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Physico-Chemical Analysis of Drinking Water Samples from Different Regions of Nagpur and Amravati in Maharashtra State, India

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Abstract

During the last few years, there has been an increasing realization that water resources are limited and must be conserved, leading to the necessity for stringent quality control. Many of the communicable diseases having the greatest impact on mankind are waterborne, and a permanent reduction in morbidity and mortality can most effectively be achieved by providing safe drinking water, Effective water quality management involves systematic programme of sampling and analysis of river, lake and ground water and all stages of waste treatment. Proven and harmonized procedures must be adopted if results are to be reliable, reproducible and comparable. Analytical procedures needed to obtain quantitative information are often a mixture of chemical, bio–chemical, biological, bacteriological, bioassay and instrumental methods. Physicochemical 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 waste water either domestic or industrial to known the pollution strength and its effect on the ecology. River water often necessitates examination of water samples from different points and under varying condition to find out the extent of pollution and natural purification that takes place in the water. Well water are examined to locate the potable sources of water as well as to study the effect of pumping in coastal areas, or in saline water tracts. Waters are also examined to test the samples to ascertain their suitability for particular trade, e.g. paper making, tanning, steam raising, dying, daring etc. In such case a particular parameter assumes importance e.g. for steam raising water should be checked for hardness and dissolved oxygen, water used in textiles should be checked for iron and hardness. Similarly domestic and industrial waste waters are analyzed for various parameters to decide upon what physical, chemical or biological treatment should be given to make them suitable for discharge either on land for irrigation or in other water bodies. Comparatively this analysis for example determination of pH, temperature, DO, COD can be done quick enough to adopt by regulatory agencies to monitor and control the ecological balance of nature. Quantitative analytical procedure fall into three broad groups, viz. gravimetric, volumetric and colorimetric estimations. Advanced techniques of analysis for certain parameters make use of special electrodes, atomic absorption spectrophotometer, chromatography etc. The objectives of the present study was to analyze physicochemical and biological parameters of drinking water samples collected from the selective localities of Maharashtra state to assess health impacts linked with the consumption of drinking water and to suggest possible mitigation measures for the identified problems. Likewise physico-chemical analysis of 45 drinking water samples was carried out to develop a data base on the quality of water being consumed in different areas of Maharashtra state. The drinking water samples were taken from the main water sources where maximum peoples were using them for drinking purpose. Physicochemical analysis of water is categorized as Mineral Analysis consisting of physical parameters and significant anions and cations, Demand Analysis covering COD, BOD, DO, Permanganate value etc., Nutrient Analysis consisting of different forms of nitrogen, phosphorous and Heavy Metal Analysis covering analysis of heavy metals by different methods along with sample pretreatment. Measurement of Temperature, pH, Conductivity, Total Dissolved Solids (TDS), Salinity, Turbidity and Dissolved Oxygen was done by Digital Water and Soil Analysis kit Labtronics Model-191E-an ISO 9001. Different methods were applied to determine the quantities of other components. Most of the water samples were within WHO/ ISI standards. For samples which do not have physico-chemical parameters within desirable limit, treatment for correction of corresponding parameter is to be done. The results of the present research work showed that drinking water collected from different areas of Maharashtra state was found to be suitable for human health. It is recommended to boil water, use aqua guards, proper chlorination, use efficient system for garbage collection and its disposal, sewage waste treatment, recycling of waste into useful products such fertilizers, education of people through media about the causes and consequences of water pollution.

Keywords: Temperature, pH, Conductivity, Total Dissolved Solids, Salinity, Turbidity, Dissolved Oxygen, BOD, COD, Hardness.

Introduction

During the last few years, there has been an increasing realization that water resources are limited and must be conserved, leading to the necessity for stringent quality control. Many of the communicable diseases having the greatest impact on mankind are waterborne, and a permanent reduction in morbidity and mortality can most effectively be achieved by providing safe drinking water. Effective water quality management involves systematic programme of sampling and analysis of river, lake and ground water and all stages of waste treatment. Proven and harmonized procedures must be adopted if results are to be reliable, reproducible and comparable.

Traditional methods employing selective, differential and non-selective media were used to isolate and identify different species of bacteria from rural drinking water reservoirs of Mount Darwin district of Zimbabwe[1]. Quality of water is an important criterion for evaluating the suitability of water for drinking and irrigation. Water quality of dug well, tube well and municipal supply of Vadekkekara Panchayath in Ernakulam District of Kerala state was studied with an objective to assess the water quality status in the study area and its potability. The water quality parameters considered were: colour, odour, turbidity, temperature, pH, electrical conductivity, total dissolved solids, acidity, alkalinity, total hardness, chloride, free CO_2 , dissolved oxygen, biological oxygen demand, chemical oxygen demand, calcium, magnesium, iron, sodium, potassium[2]. The piece of investigation was carried out to study the ground water as well as surface water quality, nutrient status and physico-chemical characteristic of Bargarh district of Orissa, India. Work has been conducted by monitoring two types of ground water i.e. dug well water and bore well water as well as ponds. Attempts were made to study and analyze the physico-chemical characteristics of the water[3]. Study of the Physico-chemical Parameters of Tamadalge Water Tank in Kolhapur District, Maharashtra has been done. Monthly Changes in Physical and Chemical Parameters Such as Water Temperature, Transparency, Turbidity, Total Dissolved Solids, pH, Dissolved Oxygen, Free Carbon dioxide, and Total Hardness, Chlorides, Alkalinity, Phosphate and Nitrates were analyzed[4]. The complete analysis of 15 drinking water samples was carried out to develop a data base on the quality of water being consumed in different areas of Abbottabad district. The qualitative and quantitative analysis of water samples of different localities was conducted to determine the exact amount of different pollutants present in water[5]. The flood of July, 2010 severely influenced on drinking water and environmental sanitation systems in 82 out of 122 districts of Pakistan. As a consequence, several humanitarian organizations launched water supply and environmental sanitation relief and rehabilitation programs in the affected areas. Field standard methods were used to examine drinking water quality of 100 randomly collected samples and communities' needs were investigated by conducting FGDs and personal interviews in two targeted districts (Swat and Sukkur). Moreover, different NGOs' approaches in the provision of drinking water and environmental sanitation services were also critical analyzed[6]. The microbiological quality of sachet and tap water in Enugu, State, and Nigeria was analyzed. All water samples were subjected to bacteriological (aerobic and anaerobic) and fungal studies using standard bacteriological and mycological methods with little modifications. For sachet water, batch of five packets both from the manufacturer and retailers were analyzed and average result taken. Five separate tap water samples were taken from the three different locations. For sachet water, E. coli and S. faecalis were isolated with colony forming units (CFU) ranging from 7 to >500. For tap water, isolates included Coliform, Cl. sp and Penicillium sp[7]. Physico-chemical analysis such as temperature, pH, dissolved Oxygen, TDS, Chloride, Total Alkalinity, Calcium and Magnesium hardness, Sulphate, Phosphate, Nitrate and fluoride of borewells, wells and lacks drinking water has been carried out from fifteen sampling stations of Gandhinagar territory area during June 2011 and Nov 2011 in order to assess water quality index[8]. Physico-chemical analysis such as temperature, salinity, alkalinity, total hardness, phosphate, sulphate, nitrate, pH, electrical conductivity, T.D.S., turbidity, dissolved oxygen, fluoride, chloride of bore-well water was carried out from twenty five sampling stations of Morbi-Malia territory during May-2010 (before monsoon) and October-2010 (after monsoon) in order to assess water quality index[9]. The ground water quality is determined in five blocks (Udwantanagar, Tarari, Charpokhar, Piro and Sahar) that lays in southern parts of district Bhojpur district of Bihar, where from each block ten ground water samples are under studied for Physico - chemical status of ground water. In Physico-chemical analysis, various quality parameter are measured including pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS),total hardness(TH), content of calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride(Cl^-), sulphate (SO_4^{2-}), Iron (Fe), DO, BOD, COD, Total alkalinity (TA) and Nitrate (NO_3^{2-}) concentration present in ground water. Also all parameters were compared with ICMR standards of water quality; also in present research paper classification of water samples of five blocks was investigation on the basis of TDS and TH[10]. Physicochemical and bacteriological analyses of water samples were carried out from five wash borehole used for drinking purpose in Maiduguri Metropolis, Nigeria. The bacteriological analysis was carried out using multiple tube (most probable number) technique for enumeration of both total coliform count and differential Escherichia coli count. The results obtained were compared with World Health Organization (WHO), National Agency for Food and Drug Administration and Control (NAFDAC) and Nigeria Standard of Drinking Water Quality (NSDWQ) standard for drinking water[11]. Water quality of Kamrup district in Assam has been analyzed and it was found that the water in this area is more or less free from any harmful effects[12]. Preventive measures yield much higher cost effective benefits as compared to remedial measures. To verify this hypothesis, a survey was conducted in two different regions of Rawalpindi district of Pakistan by comparing the cost on medication and mitigation expenditures for reduction in the burden of water borne diseases. A field questionnaire was used to estimate the expenditures on disinfection and sanitation. Correlation was worked out between the rate of water related diseases (V_{WRD}), unsafe drinking water (C_{DW}), poor sanitation (P_S), unhealthy personal hygiene and environment (UH_{PHE}). A simulation model "Victim's Rate Calculator" was developed to forecast the estimated number of victims within a population[13].

Over the last few years the concentrations of sulphate and nitrate ions in water have greatly increased in areas that are intensively farmed due to the widespread use of fertilizers such as ammonium sulphate and ammonium nitrate. The quality of water is of vital concern for mankind since it is directly linked with human welfare. The major sources of water pollution are domestic waste from urban and rural areas, and industrial wastes which are discharged into natural water bodies. Water pollution is a stage of deviation from the pure condition, whereby its normal function and properties are affected. Therefore, it is necessary to understand water pollution and its control. Analytical procedures needed to obtain quantitative information are often a mixture of chemical, bio–chemical, biological, bacteriological, bioassay and instrumental methods. Physicochemical 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 waste water either domestic or industrial to known the pollution strength and its effect on the ecology. River water often necessitates examination of water samples from different points and under varying condition to find out the extent of pollution and natural purification that takes place in the water. Well water are examined to locate the potable sources of water as well as to study the effect of pumping in coastal areas, or in saline water tracts. Waters are also examined to test the samples to ascertain their suitability for particular trade, e.g. paper making, tanning, steam raising, dying, daring etc. In such case a particular parameter assumes importance e.g. for steam raising water should be checked for hardness and dissolved oxygen, water used in textiles should be checked for iron and hardness. Similarly domestic and industrial waste waters are analyzed for various parameters to decide upon what physical, chemical or biological treatment should be given to make them suitable for discharge either on land for irrigation or in other water bodies. Comparatively this analysis for example determination of pH, temperature, DO, COD can be done quick enough to adopt by regulatory agencies to monitor and control the ecological balance of nature. Quantitative analytical procedure fall into three broad groups, viz. gravimetric, volumetric and colorimetric estimations. Advanced techniques of analysis for certain parameters make use of special electrodes, atomic absorption spectrophotometer, chromatography etc.

The objectives of the present study was to analyze physicochemical and biological parameters of drinking water samples collected from the selective localities of Maharashtra state to assess health impacts linked with the consumption of drinking water and to suggest possible mitigation measures for the identified problems.

Materials and Methods

Collection of water samples: During water quality investigation, the selection of sampling points is more important than actual chemical analysis of water. A successful sampling program entails the selection of sampling points in line with objective of the study. Since various natural and man-made factors are responsible for water pollution. Therefore, there is no general rule that governs the selection of sampling sites. For the purpose of water quality estimation, the selection of sampling sites require, on a prior basis, extensive investigation and field survey of such factors/sources, such as waste discharges, natural and man-made pollutants, chemical treatments, underground water resources, agro wastes, seasonal variations, surface runoff, geographic weathering, etc. In addition, full information on population density around a given water source and behavioral aspects of people is also required. For this purpose, all different locations/sampling sites were outlined and drinking water samples were taken from the main water sources where maximum peoples were using them for drinking purpose. The samples were analyzed as soon as it was possible. A total of 45 water samples were collected. The sources and locations of samples are given in Table-1.

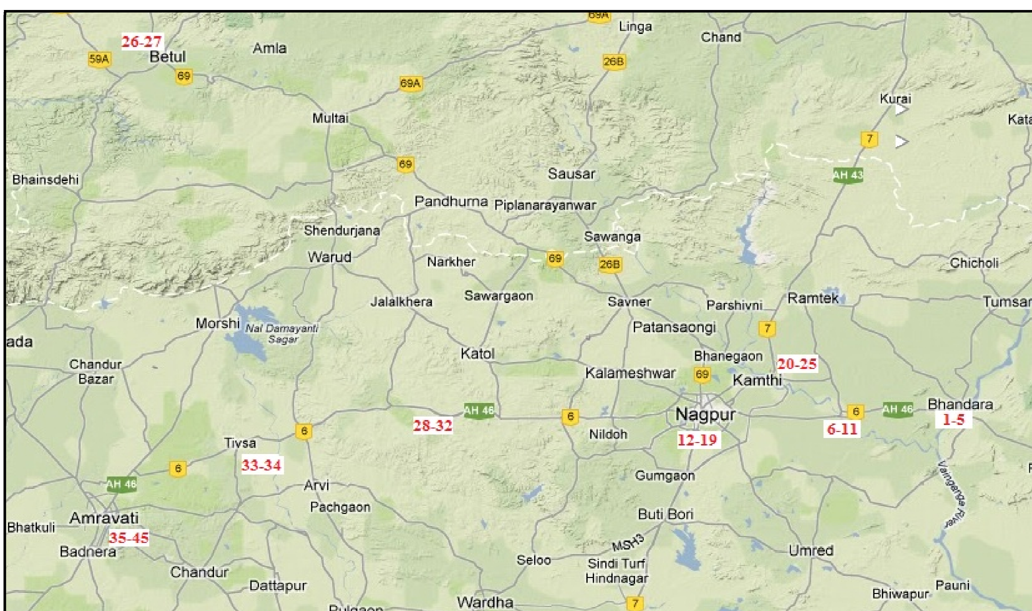

Figure-1
Location of water samples

Table-1
Location of water samples

Sample No.	Source	Location
1	River water	Vainganga river, Bhandara
2	Water supply from Vainganga River	Azad ward, Bhandara
3	Well Water	Azad ward, Bhandara
4	Bore well water	Azad ward, Bhandara
5	Well Water	Karbi district, Bhandara
6	Bore well water	Marodi, Mauda
7	River water	Kanhan river, Mauda
8	Bore well water	Malgaon
9	Well water	Malgaon
10	Water supply from Kanhan River	Pardi
11	Well water	Kharbi square, Nagpur
12	Pond water	Sonegaon Talao, Nagpur
13	Water supply from Pench Prakalp	Nagpur Municipal Corporation, Nagpur
14	Well water	Somalwada, Nagpur
15	Aquagard water of well water	Somalwada, Nagpur
16	Bore well water	Sawarkar Nagar, Nagpur
17	Pond water	Ambazari Talao, Nagpur
18	Tap Water	Ambazari Talao, Nagpur
19	Pond water	Futara Talao, Nagpur
20	River water	Kanhan river, Kamptee
21	Bore well water	Kamptee
22	Pond water	Koradi
23	Bore well water	Koradi
24	Well water	Koradi
25	Bore well water	Thermal power station, Koradi
26	Water supply from Mandai River	Chincholi, District Betul, Madya Pradesh
27	Bore well water	Chincholi, District Betul, Madya Pradesh
28	Bore well water	Gondkheri
29	Well water	Gondkheri
30	Bore well water through Tank	Kondali
31	Bore well water	Kondali
32	Well water	Talegaon
33	Well water	Tiwsa
34	Well water through Tank	Mozari
35	Well water	Tahsil office, Amravati
36	Water supply Upper Wardha Prakalp	Amravati Municipal Corporation, Amravati
37	Bore well water	Sharda Nagar, Amravati
38	Bore well water	Durga Vihar, Amravati
39	Well water	Adarsha Nagar, New Amravati
40	Well water	Railway station, New Amravati
41	Tank Water	Water purification centre, MIDC, Amravati
42	Pond water	Chatri Talao, Amravati
43	Pond water	Wadali Talao, Amravati
44	Well water	Gadge Nagar, Amravati
45	Bore well water	Panchwati, Amravati

Physicochemical analysis of water is categorized as Mineral Analysis consisting of physical parameters and significant anions and cations, Demand Analysis covering COD, BOD, DO, Permanganate value etc., Nutrient Analysis consisting of different forms of nitrogen, phosphorous and Heavy Metal Analysis covering analysis of heavy metals by different methods along with sample pretreatment.

Mineral Analysis: Temperature: Measurement of temperature is an important parameter required to get an idea of self purification of rivers, reservoirs and control of treatment plant. Water temperature is also important parameter for fish life. It is the important factor for calculating the solubility of oxygen and carbon dioxide, bicarbonate and carbonate equilibrium. The temperature of drinking water has an influence on its taste.

pH: The pH of natural water usually lies in the range of 4.4 to 8.5. Its value is governed largely by the carbon dioxide / bicarbonate / carbonate equilibrium. It may be affected by humid substances by changes in the carbonates equilibrium due to the bioactivity of plants and in some cases by hydrolysable salts. The effect of pH on the chemical and biological properties of liquids makes its determination very important. It is used in several calculations in analytical work and its adjustment is necessary for some analytical procedures. The pH determination is usually done by electrometric method which is the most accurate method and free of interference.

Conductivity: Conductivity measurement gives rapid and practical estimate of the variations in the dissolved mineral contents of water supply.

Turbidity: Turbid waters are undesirable from aesthetic point of view in drinking water supplies and may also affect products in industries. Turbid water also poses a number of problems in water treatment plants. Turbidity is measured by an instrument called Turbidimeter.

Colour: Colour is determined by visual comparison of the sample with known concentration of coloured solution. Colour is expressed in terms of Hazan standard unit.

Floatables: For evaluating the possible effect of waste disposal into surface waters, one of the important criterions is the amount of floatable materials in the waste. Two general types of floatables are particulate matter that includes “grease balls” and liquid components capable of spreading as a thin highly visible film over large areas. They are measured with the help of Floatable sampler with mixer and Floatable oil tube. The minimum detectable concentration is approximately 1 ppm.

Solids: All solids are measured gravimetrically except settleable solids by volume and Total dissolved solids by specific conductance.

Acidity: Water containing mineral acidity (due to H_2SO_4, HCl and HNO_3) are unacceptable. Further, acid water pose problem of corrosion and interfere in water softening. Acidity can be calculated by neutralizing samples to pH 4.3.

Alkalinity: Alkalinity values provide guidance in applying proper doses of chemicals in water and waste water treatment processes, particularly in coagulation, softening and operational control of anaerobic digestion. Alkalinity of sample can be estimated by titrating with standard sulphuric acid.

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, sewage discharges, irrigation drainages etc. Each of these sources may result in local contamination of both surface water and ground water. Chloride is determined by titration with standard silver nitrate.

Fluorides: Fluoride ions have dual significance in water supplies. High concentration of Fluoride causes dental fluorisis (Disfigurement of the teeth). At the same time, a concentration less than 0.8 mg / L results in dental caries. Hence, it is essential to maintain the Fluoride concentration between 0.8 to 1.0 mg / L in drinking water. For the determination of fluoride ion in water, the colorimetric method (SPADNS) is the most satisfactory and applicable to variety of samples. Under acid condition fluorides (HF) react with zirconium SPADNS solution and the colour of reagent gets bleached due to formation of ZrF_6. Since bleaching is a function of fluoride ions, it is directly proportional to the concentration of fluoride.

Sulphate: Sulphate ions usually occur in natural waters. Many sulfate compounds are readily soluble in water. Most of them originate from the oxidation of sulfite ores, the solution of Gypsum and anhydride, 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) produced by the photocatalytic oxidation of sulphur dioxide comes with water vapors to form sulphuric acid which is precipitated as acid rain or snow. Sulfate causes a problem of scaling in Industrial water supplies, and problem of odour and corrosion in waste water treatment due to its reduction to H_2S. Sulphate ions are precipitated as $BaSO_4$ in acidic media (HCl) with Barium Chloride. The absorption of light by this precipitated suspension is measured by spectrophotometer at 420 nm.

Hardness: Hardness of water is caused by dissolved polyvalent metallic ions. In fresh water, the principal hardness causing ions are calcium and magnesium. However, the iron strontium, iron, barium and manganese also contribute to hardness. Although hardness is caused by cations, it may also be discussed in term of carbonate (temporary) and non - carbonate (permanent) hardness. Carbonate hardness refers to the amount of carbonate 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. Non - carbonate hardness is caused by the association of the hardness causing cation with sulfate, chloride or nitrate and is referred to as "permanent hardness" because it cannot be removed by boiling. In alkaline condition, EDTA reacts with Ca and Mg to form a soluble chelated complex. Ca and Mg ions develop wine red colour with eriochrome black T under alkaline condition. When EDTA is added as a titrant, Ca and Mg divalent ions get complexed resulting in a sharp change from wine red to blue which indicates end point of the titration. The pH of this titration has to be maintained at 10. At a higher pH i.e. about 12 Mg^{++} ion precipitates and only Ca^{++} ion remains in solution. At this pH Murexide 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.

Demand Analysis: Dissolved oxygen: All living organisms are dependent upon oxygen in one form or other to maintain the metabolic processes that produce energy for growth and reproduction. Aerobic processes are the subject of great interest for their need for free oxygen. Dissolved oxygen (DO) is also important in precipitation and dissolution of inorganic substances in water. It is necessary to know DO levels to assess quality of raw water and to keep a check on stream pollution. In liquid waste dissolved oxygen is the factor that determines whether the biological changes are brought out by aerobic or anaerobic organisms.

Biochemical Oxygen Demand: The Biochemical Oxygen Demand (BOD) test is widely used to determine the pollutional load of waste waters, the degree of pollution in lakes and streams at any time and their self purification capacity and efficiency of waste water treatment methods. The test is mainly a bio-assay procedure, involving measurement of O_2 consumed by bacteria while stabilizing organic matter under aerobic conditions.

Chemical oxygen Demand: Chemical Oxygen Demand (COD) test determine the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The organic matter gets oxidized completely by $K_2Cr_2O_7$ in the presence of H_2SO_4 to produce CO_2 and H_2O. The excess $K_2Cr_2O_7$ remaining after the reaction is titrated with $Fe(NH_4)_2(SO_4)_2$. The dichromate consumed gives the O_2 required for oxidation of the organic matter.

Nutrient Analysis: Nitrogen (Total): Presence of nitrogen is of a great significance in sanitary engineering practices in many respects; prior to introduction of bacteriological analysis procedures, determination of various forms of nitrogen in water was done to assess its bacteriological quality. Presence of organic and ammonia nitrogen (total nitrogen) is accepted as a chemical evidence of recent organic pollution particularly of animal origin. Presence of nitrogen in appropriate amount in waste water is necessary for its treatment through biological processes. Knowledge of nitrogen in waste waters is important when it is used as an irrigant. In the presence of sulphuric acid mercuric sulfate catalyst organically bound nitrogen gets converted into ammonium sulfate. Potassium sulfate is added to raise the boiling point of sulfuric acid from 345^oC to 370^oC. The digestate is diluted, made alkaline with NaOH and distilled. The liberated ammonia is absorbed in boric acid. The absorbed ammonia is determined by titration.

Nitrogen (Ammonia): Ammonia is produced by the microbiological degradation of organic nitrogenous matter. It appears therefore, in many ground as well as surface waters. Concentrations of Ammonia above a certain level in water polluted either due to sewage or industrial wastes are toxic to fishes. Ammonia produces a yellow coloured compound when reacted with alkaline Nessler reagent, provided the sample is clarified properly. Pre-treatment with $ZnSO_4$ and NaOH precipitates Ca, Fe, Mg and sulfide and removed turbidity and and apparent colour. Addition of EDTA (before Nessler reagent) or Rochelle salt solution prevents precipitation of residual Ca and Mg in the presence of alkaline Nessler reagent.

Nitrogen (Nitrite): Nitrite in waters is either due to oxidation of ammonium compounds or due to reduction of nitrate. Higher concentrations are present in industrial wastes, sewage and in biologically purified effluents and in polluted streams. Nirite is determined through formation of a reddish purple azodye produced at pH 2-2.5 by compling diazotized sulphanilic acid with N-(1-Naphthyl) ethylenediamine dihydrochloride (NED-dihydrochloride).

Nitrogen (Nitrate): Nitrate is the most highly oxidized form of nitrogen compounds commonly present in natural waters, because it is the product of the aerobic decomposition of organic nitrogenous matter. Significant sources of nitrate are chemical fertilizers, decayed vegetable and animal matter, domestic effluents, sewage sludge disposal to land, industrial discharge and leachates from refuse dumps and atmospheric washout. Depending on the situation, these sources can contaminate streams, rivers, lakes and ground water, especially wells. Nitrate reacts with phenol disulphonic acid and produces a nitro derivative which in alkaline solution develops yellow colour due to rearrangement of its structure. The colour produced follows Beer's law and is proportional to the concentration of NO_3 present in the sample.

Phosphate - Total and other forms: Presence of phosphates in water and waste water analysis has a great significance. Phosphates 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 microorganisms. Though phosphate possess problems in surface waters, its presence is necessary for biological degradation of waste waters. 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. The intensity of the blue colored complex is measured which is directly proportional to the concentration of phosphate present in the sample.

Metal Analysis: Estimation of metals in potable water, domestic waste water industrial effluents is very important because, some metals are essential where as others may adversely affect water consumers, waste water treatment systems or the biological systems of water bodies. Some metals may be either beneficial or toxic depending on their concentrations. Metals may be determined satisfactorily by Atomic Absorption Spectrophotometer, Polarography or Colorimetric methods.

Arsenic: Arsenic occurs naturally in all environmental media and is usually present in the form of compounds with sulfur and with many metals. Most of the arsenic found in water derives from industrial discharges, the higher concentration, other than those occuring naturally in spring waters are usually in areas of high industrial activity. The determination of arsenic has been of importance to public health agencies for many years because of the toxicity of arsenic compounds. Arsenic in water is carcinogenic. Inorganic arsenic is reduced to arsine, AsH_3 by zinc in acid solution. The arsine is then passed through a scrubber containing glass wool impregnated with lead acetate solution and into an absorber tube containing silver diethyl dithio carbamate (SDDC) dissolved in pyridine. In the absorber, arsenic reacts with the silver salt of SDDC forming a soluble red complex which is measured spectrophotometrically at 535 nm.

Cadmium: Cadmium is uniformly distributed in trace amounts in the earth's crust. Generally Zinc ores contain small amounts of cadmium. Cadmium is highly toxic and responsible for several cases of poisoning through food. Small quantities of Cd cause adverse changes in the arteries of human kidneys. Cadmium enters water through industrial discharges or the deterioration of galvanized pipes. Cadmium ions under suitable conditions react with dithizone to form pink to red colour that can be extracted with chloroform. The color obeys Beers law and the cadmium concentration can be obtained from calibration curve prepared from a standard cadmium solution treated in the same manner as the sample.

Chromium: Most rocks and soil contains small amounts of chromium. Because of low solubility, the levels found in water are usually low. However, there are examples of contamination of water, in some cases serious, in which effluents containing chromium compounds have been discharged to rivers. Organic matter is destroyed. Chromium is oxidized by permanganate to chromate. Chromate forms a violet complex with sym-diphenylcarbazide. Efficiency oxidation can be checked by running color development with a known quantity of trivalent chromium.

Copper: Metallic copper is used in alloys for making cooking utensils, extensively in the electrical industry and for pipes and many other purposes due to its high conductivity or corrosion resistance. Water treatment processes usually result in the removal of trace metals from water but the copper concentration in drinking water at the consumer's tap can be higher than in either the source water or the treated water entering the supply. Various chemical and physical characteristics of the distributed water influence the leaching of copper from the distribution system and house hold plumbing. The presence of copper in the water supply may interfere with the intended domestic uses of water. Copper is an essential element in human metabolism. However, intake of excessively large doses leads to severe mucosal irritation and corrosion wide spread capillary damage, hepatic and renal damage and central nervous system irritation followed by depression. Cuprous ion in neutral or slightly acidic solution reacts with neocuproine to form a complex in which 2 moles of the neocuproine are bound by 1 mole of Cu^+ ion. The complex can be extracted by an organic liquids chloroform-methanol mixture, to give a yellow solution. The colour system follows beer's law. The sample is treated with hydroxylamine-hydrochloride to reduce copper to the cuprous condition and with sodium citrate to complex metallic ions that might give precipitates when the pH is raised. The pH is adjusted to 4 to 6 by the addition of ammonia, a solution of neocuproine in methanol is added and the resultant complex is extracted into chloroform. After dilution of the chloroform to an exact volume with methanol, the absorbance of the solution is measured at 457 nm.

Results and Discussion

Result of mineral analysis is given in Table-2, Demand Analysis and Nutrient Analysis is given in Table-3.

While analysis of As, Cd, Cr and Cu metal shows its absence in all water sample. Desirable limit of drinking water for various parameters are Temp 25^{o}C, pH 6.5-8.5, Turbidity 5 NTU, Colour 5 Hazen Units, Total Dissolved Solids 500 ppm, Salinity 100 ppm, Alkalinity 200 ppm, Chloride 250 ppm, Fluoride 1 ppm, Sulfate 200 ppm, Total Hardness 300 ppm, Calcium Hardness 75 ppm, Magnesium Hardness 30 ppm, Dissolved Oxygen 3 ppm and above, BOD 2 ppm and above, COD 250 ppm, Nitrogen 10 ppm, Ammonia 5 ppm, Nitrite 10 ppm, Nitrate 45 ppm, Phosphate 5 ppm, Arsenic 0.01 ppm, Cadmium 0.01 ppm, Copper 0.05 ppm, Chromium 0.05 ppm. Most of the water samples were within WHO / ISI standards. For samples which do not have physico-chemical parameters within desirable limit, treatment for correction of corresponding parameter is to be done.

Table-2a
Mineral Analysis

Sample No	Temp °C	pH	Conductance m.s./cm (mMhos/cm)	TDS ppt (g/litre)	Salinity ppt (g/litre)	Turbidity NTU	Colour Units	Floatables		Solids					
								Particulate Floatables ppm	Floatable Oil & Grease ppm	Total Solids (A) ppm	Total Volatile Solids (B) ppm	Total Suspended (nonfiltrable) Solids (C) ppm	Volatile suspended (nonfiltrable) Solids (D) ppm	Total Dissolved (Filtrable) solids (A-C) ppm	Settleable solids ppm
1	26.7	8.37	0.30	0.19	0.0	3	1	1	0.1	191.5	0	1.5	0	190	0.1
2	25.1	8.05	0.30	0.19	0.0	0	0.1	0	0	190	0	0	0	190	0
3	26.3	7.26	1.65	1.05	0.9	1	0.2	0.1	0	1052	1	2	0.1	1050	0.2
4	28.0	7.15	0.73	0.48	0.3	6	0	0	0	480	0.1	0	0	480	0
5	28.3	7.56	0.94	0.61	0.4	2	0.3	0	0	611.7	0	1.7	0.1	610	0.3
6	28.0	7.10	0.88	0.58	0.4	1	0	0	0	580	0	0	0	580	0
7	28.3	8.47	0.45	0.29	0.1	2	0.5	0.2	0.1	290	0.2	0	0	290	0
8	29.8	6.93	2.20	1.45	1.3	15	0.1	0	0	1452	0.3	2	0.2	1450	0.1
9	29.1	7.37	1.12	0.73	0.6	2	0.1	0	0	731.2	0	1.2	0	730	0
10	29.0	8.13	0.49	0.31	0.2	0	0	0	0	310	0.4	0	0	310	0
11	29.0	7.64	2.28	1.50	1.4	0	0	0.1	0	1502.1	2	2.1	0.3	1500	0.4
12	28.1	9.97	0.30	0.19	0.0	12	2	0.3	0.2	190	0	0	0	190	0
13	26.5	8.30	0.28	0.18	0.0	0	0	0	0	180	0	0	0	180	0
14	27.8	7.30	1.10	0.74	0.6	0	0	0	0	741	0.2	1	0	740	0
15	26.6	7.36	1.06	0.70	0.5	1	0	0	0	701.4	0.2	1.4	0	700	0
16	28.3	7.25	0.59	0.38	0,2	0	0	0	0	380	0	0	0	380	0
17	26.7	8.41	0.41	0.27	0.1	4	0.1	0	0	271.1	0	1.1	0	270	0
18	26.5	8.06	0.29	0.19	0.0	0	0	0	0	190	0	0	0	190	0
19	25.0	8.11	0.48	0.31	0.1	6	1	0	0.2	311.4	0	1.4	0	310	0

20	28.8	8.37	0.75	0.49	0.3	3	0.4	0.2	0	490.1	0.1	0.1	0	490	0
21	29.3	7.03	2.57	1.69	1.5	1	0	0	0	1693.4	1.5	3.4	0.1	1690	0.2
22	29.0	8.56	0.46	0.29	0.1	2	2	1	0.3	291.6	0	1.6	0	290	0
23	29.6	8.28	0.30	0.18	0.0	3	0	0	0	180	0	0	0	180	0
24	29.8	8.10	0.62	0.39	0.2	0	0.2	0	0	391	0.2	1	0	390	0
25	29.8	7.52	0.79	0.51	0.3	6	0	0	0	512	0.1	2	0	510	0
26	27.0	6.84	1.66	1.09	0.9	9	0	0	0	1091.1	1.2	1.1	0.4	1090	0.1
27	27.3	6.94	1.96	1.27	1.1	0	0	0	0	1270.1	0.9	0.1	0	1270	0
28	28.6	7.74	1.33	0.87	0.7	0	0	0	0	871	0.3	1	0.2	870	0
29	28.6	7.70	0.91	0.59	0.4	0	0	0	0	590.2	0.4	0.2	0	590	0
30	28.7	7.26	1.08	0.71	0.5	0	0.1	0	0	710.6	0.9	0.6	0	710	0
31	28.7	9.02	0.78	0.51	0.3	0	0	0	0	510	0.1	0	0	510	0
32	28.7	7.80	0.63	0.41	0.2	1	0.1	0	0	410.3	0	0.3	0	410	0
33	28.7	7.43	1.31	0.86	0.7	0	0.2	0	0	860.5	0.1	0.5	0	860	0
34	28.6	7.40	0.69	0.45	0.3	0	0	0	0	450.1	0	0.1	0	450	0
35	29.9	7.04	1.57	1.07	1.0	1	0	0	0	1070	1	0	0	1070	0
36	24.3	8.05	0.29	0.19	0.1	0	0	0	0	190.4	0	0.4	0	190	0
37	24.3	7.34	1.31	0.86	0.8	0	0	0	0	860.2	0.2	0.2	0	860	0
38	24.3	8.40	0.87	0.57	0.5	0	0	0	0	570.2	0	0.2	0	570	0
39	24.3	7.79	1.0	0.67	0.6	0	0	0	0	670	0.1	0	0	670	0
40	26.5	7.53	1.39	0.97	0.9	1	0	0	0	970	0.1	0	0	970	0
41	27.7	7.95	1.12	0.74	0.7	1	0	0	0	741	0.1	1	0.1	740	0.1
42	27.1	8.67	0.33	0.22	0.1	5	2	0.7	0	220.3	0	0.3	0	220	0
43	28.5	8.86	0.41	0.27	0.1	13	3	0.1	0	270	0	0	0	270	0
44	25.4	8.10	1.20	0.86	0.7	0	0	0	0	700	0.1	0	0	700	0
45	24.4	7.50	0.94	0.71	0.6	0	0	0	0	600.2	0.1	0.2	0	600	0

Note: Measurement of Temperature, pH, Conductivity, Total Dissolved Solids (TDS), Salinity, Turbidity done by Digital Water and Soil Analysis kit Labtronics Model-191E-an ISO 9001.

Table-2b
Mineral Analysis

Sample No	Acidity due to CO_2 as $CaCO_3$ ppm	Alkalinity as HCO_3^- ppm	Cloride (Cl^-) ppm	Fluoride (F^-) ppm	Sulphate (SO^{4-}) ppm	Hardness				
						Total Hardness as $CaCO_3$ ppm (A)	Calcium Hardness as $CaCO_3$ ppm (B)	Magnesium Hardness as $CaCO_3$ ppm (A) - (B)	Alkaline Hardness as $CaCO_3$ ppm	Non Alkaline Hardness as $CaCO_3$ ppm
1	10	270	0	0.6	50	170	100	70	0	170
2	30	255	9.2	0.6	50	130	80	50	0	130
3	90	675	87.6	0.7	45	425	200	225	0	425
4	30	420	23.0	0.6	42	270	150	120	0	270
5	30	630	23.0	0.7	43	380	170	210	0	380
6	80	645	13.8	0.9	44	345	145	200	0	345
7	40	300	18.4	0.8	45	150	80	70	0	150
8	100	525	230.4	0.8	39	300	110	190	0	300
9	90	600	69.1	0.7	40	360	200	160	0	360
10	20	330	18.4	1.0	45	130	88	42	0	130
11	50	540	202.8	1.0	40	315	90	225	0	315
12	10	195	9.2	1.2	54	95	70	25	0	95
13	20	225	4.6	2.1	13	101	92	9	0	101
14	60	540	78.4	0.8	20	312	110	202	0	312
15	70	570	78.4	0.8	20	270	110	160	0	270
16	40	375	18.4	0.9	24	225	90	135	0	225
17	30	225	36.9	0.8	30	125	77	48	0	125
18	20	225	9.2	0.8	30	135	100	35	0	135
19	60	345	23.0	1.4	40	170	95	75	0	170

20	70	435	46	0.9	45	235	125	110	0	235
21	60	375	308.8	0.6	40	165	105	60	0	165
22	20	270	27.6	1.6	50	105	70	35	0	105
23	30	225	9.2	1.2	30	90	65	25	0	90
24	40	390	32.2	0.7	25	215	115	100	0	215
25	70	315	55.4	0.7	25	105	60	45	0	105
26	60	330	147.4	0.8	58	155	85	70	0	155
27	120	525	170.6	0.8	60	275	135	140	0	275
28	20	480	106.0	0.7	32	255	133	122	0	255
29	50	480	41.5	0.6	33	240	155	85	0	240
30	50	330	73.7	0.9	20	180	112	68	0	180
31	10	45	106.0	1.0	20	40	30	10	0	40
32	40	300	13.8	0.7	25	160	99	61	0	160
33	60	540	32.3	0.6	25	290	170	120	0	290
34	50	510	18.4	0.9	28	310	165	145	0	310
35	70	540	331.8	1.1	16	270	170	100	0	270
36	10	225	6.9	0.6	0	119	83	36	0	119
37	40	555	103.7	0.8	33	349	92	257	0	349
38	10	105	138.3	0.8	53	92	73	19	0	92
39	30	570	59.9	2.5	7	349	110	239	0	349
40	60	300	281.2	0.9	20	100	70	30	0	100
41	50	585	327.2	0.9	18	385	200	185	0	385
42	30	270	9.2	1.1	40	145	98	47	0	145
43	30	330	87.6	1.0	42	155	80	75	0	155
44	40	500	90.6	1.2	15	200	90	110	0	200
45	30	225	110.5	0.8	40	100	80	20	0	100

Note: Measurement of Temperature, pH, Conductivity, Total Dissolved Solids (TDS), Salinity, Turbidity done by Digital Water and Soil Analysis kit Labtronics Model-191E-an ISO 9001.

Table-3
Demand Analysis and Nutrient Analysis

Sample No.	DO		BOD ppm	COD ppm	Nitrogen Total N ppm	Nitrogen Ammonia NH_3 ppm	Nitrogen Nitrate NO_2^- ppm	Nitrogen Nitrate NO_3^- ppm	Total Dissolved and Suspended forms of Phosphates (A)			Total Dissolved and Suspended organophosphorus (1)-[(2)+(3)] ppm (4)	Filtrable (Dissolved) forms of Phosphates (B)			Filtrable (Dissolved) Organo Phosphorus (5)-[(6)+(7)] ppm (8)	Particulate Phosphate (A) –(B)			Particulate Organophosphorous (4) –(8) ppm (12)
	DO_0 ppm	DO_5 ppm							Total Dissolved and Suspended forms of Phosphates ppm (1)	Total Dissolved and Suspended Orthophosphates ppm (2)	Total Dissolved and Suspended Acid hydrolyzable Phosphates ppm (3)		Filtrable (Dissolved) Phosphate ppm (5)	Filtrable (Dissolved) Orthophosphate ppm (6)	Filtrable (Dissolved) Acid hydrolyzablephosphate ppm (7)		Total Particulate Phosphate (1) –(5) ppm (9)	Particulate Orthophosphate (2) – (6) ppm (10)	Particulate Acid Hydrolyzable Phosphate (3) –(7) ppm (11)	
1	6.6	6.1	5	10	6	0	4	12	3	1.5	0.5	1.0	2	1.0	0.2	0.8	1	0.5	0.3	0.2
2	6.5	6.0	5	5	4	0	3	8	2	1.0	0.2	0.8	1.5	0.8	0.1	0.6	0.5	0.2	0.1	0.2
3	5.9	5.6	3	3	2	0	0	3	1	0.6	0.1	0.3	0.7	0.5	0	0.2	0.3	0.1	0.1	0.1
4	5.9	5.8	1	2	2	0	1	4	0.5	0.2	0.1	0.2	0.4	0.2	0.1	0.1	0.1	0	0	0.1
5	6.1	5.6	5	4	8	0	2	5	1.4	0.9	0.4	0.1	1.1	0.8	0.3	0	0.3	0.1	0.1	0.1
6	6.5	6.1	4	4	3	0	1.2	3.8	0.7	0.3	0.1	0.3	0.6	0.2	0.1	0.3	0.1	0.1	0	0
7	7.1	6.1	10	15	2.2	0	2	4	2.8	1.2	0.6	1.0	2.6	1.1	0.5	1.0	0.2	0.1	0.1	0
8	6.4	6.2	2	2	1.4	0	0	2	0.9	0.4	0.1	0.4	0.8	0.3	0.1	0.4	0.1	0.1	0.0	0.0
9	7.0	6.1	9	4	1.9	0	0	3	1.8	1.0	0.3	0.5	1.7	1.0	0.3	0.4	0.1	0.0	0.0	0.1
10	7.1	6.2	9	6	4	0	0.8	6	2.0	1.2	0.4	0.4	1.8	1.1	0.3	0.4	0.2	0.1	0.1	0.0
11	6.8	6.2	6	8	9	0	0.2	13	1.6	0.8	0.5	0.3	1.5	0.8	0.4	0.3	0.1	0.0	0.1	0.0
12	7.4	6.4	10	15	6.4	0	0.1	8	2.5	1.4	0.8	0.3	2.4	1.4	0.7	0.3	0.1	0.0	0.1	0.0
13	7.0	6.5	5	2	3.2	0	0	4	0.4	0.2	0.1	0.1	0.3	0.2	0.1	0.0	0.1	0.0	0.0	0.1
14	7.0	6.4	6	4	4.5	0	0.3	6.8	1.6	0.7	0.4	0.5	1.5	0.6	0.4	0.5	0.1	0.1	0.0	0.0
15	7.0	6.4	6	2	4.0	0	1.0	6.0	1.5	0.9	0.5	0.1	1.4	0.9	0.4	0.1	0.1	0.0	0.1	0.0
16	7.0	6.4	6	4	3.8	0	1.1	4.5	1.0	0.5	0.2	0.3	0.9	0.4	0.2	0.3	0.1	0.1	0.0	0.0
17	6.9	6.3	6	8	5.2	0	2.3	6.0	1.2	0.6	0.3	0.3	1.0	0.5	0.2	0.3	0.2	0.1	0.1	0.0
18	6.9	6.7	2	7	5.0	0	2.2	7.8	1.2	0.6	0.3	0.3	1.0	0.5	0.2	0.3	0.2	0.1	0.1	0.0

19	6.6	6.3	3	20	8.6	0	3.4	10.4	3.5	2.5	0.5	0.5	3.4	2.5	0.4	0.5	0.1	0.0	0.1	0.0
20	7.7	6.4	13	12	7.7	0	3.0	8.9	2.9	2.1	0.4	0.4	2.8	2.1	0.3	0.4	0.1	0.0	0.1	0.0
21	6.7	6.4	3	6	4.6	0	2.9	6.7	0.8	0.4	0.1	0.3	0.7	0.4	0.1	0.2	0.1	0.0	0.0	0.1
22	7.1	6.2	9	22	11.0	0	4.6	12.2	3.8	2.6	0.6	0.6	2.6	2.5	0.5	0.6	0.2	0.1	0.1	0.0
23	7.2	6.4	8	20	10.5	0	4.1	11.4	3.6	2.5	0.5	0.6	3.5	2.5	0.4	0.6	0.1	0.0	0.1	0.0
24	6.7	6.0	7	6	4.0	0	0	5.6	1.6	0.9	0.3	0.4	1.6	0.9	0.3	0.4	0.0	0.0	0.0	0.0
25	6.6	6.0	6	4	3.8	0	0	4.0	0.8	0.4	0.1	0.3	0.7	0.3	0.1	0.3	0.1	0.1	0.0	0.0
26	6.8	5.8	10	16	8.0	0	1.2	9.0	3.8	2.5	0.5	0.8	3.7	2.5	0.4	0.8	0.1	0.0	0.1	0.0
27	6.8	6.3	5	12	4.0	0	0	5.9	2.0	1.1	0.4	0.5	2.0	1.1	0.4	0.5	0.0	0.0	0.0	0.0
28	6.4	6.3	1	5.6	3.2	0	0	4.0	0.9	0.6	0.2	0.1	0.8	0.6	0.1	0.1	0.1	0.0	0.1	0.0
29	6.4	6.1	3	7.2	4.8	0	0.8	5.6	1.2	0.6	0.3	0.3	1.2	0.6	0.3	0.3	0.0	0.0	0.0	0.0
30	6.4	6.2	2	6.0	2.2	0	0	3.0	0.8	0.4	0.2	0.2	0.7	0.3	0.2	0.2	0.1	0.1	0.0	0.0
31	6.2	6.1	1	4	2.0	0	0	4.0	0.8	0.4	0.2	0.2	0.8	0.4	0.2	0.2	0.0	0.0	0.0	0.0
32	6.3	6.3	0	8.9	6.5	0	1.4	8.1	1.2	0.6	0.3	0.3	1.1	0.5	0.3	0.3	0.1	0.1	0.0	0.0
33	6.1	6.0	1	8.0	5.4	0	2.1	7.0	1.6	0.8	0.5	0.3	1.5	0.8	0.5	0.2	0.1	0.0	0.0	0.1
34	6.6	6.1	5	6.0	4.4	0	0.4	6.0	1.3	0.7	0.4	0.2	1.3	0.7	0.4	0.2	0.0	0.0	0.0	0.0
35	8.5	5.6	29	4.0	1.0	0	0	2.0	0.6	0.3	0.1	0.2	0.6	0.3	0.1	0.2	0.0	0.0	0.0	0.0
36	3.8	0.3	35	3	1.0	0	0	2.0	0.2	0.1	0.0	0.1	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0
37	5.8	0.6	52	5	2.0	0	0	3.5	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
38	3.0	0.3	2	5	1.4	0	0	3.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
39	3.4	1.2	22	8	1.2	0	0	2.6	1.0	0.6	0.3	0.1	0.9	0.5	0.3	0.1	0.1	0.1	0.0	0.0
40	5.0	4.7	3	10	4.0	0	1.0	6.2	1.2	0.7	0.4	0.1	1.1	0.6	0.4	0.1	0.1	0.1	0.0	0.0
41	6.7	3.5	32	2	1.0	0	0	2.1	0.3	0.2	0.1	0.0	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0
42	9.2	3.5	57	16	9.2	0	2.8	10.6	3.9	1.4	0.9	1.6	3.8	1.4	0.9	1.5	0.1	0.0	0.0	0.1
43	10.9	0.9	100	12	8.6	0	2.3	9.4	4.0	2.5	1.0	0.5	3.9	2.5	0.9	0.5	0.1	0.0	0.1	0.0
44	4.0	2.6	14	9	3.0	0	0	5.2	1.1	0.6	0.4	0.1	1.0	0.6	0.4	0.0	0.1	0.0	0.0	0.1
45	4.2	0.4	38	5	1.8	0	0	3.2	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Note: Measurement of Dissolved Oxygen done by Digital Water and Soil Analysis kit Labtronics Model-191E-an ISO 9001

Conclusion

Physico-chemical analysis of 45 drinking water samples was carried out to develop a data base on the quality of water being consumed in different areas of Maharashtra state. The drinking water samples were taken from the main water sources where maximum peoples were using them for drinking purpose. Measurement of Temperature, pH, Conductivity, Total Dissolved Solids (TDS), Salinity, Turbidity and Dissolved Oxygen was done by Digital Water and Soil Analysis kit Labtronics Model-191E-an ISO 9001. Different methods were applied to determine the quantities of other components. Most of the water samples were within WHO / ISI standards. For samples which do not have physico-chemical parameters within desirable limit, treatment for correction of corresponding parameter is to be done.

The results of the present research work showed that drinking water collected from different areas of Maharashtra state was found to be suitable for human health. It is recommended to boil water, use aqua guards, proper chlorination, use efficient system for garbage collection and its disposal, sewage waste treatment, recycling of waste into useful products such fertilizers, education of people through media about the causes and consequences of water pollution.

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