardness is the sum of the hardness contributed by carbonate ions, non-carbonate (Chlorides, Sulphates and Nitrates) ions and ions that result in pseudo hardness (Sodium, Potassium and Ammonium). The organic matter rich in nitrates, potassium, sodium and ammonium ions in the form of TDS and TSS are the reason for high 'r' values of Total Hardness with TSS, TDS while low with Alkalinity. [Refer Table No.4]

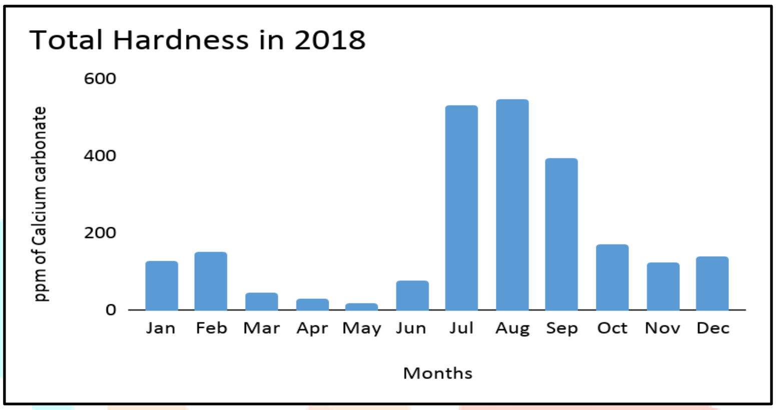



**Fig. 11.: Total Hardness of water for the year 2018.**

**Table 4.: Karl Pearson's coefficient of correlation within various Parameters**

| Karl Pearson's coefficient of Correlation | | | | | |
|---|---|---|---|---|---|
| **Physico-chemical parameters** | **Conductance** | **TDS** | **TSS** | **Alkalinity** | **Total Hardness** |
| **Conductance** | 1 | | | | |
| **TDS** | 0.14 | 1 | | | |
| **TSS** | 0.33 | 0.55 | 1 | | |
| **Alkalinity** | 0.01 | 0.25 | 0.18 | 1 | |
| **Total Hardness** | 0.85 | 0.61 | 0.92 | 0.002 | 1 |

## IV. CONCLUSION

Based on the literature survey and the extent of work done on the specific stretch of the river and the purpose for which the water from the river is utilized viz. for drinking purposes, it is very essential to monitor the water quality. Since it is a natural flowing water body it is vital that such monitoring be carried out for a prolonged period of time. Accordingly, the project was designed various parameters were analyzed on a monthly basis for 3 years. Upon comparison of the results with the standard values stated by the World Health Organization, BIS and EPA, only pH of the river at Rayate sampling site is within the range expected. The values of all the other parameters are continuously higher than the expected ones. As this river water contains fishes and is used by local residents for drinking purposes, agricultural activities and cattle shed, it is necessary to take care of this river water and take preventive measures from further deterioration of the water. It was found that when the water was preserved in an air tight container, the microbial counts almost disappeared on the fifth day after its initial increase, leading to increase in potability. The findings also indicate severe lack of socio-environmental awareness among the locals. When such polluted water enters into the food chain, bioaccumulation in organisms causes health problems to life. This phenomenon was most aptly stated in the book titled 'Silent Spring' by Rachel Carson.

**Table 5.: Represent a comparison of values as specified by different standards and observed values.**

| Sr. No. | Parameter | Technique used | WHO standard | Indian Standard | EPA guidelines | Observed |
|---|---|---|---|---|---|---|
| 1. | Temperature | Thermometer | - | - | - | 35°C |
| 2. | pH | pH meter | 6.5 – 9.5 | 6.5 – 9.5 | 6.5 – 9.5 | 8.4 |
| 3. | Conductance | Conductivity meter | - | - | 2500 μS/cm | 34000 μS/cm |
| 4. | B. O. D. | Incubation followed by titration | 6 ppm | 4 ppm | 5 ppm | 6.8ppm |
| 5. | C. O. D. | Closed Reflux method | 10 ppm | - | 40 ppm | 68.5ppm |
| 6. | Acidity | Acid – Base titration | - | - | - | 13.2ppm |
| 7. | Alkalinity | Acid – Base titration | - | 200 ppm | - | 158.9ppm |
| 8. | T. D. S | Gravimetric method | - | 500 mg/L | - | 23333.3mg/L |
| 9. | T. S. S | Gravimetric method | - | - | - | 2640 mg/L |
| 10. | Total Hardness | Complexometric Titration | 200 ppm | 200 ppm | < 200 ppm | 550 ppm |

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