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# ASSESSMENT OF PHYSICO-CHEMICAL CHARACTERISTICS OF WATER IN MANGROVE ECOSYSTEM

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## *ABSTRACT*

*The present investigation was carried out to assess the physico-chemical characteristics of Mangrove region in the Kavi, Dhuvara and Somnath for a period of ten (10) months. Surface water samples were collected from the chosen sampling stations at fortnightly intervals and analyzed to provide baseline information on the physico-chemical characteristics of these coastal biotopes. During the study period, variations observed in different water quality parameters of mangrove stations respectively. The present study would be helpful in assessing the changes in water quality that might happen in long run due to port development, regular port activities, industries that are in operation in and around the port area, shrimp farming etc.*

***Key words:*** *Water analysis, Mangroves, Environment, Physico-chemical analysis*

## INTRODUCTION

Mangrove dominated environments occupy some 23 million hectares of the global tropical coastline and have relatively become a topic of intense scientific interest due to their recognized ecological value, resulting in a corresponding interest in planning, pollution and productivity (Snedaker, 1982).The restricted distribution of mangrove is due to the sensitivity of mangroves to frost and cold temperature (Walter, 1977). These forests cover the flats between the mean sea level and extreme high water (Macnae, 1966) and the site condition is characterized by the accumulation of loose mud and silt (Womersley, 1983).

Mangrove conservation and development has been given very high importance in Gujarat, resulting in being the only state which has registered an increase of 45 sq km of mangrove cover (FSI, 2013). In Gujarat, mangrove cover is distributed over four regions, Kachchh, Gulf of Kachchh& Saurashtra and South Gujarat (including Gulf of Khambhat- Dumas Ubharat areas) which have15.6%, 0.3% and 12.6% of the total mangrove cover of the State respectively.

The world is losing mangrove forests at an alarming rate. Scientists estimate that 50% of our mangroves have disappeared during the last five decades and every year we lose roughly another 1 percept. Warmer temperatures will increase evaporation rates and salinity in the sediments on the landward fringe of a mangrove forest. This may cause a die-back of mangroves or a reduction in diversity (Huxham*et al.,* 2010). Mangrove ecosystems mostly grow in the intertidal zones in tropical and sub-tropical regions and are likely to be primarily indicators of the effects of climate change. Mangrove supports numerous ecosystem services such as fisheries production and nutrient cycling.Blasco F *et al*, 1996, studied the unique biological characteristics of mangroves. According to them it was interesting to assess the extent to which these ecosystems can be used as indicators of coastal change or sea-level rise.From their studies of mangrove mortality at several locations, it appears that these coastal ecosystems are so specialized that any minor variation in their hydrological or tidal regimes causes noticeable mortality. Each species of mangrove occurs in ecological conditions that approach its level of limitation with regard to salinity of the water and soil, as well as the inundation regime. We aim from this study to obtain indicators that can be used in the future to compare between the mangrove forests growing on the islands, those that grow on the coast, also see the changes that occur and environmental pressures facing the mangrove forests on the Gujarat. On a practical level, this study will allow us to learn some methods and means environmental assessment of mangrove forests and gain a lot of experience in the field.

## MATERIAL METHODS

1 Field survey and sample collection

A systematic fieldwork has been carried out in the entire study area for collection of primary and secondary data and samples for laboratory examinations. Secondary information is collected from various State and Central government departments like, Department of Water Resources, Forest

department, published MoEF report, Gujarat Biodiversity Board, Gujarat Ecological Commission reports, etc. There are following principle for collection of water sample.

Water sampling was done along the study area before that the study area was mapped using Google Earth and GIS in order to understand the dimensions of the Kavi, Dhuvara and Somnath. Random sampling was carried out by taking the length of the mangrove growth pattern in to consideration along with its surrounding. A total of 20 sample were collected which were marked on the GPS. The samples in the bottles were then immediately used the next day for Analytical purpose (Caspers H, 1985).

***1.*** *pH*

The temperature and pH of water samples were analyzed on board. The other chemical parameters were analyzed in laboratory using standard methods. The collection and transport of water samples has been done with great concern to avoid contamination. The various methods used for water analysis are furnished along with respective references. Great care has been taken to produce quality base-line information regarding water analysis in the study area.

pH was measured by the use of buffers. (pH 7 and 10) For calibration and calibrate the probe meter sample water can be collected in any glass container. Place the probe in the sample and wait for the meter to equilibrate. Adjust the probe to temperature of the sample before allowing it to equilibrate. The meter will have come to equilibrium when the signal becomes steady. Nevertheless, do not agitate the sample since this may cause changes in the pH. Note pH reading.

Acidic: Up to 6.5
Normal: 6.51 To 8.20
Alkaline: 8.21 To above

***2.*** *EC*

EC or Electrical Conductivity of water is capability to conduct an electric current. Salts and other chemicals that are dissolved in water can break down into positively and negatively charged ions. These free ions in the water conduct electricity and so the water electrical conductivity depends on the concentration of ions. Following steps should be taken for water Sample collection and analysis. First Calibrate EC meter 0.01N Potassium Chloride Solution- 1.41 (µS/cm per mg/L.) Take water in beaker and keep EC meter in it to note the reading.

***3.*** *TDS (Total Dissolve Solid):*

Total dissolved solids (TDS) is used to calculate the dissolved combined content of all inorganic and organic substances available in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form. The principal application of TDS is to study water quality for streams, rivers, and lakes and analyse if it is suitable or not. TDS is generally not considered a primary pollutant. The TDS test is very easy to follow. Take a Water Sample and dip the TDS meter in sample. Take the Reading.

***4.*** *Turbidity:*

There are certain methods to measure Turbidity of water. For this test, Nephelometric method was used. Turbidity meter was started before 30 min before the test and 400 NTU Solution was prepared. Calibrate turbidity meter to 400 NTU using standard solution by adjusting the calibration knob and calibrate the turbidity meter to 0 NTU using distilled water. Take the reading of the turbidity meter was taken by inserting the sample.

***5.*** *COD [Chemical Oxygen Demand]:*

There are certain methods for measure COD. We have use Open Reflux Method as Add 50 ml of sample or an aliquot diluted to 50 ml with distilled water in a 500 ml refluxing flask. Add 1g $HgSO_4$, few glass beads, and 5 ml sulphuric acid reagent, mix, cool. Add 25 ml of 0.0417M $K_2Cr_2O_7$ solutions, mix. Connect the flask to the condenser and turn on cooling water, add additional 70 ml of sulphuric acid reagent through open end of condenser, with swirling and mixing. Reflux for 2 hours; cool, wash down condenser with distilled water to double the volume of contents, cool Add 2 drops of Ferroin indicator, titrate with FAS the remaining potassium dichromate, until a colour change from bluish green to reddish brown. Also reflux and titrate a distilled water blank with reagents than Use standard 0.00417M $K_2Cr_2O_7$, and 0.025M FAS, when analysing very low COD samples after Take a reading.

$$\text{COD, mgO2/l} = \frac{(A-B)*M*8000}{\text{ml of Sample}}$$

Where:
A= FAS used for blank, ml
B= FAS used for sample, ml
M= Morality of FAS

***6.*** *DO & BOD*

Oxygen dissolved in water is referred as Dissolved Oxygen (DO). The DO content is estimated titrimetrically using Winkler's method. Biochemical Oxygen Demand (BOD) is measured by incubation followed by the estimation of dissolved oxygen content (Winkler's method), using the $5^{th}$ day BOD (mg/1) method as described in APHA (1998).

***7.*** *Sulphates and Chlorides*

Sulphates in the water samples are measured using turbidimetric method. This is the routine method for sulphate estimation and is based on precipitation of sulphate after adding barium. The concentration of sulphate is determined spectrophotometrically from the absorbance of light by barium sulphate at wavelength of 420 nm. Chlorides in water samples are measured by argentometric method. Silver nitrate reacts with chloride to form insoluble white precipitate of AgCl. At the end point, when all the chlorides get precipitated, free silver ions react with chromate to form silver chromate of reddish brown colour.

***8.*** *Fluoride:*

For the analysis of Fluorides electrode was prepared by filling the electrode filling Solution. The required number of standard was prepared and adjusted to necessary pH by adding ionic strength adjuster. Calibration of the instrument was done using the prepared standards. Readings were taken in measurement mode and readings were obtained directly in mg/l.

***9.*** *Hardness, Calcium and Magnesium*

Hardness is determined by EDTA titration method. Calcium and Magnesium form a complex of wine red colour with Eriochrome Black T at pH of 10.0 ± 0.1. The former complex is broken down with the addition of EDTA, which has strong affinity towards Ca2+ and Mg2+ and a new complex of blue colour is formed. Calcium is determined by EDTA using murexide (ammonium purpurate) as indicator. The value of magnesium can be obtained by subtracting the value of calcium from the total of Ca2 + + Mg2 + (i.e., hardness).

***10.*** *Sodium and Potassium*

The major ions like sodium and potassium are determined using flame photometer (Systronix. 128) based on the procedure described in APHA (1995). A characteristic light is produced due to excitation of electrons when the sample with sodium is sprayed into a flame. Similar is the case of potassium estimation. The concentration of sodium and potassium in water samples are read on the dial by using required filters.

***11.*** *Phosphate*

There are following reagents uses in test. Sulphuric acid, $H_2SO_4$, 5N: Dilute 70 ml conc. $H_2SO_4$ to 500 ml with distilled water, Potassium antimony titrate solution: Dissolve 1.3715g K (SbO) $C_4H_4O_6.1/2\ H_2O$ in 400 ml distilled water and dilute to 500 ml, store in glass-stopper bottle. Ascorbic acid, 0.1M: Dissolve 1.76g ascorbic acid in 100 ml distilled water, keep at $4^oC$, which can be use within a week. There are certain methods for measure Phosphate. We have use Ascorbic Acid Spectro - photometric method. As Treatment of sample: Take 50 ml sample into a 125 ml conical flask, add 1 drop of phenolphthalein indicator. Discharge any red colour by adding 5N $H_2SO_4$. Add 8 ml combined reagent and mix, Wait for 10 minutes, but no more than 30 minutes and measure absorbance of each sample at 880nm. Use reagent blank as reference. Prepare a blank sample by adding all reagents except ascorbic acid and potassium antimony titrate to the sample. Subtract blank absorbance from sample absorbance reading. Preparation of calibration curve: Prepare calibration from a series of standards between 0.15-1.30 mg/l ranges.

***12.*** *Salinity*

For salinity estimation, the procedure outlined in APHA (1998) is followed. Sodium chloride reacts with silver nitrate to form sodium nitrate and a curdy precipitate of silver chloride. Potassium chromate imparts a yellow colour to the sample containing sodium chloride. Using silver chloride, titrimetric analysis has been carried out. For the estimation of salinity, samples are collected in polythene bottles and estimated titrimetrically by chlorosity method (Grasshoff, 1983).

***13.*** *Trace Metal Analysis*

The metals such as Fe, Mn, AI, Zn, Pb, Cu, Cr, Cd, Co and Ni in pre-concentrated water samples are analyzed using double beam atomic absorption spectrophotometer following APHA (1998).

***14.*** ***Analysis by Atomic Absorption Spectrophotometer (AAS)***

The concentration of metals is easily determined by atomic absorption spectrophotometer (AAS). The atomic absorption uses essentially monochromatic radiation to excite vaporized atoms in their ground state. The instrument consists of a light source, a cell (consisting of the aspirated sample), a monochromator, and a detection system. The light source, usually a hollow cathode tube, emits essentially line radiation of wavelength that is being absorbed by the element under study (Table 7). This is accomplished by making the source out of sample element. Thus, if iron is to be determined, a lamp having an iron cathode is used.

## RESULTS

Water sample of the study area was collected and different physic-chemical parameters were tested. Selection of parameters for testing of water samples were solely depends upon for purpose and the need its quality and purity. Water does content different types of floating, dissolved, suspended, microbiological and bacteriological impurities. Some physical test to be performed for testing of its physical appearance were pH, turbidity, TDS etc, while chemical tests performed were BOD, COD, dissolved oxygen, alkalinity, hardness and other characters.

*1. pH*

pH is most important in analysing the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH is positively correlated with electrical conductance and total alkalinity(Guptaa 2009).

The below table depicts the pH reading of the study area. The average pH of the Mahi is 7.15, Stambeshwar region have 7.73 and the Veraval region have 7.45. The higher pH values observed suggests that carbon dioxide and carbonate-bicarbonate equilibrium is affected more due to change in physicochemical condition (Karanth 1987).

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 7.8 | 7.8 | 7.8 |
| 2 | 7.6 | 7.6 | 7.6 |
| 3 | 7.2 | 8.6 | 7.2 |
| 4 | 7.9 | 8 | 7.3 |
| 5 | 6 | 7 | 7.8 |
| 6 | 6.4 | 7.4 | 7 |
| **Mean** | **7.15** | **7.73** | **7.45** |
| **SE** | **0.32** | **0.22** | **0.14** |
| **SD** | **0.78** | **0.55** | **0.33** |

**Table 1: pH of the study area**

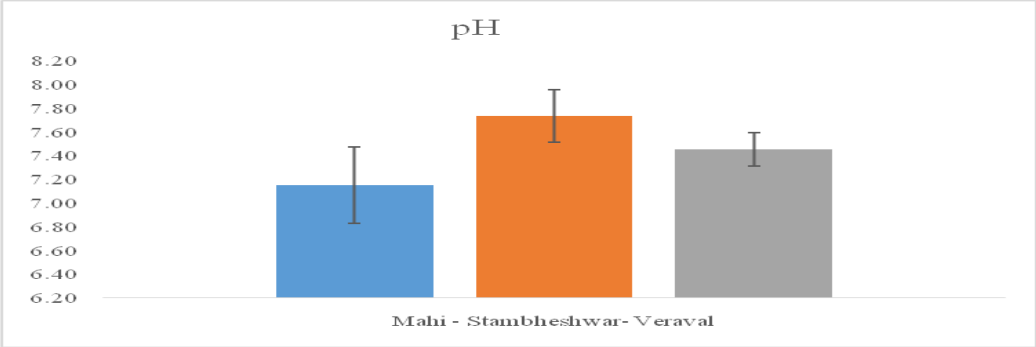


**Figure 1: Graph of pH of the study area**

The comparative pH ratio of the study area is depicted in the above graph. The Standard error and Standard deviation of pH was also calculated. As the pH of Mahi is higher than the other two, Standard error of the Mahi was also high. The value is 0.32. The standard error of Stambeshwar and Veraval is 0.22 and 0.14 respectively.

*2. EC*

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 6170 | 2500 | 1005 |
| 2 | 3270 | 1200 | 985 |
| 3 | 1200 | 3000 | 1200 |
| 4 | 2500 | 3200 | 1050 |
| 5 | 3000 | 1000 | 1000 |
| 6 | 2320 | 1500 | 1250 |
| **Mean** | **3076.67** | **2066.67** | **1081.67** |
| **SE** | **683.94** | **389.51** | **46.62** |
| **SD** | **1675.65** | **954.29** | **114.22** |

Electrical Conductivity (EC) shows significant correlation with the parameters such as temperature, pH value, alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand and chloride and iron concentration of water.

Table 2: EC of the study area

The above table depicts the EC reading of the study area. The average EC of the Mahi is 3076.67, Stambeshwar region have 2066.67 and the Veraval region have 1081.67. The high EC is due to different dissolved solids and impurities in the water. Mahi have high EC that proves the corrosive nature of that area is high.

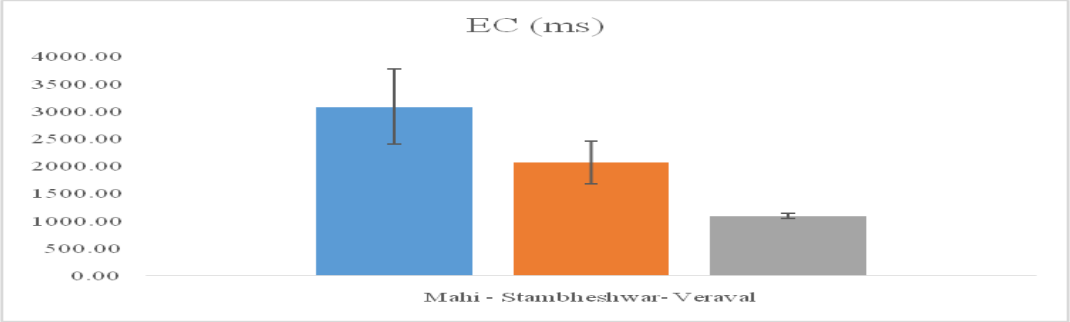


**Figure 2: Graph of EC of the study area**

The standard error and standard deviation were calculated for the samples collected from the study area. Standard deviation was calculated by the formula STD * EV/ Mean. The result obtained is 1675.65 for Mahi, 954.29 for Stambeshwar and 114.22 for Veraval. The standard error was calculated by Standard Deviation/ 2.45. The value obtained is 683.94, 389.51 and 46.62 for Mahi, Stambeshwar and Veraval respectively.

*3. TDS*

Total Dissolved Solids (TDS) is an indication of all of the solids constituents of water that are suspended and dissolved in it. These dissolved solids can be of the organic and inorganic nature. Water flow and tidal current add solid particles in the sea water or to surrounding area.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi-Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 3950 | 2000 | 2000 |
| 2 | 1930 | 1500 | 1650 |
| 3 | 2000 | 3600 | 1800 |
| 4 | 3600 | 2600 | 2503 |
| 5 | 2500 | 1560 | 1450 |
| 6 | 3020 | 1250 | 1200 |
| **Mean** | **2833.33** | **2085** | **1767.17** |
| **SE** | **341.06** | **359.68** | **185.50** |
| **SD** | **835.60** | **881.22** | **454.48** |

**Table 3: TDS of the study area**

In present study total dissolved solids in water ranges from 1930 to 3950 in Mahi region, Stambheshwar accounts for 1250 to 3600 and Veraval contributes from 1200 to 2503. The cumulative average is 2833.33 of Mahi and Stambeshwar have 2085. Veraval contributes 1767.17 of total TDS. Mean total dissolved solids in water value was observed higher at Mahi, as compared to other sites and the mean variation between the sites was very significant (ANOVA)

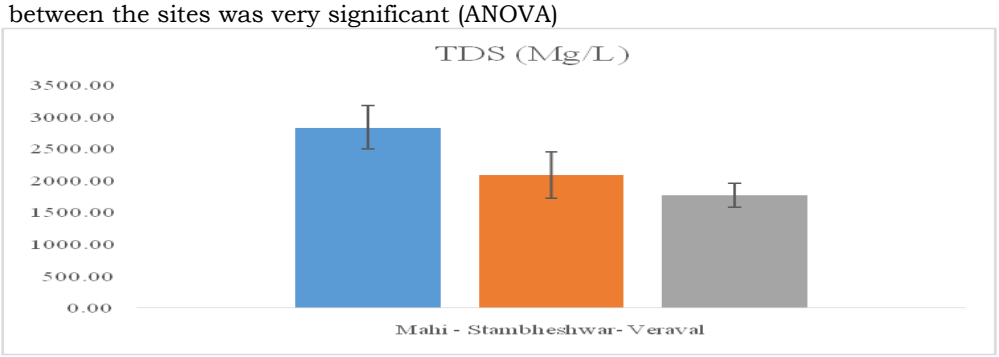


**Figure 3: Graph of TDS of the study area**

Standard error of the study area is 341.06, 359.68 and 185.50 for Mahi, Stambeshwar and Veraval respectively. The standard deviations for the study area are 835.60 for Mahi, 881.22 for Stambeshwar and 454.48 for Veraval.

*4. TURBIDITY*

Turbidity is used to measure the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids (TSS) in the water, the murkier it seems and the higher the turbidity by measuring the turbidity, the quality of water can be measured.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 10 | 5 | 4 |
| 2 | 16 | 10 | 8.6 |
| 3 | 4 | 15 | 10 |
| 4 | 5 | 23 | 5 |
| 5 | 4 | 12 | 3 |
| 6 | 8 | 8 | 8 |
| **Mean** | **7.83** | **12.17** | **6.43** |
| **SE** | **1.90** | **2.57** | **1.15** |
| **SD** | **4.67** | **6.31** | **2.82** |

**Table 4: Turbidity of the study area**

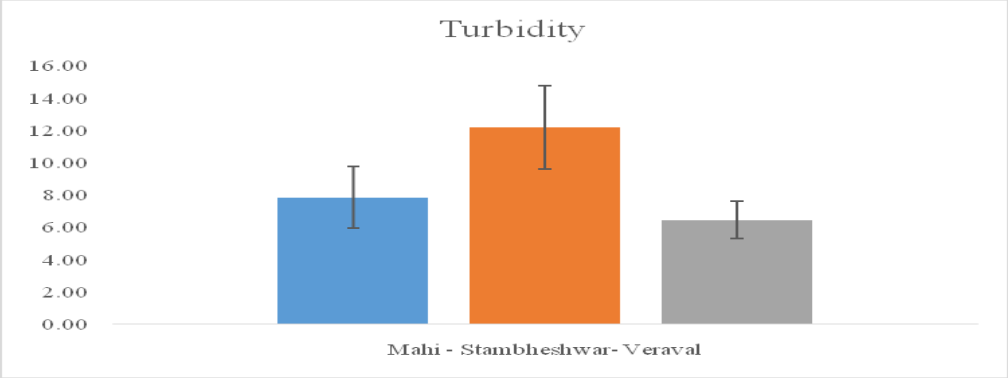


**Figure 4: Graph of Turbidity of study area**

The above table and graph depicts the turbidity reading of the study area. The average turbidity of the Mahi is 7.83 NTU, Stambeshwar region have 12.17 NTU and the Veraval region have 6.43 NTU. Standard error of the study area is 1.90, 2.57 and 1.15 for Mahi, Stambeshwar and Veraval respectively. The standard deviations for the study area are 4.67 for Mahi, 6.31 for Stambeshwar and 2.82 for Veraval.

*5. SODIUM*

The below table and graph depicts the Sodium content reading of the study area. The average sodium of the Mahi is 3076.67 Mg/L. Stambeshwar region have 2066.67 Mg/L and the Veraval region has 1081.67 Mg/L

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 6170 | 2500 | 1005 |
| 2 | 3270 | 1200 | 985 |
| 3 | 1200 | 3000 | 1200 |
| 4 | 2500 | 3200 | 1050 |
| 5 | 3000 | 1000 | 1000 |
| 6 | 2320 | 1500 | 1250 |
| **Mean** | **3076.67** | **2066.67** | **1081.67** |
| **SE** | | | |

**Table 5: Sodium of the study area**

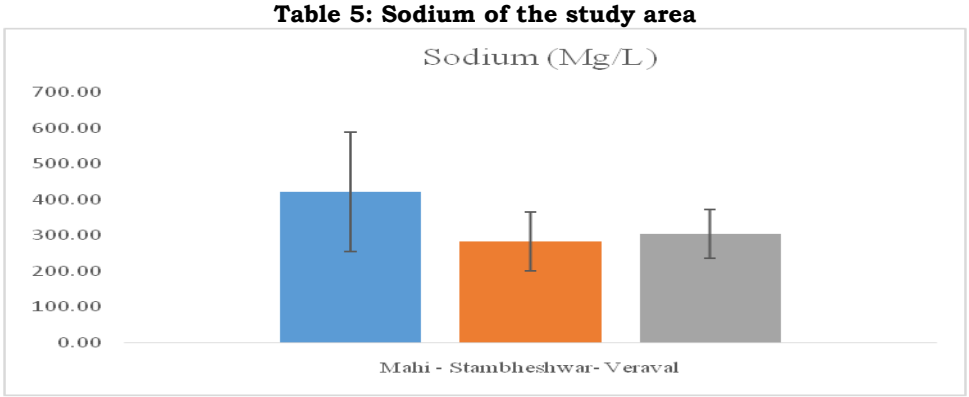


**Figure 5: Graph of sodium of study area**

Standard error of the study area is 1.90, 2.57 and 1.15 for Mahi, Stambeshwar and Veraval respectively. The standard deviations for the study area are 4.67 for Mahi, 6.31 for Stambeshwar and 2.82 for Veraval.

### *6. POTASSIUM*

The below table and graph depicts the total potassium content available in the study area. The average potassium of the Mahi is 8.68 Mg/L. Stambeshwar region have 7.5 Mg/L and the Veraval region have 3.25 Mg/L. The potassium content of Mahi region is higher than the other two.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 27 | 12 | 5 |
| 2 | 15 | 15 | 2.6 |
| 3 | 2.1 | 10 | 3.9 |
| 4 | 3.2 | 3.2 | 3.2 |
| 5 | 2.5 | 2.5 | 2.5 |
| 6 | 2.3 | 2.3 | 2.3 |
| **Mean** | **8.68** | **7.5** | **3.25** |
| **SE** | **4.19** | **2.26** | **0.42** |
| **SD** | **10.27** | **5.54** | **1.04** |

**Table 6: Potassium of study area**

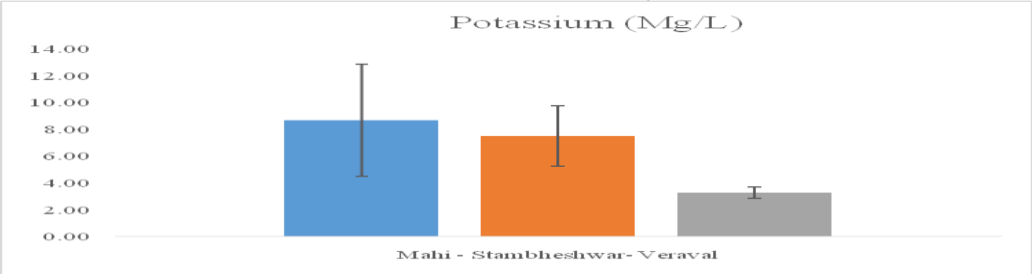


**Figure 6: Graph of Potassium of study area**

Standard error of the study area is 4.19 for Mahi, Stambeshwar accounts for 2.26 and Veraval for 0.42. The standard deviations for the study area are 10.27 for Mahi, 5.54 for Stambeshwar and 1.04 for Veraval.

### *7. CALCIUM*

Calcium is most abundant ions in fresh water and is important in plant precipitation. The below table and graph illustrates the total calcium content available in the study area. The average calcium of the Mahi is 35.50 Mg/L. Stambeshwar region have 35.5 Mg/L and the Veraval region have 30 Mg/L. The calcium content of the entire three regions is almost equal which clearly states the water is suitable for the mangrove growth.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of Stambheshwar, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 52 | 52 | 32 |
| 2 | 40 | 40 | 26 |
| 3 | 28 | 28 | 28 |
| 4 | 33 | 33 | 39 |
| 5 | 25 | 25 | 20 |
| 6 | 35 | 35 | 35 |
| **Mean** | **35.50** | **35.5** | **30** |
| **SE** | **3.94** | **3.94** | **2.77** |
| **SD** | **9.65** | **9.65** | **6.78** |

**Table 7: Calcium of the study area**

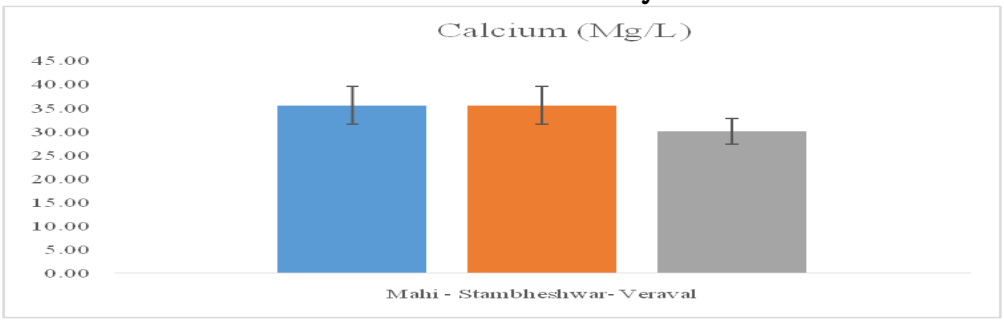


**Figure 7: Graph of Calcium of study area**

Standard error of the study area is 3.94 for Mahi, Stambeshwar accounts for 3.94 and Veraval for 2.77. The standard deviations for the study area are 9.05 for Mahi, 9.65 for Stambeshwar and 6.78 for Veraval.

*8. MAGNESIUM*

Magnesium is a relatively abundant element in the earth's crust and ranks 8thin abundance among the elements. It is found in all natural waters and its source lies in rocks. Normally, it is present in lower concentration than calcium.

The below table and graph depicts the Magnesium reading of the study area. The average Magnesium of the Mahi is 57.97 Mg/L. Stambeshwar region have 34.53 Mg/L and the Veraval region have 29.67 Mg/L.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of Stambheshwar, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 70.5 | 25.5 | 50.5 |
| 2 | 46.2 | 46.2 | 29.6 |
| 3 | 79 | 66.3 | 36 |
| 4 | 55.2 | 23.6 | 20.9 |
| 5 | 25.6 | 25.6 | 15 |
| 6 | 71.3 | 20 | 26 |
| **Mean** | **57.97** | **34.53** | **29.67** |
| **SE** | **8.10** | **7.39** | **5.10** |
| **SD** | **19.85** | **18.10** | **12.49** |

**Table 8: Magnesium of study area**

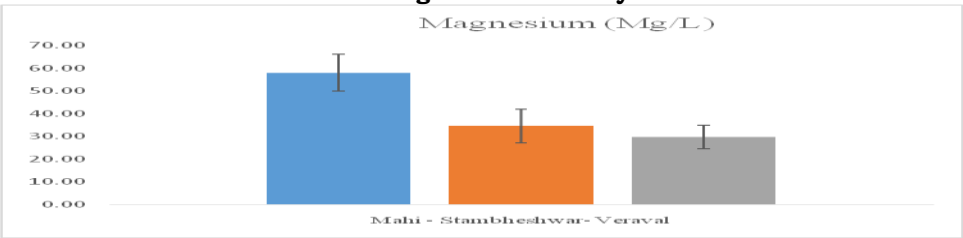


**Figure 8: Graph of Magnesium of study area**

High concentration of magnesium proves to be diuretic and laxative, and reduces the utility of water. Mahi region accounts high magnesium content and Veraval ranks lowest among the study areas. Standard error of the study area is 8.10 for Mahi, Stambeshwar accounts for 7.39 and Veraval for 5.10. The standard deviations for the study area are 19.85 for Mahi, 18.10 for Stambeshwar and 12.49 for Veraval.

*9. CHLORIDE*

The presence of chlorides in natural waters can mainly be attributed to dissolution of salt deposits in the form of ions ($Cl^-$).

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 1207 | 1000 | 230 |
| 2 | 568 | 568 | 326 |
| 3 | 200 | 869 | 569 |
| 4 | 50 | 253 | 356 |
| 5 | 66 | 66 | 195 |
| 6 | 321 | 230 | 394 |
| **Mean** | **472.75** | **551.2** | **345** |
| **SE** | **222.61** | **161.60** | **54.39** |
| **SD** | **545.39** | **395.93** | **133.25** |

**Table 9: Chloride of study area**

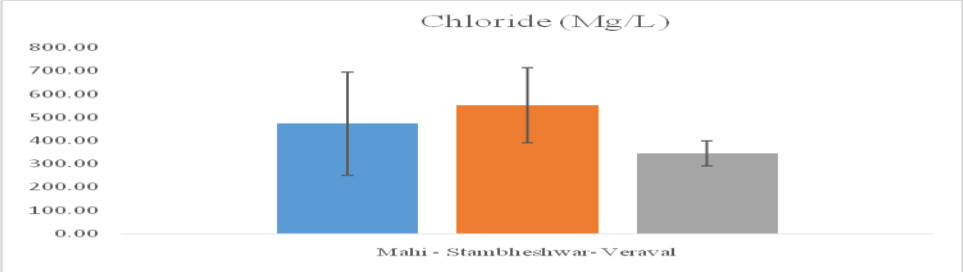


**Figure 9: Graph of Chloride of study area**

The table and graph states the Chloride of the study area. The average chloride of the Mahi is 472.75 Mg/L. Stambeshwar region have 551.2 Mg/L and the Veraval region have 345 Mg/L. The high concentrations of chloride may indicate pollution by sewage, industrial wastes, intrusion of seawater or other saline water. It is the major form of inorganic anions in water for aquatic life. Standard error of the study area is 222.61 for Mahi, Stambeshwar accounts for 161.60 and Veraval for 54.39. The standard deviations for the study area are 545.39 for Mahi, 395.93 for Stambeshwar and 133.25 for Veraval.

*10. SULPHATE IN MG/L*

Sulphates are found in all natural waters, particularly those with high salt content. Besides industrial pollution and domestic sewage, biological oxidation of reduced sulphur species also adds to sulphate content.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 52.9 | 20 | 15.6 |
| 2 | 30.4 | 30.4 | 18.2 |
| 3 | 25 | 25 | 13.69 |
| 4 | 36 | 36 | 26 |
| 5 | 39.6 | 26.3 | 15.4 |
| 6 | 45 | 45 | 12 |
| **Mean** | **38.15** | **30.45** | **16.82** |
| **SE** | **4.10** | **3.64** | **1.02** |
| **SD** | **10.04** | **8.93** | **4.95** |

**Table 10: Sulphate of the study area**

The Sulphate content of the study area is given below. The average Sulphate of the Mahi is 38.15 Mg/L. Stambeshwar region have 30.45 Mg/L and the Veraval region have 16.82 Mg/L. Standard error of the study area is 4.10, 3.64 and 1.02 for Mahi, StambeshwarandVeraval respectively. The standard deviations for the study area are 10.04 for Mahi, 8.93 for Stambeshwar and 4.95 for Veraval

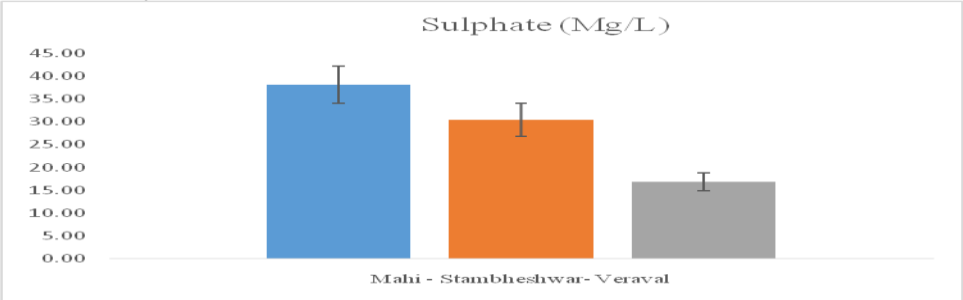


**Figure 10: Graph of Sulphate of study area**

The sulphate of the Mahi region is highest and that of Veraval is lowest. Sulphates are soluble in water imparting hardness with other cautions. Sulphate causes scaling in industrial water supplies, odour and corrosion problems due to its reduction to hydrogen sulphide.

*11. CARBONATE*

Whenever the pH touches 8.3, the presence of carbonates is indicated. Below pH 8.3, the carbonates are converted into equivalent amount of bicarbonates. The Carbonate content of the study area is given below. The average carbonate of the Mahi is 32.67 Mg/L. Stambeshwar region have 8.00 Mg/L and the Veraval region have 2 Mg/L.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 75 | 20 | 2 |
| 2 | 25 | 25 | 5 |
| 3 | 0 | 23 | 3 |
| 4 | 0 | 22 | 3 |
| 5 | 23 | 26 | 2 |
| 6 | 0 | 21 | 4 |
| **Mean** | **32.67** | **8.00** | **2** |
| **SE** | **15.68** | **5.07** | **0.77** |
| **SD** | **38.42** | **12.41** | **1.90** |

**Table 11: Carbonate of the study area**

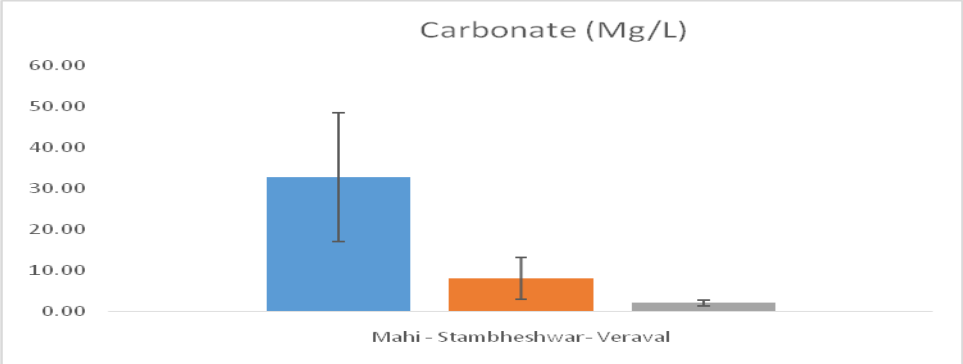


**Figure 11: Graph of Carbonate of the study area**

Standard error of the study area is 15.68, 5.07 and 0.77 for Mahi, Stambeshwar and Veraval respectively. The standard deviations for the study area are 38.42 for Mahi, 12.41 for Stambeshwar and 1.90 for Veraval.

*12. BI CARBONATE*

Bicarbonates decompose to give carbon dioxide and water. Below given table and graph shows the bicarbonate content of the study area viz Mahi, Stambeshwar and Veraval. The average bicarbonates of the Mahi are 178.67Mg/L. Stambeshwar region have 137.83 Mg/L and the Veraval region have 87 Mg/L.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 336 | 114 | 100 |
| 2 | 244 | 155 | 125 |
| 3 | 116 | 228 | 29 |
| 4 | 155 | 130 | 96 |
| 5 | 121 | 100 | 136 |
| 6 | 100 | 100 | 36 |
| **Mean** | **178.67** | **137.83** | **87** |
| **SE** | **37.86** | **19.93** | **18.31** |
| **SD** | **92.76** | **48.82** | **44.86** |

**Table 12: Bicarbonates of the study area**

The standard error of Mahi is 37.86, Stambeshwar is 19.93 and Veraval is 18.31. Standard deviation of Mahi is highest among all. The values of Mahi, Stambeshwar and Veraval are 92.76, 48.82 and 44.86 respectively.

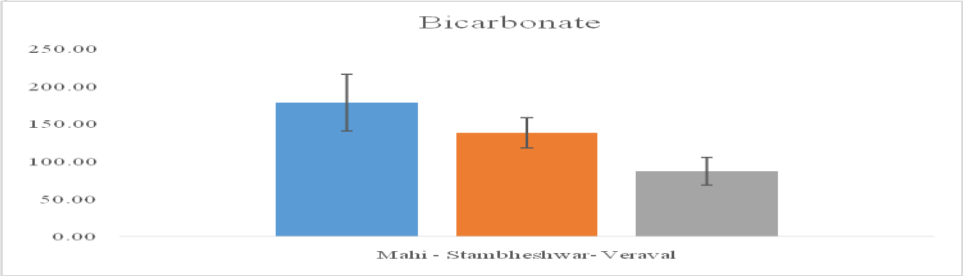


**Figure 12: Graph of Bicarbonates of the study area**

Due to increased rate of organic decomposition carbon dioxide is liberated, utilization of carbon dioxide during photosynthesis leads to enhancement of total alkalinity in the study area. Thus, Mahi accounts for high bicarbonate level and Veraval have less content. Similar phenomenon has been reported by Secnayya (1971) and Harshey*et al.* (1982).

*13. NITRATE*

Nitrate is naturally occurring inorganic ions present in our surrounding. The decomposition of organic materials releases ammonia in soil. This ammonia oxidizes to form nitrate.The highest amount of nitrate concentration was known to support the formation of blooms.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 25.4 | 12.3 | 0.4 |
| 2 | 5.5 | 10 | 0.09 |
| 3 | 12.5 | 2 | 6 |
| 4 | 36 | 25 | 10 |

| | | | |
|---|---|---|---|
| 5 | 12.6 | 2 | 2 |
| 6 | 25 | 0 | 0 |
| **Mean** | **15.45** | **10.26** | **3** |
| **SE** | **5.74** | **3.86** | **1.77** |
| **SD** | **14.07** | **9.46** | **4.34** |

**Table 13: Nitrate of the study area**

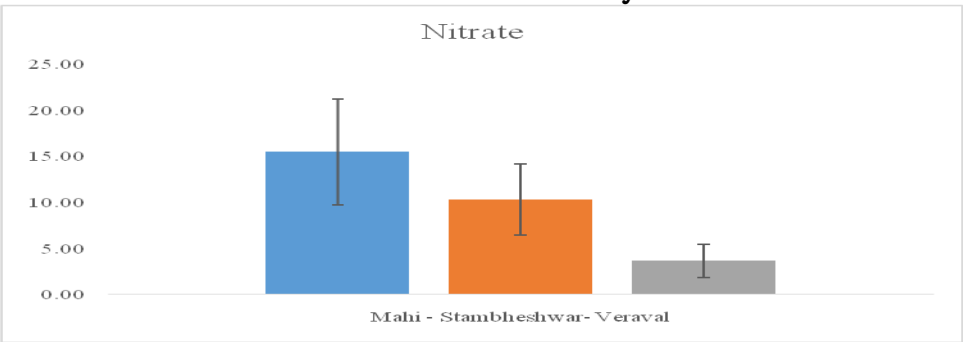


**Figure 13: Graph of Nitrate of the study area**

The above graph illustrates the Nitrate of the study area. The nitrate level of the Mahi is 15.45 Mg/L. Stambeshwar region have 10.26 Mg/L and the Veraval region have 3 Mg/L. Nitrate content of the Mahi have highest ratio and that of Veraval accounts for lowest. The difference shows Mahi have large amount of inorganic content.

The standard error of Mahi is 5.74, Stambeshwar is 3.86 and Veraval is 1.77. Standard deviation of Mahi is highest among all. The values of Mahi, Stambeshwar and Veraval are 14.07, 9.64 and 4.34 respectively.

*14. PHOSPHATE*

Phosphates exist in three forms:-Orthophosphate, Metaphosphate (or polyphosphate) and organically bound phosphate. Each compound contains phosphorous in a different chemical arrangement.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 0.07 | 0.5 | 0.9 |
| 2 | 0.42 | 0.32 | 0.23 |
| 3 | 0.02 | 0.02 | 0.02 |
| 4 | 0.05 | 0.05 | 0.08 |
| 5 | 1.5 | 0.06 | 0.06 |
| 6 | 1.5 | 0.7 | 0.9 |
| **Mean** | **0.59** | **0.28** | **0.37** |
| **SE** | **0.29** | **0.11** | **0.17** |
| **SD** | **0.72** | **0.28** | **0.42** |

**Table 14: Phosphate of study area**

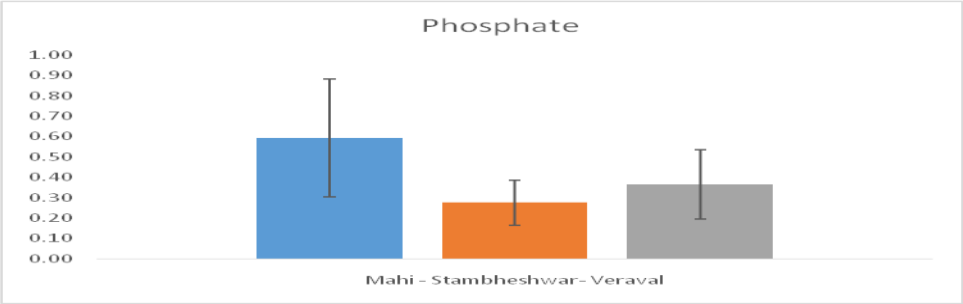


**Figure 14: Graph of Phosphate of study area**

The above graph illustrates the Phosphate of the study area. The phosphate level of the Mahi is 0.59 Mg/L. Stambeshwar region have 0.28 Mg/L and Veraval region have 0.37 Mg/L. The standard error of Mahi is 0.29, Stambeshwar is 0.11 and Veraval is 0.17. Standard deviation of Mahi is highest among all. The values of Mahi, Stambeshwar and Veraval are 0.72, 0.28 and 0.42.

*15. FLUORIDES*

Fluorides have dual significance in water supplies. High concentration causes water impurities and lower concentration (<0.8 mg/L) causes harmful disease.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi-Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | 0.93 | 0.16 | 0.56 |
| 2 | 0.94 | 0.63 | 0.26 |
| 3 | 0.15 | 0.35 | 0.05 |
| 4 | 0.25 | 0.65 | 0.65 |
| 5 | 0.33 | 0.3 | 0.02 |
| 6 | 0.65 | 0.03 | 0.03 |
| **Mean** | **0.54** | **0.35** | **0.26** |
| **SE** | **0.14** | **0.10** | **0.11** |
| **SD** | **0.35** | **0.25** | **0.28** |

**Table 15: Fluorides of study area**

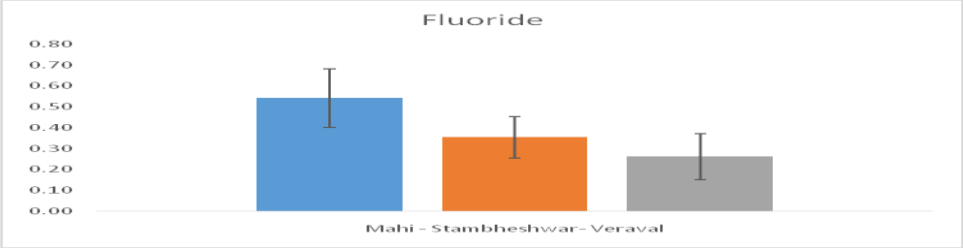


**Figure 15: Graph of Fluoride of the study area**

The above graph depicts the Fluoride of the study area. The fluroide level of the Mahi is 0.54 Mg/L. Stambeshwar region accounts for 0.35 Mg/L and Veraval region contributes 0.26 Mg/L. The standard error of Mahi is 0.14, Stambeshwar is 0.10 and Veraval is 0.11. Standard deviation of Mahi is highest among all. The values of Mahi, Stambeshwar and Veraval are 0.35, 0.25 and 0.28

**16. *COD***

Chemical Oxygen Demand (COD) is easy, inexpensive means to determine organics in water.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 300 | 35 | 20.5 |
| 2 | 225 | 22 | 22 |
| 3 | 96 | 100 | 26.3 |
| 4 | 36.6 | 72 | 36 |
| 5 | 225 | 105 | 46 |
| 6 | 253 | 29 | 29 |
| **Mean** | **189.27** | **60.5** | **29.97** |
| **SE** | **41.18** | **15.05** | **3.92** |
| **SD** | **100.88** | **36.87** | **9.60** |

**Table 16: COD of the study area**

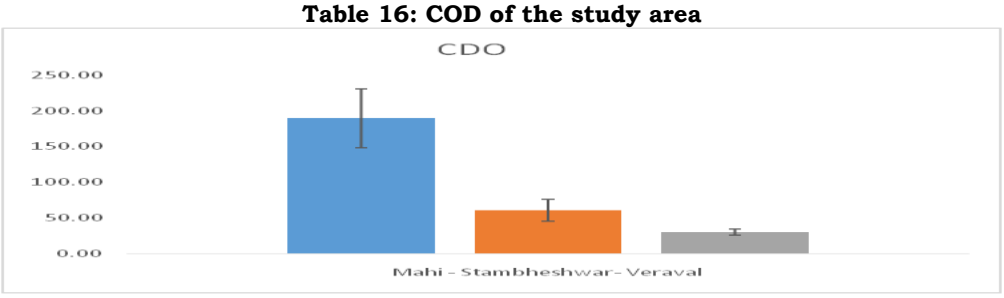


**Figure 16: Graph of COD of the area**

Chemical oxygen demand of the study area is given in the above table and graph. Mahi region counts high amount of COD in water 189.27. The contamination in the water is high in Mahi area than other two. COD at Stambeshwar region is60.5 and Veraval region contributes 29.97. The standard deviation for Mahi is 100.88, 36.87 for Stambeshwar and 9.60 for Veraval. The standard error is 41.18, 15.05 and 3.92 for Mahi, Stambeshwar and Veraval respectively.

*17. DO*

The dissolved oxygen registered a fall generally during the monsoon season. During decomposition process of organic matter, dissolved oxygen (DO) will be consumed largely for mineralization.

| Sample | Water Analysis of Mahi River Dhuvaran | Water Analysis of StambheshwarMahadev, Kavi- Kamboi) | Water Analysis of Veraval - Somnath) |
|---|---|---|---|
| 1 | 17.7 | 20 | 0.07 |
| 2 | 13 | 2 | 0.02 |
| 3 | 8.4 | 7.6 | 5.2 |
| 4 | 8.68 | 6 | 6 |
| 5 | 8.45 | 6.9 | 6.8 |

| | | | |
|---|---|---|---|
| 6 | 8.78 | 5.2 | 7.9 |
| **Mean** | **10.84** | **7.95** | **4.33** |
| **SE** | **1.55** | **2.54** | **1.40** |
| **SD** | **3.80** | **6.22** | **3.44** |

**Table 17: Dissolved oxygen of the study area**

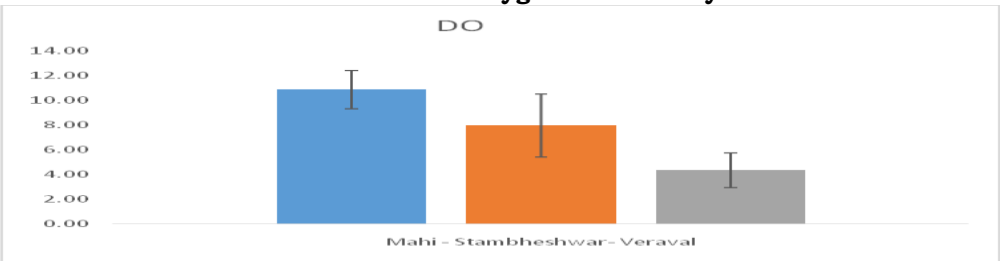


**Figure 17: Graph of Dissolved Oxygen of the study area**

Dissolved oxygen of the study area is given in the above table and graph. Mahi region counts high amount of DO in water 10.84. The contamination in the water is high in Mahi area than other two. DO at Stambeshwar region is 7.95 and Veraval region contributes 4.33. The standard deviation and standard error is calculated by the formula STD * EV/Mean. The value obtained is 3.80 for Mahi, 6.22 for Stambeshwar and 3.44 for Veraval. The standard error is 1.55, 2.51 and 1.40 for Mahi, Stambeshwar and Veraval respectively.

In conclusion, this study will provide baseline information on these parameters of Mangrove region in the Kavi, Dhuvara and Somnath which would be helpful in assessing the changes in water quality that might happen in long run due to port development, regular port activities, industries that are in operation in and around the port area, shrimp farming etc.

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