Project Report

IMPACT OF PoP MADE IDOLS STRUCTURE ON IMMERSION IN WATER BODIES

Sponsor:

M.P. Pollution Control Board
Paryavaran Parisar, Bhopal, (M.P.)

CSIR-Advanced Materials and Processes Research Institute
(CSIR-AMPRI), Hoshangabad Road, Bhopal - 462026 (M.P.)

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Dr. Mohd. Akram Khan
(Principal Scientist & PI)

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3.	Dr. S.S. Amritphale, Chief Scientist	Co-Principal Investigator
4.	Dr. Swati Lahiri, Sr. Principal Scientist	Member
5.	Dr. Prabha Padmakaran, Technical Officer	Member
6.	Ms. Sapana Guru	Project Assistant-II

MADHYA PRADESH POLLUTION CONTROL BOARD (MPPCB), BHOPAL (M.P)

PROJECT TEAM

1.	Dr. N.P. Shukla	Chairman
2.	Shri A. A. Mishra	Member Secretary
3.	Dr. Reeta Kori	Chief Scientific Officer
4.	Dr. Abhaya K. Saxena	Chief Chemist
5.	Dr. Alok Saxena	Scientist

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1.0 Introduction

Water is the most vital resource for life as it supports life on earth and around which the entire fabric of life is woven and the aquatic ecosystem exists. Sea, rivers, ponds and lakes are natural resources of water. The requirement of water is essential for all forms of life i.e. from micro-organisms to human beings. Water pollution is a major global problem. It occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds. Water pollution occurs due to the city sewage and industrial waste discharge into river in addition to many religious activities and now became a threat to the ecosystem. Serious problem exists today as most of the water resources have reached to a point of crisis due to unplanned urbanization and industrialization.

Water pollution is a state of deviation from pure condition, whereby its normal functioning and properties are affected. There cannot be life without fresh water, which is only 2.70 % of the total water available on the earth. The scarcity and diversity of water resources in different regions and its equitable and sustainable use has become a matter of vital importance. The natural resource, water, is of vital importance for human and animal life, maintaining economical balance and achieving economic development. Water bodies also play a significant and vital role in performing religious and social rituals. These rituals include taking holy dip in sacred rivers, idols immersion, holy bathing etc. Thousands of idols, tazias and artificial structures are immersed in water bodies such as lakes, reservoirs, ponds, rivers and canals in and around different parts of India.

Idols are made of so many materials like, wood, stone, bamboo, jute, grass, clay and Plaster of Paris (PoP). To make these idols decorative and attractive they are painted with bright synthetic colour or lead oxide (Sindoor-orange in colour) mixed with oils which contain large amount of heavy metals. Wood, stone, grass, jute flowers, germinated seeds, leaves etc. cause short term deterioration of water quality due to their decay. On the other hand, paints with plenty of heavy metals cause health hazards in the long run. Survival and quality of human life largely depends on adequate availability of clean and wholesome water basically for drinking and secondarily for other purpose. The natural resource, water, is of vital importance for human and animal life, maintaining economical balance and achieving economic development.

The scarcity and diversity of water resources in different regions and its equitable and sustainable use has become a matter of vital importance. New materials like Plaster of Paris (PoP), paints containing hazardous dyes and chemicals and being used for 'modernizing' the representation of these idols without much thought being given to the issue of toxicity and its impact on the environment. The growing size of idol and the desire for making them more and more colourful has forced idol-makers to shift from clay to Plaster of Paris (PoP) as the base material. Immersion of hundreds and thousands of idols made of these materials is wreaking havoc on these water bodies. When idols made of Plaster of Paris is immersed in the water, it changes the form to gypsum, thus adding a large amount of material to the water that breaks down very slowly, while adding to hardness of water, both of which deteriorate the life carrying capacity and quality of the water. Plaster of Paris cause harmful impact on idol makers through direct contact with eyes and skin that can cause irritation in eyes, skin, and mucous membrane and affect the respiratory system.

Normally, idols are made of clay but these days, non-biodegradable Thermocole and paints containing heavy and toxic metals are also used. Added clay results in siltation of lakes while immersed biodegradable materials contaminate the quality of the lake water. The chemical paints used to colour these idols contain toxic, heavy metals which are potentially hazardous and magnify biologically along the food chain. Parameters like turbidity, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) become higher on immersion of such idols during the festive seasons. Out of all the materials used in making the idols, Thermocole is non-biodegradable while paints & colours contain toxic and hazardous heavy metals such as manganese, iron, zinc, chromium, lead, cadmium, nickel, mercury etc.

The chemical paints used to decorate the idols increase the heavy metal concentration and acidity in the water bodies where they are immersed. Idol are also made of so many materials like, wood, stone, bamboo, jute, grass, clay and Plaster of Paris (PoP). To make these idols decorative and attractive they are painted with bright synthetic colour or lead oxide (Sindoor-orange in colour) mixed with oils which contain large amount of heavy metals. Wood, stone, grass, jute flowers, germinated seeds, leaves etc. cause short term deterioration of water quality due to their decay. On the other hand, paints with plenty of heavy metals cause health hazards in the long run. Survival and quality of human life largely depends on adequate availability of clean and wholesome water primarily for drinking and secondarily for other purposes.

Lead and chromium which also add through Sindoor in the water bodies are highly toxic even in small concentration for human beings through the process known as bio-accumulation and bio-magnification. When immersed, these colours and chemicals dissolve slowly leading to significant alternation in the water quality. The heavy metals especially manganese, lead and mercury when excess in water cause skin diseases. The concentration of calcium increases significantly in the lake water after the idol immersion. Magnesium, molybdenum and silicon concentration also increases significantly in the lake water after idol immersion. Though magnesium is non-poisonous, it increases the average concentration of heavy metals, especially arsenic, lead and mercury. Over the years, the average concentration of heavy metals, especially manganese, lead and mercury also increases considerably in lake water as compared to specification of desirable limits.

The idols are made up of Plaster of Paris, clay and cloth supported by small iron rods, and is painted with different metal-based paints. On immersion of these idols in the water bodies, the water is contaminated with these metals paints and change in chemical load in the water body is expected. When idols are immersed, these coloured chemicals dissolve slowly leading to significant alteration in the water quality.

Idols are made of clay but non-biodegradable Thermocole and paints containing heavy metals are also used. Water supports life on earth and round which the entire fabric of life is woven. The requirement of water is in all lives, i.e. from micro-organisms to man, is serious problem today because all water resources have been reached to a point of crisis due to unplanned urbanization and industrialization. Water pollution is a state of deviation from pure condition, whereby its normal functioning and properties are affected. Aggravated environmental problem often reflect the misuse or misunderstanding of technology. The untreated wastewater contains effluent rich in phosphate, caustic soda and detergent, etc. Organic enrichment of the lake through floral offerings, idol immersion and decomposition of aquatic weeds are also the significant causes of its eutrophication. The overall impact has resulted in deterioration of the water quality, accumulation of toxic chemical and sediments, shrinking of lake area and above all a loss of aesthetic value. The research study has been carried out to understand the status of water bodies and lake. There is a need for continuous monitoring of pollution level in order to promote better living conditions around the lake.

Pollution of water bodies is a concern in today's era. Idol immersion activities during certain festive occasions are adding to the pollution load of the water-bodies. Non-biodegradable materials and synthetic paints used for making these idols are posting serious threat to aquatic life and environment. Water quality assessment is an important exercise to evaluate the nature and extent of pollution in order to take appropriate control measures. The present work is concerned about the water quality assessment to evaluate the nature and extent of pollution in water body. The issues of water are becoming increasingly important to environment particularly with respect to human and food security. Festivals on the other hand are an integral part of rich and diverse cultural heritage of India but they add to water pollution through different activities.

In present situation the materials used for making idols has led to use of non-biodegradable materials like Plaster of Paris, Plastic, Thermocole, synthetic colours etc. which deteriorate the water quality. Moreover, the chemical paints used to paint these idols contain heavy metals which are potentially hazardous and bio magnify along the food chain pollution due to water immersion has many social, religious, scientific and environmental dimensions. Increase in chemical pollutants after idol immersion in the lake water has been reported. Turbidity is caused by a wide variety of suspended particles that range in size from colloidal to coarse dispersions depending on the degree of turbulence.

Idol immersion add large quantities (clay, slit etc.) and some organic materials (straw, jute, flowers, leave and germinated grains) to the water bodies thus contributing to the turbidity. The water colour is disturbed completely during the idol immersion causing high turbidity. The total hardness of water in the immersion and post immersion samples is also high. Although hardness is not a pollution meter, it indicates the water quality. Increase in Ca, Mg and total hardness during immersion has also been reported. The idol are painted with oil paints of various colours viz. red, yellow, orange, white, black, golden and skin colour. These paints contain heavy metals like Cu, Zn, Cr, Cd, Pb, Fe, As & Hg which are non-biodegradable and bio-accumulate & bio-magnify along the food chain and are neuro and nephro toxic & some of them are even carcinogenic. Increase in concentration of heavy metals like As, Cr, Cd, Hg, Mn, Ni, Pb due to immersion of idol in the lake waters has also been reported.

2.0 Physico-Chemical Characterisation

The basic sampling and characterization techniques involved in analysis include physical parameters, inorganic parameters, organic parameters and heavy metals. Physico-chemical analysis is the prime consideration to assess the quality of water for its best usage say for drinking, bathing, fishing, industrial processing and so on, while for wastewater either domestic or industrial to know the pollution strength and its effect on the ecology. A detailed outline of the schematic diagram followed for characterisation is as shown below:

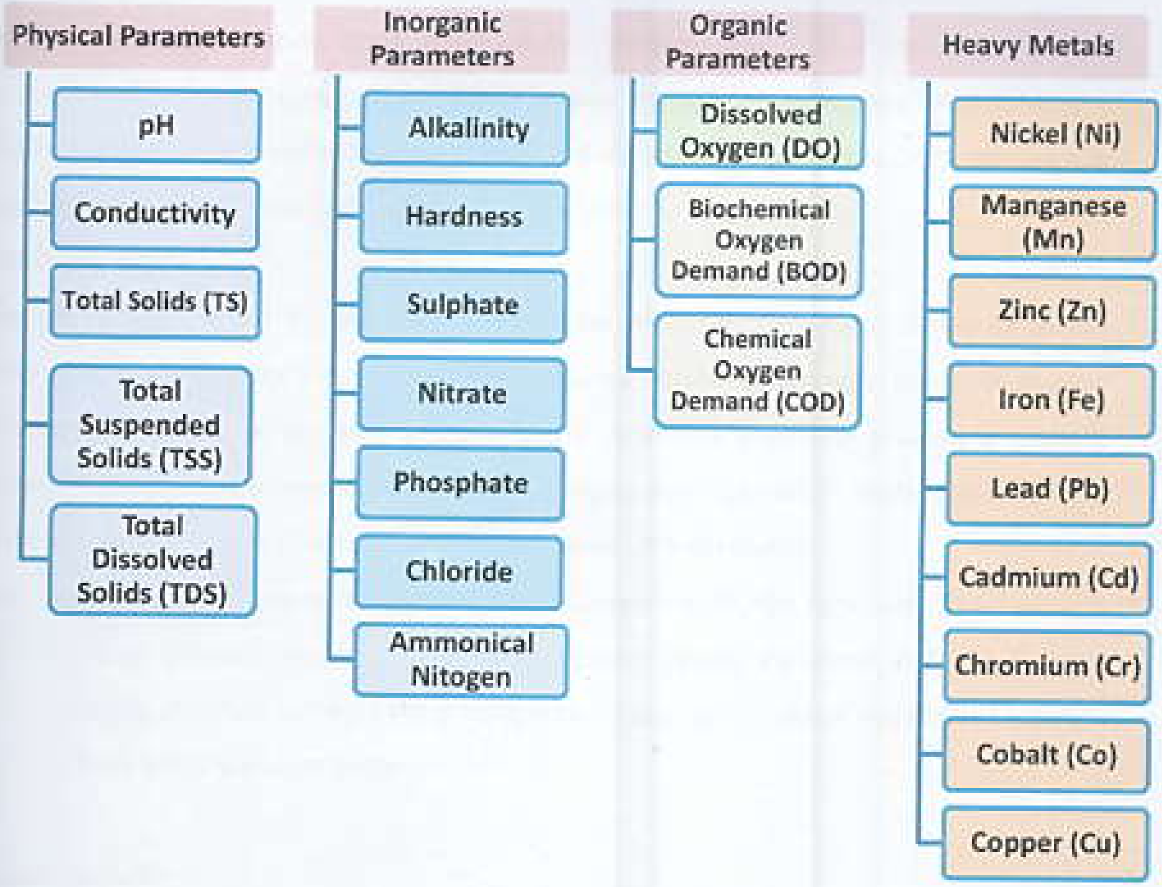


Figure 1.0: Schematic Description of Physico-Chemical Parameters

2.1 pH

The pH of a solution is measured as negative logarithm of hydrogen ion concentration. At a given temperature, the intensity of the acidic or basic character of a solution is indicated by pH or hydrogen ion concentration. pH values from 0 to 7 are diminishing acidic, 7 to 14 increasingly alkaline and 7 is neutral.

Measurement of pH in one of the most important and frequently used tests, as every phase of water and wastewater treatment and waste quality management is pH dependent. The pH of natural water usually lies in the range of 4 to 9 and mostly it is slightly basic because of the presence of bicarbonates and carbonates of alkali and alkaline earth metals. pH value is governed largely by the carbon dioxide/ bicarbonate/ carbonate equilibrium. It may be affected by humic substances, by changes in the carbonate equilibriums due to the bioactivity of plants and in some cases by hydrolysable salts. The effect of pH on the chemical and biological properties of liquid makes its determination very important. It is used in several calculations in analytical work and its adjustment to an appropriate value is absolutely necessary in many of analytical procedures.

Working Principle

The pH is determined by measurement of the electromotive force (EMF) of a cell comprising of an indicator electrode (an electrode responsive to hydrogen ions such as glass electrode) immersed in the test solution and a reference electrode (usually a calomel electrode). Contact is achieved by means of a liquid junction, which forms a part of the reference electrode. The EMF of this cell is measured with pH meter.

Since the pH is defined operationally on a potentiometric scale, the measuring instrument is also calibrated potentiometrically with an indicating (glass) electrode and a reference electrode using standard buffers having assigned pH value so that $pH_B = -\log10\ [H+]$ where pH_B= assigned pH of standard buffer.

2.2 Conductivity

Conductivity is the capacity of water to carry an electrical current and varies both with number and types of ions in the solutions, which in turn is related to the concentration of ionized substances in the water. Most dissolved inorganic substances in water are in the ionized form and hence contribute to conductance.

Working Principle

The method is used to measure the conductance generated by various ions in the solution/water. Rough estimation of dissolved ionic contents of water sample can be made by multiplying specific conductance (in mS/cm) by an empirical factor which may vary from 0.55 to 0.90 depending on the soluble components of water and on the temperature of measurement. Conductivity measurement gives rapid and practical estimate of the variations in the dissolved mineral contents of a water body.

2.3 Turbidity

Suspension of particles in water interfering with passage of light is called turbidity. Turbidity is caused by wide variety of suspended matter which range in size from colloidal to coarse dispersions depending upon the degree of turbulence and also ranges from pure inorganic substance to those that are highly organic in nature. Turbid waters are undesirable from aesthetic point of view in drinking water supplies and may also affect products in industry. Turbid water also poses a number of problems in water treatment plants. Turbidity is measured to evaluate the performance of water treatment plants.

Working Principle

Turbidity can be measured either by effect on the transmission of light which is termed as Turbidimetry or by its effect on the scattering of light which is termed as Nephelometry. Turbidimetry can be used for sample with moderate turbidity and Nephelometer for sample with low turbidity. Higher the intensity of scattered light higher the turbidity.

2.4 Total Dissolved Solids (TDS)

The total dissolved solids (TDS) in water consist of inorganic salts and dissolved materials. In natural waters, salts are chemical compounds comprised of anions such as carbonates, chlorides, sulphates and nitrates (primarily in ground water) and cations such as potassium (K), magnesium (Mg), calcium (Ca), and sodium (Na). In ambient conditions, these compounds are present in proportions that create a balanced solution. If there are additional inputs of dissolved solids to the system, the balance is altered and detrimental effects may be seen. Inputs include both natural and anthropogenic source.

2.5 Dissolved Oxygen (DO)

All living organisms are dependent upon oxygen in one form or the other to maintain the metabolic processes that produce energy for growth and reproduction. Aerobic processes are of great interest, which need free oxygen for wastewater treatment. Dissolved Oxygen (DO) is also important in precipitation and dissolution of inorganic substances in water. DO levels in natural waters and wastewaters depend on physical, chemical and biological activities in water bodies. The solubility of atmospheric oxygen in fresh water ranges from 14.6mg/L at 0°C to about 7.0mg/L at 35°C under normal atmospheric pressure. Since it is poorly soluble gas, its solubility directly varies with the atmospheric pressure at any given temperature. Analysis of DO is a key test in water pollution control and wastewater treatment processes. The following illustrations reveal importance of DO as a parameter:

- It is necessary to know DO levels to assess quality of raw water and to keep a check on stream pollution.
- In wastewaters, dissolved oxygen is the factor that determines whether the biological changes are brought out by aerobic or anaerobic organisms. - DO test is the basis of BOD test which is an important parameter to evaluate pollution potential of wastes.
- DO is necessary for all aerobic biological wastewater treatment processes.
- Oxygen is an important factor in corrosion. DO test is used to control the amount of oxygen in boiler feed waters either by chemical or physical methods.

Winkler Method with Azide Modification

Working Principle

Oxygen present in sample rapidly oxidises the dispersed divalent manganous hydroxide to its higher valence, which is precipitated as a brown hydrated oxide after the addition of NaOH/ KOH and Potassium Iodide. Upon acidification, manganese reverts to divalent state and liberates iodine from KI equivalent to the original DO content. The liberated iodine is titrated against $Na_2S_2O_3$ (N/40) using starch as an indicator. Chemical reactions involved in the method are given below:

1. $MnSO_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4$ (white ppt)
2. $2Mn(OH)_2 + O_2 \longrightarrow 2MnO(OH)_2$ (Brown ppt)
3. $Mn(OH)_2 + 2(H_2SO_4)_2 + 3H_2O$
4. $Mn(SO_4)_2 + 2KI \longrightarrow MnSO_4 + K_2SO_4 + I_2$
5. $2Na_2S_2O_3.5H_2O + I_2 \longrightarrow Na_2S_4O_6 + 2NaCl + 10H_2O$

6. $2NaN_3 + H_2SO_4 \longrightarrow 2HN3 + Na_2SO_4$

7. $HNO_2 + HN_3 \longrightarrow N_2 + N_2O + H_2O$

2.6 Alkalinity

Working Principle

Alkalinity of sample can be estimated by titrating with standard sulphuric acid (0.02N) at room temperature using phenolphthalein and methyl orange indicator. Titration to decolourisation of phenolphthalein indicator will indicate complete neutralization of OH^- and ½ of CO_3^{--} while sharp change from yellow to orange of methyl orange indicator will indicate total alkalinity (complete neutralisation of OH^-, CO_3^{--}, HCO_3^-).

2.7 Hardness

Water hardness is a traditional measure of the capacity of water to precipitate soap. Hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions. It is caused by dissolved polyvalent metallic ions. In fresh water, the principal hardness causing ions are calcium and magnesium which precipitate soap. Other polyvalent cations also may precipitate soap, but often are in complex form, frequently with organic constituents, and their role in water hardness may be minimal and difficult to define. Total hardness is defined as the sum of the calcium and magnesium concentration, both expressed as $CaCO_3$, in mg/L. The degree of hardness of drinking water has been classified in terms of the equivalent $CaCO_3$ concentration as follows:

Soft 0-60 mg/L

Medium 60-120mg/L

Hard 120-180mg/L

Very hard >180mg/L

Although hardness is caused by cation, it may also be discussed in terms of carbonate (temporary) and non-carbonate (permanent) hardness. Carbonate hardness refers to the amount of carbonates and bicarbonates in solution that can be removed or precipitated by boiling. This type of hardness is responsible for the deposition of scale in hot water pipes and kettles. When total hardness is numerically greater than that of total alkalinity expressed as $CaCO_3$, the amount of hardness equivalent to alkalinity is called carbonate hardness. When the hardness is numerically equal to less than total alkalinity, all hardness is carbonate hardness. The amount of hardness in excess of total alkalinity expressed as $CaCO_3$ is non-carbonate hardness. Non-carbonate hardness is caused by the association of the hardness-causing cation with sulphate, chloride or nitrate and is referred to as "permanent hardness". This type of hardness cannot be removed by boiling.

Public acceptability of the degree may vary considerably from community depending on local conditions, and the association. The taste threshold for magnesium is less than that for cation.

EDTA Titration Method

Working Principle

Hardness is determined by the EDTA method in alkaline condition; EDTA and its sodium salts from a soluble chelated complex with certain metal ions. Calcium and Magnesium ions develop wine red colour with Eriochrome black T in aqueous solution at pH 10.0 ± 0.1. When EDTA is added as a titrant, Calcium and Magnesium divalent ions get complexed resulting in sharp change from wine red to blue which indicates end-point of the titration. Magnesium ion must be present to yield satisfactory point of the titration. Hence, a small amount of complexometically neutral magnesium salt of EDTA is added to the buffer. The sharpness of the end point increases with increasing pH. However, the specified pH of 10.0 ± 0.1 is a satisfactory compromise. At a higher pH i.e. at about 12.0 Mg^{++} ions precipitate and only Ca^{++} ions remain in solution. At this pH murexide (ammonium purpurate) indicator forms a pink colour with Ca^{++}. When EDTA is added Ca^{++} gets complexed resulting in a change from pink to purple which indicates end point of the reaction. To minimise the tendency towards $CaCO_3$ precipitation limit the duration of titration period to 5 minutes.

2.8 Chloride

The presence of chloride in natural waters can be attributed to dissolution of salt deposits, discharges of effluents from chemical industries, oil well operations and seawater intrusion in coastal areas. Each of these sources may result in local contamination of both surface water and groundwater. The salty taste produces by chloride depends on the chemical composition of the water. A concentration of 250mg/L may be detectable in some waters containing sodium ions. On the other hand, the typical salty taste may be absent in water containing1000mg/L chloride when calcium and magnesium ions are predominant. High chloride content may harm pipes and structures as well as agricultural plants.

Argentometric method

This method is used for the analysis of the chloride ion present in the natural water. The mercurimetric method is recommended when an accurate determination of chloride is required, particularly at low concentrations. The potentiometric method is suitable only when the sample is coloured or turbid, argentometric method is the simplest one can be the method of choice for variety of samples.

Working Principle

The quality of sample for estimation of chloride should be 100mL or a suitable portion diluted to 100mL. Chloride is determined in a natural or slightly alkaline solution by titration with standard silver nitrate, using potassium chromate as indicator. Silver chloride is quantitatively precipitated before red silver chromate is formed. The chemical reactions involved in this method are given below:

1. $Ag^{+}+Cl^{-} \longrightarrow AgCl$ (White precipitate)
2. $2Ag^{+}+ CrO_4^{--} \longrightarrow AgCrO_4$ (Red precipitate)

2.9 Phosphate

Phosphorous occurs in natural waters and in wastewater almost solely in the form of various types of phosphates. These forms are commonly classified into orthophosphates and total phosphates. These may occur in the soluble form, in particles of detritus or in the bodies of aquatic organisms.

The various forms of phosphates find their way into wastewater, effluents and polluted water from a variety of sources. Larger quantities of the same compounds may be added when the water is used for laundering or other cleaning, since these materials are major constituents of many commercial cleaning preparations. Orthophosphates applied to agricultural or residential cultivated land as fertilizers are carried into surface waters with storm runoff and to a lesser extent with melting snow. Organic phosphates are formed primarily by biological processes. They are contributed to sewage by body wastes and food residues.

Presence of phosphates in water and wastewater analysis has a great significance. Phosphate in small concentration are used in water supplies to reduce scale formation, to increase carrying capacity of mains, to avoid corrosion in water mains, to remove iron and manganese in micro quantities and in coagulation especially in acid conditions. The presence of phosphate in large quantities in fresh waters indicates pollution through sewage and industrial wastes. It promotes growth of nuisance causing micro-organisms. Though phosphate possess problems in surface waters, its presence is necessary for biological degradation of wastewaters. Phosphorus is an essential nutrient for the growth of organisms and helps for the primary productivity of a body of water.

Principle

In acidic condition, orthophosphate reacts with ammonium molybdate to form molybdophosphoric acid. It is further reduced to molybdenum blue by adding reducing agent such as stannous chloride or ascorbic acid. The blue colour developed after addition of ammonium molybdate is measured at 690 or 880nm within 10-12 minutes after development of colour by using blank. The concentration is calculated from the standard graph. The intensity of the blue coloured complex is measured which is directly proportional to the concentration of phosphate present in the sample.

2.10 Nitrate (NO_3^-)

Determination of nitrate (NO_3^-) is difficult because of the relatively complex procedures required, the high probability that interfering constituents will be present and the limited concentration ranges of the various techniques. Nitrate is the most highly oxidised form of nitrogen compounds commonly present in natural waters. Significant sources of nitrate are chemical fertilizers, decayed vegetable and animal matter, domestic effluents, sewage sludge disposal to land, industrial dischargeand leachates from refuse dumps and atmospheric washout. Depending on the situation, these sources can contaminate streams, rivers, lakes and ground water. Unpolluted natural water contains minute amounts of nitrate. Excessive concentration in drinking water is considered hazardous for infants because of its reduction to nitrite in intestinal track causing methemoglobinaemia. In surface water, nitrate is a nutrient taken up by plants and converted into cell protein. The growth stimulation of plants, especially of algae may cause objectionable eutrophication.

Nitrate in water sample is estimated through spectrophotometer by Cadmium reduction method

Principle

Cadmium metal reduces nitrates present in the sample to nitrite. The nitrite ion reacts in an acidic medium with sulfanilic acid to form an intermediate diazonium salt. This salt couples to gentisic acid to form an amber-coloured product.

2.11 Sulphate (SO_4^{2-})

Sulphate ions usually occur in natural waters. Many sulphate compounds are readily soluble in water. Most of them originate from the oxidation of sulphate ores, the solution of gypsum and anhydrite, the presence of shales, particularly those rich in organic compounds, and the existence of industrial wastes. Atmospheric sulphur dioxide formed by the combustion of fossil fuels and emitted by the metallurgical roasting processes may also contribute to the sulphate compounds of water. Sulphur trioxide (SO_3) produces by the photolytic oxidation of sulphur dioxide comes with water vapours to form sulphuric acid which is precipitated as acid rain or snow. Sulphur-bearing mineral are common in most sedimentary rocks. In the weathering process gypsum (calcium sulphate) is dissolved and sulphide minerals are partly oxidised, giving rise to a soluble form of sulphate that is carried away by water. In humid region, sulphate is readily leached from the zone of weathering by infiltrating waters and surface run off but in semiarid and arid regions the soluble salts may accumulate within a few tens of feet of land surface. Where this occurs, sulphate concentration in shallow ground water may exceed 5000mg/L and gradually decrease with depth.

Ingestion of water containing high concentration of sulphate can have a laxative effect, which is enhanced when sulphate is consumed in combination with magnesium. Water containing magnesium sulphate at levels about 1000 mg/L acts as a purgative in human adults. Taste threshold concentrations for the most prevalent sulphate salts are 200-500mg/L for sodium sulphate, 250-900mg/L for calcium sulphate, and 400-600mg/L for magnesium sulphate. Essentially on the basis of above values, which are also allied to the cathartic effect of sulphate, a guidelines value of 400mg/L is proposed. Sulphates cause scaling in water supplies, and problem of odour and corrosion in wastewater treatment due to its reduction to H_2S.

Principle

This method is used for the determination of sulphate ions. Sulphate ion (SO_4^{2-}) is precipitated in an acetic acid medium with Barium chloride ($BaCl_2$) so as to form Barium sulphate ($BaSO_4$) crystals of uniform size. The reaction involved is given below:

$Ba^{++} + SO_4^{2-} \longrightarrow BaSO_4$ (White suspension)

Light absorbance of the $BaSO_4$ suspension is measured by a photometer or the scattering of light by Nephelometer.

2.12 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand is a widely used technique to express the concentration of organic matter in waste water samples. It is a measure of the amount of dissolved oxygen used by microorganisms in the water.

Principle: Under alkaline conditions (by adding Alkaline-iodide-azide), the manganese sulphate produces a white precipitate of manganese hydroxide. This reacts with the dissolved oxygen present in the sample to form a brown precipitate. On acidic condition, manganese diverts to its divalent state and release iodine. This released iodine is titrated against Sodium Thiosulphate using starch as an indicator

2.13 Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) determines the amount of oxygen required for chemical oxidation of organic matter using a strong chemical oxidant, such as potassium dichromate under reflux conditions.

Open Reflux Principle:

- Suitable for a wide range of wastes with a large sample size.
- Due to it higher oxidizing ability dichromate reflux method is preferred over other procedures using other oxidants (e.g. potassium permanganate).
- Oxidation of most organic compounds is up to 95-100% of the theoretical value.

3.0 Working Principle of Instruments Used in Characterization and Evaluation

3.1 Atomic Absorption Spectrophotometer

Atomic absorption spectroscopy is based on the principle that when a beam of electromagnetic radiation is passed through a substance, the radiation may either be absorbed or transmitted depending upon the wavelength of the radiation. The absorption of radiation would bring about an increase in the energy of the molecule. The energy gained by the molecule is directly proportional to the wavelength of radiation. The increase in the energy of the molecule leads to the electronic excitations where electrons jump to higher energy levels. A particular wavelength that a given molecule can absorb depends upon the changes in vibration, or rotational or electronic states.

When a monochromatic radiation of frequency v is incident on a molecule, the molecule in the gaseous state E1 absorbs a photon of energy hv, it undergoes a transition from lower energy level to higher energy level. A detector is placed to collect the radiation after interaction with the molecule which shows that intensity has reduced. With wide range of frequencies, the detector shows the energy has been absorbed only from the frequency.

$$v = (\Delta E)/h$$

Therefore, we obtain an absorption spectrum which is defined as a record of the radiation absorbed by the given sample as a function of wavelength of radiation. The energy difference between the levels is given as,

$$\Delta E = E2 - E1 = hv = hc/\lambda$$

The light source, called a hollow cathode tube, is a lamp that emits exactly the wavelength required for the analysis (without the use of a monochromator). The light is directed at the flame containing the sample. The flame is typically wide (4-6 inches), giving a reasonably long path length for detecting small concentrations of atoms in the

flame. The light beam then enters the monochromator, which is tuned to a wavelength that is absorbed by the sample. The detector measures the light intensity, which after adjusting for the blank, is output to the readout, much like in a single beam molecular instrument. Also, as with the molecular case, the absorption behaviour follows Beer's Law and **concentration (c)** of unknowns are determined in the same way. All atomic species have absorptivity **(a)** and the width of the flame is the **path length (b)**. Thus, absorbances (A) of standards and samples are measured and concentrations determined as with previously presented procedures, with the use of **Beer's Law (A = a b c).** The Beer-Lambert law (or Beer's law) is the linear relationship between absorbance and concentration of an absorbing species. The general Beer-Lambert law is usually written as:

$$A = a(\lambda) * b * c$$

Where A is the measured absorbance, a(λ) is a wavelength-dependent absorptivity coefficient, b is the path length, and c is the analyte concentration. When working in concentration units of molarity, the Beer-Lambert law is written as:

$$A = \varepsilon * b * c$$

Where, Ɛ is the wavelength-dependent molar absorptivity coefficient with units of $M^{-1}\ cm^{-1}$. Data are frequently reported in percent transmission (I/I_0 * 100) or in absorbance [$A = \log(I/I_0)$]. The latter is particularly convenient.

In the atomic absorption spectrometer, the source of radiation in the spectrometer is the tungsten filament emitting white light or hydrogen discharge lamp. The radiation from the source is directed by a mirror on the sample. The radiation then passes through an analyser (the grating), which selects the frequency reaching the detector at any given time. The signal from the detector passes then to a recorder which is attached to the analyser so as to produce a trace of the absorbance of varying frequencies.

AAS make- Thermo Fischer model iCE 3000 series available at CSIR-AMPRI Bhopal consists of following three parts:

- Flame mode
- Graphite furnace
- Hydride generator

Figure 2.0: Atomic Absorption Spectrophotometer

3.2 Spectrophotometer

The Spectrophotometer is a much more refined version of a colorimeter. In a colorimeter, filters are used which allow a broad range of wavelengths to pass through, whereas in the spectrophotometer a prism (or) grating is used to split the incident beam into different wavelengths. By suitable mechanisms, waves of specific wavelengths can be manipulated to fall on the test solution. The range of the wavelengths of the incident light can be as low as 1 to 2nm. The spectrophotometer is useful for measuring the absorption spectrum of a compound, that is, the absorption of light by a solution at each wavelength.

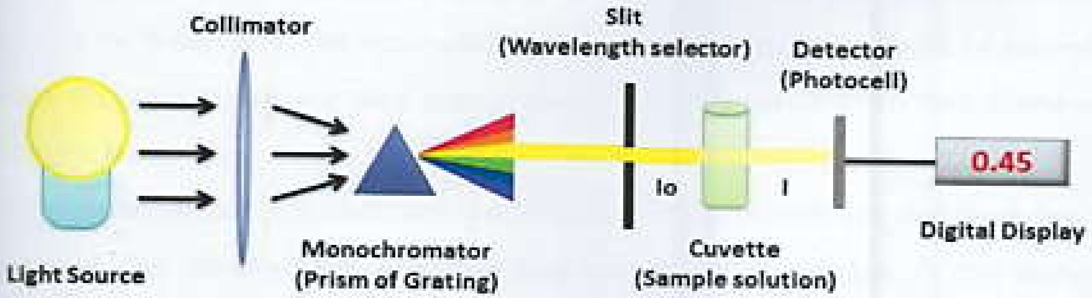


Figure 3.0 Basic Principle of Spectrophotometer

The use of spectrophotometer is based on Beer-Lambert law which relates the amount of light transmitted through a colored solution to be a function of the length of light path and the concentration of the absorbing media. A spectrophotometer is made up basically of a light source which can be the visible or ultraviolet region, a monochromator, the sample cell and the detectors or photocells. The light source is usually a tungsten lamp (for spectrophotometer that operates in the visible region such as spectronic 20 and visible spectronic 21) and a hydrogen or deuterium lamp (for spectrophotometers capable of operating within the UV spectrum) the UV- visible "spec" is equipped with the two types of lamps.

The incident light of particular wavelength selected with the monochromator is absorbed by the test solution resulting in lowered intensity of transmitted light. The photomultiplier sends signal to the photometer to display the result. The monochromator is made of grating or prisms to produce light with a slit width wavelength range of 5mm.

4.0 Study Area

In case of Bhopal, Upper Lake was a source of water as well and hence it was essential to shift the idol immersion activity away from the traditional immersion site Sheetal Das ki Bagiya, since immersion activity could not be stopped. This would entail alternative immersion sites nearby so that the public would agree to use the new sites provided to it. At that time the spill channel of the Upper Lake near the city was being deepened and widened as one of the project components by removing silt for ensuring the designed efflux. An alternate immersion site was identified at Prempura on the channel, well connected with roads. The flow of the spill channel being towards the outfall, the pollutants would not flow back to the main body. The accumulated slit due to idol immersion would be flushed out when the gates of the lake were opened during the rainy season to remove excess water from the lake.

The prospective idol immersion site was proposed to the government and their clearance obtained. The identified site was developed by using the excavated silt and stones for constructing and immersion bay at minimum extra cost. A 200-meter long Prempura immersion bay was constructed where sufficient water was available round the year for idol immersion purposes. The site was provided with proper electricity facilities, approach road and vehicle parking. Besides this, platforms for big idols and cranes were constructed for the convenience of people. Another interesting facet has been the reduction of the idol immersion both in number and in weight over the years which shows the attitudinal shift of the public to smaller sized idol on account of the increased awareness. Now, Prempura Ghat is the accepted immersion site.

Figure 4.0: Impact of Idol Immersion on the Quality of Water Bodies

5.0 Objectives of the Study

The approach of the present study is to study the impact of PoP made idol structures on water quality after immersion in water bodies. The impact of idol immersion causing any possible nuisance on the water quality shall be studied at the lab scale experimental level and results shall be presented in the report.

1. Setting up of lab scale facilities in the laboratory to carry out experimental work of idol immersion using large size tanks.
2. Setting up of one water tank as reference medium for the study and immersion of PoP made idol structures in one tank and earthen clay/soil made idol structures in another tank in the laboratory.
3. Periodic collection of samples from the set-up lab scale water bodies (large size water tanks) before and after the immersion of idol structures and characterization of water sample used for the reference purpose.
4. Detailed Physico-chemical characterization of water samples collected at regular intervals from idol immersed tanks and its analysis for parameters like pH, alkalinity, hardness, total solids, chlorides, Sulphate, DO, BOD, COD etc.
5. Determination of heavy metals like iron, copper, lead, manganese, cadmium, chromium, nickel present in the water samples before and after the immersion of idols in the water tanks through AAS technique.
6. Comparative study on the results collected before and after the immersion of different types of idol structures and its overall impact on the water quality.
7. Preparation of the final report incorporating the findings of the study and submission to M.P. Pollution Control Board, Bhopal.

6.0 Sampling Locations & Description

Sample No.	Sampling locations
TW	Tap Water
PPB	Prempura Ghat water sample before immersion
TC	Tap water + Clay idol
TP	Tap water + PoP idol
PPP	Prempura water + PoP Idol
PPC	Prempura water + Clay Idol
TCP	Tap water + Clay + PoP
PP	Prempura Water on 3rd day after immersion

7.0 Sample Collection and Analysis

The research study has been carried out to understand the statues of lake. The water samples were collected from surface layer and the site of idol immersion at different intervals i.e. pre-immersion, during immersion and post immersion. Pre-idol immersion samples were collected a week before the commencement of the immersion activities i.e. on 17.09.2014 (Phase-I) and (Phase-II 25.9.2014). During idol immersion samples were collected during the immersion activities i.e. Phase-III {01.10.2014} & Phase-IV {08.10.2014}). Post idol immersion samples were collected fifteen days after the completion of immersion activities (Phase-V {22.10.2014} & Phase-VI {10.11.2014}.After collecting the samples, they were analyzed as per standard methods.

Figure 5.0: Collection of Samples from Prempura Ghat, Bhopal


Figure 6.0: Idols Purchased from Market and Used for Experimental Work

8.0 Methodology

The physico-chemical characterization was followed using advanced techniques of analysis like atomic absorption spectrophotometer, special electrodes, TCLP, titration etc which are described below in detail.

8.1 pH

a. Before use, remove electrodes from storage solutions and rinse with distilled water.

b. Dry electrodes by gently blotting with a soft tissue paper, standardise instrument with electrodes immersed in a buffer solution within 2 pH units of sample pH.

c. Remove electrodes from buffer, rinse thoroughly with distilled water and blot dry.

d. Immerse in a second buffer below pH 10, approximately 3 pH units different from the first, the reading should be within 0.1 units for the pH of second buffer.

e. For samples analysis, establish equilibrium between electrodes and sample by stirring sample to ensure homogeneity and measure pH.

f. For buffered samples (or those with high ionic strength), condition the electrodes after cleaning by dipping them into the same sample, and read pH.

g. With poorly buffered solutions (dilute), equilibrate electrodes by immersing in three or four successive portions of samples. Take a fresh sample and record the pH.

8.2 Conductivity

Conductivity can be measured as per the instruction manual supplied with the instrument and the results may be expressed as mS/m or mS/cm. Note the temperature at which measurement is made. Conductivity meter needs very little maintenance and gives accurate results.

1. Calibrate the conductivity cell with the help of standard KCL solution and determine the cell constant.
2. Dip the conductivity cell assembly in water sample taken in a 50or 100 ml beaker and record the conductivity. If the value is too low, change the adjustment accordingly. Record the temperature of water during the test.
3. Observed values of EC are multiplied by the cell constant (usually given on conductivity cell) and a temperature factor to express results at 25°C.
4. Remove the cell from soil suspension, clean with distilled water and dip into a beaker of distilled water. EC is expressed as mS/cm.
5. Keep the conductivity cell in distilled water when not in use.

8.3 Turbidity

Solution (i): Dissolve 1g hydrazine sulphate $(NH_2)_2.H_2SO_4$, in distilled water and dilute to 100 mL in a volumetric flask.

[Caution: Hydrazine sulphate is a carcinogen; avoid inhalation, ingestion, and skin contact. Formazine suspensions can contain residual hydrazine sulphate.]

Solution (ii): Dissolve 10.0g hexamethylenetetramine, $(CH_2)_6N_4$, in distilled water and dilute to 100mL in a volumetric flask.

In flask, mix 5.0 mL solution (i) and 5.0 mL solution (ii). Let stand for 24 hr at 25± 3ºC. This results in a 400-NTU suspension. Transfer stock suspension into an amber glass or other UV-light-blocking bottle for storage. Make dilutions from this stock suspension.

Dilute turbidity suspensions: Dilute 400 NTU primary standard suspensions with high-quality dilution water. Prepare immediately before use and after use.

Working standards can be prepared by dilution of the following quantities of the stock formazin turbidity suspension (nominal 400 NTU) to 200 mL.

8.4 Alkalinity

a. Take 25 or 50mL sample in a conical flask and add 2-3 drops of phenolphthalein indicator.

b. If pink colour develops titrate with 0.02N H_2SO_4 till disappears or pH is 8.3. Note the volume of H_2SO_4 required.

c. Add 2-3 drops of methyl orange to the same flask and continue titration till pH comes to 4.5 or yellow colour changes to orange. Note the volumes of H_2SO_4 required.

d. In case pink colour does not appear after addition of phenolphthalein continue as above.

8.5 Dissolved Oxygen

1. Collect sample in a BOD bottle using Do sampler.
2. Add 2mL $MnSO_4$ followed by 2mL of alkali-iodide-azide reagent to a sample collected in 250 to 300mL bottle up to the brim. The tip of the pipette should be below the liquid level while adding these reagents. Stopper immediately. Rinse the pipettes before putting them to reagent bottles.
3. Mix well by inverting the bottle 2-3 times and allow the precipitate to settle leaving 150mL clear supernatant. The precipitate is white if the sample is devoid of oxygenand becomes increasingly brown with rising oxygen content.
4. At this stage, add 1mL conc. H_2SO_4. Replace the stopper and mix well till precipitate goes into solution.
5. Take 203mL of this solution in a conical flask and titrate against standard $Na_2S_2O_3$ solution using starch (2mL) as an indicator. When 1mL MnSO4 followed by 1mL alkali-iodide-azide reagent is added to the samples as in (2) above, 2mL of original sample is lost. Therefore, 203mL is taken for titration which will correspond to 200mL of original sample.

8.6 Hardness

Total Hardness

a. Take 25mL well mixed sample in conical flask.

b. Add 1-2mL buffer solution followed by 1mL inhibitor.

c. Add a pinch of Eriochrome black T and titrate with standard EDTA (0.01M) till wine red colour changes to blue, note down the volume of EDTA required (A).

d. Run a reagent blank. Note the volume of EDTA (B).

e. Calculate volume of EDTA required by sample, C = (A-B).

Calcium Hardness

a. Take 25mL sample in a conical flask.
b. Add 1mL NaOH to raise pH to 12.0 and a pinch of Murexide indicator.
c. Titrate immediately with EDTA till pink colour changes to purple. Note the volume of EDTA required (A1).
d. Run a reagent blank. Note the mL of EDTA required (B1) and keep it aside to compare end points of sample titrations.
e. Calculate the volume of EDTA required by sample, C1 = A1 -B1.
f. Standardise the EDTA (0.1M) solution using standard calcium solution.

8.7 Chloride

a. Take 50mL well mixed sample adjusted to pH 7.0-8.0and add 1.0mL K_2CrO_4.
b. Titrate with standard $AgNO_3$ solution till $AgCrO_4$ starts precipitating as pale red precipitate
c. Standardise $AgNO_3$ against standard NaCl.
d. For better accuracy titrate distilled water (50mL) in the same way to establish reagent blank.

8.8 Sulphate:

SulfaVer 4 method (Adopted from Standard Methods for the Examination of Water and Waste Water). Procedure is equivalent to USEPA method 375.4 for waste water.

a. Enter the appropriate stored program number for sulphate (SO_4^-) powder pillows. Press 680 ENTER. The display will show : Dial nm to 450
b. Rotate the wavelength dial until the small display shows 450 nm. When the correct wavelength is dialed in the display will quickly show: Zero Sample then mg/L SO_4^-
c. Fill a clean sample cell with 25 mL of sample.
d. Add the content of SulfaVer 4 Sulfate Reagent Powder Pillow to the sample cell. Swirl to dissolve. A white turbidity will develop if sulphate is present.
e. Press SHIFT TIMER. A five minute reaction period will begin. Allow the cell to stand undisturbed.

f. When the timer beeps, the display will show mg/L SO_4^-. Fill a second sample cell with 25 mL of sample (the blank).
g. Place the blank into the cell holder. Close the light shield.
h. Press Zero. The display will show zeroing then 0.0 mg/L SO_4^-.
i. Within five minutes after the beeps, place the prepared sample into the cell holder. Close the light shield.
j. Press READ. The display will show Reading... then the result in mg/L SO_4^- will displayed.

8.9 Phosphate

PhosVer 3 (Ascorbic acid) method (Adopted from Standard Methods for the Examination of Water and Waste Water). Procedure is equivalent to USEPA method 365.2 for waste water.

a. Enter the appropriate stored program number for phosphorous (PO_4^{3-}) powder pillows. Press 490 ENTER. The display will show: Dial nm to 890.
b. Rotate the wavelength dial until the small display shows 890 nm. When the correct wavelength is dialed in the display will quickly show: Zero Sample then mg/L PO_4^{3-}.
c. Insert a 10mL Cell Rinse into the cell compartment.
d. Fill a 10mL clean sample cell with 10mL of sample.
e. Add the content of PhosVer 3 Phosphate Reagent Powder Pillow for 10 mL sample of the cell. Swirl to dissolve. A blue colour will form if phosphate is present.
f. Press SHIFT TIMER. A two- minute reaction period will begin. Allow the cell to stand undisturbed.
g. Fill a second 10 mL sample cell with 10mL of sample (the blank).
h. When the timer beeps, the display will show mg/L PO_4^{3-}.Place the blank into the cell holder. Close the light shield.
i. Press Zero. The display will show zeroing then 0.0 mg/L PO_4^{3-}.
j. Place the prepared sample into the cell holder. Close the light shield.
k. Press READ. The display will show Reading then the result in mg/L PO_4^{3-} will displayed.

8.10 Nitrate

Cadmium Reduction Method

a. Enter the appropriate stored program number for nitrate (NO_3^-) powder pillows. Press 355 ENTER. The display will show: Dial nm to 500.

b. Rotate the wavelength dial until the small display shows 500 nm. When the correct wavelength is dialled in the display will quickly show: Zero Sample then mg/L NO_3^-.

c. Fill a 25mL clean sample cell.

d. Add the content of NitraVer 5 Nitrate Reagent Powder Pillow to the cell (the prepared sample).

e. Press SHIFT TIMER. Shake the cell vigorously until the timer beeps in one minute.

f. When the timer beeps, press SHIFT TIMER. A five-minute reaction period will begin. An amber colour will develop if nitrate is present.

g. Fill another sample cell with 25mL of sample (the blank).

h. When the timer beeps, the display will show mg/L NO_3^-.Place the blank into the cell holder. Close the light shield.

i. Press Zero. The display will show zeroing then 0.0 mg/L NO_3^-.

j. Place the prepared sample into the cell holder. Close the light shield.

k. Press READ. The display will show Reading then the result in mg/L NO_3^-will displayed.

9.0 Result and Discussion

Samples were collected and preserved. Samples were collected from each station before the idol immersion that was before Ganesh idol immersion and the post immersion. After collecting the samples, they were analysed as per standard methods.

The idols were immersed in the lab scale tanks in the manner as shown below:

Figure 7.0: Immersion of the PoP Idols in the Lab Scale Immersion Tanks

9.1 Pre-Idol Immersion Analysis: Phase-I & Phase-II

9.1.1 Phase-I: Physical Parameters

pH is an important preliminary examination of sample to be tested in order to know the general behaviour of the sample under analysis. It is significantly needed to check the pH of the sample because chemical reactions depend on pH, water supply and waste water treatment, Water Softening, Precipitation, Coagulation, Disinfection, Corrosion, Control, Alkalinity and CO_2 Measurement & fluoride activity. pH range of 6.5 to 8.5 is normally accepted as per guideline suggested by IS 10500 : 2012. Water samples under this range suggest slightly acidic and basic nature of the sample. Analysis of Phase- I water sample coded as TW, PPB, TC, TP, PPP, PPC, TCP and PP was found within the range 7.5-8.2 of normally accepted value as shown in Table No.1 & Graph No.1

Conductivity is ability of water to carry an electrical current. This ability mainly depends on presence of anion and cations in water and also depends on mobility, valence of ions and temperature. The WHO permissible limit for EC in water is 600 µS/cm. Higher the concentration of acid, base and salts in water, a higher will be the electrical conductivity. Generally higher the EC, higher is the total dissolved solids. Analysis results of Phase-I water samples shows that 235-1579 µS/cm have EC slightly above the permissible limit as shown in Table No.1 & Graph No.2

Total Solids (TS) is sum of Total Suspended Solids (TSS) and Total dissolved solids (TDS). The concentration of total solids was found in the range of 172.9-1026 mg/L as shown in Table No.1.0 & Graph No.3.0

Total dissolved solids (TDS) are the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulphate, and nitrate anions. The presence of dissolved solids in water may affect its taste. The presence of dissolved solids in water may affect its taste. The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre; good, between 300 and 600 mg/litre; fair, between 600 and 900 mg/litre; poor, between 900 and 1200 mg/litre; and unacceptable, greater than 2000 mg/litre as per IS 10500 : 2012. Analysis of phase- I water samples was found in the range of 112.6-786.0 mg/L as shown in Table No. 1.0 & Graph No. 4.0.

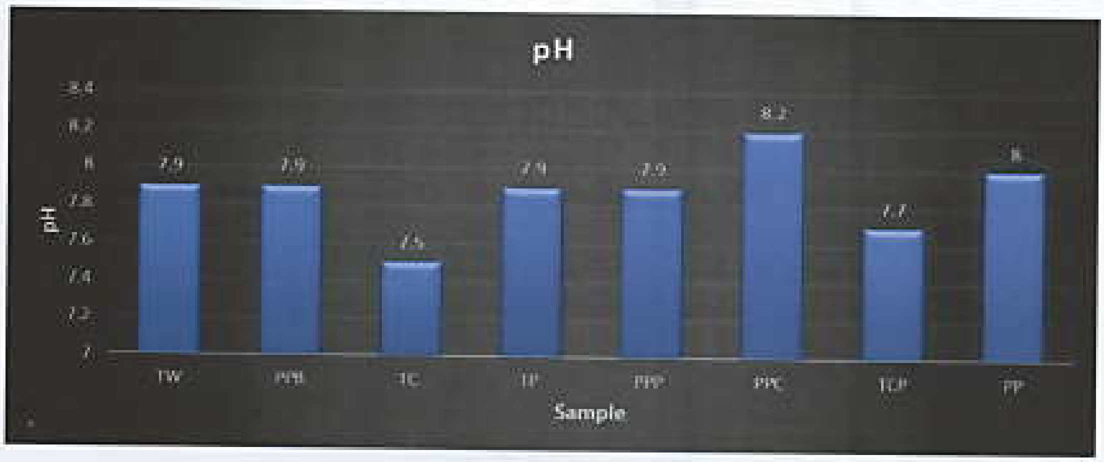
The concentration of Total Suspended Solids ranges from mg/L 24 mg/L to 240 mg/L. The maximum and minimum concentration of TSS was found in TP and TC respectively, as shown in Table No. 1.0 & Graph No. 5.0.

Dissolved oxygen is an important parameter of water quality, which is an index of physical and biological processes taking place in water. Dissolved oxygen in water maintains the higher form of life and keeps the proper balance of various populations, thus making the water body healthy. The result indicate that dissolved oxygen is maximum in TW (Tap water) 6.22 mg/L and minimum in TC (Tap water+ Clay) 4.51 mg/L as shown in Table No. 1.0 & Graph No. 6.0.

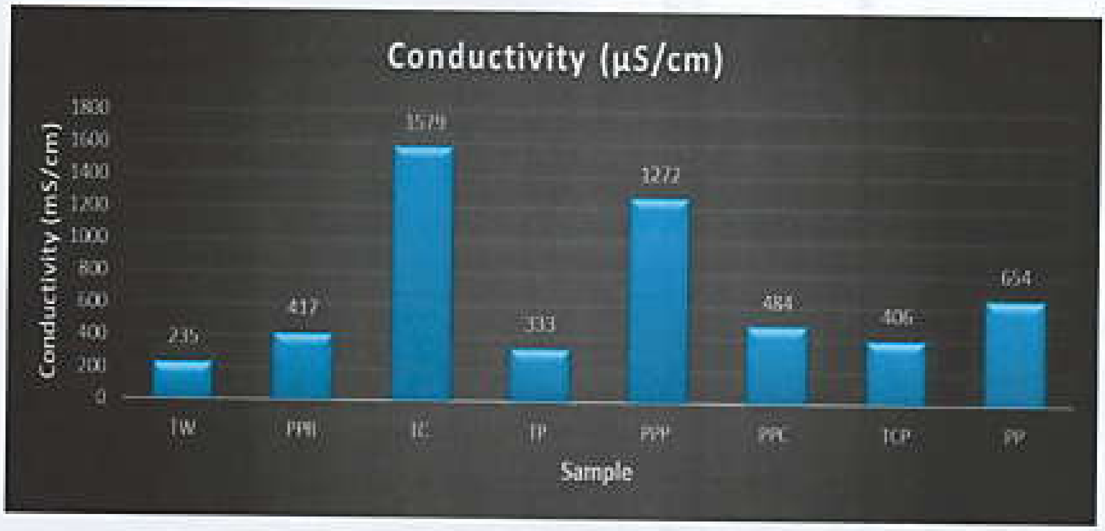
Salinity content of phase- I water samples lies in the range of 0.1 - 0.8. All the physical parameters viz. pH, Conductivity, TDS and Salinity results of the surface water samples are obtained at the temperature range of 27.2°C - 31°C as elucidated in the table below:

Table 1.0: Phase-I Idol Immersion Results-Physical parameters

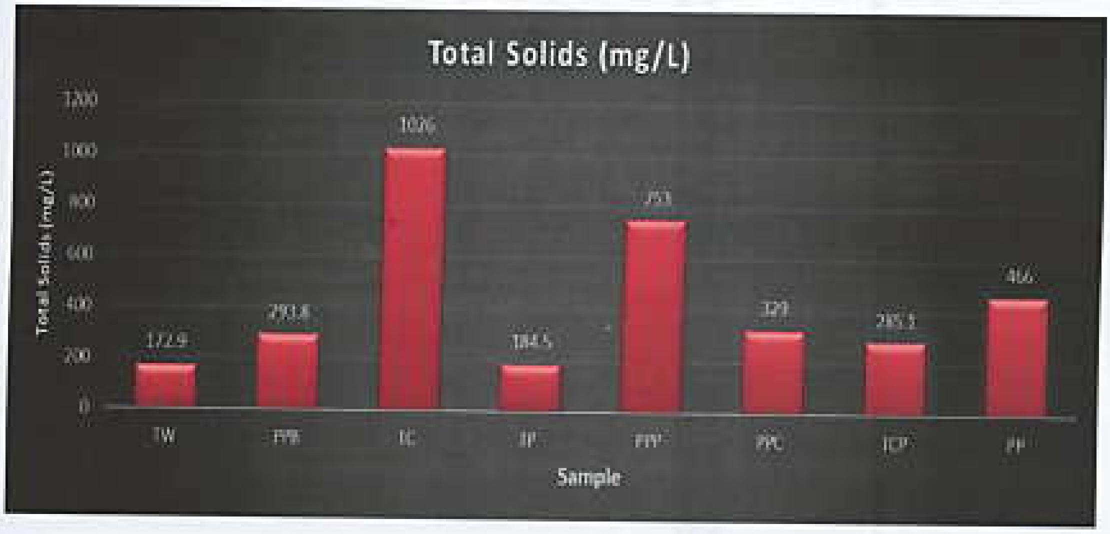
Sample	pH	Conductivity (µS/cm)	TS (mg/L)	TDS (mg/L)	SS (mg/L)	DO (mg/L)	Salinity	Temp (°C)
TW	7.9	235	172.9	112.6	60.3	6.22	0.1	31.0
PPB	7.9	417	293.8	201.0	92.8	5.98	0.2	30.7
TC	7.5	1579	1026	786.0	240	4.51	0.8	27.2
TP	7.9	333	184.5	160.5	24	4.83	0.2	27.2
PPP	7.9	1272	753	629.0	124	5.41	0.6	27.7
PPC	8.2	484	329	234.0	95	5.69	0.2	28.0
TCP	7.7	406	285.1	196.1	89	5.63	0.2	27.8
PP	8.0	654	466	318.0	148	5.75	0.3	28.2



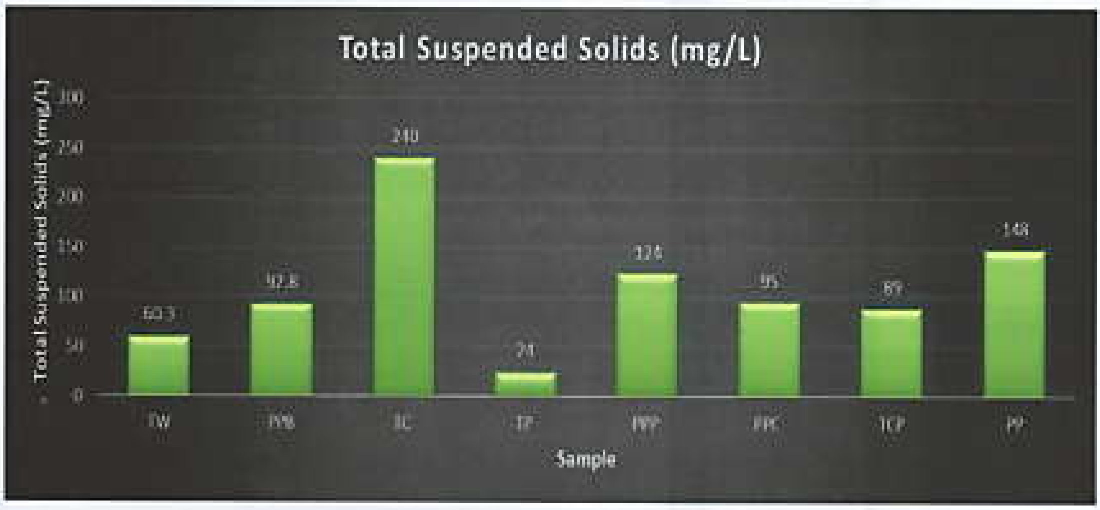
Graph 1.0: Phase-I Idol Immersion physical parameters: pH



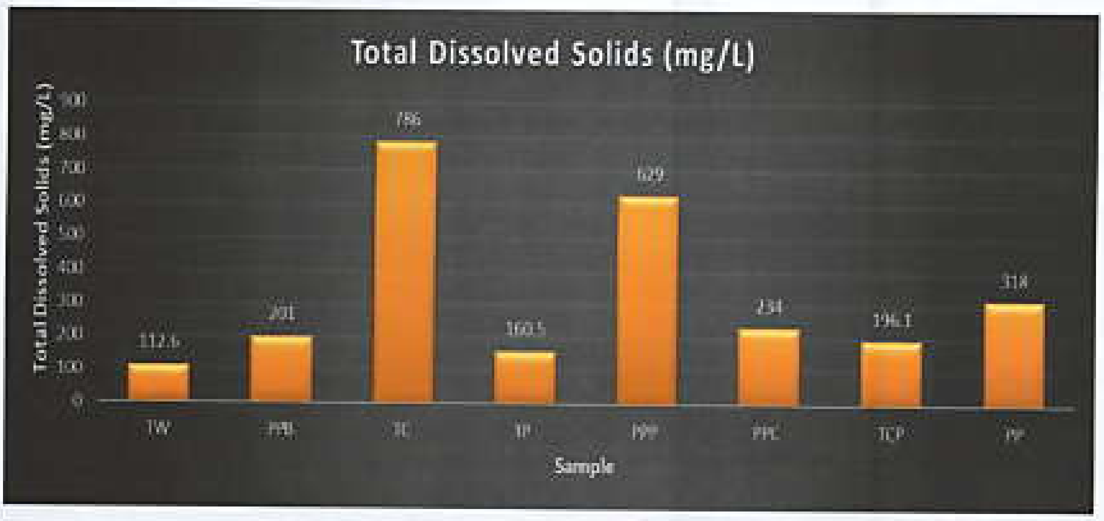
Graph 2.0: Phase-I Idol Immersion physical parameters: Conductivity



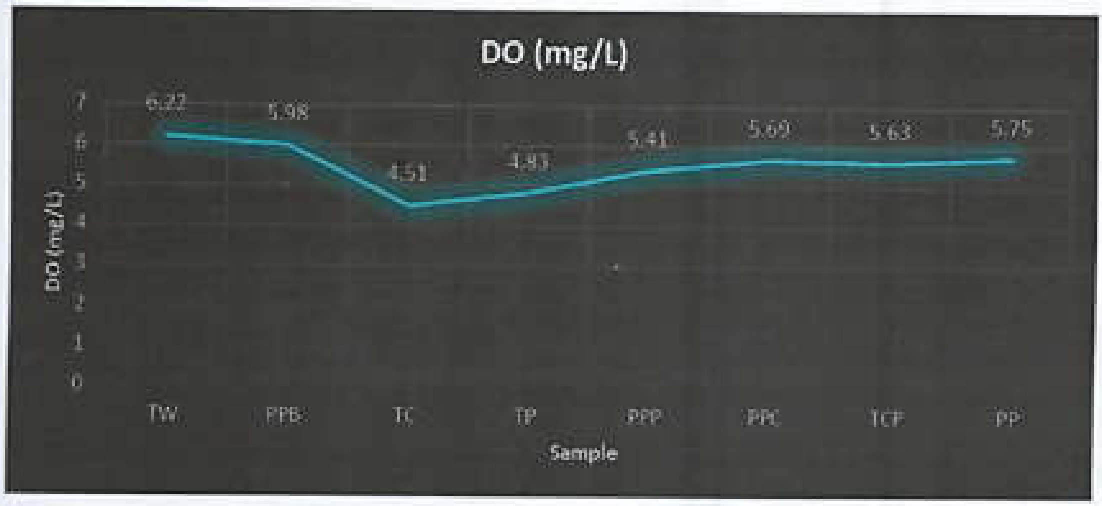
Graph 3.0: Phase-I Idol Immersion physical parameters: Total Solids



Graph 4.0: Phase-I Idol Immersion physical parameters: Total Suspended Solids



Graph 5.0: Phase-I Idol Immersion physical parameters: Total Dissolved Solids



Graph 6.0: Phase-I Idol Immersion physical parameters: Dissolved Oxygen

9.1.2 Phase-I Inorganic parameters

Inorganic parameters covered under pre-immersion analysis are discussed in the Table No.2. As pH of the surface water lies in the range of 6.5-7.8 which is nearly alkaline hence total acidity was not applicable in this case. Total alkalinity is a measurement of all alkaline substances dissolved in the water. These substances are primarily hydroxides, carbonates and bicarbonates, along with a few others. These alkaline substances buffer pH in the water. According to IS 10500:2012 of drinking water acceptable limit is 200mg/L and permissible limit is 600mg/L. Total alkalinity found in the sample lies in the range of 10 – 50 mg/L which is absolutely under acceptable limit as explained in Graph No.7.

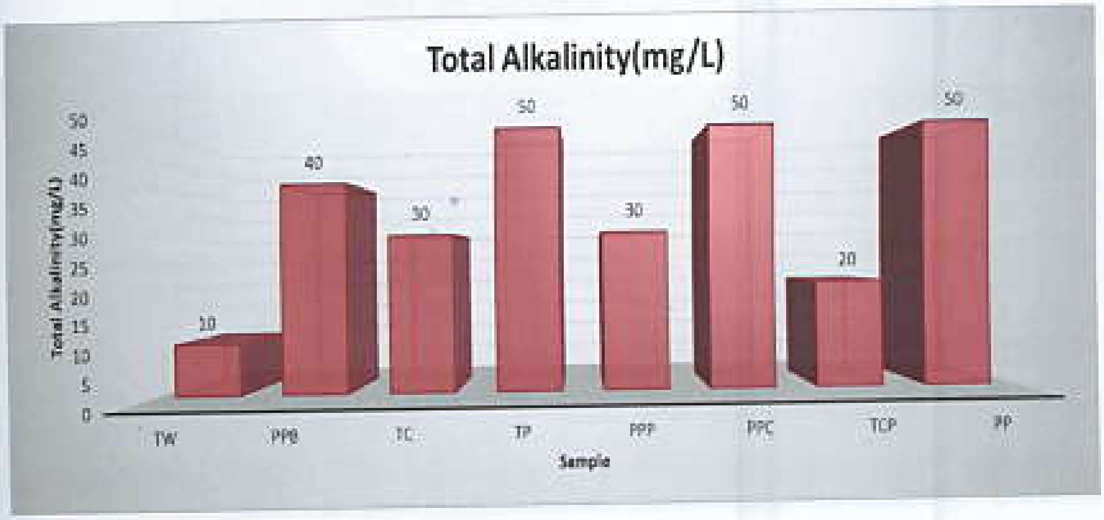
Total Hardness is defined as the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate, in mg/L. According to IS 10500:2012 of drinking water, acceptable limit is 200 mg/L and permissible limit is 600 mg/L of Total hardness in terms of calcium carbonates. The total hardness found in pre-immersion analysis was in the range of 117.7-1027 mg/L which is under acceptable limit except TC (Tap water + Clay) & PPP (PoP + Prempuraghat) which was found to be 1027 mg/L & 738.3 mg/L respectively as given in Table No.2 & Graph No.8. Calcium and Magnesium hardness acceptable limit according to IS 10500:2012 is 75 & 30 mg/L respectively. Ca & Mg hardness in sample was found to be in the range of 74.9 – 909.5 mg/L & 42.8 – 198.4 mg/L respectively.

Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater treatment and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks. According to IS 10500: 2012 of drinking water, acceptable limit is 45 mg/L and there is no relaxation in permissible limit. In the present study nitrate was found in range of 0.7 – 1.4 mg/L. as shown in Graph no. 9. The increased application of fertilizers, use of detergents and domestic sewage greatly contribute to the heavy loading of phosphorous in the water. The concentration of Phosphate in pre-immersion was found to be in the range of 0.28 – 2.72 mg/L as shown in Table No. 2 & Graph No. 10. Sulphate is widely distributed in nature and may be present in natural waters. The main source of sulphur is the rocks present near the water-bodies and biochemical action of anaerobic bacteria. According to the IS 10500:2012 acceptable limit is 200 mg/L and permissible limit is 400 mg/L of Sulphate in drinking water.

The concentration of Sulphate in pre-immersion analysis was found to be in the range of 8 - 1250 mg/Las shown in Graph No.11. Tap water has minimum sulphate content (9.0mg/L) and TC, PPP has maximum of 1250 mg/L and 1050 mg/L respectively. Ammonical Nitrogen in the given samples was in range of 0.15 mg/L to 1.11 mg/L. Main sources of chloride in river waters are sediments, sewage and trade and industrial effluents, if present. The IS 10500 (Indian Standard) suggested the standard of chloride is 250 mg/l. The concentration of Chloride in surface water samples in pre-monsoon was found to be in the range of 23.9 – 86.1 mg/L as shown in Table No. 2 & Graph No.13.

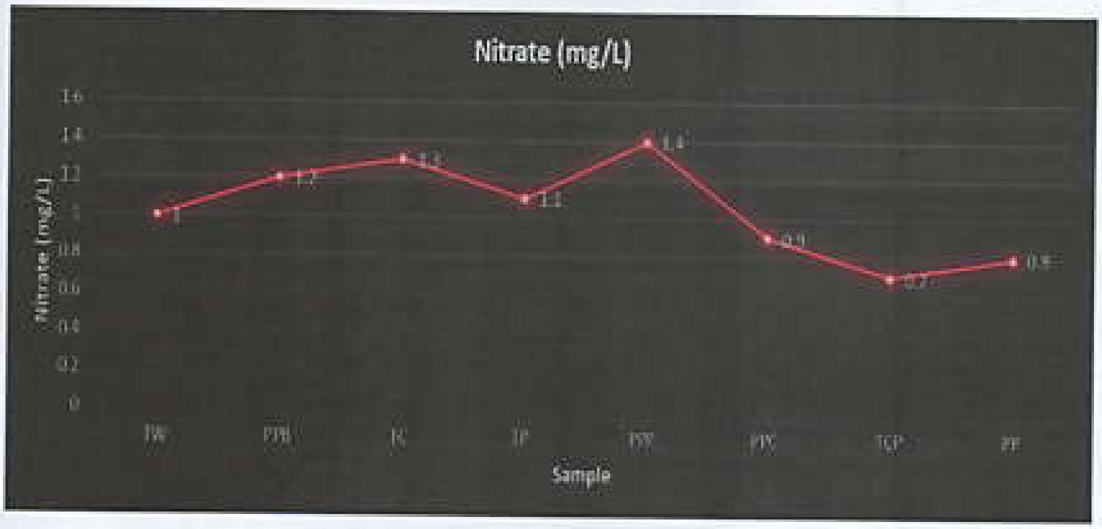
Table 2.0: Phase-I Idol Immersion Results – Inorganic parameters

Sample	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)			NO_3^- (mg/L)	PO_4^{2-} (mg/L)	SO_4^{2-} (mg/L)	Amm. N_2 (mg/L)	Cl^- (mg/L)
		Total	Ca	Mg					
TW	10	117.7	74.9	42.8	1.0	0.28	09	0.26	86.1
PPB	40	181.9	117.7	64.2	1.2	1.65	18	0.21	86.1
TC	30	1027.0	909.5	117.5	1.3	1.64	1250	1.11	28.7
TP	50	181.0	74.9	106.1	1.1	0.35	54	0.16	23.9
PPP	30	738.3	576.1	162.2	1.4	2.72	1050	0.24	52.6
PPC	50	192.6	107.0	85.6	0.9	1.64	31	0.18	43.0
TCP	20	192.6	96.3	96.3	0.7	0.25	102	0.15	28.7
PP	50	316.1	117.7	198.4	0.8	1.88	62	0.21	47.9

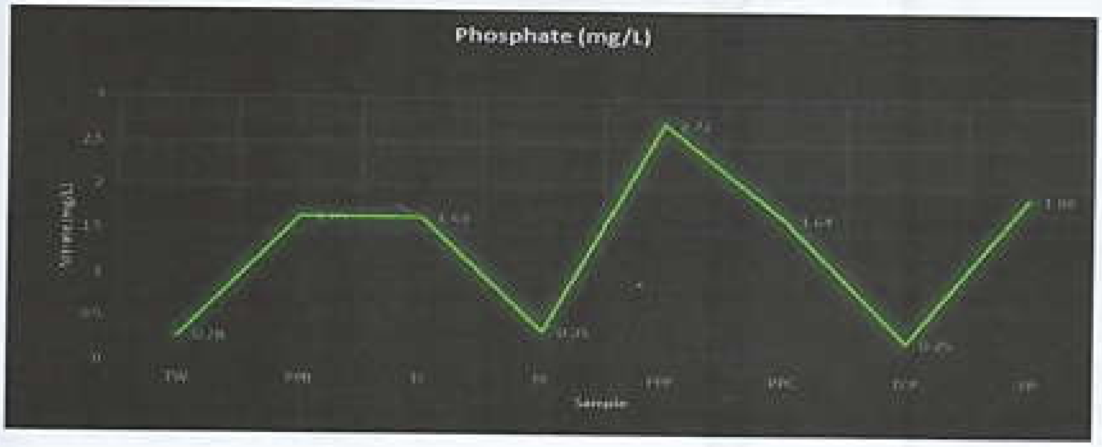


Graph 7.0: Phase-I Idol Immersion inorganic parameters: Total Alkalinity

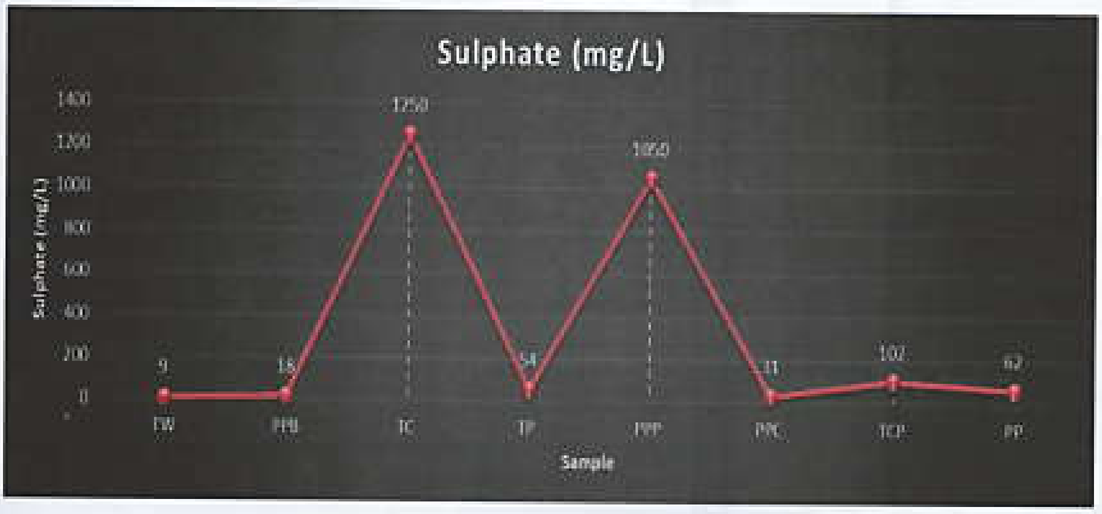
Graph 8.0: Phase-I Idol Immersion inorganic parameters: Total Hardness



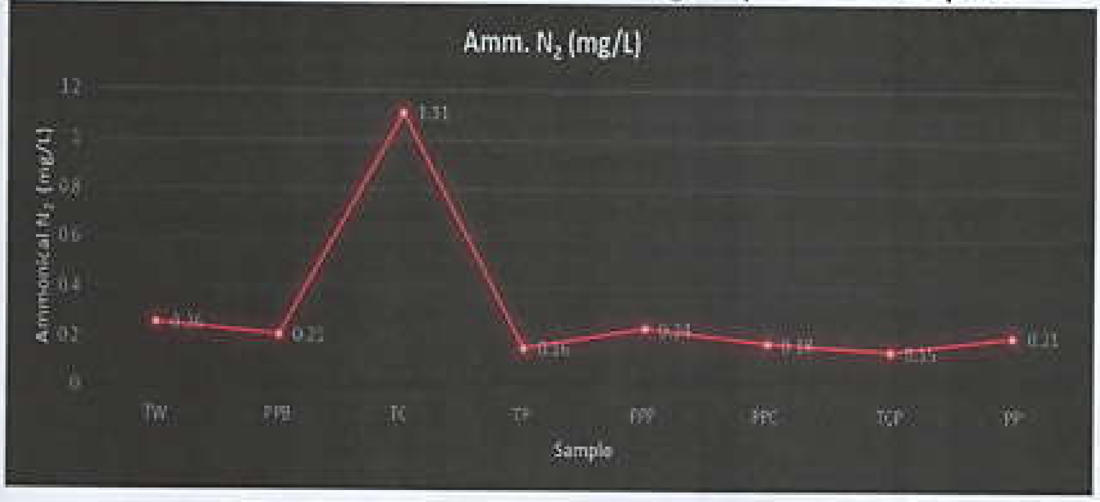
Graph 9.0: Phase-I Idol Immersion inorganic parameters: Nitrate



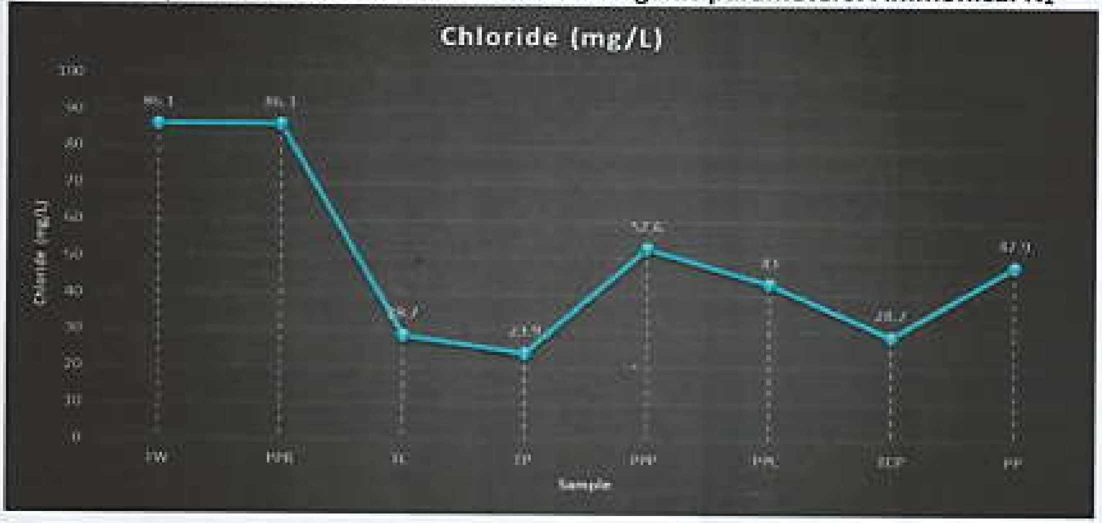
Graph 10.0: Phase-I Idol Immersion inorganic parameters: Phosphate



Graph 11.0: Phase-I Idol Immersion inorganic parameters: Sulphate



Graph 12.0: Phase-I Idol Immersion inorganic parameters: Ammonical N_2



Graph 13.0: Phase-I Idol Immersion inorganic parameters: Chloride

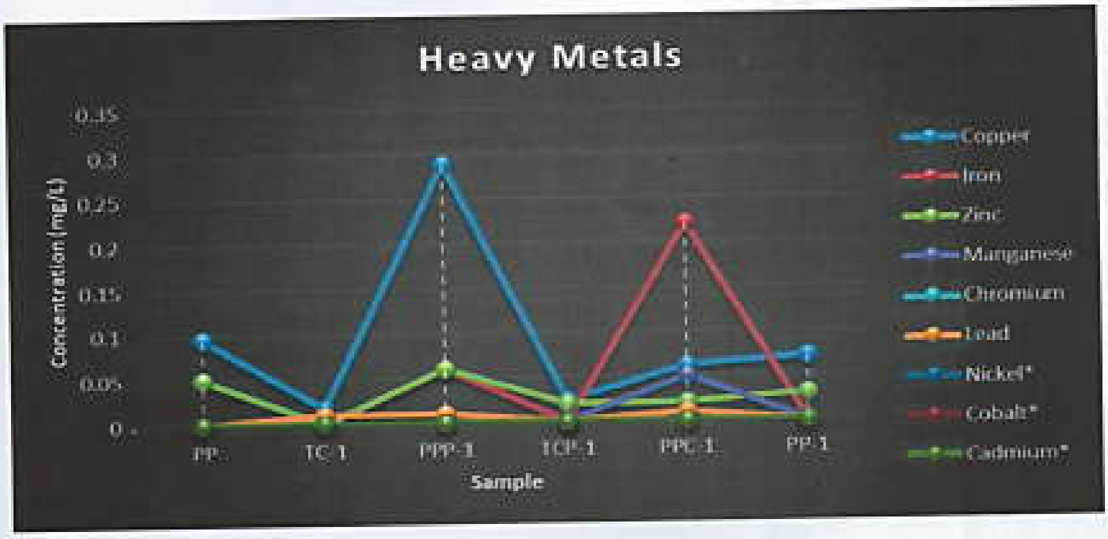
9.1.3 Phase-I Heavy Metal Analysis

Heavy Metal analysis was carried out at Madhya Pradesh Pollution Control Board (MPPCB), Bhopal using Atomic Absorption Spectrophotometer. Metals which were preferred for analysis were Nickel, Manganese, Zinc, Iron, Lead, Cadmium, Chromium, Copper and Cobalt. Analysis results were mainly calculated in ppm (parts per million) level. According to IS 10500:2012 of drinking water acceptable limit of Nickel, Manganese & Iron are 0.02, 0.1 & 0.3 ppm respectively. Pre-immersion analysis of the samples shows the presence of Nickel was not detectable, Manganese was found in traces in TP and PPC. 0.04 ppm of Iron was found in TP whereas 0.06 ppm and 0.22 ppm of iron was detected in PPP and PPC respectively. Copper was found in considerable amount in all samples as shown in Table No. 3 & Graph No. 14. Presence of lead was noticed in the samples as 0.07 ppm in PP, 0.12 ppm in TC, 0.04 ppm in TP, 0.12 ppm in PPP and 0.1 ppm in PP. Excess of iron facilitates growth of iron bacteria which causes blocking of pipes, meters etc. Acute exposure of Nickel in the human body is associated with a variety of chemical symptoms and signs such as nausea, vomiting, headache, giddiness etc. PPP water samples shows typically higher concentration of Cu, Fe, Pb, Mn, Fe & Zn than other sample locations as shown in table below.

Table 3.0: Phase-I Idol Immersion Results – Heavy Metal analysis

No.	Analyte Tested	Unit	Method No.	PP	TC-1	TP-1	PPP-1	TCP-1	PPC-1	PP-1
1.	Copper	mg/l	APHA, 22nd Edition, 2012	0.096	0.017	0.048	0.288	0.024	0.062	0.072
2.	Iron	mg/l		ND	ND	0.04	0.06	ND	0.22	ND
3.	Zinc	mg/l		0.05	ND	0.01	0.06	0.02	0.02	0.03
4.	Manganese	mg/l		ND	ND	0.01	ND	ND	0.05	ND
5.	Chromium	mg/l		ND	0.01	ND	0.01	ND	0.01	ND
6.	Lead	mg/l		0.07	0.12	0.04	0.12	ND	ND	0.10
7.	Nickel*	mg/l		ND	ND	ND	ND	ND	ND	ND
8.	Cobalt*	mg/l		ND	ND	ND	ND	ND	ND	ND
9.	Cadmium*	mg/l		ND	ND	ND	ND	ND	ND	ND

ND - Not Detected*



Graph 14.0: Phase-I Idol Immersion Heavy Metal Analysis

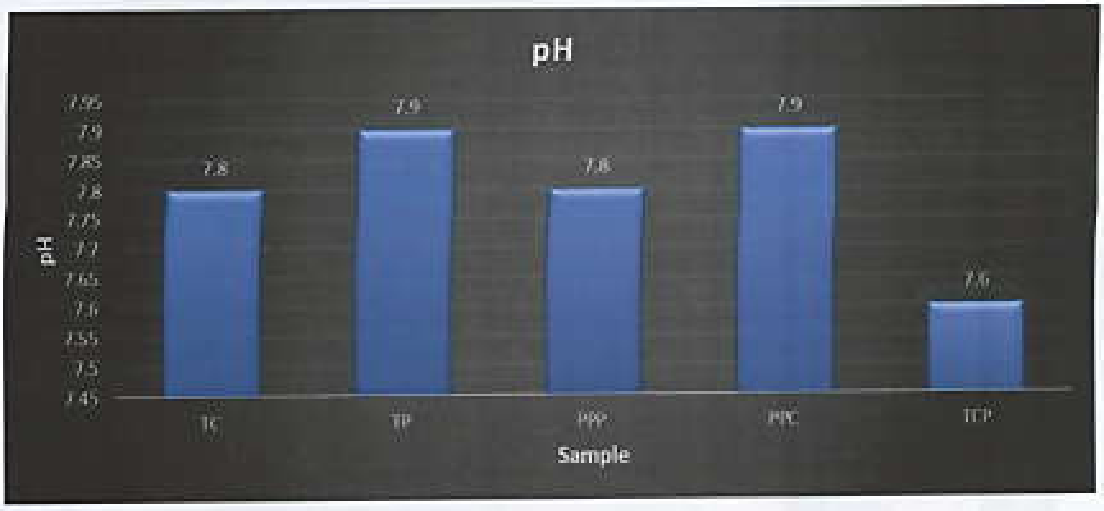
9.1.4 Phase-II Physical Parameters

pH range of 6.5 to 8.5 is normally accepted as per guideline suggested by IS 10500:2012. In this study pH values were found in the range of 7.6 to 7.9 in the phase-II of pre-immersion analysis as given in Table No.4 & Graph No.15. This shows that pH was observed to be slightly alkaline. Electrical conductivity- Higher the concentration of acid, baseband salts in water, a higher will be the EC. In this study the value of EC was found in the range of 231-564 µS/cm. Table No. 4.0 & Graph No.16.0.

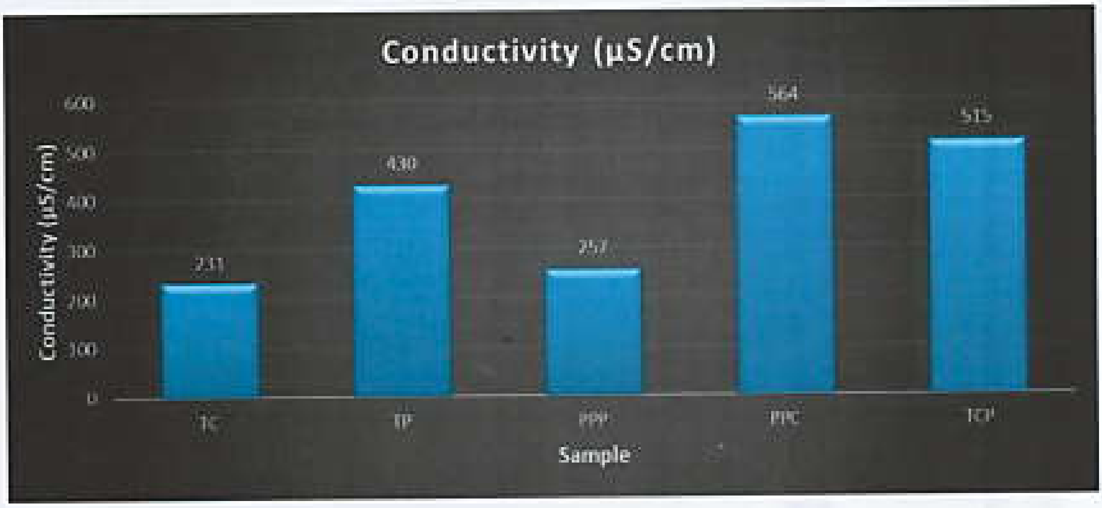
Total Solids were found in range of 266 mg/L to 1810 mg/L. Maximum Total Solids were found in PPP samples. Total dissolved solids are an important parameter in drinking water quality standard. It develops particular taste to the water and at higher concentration reduces its potability. Water with more than 500mg/l TDS usually has a disagreeably strong taste. High TDS levels generally indicate hard water, which can cause scale build up in pipes, valves and filters. Value ranges from 208 - 1304 mg/L as described in Graph No.18.0. Suspended Solids were found in range of 58-582 mg/L. Salinity of samples in phase-II analysis was found in the range of 0.2 – 1.3 at temperature in the range of 29.7°C – 29.8 °C. Dissolved Oxygen was found in the range of 4.76-5.93 mg/L as depicted in Graph 20.0.

Table 4.0: Phase-II Idol Immersion Results -Physical parameters

mple	pH	Conductivity (µS/cm)	TS (mg/L)	TDS (mg/L)	SS (mg/L)	Salinity	DO (mg/L)	Temp (°C)
	7.8	231	1750	1168	582	1.2	5.93	29.7
	7.9	430	266	208	58	0.2	5.74	29.8
P	7.8	257	1810	1304	506	1.3	5.48	29.8
C	7.9	564	358	273	85	0.3	5.12	29.8
P	7.6	515	313	249	64	0.2	4.76	29.8

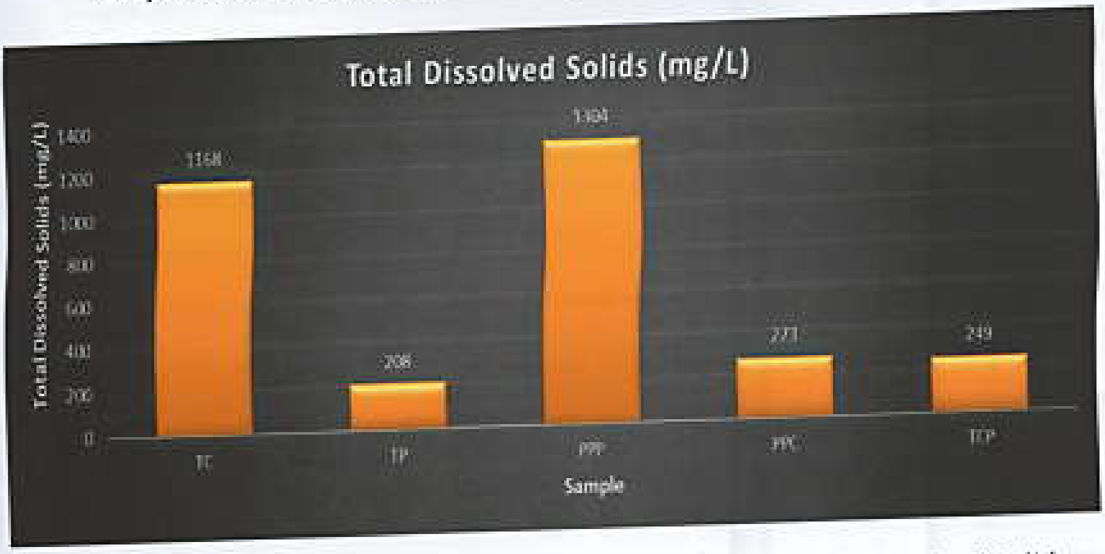


Graph 15.0: Phase-II Idol Immersion physical parameters: pH

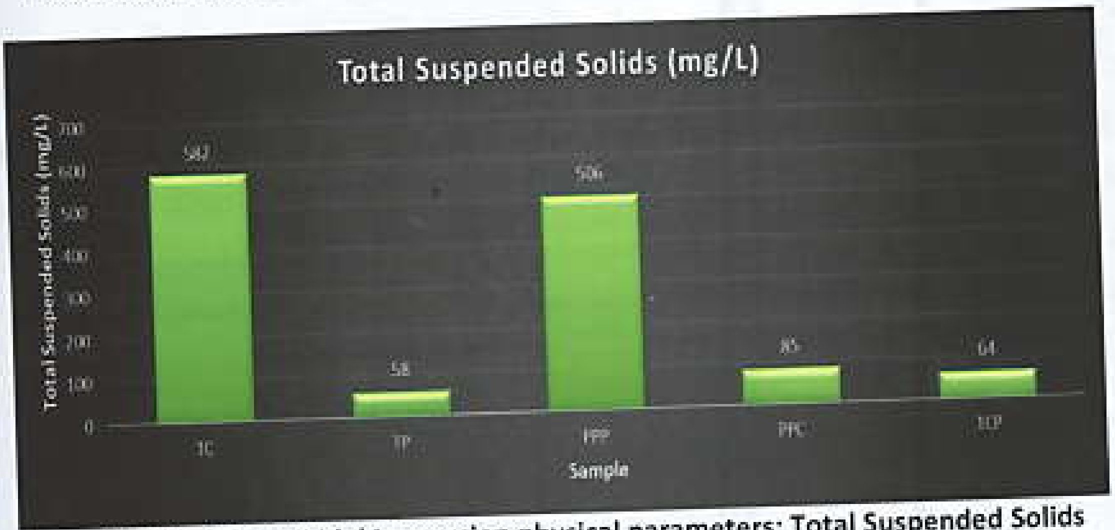


Graph 16.0: Phase-II Idol Immersion physical parameters: Conductivity

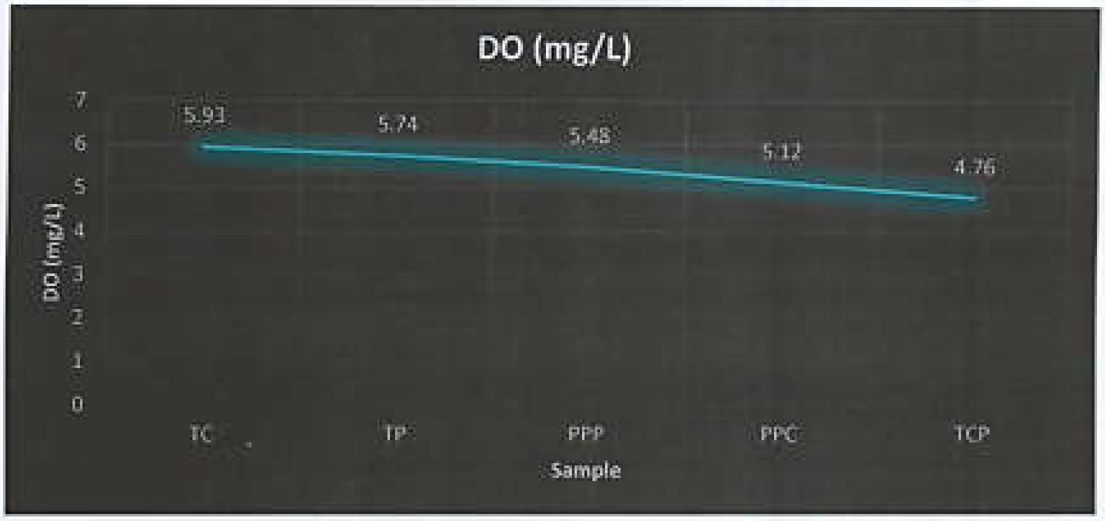
Graph 17.0: Phase-II Idol Immersion physical parameters: Total Solids



Graph 18.0: Phase-II Idol Immersion physical parameters: Total Dissolved Solids



Graph 19.0: Phase-II Idol Immersion physical parameters: Total Suspended Solids



Graph 20.0: Phase-II Idol Immersion physical parameters: Dissolved Oxygen

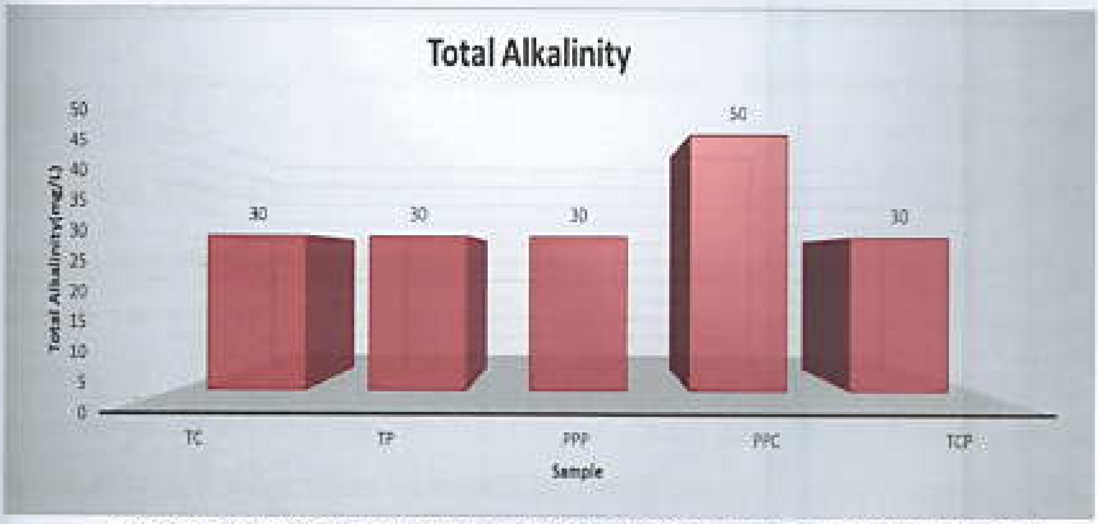
9.1.5 Phase-II Inorganic parameters

In Phase-II analysis total alkalinity was observed in range of 30 - 50 mg/L as shown in Table No. 5.0 & Graph No. 21.0. The acceptable limit for total alkalinity as per IS 10500 is 200 mg/L whereas the permissible limit for the same is 600 mg/L. therefore it can be concluded that total alkalinity in all samples of phase- II were under permissible limit and safe for use.

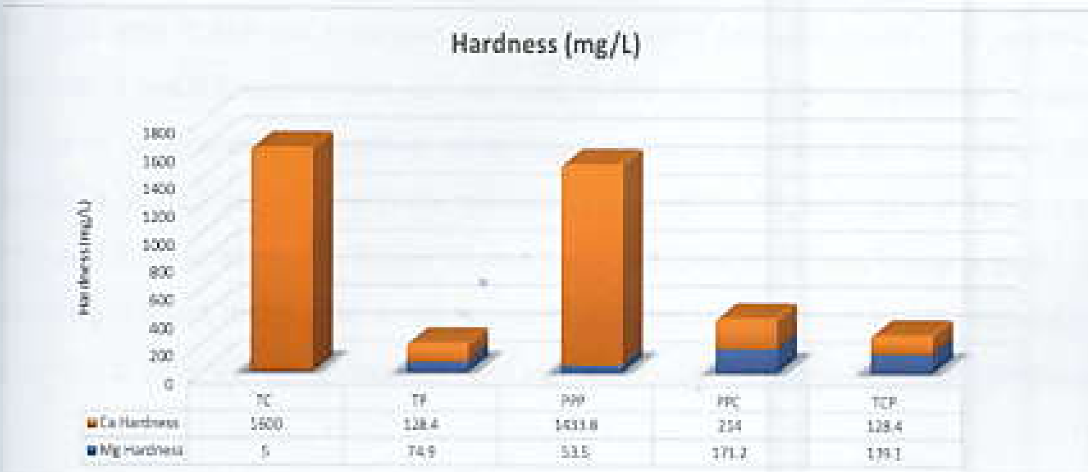
The desirable limit as per IS-10500 Standards for hardness is 200 mg/L whereas the permissible limit for the same is 600 mg/L beyond this limit encrustation in water supply structure and adverse effects on domestic use will be observed. In phase-II, the total hardness varying from 203.3 mg/L to 1605 mg/L as shown in Table No. 5.0 & Graph No. 22.0. Maximum hardness (1605 mg/L) was observed in TC (Tap water + Clay) and minimum (203.3 mg/L) in TP (Tap water+ PoP). Thus, Table No. 5.0 showed that all the values of total hardness were not under permissible limit of IS 10500. The desirable limit for chlorides is 250 mg/L as per IS-10500 Standards whereas, permissible limit of the same is 1000 mg/l beyond this limit taste and corrosion and palatability are affected. The chloride level in the phase-II samples collected in the study area were ranging from 23.9 mg/L to a maximum of 57.4 mg/L as shown in Table No. 5.0& Graph No.23.0. The chloride concentration in all samples was within the desirable limits.

Table 5.0: Phase-II Idol Immersion Results – Inorganic parameters

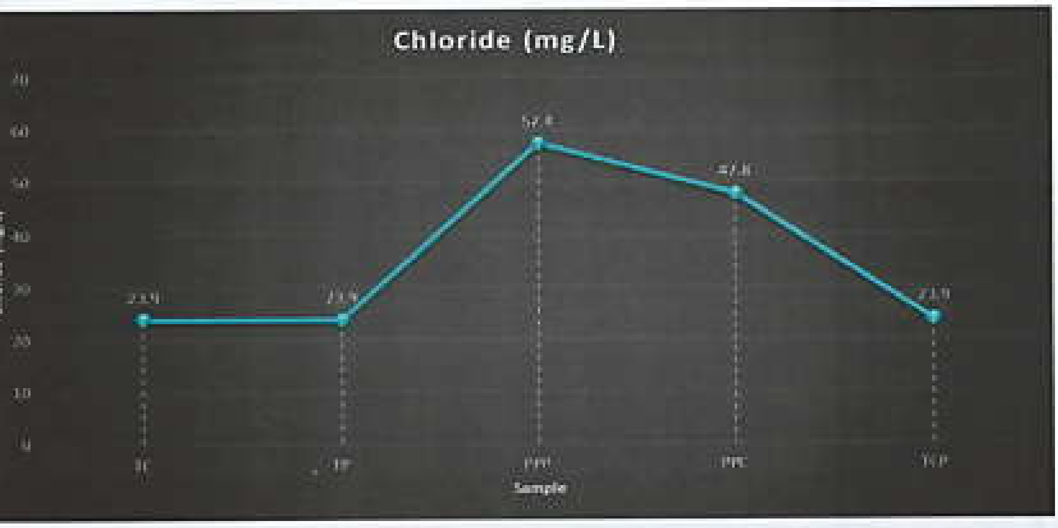
Sample	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)			SO_4^{2-} (mg/L)	NO_3^- (mg/L)	PO_4^{2-} (mg/L)	Cl^- (mg/L)
		Total	Ca	Mg				
TC	30	1605	1600	05	-	-	-	23.9
TP	30	203.3	128.4	74.9	-	-	-	23.9
PPP	30	1487.3	1433.8	53.5	-	-	-	57.4
PPC	50	385.2	214	171.2	-	-	-	47.8
TCP	30	267.5	128.4	139.1	-	-	-	23.9



Graph 21.0: Phase-II Idol Immersion inorganic parameters: Total Alkalinity



Graph 22.0: Phase-II Idol Immersion inorganic parameters: Total Hardness



Graph 23.0: Phase-II Idol Immersion inorganic parameters: Chloride

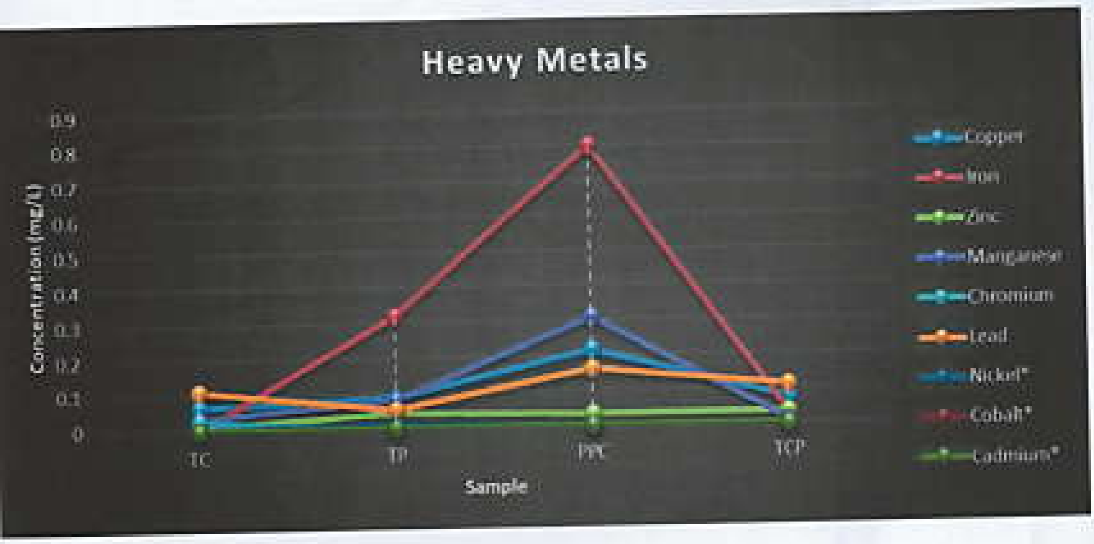
..6 Phase-II Heavy Metal analysis

avy Metal analysis was carried out at Madhya Pradesh Pollution Control Board (MPPCB opal) using Atomic Absorption Spectrophotometer. Metals which were preferred for alysis were Nickel, Manganese, Zinc, Iron, Lead, Cadmium, Chromium, Copper and Cobalt. alysis results were mainly calculated in ppm (parts per million) level. According to IS 500:2012 of drinking water acceptable limit of Nickel, Manganese & Iron are 0.02, 0.1 & 3 ppm respectively. Pre-immersion analysis of the samples shows the presence of Nickel s detected in traces in TP and PPP, Manganese was found in 0.03 ppm in TC, 0.08 ppm in , 0.02 ppm in PPP and 0.31 ppm in PPC. 0.32 ppm of Iron was found in TP whereas 0.02 m, 0.03 and 0.8 ppm of iron was detected in PPP, TCP and PPC respectively. Copper was und in considerable amount in all samples as shown in Table No. 6 & Graph No. 24. esence of lead was noticed in the samples as 0.11 ppm in TC, 0.05 ppm in TP, 0.16 ppm in C and 0.11 ppm in TCP. Excess of iron facilitates growth of iron bacteria which causes ocking of pipes, meters etc. Acute exposure of Nickel in the human body is associated with variety of chemical symptoms and signs such as nausea, vomiting, headache, giddiness etc.

Table 6.0: Phase-II Idol Immersion Results – Heavy Metal analysis

...o.	Analyte Tested	Unit	Method No.	TC	TP	PPP	PPC	TCP
1.	Copper	mg/l	APHA, 22nd Edition, 2012	0.064	0.085	0.038	0.216	0.073
2.	Iron	mg/l		ND	0.32	0.02	0.80	0.03
3.	Zinc	mg/l		0.01	0.04	0.01	0.03	0.03
4.	Manganese	mg/l		0.03	0.08	0.02	0.31	0.01
5.	Chromium	mg/l		0.02	ND	0.02	ND	ND
6.	Lead	mg/l		0.11	0.05	ND	0.16	0.11
7.	Nickel	mg/l		ND	0.01	0.01	ND	ND
8.	Cobalt*	mg/l		ND	ND	ND	ND	ND
9.	Cadmium*	mg/l		ND	ND	ND	ND	ND

...D - Not Detected*



Graph 24.0: Phase-II Idol Immersion Heavy Metal Analysis

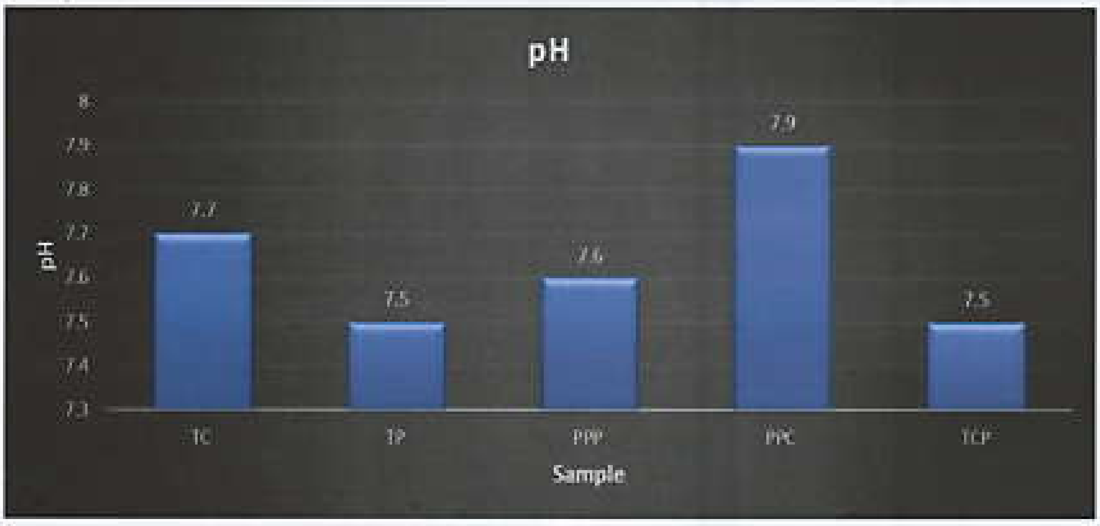
9.2 During Idol Immersion Analysis: Phase-III & Phase-IV

9.2.1 Phase-III Physical Parameters

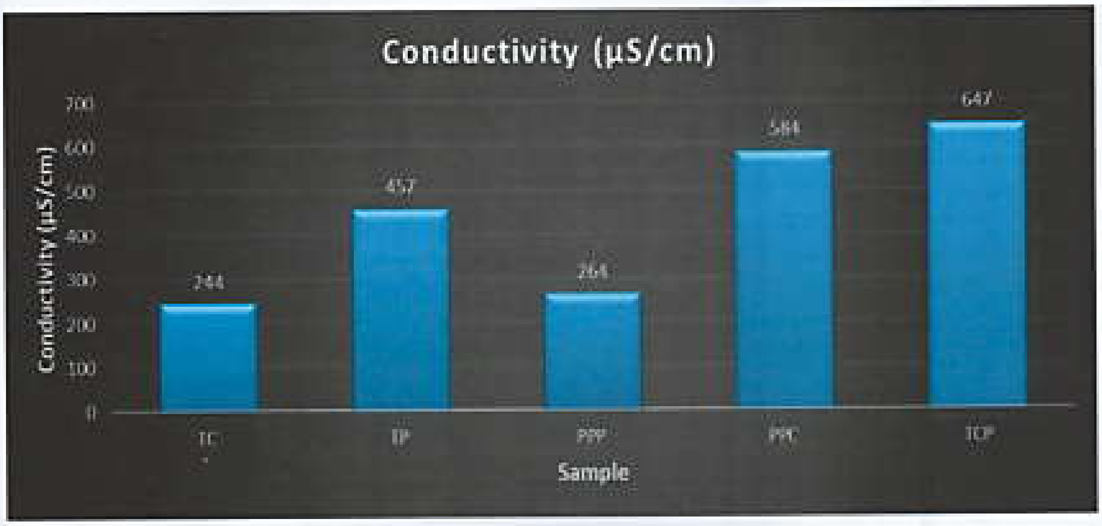
The pH of water is important because it governs solubility of nutrients. In phase-III pH was found in range of 7.5-7.9 and conductivity was found between 244-647 µS/cm. Total Solids were found in range of 331 mg/L to 1521 mg/L. Maximum Total Solids (1521 mg/L) were found in PPP samples. Total dissolved solids are an important parameter in drinking water quality standard. It develops particular taste to the water and at higher concentration reduces its potability. Water with more than 500mg/l TDS usually has a disagreeably strong taste. High TDS levels generally indicate hard water, which can cause scale build up in pipes, valves and filters. Value ranges from 221 - 1343 mg/L as described in Graph No.28.0. Suspended Solids were found in range of 77-230 mg/L. Salinity of samples in phase-II analysis was found in the range of 0.2 – 1.4 at temperature in the range of 29.3°C – 29.7 °C. Dissolved Oxygen was found in the range of 5.28-5.97 mg/L as depicted in Graph 30.0.

Table 7.0: Phase-III Idol Immersion Results -Physical parameters

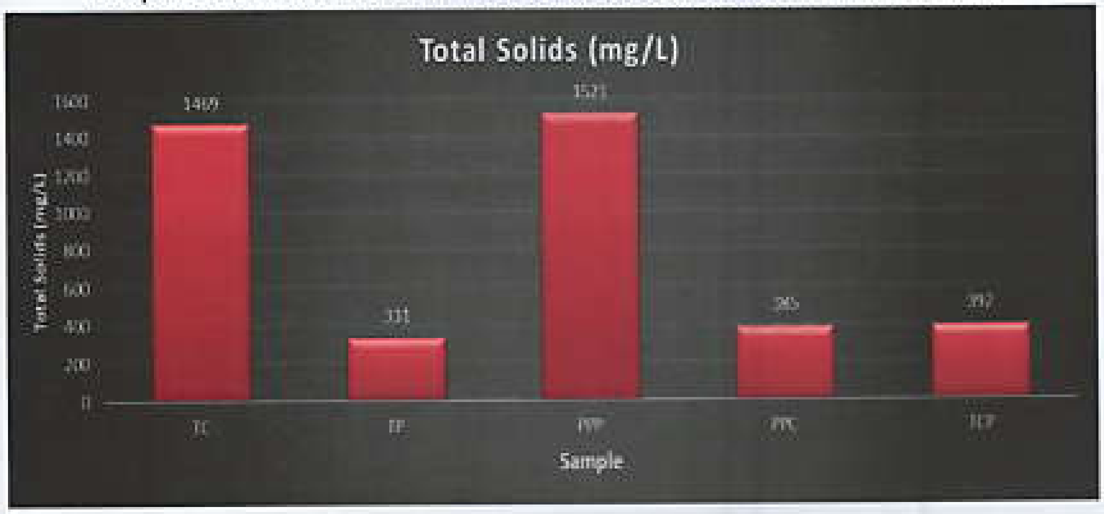
Sample	pH	Conductivity (µS/cm)	TS (mg/L)	TDS (mg/L)	SS (mg/L)	DO (mg/L)	Salinity	Temp (°C)
TC	7.7	244	1469	1239	230	5.63	1.3	29.3
TP	7.5	457	331	221	110	5.44	0.2	29.6
PPP	7.6	264	1521	1343	178	5.28	1.4	29.4
PPC	7.9	584	385	284	101	5.97	0.3	29.6
TCP	7.5	647	392	315	77	5.50	0.3	29.7 °C



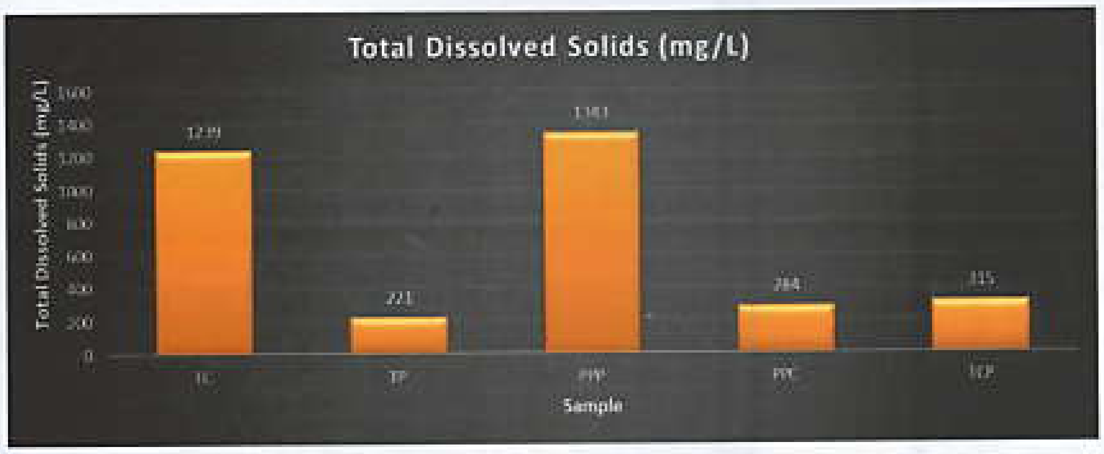
Graph 25.0: Phase-III Idol Immersion physical parameters: pH



Graph 26.0: Phase-III Idol Immersion physical parameters: Conductivity

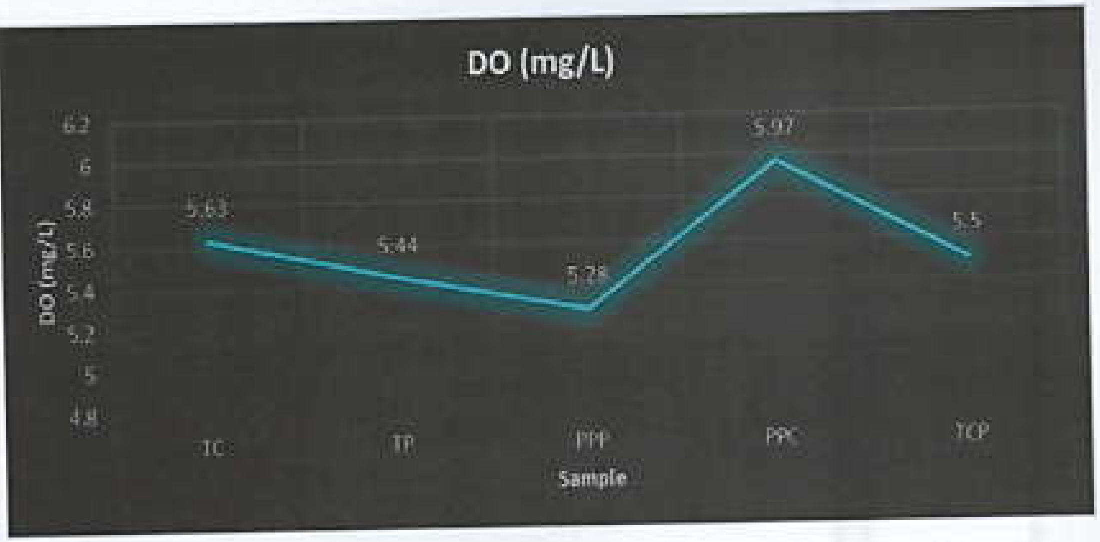


Graph 27.0: Phase-III Idol Immersion physical parameters: Total Solids



Graph 28.0: Phase-III Idol Immersion physical parameters: Total Dissolved Solids

Graph 29.0: Phase-III Idol Immersion physical parameters: Total Suspended Solids



Graph 30.0: Phase-III Idol Immersion physical parameters: Dissolved Oxygen

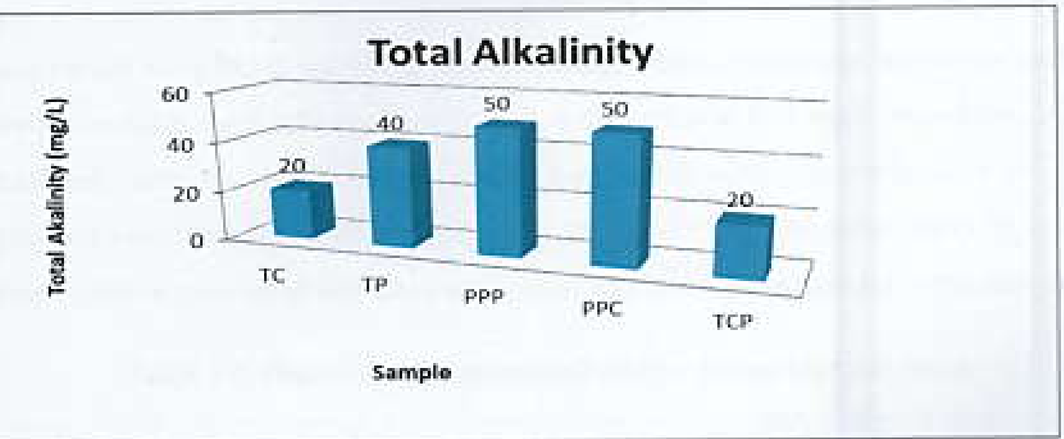
2.2 Phase-III Inorganic parameters

phase-III Total Alkalinity was found in the range of 20-50 mg/L whereas the Total ardness was found in the range of 246.1-1701.3 mg/L. Maximum Hardness i.e. 1701.3 mg/L as found in PPP sample (Prempura ghat + PoP) as given in Table no. 8.0 and graph 32.0 The esirable limit as per IS-10500 Standards for hardness is 200 mg/L whereas the permissible mit for the same is 600 mg/L beyond this limit encrustation in water supply structure and dverse effects on domestic use will be observed. Thus, it can be seen that sample TC and PP were exceeding even the permissible limit of total hardness. The desirable limit for hlorides is 250 mg/L as per IS-10500 Standards whereas, permissible limit of the same is

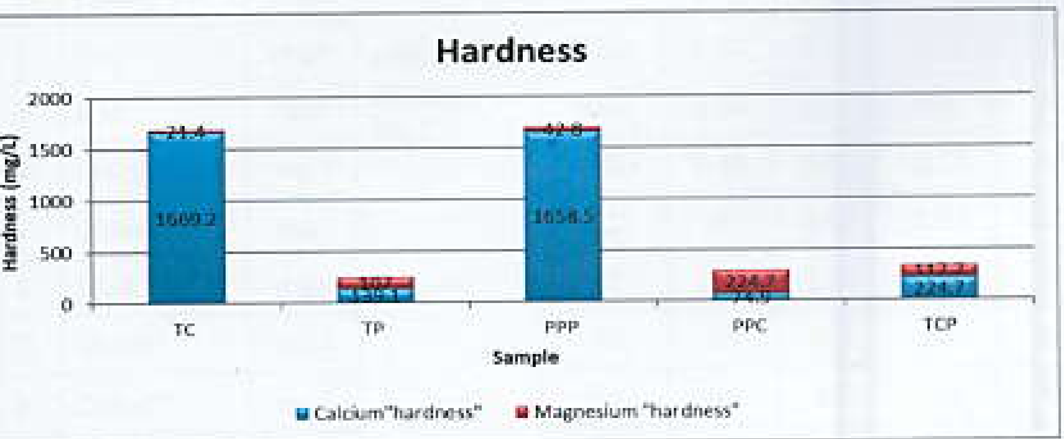
0 mg/l beyond this limit taste, corrosion and palatability are affected. The chloride level he phase-III samples collected in the study area were ranging from 23.9 mg/L to a ximum of 47.8 mg/L as shown in Table No. 8.0& Graph No. 33.0. The chloride centration in all samples was within the desirable limits.

Table 8.0: Phase-III Idol Immersion Results – Inorganic parameters

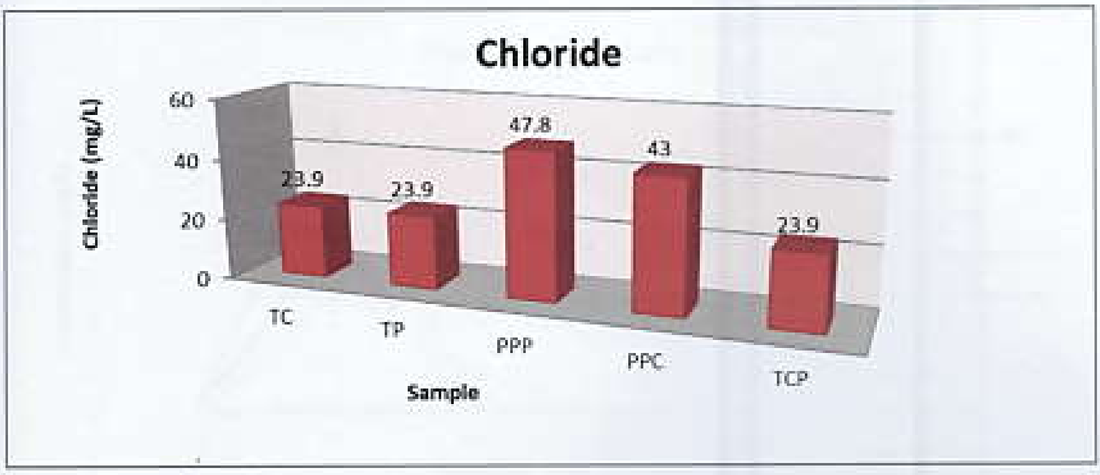
mple	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)			SO_4^{2-} (mg/L)	NO_3^- (mg/L)	PO_4^{2-} (mg/L)	Cl^- (mg/L)
		Total	Ca	Mg				
	20	1690.6	1669.2	21.4	-	-	-	23.9
	40	246.1	139.1	107	-	-	-	23.9
P	50	1701.3	1658.5	42.8	-	-	-	47.8
C	50	299.6	74.9	224.7	-	-	-	43.0
P	20	342.4	224.7	117.7	-	-	-	23.9



Graph 31.0: Phase-III Idol Immersion inorganic parameters: Total Alkalinity



Graph 32.0: Phase-III Idol Immersion inorganic parameters: Total Hardness



Graph 33.0: Phase-III Idol Immersion inorganic parameters: Chloride

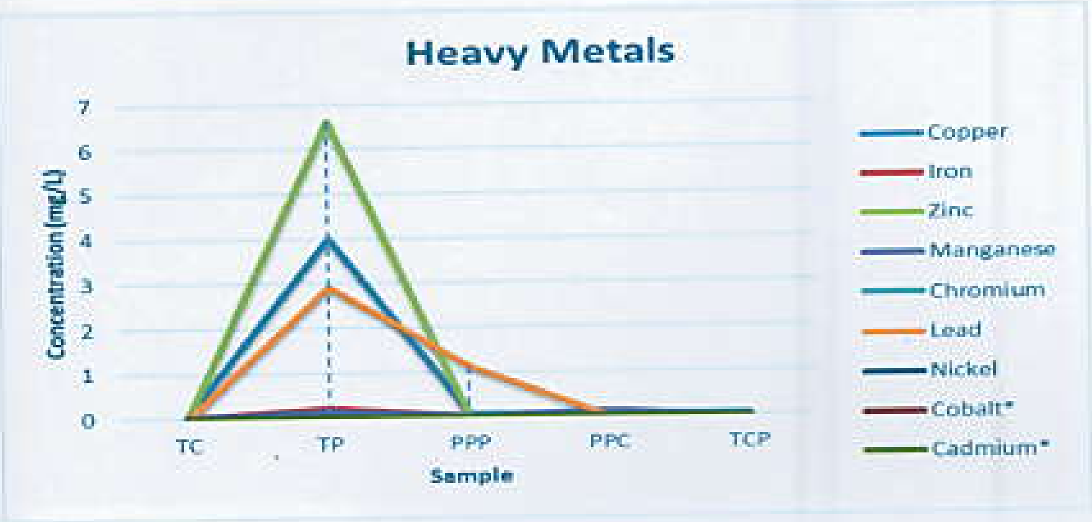
9.2.3 Phase-III Heavy Metal analysis

For determination of heavy metals method APHA, 22nd Edition, 2012 was followed. Heavy metal analysis of sample was carried out at MPPCB Bhopal. During phase-III presence of heavy metals were found maximum in PPP as copper, iron, manganese, chromium and lead were found 0.076 mg/l, 0.03 mg/L, 0.03 mg/L, 0.02 mg/L and 1.14 mg/L respectively. Nickel, cobalt and cadmium were below detection limit. Maximum concentration of zinc (6.63 mg/L) was found in TP. Moreover, 2.91 and 1.14 ppm of lead was detected in TP and PPP indicating these samples of PoP were highly toxic and injurious to health of common public.

Table 9.0: Phase-III Idol Immersion Results – Heavy Metal analysis

No.	Analyte Tested	Unit	Method No.	TC	TP	PPP	PPC	TCP
1.	Copper	mg/l	APHA, 22nd Edition, 2012	0.077	3.994	0.076	0.036	0.034
2.	Iron	mg/l		0.02	0.22	0.03	0.01	ND
3.	Zinc	mg/l		0.01	6.63	ND	ND	ND
4.	Manganese	mg/l		0.02	0.15	0.03	0.11	ND
5.	Chromium	mg/l		0.02	ND	0.02	0.01	0.01
6.	Lead	mg/l		ND	2.91	1.14	ND	ND
7.	Nickel	mg/l		ND	ND	ND	ND	ND
8.	Cobalt*	mg/l		ND	ND	ND	ND	ND
9.	Cadmium*	mg/l		ND	ND	ND	ND	ND

ND - Not Detected*



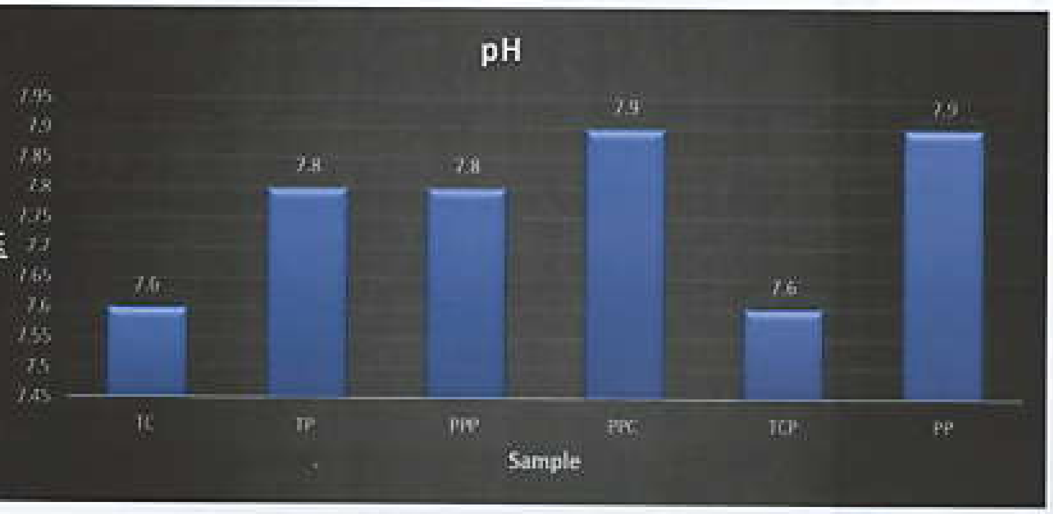
Graph 34.0: Phase-III Idol Immersion Heavy Metal Analysis

9.2.4 Phase-IV Physical parameters

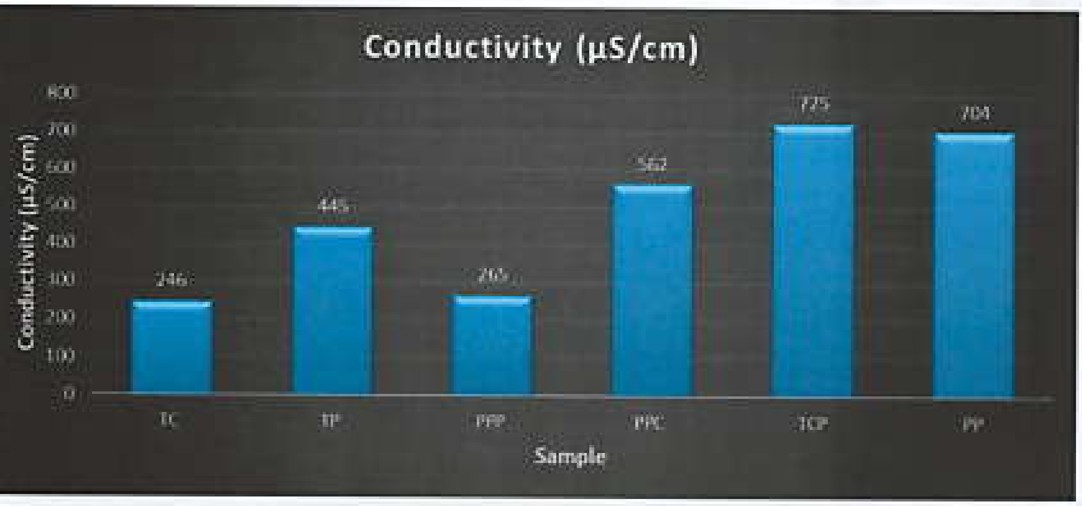
In phase-IV pH was found in the range of 7.6-7.9. So, it can be clearly seen that pH increases during immersion activities. However, pH of the samples was within the acceptable limits of IS-10500(2012). EC measurement is an excellent indicator of TDS, which is a measure of salinity that affects the taste of potable water. The Electrical Conductivity of phase-IV was observed to be in the ranges of 246 – 725 µS/cm and TDS was found to be in the range of 215-1348 mg/L. total Solids was observed in the range of 394-1939 mg/L and suspended solids in the range 179-591 mg/L. Dissolved oxygen was found maximum i.e. 6.36 mg/L in PP (Prempura Ghat) samples. Salinity varied from 0.2 to 1.4.

Table 10.0: Phase-IV Idol Immersion Results -Physical parameters

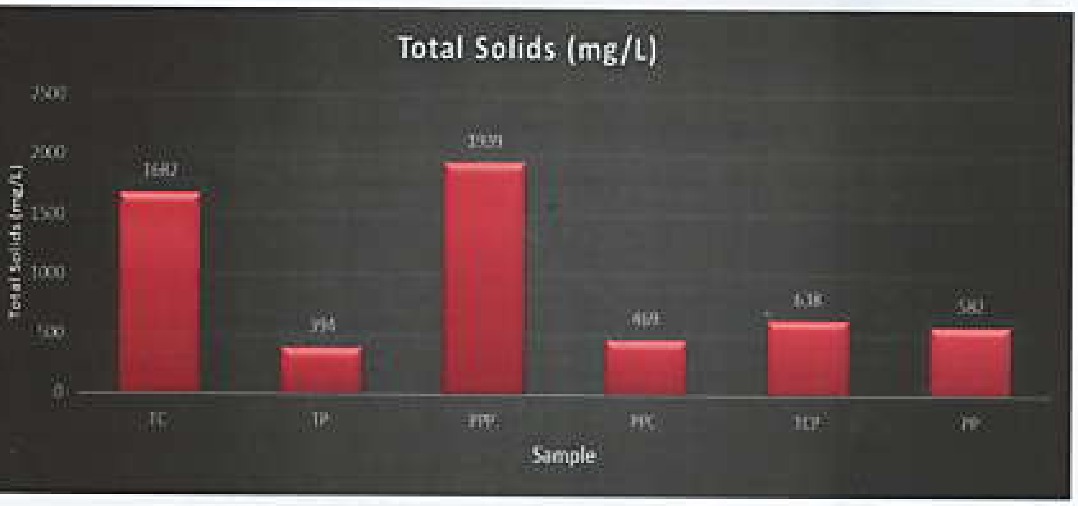
Sample	pH	Conductivity (µS/cm)	TS (mg/L)	TDS (mg/L)	SS (mg/L)	DO (mg/L)	Salinity	Temp. (°C)
TC	7.6	246	1682	1244	438	6.4	1.3	28.2
TP	7.8	445	394	215	179	5.92	0.2	28.2
PPP	7.8	265	1939	1348	591	6.05	1.4	28.3
PPC	7.9	562	469	273	196	6.12	0.3	28.2
TCP	7.6	725	638	353	285	6.3	0.4	28.1
PP	7.9	704	582	343	239	6.36	0.3	28.1



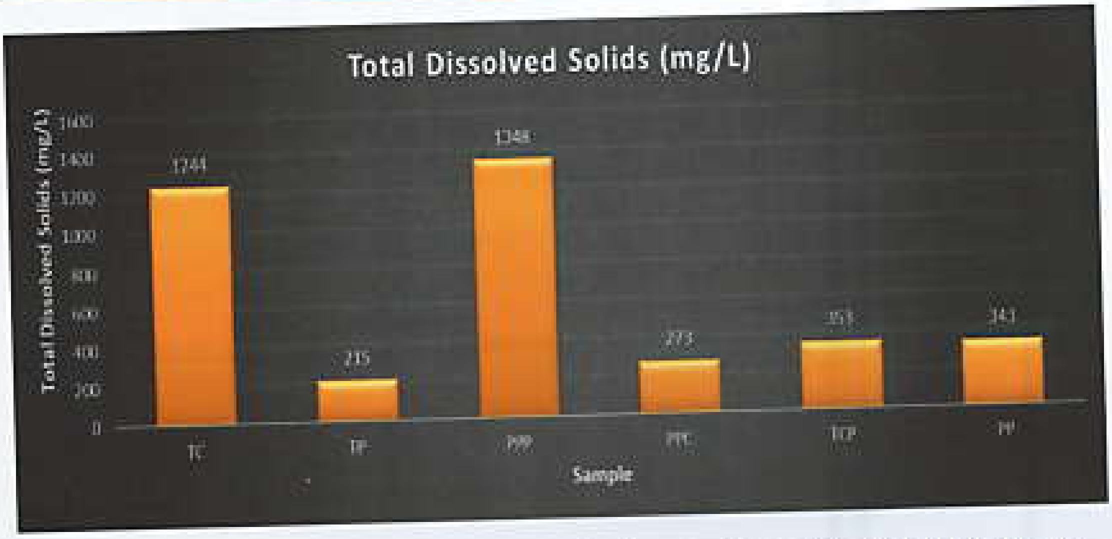
Graph 35.0: Phase-IV Idol Immersion physical parameters: pH



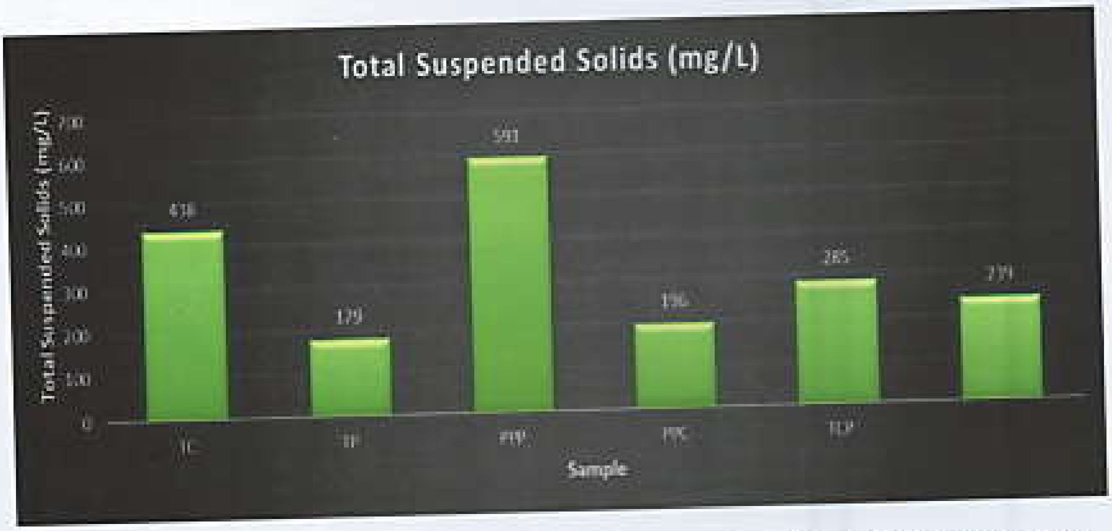
Graph 36.0: Phase-IV Idol Immersion physical parameters: Conductivity



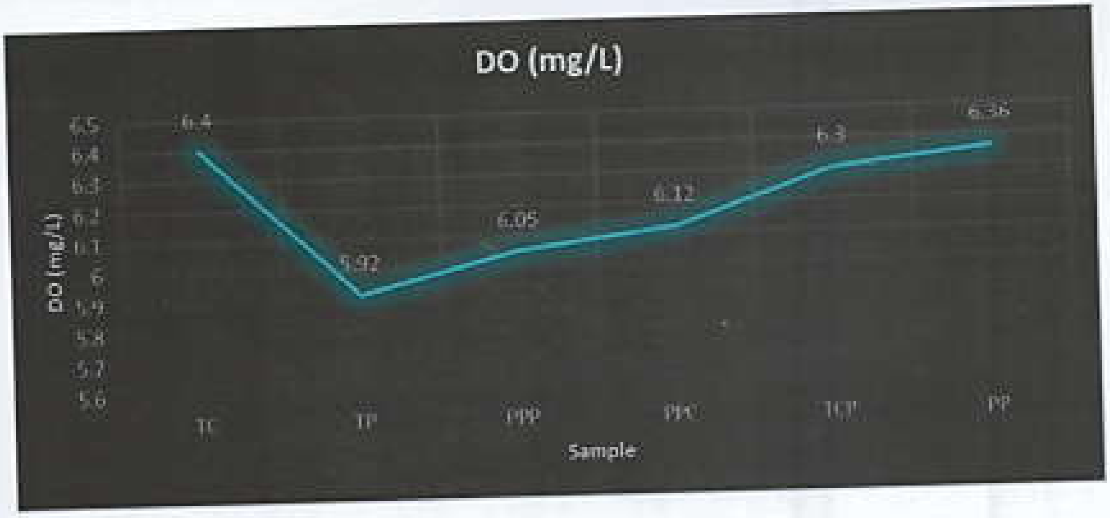
Graph 37.0: Phase-IV Idol Immersion physical parameters: Total Solids



Graph 38.0: Phase-IV Idol Immersion physical parameters: Total Dissolved Solids



Graph 39.0: Phase-IV Idol Immersion physical parameters: Total Suspended Solids



Graph 40.0: Phase-IV Idol Immersion physical parameters: Dissolved Oxygen

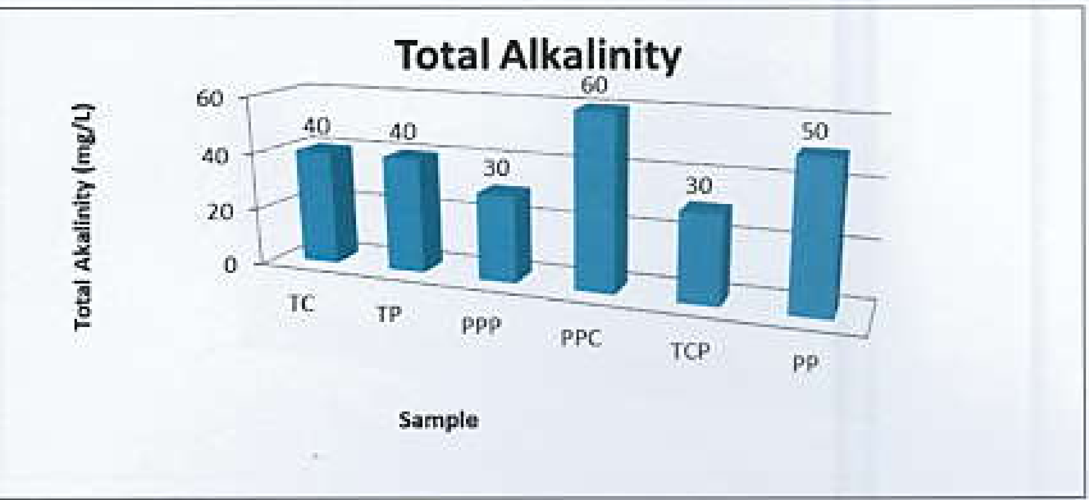
9.2.5 Phase-IV Inorganic Parameters

Total Alkalinity in phase-IV was found in the range of 30-60 mg/L. The acceptable limit for total alkalinity as per IS 10500 is 200 mg/L whereas the permissible limit for the same is 600 mg/L. therefore it can be concluded that total alkalinity in all samples of phase- II were under permissible limit and safe for use. The desirable limit as per IS-10500 Standards for hardness is 200 mg/L whereas the permissible limit for the same is 600 mg/L. In phase-IV total hardness was found in the range of 246.1 -1819 mg/L.

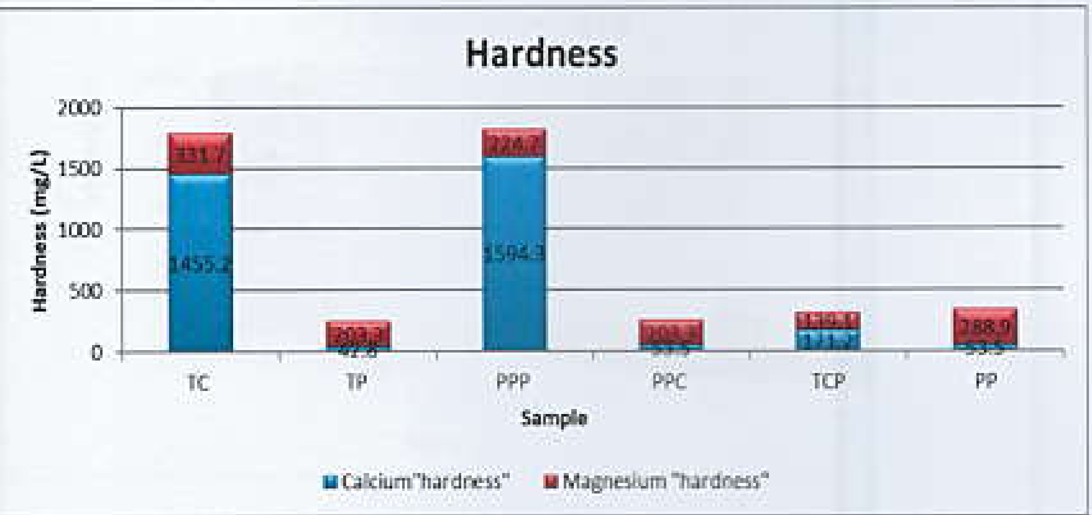
If sulphate concentration exceeds above 500 mg/l it has laxative effect and gastrointestinal irritation occurs. This effect leads to dehydration in infants. In the Present study, over all the concentration range of sulphate in Phase-IV varied between 13 to 1900 mg/L. Maximum concentration of 1900 mg/L was observed in TC (Tap water + Clay). According to IS 10500 acceptable limit of sulphate is 200 mg/L and permissible limit is 400 mg/L. Thus, the entire values shown in Graph No.45.0 were under acceptable limits of standards except of TC and PPP. In phase-IV the nitrate content was found to be 0.3 to 1.8 mg/L as shown in Table No.11.0& Graph No.42.0. In phase-IV the phosphate Concentration ranged from 0.13 to 5.13 mg/L as shown in Table No. 11.0& Graph No.43.0. The Maximum concentration of phosphate 5.13 mg/L was observed at the location PP (Prempura Ghat), while Minimum concentration of phosphate was detected to be 0.13 mg/L at T (Tap water + Prempuraghat) sampling station. Ammonical nitrogen was present in the range of 0.17-2.34 mg/L. Chloride content was varied from 23.9 mg/L to 57.4 mg/L, this indicates that the chloride content is within acceptable limit (250 mg/L) as per IS 10500.

Table 11.0: Phase-IV Idol Immersion Results – Inorganic parameters

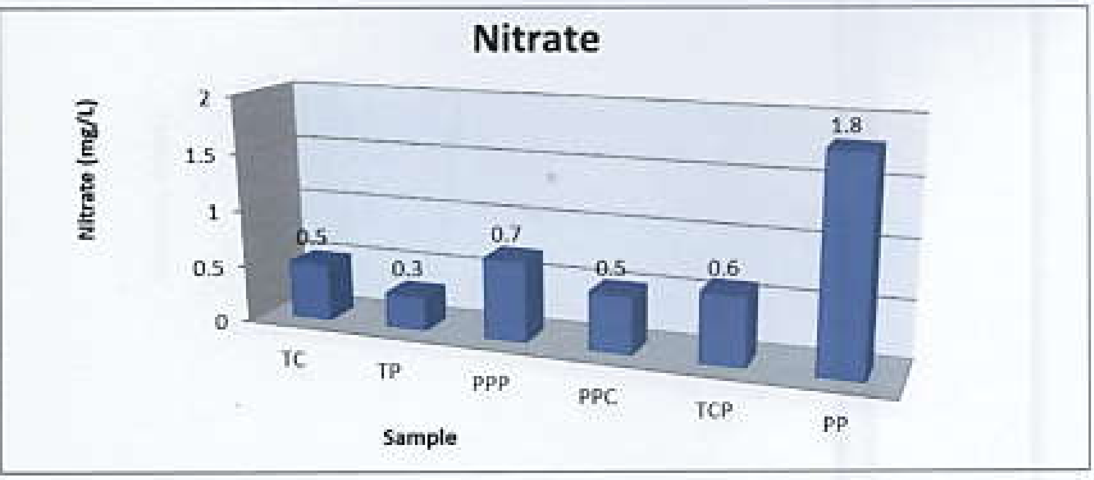
Sample	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)			NO_3^- (mg/L)	PO_4^{2-} (mg/L)	SO_4^{2-} (mg/L)	Amm. N_2 (mg/L)	Cl^- (mg/L)
		Total	Ca	Mg					
TC	40	1786.9	1455.2	331.7	0.5	0.56	1900	2.34	23.9
TP	40	246.1	42.8	203.3	0.3	0.13	29	0.64	23.9
PPP	30	1819	1594.3	224.7	0.7	2.28	1800	1.88	57.4
PPC	60	256.8	53.5	203.3	0.5	0.36	13	0.18	52.6
TCP	30	310.3	171.2	139.1	0.6	0.16	300	0.17	28.7
PP	50	342.4	53.5	288.9	1.8	5.13	52	0.21	52.6



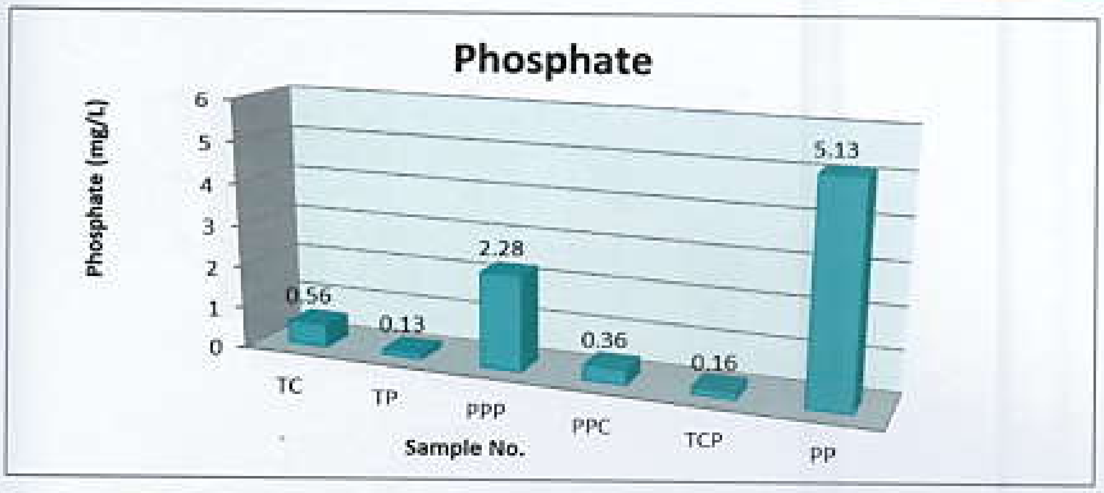
Graph 41.0: Phase-IV Idol Immersion inorganic parameters: Total Alkalinity



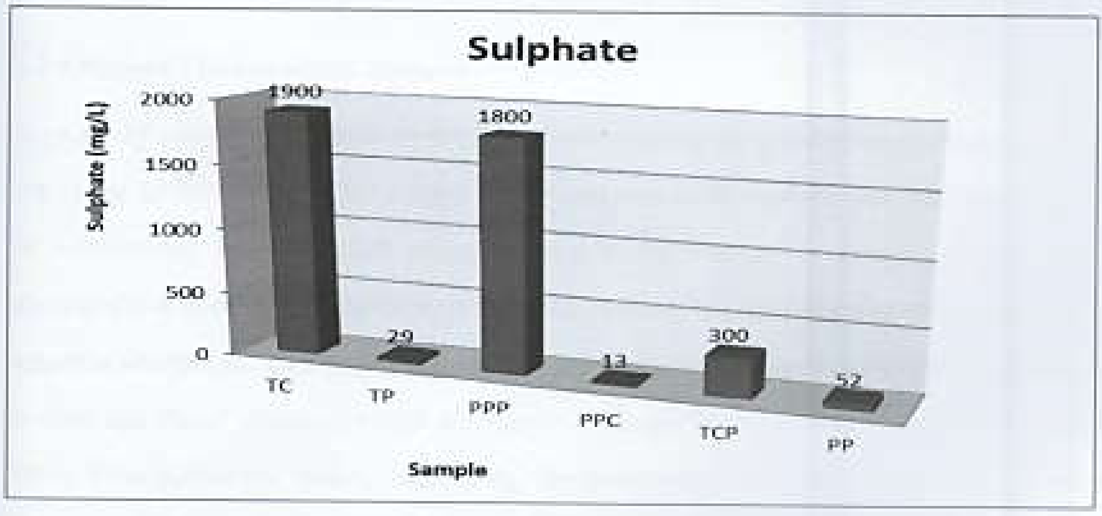
Graph 42.0: Phase-IV Idol Immersion inorganic parameters: Total Hardness



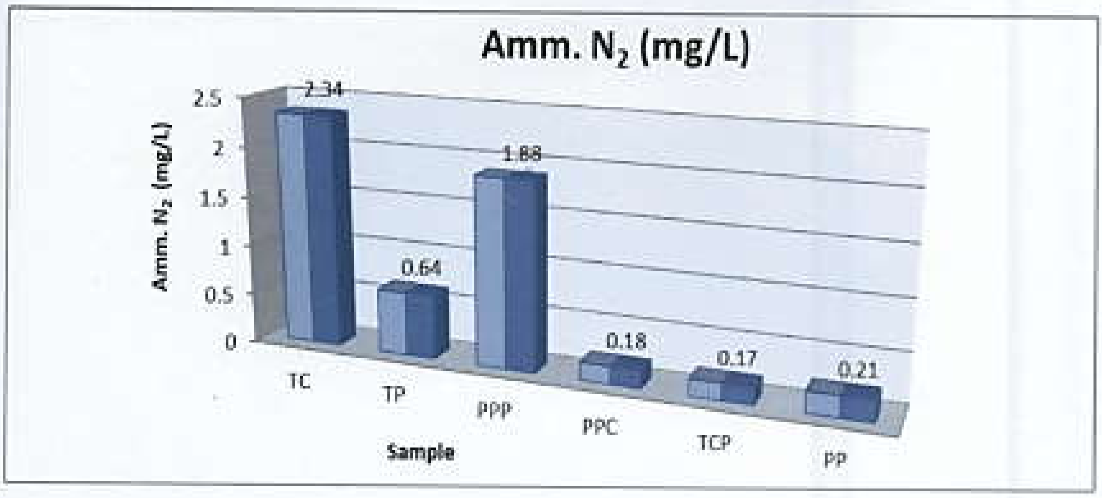
Graph 43.0: Phase-IV Idol Immersion inorganic parameters: Nitrate



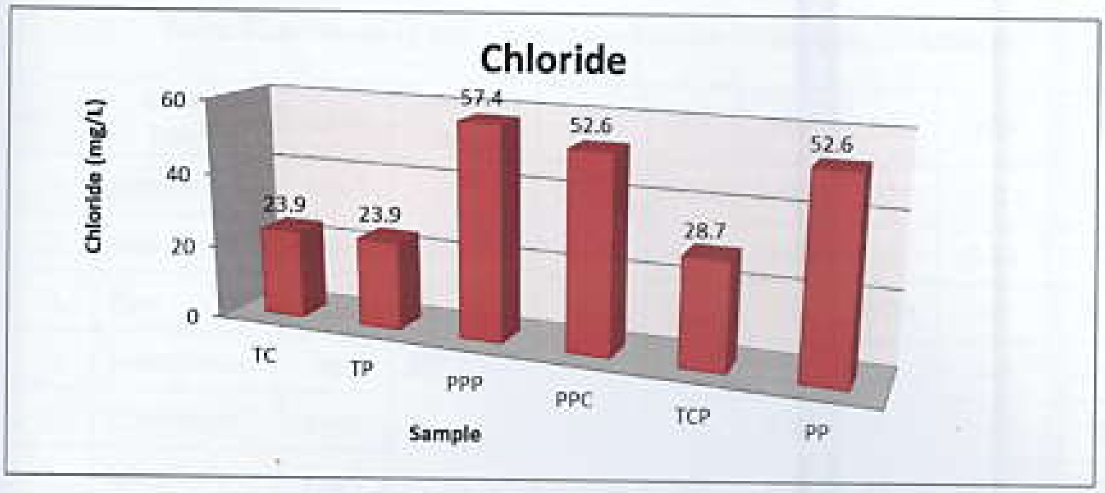
Graph 44.0: Phase-IV Idol Immersion inorganic parameters: Phosphate



Graph 45.0: Phase-IV Idol Immersion inorganic parameters: Sulphate



Graph 46.0: Phase-IV Idol Immersion inorganic parameters: Ammonical N_2



Graph 47.0: Phase-IV Idol Immersion inorganic parameters: Chloride

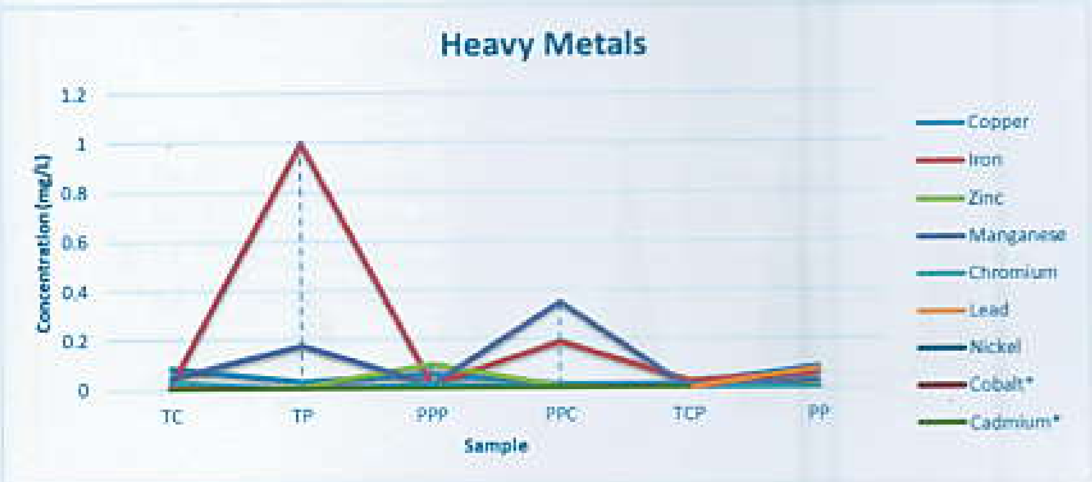
9.2.6 Phase-IV Heavy Metal analysis

In phase-IV cooper was found in the range of 0.016 mg /L to 0.085 mg/L. Iron was found in the range of 0.03 mg/L to 0.19 mg/L. 0.01 mg/L and 0.08 mg/L of lead was found in TC and PP respectively. Lead is a toxic substance that poses a variety of dangers for humans. Lead damages the central and peripheral nervous system, the kidneys and the body's ability to regulate vitamin D. Lead negatively affects the formation of red blood cells. Very high levels of lead can cause seizures, coma and death. At lower levels of exposure, a child can suffer from developmental delay, lower IQ, hyperactivity, learning disabilities, behavioural problems, impaired hearing and stunted growth. Nickel, cobalt and cadmium were not detected in phase-IV. Chromium was found in TC, PPP and TCP in 0.03 mg/L, 0.02 mg/L and 0.01 mg/l respectively.

Table 12.0: Phase-IV Idol Immersion Results – Heavy Metal analysis

No.	Analyte Tested	Unit	Method No.	TC	TP	PPP	PPC	TCP	PP
1.	Copper	mg/l	APHA, 22nd Edition, 2012	0.085	0.033	0.063	0.017	0.016	0.085
2.	Iron	mg/l		0.02	1.0	0.02	0.19	0.03	0.06
3.	Zinc	mg/l		ND	0.01	0.10	0.01	ND	0.02
4.	Manganese	mg/l		0.05	0.18	0.02	0.35	ND	0.03
5.	Chromium	mg/l		0.03	ND	0.02	ND	0.01	ND
6.	Lead	mg/l		0.01	ND	ND	ND	ND	0.08
7.	Nickel	mg/l		ND	ND	ND	ND	ND	ND
8.	Cobalt*	mg/l		ND	ND	ND	ND	ND	ND
9.	Cadmium*	mg/l		ND	ND	ND	ND	ND	ND

ND - Not Detected*



Graph 48.0: Phase-IV Idol Heavy Metal Analysis

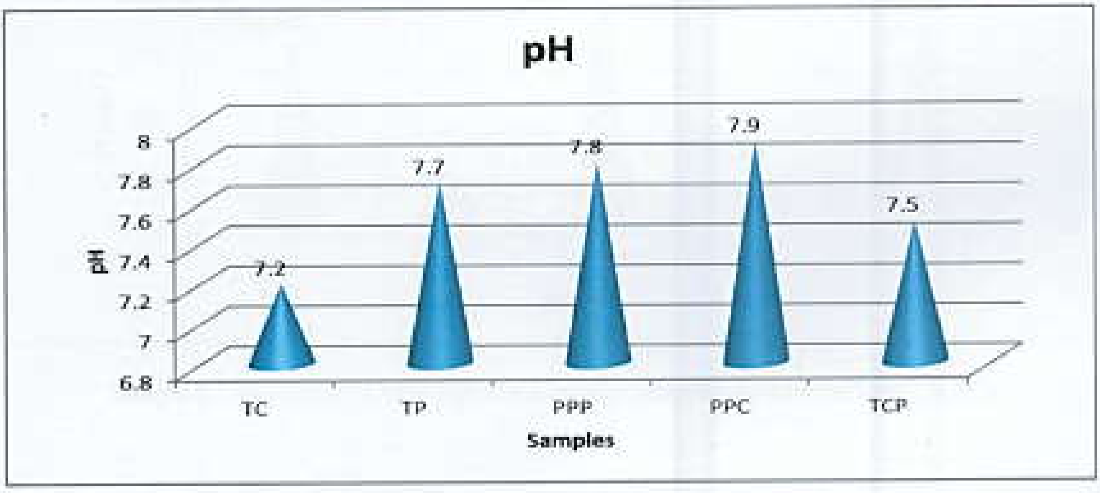
9.3 Post-Idol Immersion Analysis: Phase-V & Phase-VI

9.3.1 Phase-V physical parameters

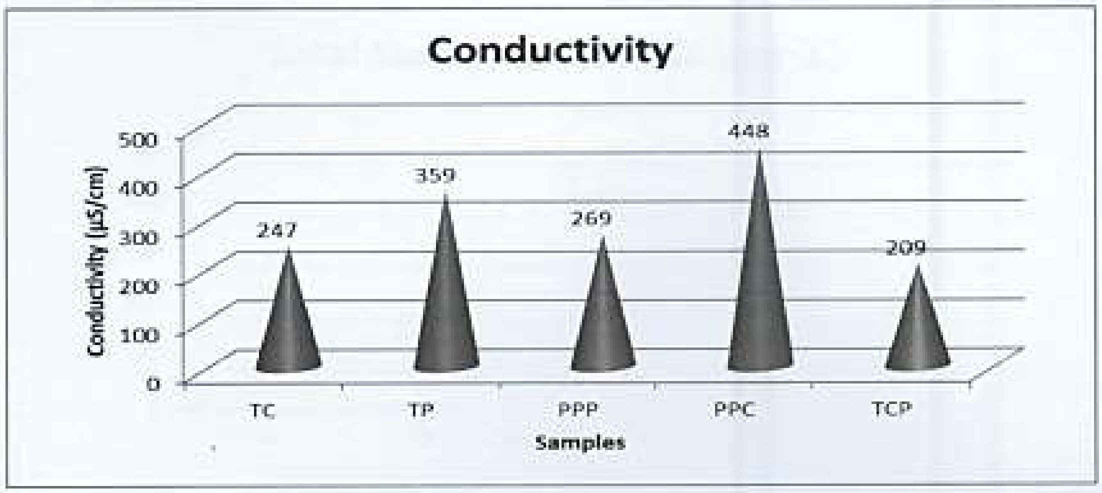
During Post idol immersion water samples coded as TC, TP, PPP, PPC and TCP were analysed. In phase-V pH was found to be the range of 7.2- 7.9 which is acceptable as per IS-10500 as shown in Table no. 13.0 and Graph no.49.0. The WHO permissible limit for EC in water is 600 µS/cm. Analysis results of Phase-V water samples shows that EC was found in the range of 209 µS/cm to 448 mS/cm as shown in Table No. 13.0 and Graph No. 50.0. The concentration of Total Solid (TS), Total Dissolved Solid (TDS) and Suspended Solid (SS) were found in the range of 256-1463 mg/l, 173-1369 mg/L and 83-500 mg/L respectively as shown in Table No. 13.0 and Graph No. 51.0,.52.0 and 53.0. Salinity of the post idol Immersion water samples were found in the range of 0.2- 1.4 as shown in Table No. 13.0. Dissolved oxygen was observed in the range of 4.33 mg/L to 5.17 mg/L.

Table 13.0: Phase-V Idol Immersion Results -Physical parameters

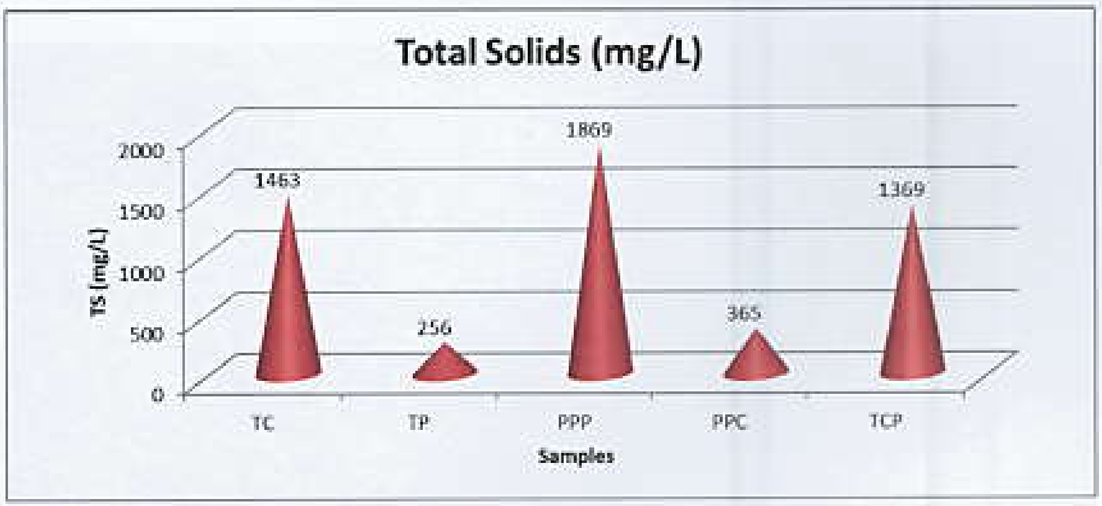
Sample	pH	Conductivity (µS/cm)	TS (mg/L)	TDS (mg/L)	SS (mg/L)	DO (mg/L)	Salinity	Temp. (°C)
TC	7.2	247	1463	1250	213	5.17	1.3	26.5
TP	7.7	359	256	173	83	4.86	0.2	26.5
PPP	7.8	269	1869	1369	500	4.75	1.4	26.5
PPC	7.9	448	365	216	149	4.48	0.2	26.5
TCP	7.5	209	1369	1052	317	4.33	1.1	26.6



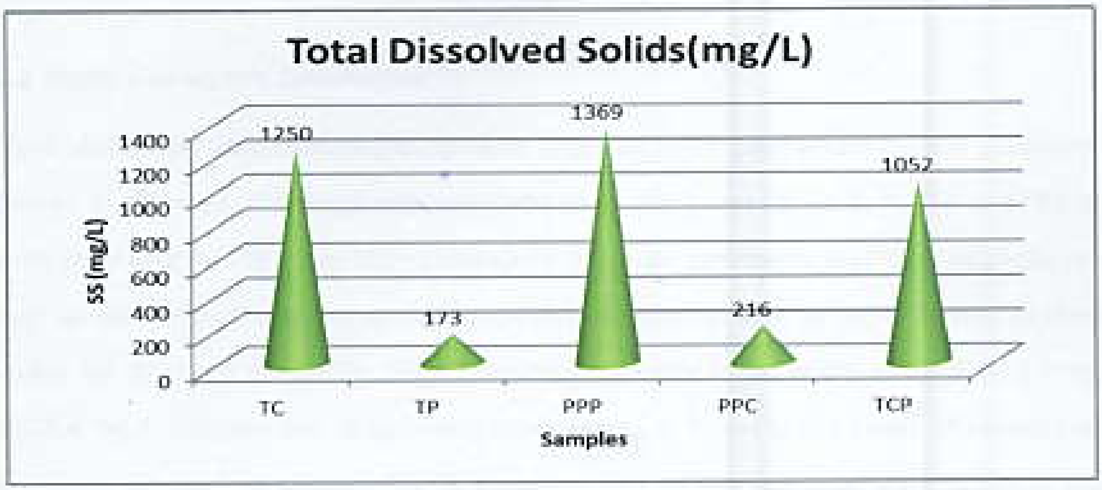
Graph 49.0: Phase-V Idol Immersion physical parameters: pH



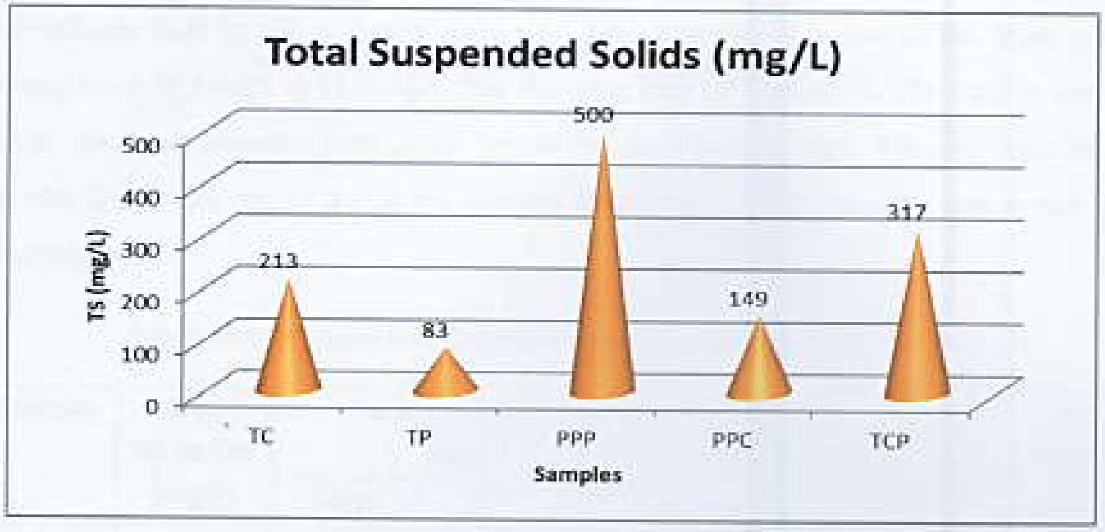
Graph 50.0: Phase-V Idol Immersion physical parameters: Conductivity



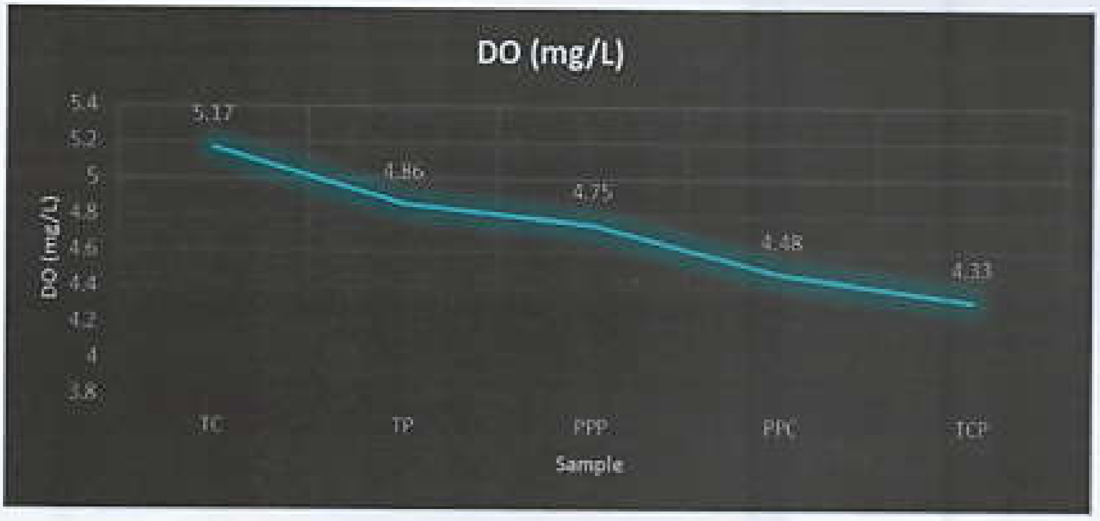
Graph 51.0: Phase-V Idol Immersion physical parameters: Total Solids



Graph 52.0: Phase-V Idol Immersion physical parameters: Total Dissolved Solids



Graph 53.0: Phase-V Idol Immersion physical parameters: Total Suspended Solids



Graph 54.0: Phase-V Idol Immersion physical parameters: Dissolved oxygen

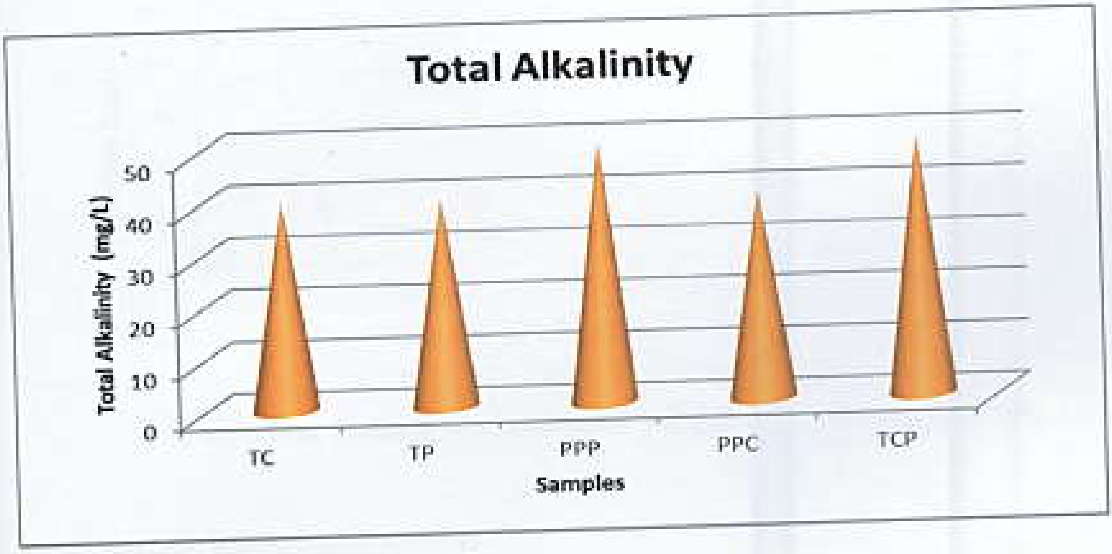
9.3.2 Phase-V Inorganic parameters

In post-idol Immersion analysis (phase-V) of water samples total alkalinity was observed in range of 40-50 mg/L. Minimum concentration of 40 mg/L was found in TC, TP and PPC and maximum 50 mg/L in PPP and TCP respectively. It can be concluded that total alkalinity in all water samples of post idol immersion are under permissible limit as per IS 10500, as shown in Table No. 14.0 and Graph No. 55.0. Total Hardness was found in the range of 224.7 mg/L – 1754.8 mg/L. Calcium and Magnesium hardness were found in the range of respectively. Thus, Table No. 14.0 and Graph No.56.0 showed that all the values of total hardness were under permissible limit of IS 10500.

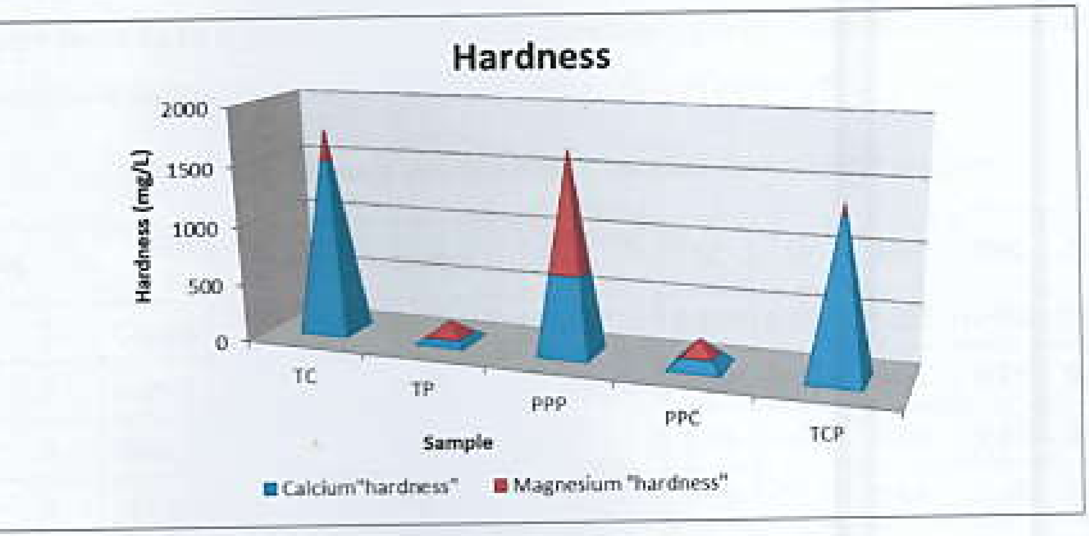
The chloride level in the post-idol immersion water samples collected in the study were ranging from 28.7 mg/L to 81.5 mg/L. The desirable limit for chlorides is 250 mg/L as per IS-10500 Standards whereas, permissible limit of the same is 1000 mg/L. it is clear from Table No.14.0 and Graph No. 57.0 that the chloride concentration in all samples was within the desirable limits.

Table 14.0: Phase-V Idol Immersion Results – Inorganic parameters

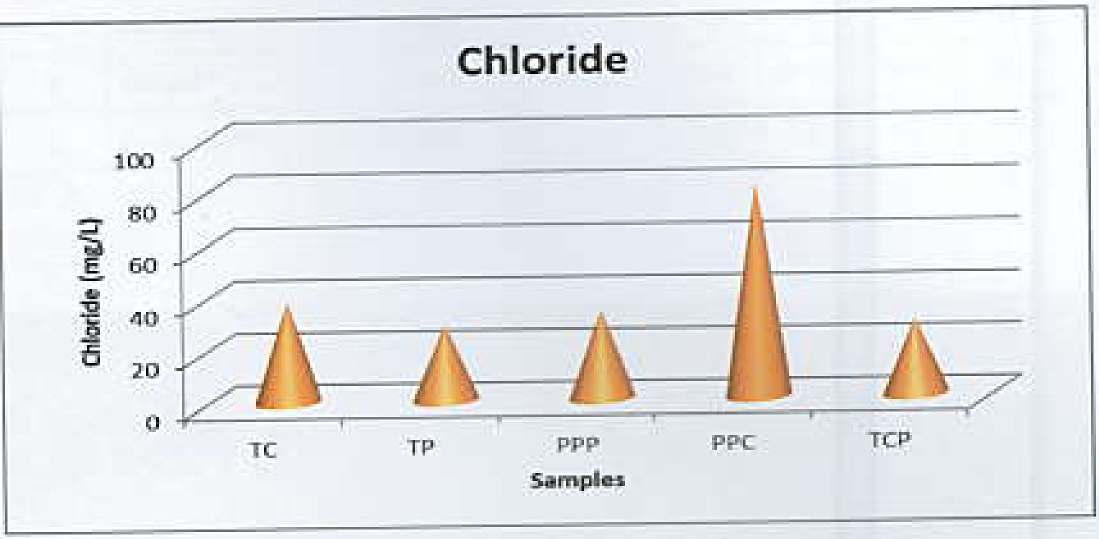
Sample	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)			SO_4^{2-} (mg/L)	NO_3^- (mg/L)	PO_4^{2-} (mg/L)	Cl^- (mg/L)
		Total	Ca	Mg				
TC	40	1754.8	1498	256.8	-	-	-	38.2
TP	40	171.2	53.5	117.7	-	-	-	28.7
PPP	50	1690.6	694	996.6	-	-	-	33.5
PPC	40	224.7	96.3	128.4	-	-	-	81.5
TCP	50	1391	1305.4	85.6	-	-	-	28.7



Graph 55.0: Phase-V Idol Immersion inorganic parameters: Total Alkalinity



Graph 56.0: Phase-V Idol Immersion inorganic parameters: Total Hardness



Graph 57.0: Phase-V Idol Immersion inorganic parameters: Chloride

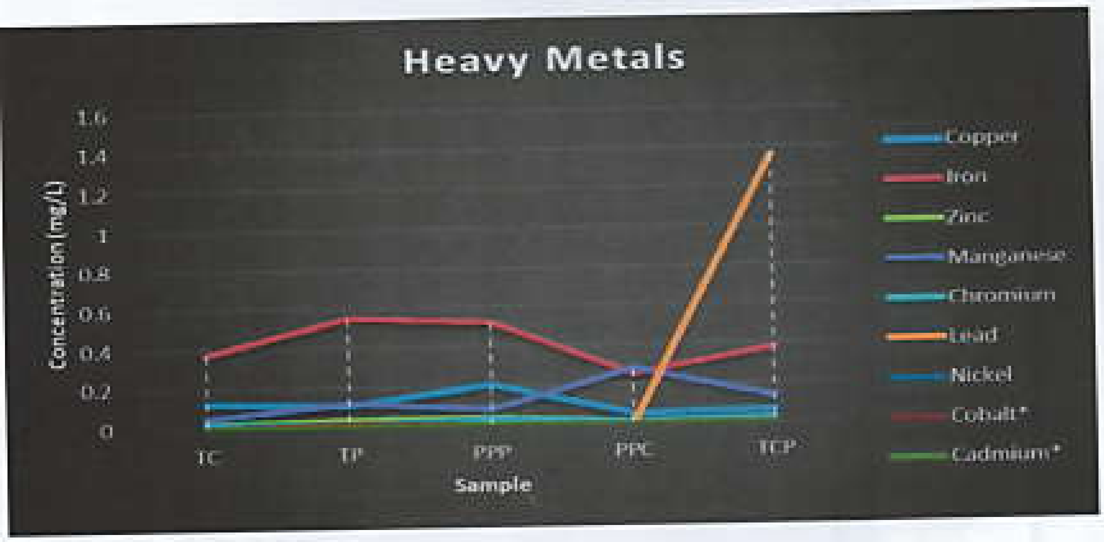
9.3.3 Phase-V Heavy Metal analysis

The changes obtained in the heavy metal content of Prempura ghat water sample due to the immersion of painted idols are presented in Table No. 15.0 and graph 58.0. The concentration of Copper, Iron, Zinc, Manganese and Chromium in samples TC, TP, PPP, PPC and TCP were found in the range of 0.050- 0.126 ppm, 0.25- 0.55 ppm, 0.01- 0.04 ppm, 0.05- 0.28 ppm, 0.01- 0.03 ppm respectively. However, concentration of Lead in TC and TCP ere found to be 0.01ppm and 1.36 ppm respectively. Other heavy metals include Nickel, obalt and Cadmium were Below Detection Limit (BDL) at ppm level.

Table 15.0: Phase-V Idol Immersion Results – Heavy Metal analysis

No.	Analyte Tested	Unit	Method No.	TC	TP	PPP	PPC	TCP
1.	Copper	mg/l	APHA, 22nd Edition, 2012	0.126	0.107	0.205	0.050	0.062
2.	Iron	mg/l		0.37	0.55	0.52	0.25	0.38
3.	Zinc	mg/l		0.02	0.03	0.04	0.01	0.01
4.	Manganese	mg/l		0.05	0.12	0.08	0.28	0.13
5.	Chromium	mg/l		0.02	0.01	0.03	0.01	0.02
6.	Lead	mg/l		ND	0.01	ND	ND	1.36
7.	Nickel	mg/l		ND	ND	ND	ND	ND
8.	Cobalt*	mg/l		ND	0.01	ND	ND	ND
9.	Cadmium*	mg/l		ND	ND	ND	ND	ND

ND - Not Detected*



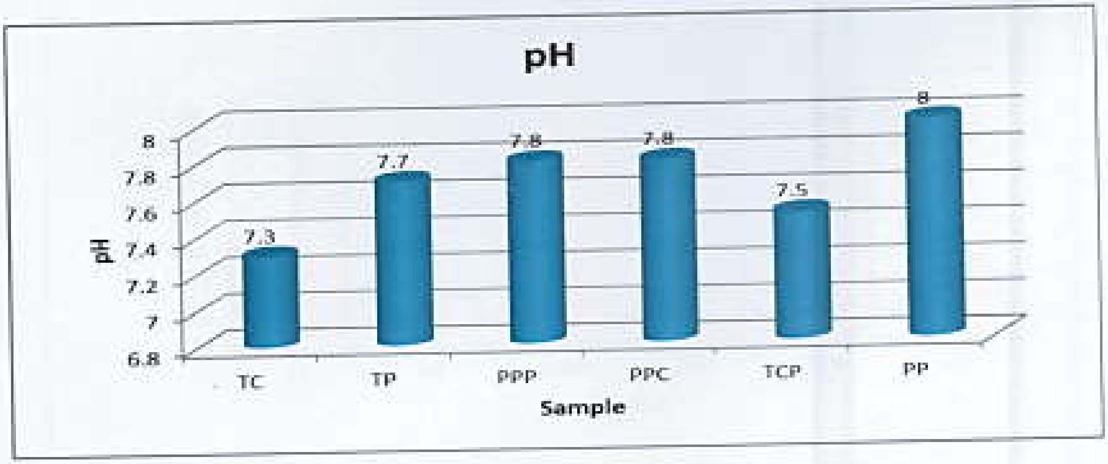
Graph 58.0: Phase-V Idol Immersion Heavy Metal Analysis

9.3.4 Phase-VI Physical parameters

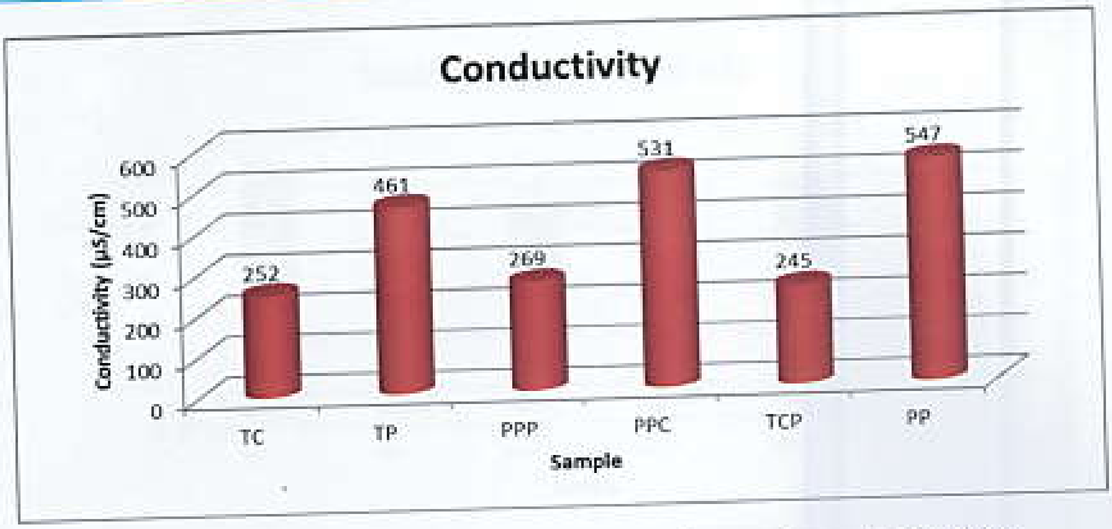
The water samples collected in phase- VI were coded as TC, TP, PPP, PPC, TCP and PP. During this period, pH in water samples was found to be the range of 7.3- 8.0 which is acceptable as per IS-10500 as shown in Table no. 16.0 and Graph no. 59.0. The EC of phase-VI water samples was found in the range of 252 µS/cm to 547 µS/cm. The maximum concentration of Electrical Conductivity was found to be 547 mS/cm in PP whereas minimum 245 mS/cm in TCP, as shown in Table No. 14.0 and Graph No. 60.0. The concentration of Total Solid (TS), Total Dissolved Solid (TDS) and Suspended Solid (SS) were found in the range of 399-1660 mg/L, 223-1369 mg/L and 176-446 mg/L respectively as shown in Table No. 16.0 and Graph No. 61.0, 62.0 and 63.0. Salinity of the phase- VI water samples were found in the range of 0.2- 1.4 and all physical parameters were analyse in the temperature ranges from 26.4- 26.5 ^{0}C, as shown in Table No. 16.0. Dissolved oxygen was found in the range of 2.91-4.69 mg/L as indicated in graph 64.0.

Table 16.0: Phase-VI Idol Immersion Results -Physical parameters

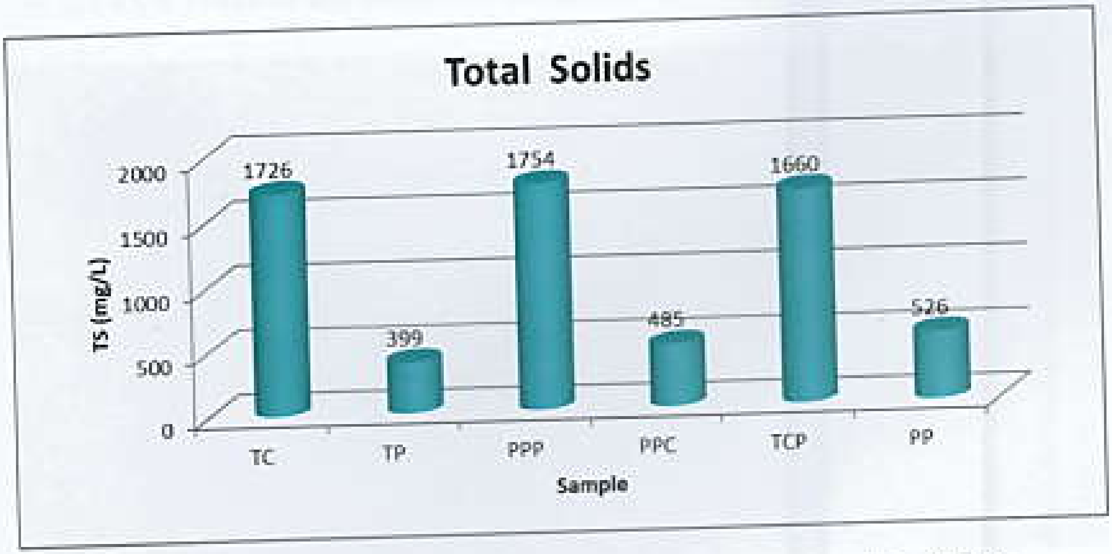
Sample	pH	Conductivity (µS/cm)	TS (mg/L)	TDS (mg/L)	SS (mg/L)	DO (mg/L)	Salinity	Temp. (°C)
TC	7.3	252	1726	1280	446	4.18	1.3	26.5
TP	7.7	461	399	223	176	4.05	0.2	26.5
PPP	7.8	269	1754	1369	385	4.69	1.4	26.5
PPC	7.8	531	485	257	228	3.76	0.3	26.5
TCP	7.5	245	1660	1241	419	4.29	1.3	26.4
PP	8.0	547	526	265	261	2.91	0.3	26.4



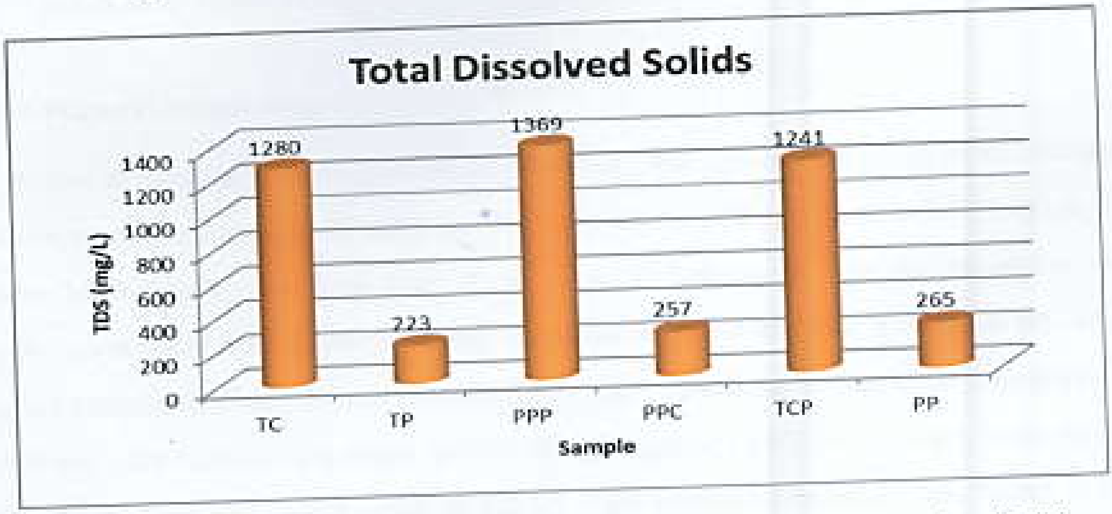
Graph 59.0: Phase-VI Idol Immersion physical parameters: pH



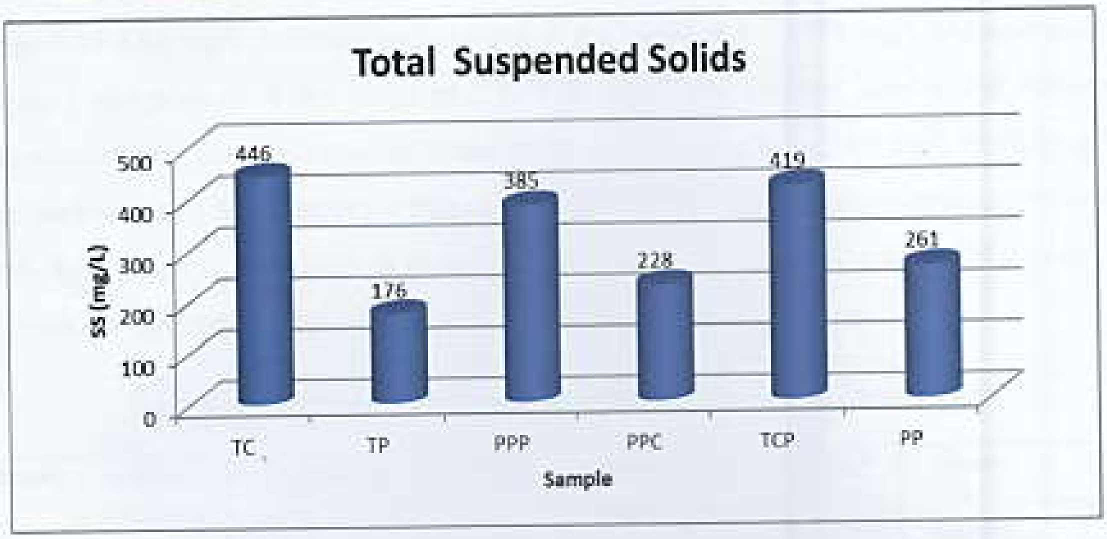
Graph 60.0: Phase-VI Idol Immersion physical parameters: Conductivity



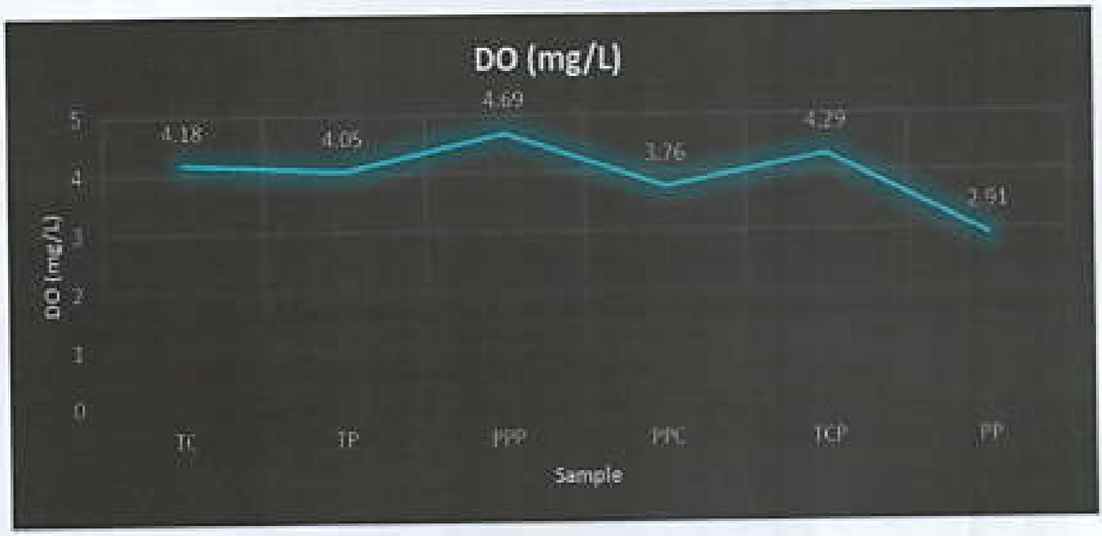
Graph 61.0: Phase-VI Idol Immersion physical parameters: Total Solids



Graph 62.0: Phase-VI Idol Immersion physical parameters: Total Dissolved Solids



Graph 63.0: Phase-VI Idol Immersion physical parameters: Total Suspended Solids



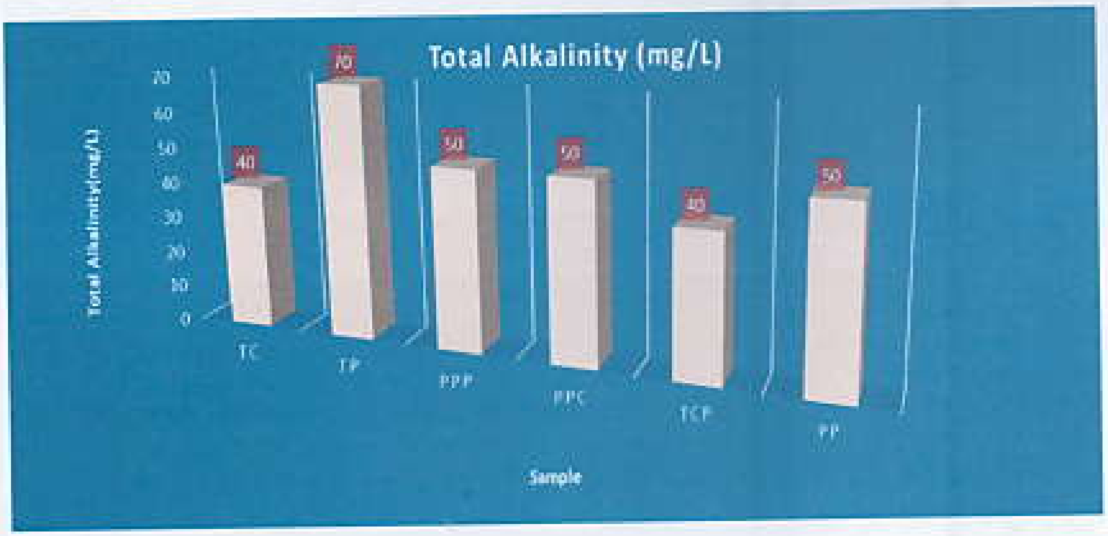
Graph 64.0: Phase-VI Idol Immersion physical parameters: Heavy Metal Analysis

9.3.5 Phase-VI Inorganic parameters

In Phase- VI water sample analysis of total alkalinity was observed in range of 40-70 mg/L. Minimum concentration of 40 mg/L was found in TC and TCP and maximum 70 mg/L in TP. It can be concluded that total alkalinity in all water samples of post idol immersion are under permissible limit as per IS 10500, as shown in Table No. 17.0 and Graph No. 65.0. Total Hardness was found in the range of 139.1 mg/L – 1883 mg/L. Calcium and Magnesium hardness were found in the range of 32.1-1572.9 mg/L and 64.2-1347.4 mg/L respectively. Nitrate was observed in the range of 0.7-1.5 mg/L whereas phosphate was found in the range 0.14-4.53 mg/L. Sulphate was present in the range of 5 – 1950 mg/L and Ammonical nitrogen was present in the range of 0.31-1.88 mg/L. The chloride level in the post-idol immersion water samples collected in the study were ranging from 23.9 mg/L to 62.2 mg/L. The desirable limit for chlorides is 250 mg/L as per IS-10500 Standards whereas permissible limit of the same is 1000 mg/l. It is clear from Table No. 17.0 and Graph No. 71.0 that the chloride concentration in all samples was within the desirable limits.

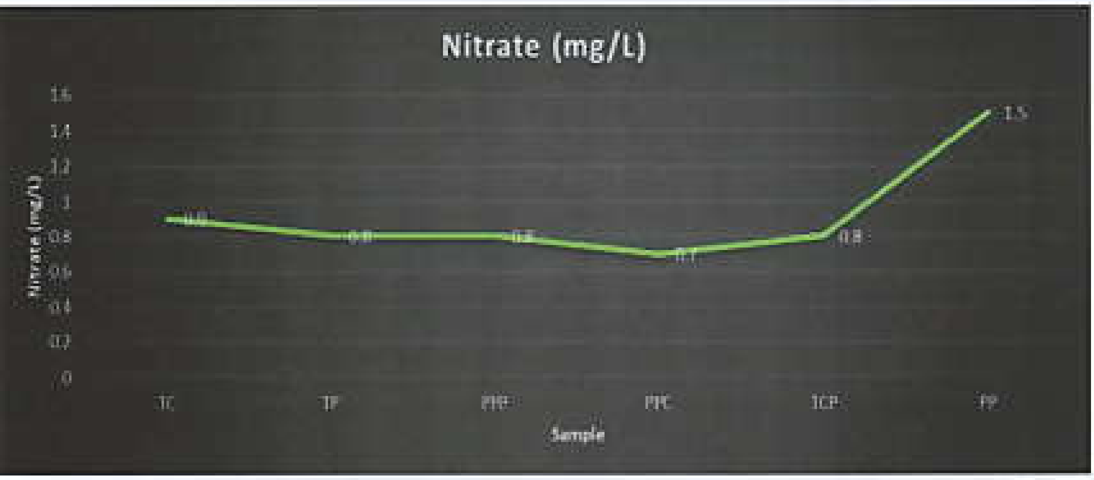
Table 17.0: Phase-VI Idol Immersion Results – Inorganic parameters

Sample	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)			NO_3^- (mg/L)	PO_4^{2-} (mg/L)	SO_4^{2-} (mg/L)	Amm. N_2 (mg/L)	Cl^- (mg/L)
		Total	Ca	Mg					
TC	40	1883	1572.9	310.1	0.9	0.74	1550	1.84	33.5
TP	70	235.4	85.2	150.2	0.8	0.39	11	0.31	28.7
PPP	50	1808.3	1487.3	321	0.8	2.24	-	1.88	62.2
PPC	50	246.1	32.1	214	0.7	0.17	5	0.31	52.6
TCP	40	1391	43.6	1347.4	0.8	0.14	1950	1.62	23.9
PP	50	139.1	74.9	64.2	1.5	4.53	15	0.32	38.2

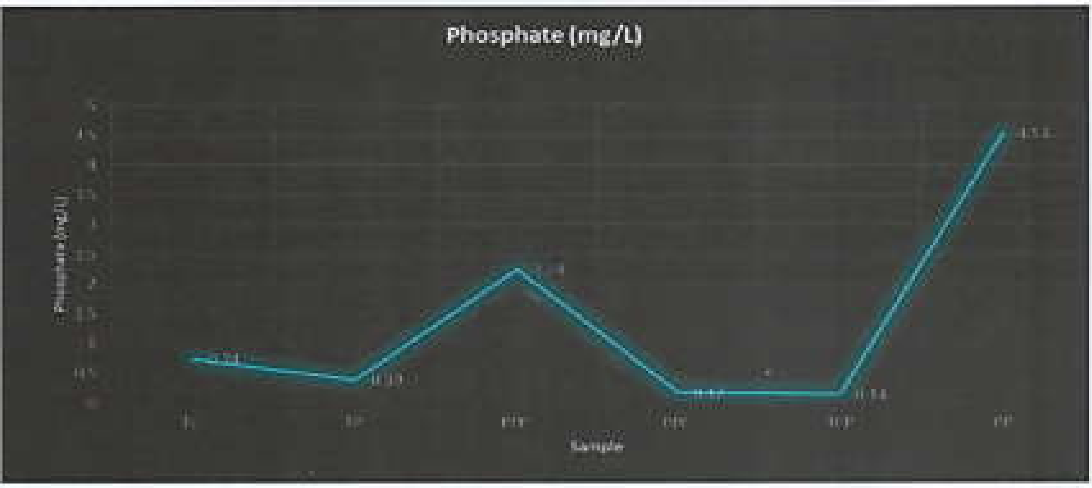


Graph 65.0: Phase-VI Idol Immersion inorganic parameters: Total Alkalinity

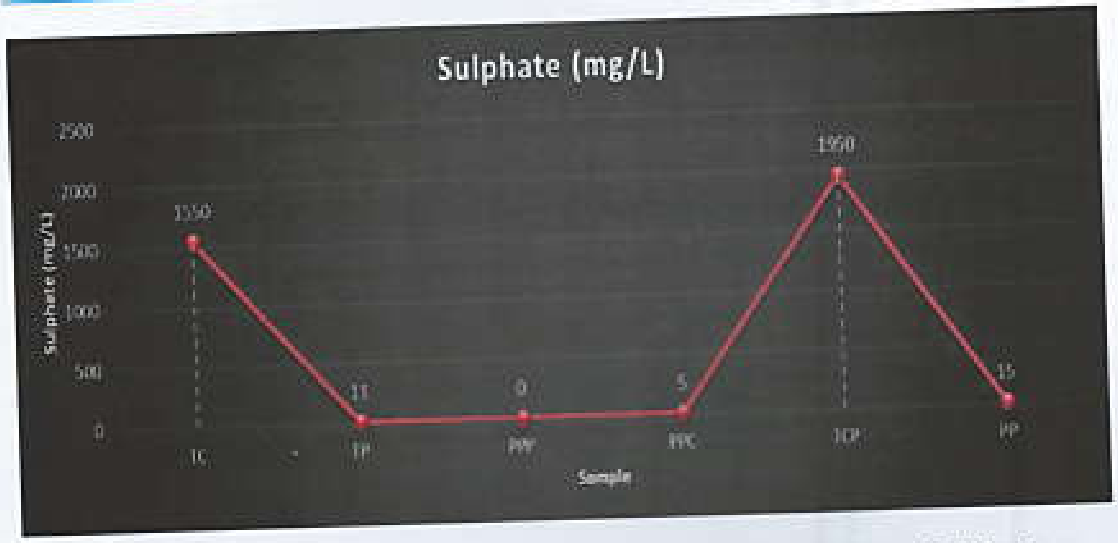
Graph 66.0: Phase-VI Idol Immersion inorganic parameters: Total Hardness



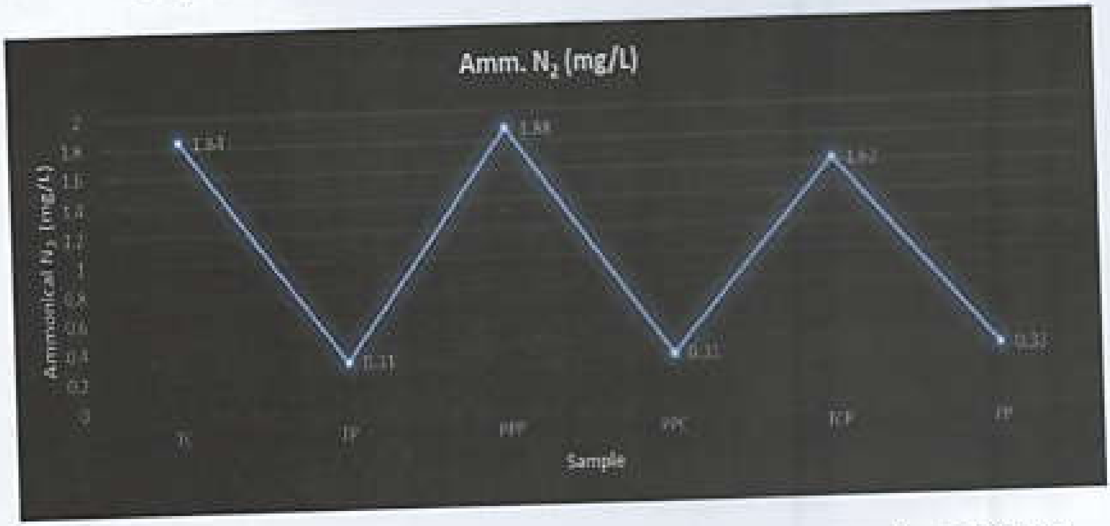
Graph 67.0: Phase-VI Idol Immersion inorganic parameters: Nitrate



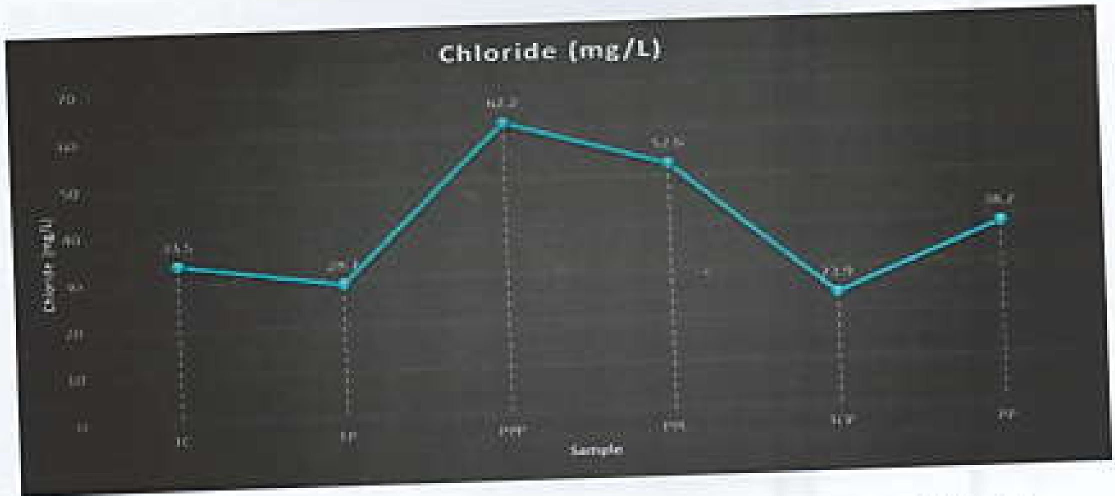
Graph 68.0: Phase-VI Idol Immersion inorganic parameters: Phosphate



Graph 69.0: Phase-VI Idol Immersion inorganic parameters: Sulphate



Graph 70.0: Phase-VI Idol Immersion inorganic parameters: Ammonical N_2



Graph 71.0: Phase-VI Idol Immersion inorganic parameters: Chloride

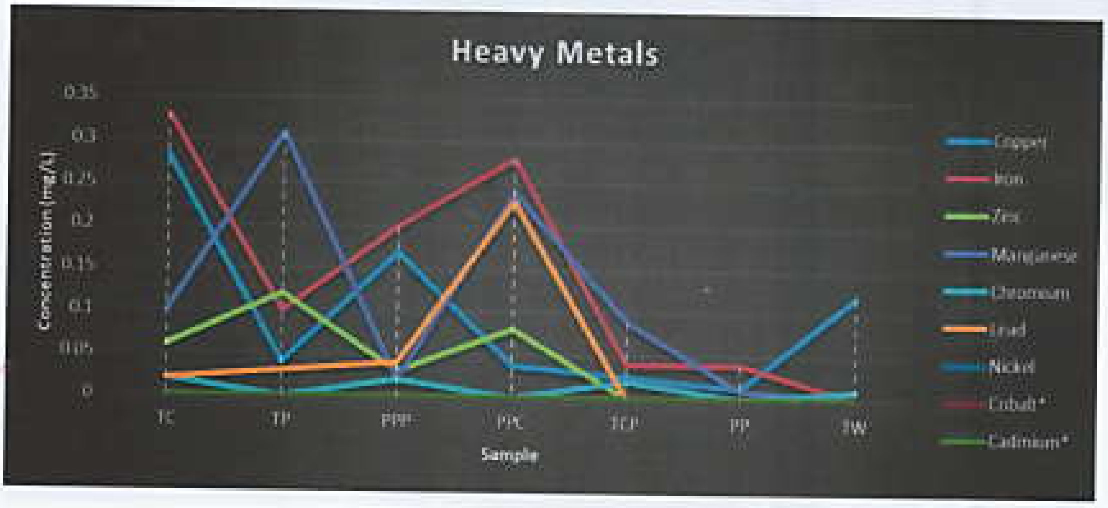
9.3.6 Phase-VI Heavy Metal analysis

The changes obtained in the heavy metal content in Phase-VI of Post- idol immersion period are presented in Table No. The concentration of Copper in TC, TP, PPP, TCP, PP and TW were found in the range of 0.012- 0.282 ppm. The concentration of Iron in water sample TC, TP, PPP, PPC, TCP and PP was found in the range of 0.04- 0.28 ppm, Zinc 0.01- 0.12 ppm, Manganese 0.01- 0.31 ppm, Chromium 0.01- 0.02 ppm and Lead 0.02- 0.23 ppm. All other heavy metals like Nickel, Cobalt and Cadmium were found below detection limit (BDL) at ppm level as shown in Table No.18.0 and Graph No. 72.0.

Table 18.0: Phase-VI Idol Immersion Results – Heavy Metal analysis

No.	Analyte Tested	Unit	Method No.	TC	TP	PPP	PPC	TCP	PP	TW
1.	Copper	mg/l	APHA, 22nd Edition, 2012	0.282	0.040	0.170	0.037	0.025	0.012	0.12
2.	Iron	mg/l		0.33	0.10	0.20	0.28	0.04	0.04	ND
3.	Zinc	mg/l		0.06	0.12	0.03	0.08	ND	ND	0.01
4.	Manganese	mg/l		0.10	0.31	0.02	0.24	0.09	0.01	ND
5.	Chromium	mg/l		0.02	ND	0.02	ND	0.02	ND	0.01
6.	Lead	mg/l		0.02	0.03	0.04	0.23	ND	ND	ND
7.	Nickel	mg/l		ND	ND	ND	ND	ND	ND	ND
8.	Cobalt*	mg/l		ND	ND	ND	ND	ND	ND	ND
9.	Cadmium*	mg/l		ND	ND	ND	ND	ND	ND	ND

ND - Not Detected*



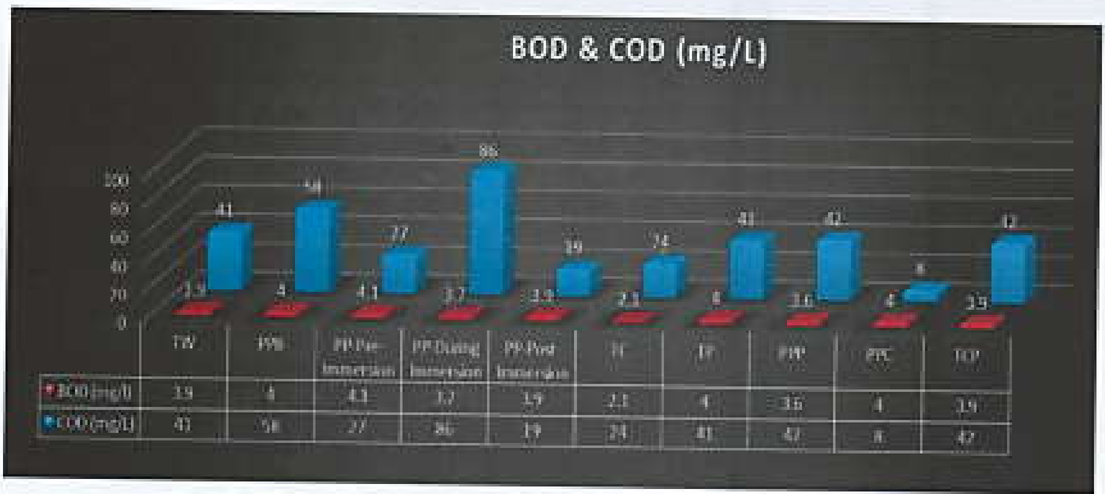
Graph 72.0: Phase-VI Idol Immersion Heavy Metal Analysis

9.4 Organic Parameters: Biochemical Oxygen Demand (BOD) & Chemical Oxygen Demand (COD)

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. BOD of Prempura Ghat samples before, during and after idol immersion was noted as 4.1 mg/L, 3.7 mg/L and 3.9 mg/L. Similarly, COD of these samples was 27mg/L, 86 mg/L and 19 mg/L respectively as given in Table no. 19.0 and graph 73.0. Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days. Maximum COD was observed in Prempura ghat samples during idol immersion indicating concentration of chemicals increases in samples during immersion as compared to pre-immersion.

Table 19.0: Idol Immersion Organic Parameters – BOD & COD

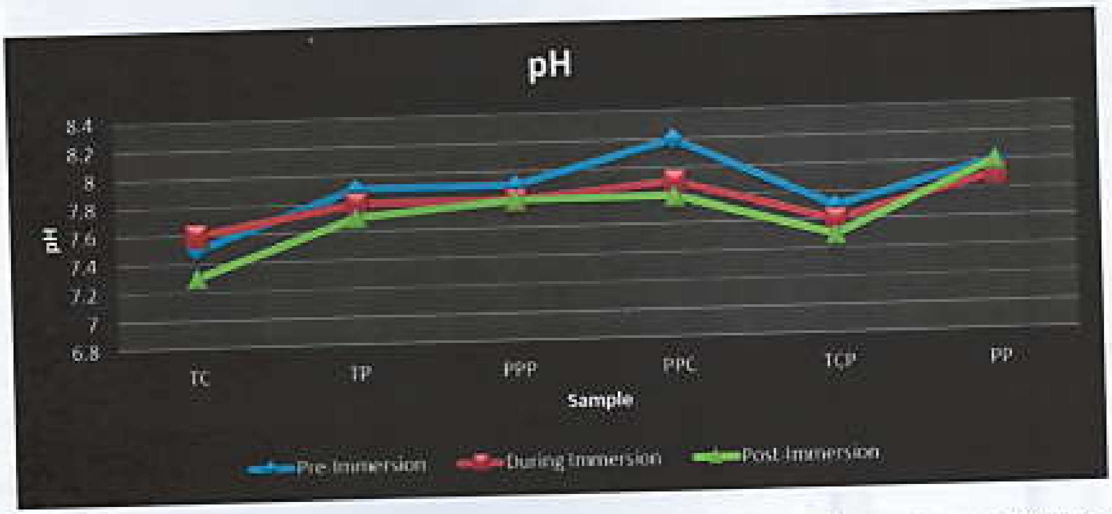
Samples	BOD (mg/L)	COD (mg/L)
TW	3.9	41
PPB	4.0	58
PP-Pre-Immersion	4.1	27
PP-During-Immersion	3.7	86
PP-Post-Immersion	3.9	19
TC	2.1	24
TP	4.0	41
PPP	3.6	42
PPC	4.0	8
TCP	3.9	42



Graph 73.0: Phase-VI Idol Immersion Organic parameters: BOD & COD

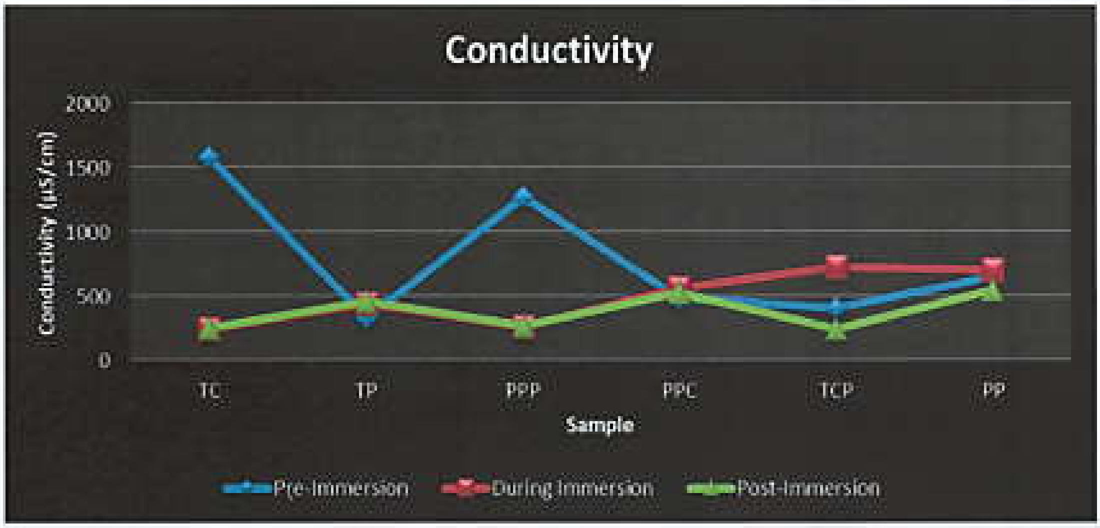
Comparative Results of Pre-Immersion, During and Post-Immersion

: pH was found alkaline during the study period. The pH varied from 7.5-8.0 in pre-mersion, 7.6-7.9 in immersion and 7.3-8.0 in post immersion period. In the present study, wering of pH during immersion has been observed. It can be seen from the graph that aximum was found in PPC i.e. Samples containing Prempura water and Clay Idol. The lues are however, within the acceptable limits of 6.5- 8.5 as per guideline suggested by IS 500. The present study reveals a pattern of pH values as shown in Graph No.74.0.



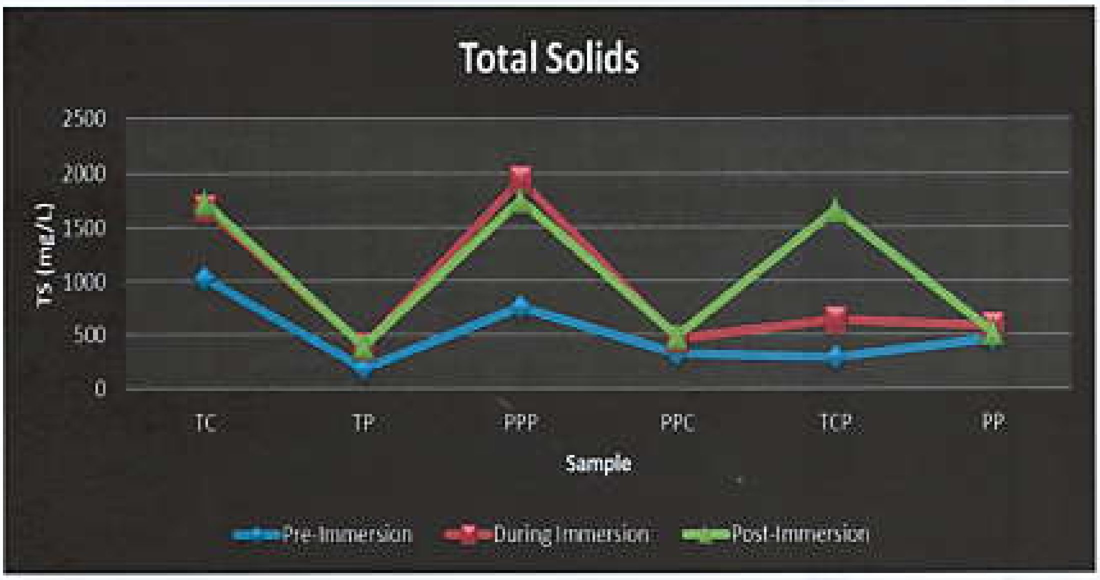
Graph 74.0: Comparative study of pre-immersion, during& post-immersion analysis: pH

Conductivity: In present study electrical conductivity was observed to be in the range of 333-1579 µS/cm during pre-immersion analysis and 246-725µS/cm during immersion and 252-547µS/cm during post-immersion. It is clear from Graph No.75.0 that electrical conductivity was maximum during pre-immersion which showed higher concentration of dissolved salts in water. Low value of EC during and post-immersion showed that the water was almost polluted with lesser amount of dissolved salts.



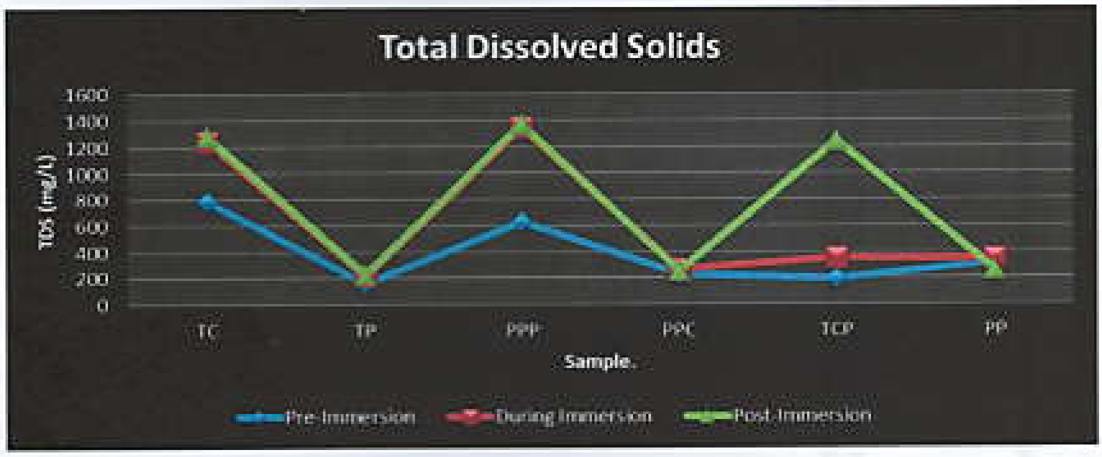
Graph75.0: Comparative study of pre-immersion, during& post-immersion analysis: Conductivity

Total Solids: On an average, Total Solids increased in Post-Immersion analysis as compared to other two. The value of Total Solids varied from 184.5- 1026 mg/L in pre-immersion to 399-1726 mg/L in post immersion analysis. During immersion activities Total Solids were found in the range of 394-1939 mg/L. This showed that pollution rate increased in post-immersion analysis. Maximum Total Solids were found in sample PPP during immersion and post-idol immersion.



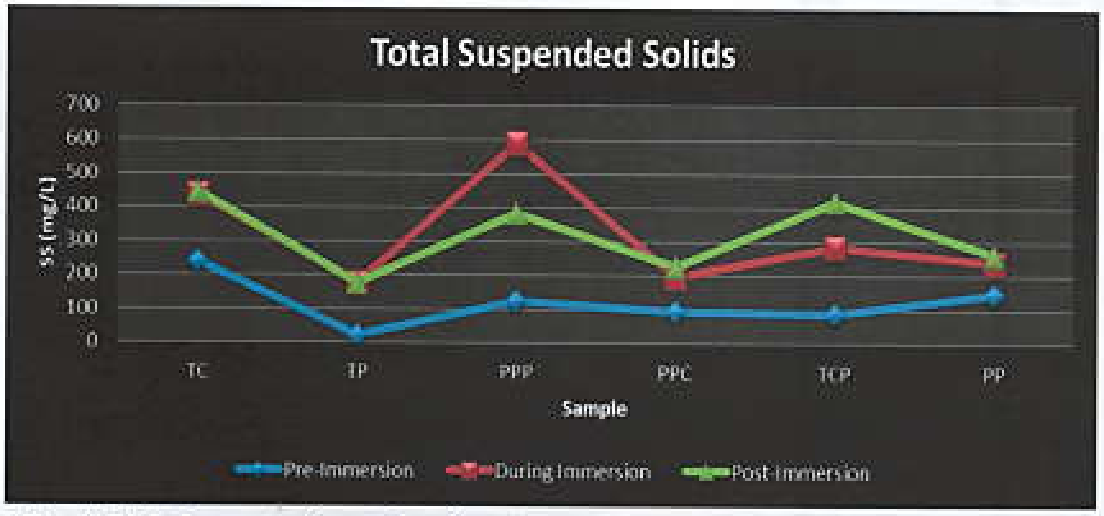
Graph 76.0: Comparative study of pre-immersion, during& post-immersion analysis: TS

DS: The presence of dissolved solids in water may affect its taste. In present study oncentration of TDS ranged between 160.5 mg/L to 786 mg/L during pre-immersion nalysis, 215-1348 mg/L during immersion and 223-1369 mg/L during post-immersion nalysis. Except sample TC (Tap water + Clay Idol) & PPP (Prempura water + PoP Idol) all ther samples are within acceptable limit as per the guideline of IS 10500:2012, as shown in raph No.77.0. The comparative study showed that during post-immersion concentration of DS is higher than pre-immersion of idols.



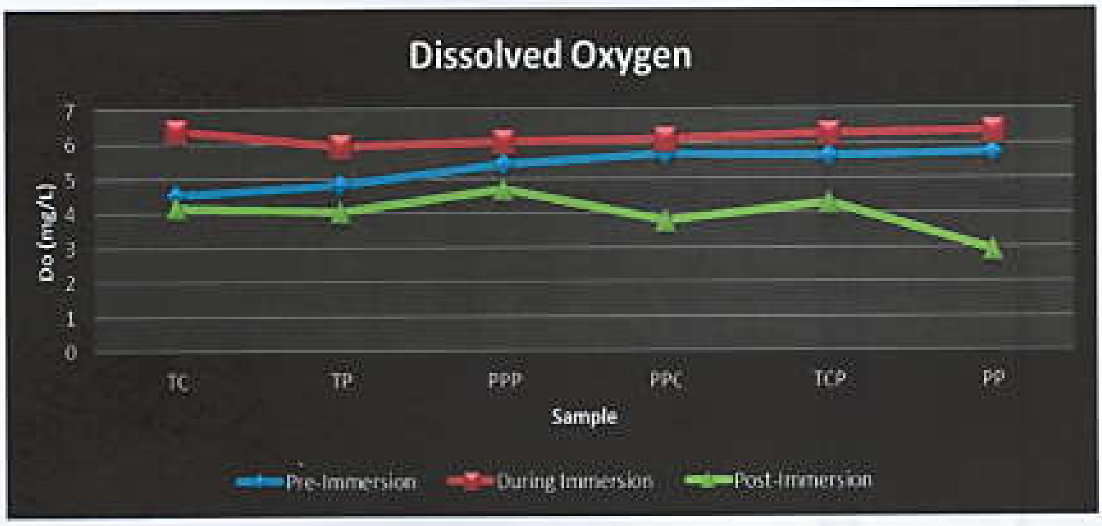
Graph 77.0: Comparative study of pre-immersion, during& post-immersion analysis: TDS

otal suspended solids: Total suspended solids almost doubled during immersion period nd the post immersion period in the collected water samples as compared to pre-mmersion. It can be seen from the graph that TSS was maximum in PPP samples as ompared to all other samples. The value of SS was found in the range of 24-240 mg/L, 179-71 mg/L and 176-446 mg/L during pre-immersion, immersion and post-immersion espectively.



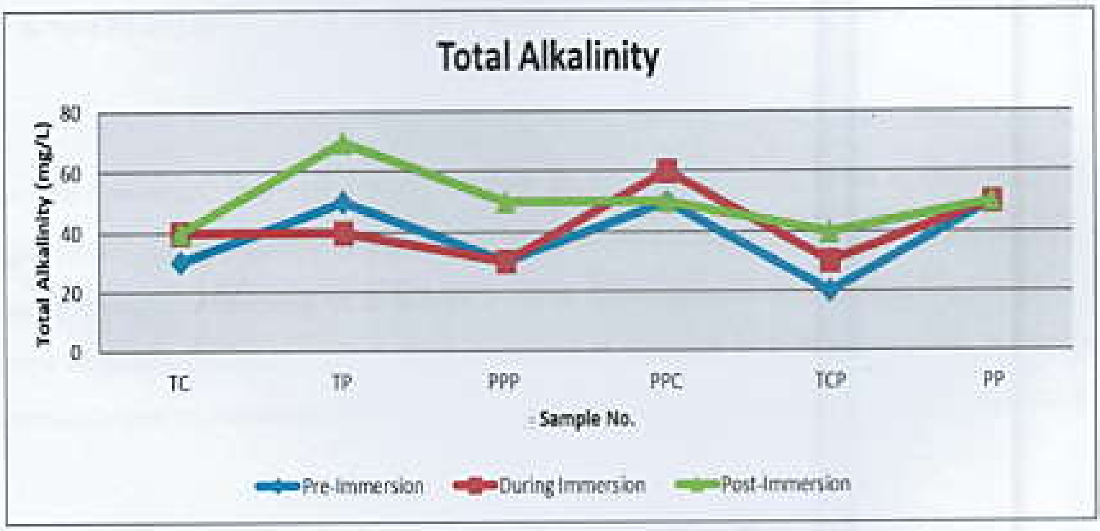
Graph 78.0: Comparative study of pre-immersion, during& post-immersion analysis: TSS

Dissolved oxygen: DO is an important parameter of water quality, which is an index of physical and biological processes taking place in water. Dissolved oxygen in water maintains the higher form of life and keeps the proper balance of various populations, thus making the water body healthy. Decreased DO levels may also be indicative of too many bacteria and an excess amount of biological oxygen demand (BOD). In present study, Dissolved oxygen was found to be in the range of 4.51 – 5.75 mg/L in the pre-immersion samples, while 5.92 – 6.36 mg/L and 2.91 - 4.69 mg/L in immersion and post immersion samples respectively. The results indicate that dissolved oxygen is maximum PP samples during idol immersion i.e. 6.36 mg/L and minimum (2.91 mg/L) was also observed in PP samples during post-immersion analysis, as shown in Graph No.79.0. However, it can be clearly seen from the graph that DO increases during immersion activities and then further decreases in post-immersion analysis.



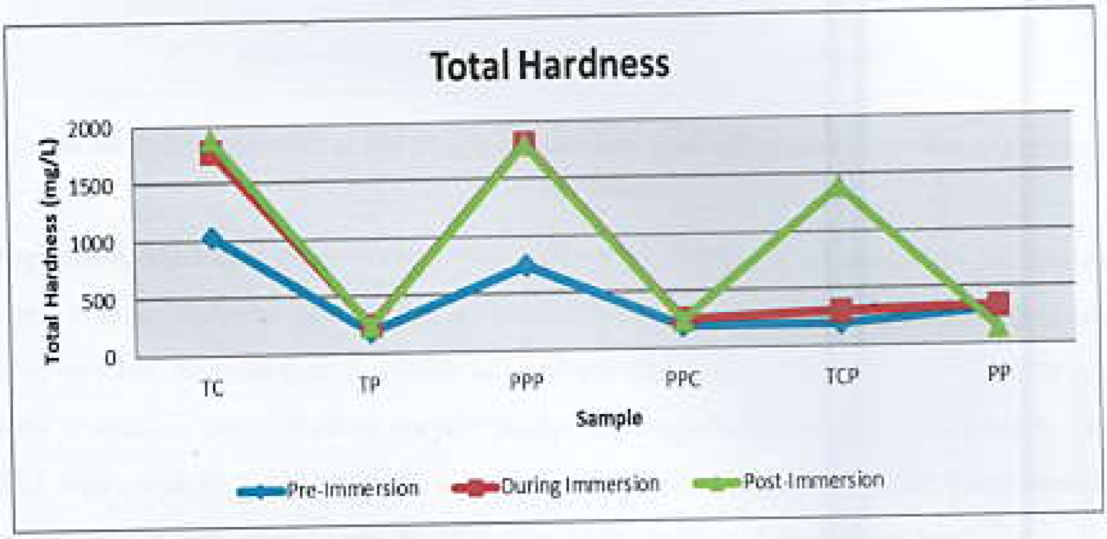
Graph 79.0: Comparative study of pre-immersion, during& post-immersion analysis: DO

lkalinity: In present study it is ranged between 30 mg/L to 50 mg/L during pre-immersion 0-60mg/L during immersion and 40-70 mg/L during post-immersion. It was found that alues of all water samples are within acceptable limit as per the guideline of IS 10500:2012, s shown in Graph No.80.0. Excess alkalinity in water is harmful for irrigation which leads to oil damage and reduce the crop yield.



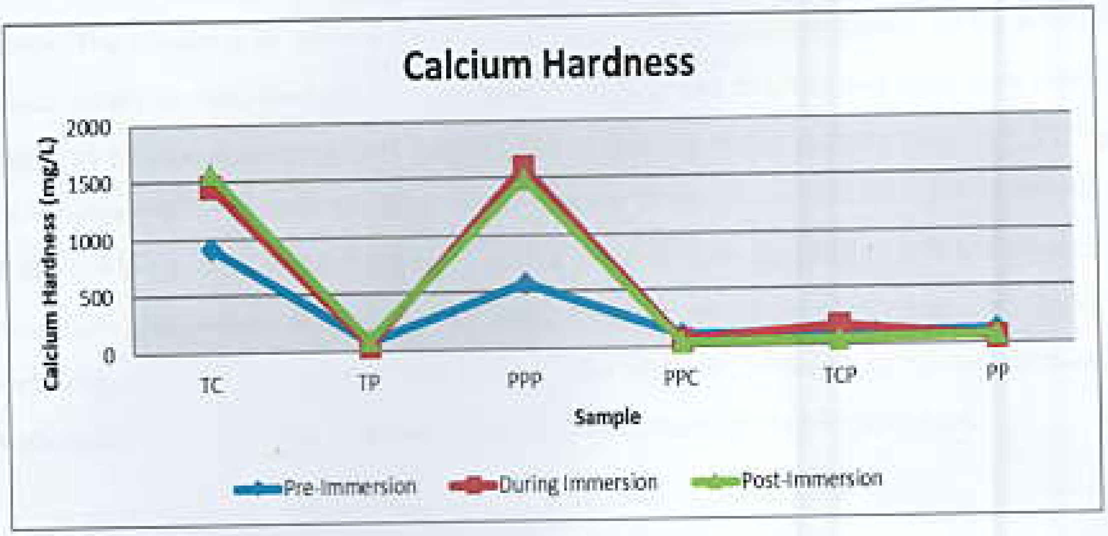
Graph 80.0: Comparative study of pre-immersion, during& post-immersion analysis: Total Alkalinity

tal Hardness: It is defined as the sum of the calcium and magnesium concentrations, both pressed as calcium carbonate, in mg/L. According to IS 10500: 2012 of drinking water ceptable limit is 200 mg/L and permissible limit is 600 mg/L of Total hardness in terms of lcium carbonates. In present study it is ranged between 181 mg/L to 1027 mg/L in pre-mersion, 246.1-1819 mg/L during immersion and 139.1 mg/L to 1883 mg/L during post-mersion respectively. It is observed that total hardness in all water samples are not within ermissible limit except TC and PP, as shown in Graph No. 81.0.



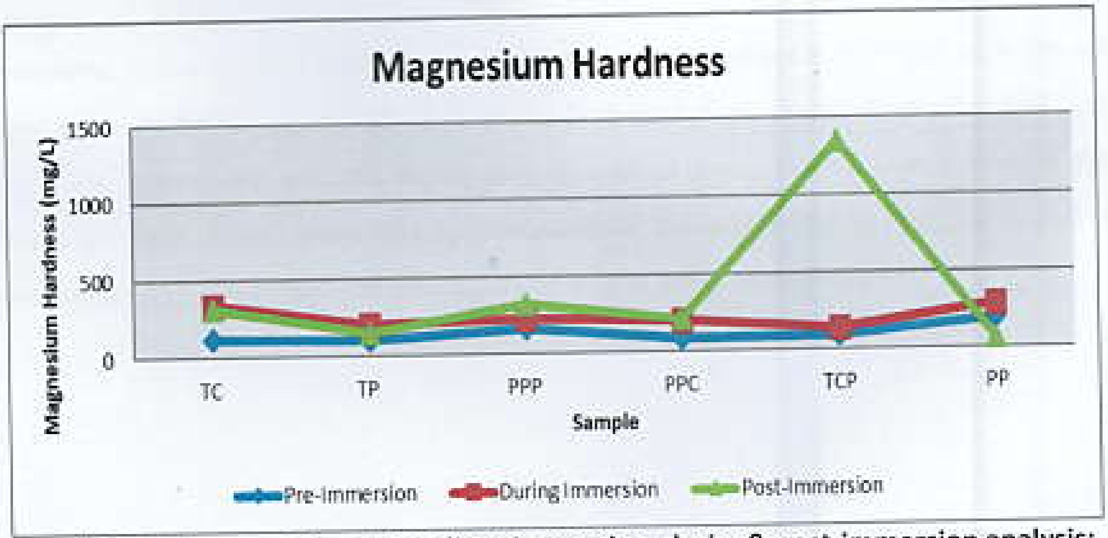
Graph 81.0: Comparative study of pre-immersion, during& post-immersion analysis: Total Hardness

Calcium Hardness: In present study calcium hardness was found to be in the range of 74.9 mg/L to 909.5 mg/L during pre-immersion, 42.8-1594.3 mg/L and 32.1-1572.9 mg/L during post-immersion. According to IS 10500: 2012 of drinking water acceptable limit is 75 mg/L in terms of calcium carbonates. Due to presence of gypsum in PoP made idols maximum Ca hardness were found in sample PPP. The comparative result was depicted in Graph No.82.0.



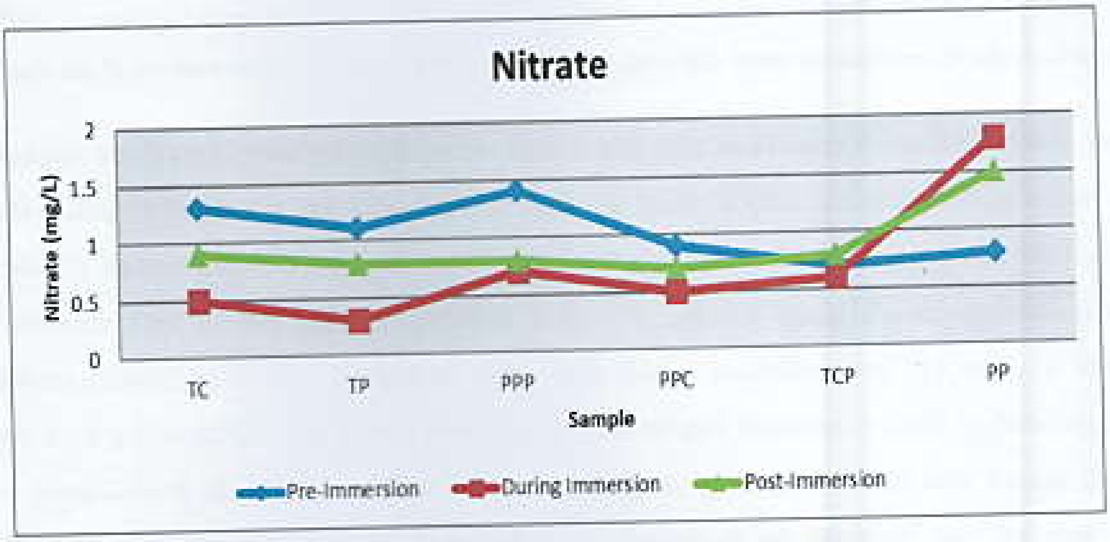
Graph 82.0: Comparative study of pre-immersion, during& post-immersion analysis: Calcium Hardness

Magnesium hardness: Magnesium is an important constituent of seawater and estuarine water. It is an essential constituent of chlorophyll molecule without which no ecosystem could operate. According to IS 10500: 2012 of drinking water acceptable limit is 30 mg/L in terms of calcium carbonates. In present study it is ranged between 85.6-198.4 mg/L, 139.1-331.7 mg/L and 64.2-1347.4 mg/L during pre-immersion, immersion and post-immersion respectively, as shown in Graph No.83.0. The study showed that calcium hardness is higher than magnesium hence it may be suggested that hardness of water is mainly due to salts of calcium



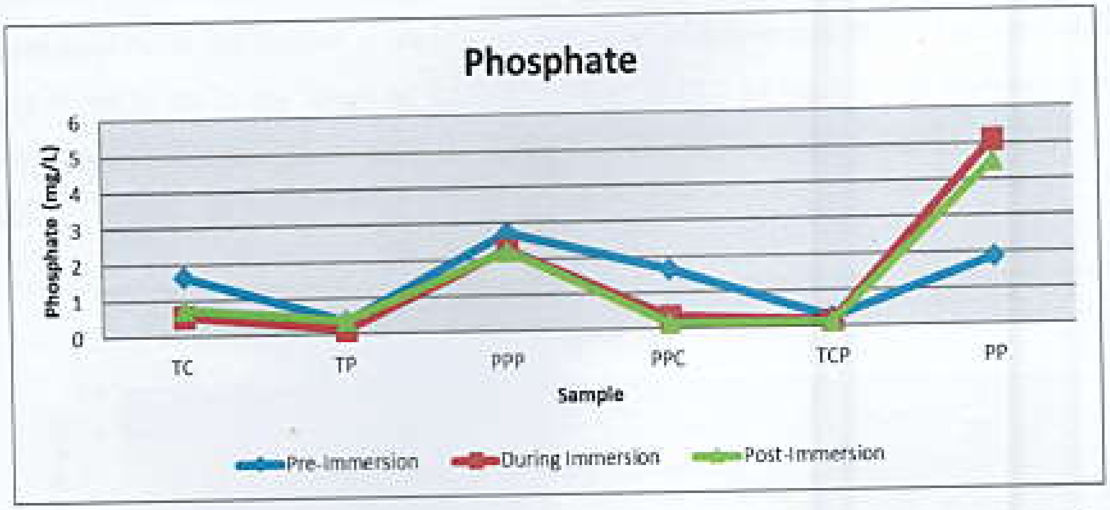
Graph 83.0: Comparative study of pre-immersion, during& post-immersion analysis: Magnesium Hardness

trate: The presence of normal levels of nitrates usually does not have a direct effect on uatic insect or fish. However excess level of nitrate can create conditions that make it fficult to survive. According to IS 10500:2012 of drinking water acceptable limit is 45 mg/L d no relaxation in permissible limit. In the present study nitrate was found in range of0.7–4 mg/L, 0.3-1.8 mg/L and 0.7-1.5 mg/L during pre-monsoon, immersion and post-monsoon spectively. The values of nitrate in all water samples are within acceptable limit which is early shown in Graph No.84.0. This comparative study also reveals that concentration of trate is slightly less during and post immersion as compared to pre-immersion.



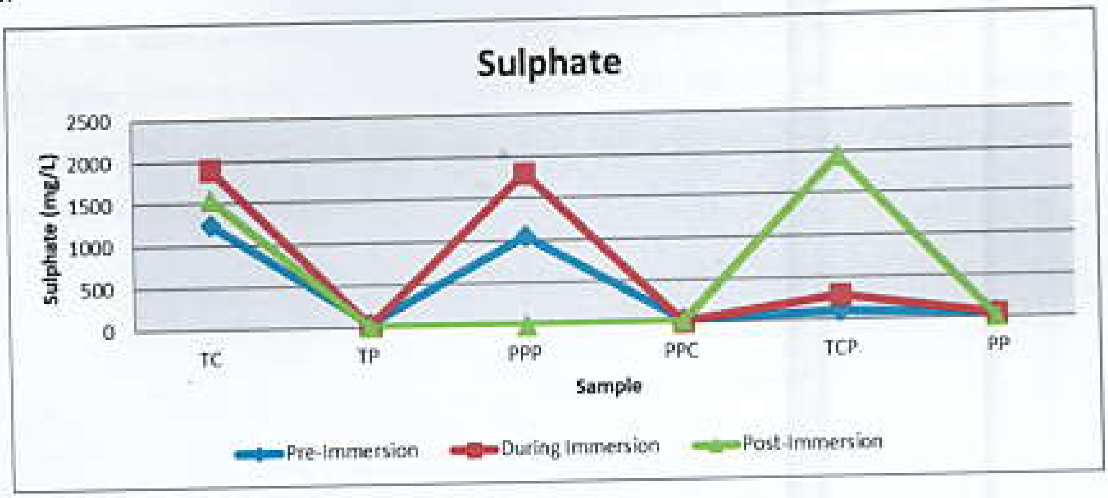
Graph 84.0: Comparative study of pre-immersion, during& post-immersion analysis: Nitrate

Phosphate: In the present study the concentration of phosphate in all water samples were found to be in the range of 0.25- 2.72 mg/L, 0.13-5.13 mg/L in pre-immersion and during immersion respectively whereas during post-immersion it was ranged from 0.14-4.53 mg/L. The comparative studies show that concentration of phosphate during post-immersion was less compared to pre-immersion which may be due to influx of freshwater.



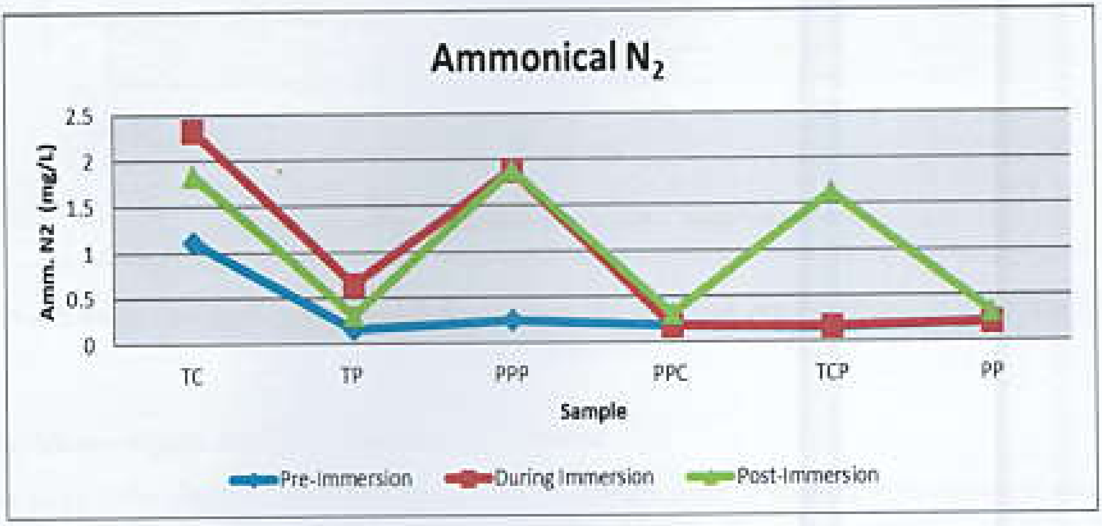
Graph 85.0: Comparative study of pre-immersion, during& post-immersion analysis: Phosphate

Sulphate: Sulphate is widely distributed in nature and may be present in natural waters. The main source of Sulphur is the rocks present near the water-bodies and biochemical action of anaerobic bacteria. According to IS 10500:2012 acceptable limit of Sulphate is 200 mg/L and permissible limit is 400 mg/L in drinking water. In present study the concentration of sulphate ranged between 31 mg/L to 1250 mg/L during pre-immersion, 13 mg/L to 1900 mg/L during immersion and during post-monsoon it ranged between 5 mg/L to 1950 mg/L. The comparative study shows that the concentration of sulphate was less during post analysis except for sample TCP. The higher concentration of Sulphate may be due to presence of chemicals in paints containing sulphur. High concentrations of sulphate stimulate the action of sulphur reducing bacteria, which produces a gas highly toxic to fish life.



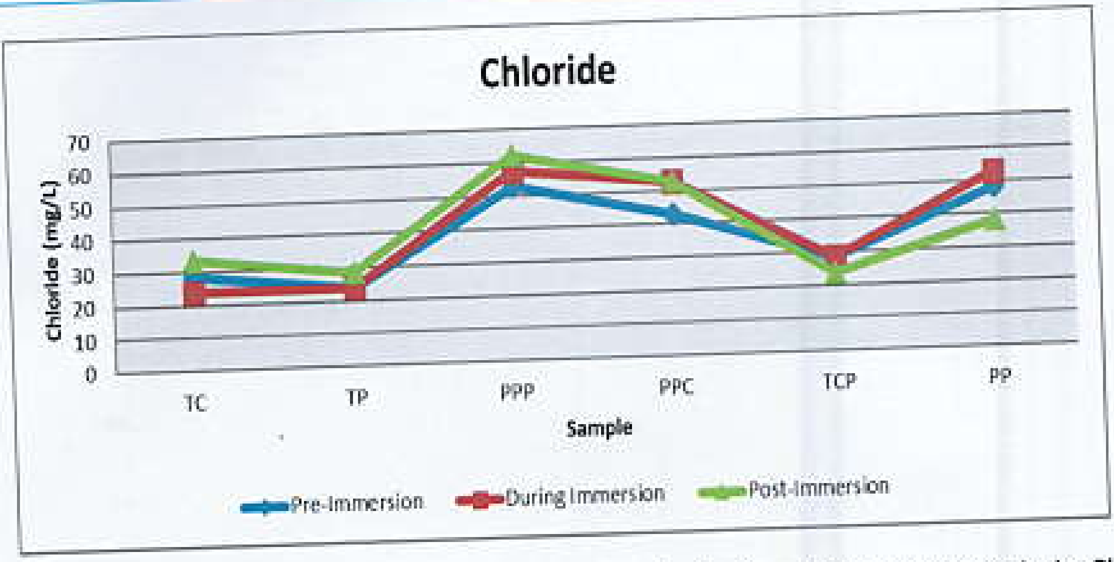
Graph 86.0: Comparative study of pre-immersion, during& post-immersion analysis: Sulphate

Ammonical N_2: In the present study the concentration of Ammonical N_2 in all water samples were found to be in the range of 0.15- 1.11 mg/L, 0.17-2.34 mg/L in pre-immersion and during immersion respectively whereas during post-immersion it was ranged from 0.31-1.88 mg/L.



Graph 87.0: Comparative study of pre-immersion, during& post-immersion analysis: Amm. N_2

Chloride: Chloride is the common anion found in water. Its concentration in natural waters varies from a few milligrams to several thousand milligrams per litre. In coastal region and estuary, seawater intrusion may contribute to the chloride content of inland water. It ranged from 23.9 mg/L to 52.6 mg/L during pre-immersion, 28.7 mg/L to 57.4 mg/L during immersion and 23.9 mg/L to 66.2 mg/L during post-immersion. However, values of all water samples are within acceptable limit during the analysis which is clearly shown in Graph No. 88.0. Higher concentration of chloride was found in PPP, PPC and PP samples as compared to TC, TP and TCP indicating that idols made from PoP and immersed in Prempura Ghat were having higher chloride content.



Graph 88.0: Comparative study of pre-immersion, during& post-immersion analysis: Chloride

10.0 Mineralogical Study of Colours and Pigments

The x-ray diffraction pattern (XRD) of different colours used in making and colouring of the idols were also analysed to study the presence of various mineralogical phases and the likelihood of the impact that they make on immersion in water bodies especially with reference to presence of different types of heavy metals in the synthetic colours. The XRD patterns and their peaks are as given below:

10.1 Mineralogical studies of Golden Colour

In X-ray diffraction (XRD) pattern of Golden colour used in coloring of idols. It was that notable distinct peaks of Nickel Zinc Carbide ($Ni_3ZnC_{0.7}$) 4.7 C (2.11, 1.83, 1.29) and Cadmium Arsenide (Cd_3As_2)F (2.14, 3.49, 1.82) were found.

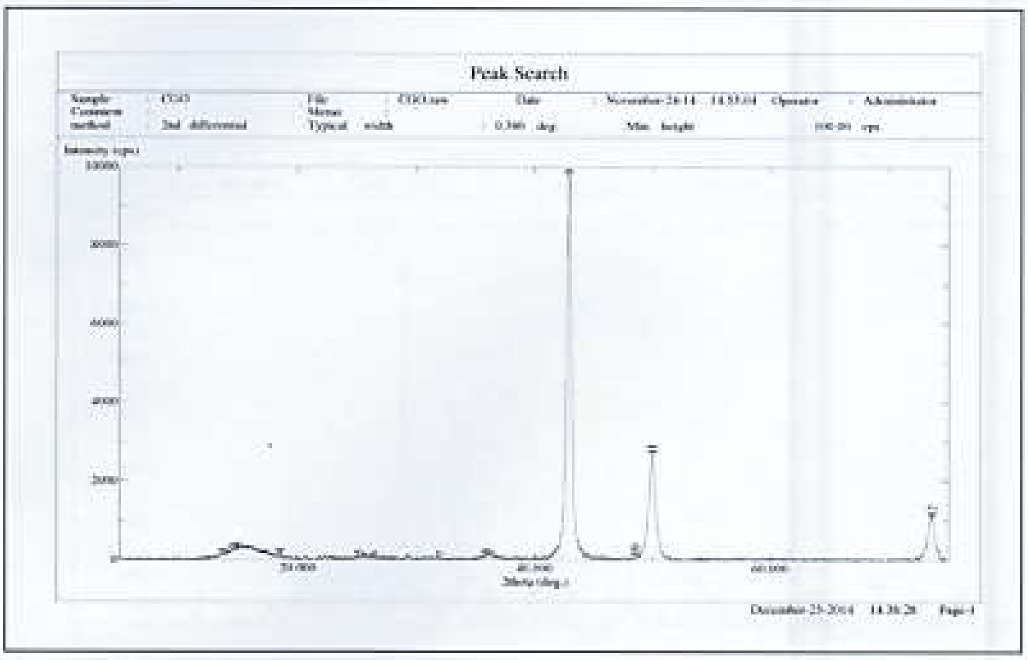


Figure 8.0: X-Ray Diffraction pattern of Golden colour

10.2 Mineralogical Studies of Yellow Colour

In X-ray diffraction (XRD) pattern of yellow colour which is used for coloring idols following peaks were observed:

Titanium Oxide (TiO_2) : 3.51, 2.90, 3.47

Lead Oxide (Pb_2O_3) : 3.03, 2.96, 3.225

Iron Oxide Hydrate ($Fe_2O_3.1.2H_2O$) : 2.52, 1.48, 2.25

Zinc Chromate ($ZnCr_2O_4$) : 2.51, 2.95, 1.47

Chromate (CrO_3) : 3.44, 4.19, 3.38

Strontium Chromate ($SrCrO_4$) : 2.79, 1.93, 4.45

Cinnabar (HgS) : 3.36, 2.86, 1.89

Mercuric Sulphate (Hg_2SO_4) : 3.04, 4.43. 4.18

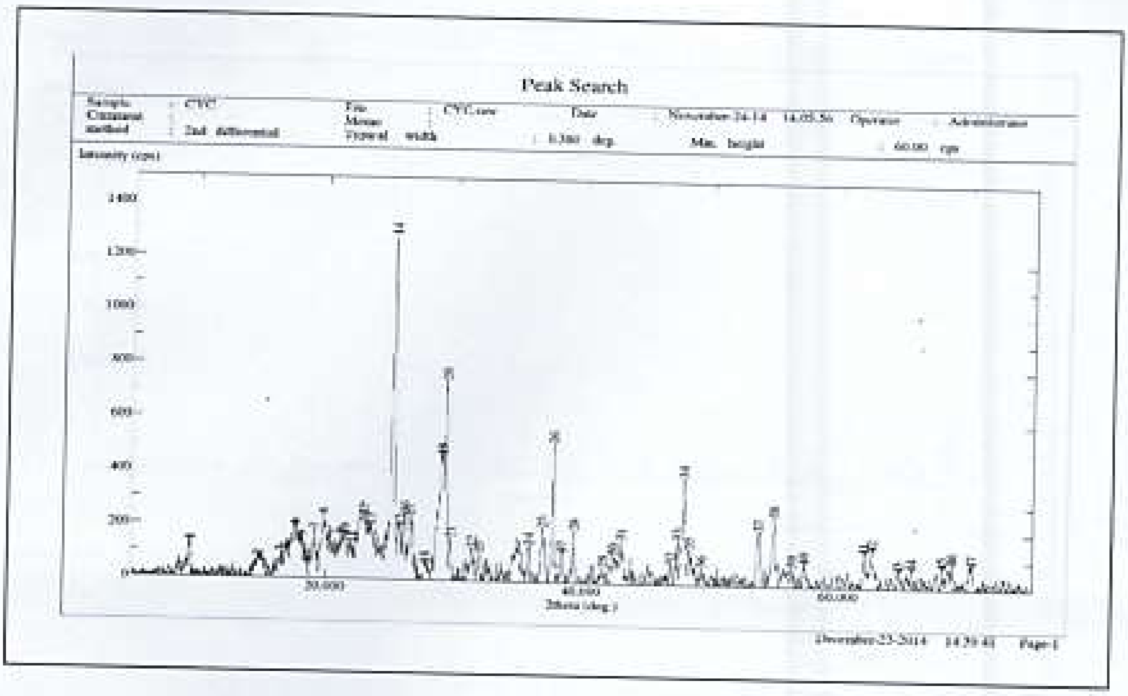


Figure 9.0: X-Ray Diffraction pattern of yellow colour

10.3 Mineralogical studies of Dry Mud and Wet Mud

The X-ray diffraction (XRD) of Dry Mud and Wet Mud which is used for making Ganesh Idols done to study the presence of various mineralogical phases. It was found that Quartz (3.34, .26, 1.82) is present as major constituent in mineral phase followed by Sodium silicate ydrate (4.30, 2.79, 2.56), Magnetite (2.53, 1.49, 2.97) and magnesium Chloride (2.56, 1.82, .96) as minor phases as shown in Figure10.0.

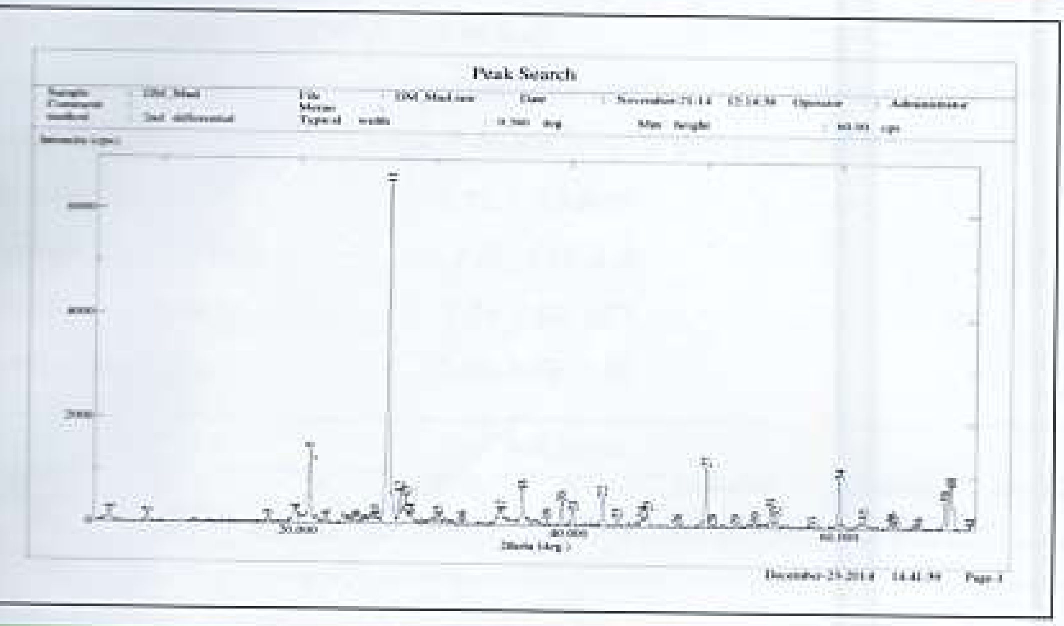


Figure 10.0: X-Ray Diffraction Pattern of Dry Mud

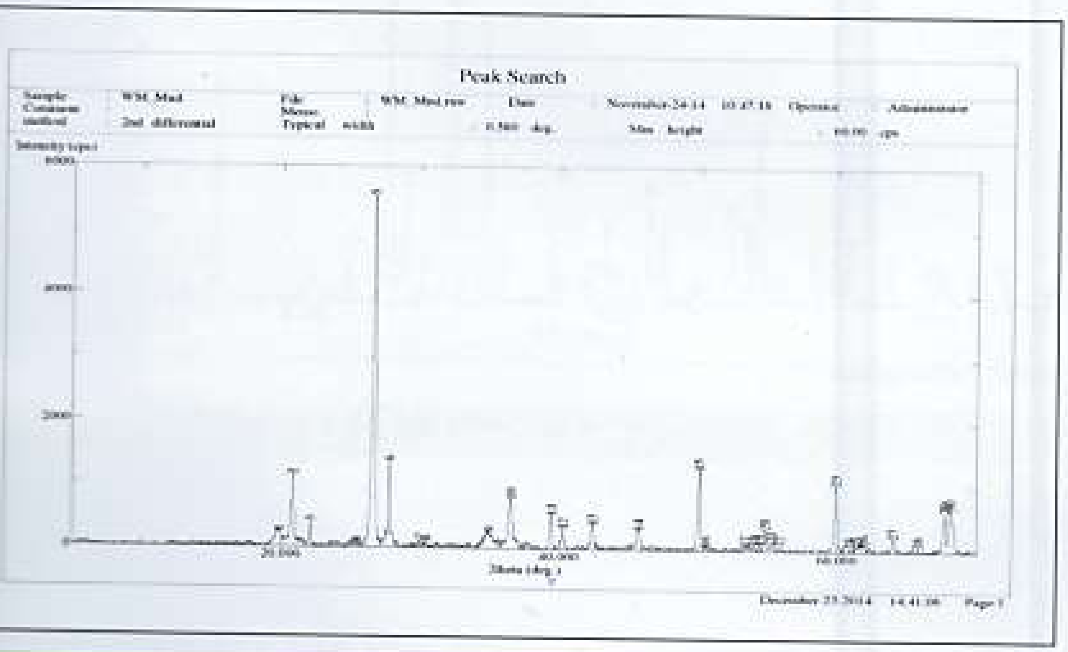


Figure 11.0: X-Ray Diffraction pattern of Wet Mud

0.4 Mineralogical studies of Plaster of Paris

he X-ray diffraction (XRD) of Plaster of Paris used for making idols showed following as ajor constituents in mineral phase followed byminor phases as shown below:

me (CaO) : 2.41, 1.70, 2.78

ypsum ($CaSO_4.2H_2O$) : 2.87, 4.28, 2.68

ri-calcium Silicate (Ca_3SiO_5) :2.79, 2.65, 3.07

alcite ($CaCO_3$) :3.03, 1.87, 3.85

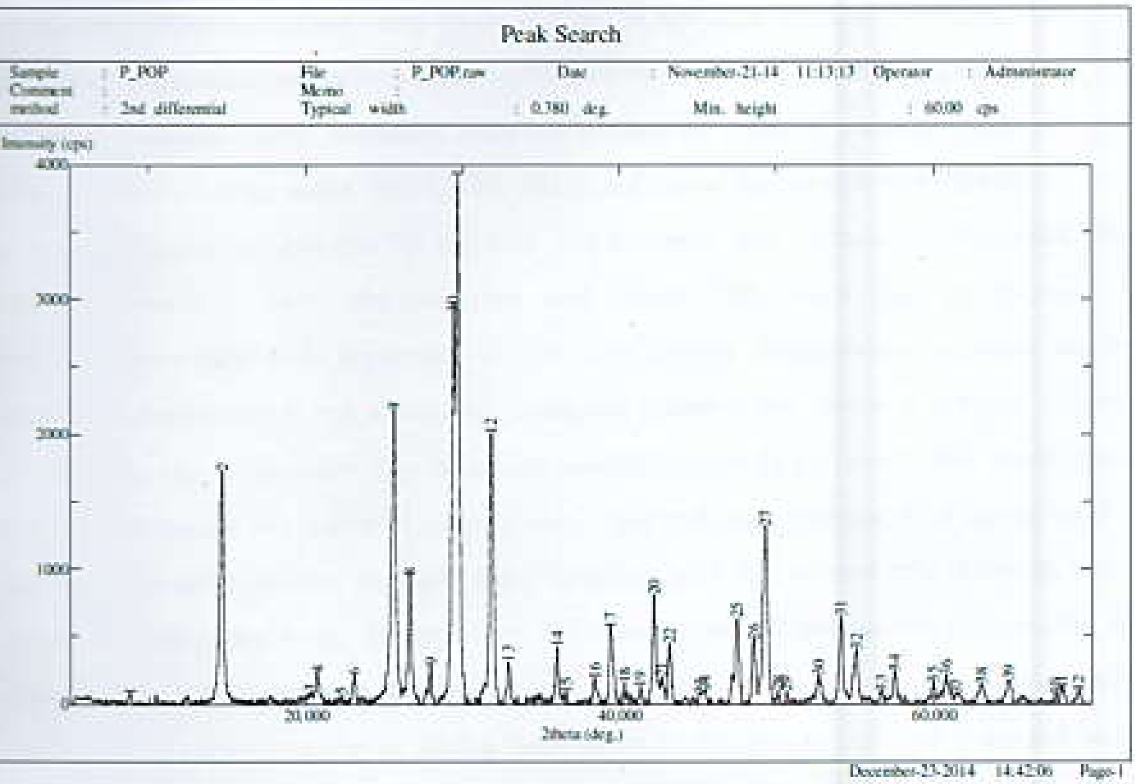


Figure 12.0: X-Ray Diffraction pattern of Plaster of Paris

.0 Conclusions

e present study aims to analyse impact of PoP made idols structure on water bodies. Idols ade from PoP and clay were immersed in water collected from Prempura Ghat, Bhopal as ell as in tap water at CSIR-AMPRI, Bhopal in the laboratory to study the difference in their npacts. Certain physico-chemical parameters were performed in these samples as have een stated above. Based on the study, it was found that idol made from PoP are more armful as compared to that made from clay. Moreover it was also concluded that Idols mmersed in Prempura Ghat were more polluted in terms of physico-chemical parameters nd heavy metals analysis as compared to idols immersed in tap water in the tank.

All the parameters were compared with the acceptable limits of standards as per Indian Standards for drinking water (BIS: 10500, 2012) and found that sample PPP (Prempura Ghat + PoP idol) were not suitable for drinking and domestic use. Samples of Prempura Ghat before immersion were also analysed and found that there was an increase in contamination after idols immersion in the Ghat causing deterioration of water quality.

Plaster of Paris (PoP) is not a naturally occurring material and contains gypsum, sulphur, phosphorus and magnesium. The idols take several months to dissolve in the water and in the process poison the water of lakes, ponds, rives and seas. The chemical paints used to decorate the idols contain mercury, lead, cadmium and carbon and this increases heavy metal content in the water as seen from the results. Several accessories used during the Ganesh Puja like Thermocole, plastic flowers, cloth, incense, camphor and numerous other materials are dumped carelessly adding more strain to the already polluted rivers and lakes. Careless dumping of idols in water bodies blocks the natural flow of water. This results in stagnation and breeding of mosquitoes and other harmful pests. The polluted water causes several diseases including skin diseases. The pollution from idols also damage the ecosystem kills fishes, water plants and aquatic life. In many areas, the same polluted water gets pumped into homes. The metal content present in the idol structures pollute the water bodies and make the water unsafe and unfit for drinking and other purposes.

The overall impact has resulted in deterioration of the water quality, accumulation of toxic chemicals and sediments. The clay/natural soil made idols are more environment friendly in nature. The results have shown that there is marginal increase in heavy metals and other contaminants which affect the capacity and quality of the water bodies. In view of the dverse impacts, natural clay-based idols with eco-friendly and natural colours should be sed in making of the idols so as to preserve the water quality of the water bodies.

.0 Recommendations

ere are several eco-friendly ways that can be adopted to prevent reckless pollution of ter bodies:

- One could reuse the same idol every year and immerse a betel nut instead to symbolically complete the ritual.
- Use eco-friendly clay idols painted with natural colours. Making idols out of naturally occurring materials like clay or sandalwood paste is always a better option, since the idols dissolve completely in water.
- Decorating the idols with garlands, paint synthesized from plant pigments and turmeric.
- Avoid public water bodies to immerse the idols, instead immerse idol in bucket or tub. Immersing the idols in small, closed tanks than water bodies helps controlling the pollution.
- Use permanent idols made of stone and perform a symbolic immersion and reuse the idol each year.