RESULTS AND DISCUSSION:

3.1 Background

The global production of organic chemicals has raised tremendously during the last decade. The toxic chemicals created during chemical processes are given out to water-bodies such as pond, lakes, rivers and sea and the biotic environment in them becomes harmful for natural organisms normally growing in it. With rapid urbanization and fast growing cities, their maintenance of water quality and sanitation infrastructure did not increase, along with population growth, especially for the developing countries, they released their sewage effluent in to river water, and in open land without any treatment. The soluble pollutants and ionic species in these effluents, slowly, percolate through soil bed and adversely affect the quality of the soil. In addition to the changes in the soil profile, the possibility of the deterioration of underground water resources also enhances.

The concerned authorities have begun to discourage the use of ground water for drinking and farming as far as possible, in spite of the seriousness of the problem, no systematic study has been carried out, to assess the magnitude of pollution by waste effluents in satpura region. A study was therefore carried out to investigate the quality of Tapti River water and their impacts on surrounding ground water, soil, sediment etc. During the course of present study we are finding out the physico-chemical characteristic, detection of heavy metals, detection and identification of organic compound including BHC and DDT, by GC/MS techniques. Also modified and developed low cost methodsto remove the heavy metals in River water. Thus the results observed during the present study are being described and discussed under the following sections.

3.1.1 SECTION- I: Physico-chemical characteristics of Tapti River Water, aquatic sediment and nearby soil

3.1.2 SECTION-II: Detection of metal in River water, aquatic sediment and nearby soils.

3.1.3 SECTION-III: Detection and identification of organic compound like BHC and DDT by GC/MS techniques.

3.1.4 SECTION-IV: Effect of River water on adjoining ground water quality, and soils Quality.

3.1.5 SECTION-V: Suggested new cost effective methodsto the remove toxic heavy metals ions from waste water be four releasing it to water bodies.

3.1.6 SECTION-VI: Data processing for statistical analysis.
SECTION-I

PHYSICO CHEMICAL CHARACTERISTICS OF RIVER WATER, SEDIMENTS
AND SOIL

3.1.1 Introduction:-

The environment and the eco-system are badly affected by social, agricultural and industrial activities by human population. Riverwater, ground water and soil, all are polluted by increasing use of chemicals in the form of fertilizers and pesticides.

The ecosystem is destabilized and causes ill effect on the health of the human beings as well as all other living organism\(^1\).

The physical and chemical characteristic of any riverine water, sediment, play an important role of ecological significance especially in river ecosystem. It reflects the history of the pollution. All type of organic and inorganic solid and liquid matter present in effluent, solid waste is released, discharged into river water\(^2\). The water and, sediments act as both carrier and sink for contaminants in aquatic environment. These sediments provide food stuff for living organism. The distribution of hazardous waste in various fractions in aquatic ecosystem is very much useful in assessing the potential impact on biota. Base line studies are required to determine the status of river in quality to give complimentary data on the physico-chemical characteristics of water, sediments and soil\(^3\).

Physico-chemical characteristics of the river water sediments and soil depend on the location, environmental conditions and external factors like contamination.

The quality of soil and sediment depends directly on the quality of water coming in contact with it or mixing with it. The quality of water used in irrigation, manures, adjoining habitation, and nature of crop/Plants also affect the quality of soil. Under the present investigation, some salient parameter like pH, Electrical conductivity (EC), Hardness, total alkalinitites, bicarbonates phosphate, chloride, calcium, magnesium, sodium, potassium etc. Of all the above samples collected from different sites from Sulwade to Ukai dam, have been studied for the purpose of comparison. As a control, some samples (water, sediment and soil) from a nearby site, which have never been affected by waste effluents from different sources, the river water, sediment and nearby soil, were collected and analyzed.

For the evaluation of the above parameters particularly for soil and sediments 1:5 soil/sediments water extracts have been taken and the results thus obtained are being described and discussed under the following headings.
3.1.1 Physico-chemical Characteristics:

The physical and chemical properties of River water samples are compared with WHO, BIS, ICMR, ISI standards, hazardous metals in aquatic sediment is compared with Average shale values guideline in for hazardous metals in nearby soil by phytotoxic level in the GLC guidelines.

3.1.1.1 pH (potential hydrogenii).

pH measures the hydrogen ion concentration. It is measured on a log scale and equals to negative log of hydrogen ion concentration.

$$\text{pH} = -\log_{10}[\text{H}^+]$$

The pH is a measure of the relative acidity or alkalinity of water.

Most natural water is generally alkaline due to presence of sufficient quantities of carbonates. pH of water gets drastically changed with time, due to the exposure to air, biological activity and temperature changes. Significant change in pH occurs due to disposal of waste effluent water, acid, minerals etc, in natural water. pH also changes diurnally and seasonally. Due to variation in pH, photosynthetic activities which increase with pH, and due to consumption of CO$_2$ It is most outstanding physiological characteristics of the soil and water. It influences many physical and chemical properties of the soil and governs the growth of plants and the activity of micro-organism in it. Chang in the pH values do not affect human health but very low pH values gives water acidic, acidic-sour taste and kill small micro-organisms and very high value of pH makes water strongly alkaline and bitter in taste making it unfit for human consumption. The property of chlorine in water to kill bacteria gets reduced if the pH of water is more. When the pH of water is high, formation of tri-halo-depravities’, which are toxic in nature, takes place easily. If the pH of water is low corrosion of metallic surfaces in contact starts which releases toxic metals compounds from Zinc, Lead, Cadmium and Copper. In water supplies, pH is also an important factor in fixing alum dose in drinking water treatment. The activity of bacteria in soil and sediments considerably decreases, when pH falls below five to three. Under normal biological environment a pH range is 6.0 to 7.5 is considered normal optimum Thenitrifications in soil take place vigorously.
In the above range and the intake of nutrients in the plants is found to be highly conducive. The Availability of nutrients like Phosphorous, Magnesium, Calcium, Iron etc., to the physiological condition, biochemical changes, control of the absorption and distribution of cations, solubility of many soil constituents etc, are also found to be pH dependent.

During the course of present study (Table 3.1), The pH of the Tapti River water collected from different stations in wet and dry seasons was found to be 6.5 to 8.5. The maximum pH in dry season at Kukarmunda, Ukai dam, & Sulwade due to high photosynthetic activity and high biological activity slightly alkaline nature of water due to Geology of catchment area and low pH in wet season at Prakasha station due to dilution effect of rain water and acidic water is discharged in river due to domestic or industrial activity. When the pH above 7.5 presence of Calcium and Magnesium Carbonates is suspected and when the pH is above 8.5 we can conclude the presence of strong Na ions.

The water samples under study showed slightly acidic to alkaline nature. The observed pH values were within limits given by WHO and ISI. Yadav and Kumar Rajesh recorded the maximum and minimum pH values of water samples from 7.2 to 8.5 of Kosi River in Rampur District U.P. India. They concluded slightly alkaline nature of water samples. pH values were within the desirable limit prescribed by WHO, ISI, ICMR.

During the present study periods (Table 3.2) the pH of sediments samples varies from 7.14 to 10.2 at Prakasha and Kukarmunda stations was recorded. Lowest pH in wet season was due to acidic effluent discharge from nearby industry and villages and high pH was recorded in dry season due to deposition of tremendous amount of sediments. This sediments deposition was due to, back water of Ukai dam near Songarh. These deposited sediments contain much CaCO3, MgCO3 which are calcareous on hydrolysis of CaCO3 and MgCO3, release OH ion which contributes to alkalinity in sediments. Sing et al reported the pH of Gomati River was alkaline in the range of 7.62 and 8.27.

During the study period, (Table 3.3) the pH of soil samples nearby Tapti River are in range of 6.02 to 8.12 at Kukarmundastation. The minimum pH at Kukarmuda station in dry season, may be due to the acids produced by the microorganisms and the activities of the roots of higher plants, particularly with regard to acidic exudates. The maximum value of pH was recorded in wet season may be due to biotic activities, and cropping system.

Shrivastava et al reported higher and lower pH values of soil samples collected from Nandurbar town area as 8.5 to 8.9 where as pH at control site was reported 7.7. A comparative study indicates that there is an increase in the alkaline nature of soil samples under study.
3.1.1.2 Electrical conductivity (EC):-

Electrical conductance is very important regarding the salinity to indicate the purity of water. Water capacity of substance or a solution to conduct electric current is denoted by E.C. when the resistance is less the conductivity is more and Conductivity is the reciprocal of the resistivity Conductivity is expressed in mmho or µmho. Conductivity is highly dependent on temperature at 25°C EC was calculated at 25°C to maintain the comparability of data from various sources\textsuperscript{21,22,23}. The electric conductance of water is the sum of all ionic conductance’s of the ionic constituents. The conductivity of distilled water ranges from 0.001 to 0.005 mmoh/cm but the presence of salt and contamination with waste water increases the conductivity of the water. It has no health significance as such. However it is an important criterion for determining stability of water and use of waste water for irrigation\textsuperscript{24,25,26} conductance in sediments depend up on the percentage of ion such as Cl\textsuperscript{-}, SO\textsubscript{4}\textsuperscript{2-}, PO\textsubscript{4}\textsuperscript{3-}, HCO\textsubscript{3}\textsuperscript{-}, Na\textsuperscript{+}, K\textsuperscript{+}, Ca\textsuperscript{++}, Mg\textsuperscript{++}etc and also lower conductance will indicate presence of silicate material\textsuperscript{27}.

The conductivity of soil extract depends on location of area and nature of soil. It varies from place to place and it is also influenced by external factors like quality of surface water, nature of plant growth and type of water used for irrigation. Higher the concentration of acid and bases and salt in water, higher will be the conductivity. Electrical conductivity of soil solution gives an idea about the presence of the available micro nutrients in the soil. The available micronutrients have pronounced effect on the growth, flowering, fruiting of plants\textsuperscript{23}. On the basis of EC values researchers have classified irrigation water in to five groups; excess salinity reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrients from soil. In alkali Hazards, SAR values below 10 indicate good water for irrigation purposes\textsuperscript{24}.

<table>
<thead>
<tr>
<th>Table 3.4</th>
<th>Irrigation water quality classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water class</td>
<td>Salinity Hazards</td>
</tr>
<tr>
<td></td>
<td>EC(µmohs/cm)</td>
</tr>
<tr>
<td>Excellent</td>
<td>Up to 250</td>
</tr>
<tr>
<td>Good</td>
<td>250 – 750</td>
</tr>
<tr>
<td>Fair / Medium</td>
<td>750 -2250</td>
</tr>
<tr>
<td>Poor / bad</td>
<td>&gt;2250</td>
</tr>
<tr>
<td>Very poor/Bad</td>
<td>&gt; 4000</td>
</tr>
</tbody>
</table>
Table 3.5  Rating for soil based on EC (μmohs/cm)

<table>
<thead>
<tr>
<th>Parameter mmohs/cm</th>
<th>Rating for Hazard mmohs/cm</th>
<th>Suitability for crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.8</td>
<td>Normal for most crops</td>
<td></td>
</tr>
<tr>
<td>EC</td>
<td>0.8-1.6</td>
<td>Injurious to some crops</td>
</tr>
<tr>
<td>1.6-3.2</td>
<td>Injurious to most crops</td>
<td></td>
</tr>
<tr>
<td>3.2 to above</td>
<td>Injurious to all crops</td>
<td></td>
</tr>
</tbody>
</table>

A perusal of (Table 3.6) clearly indicates that the electrical conductivity of water varies from 107.3 to 301.2 μmohs/cm. The minimum EC values were recorded in wet season samples at Sayla station while maximum was recorded in dry season for samples Sayla. Lower EC in wet season may be due to dilution effect, and location wise changes in EC was statistically significant while in dry season the increase in values may be due to the evaporation and reduced discharge of sewage water to the river and also due to geological effect. All water samples were below the BIS, WHO limits. Rekha Rani et al reported EC for three seasons in the range of 288 to 395 μmohs/cm in Narmada River water near Satna city Madhya Pradesh, India. The conductivity of sediment samples (Table 3.7) was found to be between 200 to 670.12 μmohs/cm. The conductivity values in Tapti River basin sediments collected from Sulwade station to Ukai Dam are comparatively lower than soil samples. This is because of the River Tapti is flowing in the adjoining vicinity so that water soluble salts are being decreased. The lowest value of EC of the collected sediment samples due to the percentage of ion such as Cl⁻, SO₄²⁻, PO₄³⁻, HC₀₃⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, etc. and higher value of EC will indicate higher level of silicate Taghinia H.A. et al reported EC of Kabini River sediment in the range of 62 to 396 μmhos/cm. During the course of the present study, (Table 3.8) EC values of soil samples range from 640 to 1010 μmohs/cm at Prakasha and Saylastations. The lowest value at Prakasha station in wet season was due to use of high yielding crop varieties. Intensive cropping and restricted use of organic wastes, accelerates the removal of micro nutrients from soil, as a result of which, their deficiencies were compiling up. The increase in EC value at Sayla station in wet season is due to the agricultural runoff, movement of ions, irrigation, fertilizers and accumulation of salts.
3.1.1.3 Total alkalinity (TA):

Alkalinity of a water sample refers to its capacity to neutralize acids. It is the sum total capacity of chemical components in water that tends to rise. The high pH of alkaline water is due to presence of free hydroxyl ions and hydrolysis of salts formed by weak acids and strong bases.

\[ A^- + HOH \rightleftharpoons HA + OH^- \]

Total alkalinity of a solution is the number of milliequivalents of acids used in titration to combine with all hydroxyl ions. When CO2 dissociates in water, alkalinity is given to natural water. Carbonated salt produces double the hydroxyl ion than the bicarbonates. Therefore the total alkalinity caused by

\[
\begin{align*}
\text{H}_2\text{O} + \text{CO}_2 & \rightleftharpoons \text{H}_2\text{CO}_3 \\
\text{H}_2\text{CO}_3 & \rightleftharpoons \text{H}^+ + \text{HCO}_3^- \\
\text{HCO}_3^- & \rightleftharpoons \text{H}^+ + \text{CO}_3^{2-} \\
\text{CO}_3^{2-} + 2\text{H}_2\text{O} & \rightleftharpoons \text{H}_2\text{CO}_3 + 2\text{OH}^- \\
\text{HCO}_3^- & \rightleftharpoons \text{H}_2\text{CO}_3 + \text{OH}^- \\
\end{align*}
\]

Total alkalinity = \( \text{HCO}_3^- + 2\text{CO}_3^{2-} + \text{OH}^- + \text{H}^+ \)

Alkalinity is important for aquatic life because it acts as a buffer, controlling the pH fluctuation. Excessive alkalinity may cause eye irritation in humans. Surface water with alkalinity 200mg/L are potentially sensitive to heavy acid deposition, “Alkalinity in itself is not harmful to human beings, still the water with less than 100 mg/L values are desirable for domestic use”. Naturally colored waters contain humates (Salt of humic and folic acid) which also adds to the alkalinity of water. The alkalinity value is also important in calculating of those elements and bio acids in water. Alkalinity producing substances such as sodium bicarbonate are added to check corrosion in soft water supplies. Alkalinity measurements are also important in controlling water and waste water treatment processes. The ratio of alkalinity to that of alkaline earth metals is good parameter determining the standard of irrigation water.
The main sources of natural alkalinity are rocks which contain carbonate bicarbonate and hydroxide compounds. Borates, Silicates and Phosphates may also contribute to alkalinity\textsuperscript{35}. The alkalinity also affects the soil texture and permeability. The variation in alkalinity value may be due to irregular distribution of basic salts, biological activities of microorganism, and climate conditions\textsuperscript{36, 37}. Alkalinity occurs, when there is a comparatively high degree of basic saturation of salts, especially Ca, Mg, and Na\textsubscript{2}CO\textsubscript{3} also gives a preponderance of OH\textsuperscript{-} ion over H\textsuperscript{+} ion in soil solution.

During the present study (Table 3.9), total alkalinity in water ranges from 121.3 to 237.3 mg/L. The minimum value recorded in wet season at Ukai Dam station was due to the dilution effect and at high flow rate, maximum salts are leached out and maximum value recorded in dry season at Prakasha station due to the large surface area, high evaporation rate, and flow of water stopped due to construction of barrage of the river. So increase in concentration samples of total alkalinity values were observed to be just high as compared to WHO and ISI standard limits Chatterjee\textsuperscript{36} reported alkalinity of Damodar River in range of 118.9 to 218.3mg/L. They concluded that few stations values were just above potable water standards. They concluded that at few stations water pollution was caused by waste water discharge by its tributaries and human activity.

A perusal of (Table 3.10) Total Alkalinity of sediment samples varies from 280.5 to 578.1 mg/L in wet and dry season at Sulwade and Sayla stations was found to be higher in comparison of soil and water samples due to high alkaline pH of sediment sample Nnaji et al\textsuperscript{38} compared Galma River sediment alkalinity in the downstream area ranges from 61 to 69 mg CaCO\textsubscript{3}/L and from 29.0 to 73.0 mg CaCO\textsubscript{3}/L in the upstream area.

The soil sample under study shows (Table 3.11) total alkalinity varies from 198.4 to 311.3mg/L in wet and dry season at Sayla and Sulwade stations. The variation in the alkalinity values may be due to irregular distribution of basic salts (Compounds), biological activates of microorganism and, climatic conditions\textsuperscript{39,40}.

Singare et al\textsuperscript{41} studies soil pollution along Kalwa bridge at Thane (M.S.), average Total alkalinity values varies from 19.0 to 20.1. mg./L. Due to dilution in mansoon season alkalinity is found to be low.
3.1.1.4 Chlorides:-

Chlorides occurrence in all natural water is widely varying in concentration. The chlorides content normally increases as the mineral content increases\textsuperscript{42}. Also indicators of pollution due to organic wastes of animal or Industrial origin with nitrogenous compounds, Human body releases a very high quantity (6 gm per person per day) of chloride.

Chloride plays an important role in deciding the pH of samples. Chlorides up to 250mg\textper GDPR\ text  are not harmful in potable water \textsuperscript{43}, but in excess, it produces salty taste, depending up on chemical composition of water. Chlorine and its compounds are respiratory irritants, highly corrosive and cause damage to vegetation. If a chloride like soluble NaCl is present in water, it should not be used for drinking and cooking purposes especially for persons suffering from certain heart disease\textsuperscript{44}. Chloride is not absorbed by the soil, it moves readily with soil water. Chlorides are harmless to organism but it converts to Cl\textsuperscript{–}, ClO\textsuperscript{2–}, and ClO\textsubscript{3}–-which are toxic\textsuperscript{45}. When chlorideson combination with, Phenol or ammonia and Cyanides become more toxic\textsuperscript{46}. High level of chloride content kills the microorganisms which are important factor of food chain in aquatic life\textsuperscript{47}. About 8 to 15gm of sodium chloride is excreted by a person per day.

Chlorides are highly soluble with most of the naturally occurring cation and are not precipitated, regimented and cannot be removed biologically in treatment of waste. It is harmless up to 1500mg/L concentration but produces a salty taste at 250-500mg/L level. Exess amount chlorides present in water can react with calcium in concrete and calcite is formed. At higher temperatures Magnesium chlorides releases HCl which is highly corrosive n affect inner metallic surfaces of boilers\textsuperscript{76}. Chlorine is also known to influence photosynthesis and root growth and suffers if it is absent. Sometimes, equipment failure or damage of chlorine container leads to leakage of chlorine into the atmosphere and it is added to soil in considerable quantities each year through rain water. The presence of chlorine in soil gives raises to the formation of chloro complexes\textsuperscript{48}.

The samples under study (Table 3.12) showed chloride contents in water ranged from 89.8 to 192.3 mg/L at Prakash and Kukarmuda station in wet and dry season. Seasonal fluctuation in chloride contents were observed during study period. This is due to temperature effect in wet and dry season, which is a geological factor\textsuperscript{49,50&51}. The chloride contents were found to be within prescribed limits recommended by WHO ISI, ICMR standards.
Rita N. Kumar et al\textsuperscript{52} reported the chloride contents ranged from 41.74 to 102.07 mg/L in Sabarmati river water due to organic waste of animals and of industrial origin\textsuperscript{53,54}. They concluded that the chloride concentrations were within the limit prescribed for drinking water. A perusal (Table 3.13) the concentration of chloride in sediment samples was found to be between 215.4 to 577.4 mg/L in wet and dry season at Prakasha and Ukai dam stations. High chloride concentration due to release of industrial effluents above these stations. During the study period (Table 3.14) concentration of chloride in soil ranged from 44.3 to 97.6 mg/L in wet and dry season at Kukarmuda and Sayla stations. Low chloride value in soil may be due to rain fall which leaches the salt out of soil, during Mansoon and highest in pre Mансoon due to input of organic matter of animal origin 5.6.

Anu et al\textsuperscript{55} have collected and analyzed soil samples near of Shahpura Lake of Bhopal (M.P.) they found that chloride contents of soil samples ranged from 255.8 mg/Kg to 530.6 mg/Kg.

\subsection*{Bicarbonate:-}
Sodium carbonate is present in mineral springs but in traces in most natural water, Sodium and Potassium Carbonates are water soluble but carbonates of Calcium and Magnesium are insoluble in water, but soluble in acid. If soluble carbonates are applied in irrigation water to soil, in absence of calcium and magnesium, soil becomes alkaline. If Calcium and Magnesium are present, CaCO\textsubscript{3} is precipitated and it has no harmful effect on soil, Sodium Carbonate is undesirable in irrigation water. The alkalinity in the soil and sediments may be due to the presence of Carbonate and Bicarbonates. The Bicarbonates are formed in soil by two separate routes. In the first process, carbon dioxide dissolves in water and the carbonic acid thus produced, reacts with limestone or any other carbonates present in the soil, resulting in the formation of soluble bicarbonates.

\begin{align*}
\text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2 & \rightarrow \text{Ca} \ (\text{HCO}_3)_2 \\
\text{Insoluble} & \rightarrow \text{Soluble}
\end{align*}

These bicarbonates, being soluble in water are able to percolate through the soil and may be the main source of the bicarbonates present in the water soluble-extracts. Carbonic acid formed by the solution of CO\textsubscript{2} in water itself is a weak acid, and its dissociation can be represented by the following equations.
H$_2$CO$_3$ + H$_2$O $\rightarrow$ H$_3$O$^+$ + HCO$_3^-$

$P_{ka1} = 4.52 \times 10^{-7}$

HCO$_3^-$ + H$_2$O $\rightleftharpoons$ (H$_3$O)$^+$ + CO$_3^{2-}$

$P_{ka2} = 4.69 \times 10^{-11}$

Plant species differ markedly in their tolerance to bicarbonate ion, which some time exert specific toxic effluent. It also results in serious injury, even at low osmotic concentration. Bean and Dallies grass are very sensitive, while Rhodes grass and Beet are relatively tolerant. Studies in sand culture indicate that bicarbonate ion affect uptake and metabolism of nutrients by plants and that the nature of these effects varies with plant species$^{23,56}$.

A perusal of (Table 3.15). Show that bicarbonate in water samples varies from 21.2 to 50.3 mg/L in wet and dry season at Sayla and Prakasha stations. We can conclude the water samples contain carbonate of Calcium and Magnesium, rainfall, geology of area. Concentration of bicarbonate in all samples were below the limits During study the period (Table 3.16), concentration of bicarbonate in sediment samples varied from 313.3 to 1012.3 mg/L in wet and dry season at Sulwade and Ukai dam stations. High concentration was due to bicarbonate salts which are presents on soil surfaces.

Krupadam et al $^{57}$ studied geochemical fractionation of heavy metals in sediments of the Tapti estuary. The bicarbonates values varied from 1.73 to 4.03 mg/L.

A perusal of (Table 3.17) Concentration of bicarbonate in soil samples varies from 0.238 to 0.491 mg/L in wet and dry season at Sayla and Kukarmunda Stations.

Vediya and Patel $^{58}$ analyzed bicarbonate levels in soil samples collected from in, and around Modasa(Gujarat). They reported the bicarbonate concentration ranged from 207.4 to 341.6 mg/L. The high concentration is due to fast industrial growth and use of fertilizers$^{59,60}$.

3.1.1.6 Phosphate:-

Phosphate present in natural water in inorganic form such as PO$_4^{3-}$, HPO$_4^{2-}$, H$_2$PO$_4$ it is an important constituent of biological system. It may be present in organic form.

Phosphorous is important constituent of soil. The growth of plants and crop depends upon presence of proper amount of phosphates in the soil$^{61,62}$. The plant takes up not only water soluble phosphate, but also those, which are soluble in water and acids like carbonic acid, malefic acid. These acids have capacity to dissolve some water insoluble soil derived phosphates. Phosphate occurs in water as a result of domestic sewage, detergents, agricultural effluents, with fertilizers and industrial waste water. Bulk of weathering of rocks, soluble alkali, and metalphosphate are carried to the estuaries. High concentration is indicative
Of organic pollution. Seasonal variation of phosphate in river water is due to the processes like adsorption and desorption of \( \text{PO}_4^{3-} \) and buffering action of sediments under varying environmental conditions.\(^63\)

In the presence of oxygen, phosphates are co-precipitated with the complex insoluble oxides of Fe and Mn, Al and Ca are also capable of Co-precipitating phosphates with their insoluble salts in presence of oxygen at higher redox potential, the net tendency of phosphate in waters is to get precipitated and fast to the sediments resulting in the overall decrease of phosphate in water.\(^64,65\) Higher the concentration of phosphate, therefore is, indicative of pollution. Phosphate concentration above 2mg/L can be considered as an indication of high pollution. The prime concern of phosphate lies in the ability to increase the growth of nuisance, algae and eutrophication. The quality criterion for phosphorus in waters is only to check nuisance growth of algae and processes of eutrophication; soil contains inorganic and organic compounds of phosphoric acid, with predominance of Inorganic phosphates. The phosphates of all univalent cations are readily soluble in water and therefore, these are easily up taken up by the root system. The same applies to mono calcium and mono magnesium dehydrates (\( \text{CaHPO}_4\cdot2\text{H}_2\text{O}, \text{MgPO}_4\cdot2\text{H}_2\text{O} \)) which are much more soluble than anhydrate calcium-biphosphate, because of the rapid adsorption of phosphoric acid anion in soil chemically. the soil contains extremely small amount of water soluble phosphorus (<1mg/Kg of dry soil) compound, organic phosphorus compounds of the soil are present in the humus. Higher the humus contents in the soil, richer the organic phosphates. Organic phosphates are mineralized by various microbes in the soil.

During the study period (Table 3.18) the concentration of phosphate in water varied from 0.01 to 1.2 mg/L in wet season at Ukaidam and Prakasha stations, high phosphate in rainy or wet Seasons is due to generation and released of total phosphate from bottom mud in to water Column by turbulence and mixing. Moreover, the bulk of withering of rocks, soluble alkali metals phosphates are carried to the river water.\(^66\) Addition of phosphates applied in the agricultural fields as a fertilizer and alkali phosphates used in households as detergents, can be other source of inorganic phosphates during the wet season. Low concentration in dry season is due to flow of fresh water, low salinity and utilization of phosphate by phytoplankton also by adsorption and desorption of phosphates and buffering action of sediments under varying environmental conditions. All samples except Ukai dam station in wet season were above the BIS limits.
Sharma et al. Reported phosphate in Narmada River at Hoshangabad city (M.P.) ranges from 0.16-0.19 mg/L are just above the BIS Limit.

A perusal of (Table 3.19) Concentration of phosphate in sediments samples varied from 50.4 to 85.2 mg/L in wet and dry seasons at Sulwade and Ukai Dam stations.

Nnajie et al. Reported mean concentration of phosphate in Galma River upstream area show 5.16 mg/L and downstream area show 4.03 mg /L.

During present study (Table 3.20) the concentration of phosphate in soil sample varies from 23.4 to 42.0 mg/L in dry and wet seasons at Ukai dam and Prakasha stations. Raiy et al. compared soil irrigated with sewage water and canal water. They reported 104.88 mg/ Kg and 23.43 mg/Kg phosphate soil irrigated with sewage water contains higher amount of phosphate which play significant role in plant growth.

3.1.1.7 Total Hardness:-

Total Hardness of water is not a pollution parameter but indicates water quality. Hardness of water body is regulated largely by the level of Calcium and Magnesium salts, other metal such as Iron, Manganese and Aluminum also contribute to hardness. Nitrate, Sulphate, Silicates, Bicarbonate, and Chloride etc anion Present in water it becomes hard which hinders production lather due to soap and increases the boiling point of water. Temporary hardness is due to carbonate and Bicarbonate of salt it can remove by boiling the water but Chlorides and Sulphates of metals makes its permanent hardness. Such water is not useful for domestic use in washing, cleaning and laundering. For some plants and some fish hard water is suitable, they are said to prefer hardness. High levels hardness values will affect the transfer of nutrients and waste products through cell membranes and can affect egg fertility. Proper functioning of internal organs such as kidneys and growth. Within proper range, most fish and plants can successfully adapt to local hardness conditions although breeding may be impaired.

Hardness does not directly affect human health but there is some evidence that hard water leads to heart diseases or kidney stones, uratary crystalisation. If the hardness of water is more, precipitation, and cake formation takes place at higher temperatures and the effect of urolithiasis is seen. It is undesirable due to the formation of heat retarding scale in the boilers and other heat exchange equipment’s. The hardness may be advantageous in certain condition when water with hardness above 200mg/L prevents the corrosion in the pipes by forming a thin layer of scale and reduces the entry of heavy metals from the pipes to the water. High hardness.
Shows poor water quality. The abnormal value of hardness may be due to the discharge of domestic sewage, paper, textile and chemical waste. High level of hardness maybe due to proximity and hydraulic connection of ground water sources to the creek.

Hardness of water samples (Table 3.21) under study varied from 137.4 to 317.14 mg/L in wet and dry seasons at Ukai Dam and Sayla stations. The hardness of water depends up on rain fall, and geology of catchment area, its values depends on seasonal variations. During study period was found to be within desirable limits recommended by WHO, but just above BIS and ICMR Limit.

Mahadev and Gholami\textsuperscript{75} analyzed upstream and downstream water of Cauvery River around KRS dam Karnataka (India) ranges from 56-89 mg/L. They concluded thatat all sampling stations, hardness was below detection limits prescribed by WHO.

Perusal of (Table 3.22) represents that the sediment samples ranged between 198.4 and 617.3 mg/L in wet and dry seasons at Sulwade and Ukai Dam respectively.

Taghini et al\textsuperscript{76} analyzed Kabini River sediments hardness varies from 168 to 544 mg/L. Maximum hardness is due to high concentration of exchangeable cations.

A perusal (Table 3.23) represents that the hardness of soil varied from 147.1 to 294.3 in wet and dry seasons at Kukarmunda station. The results are show that Calcium and Magnesium salts are being adsorbed on soil surface, soil hardness has increased.
Table 3.1  pH of the water sample collected in Tapti River

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$\bar{X}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>6.8</td>
<td>7.8</td>
<td>7.1</td>
<td>8.5</td>
<td>7.55</td>
<td>0.759</td>
<td>0.379</td>
<td>7.55 ± 1.208</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>7.2</td>
<td>8.1</td>
<td>6.7</td>
<td>8.3</td>
<td>7.575</td>
<td>0.754</td>
<td>0.377</td>
<td>7.575 ± 1.200</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>7.9</td>
<td>8.5</td>
<td>7.8</td>
<td>8.4</td>
<td>8.15</td>
<td>0.351</td>
<td>0.175</td>
<td>8.15 ± 0.558</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>6.5</td>
<td>8.4</td>
<td>6.7</td>
<td>7.5</td>
<td>7.275</td>
<td>0.8655</td>
<td>0.432</td>
<td>7.275 ± 1.377</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>7.4</td>
<td>8.3</td>
<td>7.9</td>
<td>8.5</td>
<td>8.025</td>
<td>0.4856</td>
<td>0.2428</td>
<td>8.025 ± 0.772</td>
</tr>
<tr>
<td>Sr. No.</td>
<td>Site of Sample Collection</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>$\bar{x}$</td>
<td>S.D.</td>
<td>S.E.</td>
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<td>S1</td>
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<td>8.12</td>
<td>8.13</td>
<td>8.11</td>
<td>8.13</td>
<td>8.415</td>
<td>0.590</td>
<td>0.295</td>
<td>8.415 ± 0.938</td>
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<tr>
<td>S2</td>
<td>Sayla</td>
<td>8.7</td>
<td>8.14</td>
<td>8.8</td>
<td>8.20</td>
<td>8.46</td>
<td>0.338</td>
<td>0.169</td>
<td>8.46 ± 0.5381</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMund a</td>
<td>9.2</td>
<td>10.2</td>
<td>8.1</td>
<td>9.78</td>
<td>9.32</td>
<td>0.910</td>
<td>0.455</td>
<td>9.32 ± 1.4491</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>8.2</td>
<td>7.99</td>
<td>7.14</td>
<td>7.99</td>
<td>7.83</td>
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<td>0.235</td>
<td>7.83 ± 0.748</td>
</tr>
<tr>
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<td>Sulwade</td>
<td>8.11</td>
<td>8.21</td>
<td>8.2</td>
<td>8.23</td>
<td>3.187</td>
<td>0.053</td>
<td>0.026</td>
<td>8.187 ± 0.084</td>
</tr>
</tbody>
</table>

Table 3.2  pH of sediment samples collected in Tapti River
Table 3.3  pH of soil samples collected in and around Tapti River.

<table>
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<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$\bar{x}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>6.87</td>
<td>7.90</td>
<td>6.66</td>
<td>7.54</td>
<td>7.242</td>
<td>0.577</td>
<td>0.288</td>
<td>7.242 ± 0.918</td>
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<tr>
<td>S2</td>
<td>Sayla</td>
<td>7.2</td>
<td>7.51</td>
<td>7.44</td>
<td>6.87</td>
<td>7.255</td>
<td>0.288</td>
<td>0.144</td>
<td>7.255 ± 0.4597</td>
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<td>KukarMunda</td>
<td>7.13</td>
<td>6.02</td>
<td>8.12</td>
<td>7.76</td>
<td>7.3025</td>
<td>0.8412</td>
<td>0.420</td>
<td>7.3025 ± 1.338</td>
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<tr>
<td>S4</td>
<td>Prakasha</td>
<td>7.54</td>
<td>8.2</td>
<td>6.99</td>
<td>7.27</td>
<td>7.5</td>
<td>0.517</td>
<td>0.258</td>
<td>7.5 ± 0.8239</td>
</tr>
<tr>
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<td>Sulwade</td>
<td>6.14</td>
<td>7.82</td>
<td>6.3</td>
<td>6.15</td>
<td>6.6025</td>
<td>0.8149</td>
<td>0.407</td>
<td>6.6025 ± 1.2965</td>
</tr>
</tbody>
</table>

52
Table 3.6  EC (μmohs/cm) of water samples collected in Tapti River

<table>
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<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
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<tbody>
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<td>S1</td>
<td>Ukai Dam</td>
<td>126.3</td>
<td>247.3</td>
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<td>207.17</td>
<td>64.079</td>
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<td>$207.17 \pm 101.95$</td>
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<td>Sayla</td>
<td>186.8</td>
<td>203.6</td>
<td>107.3</td>
<td>301.2</td>
<td>199.72</td>
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<td>39.81</td>
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<td>$199.72 \pm 126.68$</td>
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<td>KukarMunda</td>
<td>260.3</td>
<td>196.8</td>
<td>205.4</td>
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<td>$235.3 \pm 64.19$</td>
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<td>Prakasha</td>
<td>167.4</td>
<td>226.3</td>
<td>237.4</td>
<td>197.3</td>
<td>207.1</td>
<td>31.40</td>
<td>15.70</td>
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<td>$207.1 \pm 49.96$</td>
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<td>Sulwade</td>
<td>211.6</td>
<td>226.3</td>
<td>163.4</td>
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<td>203.42</td>
<td>27.52</td>
<td>13.76</td>
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<td>$203.42 \pm 43.79$</td>
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</tr>
<tr>
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<td>Ukai Dam</td>
<td>640.1</td>
<td>670.12</td>
<td>623.17</td>
<td>662.31</td>
<td>648.92</td>
<td>21.365</td>
<td>10.682</td>
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<tr>
<td>S2</td>
<td>Sayla</td>
<td>562.65</td>
<td>612.27</td>
<td>478.16</td>
<td>592.12</td>
<td>561.3</td>
<td>59.053</td>
<td>29.526</td>
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<td>KukarMunda</td>
<td>300.23</td>
<td>400.23</td>
<td>315.77</td>
<td>278.14</td>
<td>323.59</td>
<td>53.373</td>
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<td>Prakasha</td>
<td>200.33</td>
<td>250.13</td>
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<td>378.54</td>
<td>261.667</td>
<td>80.602</td>
<td>40.301</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>200.00</td>
<td>267.78</td>
<td>215.61</td>
<td>212.17</td>
<td>223.89</td>
<td>30.016</td>
<td>15.00</td>
</tr>
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</table>
Table 3.8  EC in (µmhos/cm) of soil samples collected in and around Tapti River.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$\bar{x}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>875.0</td>
<td>880.0</td>
<td>830.0</td>
<td>875.0</td>
<td>865.0</td>
<td>23.452</td>
<td>11.72</td>
<td>$865.0 \pm 37.312$</td>
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<tr>
<td>S2</td>
<td>Sayla</td>
<td>1010.0</td>
<td>970.0</td>
<td>904.0</td>
<td>940.0</td>
<td>356.0</td>
<td>44.988</td>
<td>22.494</td>
<td>$356.0 \pm 71.577$</td>
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<tr>
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<td>KukarMunda</td>
<td>900.0</td>
<td>920.0</td>
<td>875.0</td>
<td>905.0</td>
<td>900.0</td>
<td>18.708</td>
<td>9.354</td>
<td>$900.0 \pm 29.764$</td>
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<tr>
<td>S4</td>
<td>Prakasha</td>
<td>675.0</td>
<td>700.0</td>
<td>640.0</td>
<td>720.0</td>
<td>689.75</td>
<td>34.490</td>
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<tr>
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<td>Sulwade</td>
<td>674.0</td>
<td>880.0</td>
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<td>880.0</td>
<td>776.0</td>
<td>120.09</td>
<td>60.049</td>
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</table>
### Table 3.9
Total alkalinity (mg/L) in water samples collected in Tapti River.

<table>
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<th>Site of Sample Collection</th>
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<th>4</th>
<th>$\bar{X}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>121.3</td>
<td>187.1</td>
<td>146.3</td>
<td>206.3</td>
<td>165.25</td>
<td>38.52</td>
<td>19.26</td>
<td>165.25 ± 61.29</td>
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<tr>
<td>S2</td>
<td>Sayla</td>
<td>137.4</td>
<td>212.3</td>
<td>157.3</td>
<td>208.3</td>
<td>178.82</td>
<td>37.27</td>
<td>18.63</td>
<td>178.82 ± 59.30</td>
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<td>KukarMunda</td>
<td>167.1</td>
<td>197.4</td>
<td>165.4</td>
<td>187.6</td>
<td>179.37</td>
<td>15.68</td>
<td>7.84</td>
<td>179.37 ± 24.96</td>
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<td>Prakasha</td>
<td>178.2</td>
<td>203.4</td>
<td>198.0</td>
<td>237.3</td>
<td>204.22</td>
<td>24.56</td>
<td>12.28</td>
<td>204.22 ± 39.08</td>
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<td>Sulwade</td>
<td>158.3</td>
<td>169.7</td>
<td>203.4</td>
<td>183.4</td>
<td>178.7</td>
<td>19.40</td>
<td>9.70</td>
<td>178.7 ± 30.86</td>
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Table 3.10  Total alkalinity (mg/L) in sediments samples collected in Tapti River.

<table>
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<th>Sr. No.</th>
<th>Site of Sample Collection</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>412.7</td>
<td>503.6</td>
<td>436.1</td>
<td>512.4</td>
<td>49.329</td>
<td>24.664</td>
<td>466.205 ± 78.483</td>
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<td>Sayla</td>
<td>402.1</td>
<td>516.2</td>
<td>478.5</td>
<td>578.1</td>
<td>73.600</td>
<td>36.800</td>
<td>493.725 ± 117.098</td>
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<td>KukarMunda</td>
<td>391.6</td>
<td>416.9</td>
<td>364.6</td>
<td>317.3</td>
<td>42.605</td>
<td>21.302</td>
<td>327.6 ± 67.784</td>
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<tr>
<td>S4</td>
<td>Prakasha</td>
<td>378.1</td>
<td>409.3</td>
<td>312.1</td>
<td>302.5</td>
<td>51.622</td>
<td>25.811</td>
<td>350.51 ± 82.131</td>
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<td>Sulwade</td>
<td>280.5</td>
<td>326.8</td>
<td>301.1</td>
<td>291.3</td>
<td>19.795</td>
<td>9.897</td>
<td>299.942 ± 31.493</td>
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</tbody>
</table>

61
Table 3.11  Total alkalinity (mg/L) in soil samples collected around Tapti River.

<table>
<thead>
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<th>Site of Sample Collection</th>
<th>1</th>
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<th>3</th>
<th>4</th>
<th>$\bar{x}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>236.8</td>
<td>212.1</td>
<td>223.5</td>
<td>245.3</td>
<td>231.675</td>
<td>18.149</td>
<td>9.0745</td>
<td>231.675 ± 28.875</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>198.4</td>
<td>219.1</td>
<td>244.1</td>
<td>239.6</td>
<td>225.3</td>
<td>20.976</td>
<td>10.488</td>
<td>225.3 ± 33.372</td>
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<td>KukarMunda</td>
<td>257.4</td>
<td>246.3</td>
<td>199.4</td>
<td>238.4</td>
<td>235.375</td>
<td>25.217</td>
<td>12.608</td>
<td>235.375 ± 40.121</td>
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<tr>
<td>S4</td>
<td>Prakasha</td>
<td>236.1</td>
<td>297.3</td>
<td>233.4</td>
<td>217.9</td>
<td>246.175</td>
<td>35.014</td>
<td>17.507</td>
<td>246.175 ± 55.707</td>
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<td>Sulwade</td>
<td>264.6</td>
<td>278.4</td>
<td>269.3</td>
<td>311.3</td>
<td>280.9</td>
<td>21.060</td>
<td>10.530</td>
<td>280.9 ± 33.507</td>
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Table 3.12  Chloride (mg/L) in water samples collected in Tapti River.

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<th>3</th>
<th>4</th>
<th>$\bar{x}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
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<td>110.7</td>
<td>190.2</td>
<td>107.9</td>
<td>169.1</td>
<td>144.47</td>
<td>41.537</td>
<td>20.76</td>
<td>144.47 ± 66.08</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>118.2</td>
<td>178.4</td>
<td>98.4</td>
<td>178.0</td>
<td>143.25</td>
<td>41.15</td>
<td>20.57</td>
<td>143.25 ± 65.48</td>
</tr>
<tr>
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<td>KukarMunda</td>
<td>126.3</td>
<td>96.3</td>
<td>127.0</td>
<td>192.3</td>
<td>135.47</td>
<td>40.49</td>
<td>20.24</td>
<td>135.47 ± 64.42</td>
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<tr>
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<td>Prakasha</td>
<td>89.8</td>
<td>170.1</td>
<td>168.4</td>
<td>169.4</td>
<td>149.42</td>
<td>39.75</td>
<td>19.87</td>
<td>149.42 ± 63.25</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>102.3</td>
<td>159.3</td>
<td>136.2</td>
<td>168.3</td>
<td>141.52</td>
<td>29.43</td>
<td>14.71</td>
<td>141.52 ± 46.83</td>
</tr>
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</table>
Table 3.13  Chloride (mg/L) in sediment samples collected in Tapti River.

<table>
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<th>Sr. No.</th>
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<th>1</th>
<th>2</th>
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<th>4</th>
<th>( \bar{x} )</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 Ukai Dam</td>
<td></td>
<td>412.7</td>
<td>577.4</td>
<td>398.0</td>
<td>521.2</td>
<td>477.325</td>
<td>86.426</td>
<td>43.213</td>
<td>477.325 ± 137.505</td>
</tr>
<tr>
<td>S2 Sayla</td>
<td></td>
<td>378.2</td>
<td>470.2</td>
<td>317.6</td>
<td>437.6</td>
<td>400.9</td>
<td>67.338</td>
<td>33.669</td>
<td>400.9 ± 107.136</td>
</tr>
<tr>
<td>S3 KukarMunda</td>
<td></td>
<td>315.0</td>
<td>317.0</td>
<td>347.4</td>
<td>404.2</td>
<td>345.9</td>
<td>41.597</td>
<td>20.798</td>
<td>345.9 ± 66.182</td>
</tr>
<tr>
<td>S4 Prakasha</td>
<td></td>
<td>278.3</td>
<td>302.1</td>
<td>215.4</td>
<td>378.3</td>
<td>293.525</td>
<td>67.319</td>
<td>33.659</td>
<td>293.525 ± 107.104</td>
</tr>
<tr>
<td>S5 Sulwade</td>
<td></td>
<td>250.6</td>
<td>288.4</td>
<td>236.4</td>
<td>305.1</td>
<td>270.125</td>
<td>32.019</td>
<td>16.009</td>
<td>270.125 ± 50.943</td>
</tr>
</tbody>
</table>
Table 3.14  Chloride (mg/L) in soil samples collected in an around Tapti River.

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<th>2</th>
<th>3</th>
<th>4</th>
<th>( \bar{x} )</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
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<td>Ukai Dam</td>
<td>66.4</td>
<td>63.3</td>
<td>67.4</td>
<td>51.3</td>
<td>62.1</td>
<td>7.4085</td>
<td>3.7042</td>
<td>62.1 ± 11.787</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>78.8</td>
<td>71.9</td>
<td>88.4</td>
<td>97.6</td>
<td>84.175</td>
<td>11.219</td>
<td>5.609</td>
<td>84.175 ± 17.850</td>
</tr>
<tr>
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<td>KukarMunda</td>
<td>44.3</td>
<td>89.9</td>
<td>69.1</td>
<td>64.9</td>
<td>67.05</td>
<td>18.695</td>
<td>9.347</td>
<td>67.05 ± 29.743</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>57.1</td>
<td>81.0</td>
<td>73.4</td>
<td>74.0</td>
<td>71.375</td>
<td>10.122</td>
<td>5.0613</td>
<td>71.375 ± 16.1052</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>51.8</td>
<td>59.4</td>
<td>68.7</td>
<td>78.4</td>
<td>64.575</td>
<td>11.519</td>
<td>5.7599</td>
<td>64.575 ± 18.328</td>
</tr>
<tr>
<td>Sr. No.</td>
<td>Site of Sample Collection</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>$\bar{X}$</td>
<td>S.D.</td>
<td>S.E.</td>
<td>95% CL</td>
</tr>
<tr>
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<td>----</td>
<td>---------</td>
<td>------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>S1 Ukai Dam</td>
<td>23.4</td>
<td>37.6</td>
<td>27.3</td>
<td>45.3</td>
<td>33.4</td>
<td>9.940</td>
<td>9.970</td>
<td>33.4 ± 15.82</td>
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</tr>
<tr>
<td>S2 Sayla</td>
<td>27.2</td>
<td>32.2</td>
<td>21.2</td>
<td>37.4</td>
<td>29.5</td>
<td>6.925</td>
<td>3.462</td>
<td>29.5 ± 11.01</td>
<td></td>
</tr>
<tr>
<td>S3 KukarMunda</td>
<td>40.3</td>
<td>45.3</td>
<td>23.7</td>
<td>47.2</td>
<td>39.1</td>
<td>10.687</td>
<td>5.343</td>
<td>39.1 ± 17.003</td>
<td></td>
</tr>
<tr>
<td>S4 Prakasha</td>
<td>32.2</td>
<td>36.1</td>
<td>30.4</td>
<td>50.3</td>
<td>37.2</td>
<td>9.019</td>
<td>4.509</td>
<td>37.25 ± 14.349</td>
<td></td>
</tr>
<tr>
<td>S5 Sulwade</td>
<td>31.4</td>
<td>39.3</td>
<td>32.4</td>
<td>39.3</td>
<td>35.6</td>
<td>4.291</td>
<td>2.145</td>
<td>35.6 ± 6.828</td>
<td></td>
</tr>
</tbody>
</table>
Table 3.16  Bicarbonate (mg/L) in sediment samples collected in Tapti River

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>( \bar{x} )</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>891.3</td>
<td>1012.3</td>
<td>863.1</td>
<td>992.1</td>
<td>993.717</td>
<td>73.561</td>
<td>36.780</td>
<td>993.717 ± 117.036</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>831.8</td>
<td>997.4</td>
<td>812.4</td>
<td>907.8</td>
<td>887.35</td>
<td>84.127</td>
<td>42.063</td>
<td>887.35 ± 133.847</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>631.1</td>
<td>844.2</td>
<td>513.4</td>
<td>826.4</td>
<td>703.775</td>
<td>159.457</td>
<td>79.728</td>
<td>703.775 ± 253.697</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>431.5</td>
<td>601.1</td>
<td>498.2</td>
<td>676.2</td>
<td>551.75</td>
<td>108.398</td>
<td>54.199</td>
<td>551.75 ± 172.462</td>
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<tr>
<td>S5</td>
<td>Sulwade</td>
<td>321.9</td>
<td>409.7</td>
<td>313.3</td>
<td>316.7</td>
<td>340.4</td>
<td>46.335</td>
<td>23.167</td>
<td>340.4 ±  73.719</td>
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</table>
Table 3.17  Bicarbonate (mg/L) in soil samples collected in and around Tapti River.

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<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>X</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>0.437</td>
<td>0.431</td>
<td>0.261</td>
<td>0.271</td>
<td>0.35</td>
<td>0.0971</td>
<td>0.0485</td>
<td>0.35 ± 0.154</td>
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<tr>
<td>S2</td>
<td>Sayla</td>
<td>0.238</td>
<td>0.311</td>
<td>0.461</td>
<td>0.351</td>
<td>0.340</td>
<td>0.093</td>
<td>0.0465</td>
<td>0.340 ± 0.148</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>0.352</td>
<td>0.367</td>
<td>0.352</td>
<td>0.491</td>
<td>0.390</td>
<td>0.067</td>
<td>0.033</td>
<td>0.390 ± 0.107</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>0.365</td>
<td>0.488</td>
<td>0.431</td>
<td>0.468</td>
<td>0.438</td>
<td>0.0540</td>
<td>0.0270</td>
<td>0.438 ± 0.0860</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>0.357</td>
<td>0.376</td>
<td>0.471</td>
<td>0.461</td>
<td>0.4162</td>
<td>0.0581</td>
<td>0.0290</td>
<td>0.4162 ± 0.0924</td>
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</table>
Table 3.18  Phosphate (mg/L) in water samples in Tapti River.

<table>
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<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$\bar{X}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>0.12</td>
<td>0.20</td>
<td>0.01</td>
<td>0.03</td>
<td>0.09</td>
<td>0.087</td>
<td>0.0437</td>
<td>0.09 $^\pm$ 0.1393</td>
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<tr>
<td>S2</td>
<td>Sayla</td>
<td>0.20</td>
<td>0.19</td>
<td>0.02</td>
<td>0.069</td>
<td>0.1197</td>
<td>0.0892</td>
<td>0.0446</td>
<td>0.1197 $^\pm$ 0.1420</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>0.17</td>
<td>0.31</td>
<td>0.17</td>
<td>0.02</td>
<td>0.167</td>
<td>0.1184</td>
<td>0.0592</td>
<td>0.167 $^\pm$ 0.1884</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>1.2</td>
<td>0.15</td>
<td>0.14</td>
<td>0.12</td>
<td>0.4025</td>
<td>0.5318</td>
<td>0.265</td>
<td>0.4025 $^\pm$ 0.8461</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>0.15</td>
<td>0.11</td>
<td>0.13</td>
<td>0.069</td>
<td>0.1147</td>
<td>0.0345</td>
<td>0.0172</td>
<td>0.1147 $^\pm$ 0.0550</td>
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</table>
Table 3.19  Phosphate (mg/L) in sediment samples collected in Tapti River.

<table>
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<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>( \bar{x} )</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>80.4</td>
<td>85.2</td>
<td>75.3</td>
<td>83.4</td>
<td>81.075</td>
<td>4.329</td>
<td>2.164</td>
<td>81.075 ± 6.887</td>
</tr>
<tr>
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<td>Sayla</td>
<td>75.6</td>
<td>79.4</td>
<td>80.3</td>
<td>78.4</td>
<td>78.425</td>
<td>2.036</td>
<td>1.018</td>
<td>78.425 ± 3.240</td>
</tr>
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<td>KukarMunda</td>
<td>65.3</td>
<td>75.3</td>
<td>57.3</td>
<td>76.3</td>
<td>68.55</td>
<td>8.995</td>
<td>4.497</td>
<td>68.55 ± 14.311</td>
</tr>
<tr>
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<td>Prakasha</td>
<td>60.1</td>
<td>64.2</td>
<td>62.3</td>
<td>66.1</td>
<td>63.175</td>
<td>2.570</td>
<td>1.285</td>
<td>63.175 ± 4.090</td>
</tr>
<tr>
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<td>Sulwade</td>
<td>50.4</td>
<td>52.3</td>
<td>52.3</td>
<td>57.3</td>
<td>53.075</td>
<td>2.955</td>
<td>1.477</td>
<td>53.075 ± 4.702</td>
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</tbody>
</table>

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Table 3.20   Phosphate (mg/L) in soil samples collected in and around Tapti River.

<table>
<thead>
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<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$\bar{X}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>36.5</td>
<td>26.1</td>
<td>31.2</td>
<td>23.4</td>
<td>29.3</td>
<td>5.787</td>
<td>2.893</td>
<td>29.3 ± 9.208</td>
</tr>
<tr>
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<td>Sayla</td>
<td>24.0</td>
<td>32.4</td>
<td>25.8</td>
<td>26.3</td>
<td>27.125</td>
<td>3.652</td>
<td>1.826</td>
<td>27.125 ± 5.8115</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>30.6</td>
<td>27.9</td>
<td>30.0</td>
<td>32.6</td>
<td>30.275</td>
<td>1.934</td>
<td>0.9672</td>
<td>30.275 ± 3.0778</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>37.0</td>
<td>40.0</td>
<td>42.0</td>
<td>36.6</td>
<td>38.9</td>
<td>2.563</td>
<td>1.2819</td>
<td>38.9 ± 40790</td>
</tr>
<tr>
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<td>Sulwade</td>
<td>32.3</td>
<td>33.5</td>
<td>38.6</td>
<td>29.3</td>
<td>33.425</td>
<td>3.875</td>
<td>1.937</td>
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</table>
Table 3.21  Total hardness (mg/L) in water samples collected in Tapti River water.

<table>
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<th>Site of Sample Collection</th>
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<th>3</th>
<th>4</th>
<th>$\bar{x}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>137.4</td>
<td>264.3</td>
<td>197.3</td>
<td>297.0</td>
<td>224.0</td>
<td>71.09</td>
<td>35.54</td>
<td>224.0 ± 113.11</td>
</tr>
<tr>
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<td>Sayla</td>
<td>196.0</td>
<td>214.1</td>
<td>216.4</td>
<td>317.1</td>
<td>190.91</td>
<td>126.11</td>
<td>63.05</td>
<td>190.91 ± 200.64</td>
</tr>
<tr>
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<td>KukarMunda</td>
<td>167.4</td>
<td>296.3</td>
<td>178.6</td>
<td>237.6</td>
<td>219.97</td>
<td>59.47</td>
<td>29.73</td>
<td>219.97 ± 94.62</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>203.3</td>
<td>312.6</td>
<td>184.7</td>
<td>287.2</td>
<td>246.95</td>
<td>62.47</td>
<td>31.23</td>
<td>246.95 ± 99.40</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>178.3</td>
<td>228.4</td>
<td>264.4</td>
<td>178.2</td>
<td>212.32</td>
<td>42.00</td>
<td>21.00</td>
<td>212.32 ± 66.82</td>
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</tbody>
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Table 3.22  Total hardness (mg/L) in sediment samples collected in Tapti River water.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>517.1</td>
<td>617.3</td>
<td>411.0</td>
<td>597.1</td>
<td>535.63</td>
<td>93.672</td>
<td>46.8365</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>535.63 ± 149.033</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>478.1</td>
<td>513.2</td>
<td>423.1</td>
<td>503.1</td>
<td>479.4</td>
<td>40.311</td>
<td>20.155</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>479.4 ± 64.136</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>333.1</td>
<td>471.1</td>
<td>324.8</td>
<td>411.6</td>
<td>385.17</td>
<td>69.398</td>
<td>34.699</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>385.17 ± 110.412</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>264.1</td>
<td>336.5</td>
<td>309.3</td>
<td>333.3</td>
<td>310.805</td>
<td>33.406</td>
<td>16.703</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>310.805 ± 53.149</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>264.3</td>
<td>312.1</td>
<td>198.4</td>
<td>278.6</td>
<td>263.357</td>
<td>47.709</td>
<td>23.854</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>263.357 ± 75.905</td>
</tr>
</tbody>
</table>

79
Table 3.23  Total hardness in (mg/L) soil samples collected in an around Tapti River.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$\bar{X}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>185.7</td>
<td>195.4</td>
<td>197.2</td>
<td>265.4</td>
<td>210.925</td>
<td>36.666</td>
<td>18.333</td>
<td>210.925 ± 58.335</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>200.8</td>
<td>270.4</td>
<td>167.4</td>
<td>247.3</td>
<td>221.475</td>
<td>46.231</td>
<td>23.115</td>
<td>221.475 ± 73.554</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>208.1</td>
<td>294.3</td>
<td>147.1</td>
<td>193.2</td>
<td>210.675</td>
<td>61.500</td>
<td>30.750</td>
<td>210.675 ± 97.847</td>
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<tr>
<td>S4</td>
<td>Prakasha</td>
<td>260.4</td>
<td>167.1</td>
<td>178.6</td>
<td>167.2</td>
<td>193.325</td>
<td>45.041</td>
<td>22.529</td>
<td>93.325 ± 71.660</td>
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<tr>
<td>S5</td>
<td>Sulwade</td>
<td>218.4</td>
<td>178.4</td>
<td>200.1</td>
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<td>199.1</td>
<td>16.351</td>
<td>8.175</td>
<td>199.1 ± 26.015</td>
</tr>
</tbody>
</table>

80
REFERENCE
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SECTION-II
DETECTION OF METAL IN RIVER WATER, SEDIMENT AND NEARBY SOIL

3.2.1 INTRODUCTION:-
The highly electropositive metals with density greater than 5g/cm$^3$ are termed “Heavy metals”. Heavy metals include the elements with atomic number greater than 20 excluding alkalimetal, alkaline earths, lanthanides and actinides. Metallic elements are intrinsic components of the environment$^1$.

During the last one decade, a large number of small scale chemical industries are setup near the bank of rivers in India, without any effective safeguards, solid and liquid waste matter containing organic and inorganic material, are released in river water and nearby soil without any treatment, are affecting the quality of water, aquatic food, soil and underground water resources of the adjoining area. The soluble and insoluble species in effluents form complexes$^2,3$. These metal complexes get precipitated and settle into the river bed as carbonate, hydroxide and oxides. At higher levels in water, soil and sediments are risky for plants and micro-organisms in them. Changes the water quality with toxic chemical. Such water percolate through a soil strata, and pollute the ground water resources, increases the concentration of toxic metals in environment, they get into the human food through food chain. Once they enter our body system, they disturb the bio-chemical process leading in some cases to fatal results$^4,5$.

Trace elements like Mg, Sr, Fe are essential for normal functioning of living organisms. Even toxic compounds of As, Pb, Cd, Hg are need in minute quantities but at higher levels these become killing or life threatening. Chlorophyll contains Magnesium and Iron. Also blood contains Iron. Bone and teeth are made up of Calcium$^6$. The heavy metal pollution adversely affects the soil texture, seed germination, plant reproduction, capacity regarding pollen germination and pollen tube growth$^7$. The vegetation has a mediator, water and soil. The animal and human beings consume the heavy metals present in fodder, through biomagnifications process, leads to various diseases. Many reports mention the contamination of metals in fodder and fish. It is found that solid and liquid wastes contain dangerously high concentration of toxic heavy metals like Zn, Fe, Pb, Cu, Ni, As, Hg and Cd. either separately or in combination, are toxic to all organisms$^8$.

The transport, transformation, mobilization and accumulation of these metals are of fundamental environmental importance. So it is necessary to analyze the types of solid and liquid waste effluents and materials discharged in river in and soil. These percolate in ground water which is important for metallic concentration, to study their transport and impact on the
Environment. Heavy metals are of concern to man and his environment due to their high toxicity. Metals enter in human body by different pathways and cause harmful effects. Different metals create different problems in human bodies. Higher concentration of metal ion in drinking water causes physiological disorders; many of them are quite serious. These metals have cumulative effect. The adsorption of metals in body system is high and exertion is slow. There are numerous reports on the harmful effect of heavy metals and have been reviewed by several authors. Although water is a renewable resource, its requirements in various constituents to meet agricultural, domestic, industrial and other demands indicate the need for reuses of waste water. Among the various uses of water, agricultural draws the maximum which is common practice in many parts of the world, including India. More than fifty poor countries of the world, with an area of twenty million hectares are treated with polluted or partially treated polluted water which has been used for irrigation, has an advantages of the community but also harmful for people and degrades the whole ecosystem of the concerned area as well as cause water born diseases in the said area. All polluted water contains plant nutrients, and also organic matter other than highly soluble salts and heavy metals. Harmful effects can last for several years due, to extensive use of polluted water so, it cannot only leach down the soil but has a negative effect on ground water quality. The effects of water pollution are numerous, some water pollution effects are recognized immediately where as others don’t show up for months or years. Whentoxins travel from water to all living organisms through food and water by microbiological process, it affects human hearts and kidneys and also create poor blood circulation, and skin lesion.

Some metals take part in the process of biomethylation. Biomethylation of metals is the mechanism that plays an important role in the mobilization and transport of the metals. The biomethylation of metalloids in soil and sediments appears to be a widespread phenomenon. Most attention has been given to methyl- Metals in the environment, concentrating on their detection and toxicity.

Out of the large number of metal ions detected qualitatively in the Tapti River water, aquatic sediment and nearby soil., an investigation was focused for a variety of reason only on a few of these Viz, Fe, Cu, Zn, Ni, Cd, As Hg and Pb can be determined by using ICP-AES technique at Sophisticated Analytical Instruments Facility (SAIF) IIT, Pawai Mumbai, and other metal like Ca and Mg have been analyzed by complexmetric and Na, K by Flame photometric technique. The results thus obtained are being described and discussed under following two sections.
3.2.2 Metals by complexometric and flame photometry.

3.2.3 Metals by ICP-AES

3.2.2 Metals by Flame photometry and Complexometry:

In the present investigation the Sodium and Potassium concentration was detected by flame photometry while concentration of Calcium and Magnesium was detected by complexometric method. The results thus obtained are being described under the following subheadings.

3.2.2.1 Sodium (Na):

Sodium is present in most natural water from negligible to appreciable concentrations. In natural water the major source of Sodium is weathering of various rocks. Many industrial waste and domestic sewage are rich in Sodium and increase its concentration in natural water after disposal.

Sodium salts are readily soluble in water and unlike Calcium and Magnesium, and are not precipitated in reactions to reduce its concentration. Sodium has a tendency to get absorbed on the clay particles but may be effectively exchanged by Calcium and Magnesium. During softening of water, Calcium and Magnesium ions are exchanged by Sodium ion, thus increase the concentration of Sodium in groundwater. Sodium is a light reactive cation available in soil in exchangeable form and affects the soil strongly. It easily disperses in soil when its concentrations exceed certain critical values. Due to presence of Na\(^+\) here, water and air infiltration rates are affected soil becomes hard to plough and seeding becomes difficult. Sodium also acts as a defloculating agent and displaces the divalent cation like Ca and Mg and cumulatively, the soil loses its productivity. It has been reported that Sodium imbalance in drinking water affects normal health of a person. Persons consuming drinking water with Sodium concentration excess of 107 mg/L showed elevated systolic and diastolic blood pressure. It is also reported that increase in Sodium concentration increases blood pressure. When the concentration of Sodium is high, unnatural thickening of blood vessels is seen and in pregnant women toxemia may take place.

Sodium contents in river water samples (Table No3.24) ranged from 71.2 to 98.1 mg/L. The minimum value of Sodium content was recorded for sample at Sulwade station. It may be due to dilution of water barrage, Geological factor and high concentration was recorded at UkaiDam station due to decrease in water level and high evaporation rate in summer which increases the salt concentration in water. In present study area Sodium concentration was within permissible limits recommended by WHO.
Patil P.R. et al\textsuperscript{25} reported water quality of Tapti at Bhusawal Town. The concentration of Sodium in winter season was 46.0 to 93.0 mg/L. All the water samples are well within the prescribed limits of ISI and WHO.

In the present investigation, the concentration of Sodium (Table 3.25) in sediment sample was found to be in the range of 140.2 to 190.0 mg/L at Sulwade and Kukarmunda station. This was much higher than soil samples collected in same station.

Raushankumar\textsuperscript{26} reported that, concentration of Sodium in the Sharavathi River sediment is in the range of 0.005 to 0.028 mg/L due to low nutrients present in soil.

During the present study, exchangeable Sodium concentration (Table 3.26) in soil was found from 133.2 to 150.3 mg/L at Sulwade and Kukarmunda stations. The variation in the Sodium concentration may be due to irregular distribution of Sodium salts in soil samples, cropping system, and agricultural runoffs.

Shrivastava\textsuperscript{27} analyzed soil samples from Nandurbar area. He reported the exchangeable Sodium concentration ranged from 75 to 255 mg/g.

3.2.2.2 Potassium (K):

Potassium is 3\textsuperscript{rd} essential plant micronutrient, present in weathering of rocks, in polluted water, concentration slightly increases, although it is soluble in water, it is released from dead plants, animals excrements, it is quickly, strongly bounded with clay particles, and finally it is absorbed by the roots of other plants\textsuperscript{28}. Potassium has similar chemistry like Sodium, and remains mostly in solution without undergoing precipitation. The exchanged of Potassium ion with Hydrogen ion. On a –COOH site in humus is given as.

\[
\text{Humus} \{\text{CO} – \text{OH}\} + K^+ \leftrightarrow \{\text{Humus} –\text{CO} – \text{OK}\} + H^+
\]

Mobile form of Potassium in soil is very important for the plant nutrition. Potassium’s is taken up by the plants in cationic from (K\textsuperscript{+}) and remains as such in plant cells forming only weak bonds with cell substances.

Presence of proper amount of Potassium is essential for protein-synthesis in plants, for starch formation, for translocation of plant sugars, and for the formation of grain. Potassium is also required for tuber development in root crops generally give response to application of Potassium. Available. Potassium content of soil is increased, significantly, by the sewage water application\textsuperscript{28}.

Potassium contents in water samples (Table 3.24) ranged from 9.0 to 20.0 mg/L at Ukai Dam.
And Prakasha stations. Variations in concentration due to dilution effect and decrease in water level, and low flow rate. Concentration of Potassium in all water sampling stations were below the WHO limits. Thitame and Pondhe reported that concentration of Potassium in Pravara River water in three seasons varies from 0.4 to 7.5 mg/L.

During the present study, concentration of Potassium (Table 3.25) in sediment sample varies from 25.3 to 35.0 mg/L at Sulwade and Sayla stations. The variation of concentration is due to use of Potassium fertilizers in nearby agricultural fields. During rainy season Potassium salts are dissolved in rain water and collected in Tapti River and adsorbed on the sediment surface.

Marathe reported that, the concentration of Potassium in sediment ranges from 168.2 to 367.0 kg/hq high concentration maybe due to presence of minerals of weathered rocks which release Potassium ion, these ions are adsorbed on to the cation exchanged sites. During the present study period Potassium (Table 3.26) contents ranged from 12.2 to 30.6 mg/L at Sulwade and Kukarmunda stations. This variation is due to use of Potassium fertilizers to soil, organic matter, cropping system, and presence of variable Potassium compounds in soil.

Rai Found higher concentration of potassium when soil is irrigated with sewage water in range of 121.66 to 81.66 mg/Kg.

### 3.2.2.3 Calcium:

Calcium is one of the most abundant substances in the natural water being present in high quantities in the rocks. It is leached from rocks to contaminate water. The abundance of Calcium is about 3.64% of the earth crust. It is found all over the world. It is essential for animals and plants for sustainable growth. Calcium is present in animal’s bones teeth, egg-shells, in corals and in all soils. Vertebrate bones show presence of Calcium in fluorides, Phosphates and Carbonates. Calcium gives rigidity, hardness to teeth bones and skeleton. It is found in soft tissues, body fluids. Higher consumption of Calcium (>2.5g/day) can lead to kidney stones, sclerosis of vessels.
The concentration of Calcium up to 1800 mg/L has found to have no adverse effect on human beings but is not desirable in washing, laundering and bathing due to its suppression tendency of formation of lather soap. A daily intake of 1.000mg of Calcium is essential for maintenance of osseous mass for men and women. Calcium is present in lime stone, gypsum, and fluorite and complex salts like stalagmites and Stalactites contain CaCO₃. Calcium is found in soil as a cation insoluble format, in gypsum, sparingly soluble in calcite and in insoluble form as in primary and secondary minerals and inorganic matter Calcium is secondary nutrient essential for plant growth, which is absorbed by plants in their ionic-form. The deficiency of this nutrient is less common in most agricultural soil, except strongly leached acidic, and sandy soil. The deficiency of Calcium may retard the plant growth, because it becomes available too slowly for the growing plant.

Calcium content in water (Table 3.24) samples ranged from 23.12 to 43.92 mg/L at Sulwade and Kukarmunda stations. High concentration due to decrease the water level in River, because of high temperature, oxidation of organic matter in to the substrate. Calcium contents for all samples were found to be within WHO, ISI, ICMR, BIS limits. Punkaj reported water quality of Behgul River, concentration of Calcium in the range of 45.0 to 67.0 mg/L. All the water samples were found to be within WHO, ISI, ICMR, BIS limits.

A perusal of (Table 3.25) the concentration of Calcium in sediment varied from 3000.5 to 3840.00 mg/g at Sulwade and Prakashastations. The concentration of Calcium in sediment samples is high because of the use of fertilizers containing Calcium in nearby agricultural fields and weathering of rocks in river basin. Taghinia reported concentration of Calcium in Kabini River sediment varies from 60 to 400 mg/L. High value of Calcium due to microorganisms which play an important role in the Calcium exchange at the interface between sediment and overlying water.

The present study revealed that (Table 3.26) the exchangeable Calcium concentrations in soil ranged from 1912.0 to 3400 mg/L at Sulwade and Sayla stations. Patil and Narkhede analyzed the soil samples from Sakri region (Dhule). They found the level of Calcium varied from 324.85 to 456.74 mg/L finally they predicted the considerable concentration of Calcium salts in the study area.
3.2.2.4 Magnesium:-

Magnesium is the third most abundant alkaline earth Element in the top layer of earth found in many rocky minerals, like dolomite, magnetite, olivine and serpentine. It is found in sea water, underground brines and salty layers, covers about 2% of the Earth’s crust by weight.

Sources of Magnesium in the water of various kinds are rocks and sewage. Industrial effluents are also important contributors of Magnesium, like Calcium. the concentration of Magnesium also depends upon the exchange equilibrium and presence of the ions like Sodium. Humans take in between 250 and 350 mg/day of Magnesium and need at least 200mg. At high concentration it may be cathartic and diuretic. The high concentration of Magnesium ion in the substrate is more toxic to plants than equivalent osmotic concentration of other neutral salt. This toxicity or Magnesium may be alleviated by the presence of relatively high concentrations of Calcium ion in the substrate. Magnesium forms part of the chlorophyll molecule and are directly involved in the photosynthesis of plants. Due to deficiency of Magnesium chlorophyll in green plants decreases, leaves gradually turn yellow and curl from the edges, this deficiency inhibits the development of growth of the plants. In the soil, Magnesium available to plant is in the exchangeable or water soluble forms. The absorption of Magnesium by plants depends on the amount present, the degree of Magnesium saturation, the nature of other exchangeable ions, and type of clay.

Magnesium plays an important role in various essential processes. It is involved in phosphorus transport in plant, activates certain enzymes, speeds up carbohydrates synthesis and affects the oxidation reduction process in plant tissues.

During the study period Magnesium contents in water (Table 3.24) ranged from 8.71 to 20.02 mg/L at Ukai Dam and Prakasha stations. Magnesium contents were observed to be above the limits recommended by WHO and ISI. Gejageet al. reported concentration of Magnesium in Krishna River during post Monsoon season was 12.0 mg/L within desirable limit.

The concentration of Magnesium in sediment (Table 3.25) samples was found to be detected in the range of 234.0 to 312.0 mg/L at Ukai Dam and Prakasha stations, higher concentration of exchangeable Magnesium may be due to, the amount of exchangeable and solutions form of Magnesium in sediment samples. It is also attributed to weathering of minerals and their decomposition in sediments. Taghinia reported concentration of Magnesium in Kabini River sediments varies from 4.0 to 340 mg/L.
During the present study (Table 3.26) the exchangeable Magnesium contents in soil were found from 275.0 to 633.1 mg/L at Sulwade and Sayla stations, the variation of Magnesium in soil is due to irregular distribution, also more or less uptake of Magnesium as nutrient by plants. Raushan Kumar and Dr. T.V. Ramachandra \(^{26}\) analyzed soil samples from different stations. The concentration of Magnesium ranged between 0.4 to 7.8 m eq/ 100 gm. Due to heavy rainfall heavily leaching of Magnesium takes place in well drained soils. These causes lowering of levels of Magnesium contain in the soil.

### 3.2.3 Metals by ICP-AES

In the present study the selected stations of Tapti River, water samples, sediments and nearby soil sample were collected and analyzed for the concentration of metal Fe, Cu, Zn, Ni, Cd, As, Hg, Pb, by ICP-AES technique.

#### 3.2.3.1 Iron (Fe):-

Iron is tenth most abundant element on our earth the in increasing concentration it varies from crust to core. Iron is most essential for living things from microorganisms to human; it is essential part of hemoglobin. A Normal diet can supply 7 mg of Iron for men and 11 mg for women. Lack or lower levels slowly lead to Iron deficiency and ANEMIA \(^{44,45,46}\).

Iron is an important part of the plants- oxidation-reduction reaction. As such as 75% of the cell Iron is associated with chloroplasts. Iron is structural component of cytochromes, hems and numerous other enzymes of electron transfer system. Including nitrogenous enzymes necessary for the fixation of dinitrogen gas \(^{47,48,49}\).

In aerated soils, Iron oxides are one of the least soluble of soil minerals. When soil is limed, any soluble ferric Iron (Fe3+) readily forms one of many hydrous oxides, all of which have low solubility, in intensively weathered soils, most of the primary minerals have been weathered and the more soluble materials leached away. The hydrous Iron oxides remain, because they are most resistant residue. Some oxides have 50% to 80% clay consisting primarily of Iron. The problem with soil Iron is that Iron has very low solubility in soil solution and water and the challenge is how to keep Iron sufficiently soluble for plants to absorb enough of it. In strongly acidic solution below pH 5, Iron becomes increasingly soluble and is rarely deficient \(^{50}\).

Iron contents in the water samples (Table 3.28) were ranging from 0.01 to 82.425 mg/L in dry and wet season at Prakasha and Sulwade stations. The minimum Iron content was recorded at Prakasha station in dry season, was observed to be low as compared to WHO, BIS.
and ISI standards limits. But in all the remaining samples, Iron content was observed to be high as compared to WHO, ISI, BIS, standard limits. High concentration in wet season due to effect of rainfall and runoff which causes erosion, thereby introducing into the river a lot of soil, slit and even discharge of Iron waste. This accounts for the muddy nature of river. It may be assigned to the soil-water interaction, especially within the middle and lower part of the River stretch, during winter season. The different concentrations of Iron in the water samples may be explained on the basis of solubility, mobility and other geochemical characteristics.

Raj et al. analyzed untreated sewage water of Musi River near Hyderabad India, at different stations. The concentration of Iron was higher than WHO limit. During the present study the concentrations of Iron (Table 3.29) in sediment samples were recorded from 0.01 to 0.091 mg/L in dry season at Sayla, Prakasha and Sulwade stations and Ukai Dam station. When compared with average shale value (4.72 mg/L), were below the limit.

Chakravarty and Patgir studied Dikrong River sediment. The concentration of sediment ranges from 1.628 to 1.978 mg/L due to Geology of area and there is no industrial establishment.

The average Iron concentrations in soil (Table 3.27) were recorded from 213.908 to 277.215 mg/L at Sayla and Kukarmuda stations. This variation is due to irregular distribution of Iron compounds, cropping system. When soil samples were comparing with GLC guideline, it was highly contaminated.

Bhagure and Mirgane analyzed soil near Thane region. The concentrations of Iron varied from 30.30 to 74.8 mg/kg due to lesser erosion of bed rock.

### 3.2.3.2 Zinc (Zn):

The average zinc content of the lithosphere is 80 ppm. While zinc contents of soil ranges from 10 to 300 ppm stable complexes of zinc with soil organic matter components have been known for a number of years, extracted organic molecules from soil pyrophosphate. That could form metallo-organic complexes, Zinc, is an essential trace element, it is not toxic but if Higher intake of Zn may adversely affect human health. The normal intake 15 mg/day for men and 12 mg/Kg for women is recommended. If 10-15 times this requirement of Zinc is given orally for short time it leads to stomach-cramps, nausea, and even vomiting. Taking higher doses for longer time, anemia may take place due to displacement of Fe by Zn. Pancreas may get damaged and levels of high density lipoprotein may decrease which is harmful.
Zinc compounds are as stringent, corrosive to skin, eye and mucous membranes. They cause special types of dermatitis known as “Zinc fox”. Zinc is also irritating to the digestive tract causing nausea. The trace element zinc is absorbed by soil organic matter and known to exist as exchangeable ions. Although zinc does not form insoluble compounds, their availability in soil is not generally controlled by precipitation. Although zinc may exist as an organic complex in soil solution, it may exist as the divalent cation. There is direct relation between availability of Zn and the organic carbon content of the soil. Background levels of zinc in sediments are less than 100 mg/kg. Soil levels ranges from <10 to 250 mg/kg with level greater than 500 mg/kg of contamination. Anthropogenic source of zinc far exceeds the releases from natural sources. The anthropogenic sources from discharge of untreated domestic sewage, acid mine drainage, effluent from chemical processes, ore processing, and electroplating.

Zinc contents in the water samples (Table 3.30) ranged from 0.01 to 0.736 mg/L in dry season at Prakasha and Uaki Dam stations. In two year study period, all the water in sampling station was within the WHO, ISI, BIS Limit.
Patnaik and Rao compared heavy metal in effluent water and surface water. The concentration of zinc in effluent water ranged from 4.0 to 15 mg/L and in surface water ranged from 0.517 to 19.68 mg/L. They reported that higher concentrations of metal were observed when pH was between 4.2 to 4.6 mg/L.

In sediment sample (Table 3.31) the concentration of Zinc was found to be in the range of 6.084 to 127.532 mg/L in wet season at Sayla and Sulwade stations. Zinc can enter the aquatic environment from number of sources including industrial discharge, sewage effluents and agricultural runoff. All the sampling stations except Sulwade station in wet and dry seasons exceed limit (95.0 mg/L) compared with average shale value.

In perusal of (Table 3.27) average Zinc concentration in soil was recorded from 14.882 to 44.221 mg/L at Ukai dam and Sarangkheda station. This variation clearly showed the irregular distribution of zinc salt in the soil samples under study and influence of biochemical changes directly or indirectly on the solubility and availability of micronutrients. All the soil samples exceed the phytotoxic level (0.07 -0.400 mg/L) regarding zinc content. According to GLC guideline all samples were heavily contaminated.

Singh and Singh reported zinc concentrations in the soil samples between 5.70 to 15.30 mg/kg. They concluded the higher concentration of zinc due to low pH and relatively more organic matter.
3.2.3.3 Copper (Cu):

Copper is essential for all forms of life. All living organisms require Copper in proper form and concentration. Higher levels of Cu compounds in drinking water or food causes vomiting, diarrhea, stomach cramps and nausea\(^\text{57}\). Copper is essential nutrient for plants for the synthesis of chlorophyll and functioning of certain enzymes, while at high concentration, it is toxic to inhibit growth. Plants generally absorb, high amount of Copper in presence of Calcium and Magnesium ion, but uptake is suppressed, when excess H\(^+\) ion are present in soil solution\(^\text{57}\). The daily human consumption of Copper is around 2-5 mg, 1 to 1.6 mg/day for a Child, for an adult 2mg/day. Approximately 32% of the Copper consumed is absorbed, but this varies, for example high Calcium and Iron intake reduces Copper absorption. Copper is mainly distributed in the liver, kidneys and intestines.

Sources of Copper are mainly from domestic sewage effluents, metal plating operation, chemical discharges, mining, smelting are also significant sources. Background level of Copper in sediment ranges from 10mg/kg to 75 mg/kg. Soil level ranges from <10 to 100mg/kg\(^\text{59}\). While a level of Copper above 200mg/kg is declared unfit for agricultural and recreational use, by the UK department of environment standards. Sewage sludge’s contain as high as 8000 mg/kg of Copper. Such polluted water cannot be used for irrigation and as fertilizer.

During the study the of Copper (Table 3.32) in water varied from 0.01 to 0.185mg/L. Low value of Copper indicates there are no significant sources of pollution. Highest value during dry season at Ukai Dam station is due to seasonal, high evaporation rate, so metal concentration increases. In all the samples Copper content was observed to be low, are compared to WHO, ISI, BIS, ICMR Standard limits. Khan et al\(^\text{68}\) observed level of Copper from Godavari River near Aurangabad (M.S.), India, as in the range of 1.755 to 3.640 mg/L. The highest concentration of Copper in water was recorded in May, 2005. While the minimum was in Oct, 2005.

During the study period, (Table 3.33) the concentration of Copper in sediment varied from 0.196 to 3.061 mg/L in wet season at Sulwade and Ukai Dam stations. Many researchers have concluded that for Copper, concentration decreases from pre monsoon and increases again to the post monsoon when, fresh water discharge is maximum. The concentration of Copper in sediment samples were below the average shale value (45 mg/L). Milenkaovic et al\(^\text{69}\) examined concentration of Copper in sediment from Iron Gate (Danube
River) in the range of 17.8 to 57.6 mg/kg.

In (Table 3.26) the average concentration of Copper in soils ranges from 0.370 to 0.60 mg/L at Kukarmuda and Ukai Dam stations. All the soil samples exceeded the phytotoxic level (0.060-0.125 mg/L) regarding Copper content of all the soil samples. All the soil samples are highly contaminated compared with GLC guideline with respect to Copper contents.

Okeyode and Moshood\textsuperscript{70} reported concentration of Copper in soil of Ogun-Osun River basins varied from; 19.90 to 29.00 mg/L due to large organic matter content of the soil in this location since Copper deficiency is most likely to occur in organic soil.

3.2.3.4 Arsenic (As):

Arsenic poisoning is one of the worst public problems in the world today. In the environment it occurs in organic and inorganic form. Arsenic is generally found in Arsenate and arsenite forms. It is a toxic, non essential element, and widely occurs in nature.

Arsenic is generated from burning of fossil Fuel, fertilizer plant’s liquid effluents contain metal Arsenic ranges from 0.27 to 3.2 mg/L. Arsenic a deadly poisonous metal, is well known for its toxicity to human ingestion of as little as 100mg usually results in severe poisoning and 130mg has to be fatal. Arsenic commonly occurs in insecticide, fungicides and herbicides. Among its compounds, those of As (III) are the most toxic exerts it is toxic action by attacking SH groups of an enzymes, thereby inhibiting enzyme action\textsuperscript{71,72}.

\[ \text{Enzyme} \quad \text{SH} \quad O^- \quad \text{As} - O^- \quad \text{Enzyme} \quad O^- + 2\text{OH}^- \quad \text{SH} \quad O^- \]

Arsenic is mainly present in the lungs, kidneys, blood, bones, teeth and intestinal wall. Female hair contains more Arsenic than male hair. Arsenic gets absorbed through the lungs and skin resulting in a several diseases. Evidence indicates that Arsenic in water may be carcinogenic, causing cancers of the skin and liver. The toxicity symptoms of Arsenic depend upon the dose\textsuperscript{73}. The transport of Arsenic in the environment is largely controlled by adsorption/desorption process in soil and sediments. Therefore, sediment movement is responsible for transfer of Arsenic to their ultimate sink in deep oceans and sediments\textsuperscript{74}.

During the present study, (Table 3.34,3.35&3.27) the Arsenic concentration in water, sediments and nearby soil area, was below the detection limit due to less use of Agro chemicals containing Arsenic, geology of area, also all sampling stations were away from traffic activity.
Chatterjee et al. reported that the concentration of Arsenic in Damodar River was in the range of 0.0 to 0.11 mg/L with a lower value during the post-monsoon period. The value of Arsenic in water was within the permissible limits.

Milenkovic et al. examined the concentration of Arsenic in sediment in different stations, with values ranging from 0.99 to 14.73 mg/kg.

Bhangure and Mimirgane analyzed soil near the Thane region, reporting Arsenic concentrations ranging from 0.073 to 11.2 mg/L. High levels of Arsenic in soil were due to industrial effluents discharged near the soil. All soil samples were below the limits and uncontaminated compared to the phytotoxic level (0.100-400 mg/L) and based on GLC guidelines with respect to the Arsenic content.

### 3.2.3.5 Nickel (Ni):

Nickel is the 23rd ranked abundant element in Earth’s crust. Its average concentration in the earth crust is 75 ppm. Nickel is non-toxic to mammals and exhibits only low toxicity when ingested orally. Nickel at concentrations above 0.3 ppm produces growth reduction. The total world emission of Nickel to the atmosphere was 330,000 tons per year, of which the natural and anthropogenic sources contribute to about 150,000 and 180,000 tonnes per year to the environment. Nickel enters the human body mainly via food and drinking water. As suggested by WHO standards, Nickel concentration in drinking water should be less than 0.1 mg/L. It is a micronutrient for most organisms. The soil containing Nickel in trace amounts could be better for plant growth. Nickel up to 340 mg/kg has been observed in plant tissue, but excessive units have toxic effects. In animals, these include diuretic and respiratory disorders including lung cancer following inhalation.

Polluted rivers, lakes, sediments etc. contain Nickel concentrations up to 11.0 ppm - 1.8 ppm, and 1800 ppm respectively can result in deleterious aquatic effects. Background concentration of Nickel is usually quoted as being less than 50 mg/kg. Soil level ranges from <10 to 20 mg/kg, while levels above 50 mg/kg are indicative of contamination. Data from a few representative studies concerning Nickel pollution in groundwater, river, lakes, soil and sediments and biological data from various parts of the world are reported by some researchers. During the two-year study, Nickel concentrations in the water samples (Table 3.36) was not detected, so all water sampling stations were safe for drinking purposes, prescribed under the detection limits by WHO, ISI, BIS.

Salem et al. analyzed drinking water samples from the Cairo city. The concentration of Nickel was in the range of 0.05 to 1.42 mg/L in all areas and exceeded the standard limit in all samples.
A perusal of (Table 3.37) the concentration of Nickel in sediment in range of 0.186 to 1.92 mg/L in dry and wet season at Kukarmuda and Ukai Dam stations. The concentration of Nickel in sediments samples were below the level (50.0 mg/L) prescribed by average shale value.

Abida Begum et al analyzed Cauvery River sediments. The concentrations of Nickel varied from 13.45 to 28.20 mg/kg downstream station indicate high value. Due to industrial effluents, and anthropogenic waste such as agricultural runoff, ash was discharged into river. During the study period, (Table 3.27) average Nickel contents in the soil samples range from 0.194 to 0.508 mg/L at Sarangkheda and Ukai Dam stations. The Variation of concentration due to the use of cropping systems, fertilizers, manures and, lime used in the soil. All the samples exceed phytotoxic level (0.100 mg/L) regarding Nickel content in the soil sampling station such as Ukai dam, Kukarmunda, and Sarangkheda were contaminated and Ukai dam station is heavily contaminated based on GLC guideline with respective Nickel content.

Ali Aslan et al analyzed near road side soil the concentration of Nickel in all sampling station ranged from 2 to 3 mg/kg due to fossil fuel emission.

### 3.2.3.6 Cadmium (Cd):-

Cadmium ranks 64th in order of abundance in the earth’s crust with an arrange concentration of 0.2ppm to next Mercury, Cadmium is the most notorious of heavy metal. Pollutants. Cadmium is not essential or beneficial to animal or human nutrition. For a long time it has potential toxicity.

Anthropogenic activities are the main sources responsible for Cadmium contamination. About 500 tones of Cadmium enters the environment globally per year, out of 20% from zinc mining and smelting operations, 30% from disposal of Cadmium products, 50% from phosphate fertilizer, sewage effluents and sewage sludge, fossil fuels. Cadmium is highly toxic element as in biological system and environment. It acts as effective enzyme inhibitors. They have great affinity for sulphur containing species such as SH and –S CH3. Metallo-enzymes contain metal in their structures. When one metal in one of a metalloenzyme is replaced by another metal ion of similar charge and size, the action of enzyme is inhibited.

Growing plants require Zinc and they also take up and concentrate Cadmium with the same biochemical process. At high levels, it affects plant and crops. Grown in the farm irrigated with Cadmium contaminated water, Cadmium has good tendency to adsorb on soil surface. The extent of absorption depends on the nature of soil, mineralogical composition; pH.
Cadmium contribution to food through soil, plant, animal, chain bears close scrutiny\(^85\). The toxicity of Cadmium to fresh water is influenced by the temperature, salinity, hardness; dissolved organic compound, pH and presence of other metals, the toxicity of Cadmium for fresh water species varies from 0.0018 to 126 ppm. The Cadmium toxicity to aquatic organisms depends upon the type of test organisms, its life stage, time of exposure and environmental factors such as temperature, pH, dissolved oxygen, hardness and concentration of organic legends.

ISI has recommended maximum limit of 0.2 ppm for the discharge of Cadmium containing effluents on inland surface waters for irrigation water. It has been recommended that the maximum total Cadmium should not exceed 0.05 ppm for short term and 0.01 ppm for long term use of water. This has been prescribed by National Academy of Science. According to WHO, the acceptable weekly intake of Cadmium should not be greater than 0.007 mg/g. Over a long period of time, it accumulates in the kidney and liver causing extensive damage to those organs.

During the present study Cadmium content in water (Table 3.38) ranged from 0.01 to 30.157 mg/L in wet and dry seasons. The lowest concentration was recorded in dry season. In all sampling stations was within the WHO and ISI limit but Kukarmunda station indicates highest concentration in wet season, it exceeded the limit. A previous study has been ensuring that the atmospheric precipitation is very much responsible for metal contamination in water also, low flow rate, high evaporation rate, and low pH. Near the river use of fossil fuel for domestic activities, increases the concentration of Cadmium.

Obodo\(^86\) reported that the concentration of Cadmium in Niger River and its tributaries was not detected due to good drainage system, industrial effluent was well treated. The concentration of Cadmium in sediment sample (Table 3.39) was not detected; sediment samples were below the average shale value.

Mohiuddinget al\(^87\) analyzed urban river sediment the mean concentration of Cadmium was 40.8 mg/g, exceed the average worldwide shale concentrations and average sediment values. During the study period (Table 3.27) average concentration of Cadmium in soil was not detected (below 0.01 mg/L) due to less use of fertilizer, pesticides. Near the sampling station there are no small scale industries. All soil samples were below the phytotoxic level regarding to Cadmium content, the soil was uncontaminated based on GLC guideline with respect to Cadmium content.
Vidiya and Patel reported the Cadmium contents in soil samples ranged from non-detectable level to 0.20 mg/g in and around Modasa (Gujarat India). They reported lower Cadmium level in vegetable farms as compared to agricultural soils.

3.2.3.7 Mercury (Hg):-

Mercury is widely distributed in the environment. The earth crusts contain 0.08ppm of Mercury, which is several times lower than concentration of V, Cr Ni, Zn, Cu, Co, Pb, and Cd. The major source through which Mercury enters the environment in the natural discharging of earth crust., According to WHO about 1300 tones of Mercury is discharged every year globally, in to water from natural sources.

Mercury is the most toxic of heavy metals, in the atmosphere, it is usually transformed in to ethyl and diethylMercury, and due to its ability to combine with supphydryl group,it is considered that all soluble mercuric compounds are toxic to all types of cells.In humans, Methyl Mercury is more toxic than inorganic Mercury .Because of its greater lipid solubility which allows the metal to cross biological membranes more easily. Especially in to the brain, Spinal cord and peripheral nerves and across the placenta.

Sediments are the major sinks of Mercury. In sediment contaminated with mixed industrial effluent, municipal and other waste, metal up to 2010 ppm were reported in Minimart Bay sediments of Thompson Lake in Japan.The anthropogenic source of Mercury are chloro alkali industries, electrical equipment, pesticides, paints pulp and paper, medicines, batteries, dental amalgam, thermometers, lamps, also burning of fossil fuels, smelting of metals ,cement manufacture and waste disposal. Mercury or its salts can be converted in to methyl Mercury, by an aerobic methane synthesizing bacteria in water. This conversion is facilitated by Co (III) containing vitamin B_{12} coenzyme. A CH_{3} group bonded to Co (III) on the coenzyme is transferred enzymatically by methyl coalmine to Hg2+ yielding CH_{3}Hg^{+} or (CH_{3})_{2}Hg.

\[
\text{CH}_{3} \text{(III)} \xrightarrow{\text{Co}} + \text{Hg}^{2+} \quad \text{methyl Cobalaminc} \quad \xrightarrow{(\text{ATP})} \quad \text{CH}_{3} \text{Hg}^{+} \quad \text{or (CH}_{3}\text{)}_{2}\text{Hg}
\]

An acidic medium promotes the conversation of diethyl Mercury to methyl Mercury which is soluble in water. This enters the food chain through plankton, and is concentrated by fish by a factor 1:3 or more as it passes through the food chain. A maximum concentration of 0.001ppm total Mercury in drinking water has been recommended by WHO.
During the study period (Table 3.40, 3.41&3.27) concentration of Mercury in water, sediment, and soil was below the detection limit in wet and dry seasons at, all sampling stations due to Geology of area, small industries do not use Mercury salts in processing, are the main reasons. All soil samples were below the phytotoxic level regarding to Mercury content based on GLC guideline.

Sankar et al.\textsuperscript{90} analyzed Mercury concentrations in water and sediment of Uppanar estuary in the range of 0.012 to 0.22 and 0.016 to 0.148 mg/L. Low level of Mercury in water was due to higher ingestion rate of organisms, re-suspension of sediments and absorption on to the particulates.

Singare et al.\textsuperscript{91} reported average concentrations of Mercury in dry and rainy seasons. In the Soil of Kalwa Bridge near Thane creek, 28 mg/g and 9.0 mg/g high concentration due highly populated and industrialized zone. During rainy season Mercury is washed out from soil. So concentration decreases.

Bhangure and Mirgane\textsuperscript{56}, reported concentration of Mercury in soil ranges from 1.11 to 1.54 mg/kg. When compared with Swedish soil guideline values, six stations are highly polluted due to Industrial effluents directly discharged into open land.

3.2.3.8 Lead (Pb):

Lead ranks 36\textsuperscript{th} element in order of abundance in the Earth’s crust and its concentration in the earth crust have been estimated at 12.5 ppm. Lead is the most ancient industrial poison for man. It is not essential for the functioning of human biological system and it has been recognized as a cumulative poison\textsuperscript{92, 93&94}. Lead is deposited in bone as a cumulative poison]. Lead level in blood are considered to be the best indicator of Lead from all types of exposures over 0.025 mg/ml are dangerous and may damage central nervous system, especially in children\textsuperscript{95}. Tetraethyl Lead, the main gasoline additive is the main source of anthropogenic agents in environment is about 500 x 10\textsuperscript{3} metric tons per year. Lead reacts with proteins and enzymes by binding to tetraethyl Lead. Solubility in water 15mg/L at 20\textsuperscript{0}C causes diseases such as anemia, encephalopathy and hepatitis\textsuperscript{97}.

The major biochemical effect of Lead is its interference with hems synthesis, which Leads to hematological damage. The poisoning of Lead affects many important metabolic pathways in human beings\textsuperscript{98, 99}.

ICMR has set the limit as 0.01 ppm Lead, while ISI, WHO set a limit of 0.05 ppm for drinking water, for irrigation water 5.0 ppm for long term use, and 20 ppm for short term use.
During the study (Table 3.42) period, concentration of Lead in water samples varied from 0.01 to 0.091 mg/L. Ukai Dam station reported highest concentration in wet and dry season due to solubility of Lead containing minerals in natural water. Near Ukai Dam, there is large and small scale industries setup, they use fossil fuel. Previous studies have been ensuring that the atmospheric precipitation is very much responsible for metal contamination in surface water\textsuperscript{100, 101,102}. Higher use of Agro chemical in farming is one of the main sources of Lead contamination. So at this station water was not safe for drinking prescribed by WHO and ISI BIS. But in all four sampling water stations in both seasons, Lead levels were found within desirable limits (0.05 mg/L) prescribed by WHO, ISI, BIS.

Singh et al\textsuperscript{103} reported contamination of Lead in the Gomati river, water varied from 0.0158 to 0.0276 mg/L was below the BIS and WHO guideline.

During the present study, (Table 3.43) concentration of Lead in sediment varied from 0.01 to 26.789 mg/L, highest concentration was recorded in wet season at Kukarmunda station due to agricultural run-off, Geology of area, anthropogenic activity nearby river are responsible for metallic concentration. All the sediment samples except Kukarmunda station in wet season exceed the shale value limits (20.0 mg/L).

Patnaik and Rao\textsuperscript{104} analyzed Mehadrigedda stream of Visakhapatnam. The concentrations of Lead in sediment varied from 3.473 to 35.92 mg/g. High concentration at station-II was due to discharge of industrial effluent in to this stream.

During the study period average concentration of Lead (Table 3.27) in soil was below detection limit in all sampling station, due to Geology of area, also all soil sampling station are away from villages and domestic and industrial effluent discharge and away from air pollution due to fossil fuels. So the concentration was below limit. When compared with phytotoxic level (0.100-400 mg/L) and GLC guideline.

IoanSuchu et al\textsuperscript{105} analyzed soil of central Transylvania, Romania regions, Mean highest concentration of Lead was 1521.8 mg/L recorded due to chemical and metallurgical activities in the vicinity.
Table 3.24 Concentration of exchangeable metals (mg/L) in Tapti River water

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>98.1</td>
<td>9.0</td>
<td>27.85</td>
<td>8.71</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>78.6</td>
<td>11.0</td>
<td>32.80</td>
<td>16.14</td>
</tr>
<tr>
<td>S3</td>
<td>Kukar Munda</td>
<td>80.3</td>
<td>17.0</td>
<td>43.92</td>
<td>12.10</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>75.4</td>
<td>20.0</td>
<td>38.12</td>
<td>20.02</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>71.2</td>
<td>18.2</td>
<td>23.12</td>
<td>13.03</td>
</tr>
<tr>
<td></td>
<td>mean</td>
<td>80.72</td>
<td>15.0</td>
<td>33.16</td>
<td>14.0</td>
</tr>
</tbody>
</table>
Table 3.25 Concentration of exchangeable metals (mg/L) in sediment samples collected in Tapti River

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>155.0</td>
<td>32.0</td>
<td>3800.0</td>
<td>234.0</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>180.0</td>
<td>35.0</td>
<td>3300.0</td>
<td>287.0</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>190.0</td>
<td>26.0</td>
<td>3660.0</td>
<td>298.0</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>175.0</td>
<td>31.0</td>
<td>3840.0</td>
<td>312.0</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>140.12</td>
<td>25.3</td>
<td>3000.5</td>
<td>253.1</td>
</tr>
<tr>
<td>mean</td>
<td></td>
<td>168.02</td>
<td>29.86</td>
<td>3520.1</td>
<td>278.82</td>
</tr>
</tbody>
</table>
Table 3.26 Concentration of exchangeable metals (mg/L) in soil samples collected in an around Tapti River

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Ukai Dam</td>
<td>142.1</td>
<td>17.3</td>
<td>2900</td>
<td>350.6</td>
</tr>
<tr>
<td>S2</td>
<td>Sayla</td>
<td>135.0</td>
<td>19.1</td>
<td>3400</td>
<td>633.1</td>
</tr>
<tr>
<td>S3</td>
<td>KukarMunda</td>
<td>150.3</td>
<td>30.6</td>
<td>2550</td>
<td>300.0</td>
</tr>
<tr>
<td>S4</td>
<td>Prakasha</td>
<td>147.6</td>
<td>18.4</td>
<td>2650</td>
<td>400.0</td>
</tr>
<tr>
<td>S5</td>
<td>Sulwade</td>
<td>133.2</td>
<td>12.2</td>
<td>1912.0</td>
<td>275.0</td>
</tr>
<tr>
<td></td>
<td>mean</td>
<td>141.6</td>
<td>19.52</td>
<td>2682.4</td>
<td>391.74</td>
</tr>
</tbody>
</table>
Table 3.27 Average Concentration of Hazardous metals (mg/L) in soil samples collected in and around Tapti River

<table>
<thead>
<tr>
<th>Station No.</th>
<th>Site of Sample Collection</th>
<th>Metal concentration in mg/gm.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fe</td>
</tr>
<tr>
<td>A1</td>
<td>Ukai Dam, Gujrat</td>
<td>245.69</td>
</tr>
<tr>
<td>A2</td>
<td>Sayla</td>
<td>213.908</td>
</tr>
<tr>
<td>A3</td>
<td>KukarMunda</td>
<td>277.215</td>
</tr>
<tr>
<td>A4</td>
<td>Sarangkheda</td>
<td>252.461</td>
</tr>
</tbody>
</table>

ND means less than 0.01 mg/L
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Kukurmuda</td>
<td>6.791</td>
<td>2.11</td>
<td>40.142</td>
<td>12.294</td>
<td>15.334</td>
<td>17.054</td>
<td>8.527</td>
</tr>
<tr>
<td>4</td>
<td>Prakasha</td>
<td>4.451</td>
<td>0.01</td>
<td>39.375</td>
<td>0.01</td>
<td>10.961</td>
<td>19.057</td>
<td>9.528</td>
</tr>
</tbody>
</table>
Table 3.29 Concentration of Iron (mg/L) in Tapti River Sediments

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>T</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ukai Dam</td>
<td>0.035</td>
<td>0.091</td>
<td>0.089</td>
<td>0.073</td>
<td>0.072</td>
<td>0.0259</td>
<td>0.0129</td>
<td>0.072±0.04128</td>
</tr>
<tr>
<td>2</td>
<td>Sayla</td>
<td>0.021</td>
<td>0.01</td>
<td>0.053</td>
<td>0.01</td>
<td>0.0235</td>
<td>0.02033</td>
<td>0.01016</td>
<td>0.0235±0.03235</td>
</tr>
<tr>
<td>3</td>
<td>Kukurmuda</td>
<td>0.015</td>
<td>0.05</td>
<td>0.054</td>
<td>0.02</td>
<td>0.03475</td>
<td>0.02008</td>
<td>0.01004</td>
<td>0.03475±0.03196</td>
</tr>
<tr>
<td>4</td>
<td>Prakasha</td>
<td>0.001</td>
<td>0.01</td>
<td>0.049</td>
<td>0.01</td>
<td>0.01975</td>
<td>0.0195</td>
<td>0.0097</td>
<td>0.01975±0.03102</td>
</tr>
<tr>
<td>5</td>
<td>Sulwade</td>
<td>0.012</td>
<td>0.01</td>
<td>0.043</td>
<td>0.01</td>
<td>0.01875</td>
<td>0.01619</td>
<td>0.00809</td>
<td>0.01875±0.02576</td>
</tr>
<tr>
<td>Sr. No.</td>
<td>Site of Sample Collection</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>S.D.</td>
<td>S.E.</td>
<td>95% CL</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Ukai Dam</td>
<td>0.281</td>
<td>0.699</td>
<td>0.071</td>
<td>0.736</td>
<td>0.446</td>
<td>0.324</td>
<td>0.162</td>
<td>0.446±0.516</td>
</tr>
<tr>
<td>2</td>
<td>Sayla</td>
<td>0.035</td>
<td>0.187</td>
<td>0.071</td>
<td>0.286</td>
<td>0.144</td>
<td>0.114</td>
<td>0.057</td>
<td>0.144±0.181</td>
</tr>
<tr>
<td>3</td>
<td>Kukurmuda</td>
<td>0.069</td>
<td>0.428</td>
<td>0.056</td>
<td>0.333</td>
<td>0.221</td>
<td>0.187</td>
<td>0.093</td>
<td>0.221±0.298</td>
</tr>
<tr>
<td>4</td>
<td>Prakashu</td>
<td>0.077</td>
<td>0.01</td>
<td>0.055</td>
<td>0.020</td>
<td>0.040</td>
<td>0.0310</td>
<td>0.0155</td>
<td>0.040±0.049</td>
</tr>
<tr>
<td>5</td>
<td>Sulwade</td>
<td>0.056</td>
<td>0.151</td>
<td>0.052</td>
<td>0.019</td>
<td>0.069</td>
<td>0.0568</td>
<td>0.0284</td>
<td>0.069±0.0903</td>
</tr>
</tbody>
</table>
### Table 3.31 Concentration of Zinc (mg/L) in Tapti River Sediments

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
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<th>3</th>
<th>4</th>
<th>$\bar{X}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ukai Dam</td>
<td>87.253</td>
<td>48.947</td>
<td>56.217</td>
<td>41.792</td>
<td>58.552</td>
<td>20.019</td>
<td>10.009</td>
<td>58.552±31.851</td>
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<td>4</td>
<td>Prakasha</td>
<td>21.448</td>
<td>60.419</td>
<td>51.76</td>
<td>39.111</td>
<td>43.184</td>
<td>16.927</td>
<td>8.463</td>
<td>43.184±26.931</td>
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<tr>
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<td>Sulwade</td>
<td>127.532</td>
<td>100.637</td>
<td>28.096</td>
<td>89.427</td>
<td>86.423</td>
<td>42.043</td>
<td>21.021</td>
<td>86.423±66.891</td>
</tr>
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</table>
Table 3.32 Concentration of Copper (mg/L) in Tapti River Water

<table>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ukai Dam</td>
<td>0.01</td>
<td>0.185</td>
<td>0.046</td>
<td>0.165</td>
<td>0.1015</td>
<td>0.0865</td>
<td>0.0432</td>
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<tr>
<td>2</td>
<td>Sayla</td>
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<td>0.042</td>
<td>0.01</td>
<td>0.018</td>
<td>0.016</td>
<td>0.008</td>
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<td>3</td>
<td>Kukurmuda</td>
<td>0.024</td>
<td>0.01</td>
<td>0.046</td>
<td>0.01</td>
<td>0.0225</td>
<td>0.017</td>
<td>0.0085</td>
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<td>Prakasha</td>
<td>0.01</td>
<td>0.01</td>
<td>0.043</td>
<td>0.01</td>
<td>0.0182</td>
<td>0.0165</td>
<td>0.00825</td>
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<td>0.01</td>
<td>0.04</td>
<td>0.012</td>
<td>0.0152</td>
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<td>0.0085</td>
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</table>
Table 3.33 Concentration of Copper (mg/L) in Tapti River Sediments

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
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<th>3</th>
<th>4</th>
<th>T</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ukai Dam</td>
<td>0.538</td>
<td>0.523</td>
<td>3.061</td>
<td>0.422</td>
<td>0.57</td>
<td>0.358</td>
<td>0.179</td>
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<td>2</td>
<td>Sayla</td>
<td>0.302</td>
<td>0.404</td>
<td>1.097</td>
<td>0.477</td>
<td>0.57</td>
<td>0.358</td>
<td>0.179</td>
<td>0.57±0.5705</td>
</tr>
<tr>
<td>3</td>
<td>Kukurmuda</td>
<td>0.443</td>
<td>0.401</td>
<td>2.33</td>
<td>0.397</td>
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<td>0.958</td>
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<tr>
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<td>Prakasha</td>
<td>0.324</td>
<td>0.542</td>
<td>2.311</td>
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<td>0.946</td>
<td>0.473</td>
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<td>5</td>
<td>Sulwade</td>
<td>0.196</td>
<td>0.503</td>
<td>2.24</td>
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<td>0.9623</td>
<td>0.481</td>
<td>0.809±1.5310</td>
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</table>
Table 3.34 Concentration of Arsenic (mg/L) in Tapti River Water

<table>
<thead>
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<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
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<td>ND</td>
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<td>ND</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Sayla</td>
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<td>-</td>
<td>-</td>
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<tr>
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<td>-</td>
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<tr>
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</table>

ND means less than 0.01 mg/L
Table 3.35 Concentration of Arsenic (mg/L) in Tapti River Sediments

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
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<th>4</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
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</table>

ND = Means less than 0.01 mg/L
<table>
<thead>
<tr>
<th>Sr. No.</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>( \bar{x} )</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>ND</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>-</td>
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<tr>
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</tr>
</tbody>
</table>

ND= means less than 0.01 mg/L
Table 3.37 Concentration of Nickel (mg/L) in Tapti River Sediments

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>T</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UkaiDAM</td>
<td>0.442</td>
<td>0.287</td>
<td>1.92</td>
<td>0.319</td>
<td>0.742</td>
<td>0.788</td>
<td>0.3940</td>
<td>0.742±1.2539</td>
</tr>
<tr>
<td>2</td>
<td>Sayla</td>
<td>0.246</td>
<td>0.218</td>
<td>0.529</td>
<td>0.405</td>
<td>0.362</td>
<td>0.1664</td>
<td>0.08323</td>
<td>0.362±0.2648</td>
</tr>
<tr>
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<td>Kukurmuda</td>
<td>0.282</td>
<td>0.186</td>
<td>0.56</td>
<td>0.396</td>
<td>0.356</td>
<td>0.1608</td>
<td>0.0804</td>
<td>0.356±0.2558</td>
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<tr>
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<td>Prakasha</td>
<td>0.271</td>
<td>0.288</td>
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<td>0.1480</td>
<td>0.0740</td>
<td>0.366±0.2354</td>
</tr>
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<td>0.498</td>
<td>0.242</td>
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<td>0.429</td>
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<td>0.1103</td>
<td>0.055</td>
<td>0.400±0.1756</td>
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</table>
Table 3.38: Concentration of Cadmium (mg/L) in Tapti River Water

<table>
<thead>
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<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>τ</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ukai Dam</td>
<td>0.01</td>
<td>5.469</td>
<td>0.01</td>
<td>0.329</td>
<td>1.4545</td>
<td>2.6805</td>
<td>1.3402</td>
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<tr>
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<td>Sayla</td>
<td>0.01</td>
<td>0.614</td>
<td>0.01</td>
<td>0.319</td>
<td>0.1664</td>
<td>0.2985</td>
<td>0.1492</td>
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<td>30.157</td>
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<td>0.693</td>
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<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01±0.00</td>
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Table 3.39 Concentration of Cadmium (mg/L) in Tapti River Sediments

<table>
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<th>Site of Sample Collection</th>
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<th>S.D.</th>
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</table>

ND = Means less than 0.01 mg/L
<table>
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<th>Site of Sample Collection</th>
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<th>S.E.</th>
<th>95% CL</th>
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ND means less than 0.01 mg/L
Table 3.41 Concentration of Mercury (mg/L) in Tapti River Sediments

<table>
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<th>S.E.</th>
<th>95% CL</th>
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</tr>
<tr>
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<td>-</td>
</tr>
</tbody>
</table>

ND = Means less than 0.01 mg/L
Table 3.42 Concentration of Lead (mg/L) in Tapti River water

| Sr. No. | Site of Sample Collection | 1   | 2  | 3   | 4   |  | S.D. | S.E. | 95% CL      |
|--------|---------------------------|-----|----|-----|-----| |     |     |    |            |
| 1      | Ukai Dam                  | 0.035 | 0.091 | 0.089 | 0.073 | 0.072 | 0.0259 | 0.0129 | 0.072±0.04128 |
| 2      | Sayla                     | 0.021 | 0.01 | 0.053 | 0.01 | 0.0235 | 0.02033 | 0.01016 | 0.0235±0.03235 |
| 3      | Kukurmuda                 | 0.015 | 0.05 | 0.054 | 0.02 | 0.03475 | 0.02008 | 0.01004 | 0.03475±0.03196 |
| 4      | Prakasha                  | 001  | 0.01 | 0.049 | 0.01 | 0.01975 | 0.0195 | 0.0097 | 0.01975±0.03102 |
| 5      | Sulwade                   | 0.012 | 0.01 | 0.043 | 0.01 | 0.01875 | 0.01619 | 0.00809 | 0.01875±0.02576 |
Table 3.43 Concentration of Lead (mg/L) in Tapti River Sediments

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Site of Sample Collection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$\bar{x}$</th>
<th>S.D.</th>
<th>S.E.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ukai Dam</td>
<td>0.01</td>
<td>2.324</td>
<td>0.01</td>
<td>0.01</td>
<td>0.5885</td>
<td>1.157</td>
<td>0.5785</td>
<td>0.5885±1.8407</td>
</tr>
<tr>
<td>2</td>
<td>Sayla</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01±0.00</td>
</tr>
<tr>
<td>3</td>
<td>Kukurumuda</td>
<td>26.789</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>6.704</td>
<td>13.389</td>
<td>6.694</td>
<td>6.704±21.30</td>
</tr>
<tr>
<td>4</td>
<td>Prakasha</td>
<td>0.058</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.022</td>
<td>0.024</td>
<td>0.012</td>
<td>0.022±0.0381</td>
</tr>
<tr>
<td>5</td>
<td>Sulwade</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01±0.00</td>
</tr>
</tbody>
</table>
References:

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SECTION-III
Detection and Identification of organic compound like BHC and DDT in River Water Sample by GC/MSTechniques.

3.3.1 Introduction:-

Aquatic pollution by toxic chemicals is a global problem and agriculture is a major industry of the India\(^1\). To get maximum yield from the field, use of fertilizers and use of pesticides becomes eminently important to meet out the emerging demand due to increase in population. Chlorinated organic pesticides are relatively insoluble in water but stable in salt water and it is resistant to photo degradation. They are poorly absorbed before hydrolyzed and slowly biodegradable in environment, therefore, these compounds are persistent in food chain and are readily accumulated in animal tissues, are more soluble in body fats or lipids\(^2,3\).

Aquatic animal absorb these compounds directly from water or by ingesting contaminated food. In particular, organochlorine insecticides are highly stable under different environmental conditions, are persistent in nature and cause chronic adverse effect on wild life and humans\(^4\). Indians have shown maximum DDT content (25 ppm) in body tissues in the world. But the disease can be prevented by spraying the infected sites with DDT/BHC as in case of malaria and filarial, for the last 40 years, DDT has been banned in western countries, because of concern about its long-term health effects\(^5\).

Although DDT does not act on the human nervous system, it stays in human bodies for a long time and has long term effects on humans but in developing countries, it is still in use. The researcher have reported various concentration of DDT and BHC in different part of Indian Rivers\(^6,7\).

Delhi citizens have the highest level of pesticides in their body-fat in the world. The level of DDT residue in different food stuff has been varying from 1.6-17.4 ppm in wheat, 0.8 to 16.4 ppm in rice, 2.9 to 16.9 ppm in pulses, 3.0 to 9.1 ppm in groundnut, up to 5.0 ppm in vegetables and 68.5 ppm in potatoes\(^8,9,10\).

Gas Chromatography/Mass Spectrometry (GC/MS):

The coupled gas chromatography/mass spectrometer is a very powerful tool for organic samples to identify a compound unambiguously. The GC/MS combination can deal with a few monograms of material and generate large amount of information.
When injected from the high pressure operating region of GC (~700 torr of carrier gas) too high vacuum conditions of the mass spectrometer (~10^{-5} torr) many organic compounds are soluble in certain silicon that can be used for membranes to selectively pass soluble molecules from the GC effluent stream to the spectrometer. The atoms are able to diffuse relatively rapidly through a porous material and can be selectively removed from the gas stream between GC and MS.

Several authors\textsuperscript{11-14} find out organic Residue present in River water by GC/MS. The GC/MS analysis of Tapti River water in pre-monsoon and post monsoon was carried out at Sophisticated Analytical Instrument facility (SAIF) IIT Pawai, Mumbai on Hewlett Packard GCD 1800 A instrument having detector. Electron ionization column-HP-5, length-3 cm, internal diameter-0.5 mm, carrier gas-Helium and flow rate 1 ml/min. the other conditions are given on the GC/MS trace. An entry such as 100-10-260-8 M-NEAT-HP5-CHCL3 means that the initial temperature was 100\degree C for 8 minutes and then heated at the rate of 10\degree C per minute to 260\degree C. The GC/MS from Tapti River five water samples were collected (their mass spectra sampling code no are P1, P2, P3, P4, and P5.) In period of wet season 2010. In dry season 2011 (sampling code no are P\textsubscript{I}, P\textsubscript{II}, P\textsubscript{III}, P\textsubscript{IV}, and P\textsubscript{V}) & wet season 2011 (sampling code no are P1, P2, P3, P4, P5) in 2012. In three seasons their library search compounds are given. Explanation and the discussion of identified organic compound individually, particularly regard to structural and molecular formula and molecular weight is given in (Table 3.44). The identified compound and their properties are also tabulated in (Table 3.45). So it is concluded that BHC and DDT was not present in Tapti river water.
### Table 3.44 Organic Compounds found in Tapti River water sample

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Organic Compound</th>
<th>Structure of organic compound</th>
<th>Molecular formula</th>
<th>Molecular weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Tetracosamethyl-cyclododecasiloxane</td>
<td><img src="image1" alt="Structure" /></td>
<td>C_{24}H_{72}O_{12}Si_{12}</td>
<td>448.5061</td>
</tr>
<tr>
<td>02</td>
<td>Cyclononasiloxane, octadecamethyl</td>
<td><img src="image2" alt="Structure" /></td>
<td>C_{18}H_{54}O_{3}Si_{9}</td>
<td>667.3855</td>
</tr>
<tr>
<td>03</td>
<td>1,2-Benzenedicarboxylic acid, disiooctylester</td>
<td><img src="image3" alt="Structure" /></td>
<td>C_{24}H_{38}O_{4}</td>
<td>39390.5561</td>
</tr>
<tr>
<td>04</td>
<td>Phthalic acid, 6-ethyloct-3yl 2-ethylhexyl ester</td>
<td><img src="image4" alt="Structure" /></td>
<td>C_{26}H_{42}O_{4}</td>
<td>418.609</td>
</tr>
<tr>
<td>05</td>
<td>Isothiaizole-5-carboxylic acid, 4-amino-3(4-fluoro phenyl carbamoyl)</td>
<td><img src="image5" alt="Structure" /></td>
<td>C_{11}H_{4}FN_{3}O_{3}</td>
<td>281.027</td>
</tr>
<tr>
<td>06</td>
<td>Hexanoic acid, 2-ethyl-oxybis(2,1-ethanediyloxy-2, 1-ethenediy) ester</td>
<td><img src="image6" alt="Structure" /></td>
<td>C_{26}H_{46}O_{7}</td>
<td>446.6178</td>
</tr>
<tr>
<td>07</td>
<td>Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl.</td>
<td><img src="image7" alt="Structure" /></td>
<td>C_{16}H_{46}O_{7}Si_{8}</td>
<td>579.248</td>
</tr>
<tr>
<td>08</td>
<td>Heptasiloxane, hexadecamethyl</td>
<td><img src="image8" alt="Structure" /></td>
<td>C_{16}H_{46}O_{6}Si_{7}</td>
<td>532.00</td>
</tr>
<tr>
<td></td>
<td>Chemical Name</td>
<td>Molecular Formula</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------</td>
<td>-------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>09</td>
<td>1,1-Bicyclohexyl</td>
<td>C_{12}H_{22}</td>
<td>166.3031</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Heptasiloxane</td>
<td>C_{14}H_{34}O_{6}Si_{7}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Cyclodecasiloxane, eicosamethyl</td>
<td>C_{20}H_{60}O_{10}Si_{10}</td>
<td>741.5394</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Octadecane, 3-ethyl-5(2-ethyl butyl)</td>
<td>C_{26}H_{54}</td>
<td>366.71</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>3-[18-(3-Hydroxy-propyl)-3,3,7,12,17-Petamethyl-2,3,22,24-tetrahydro-porphin-2yl]Propan-1-01</td>
<td>C_{35}H_{26}N_{4}O_{2}</td>
<td>498.29</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Tetratetracontane</td>
<td>C_{44}H_{90}</td>
<td>618.00</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Tetradecane</td>
<td>C_{14}H_{30}</td>
<td>198.3880</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Docosanoic acid 1,2,3-propanetriyl ester</td>
<td>C_{60}H_{15}O_{6}</td>
<td>1059.7987</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>2,2-Bis[4-[(4-chloro-6-C3-ethynylphenoxy)-1,3,5-triazin-6-yloxy]phenyl]Propane</td>
<td>C_{27}H_{26}Cl_{2}N_{6}O_{4}</td>
<td>687.53</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chemical Structure</td>
<td>Molecular Formula</td>
<td>Molecular Weight</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------------------</td>
<td>-------------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>1-cyclohexanone, 3,3-dimethyl-2-[5-methoxy-3-methyl-2-pentenylidene]</td>
<td>C₁₅H₂₃O₂</td>
<td>236.349</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>4-tert-Butylbenzo-18-crown-6</td>
<td>C₂₀H₂₂O₆</td>
<td>368.46</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Dodecane</td>
<td>C₁₂H₂₆</td>
<td>170.2034</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Hexadecane</td>
<td>C₁₆H₃₄</td>
<td>226.4412</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Octadecane</td>
<td>C₁₈H₃₈</td>
<td>254.500</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 3.1

Mass spectra of organic compounds found in wet season 2010 sample No P-1 collected at Ukai Dam station
Fig. 3.1.1

Acq. Data Name: E36A7
External Sample Id: P-1
Average MS1 Time: 10.6, 10.6, 1.0 AV...
Intensity: (6648)

Ionization Mode: 1:EI+

Acq. Data Name: E36A7
External Sample Id: P-1
Average MS1 Time: 13.7, 13.7, 1.0 AV...
Intensity: (2,884)

Ionization Mode: 1:EI+

Acq. Data Name: E36A7
External Sample Id: P-1
Average MS1 Time: 16.5, 16.5, 1.0 AV...
Intensity: (1,989)

Ionization Mode: 1:EI+
Fig. 3.1.2

Acq. Data Name: E36A7
External Sample Id: P-1
Average(MS[1] Time:3.9_3.9)-1.0*Aver...
$x_{10^3}$ Intensity (189861)

Acq. Data Name: E36A7
External Sample Id: P-1
Average(MS[1] Time:8.1_8.1)-1.0*Aver...
$x_{10^3}$ Intensity (20486)

Acq. Data Name: E36A7
External Sample Id: P-1
Average(MS[1] Time:8.4_8.4)-1.0*Aver...
$x_{10^3}$ Intensity (13726)

Ionization Mode: 1:EI+
Mass spectra of organic compounds found in wet season 2010 sample No P-2 collected at Sayla station
Fig. 3.2.2
Mass spectra of organic compounds found in wet season 2010 sample No P-3 collected at Kukarmunda station
Fig. 3.3.1

Acq. Data Name: E36A4
External Sample Id: P-3
Average(MS)[1] Time:3.9 .3.9)−1.0*Aver...
$x10^3$ Intensity (15488)

57.068
71.083
85.099
99.118
170.217
5

Acq. Data Name: E36A4
External Sample Id: P-3
Average(MS)[1] Time:9.1 .8.1)−1.0*Aver...
$x10^3$ Intensity (17410)

57.068
71.083
85.099
99.118
198.250
5

Acq. Data Name: E36A4
External Sample Id: P-3
Average(MS)[1] Time:8.4 .6.4)−1.0*Aver...
$x10^3$ Intensity (13138)

57.068
71.083
85.099
99.118
113.134
226.285
5
Fig. 3.3.2

Acq. Data Name: E36A4
External Sample Id: P-3
Average MS1 Time: 10.6... -1.0'Av...
Intensity (6440)

Acq. Data Name: E36A4
External Sample Id: P-3
Average MS1 Time: 13.7... -1.0'Av...
Intensity (1998)

Acq. Data Name: E36A4
External Sample Id: P-3
Average MS1 Time: 22.1... -1.0'Av...
Intensity (2834)
Fig. 3.3.4

** Search Report Page 1 of 1 **

Unknown, MDTCTR(30.0000, 30.0000, 10, Center, 80.0, 8.0, Area); E36.7RF36A.7 mw RT = 10.6 min

Compound in Library Factor = -328

Hit 1: Octadecane
C18H38, MF: 832; RMF: 880; Prob 21.1%; CAS: 593-45-3; Lib: replib; ID: 5731.

Hit 2: Octadecane
C18H38, MF: 831; RMF: 873; Prob 21.1%; CAS: 593-45-3; Lib: replib; ID: 5465.
Fig. 3.3.5

** Search Report Page 1 of 1 **

Link: Unknown: MDI[CTR[30.0000: 30.0000:0.0,0.000:0.000:0.0,Area]] E36.7RE36.4.7

Compound in Library Factor = 13%

---

** Hil 1: Hexadecane**

---

** Hil 2: Hexadecane**
Mass spectra of organic compounds found in wet season 2010 sample No P-4 collected at Prakasha station
Fig. 3.4.1

Acq. Data Name: E36A5
External Sample Id: P-4
Average([M+H]+ Time:3.1..3.3)-1.0\%Aver...
Intensity (1247)

Ionization Mode: 1:EI+

Acq. Data Name: E36A5
External Sample Id: P-4
Average([M+H]+ Time:3.5..3.9)-1.0\%Aver...
Intensity (6998)

Ionization Mode: 1:EI+

Acq. Data Name: E36A5
External Sample Id: P-4
Average([M+H]+ Time:3.1..3.1)-1.0\%Aver...
Intensity (6303)

Ionization Mode: 1:EI+
Fig. 3.4.3

** Search Report Page 1 of 1 **

Unknown: MO[CTR]0.0000, 30.0000, 10.0000, 0.0000, [Area] E28.7E36.57w

Compound in Library Factor = 1/175

HR 1: Tetradecane
C14H30, MP: 639; RMP: 870; Prob 33.4%; CAS: 629-59-4; Lit: replib; ID: 5512.

HR 2: Tetradecane
C14H30, MP: 617; RMP: 890; Prob 33.4%; CAS: 629-59-4; Lit: mainlib; ID: 21935.
Mass spectra of organic compounds found in wet season 2010 sample No P-5 collected at Sulwade station
Fig. 3.5.1

Acq. Data Name: E35A6
External Sample Id: P-6
Average(MS[1] Time:3.8-3.9)-1.0"Aver...
x10^5 Intensity (139448)

Ionization Mode: 1:EI+

57.068
71.083
85.100
98.108
170.217

Acq. Data Name: E35A6
External Sample Id: P-6
Average(MS[1] Time:6.1-6.1)-1.0"Aver...
x10^5 Intensity (17409)

57.068
71.083
85.100

99.139
113.135
198.250

Acq. Data Name: E35A6
External Sample Id: P-6
Average(MS[1] Time:8.1-8.1)-1.0"Aver...
Intensity (6553)

57.068
71.086
85.100
99.124
113.161
196.249
197.433
292.137
341.004
400.551
438.430
478.543

Ionization Mode: 1:EI+
Fig. 3.5.2

Acq. Data Name: E35A6
External Sample Id: P-5
Average(MS[1] Time:8.4...8.4)-1.0*Av...
x10^3 intensity (100226)

Ionization Mode: 1:EI+

Acq. Data Name: E35A6
External Sample Id: P-5
Average(MS[1] Time:10.6...10.6)-1.0*Av...
Intensity (4415)

Ionization Mode: 1:EI+

Acq. Data Name: E35A6
External Sample Id: P-5
Average(MS[1] Time:13.7...13.7)-1.0*Av...
Intensity (1183)

Ionization Mode: 1:EI+
Fig. 3.5.3

** Search Report Page 1 of 1 **

Unknown: MDI|CTR|30.0000: 30.0000,10,Center,80,0,0,Area] E36.7|E36|A6.7m. R.T. = 13.7 min.

Compound in Library Factor = -1440

**HIT 1:** Octadecane, 3-ethyl-5-(2-ethylbutyl)-
C25H54, MF: 578, RMF: 669; Prob 21.0%; CAS: 55282-12-7; Lib: mainlib; ID: 7340.

**HIT 2:** 3,11b-2-Hydroxy-propyl-3,7,12,17-pentamethyl-2,3,22,24-tetrahydro-porphin-2-y1propan-1-ol
C31H38N4O2, MF: 571, RMF: 579; Prob 17.0%; Lib: mainlib; ID: 190551.
Fig. 3.5.4

** Search Report Page 1 of 1 **

Unknown: MD1CTR[30.0000, 30.0000, 10.00, 0.0, 0.0, Area] E36.78E36A4.7n. R_T = 10.6

Compounded in Library Factor = 1103

HIT 1: Tetrahexacane
C44H90, MF: 658; RMF: 761; Prob 20.3%; CAS: 7098-22-4; Lib: repLib; ID: 5519.

HIT 2: Tetraheptacane
C44H90, MF: 653; RMF: 789; Prob 20.3%; CAS: 7098-22-4; Lib: repLib; ID: 5520.
Fig. 3.6

Mass spectra of organic compounds found in dry season 2011 sample no. P.I. collected at Ukai Dam Station
Fig. 3.6.1
Mass spectra of organic compounds found in dry season 2011 sample No P-II collected as sayla station
Fig. 3.7.1
Fig. 3.7.3

**Search Report Page 1 of 1**

Unknown: MDTCTR[30.0000..30.0000,10,Center,0.0,0.0,Area]] E397NE96A2.7m $R, T = 130, 91$°

Compound in Library Factor = -918

Hit 1: Tetraetracontane
C44H90, MF: 589; RMF: 774; Prob 2.01%; CAS: 7069-22-8; Lib: replib; ID: 5519.

Hit 2: Tetraetracontane
C44H90, MF: 588; RMF: 797; Prob 2.01%; CAS: 7088-22-8; Lib: replib; ID: 5520.
Fig. 3.7.4
Fig. 3.7.5

**Search Report Page 1 of 1**

Unmatched: MDT:CTR(20.000), 30.0000<10, Cntor:80.0, A. area: E:36.78E3542.7wh K 7.9 2.17

Component in library Factor = 1502

Hit 1: 1-Cyclohexene, 3,3-dimethyl-2-[3-methoxy-3-methyl-2-pentenyl]iden-

Hit 2: 4'-3-Halomethylbenzo-18-crown-6
C20H32O6, MF: 512, RMF: 680, Pob: 15.5%; CAS: 14838-26-1; Lib: marisibi; ID: 131161.
Mass spectra of organic compounds found in dry season 2011 sample No P-III collected at Kukarmunda station
Fig. 3.8.2
Fig 3.9

Mass spectra of organic compounds found in dry season 2011 sample No P-IV collected as Prakash station
Fig. 3.9.1

Acq. Data Name: E3649
External Sample Id: P-IV
Average(MS[1] Time 3.0-3.8)-1.0*Av...

Ionization Mode: 1:EI+

Intensity (5122)

5000
4000
3000
2000
1000
0

57.066
71.080
85.096
98.105
170.210

100
200
300
400
500
m/z

Acq. Data Name: E3649
External Sample Id: P-IV
Average(MS[1] Time 6.1-6.1)-1.0*Av...

Intensity (4970)

5000
4000
3000
2000
1000
0

57.066
71.080
85.096
99.114
113.129
198.343

100
200
300
400
500
m/z
Fig. 3.9.2

Acq. Data Name: E36A9
External Sample Id: P-IV
Average(MS2) Time: 8.4-8.4-1.0*Average
Intensity (29568)

Ionization Mode: 1:El+

 Ionization Mode: 1:El+

Acq. Data Name: E36A9
External Sample Id: P-IV
Average(MS1) Time: 21.0-21.0-1.0*Average
Intensity (840)

800-

73.042

600-

147.068

55.053

221.094

250.861

499.587

400-

55.053

106.517

148.066

165.720

222.095

365.037

350.132

357.116

429.115

356.084

430.113

431.112

458.587

200-

100-

200

400

600

800

m/z

200

400

600

800

m/z
** Search Report Page 1 of 1 **

Unknown: M0T|CTR|30.0000..30.0000,10,Center,0.0.0,Area@| E36.7RE|E36A9.7+m K.T. = 2.3 ± 9 min

Compound in Library Factor = 628

** Hit 1: Octastiloxane, 1.1.2.3.5.5.7.7.9.9.11.11.13.15.15-hexadecamethyl-C16|600|C7S8, MF: 702, RMF: 777, Pub: 86.6%, CAS: 19056-24-0, Lib: mainlib, ID: 37082.**

** Hit 2: Heptastiloxane, 1.1.2.3.5.5.7.7.9.9.11.11.13.13-tetracosamethyl-C14|440|C6S7, MF: 666, RMF: 753, Pub: 17.4%, CAS: 19055-23-6, Lib: mainlib, ID: 37083.**
Fig. 3.10

Mass spectra of organic compounds found in dry season 2011 sample No P-V collected at Sulwade station.
Fig. 3.10.3

** Search Report Page 1 of 1 **

Unknown: MDT[CTR][00:00:00. 00:00:00. Center,0.0,0.0,Area] E36.7RE36A8.7ew R, T. = 165.5

Compound in library factor = 1.163

| Hit 1: Octadecanoic 3-ethyl-5-2-ethylbutyl- 
| C20H34, MP: 533, RPM: 704; Pred 31.0%; CAS: 55262-12-7; Lib: mainlib; ID: 7340. |

| Hit 2: Tetracontane 
| C40H80, MP: 812; RPM: 711; Pred 13.2%; CAS: 7068-22-8; Lib: replib; ID: 8519. |
Mass spectra of organic compounds found in wet season 2011 sample No P-1 collected at Ukai Dam station
Fig. 3.11.2
** Search Report Page 1 of 1 **

Unknown: MDT[CTR(30.0000..30.0000,10,Center,80.0,0,Area);SMT(SA,3)]) E43CP.7%E43CP1.7w 13.4 m

Compound in Library Factor = -331

---

** Hit 1 : Tetracosamethyl-cyclododecasiloxane **
C24H72O12Si12; MF: 788; RMF: 852; Prob 56.0%; CAS: 18919-94-3; Lib: mainlib; ID: 108692

---

** Hit 2 : Cyclotramasiloxane, octadecamethyl-**
C18H54O6Si8; MF: 772; RMF: 966; Prob 32.3%; CAS: 555-71-8; Lib: replib; ID: 8770
** Search Report Page 1 of 1 **

Unknown: MDT[CTR[30.0000, 30.0000,10, Center; 80.00,0,Area; SMT[SA,3]] E43CP.7fl/E43CP1.7rw)
Compound in Library Factor = -1647

Hit 1: 1,2-Benzenedicarboxylic acid, disoactyl ester
C24H38O4; MF: 540; RMF: 875; Prob 10.8%; CAS: 27554-26-3; Lib: repilb; ID: 20061.

Hit 2: Phthalic acid, 6-ethylc-3-yl 2-ethylhexyl ester
C26H42O4; MF: 528; RMF: 805; Prob 7.22%; Lib: mainlib; ID: 110671.
Fig. 3.11.5

** Search Report Page 1 of 1 **

Unknown: MDT[CTR[30.0000, 30.0000, 10, Center, 80, 0, 0, Area], SMT[SA, 3]] E43CP.7flE43CP1.7rw

Compound in Library Factor = -228

Hit 1: Cyclomonasiloxane, octadecamethyl-C18H54O9Si8; MF: 794; RMF: 812; Prob: 42.7%; CAS: 556-71-8; Lib: mainlib; ID: 37893.

Hit 2: Tetracosamethyl-cyclododecasiloxane
C24H72O12Si12; MF: 791; RMF: 888; Prob: 37.7%; CAS: 18919-94-3; Lib: mainlib; ID: 108692.
Mass spectra of organic compounds found in wet season 2011 sample No P-2 collected at Sayla station
Fig. 3.12.2

** Search Report Page 1 of 1 **

Unknown: MDT[CTR[30,0000, 30,0000,10,Center,80,0,0,Area],SMT[SA,3]] E43CP:7flE43CP2.7wr16.3m
Compound in Library Factor = -282

Hit 1: Tetracosamethyl-cycloodecasiloxane
C24H72O12Si12, MF: 779; RMF: 844; Prob 62.8%; CAS: 18919-94-3; Lib: mainlib; ID: 108892.

Hit 2: Cyclononasiloxane, octadecamethyl-
C18H54O9Si9; MF: 756; RMF: 846; Prob 22.9%; CAS: 556-71-8; Lib: replib; ID: 8770.
Fig. 3.12.3

Hit 1: Isothiazole-5-carboxylic acid, 4-amino-3-(4-fluorophenylcarbamoyl)-
C11H8FN3O3S; MF: 508; RMF: 526; Prob 26.2%; Lib: mainlib; ID: 127414.

Hit 2: Hexanic acid, 2-ethyl-, oxv/bis(2,1-ethanediolxy-2,1-ethanediyl) ester
C24H46O7; MF: 496; RMF: 627; Prob 10.4%; CAS: 18265-70-7; Lib: mainlib; ID: 126885.
Mass spectra of organic compounds found in wet season 2011 sample No P-3 collected at Kukarmunda station
** Search Report Page 1 of 1 **

Unknown: MDT[CTR[00.0000,00.0000,10,Center,0.0,0.0,Area]:SMT[SA,3]] E43CP.7fE43CP.7rw

Compound in Library Factor = -299

Hit 1 : Tetracosamethyl-cyclodecasiloxane
C24H72O12Si12; MF: 767; RMF: 829; Prob 57.6%; CAS: 18919-94-3; Lib: mainlib; ID: 108892.

Hit 2 : Cyclononasiloxane, octaodecamethyl-
C18H54O9Si8; MF: 747; RMF: 832; Prob 26.3%; CAS: 556-71-8; Lib: replib; ID: 8770.
Fig. 3.13.3

** Search Report Page 1 of 1 **

Unknown: MDT[CTR[30.0000,30.0000,10,Center,80,0,0,Area],SMT[SA,3]] E43CP.7%E43CP3.7%w 14/1

Compound in Library Factor = -772

Hit 1: Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,13,13,15,15-hexadecamethyl-C16H50O7Si8; MF: 657; RMF: 694; Prob 46.4%; CAS: 19095-24-0; Lib: mainlib; ID: 37082.

Mass spectra of organic compounds found in wet season 2011 sample No P-4
collected at
Prakasha station
Fig. 3.14.2

** Search Report Page 1 of 1 **

Unknown: MDT[CTR(30.0000..30.0000,10,Center,80.00,Area);SMT[S,3]] E43CP.751IE43CP4.7\text{nw} 20.6\text{m}

Compound in Library Factor = -281

Hit 1: Tetracosamethyl-cyclododecasiloxane
C24H72O12Si12; MF: 770; RMF: 827; Prob 52.0%; CAS: 18919-94-3; Lib: mainlib; ID: 108692.

Hit 2: Heptasiloxane, hexadecamethyl-
C16H48O6Si7; MF: 741; RMF: 771; Prob 14.7%; CAS: 541-01-5; Lib: replib; ID: 25306.
Fig. 3.15

Mass spectra of organic compounds found in wet season 2011 sample No P-5 collected at Sulwade station
Fig. 3.15.1

Acq. Data Name: E43CP5
External Sample Id: P-5
Average(MS[1] Time:5.1...5.1)
Area (2463)

Ionization Mode: 1:EI+

Acq. Data Name: E43CP5
External Sample Id: P-5
Average(MS[1] Time:16.0...16.0)
Area (3764)

Ionization Mode: 1:EI+

Acq. Data Name: E43CP5
External Sample Id: P-6
Average(MS[1] Time:21.8...21.8)
Area (5583)

Ionization Mode: 1:EI+
Fig. 3.15.2

** Search Report Page 1 of 1 **

Unknown: MDT[CTR:30.0000-30.0000,10;Center,80.0,0,Area];SMT[SA.3] E43CP.7%E43CP6.7% 5-1 ~

Compound in Library Factor = .803

Hit 1: 1,1'-Bicyclohexyl
C12H22; MF: 528; RMF: 844; Prob 33.4%; CAS: 92-51-3; Lib: mainlib; ID: 44122.

Hit 2: 1,1'-Bicyclohexyl
C12H22; MF: 528; RMF: 844; Prob 33.4%; CAS: 92-51-3; Lib: repib; ID: 10142.
** Search Report Page 1 of 1 **

Unknown: MDT[CTR(30.0000, 30.0000, 10, Center, 80, 0, 0, Area)]; SMT[S.A. 3] E43CP.7fIE43CP5.7w 16-0-

Compound in Library Factor = -714

** Hit 1: ** Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl-
C16H50O7Si8; MF: 617; RMF: 664; Prob 46.6%; CAS: 19095-24-0; Lib: mainlib; ID: 37082.

** Hit 2: ** Heptasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,13-tetradecamethyl-
C14H44O8Si7; MF: 699; RMF: 696; Prob 34.8%; CAS: 19095-23-9; Lib: mainlib; ID: 37083.
**Information regarding some organic compound**

1) Octadecane

These are higher chain alkenes having less use in petro chemical industry due to high flash point making it an inefficient fuel they are used as lubricant, transformer oils, and anti corrosion agent. They are chemically inactive, they are part of the paraffin or wax Biologically occurring in nature (bacteria, fungi, plants or animals) Higher chain alkenes do not rank biologically among the essential materials but they play an important role in pheromones that acts as a chemical messenger, transmitting information from one member of a species to another member of the same species.

1) Dodecanese:-

   It is also known as dihexyl, bihexyl, alkane 12 or duodecane. It is a liquid alkane hydrocarbon, an oily liquid of the paraffin series. It has 355 isomers.

   It is used as a solvent, distillation chaser scintillate component. More over it is used as diluents for tributyl phosphate (TBP) in plants reprocessing combustion reaction. The combustion reaction of Dodecanese is as follows.

   \[
   2C_{12}H_{26}(l) + 37O_2 (g) \rightarrow 24 CO_2 (g) + 26 H_2O (g)
   \]

   \[\Delta H^\circ = -7513 \text{ KJ}\]

2) Cyclohexasiloxane:-

   This chemical is used basically as a skin conditioner and emollient just like other silicones. When it is applied to skin it easily spreads on the whole skin surface uniformly. The skin surface appears to be smooth and frictionless. It repales water and forms a protective thin film. Fine line and uneven-ness of the skin surface and wrinkles on it are made smooth. The skin surface shows certain amount of glow and the made up face seems “Plump” look.
Table 3.45  Properties of organic Compound found in Tapti River Water.

<table>
<thead>
<tr>
<th>Molecular Formula</th>
<th>Molar Volume (m³)</th>
<th>Surface Tension (dyne/cm)</th>
<th>Flash Point (°C)</th>
<th>Boiling Point (°C)</th>
<th>Molar Refractivity (g/cm³)</th>
<th>Index of Refractivity</th>
<th>Solubility</th>
<th>Melting Point (°C)</th>
<th>Viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₂₄H₇₂O₂Si₁₂</td>
<td>899.1</td>
<td>21.089</td>
<td>260.581</td>
<td>518.644</td>
<td>0.99</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₁₈H₴₄O₉Si₉</td>
<td>679.256</td>
<td>20.44869</td>
<td>198.147</td>
<td>415.671</td>
<td>0.983</td>
<td>1.437</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₂₃H₳₄O₄</td>
<td>397.067</td>
<td>35.428</td>
<td>-</td>
<td>114.577</td>
<td>0.984</td>
<td>1.489</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₁₁H₸₁₈FN₃O₅</td>
<td>-</td>
<td>-</td>
<td>260.6</td>
<td>518.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₂₃H₴₆O₇</td>
<td>170.027</td>
<td>87.008</td>
<td>154.214</td>
<td>331.380</td>
<td>1.6549</td>
<td>1.738</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₁₆H₳₅₃O₇Si₆</td>
<td>-</td>
<td>-</td>
<td>208.10</td>
<td>499.10</td>
<td>0.989</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₁₂H₳₂₂</td>
<td>-</td>
<td>-</td>
<td>168.9</td>
<td>270</td>
<td>0.917</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₂₉H₴₄</td>
<td>-</td>
<td>-</td>
<td>219.9</td>
<td>451.8</td>
<td>0.989</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₃₁H₳₅₄N₃₄O₂</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>433</td>
<td>0.8115</td>
<td>1.4523</td>
<td>51°</td>
<td>52.07</td>
<td>-</td>
</tr>
<tr>
<td>C₂₅H₳₂Cl₂N₄O₄</td>
<td>-</td>
<td>-</td>
<td>324.272</td>
<td>918.989</td>
<td>0.899</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₂₃H₳₂O₆</td>
<td>240.819</td>
<td>36.198</td>
<td>134.699</td>
<td>340.539</td>
<td>0.981</td>
<td>1.516</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₁₉H₳₄</td>
<td>-</td>
<td>-</td>
<td>71</td>
<td>214.218</td>
<td>750mg/ml</td>
<td>1.421</td>
<td>-10 to - 9°</td>
<td>-</td>
<td>1.34</td>
</tr>
<tr>
<td>C₁₄H₳₅₀</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>86°</td>
<td>-</td>
</tr>
<tr>
<td>C₁₉H₳₄₈</td>
<td>-</td>
<td>-</td>
<td>135</td>
<td>271.291</td>
<td>773 mg/ml</td>
<td>1.434</td>
<td>-</td>
<td>17-19°</td>
<td>-</td>
</tr>
<tr>
<td>C₈H₳₃₈</td>
<td>-</td>
<td>-</td>
<td>165</td>
<td>316-317</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>28-30°</td>
<td>-</td>
</tr>
</tbody>
</table>
Reference:

6. Murthy, Laxmi (2003), Hormone havoc; pesticide contamination and women’s health, inform change News and features.
SECTION-IV
IMPACT OF POLLUTED WATER ON SOIL AND GROUND WATER

[A] Impact of polluted water on soil

3.4.1 INTRODUCTION:-

In the present study area, a number of small and large scale industrial units have developed with rapidly advancing technology. Man’s impact up on the world of natural resources is urbanization with consequent increase in population and modern agricultural practices, introduce numerous pesticide, fungicides, fertilizer, also waste water from industries, Cities and villages discharge their waste in nearby water bodies. Improper dumping of solid waste results in contamination of toxic chemicals in soil. Apart from a direct pollution of soil1,2.

Indian agriculture receives most of its water from surface sources like river, reservoir, dam etc. the use of industrial or municipal waste water is common practice in many parts of the world including India. Use of polluted water for irrigation, change the physical and chemical characteristics of soil and has its impact on crop yield3,4 & 5.

The studies showed that polluted water contains large quantity of micronutrients, toxic, metals, salts such as CaSO₄, CaCO₃, and HCO₃ in soluble form and harmful micro organism changes the microbial properties of soil. Toxic metals enter through food chain and disturb the biochemical process and finally lead to serious effects on living organism. When pH of soil is 6 or more Cd is highly soluble and other heavy metals such as Na, K, Cu, Pb, Hg, As etc are less soluble. When concentration of Na, Mg and K increases in soil, it causes Calcium deficiency in soil. Magnesium deficiency in soil has been attributed to high concentration of Ca, Na, and K. The United Nations Food and Agricultural Organization (FAO) states that half of the polluted water irrigated farms in the world, are damaged by soluble salts deposited in soil7,8.

Heavy metals compounds are called permanent poisons. Once they get accumulation in plant and water, they become dangerous as they affect the production of atmospheric oxygen as well as affect living beings9.

Polluted water contains amino acids, albumins and chelations, which undergo pontification by bacterial action, release sulphur and phosphorus
compounds, the compounds, produce sulphuretted gases like $H_2S$ and $SO_2$ as well as oxides of phosphorus which causes musty and putrid smell in soil. Heavy metal compounds like Na, K, Cu, Zn, Hg, Pb, As Cd, etc can kill bacteria and all beneficial micro organism in the soil. Phospatic compounds are precipitated and catalyzed by heavy metals. They remain in soil and sediments for long time and are considered indestructible, and hazardous for all living organisms.

Soluble salts present in polluted water are responsible for soil damage, metallic corrosion, and lead to costly cleansing activity. Salt accumulation in the soil has been a perpetual problem. When soluble salt increases, EC of soil increases and it disturbs the salt balance of soil and destroys its fertility. Lead content in soil may result in the risk of neuro behavioral effect in children, toxic effect can also be seen in the plant, animals of the area, also if solid waste is not dumped properly by municipal corporation and industries, the toxic metal are leached in to the soil and the soil becomes polluted, and infertile.

On the basic of EC values a researcher has classified irrigation water into five groups. Excess salinity reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrient from soil. A “SAR” value below 10 indicates good water for irrigation purposes.

Table 3.46 Irrigation water quality classification, water class salinity Hazards.

<table>
<thead>
<tr>
<th>Alkali Hazards</th>
<th>Ec (µmohs/cm)</th>
<th>SAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>up to 250</td>
<td>up to 10</td>
</tr>
<tr>
<td>Good</td>
<td>250-750</td>
<td>10-18</td>
</tr>
<tr>
<td>Fair/Medium</td>
<td>750-2250</td>
<td>18-26</td>
</tr>
<tr>
<td>Poor/Bad</td>
<td>&gt;2250</td>
<td>&gt;26</td>
</tr>
<tr>
<td>Very poor/Bad</td>
<td>&gt;4000</td>
<td></td>
</tr>
</tbody>
</table>
Sodium adsorption is stimulated when Na\(^+\) proportion increases as compared to Ca\(^+\)Mg\(^+\) resulting in soil dispersion. At high levels of Sodium, relative to divalent cation in soil solution, Clay minerals in soil tend to swell and disperse and aggregate, tend to slake, especially under conditions of low total salt concentration and high pH. As a result, the permeability of the soil is reduced and surface becomes crusted and compacted. Under such conditions, soils ability to transmit water is severely reduced by excessive solidity. If irrigation water containing excess of CO\(^{2-}\), and HCO\(^{-}\), will precipitate Calcium, and hence Sodium will increases in soil solution, it leads to saturation of clay complex with Sodium and consequently decrease infiltration rate. The quality of water required for irrigation depends, especially on the dissolved salts like Na\(^+\), CO\(^{2-}\), Mg\(^{+2}\), and HCO\(^{-}\) and their concentration in water increase or decrease in concentration of these salts and their ratio to one another influences, the quality of water for irrigation. Neither high pH above 8.4 nor a low below 5.0 is favourable. For maximum yield of crop the type of soil is controlled by pH value at 6.0-8.2 pH. Bacteria predominate suspended matter in sewage, can blanket the soil thereby interfering with soil moisture. Also polluted water decreases soil fertility, by killing bacteria and soil microorganisms\(^{11}\).

When pesticides and fertilizers are contained in irrigated water they crowd out essential nutrients present in top soil layers, the microbes enrich the humus and initiate plant growth. Fertilizer enriched soil can’t support microbial flora; hence there remains poor humus and less nutrients while the soil can readily become eroded by wind and water. Our aim behind the study is to inform those farmers who use polluted water for irrigation. Initially they get many benefits but later it is harmful to the whole ecosystem of the concern area.

**3.4.2 Sampling and analytical technique:**

The soil samples were collected as per standard procedure and were analyzed for various physico chemical parameters as per APHA\(^{12}\). Heavy metals were analyzed by ICP-AES technique.
Table 3.47 Physico-chemical characteristics of soil irrigated with polluted water & soil irrigated with well water.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Character</th>
<th>Polluted water</th>
<th>Well water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>8.19</td>
<td>7.78</td>
</tr>
<tr>
<td>2</td>
<td>ECC µmhos/Cm</td>
<td>6235</td>
<td>2278</td>
</tr>
<tr>
<td>3</td>
<td>Chloride</td>
<td>2915.18</td>
<td>732.2</td>
</tr>
<tr>
<td>4</td>
<td>Total hardness</td>
<td>36.5</td>
<td>7.60</td>
</tr>
<tr>
<td>5</td>
<td>Total Alkalinity</td>
<td>87.12</td>
<td>15.012</td>
</tr>
<tr>
<td>6</td>
<td>Bicarbonate</td>
<td>630.15</td>
<td>472.17</td>
</tr>
<tr>
<td>7</td>
<td>Calcium</td>
<td>2.19</td>
<td>2.78</td>
</tr>
<tr>
<td>8</td>
<td>Magnesium</td>
<td>0.15</td>
<td>0.35</td>
</tr>
<tr>
<td>9</td>
<td>Sodium</td>
<td>165.11</td>
<td>23.12</td>
</tr>
<tr>
<td>10</td>
<td>Potassium</td>
<td>6.5</td>
<td>0.9</td>
</tr>
<tr>
<td>11</td>
<td>Phosphate</td>
<td>40.07</td>
<td>4.10</td>
</tr>
</tbody>
</table>

All the parameters are in mg/L except pH and EC (µmohs/cm)

Table 3.48 Concentration of metal (mg/L) in Soil irrigated with polluted water and irrigated with well water.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Metals</th>
<th>Polluted water irrigated soil</th>
<th>Well water irrigated soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fe</td>
<td>79.89</td>
<td>8.65</td>
</tr>
<tr>
<td>2</td>
<td>Cu</td>
<td>20.10</td>
<td>2.90</td>
</tr>
<tr>
<td>3</td>
<td>Zn</td>
<td>21.97</td>
<td>3.06</td>
</tr>
<tr>
<td>4</td>
<td>Ni</td>
<td>1.07</td>
<td>0.30</td>
</tr>
<tr>
<td>5</td>
<td>Cd</td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td>6</td>
<td>As</td>
<td>10.07</td>
<td>0.020</td>
</tr>
<tr>
<td>7</td>
<td>Hg</td>
<td>17.06</td>
<td>0.012</td>
</tr>
<tr>
<td>8</td>
<td>Pb</td>
<td>26.01</td>
<td>4.95</td>
</tr>
</tbody>
</table>

3.4.3 Result and discussion:

In the selected study area the physico-chemical characteristic were analyzed and metal contamination in soil irrigated by polluted water and well water. The results thus obtained are being tabulated in Table 3.47, 3.48.
A perusal of Table 3.47 indicates that all physico-chemical parameter and metallic concentration were increases 2 to 3 fold in polluted water irrigated soil than, well- water irrigated soil and all parameters and metals exceed the guide line limits. Such high concentration values affect soil properties and also affect plants which are discussed below.

### 3.4.3.1 pH:
pH of polluted water irrigated soil is high, show alkaline nature due to higher amount of basic salts present in soil, such soil becomes hard and affect crop yield and affect on the soil fertility by killing the bacteria and soil micro organism. The plant cell can absorb water with pH between 6.0 to 7.0 internal plant cells can modify the pH to levels suitable to them by either releasing or absorbing \( \text{HCO}_3^- \) anion or \( \text{Ca}^{++} \) cation. Ph above 8.4 and below 5.0 is not suitable for maximum plant growth and crop yield.

### 3.4.3.2 EC:
EC gives clear idea of soluble salts present in soil. EC depend upon the dilution of soil suspensions. Result reveals that high EC of soil means it is hard and has poor seed germination capacity, the presence of excess salt reduces the water and nutrient up take by the roots of plants.

### 3.4.3.3 Alkalinity:
High alkalinity in polluted water irrigated soil may be harmful to several crops and impair their growth, if salinity of soil increases accumulation of Cd in plants increases.

### 3.4.3.4 Chloride:
Results indicate high value of chloride due to higher amount of salts present in polluted water which get accumulated in soil and soil becomes saline, such soil has poor structure.

### 3.4.3.5 Bicarbonate:
Higher value of bicarbonate in soil means polluted water contains higher amount of \( \text{CO}_3^{2-} \) and \( \text{HCO}_3^- \) salts. They will precipitate Calcium and hence Sodium will increase in soil solution. It leads to saturation of clay complex with Sodium and consequently decreased infiltration rate.

### 3.4.3.6 Phosphorus:
In present study phosphorus in soil was much higher; phosphate causes musty and putrid smell in water.

### 3.4.3.7 Potassium:
This element is very important in plants in the processes like photosynthesis, protein synthesis, starch formation, translocation of sugars and formation of grain tuber development up to a certain limit, but above such level it decreases important nutrients in food, like vitamin C and Carotene. During the present study concentration of Potassium was found to be high.
Presence of high level of Na, Mg, and K causes Calcium deficiency in soil. Some irrigated water contains low Sodium content but higher percentage of Calcium and Magnesium as much as 60 to 80% the soluble salt may get precipitated, both Na and K salts cause extensive soil dispersion and are highly corrosive to metal. High concentration of soluble salt may be troublesome.

3.4.3.8 Zinc: Concentration of Zinc was much higher than limit; such toxicity was shown in younger leaves due to chlorosis, apparent of brown spots on the leaves of same species. If concentration of Zinc exceeds certain limits, the plant leaves show necrotic lesion the surfaces and the leaf dies. Due to toxicity of Zinc in the roots the main roots growth is affected adversely,. The branching of roots is poor and due to reduction of the roots absorption of water and nutrients gets affected the roots also become yellowish. Also it can be accumulated in root system due to low mobility.

3.4.3.9 Copper: Copper is essential micronutrients for plant growth. If the presence of copper is more than the optimum values, roots growth is affected. Copper molecules or ions tend to get deposited in the roots rather than in the shoot. Thus the shoot contains lesser and lesser amount of copper deposition.

3.4.3.10 Mercury: Mercury gets discharged into water from electric equipments, paints, pesticides, pulp and paper industries, dental amalgam, chloro-alkyl industry. During study the concentration of Mercury in soil irrigated with polluted water was much higher than, permissible limit (0.002 ppm)

3.4.3.11 Lead: During study period concentration of Lead in polluted water irrigated soil was five times higher than well water irrigated soil. Stabilization of lead in soil depends on pH of soil. Increase in lead concentration decreases the enzyme activity in soil and lowers the microbial activity, resulting in soil pollution. Bansalet al\textsuperscript{13} found that the soil under sewer water irrigated land had higher concentration of Zn, Cu, Pb and Cd when compared to fields irrigated by ground water.

Patel et al\textsuperscript{14}, reported soils irrigated with the effluents had higher contents of micronutrients and heavy metals, as compared to the corresponding well water irrigated soil.
Reference


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3.4.4 Introduction:

Ground water is an important natural resource essential for sustenance of life. In India more than 90% of rural population uses ground water for drinking and domestic purposes. It is free from pollution in its natural state but manmade activities are responsible for its pollution and renders it unfit for its intended use\textsuperscript{1,2}. Natural and anthropogenic activities, local climate, geology of the region, irrigation practices affect ground water quality. It is not affected by contamination and pollution affect open water bodies more easily. Rain water contains some natural impurities which when passing through the soil layers get removed. Such ground water is used for irrigation, industrial and household purposes including drinking\textsuperscript{3,4}.

In recent years quality of ground water has undergone a considerable change with respect to contamination of heavy metals. Studies throughout the country especially in urban areas have indicated heavy metal contamination\textsuperscript{5,6}. The physico-chemical properties of ground water clearly explain its geological profile, soil water interaction, pollution status, as well as human and animal health problems and other perspectives\textsuperscript{7}.

One of the main causes of ground water pollution is the disposal of sewage water and effluent from various industries into fresh water aquifers. Central ground water Board (CGWB) study the ground water quality of India, on Nov. 30, 2011, concluded that in general, ground water quality in shallow aquifers is suitable for use for domestic purposes except few areas in which high concentration of some constituents are reported. The concentration of Arsenic, Fluoride and Iron in deeper aquifers varies from place to place and exploration work where salinity variation was observed in the inland and coastal area. 199 districts in 19 states of India were identified with problem of excess of fluoride. In West Bengal, 79 blocks in 8 districts have been found to have Arsenic pollution sporadically beyond the permissible limit; Arsenic containing ground water is mainly in the intermediate aquifer. High Arsenic is associated with volcanic formation. High concentration of Iron has been observed in some states. The ground water pollution of heavy metal such as Chromium, Lead Nickel has been reported from some part of county, mainly due to unplanned disposal of industrial effluents\textsuperscript{8,9}. 
According to the report of CPCB (1995) the ground water of Delhi, Uttar Pradesh, and Haryana was contaminated by heavy metal and pesticides. The water tested was found to be polluted above the maximum permissible limit set by BIS.

The aim behind the present work is to provide knowledge and importance of pure underground water for drinking agricultural purposes who are totally dependent on it, and to create awareness about water-born diseases and metal toxicity.  

3.4.5 **Sampling and Analytical technique**: Collection of polluted water sample and well water sample as per standard procedure in selected study area were analyzed for various physico-chemical parameters as per APHA (1992). Heavy metals were analyzed by ICP-AES technique.

**Table 3.49 Physico chemical characteristics of polluted water and well water.**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Character</th>
<th>Polluted water</th>
<th>Well water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>5.68</td>
<td>7.85</td>
</tr>
<tr>
<td>2</td>
<td>EC</td>
<td>3170.00</td>
<td>650.00</td>
</tr>
<tr>
<td>3</td>
<td>Hardness</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>Total Alkalinity</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>Bicarbonate</td>
<td>1052.00</td>
<td>672.69</td>
</tr>
<tr>
<td>6</td>
<td>Chloride</td>
<td>1814.00</td>
<td>396.85</td>
</tr>
<tr>
<td>7</td>
<td>Phosphate</td>
<td>--</td>
<td>3.61</td>
</tr>
<tr>
<td>8</td>
<td>Sodium</td>
<td>603.83</td>
<td>81.96</td>
</tr>
<tr>
<td>9</td>
<td>Potassium</td>
<td>49.13</td>
<td>36.17</td>
</tr>
<tr>
<td>10</td>
<td>Magnesium</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>11</td>
<td>Calcium</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

All the parameters are in mg/L and EC (µmohs/cm)

**Table 3.50 Concentration of metal in (mg/L) polluted water and well water.**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Metals</th>
<th>Polluted water</th>
<th>Well water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fe</td>
<td>4.60</td>
<td>1.45</td>
</tr>
<tr>
<td>2</td>
<td>Cu</td>
<td>0.102</td>
<td>0.165</td>
</tr>
<tr>
<td>3</td>
<td>Zn</td>
<td>2.25</td>
<td>0.198</td>
</tr>
<tr>
<td>4</td>
<td>Ni</td>
<td>0.65</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>5</td>
<td>Cd</td>
<td>0.25</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>As</td>
<td>0.12</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Hg</td>
<td>0.25</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Pb</td>
<td>0.75</td>
<td>0.09</td>
</tr>
</tbody>
</table>

**3.4.6 Result and Discussion:**

A perusal of table 3.47 shows that all physico chemical parameters and metallic concentration in ground water were just near or above the WHO, limit prescribed for drinking water, such exceeded values affect human healths which are discussed in detail.

**3.4.6.1 pH:** Nature of well water is alkaline and was just below the WHO limits means basic salts are dissolved in water. When acidic water percolates in soil bed, the salts present in soil, rocks are dissolved and leach in to water so water becomes alkaline.

**3.4.6.2 EC:** Conductance is an excellent indicator of TDS, which is measure of salinity that affects the taste of potable water. During the present study the present conductivity of collected well water is just above the tolerance limit due to presence of mineral salts and gases.

**3.4.6.3 Total alkalinity:** Alkalinity is a total measure of substance in water that has acid neutralizing ability. The main source of natural alkalinity are rocks which contain carbonate, bicarbonate and hydroxide compounds, Borate, Silicates and Phosphates may also contribute to alkalinity. The well water sample is highly alkaline, exceeds the WHO limit and the bicarbonate content was below the detection limit.

**3.4.6.4 Chloride:** The chloride contents normally increases as the mineral contents increases chloride concentration in well water below the limit prescribed by WHO.

**3.4.6.5 Phosphate:** Phosphorus is one of the most important nutrient elements responsible for eutrophication. The main source is, municipal waste water. Concentration of phosphorus in well water was below the detection limit.

**3.4.6.6 Hardness:** Hardness is not a pollution parameter but indicates water quality. Hardness of water is due to the natural accumulation of salts due to contact with soil and geochemical formation. Calcium and Magnesium are the Principal
cations causing hardness. During study hardness of water was below detection limit.

3.4.6.7 Sodium: Sodium is present in most natural water from negligible to appreciable concentration. In natural water the major source of Sodium is weathering of rocks. In well water Sodium concentration was below the detection limit.

3.4.6.8 Potassium: Source of Potassium in water is weathering of rocks gives potassium compounds similarly from waste water also soluble potassium compound are given out, in water, soil and sediments excess amount of Potassium ions leads to catharsis water but in excessive amount it acts as cathartic. Concentration of Potassium was below detection limit.

3.4.6.9 Calcium and Magnesium: Calcium contributes to hardness of water and high concentration of Magnesium imparts an unpleasant taste. Presence of Calcium and Magnesium adversely affect on domestic use in well water. Calcium and Magnesium concentration was just above the detection limit.

During the study period, metallic concentration in well water was below the WHO limit.

Ashraf et al\textsuperscript{12} reported that effect of polluted water on health of common man, affected by different kind of diseases such as nail, skin, and diarrhea. A problem in his study indicates that the people are more susceptible to stomach and digestive system ailments, also blood circulation problems are created.
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PP 202-212


SECTION-V

DEVELOPMENT OF LOW COST METHODS FOR THE REMOVAL OF HEAVY METALS FROM POLLUTED WATER

3.5.1 [A] REMOVAL OF CADMIUM (II) FROM AQUEOUS SOLUTION BY MANGO PEELS (MANGIFERAINDICA) AS LOW COST ADSORBENT.

3.5.1.1 INTRODUCTION:-

When heavy metal compounds are present in the environment, air, water or soil, they are dangerous for human’s life. Cadmium is first important toxic pollutant in waste water coming from metal mining, melting, electro-plating, battery, pesticides, oil paint, and pigment industries. Large dosages of Cadmium in humans can result in tubular and glomerular damage and cause protein urea and anemia. Cadmium ions present in the environment is hazardous to plants animals and human life. These ions get in contact with bio-molecules and its concentrations goes on increasing. These ions are highly toxic and must be removed from industrial and municipal waste water before it is let mix with river water or water bodies.

Chemical precipitation, electrolytic separation, ion exchange/chelation, solvent extraction and liquid membrane filtration are some methods to remove Cadmium ions. But these conventional methods are costly and when Cadmium concentrations are low between 1 to 100 mg/L these methods become ineffective. Some of the disadvantages involved in these methods are as the metals are not completely removed, the cost of chemicals and reagents is very high, much amount heat and electricity is required making the method costlier, the reactions produce toxic and poisonous waste products and to clean these toxic products more steps, more chemicals more time and more energy is required. Bio sorption is an alternative and promising technique. It requires less amount of chemicals and is highly effective in removing toxic ions.

Toxic ions can be absorbed by some methods which are based on chemical interaction between metal ion and the functional groups present in the cell-surfaces. These interactions include electrostatic attachment ion-exchange metal-ion-chelation or complex formation. within the cell surfaces, carboxyl ate, hydroxylamine’s and phosphor are common functional groups present which help bio-absorption similarly
cell components like polysaccharides lipids and proteins also take part in toxic ion removal reactions\(^9,10\).

The effect of following parameter on the adsorption of Cd was studied spectrophotometrically.

1) Effect of Contact time.
2) Effect of adsorbent dosage.
3) Effect of pH.
4) Effect of initial concentration.

### 3.5.1.2 Materials and Methods:

#### 3.5.1.2.1 Chemicals and instruments:

All the chemicals used were of analytical reagent grade, Cadmium solution of 1000 mg/L concentration was prepared by dissolving an appropriate amount of Cd (NO\(_3\)) \(_2\) \(\cdot\) 4H\(_2\)O in deionised distilled water (DDW), Cadmium solutions of different concentration were prepared by adequate dilution of stock solution with DDW before and after Cd concentration were determine by uv. Visspectrophotometer. The pH was adjusted by adding 0.1 N NaOH or 0.1 N HNO\(_3\). The pH was measured by using pH meter.

#### 3.5.1.2.2 Preparation of adsorbent:

Mango Peel waste was collected and washed several times with DDW, then dried in air and then in hot ovens for two days at 60\(^\circ\)C temp, Cooled in room temp and grinded and made in powder form.

#### 3.5.1.3 Calibration Curve:

To determine the concentrations of Cadmium ion samples at various absorbance’s these results are useful for identification of removal capacity of mango peels as an adsorbent. Fig 3.16 show the graphical representation of calibration of Cadmium ion concentration (10 mg/L) of Cadmium ion the absorbance was 0.12 where at higher concentration 20 mg/L the absorbance was 0.23.
3.5.1.4 Result and discussion:

3.5.1.4.1 Effect of contact time:-

It was observed that contact time has great role in removal of soluble Cadmium ions in an aqueous solution. Increasing the contact time adsorption percentage also increases after some time it becomes/attains equilibrium stage. Initially concentration of Cadmium is 50 mg/250 revolutions per minutes at room temp remove 91.3 % Cadmium ions at pH 5.0 as shown in Fig 3.17 the experiments were carried out for different contact time (30 to 240 minute) with fix
Adsorbent dose (100mg) the percentages of removal increases from 30 to 180 minutes for initial metal concentration. After 180 minutes removal percentage is constant. Initially percentage of removal increase due to sorbate-sorbent contact process, when large surface area is available, the metal ions removal percentage increases.

3.5.1.4.2 Effect of adsorbent dosage:

The experiment was done at room temperature with constant pH 5, contact time 180 minutes with variable adsorbent dose 10-160 mg/50 ml. In Fig 3.18, Cadmium ion removal efficiency increased (95.2%) with increase in adsorbent dose up to 100 mg at 180 minutes contact time. Further increasing the dose does not affect the percentage removal. The removal capacity was low at high dose rate, and vice versa. This was due to metal concentration shortage in solution at high dose rates.

Fig 3.18
3.5.1.4.3 Effect of pH:-

In bio sorption process change in pH play important role. The most important factor which affects the bio-absorption of heavy metal Cd is the pH of the solution in which action takes place, the binding site dissociation is influenced, behavior of Cd ions in hydrolysis varies or changes as the pH different complexes with organic and inorganic positive and negative ions takes places and the oxidation-reduction potential and reaction mechanism is altered. At the pH value of 2.0 more no of competing hydrogen ions come into effect and bio-absorption of Cd is reduced. At the pH value of 6.0 the hydrated species of the metallic ions of Cd increase in proportion, changes the surface chemistry and affects the separation and precipitation of the appropriate salts of Cd. The use of mango peel in removing the heavy ion of Cd by using various trials and errors was studied took a long time but the effect of pH is shown in Fig 3.19, at pH5 maximum (85%) Cadmium ions are removed when Cadmium ion concentration was 50 mg/L, contact time was 180 minutes for 100mg adsorbent dose at 1 to 8 pH range.

Fig 3.19

3.5.1.4.4 Effect of initial concentration:-
Initial concentration play important role on adsorption of removal of metal in an aqueous solution. The experiment were carried with variable initial concentration such as (10, 20, 30, 40, 50, 60, 70, 80, 90, 50 mg/L) at room temperature, at pH 5 contact time 3 hr ,and 0.1 g of adsorbent dose (0.1 g/100 ml). The results shown in Fig 3.20 removal of Cadmium ion 91.3% is initially high at low concentration but Percentage of removal, efficiency decreases with increased concentration, with fix adsorbent dose if concentration increased the number of available sites for adsorption decreases and reduce the % absorption.

3.5.1.4.5 Adsorption Isotherms:-

The adsorption isotherm is highly significant technique to remove the aqueous Cadmium ion. This gives the sorption capacity of adsorbents. The equilibrium data for the removal of Cadmium by sorption on adsorbents is used in Freundlich and Langmuir isotherm.

The Langmuir equation is given as

\[
\frac{C_e}{q_e} = \frac{1}{a b} + \frac{C_e}{b}
\]
The value of $r^2$ is higher for Freundlich and Langmuir equations, fit for the adsorbent. The study show that the use of mango peels for removal of Cd (II) from aqueous solutions is good/ satisfactory. This is because of good adsorption property of mango peels. The $r^2$ value (0.925) is very close to unity, which indicates the Langmuir isotherm is applicable.

The Calculated value of $1/n$ is in between 0 and 1, which indicates the favorable adsorption of Cd (II) on mango peels powder. The $r^2$ value is close to unity, which indicates the Freundlich isotherm is applicable. The value of $R_L$ is equal to 0.000019 which is $0 < R_L < 1$ indicates that adsorption is more favorable with Mango Peels Powder.
3.5.1.6 Conclusion:

*The optimum contact time required for removal of aqueous Cd\textsuperscript{2+} ions by using Mango peels powder was 180 minutes.

*The optimum adsorbent dosage required for removal of aqueous Cd\textsuperscript{2+} ions was found to be 100 mg.

*The optimum pH for adsorption of Cadmium ion in an aqueous medium using mango peels powder was recorded to be 5.

*The percentage of removal of Cadmium ion in an aqueous solution for an initial concentration of 10 mg/L for a dosage of 100 mg of mango peels powder at pH 5 for a contact time 180 minutes was to be 91.3% but above 100 mg adsorbent dosage at same condition the % of Removal of Cadmium attains equilibrium.

* The adsorption of Cd (II) using Mango peels powder follows Freundlich isotherm. It was found to be linear over a wide range.

*Langmuir isotherm fits well in to the adsorption of Cd (II) using mango peels powder.

*The limitless separation factor (R \textsubscript{L}) for Langmuir isotherm was found to be <1 hence it predicts a favorable adsorption.

References:


3.5.2 [B] ADSORPTION OF LEAD (II) USING NEEM LEAVES (AzadiractaIndica) POWDER AS LOW COST ASORBENT

3.5.2.1 Introduction:
Excessive release of heavy metal into the environment by humans in different ways such as untreated solid and liquid waste material, many industries and municipal corporation release polluted water without any treatment to environment over use of every natural organic and inorganic material by man. Human activities are reason for pollution, have posed great problems worldwide\textsuperscript{1,2,3}.

When highly concentrated heavy metal compounds are let in rivers or water bodies, aquatic life becomes endangered and destruction of environmental balance starts. Through food chain these compounds enter living beings and cause serious diseases. These heavy metals enter bioaccumulation through the food chain in living thing, leading to a variety of incurable diseases\textsuperscript{4,5}.

Lead is a metal found in to air, water from multitude of sources, like battery manufacturing, paint, pigments fuel, photographic material and explosive manufacturing. Inorganic Pb\textsuperscript{2+} ions act as enzyme inhibitor, and due to it nervous system gets affected. The removal of Pb (II) from polluted water is a major problem. Due to the difficulty in treating such polluted water, various methods have been proposed for the treatment of waste water containing lead waste, such as chemical precipitation, Electrochemical reduction, ion exchange, Biosorption, and adsorption.

Bio sorption of heavy metals from aqueous solution is a relatively new technology for the treatment of waste water. Adsorbent material derived from low cost agricultural wastes can be used for the effective removal and recovery of heavy metal ion from waste water. The major advantages of bio sorption technology are its effectiveness in reducing the concentration of heavy metal ion to very low levels and the use of inexpensive bio sorbent materials\textsuperscript{8,9}.

Lead is a toxic metal contaminates in water according to Indian standards, permissible limit is 0.01 mg/L. Presence of heavy ions in drinking even in very very low concentrations can harm health. Lead causes mental retardation it reduces hemoglobin and cell metabolism. It damages the functioning of the nervous system, it even reduces IQ levels in young ones\textsuperscript{12,13,14}.

Neem leaves contain organic and inorganic compounds such as cellulose, hemicelluloses, pectin’s and lignin present in the cell wall are adsorption sites.
Where toxic metal ions get attached. In Neem leaves chlorophyll, carotene, anthocyanin and tannin are the sites where heavy metal ions are bio-adsorption. These sites have hydroxyl, carboxylic carbonyl, amino and nitro groups which help metals adsorption. To study the effect of following parameter on adsorption of lead ion was studied spectrophotometrically

1) Effect of pH
2) Effect of Contact time
3) Effect of initial concentration
4) Effect of adsorbent dosage.

3.5.2.2 Material and Method

3.5.2.2.1 Chemicals and Instruments:-

All chemicals used were of analytical reagents grades. Calibrated UV-V spectrophotometric method to determine the percentage of removal of lead. Lead solution of 1000 mg/L concentration was prepared by dissolving appropriate quantity of lead nitrate in one liter deionised water. This solution was further diluted to get solutions of various known concentrations of lead. 0.1 Mol/L, NaOH and 0.1 Mol/L HNO₃ solutions were prepared to maintain pH of solution by using pH meter.

3.5.2.2.2 Preparation of adsorbent:-

After collecting Neem leaves and washing them with double-distilled water the washed leaves were dried in shadow and were crushed to the mesh size of 50. One liter of 0.1N HNO₃ solution was prepared and 50 gram of Neem leave powder was added to it and kept for 24 hours to take out already adsorbed metallic ions on the bio-mass surface. washing many times with distilled water and removal of dissolved acids by filtration until it becomes neutral is an important step. After this the bio-mass is washed and dried in oven at 105°C. Placed in decicator to attain room temperature and to protect it from moisture.

3.5.2.3 Calibration Curve:-

Various concentration of Pb (II) samples are calibrated at various absorbance the calibrated results are very effective to identify the respective Pb (II) removal capacity of Neem leaves powder as an adsorbent. Fig 3.21 Show graphical representation of calibration of Pb (II). At 1 mg/l absorbance was 0.012 and 20 mg/l absorbance was 0.245.
3.5.2.4 Result and discussion:

3.5.2.4.1 Effect of pH:

In bio-sorption for removal of aqueous metal ions, pH of solution is very important parameter. 300mg of adsorbent was agitated with 100mg/100ml of lead solution for 180 minutes at room temperature. The pH of solution varied between one to seven by addition of 0.1m HNO₃ and 0.1 N NaOH.
shows the optimum percentage of removed of lead at pH 4.5 range was 88.6%, initially at pH2 .22% removal were found and maximum percentage of removal increased up to 4.5 pH then constant up to pH 5 then percentage of removal decreased with increase in pH due to abundance of OH ion causing increase hindrance to diffusion of ion. Similar observation has been reported by other workers.

Lead ions form insoluble precipitates like hydroxides at pH levels above 6 and adsorption removal is very low. At strongly acidic solution H+ ions increase, they repeal Pb2+ ions and their removal becomes easy.

3.5.2.4.2 Effect of Contact Time:
At 4.5pH and at room temperature the Neem leave adsorbent dose of 300mg per liter, the contact time ranges from 30 min to 240 min. In such optimum conditions the rate of metal ion removal becomes 92.3 % as large adsorbent surface area becomes active. At 180 min maximum ion removal takes place after which more removal is not observed.

3.5.2.4.3 Effect of initial Concentration:
The mechanism of removal of metal depend up on different factors such as nature of pH solution, metallic concentration, temperature, adsorbent dosage, the concentration of different solution of lead (II) were selected for the comparative study at room temp.at pH 4.5 contact time 180 minutes, for 0.1 g/100ml solution adsorbent dose was 300 mg, maximum removal of Pb (II) was achieved (fig 3.24) and at higher concentration it required more time. And percentage of removal was
decreased at 300mg dose. It was observe that metallic ions removal depends on contact time and amount of adsorbent dose

Fig3.24

![Effect of initial Conc.](image)

### 3.5.2.4.4 Effect of adsorbent dosage:

It is the important parameter to design the optimum system such as fix amount of adsorbent for a quick response of the analysis. The experiments were conducted with various adsorbent doses from50 to 400 mg per 100 ml/L of test solution at pH 4.5 Fig3.25 shows when the addition of the adsorbent dose increases. A maximum 92.3% removal was obtained at 300 mg of Neem leaves powder. If more than required bio-adsorbent is used, it does not significantly increase the percentage of Lead ions removal from the solution.

Fig3.25

![Effect of Adsorbent Dose](image)

### 3.5.2.4.5 Adsorption Isotherms:

The interactive process between adsorbent and the absorbents is clearly given by equilibrium isotherm. Two well known models Viz. Langmuir and Freundlich
models were applied for this study. The empirical equation based on heterogeneous surfaces is given by the Freundlich expression which can be simplified in the linear form as

\[ q_e = K_f C_e^{1/n} \]

\[ \log q_e = \log K_f + \frac{1}{n} \log C_e. \]

Where the intercept \( \log K_f \) gives the bio-absorption cation, and slop of the line \( \frac{1}{n} \) is the intensity of bio sorption. \( q_e \) is the amount of metal ion adsorbed and \( C_e \) is the concentration of metals ions in solution, both at equilibrium levels.

**Fig3.26**

![Freundlich Isotherm](image)

\[ y = 0.207x - 0.106 \]

\[ R^2 = 0.769 \]

**Table 3.52** Values of Freundlich and Langmuir constants.

<table>
<thead>
<tr>
<th>Adsorbent</th>
<th>Freundlich Constants</th>
<th>Langmuir constants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( K_f ) (mg/gm)</td>
<td>( n )</td>
</tr>
<tr>
<td>Neem Leaves Powder</td>
<td>0.8994</td>
<td>0.9578</td>
</tr>
</tbody>
</table>
When calculated value of $1/n$ is in between 0 and 1, which indicates the favorable adsorption. The value of $r^2$ indicates that the Freundlich isotherm is applicable. The $R_L$ values the shape of isotherm to be irreversible ($R_L=0$), favorable ($0<R_L<1$), linear ($R_L=0$) or unfavorable ($R_L>1$), from the above result table $R_L$ value is 0.00025 which is $0<R_L<1$ indicate that adsorption is more favorable with Neem Leaves powder and $r^2$ values (0.865) is close to unity, which indicates the Langmuir isotherm is applicable.

3.5.2.6 Conclusion:-

The optimum contact time for removal of lead ion in an aqueous solution using Neem Leaves powder was 180 minutes.
The optimum adsorbent dosage for removal of Pb (II) ion was 300 mg.
The optimum pH for adsorption of Pb (II) ion using Neem Leaves powder was to be 4.5
The percentage of Removal of lead ion for an initial concentration of 10 mg/L for 300 mg of Neem Leaves powder at pH 4.5, was found to be 92%
The adsorption of Pb (II) using Neem powder follows Freundlich isotherm it was found to be linear over wide range.
The value of $r^2$ indicates, Langmuir isotherm was well applicable in the adsorption of Pb (II) ion.
The limitless separation factor ($R_L$) for Langmuir isotherm was found to be $<1$ hence it is a favorable adsorption.
References:


3.5.3.1 INTRODUCTION:-

Fast growth in science and technology, Industrialization and population and their effect on environmental pollution is a global problem. So it is not possible to make the county completely free from environmental pollution but we can control metal pollution using technology1.

Due to anthropogenic activities undertaken by man heavy metals are discharged into river systems, cause a serious problem. Heavy metals are harmful to both human and aquatic life. They are present in soluble from in aqueous solution over a wide range pH values and quite mobile in the natural environment can enter bioaccumulation through the food chain. Metals, are essential for human development but up to certain limit. But above the limit they become toxic, leading to a variety of incurable diseases2,3,4.

Normally the toxic ions of heavy metals are removed by following methods such as chemical precipitation, chemical oxidation-reduction, filtration, ion exchange, electro-chemicals process, and reverse-osmosis. In all these meals complete removal of the targeted heavy metals ions is not possible, as it requires times, expensive apparatus, setting and chemicals these methods also are not effective when the concentration of solutions and reactants are very low.

Activated carbon is effective in removal of heavy metals from aqueous solution. However its use is restricted because of difficulty in regeneration, therefore intensive studies have been carried out to develop more and inexpensive adsorbents. They include industrial or agricultural waste products7,8, waste bio living microbial algae, for the removal of the metals ions, organic sludge which contains granular size of material in which aerobic environment is present, such as microbial algae is used2. In fact their removal efficiency is as high as that of activated carbon, because of their low adsorption capacity9.

Developing countries suffer from water pollution, the high costs of chemicals and treatment is a major problem in these countries. So Biosorption is a promising technique for removal of heavy metals from aqueous environments especially when adsorbents are derived from lignocellulosic material. Biosorption is the fast and reversible reaction of the heavy metals with biomass10,11. These biomass contain lignocelluloses have ion-exchange capacity and general sportive characteristics which are derived from their constituent polymers and structure the polymers includes extractives cellulose, hemicelluloses, pectin, lignin and protein. Agricultural by products vary greatly in their ability to remove metals from solution12. The ability of biological materials to adsorb metal ion has received considerable attention for the development of an efficient, clean and cheap technology, for waste water treatment at metal concentrations as low as 1 mg/L13,14.
In the present investigation an attempt is made to adsorb Ni (II) on Almond- leaves- powder (ALP).

### 3.5.3.2 MATERIAL AND METHODS

#### 3.5.3.2.1 REAGENTS:

High quality analytical grade chemicals were used in the reactions to get reliable results. The chemicals reagents were NiSO$_4$.6 H$_2$O, 0.1 Mol/L NaOH, 0.1, Mol /L H$_2$SO$_4$

#### 3.5.3.2.2 Preparation of Adsorbent:

After collecting sufficient almond leaves, they were washed with distilled water and dried in shadow, after which the leaves were powdered to std mesh size. 50gm of leaves powder was added to 0.1N HNO$_3$ solution and kept for 24 hours for maximum precipitation and absorption. Remove acid by filtration and washing with distilled water until the pH of filtrate becomes natural. The biomass was dried in oven at temp $105^\circ$C, then placed in dedicator to attain room temperature and to protect from moisture.

#### 3.5.3.2.3 Preparation and analysis of Ni (II) Solution:

NiSO$_4$.6H$_2$Owas dissolved and 1000mgL$^{-1}$ solution was prepared in demonized distilled water (DDW). Prepare different concentration of stock solution, use A grade Borosile glass ware, also prepare 0.1 N HCl and 0.1 N NaOH solution. Which are used to adjust pH using digital pH meter Concentration of Ni (II) contents in the solution were determined by UV-Vis spectro photometer.

**Experimental:**

The experimental procedure followed to analyze the adsorption of Nickel using non conventional biomass adsorbent. Almond leaves powder (ALP) to observe the effect of following parameter on the adsorption of Nickel by using spectrophotometrically. The pH of solution ranges from 1to 8,Contact time ranges from 0 to 240 minute and initial concentration varies from 20 to 120 mg/l and adsorbent dose varied from 100 to900 mg.

1) Effect of pH
2) Effect of contact time
3) Effect of initial concentration
4) Effect of adsorbent dosage

#### 3.5.3.3 Calibration curve:

When concentration of solution changes, absorbance also changes.Figs 3.26 show that graphical representation of calibration of Ni (II) solution. It was observed at
lower concentration (5mg) the absorbance was 0.0612 whereas at higher concentration, (20mg) the absorbance was 0.251.

3.5.3.4 Result and discussions:

3.5.3.4.1 Effect of pH: - It is well known that adsorption of heavy metals ion depends upon pH of aqueous solution. When metal ion concentration is 50 mg/L and adsorbent dose was 800mg for 1 to 8. According to several authors,

Fig 3.27

the Biosorption below pH 2 was low (25%) due to competition of H\(^+\) ion for the active sites, above pH 3 the percentage of reduction increase up to pH 6 was 91.3% due to less competition offered by H\(^+\) ion. Fig 3.27, at low pH the concentration of proton was high and metal binding sites becomes positively charged repelling the Ni (II) cation. At higher pH of 6.0 there are more negative ions taken by the sorbent
material surface, more Ni(II) ions and the effectiveness of the absorbent material decreases.

3.5.3.4.2 Effect of Contact time:-

It was observed that contact time plays important role on removal of Nickel (II) in aqueous solution. Increasing the contact time % of adsorption also increases up to 180 min afterwards, it decrease. Fig 3.28 indicate that the percentage of adsorption at 180 min was 90% at first 30 minutes 50% Nickel (II) reduction was observed due to availability of vacant sites. After 180 minutes the reduction decreases probably due to desorption of metal ion back to the solution.

Fig 3.28

3.5.3.4.3 Effect of initial concentration:-

Several researcher have concluded that % of metal reduction depends on particle size, pH of solution, optimum temperature, ionic strength of solution, contact time of the
Adsorbent. When concentration was varied from 10 to 120 mg, adsorbent dosage of 800 mg at pH 6 Fig 3.29 it is observed that when concentration increases, the percentage removal of Nickel (II) decreases, this means more ALP adsorbent is required.

3.5.3.4.4 Effect of adsorbent dose:-
It is necessary to determine the minimum amount of adsorbent dosage required to achieve an optimum level to remove the metal ion in an aqueous solution. In the present study, it was observed that the effect of adsorbent on Nickel (II) removal at optimum time, when adsorbent dosage was increased, the percentage of metal ion increases, due to large available of the surface site. At 50mg/50ml higher concentration of the test solution at 600mg adsorbent dose 95% reduction took place.

Fig 3.30
5. 3.3.4.5 Adsorption isotherm:

The adsorption isotherm results show how the adsorption molecules distribute between solid phase and liquid phase, when the adsorption process attains an equilibrium stage were made to fit the adsorption data of Ni(II) in Freundlich and Langmuir isotherms for ALP up to adsorbent dose 50 mg/50 ml of Ni(II) solution the obtained equation is

\[
\left( \log \frac{q_e}{n} \right) = \log K_f + \frac{1}{n} \log C_e
\]

Freundlich and Langmuir constant (k, f, n, b and r²) calculated from this equation are given in table.

**Fig 3.31**

![Freundlich isotherm](image)

**Table 3.53** Values of Freundlich and Langmuir constants

<table>
<thead>
<tr>
<th>Adsorbent</th>
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<th>Langmuir constants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K_f (mg/gm)</td>
<td>n</td>
</tr>
<tr>
<td>Almond Leaves Powder</td>
<td>11.246</td>
<td>1.838</td>
</tr>
</tbody>
</table>
When value for ALP is higher in Freundlich equation than that of Langmuir equation then it is better for Freundlich isotherm. Langmuir isotherm was characterized by strong bond energy as indicated by the constant ‘b’ typical monolayer adsorption. This is further supported by low values of $R_L$ which indicate a monolayer adsorption.

Therefore we conclude that, ALP shows good performance for the treatment of waste containing Nickel. Removal is largely affected by pH of the system. In present study maximum removal of Nickel was found to be at pH 6, and ALP is cheaply available anywhere. Results thus obtained are providing good base for the development of waste water treatment plants. The value of $R_L$ is equal to 0.139 which is $0 < R_L < 1$ indicates that adsorption is more favorable with Almond Leaves powder.

### 3.5.3.6 Conclusion:

* The optimum contact time for removal of Ni ion, using Almond leaves powder was 180 minutes.
* The optimum adsorbent dosage for removal of Nickel ion in an aqueous solution was found to be 800 mg.
* The optimum pH for adsorption of Ni ion from aqueous solution using Almond leaves powder was to be 6.
* The percentage of Removal of Ni ion for an initial concentration of 50 mg/L for a dosage of 800 mg of almond leaves powder at pH 6 and for a contact time of 180 minutes was found to be 89.6% where for an above 100 mg/L under same condition it was found to be 40% removal. Indicating that at a high concentration of metal ion, the efficiency of the adsorbent has been decreased.
* The adsorption of Ni (II) using ALP follows Freundlich isotherm it was found to be linear over a wide range.
* Langmuir isotherm was fitted well into the adsorption of Ni (II) using ALP.
* The limitless separation factor ($R_L$) for Langmuir isotherm was found to be $<1$ hence it predicts a favorable adsorption.
References:


SECTION-VI
STATISTICAL EVALUATION OF THE COLLECTED
PHYSICOCHEMICAL AND HEAVY METALS RESULTS

3.6 STATISTICAL METHODS AND DATA PRESENTATION:-
Studies were conducted four times on the samples of River water, sediments and soil, which increase complexity and vastness of the observation, thus the number of table for data presentation increases and it is difficult to grasp the whole situation from large number of tables. Statistics provide an objective tool for data interpretation collection of sample studies.\textsuperscript{1} If the results collected are to be interpreted and some inference is sought, or a pattern is to be studied, a data is to be tested or inter relationship between two variable of some samples are to be studied, statistical evaluation comes as the best tool.

During the courses of present investigation the following statistical parameters have been calculated for various data obtained from the physico chemical characteristics and heavy metal concentration in River water, aquatic sediments and nearby soil\textsuperscript{2,3}

1] Arithmetic mean (Average $\bar{x}$) \[1\]
2] Standard Deviation (S.D.)
3] Standard Error (S.E.)
4] 95% Confidence limit (95% CL)

The formulae used for the determination of above parameters are being described and expressed mathematically under the following headings\textsuperscript{4,5}

3.6.1 Average ($\bar{x}$):

Average is the typical representative of all observations of a variable it is commonly called as mean. The mean of a set of data was calculated by using the following formula.

\[
\text{Arithmetic mean } (\bar{X}) = \frac{\text{Sum of all values}}{\text{No of total values}} = \frac{\sum X}{N}
\]

For the evaluation of S.D, variance was calculated as the arithmetic mean of the square of the deviation of the values from the mean of the data. The relation given below calculated it.

\[
\text{Variance} = \frac{\sum (X - \bar{X})^2}{n-1}
\]

The standard deviation was calculated by taking square root of variance,

\[
\text{Standard deviation} = \bar{X} = \sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}
\]

Standard deviation shows the degree of spread of normal curve of disturbance (fig 3.31) the more flattened the curve more, variability in data, thus more the standard deviation.

Standard deviation indicates that nearby 68% of the values will fluctuate about the mean by 1S.95% values will fluctuates 2S about the mean. While 99.7% values by fig shows that function of standard deviation about the mean value of the sample.

Fig 3.31

Variation of Standard Deviation about the mean

3.6. 3 Standard Error (S.E.):

It is the measure of the reliability of the mean of a data, and was calculated by using the following formula.

\[
\text{S.E.} = \sqrt{\frac{\sum (X - \bar{X})^2}{n}}
\]
Standard error

The determination of standard error indicates that if n values are distributed about X with variances $S^2$, then the mean X of these values will be distributed about the mean ($\mu$) by one standard error, two thirds of the time. It means if in a large population, several means are determined, then about two thirds of the means will be deviated by one standard error. The lesser the value of standard error, the more reliable is the mean.

3.6.4 95% confidence limits (95% CL):

It is possible that the mean obtained for a sample may not be the true value of actual mean of the population. To express this uncertainty, confidence limit are assigned to the observed mean (X). Most often, to get satisfactory results, the value of confidence limit is chosen as 95% It means that observed means will enclose the true mean with the frequency of this confidence limits were determined by using following formula.

$$95\% \text{ confidence limits} = \bar{x} \pm (t \times SE)$$

The value of ‘t’ was obtained from the ‘t’ distribution table by entering n-1 degree of freedom for the probability 0.05(5%)
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