MINOR RESEARCH PROJECT

Under XII Plan Guidelines (2012-17)

Project title

"Study on the quality of drinking water of some major residential areas of Tumkur town with reference to human welfare."

15-16 MRP 14-15 / KATU008 / UGC-SWRO 4th February 2015

Final report
Submitted to
The Joint Secretary and Head
South Western Regional Office (SWRO)

ज्ञान - विज्ञानं विमुक्तये

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ಶ್ರೀ ಸಿದ್ಧಗಂಗಾ ಕಲಾ, ವಿಜ್ಞಾನ ಮತ್ತು ವಾಣಿಜ್ಯ ಮಹಿಳಾ ಕಾಲೇಜು, ಬಿ.ಹೆಚ್. ರಸ್ತೆ, ತುಮಕೂರು-

NAACAccredited "A" Grade

Ref. No. SSCW:

DECLARATION AND CERTIFICATE

I hereby declare and certify that the Minor research Project entitled "Study on the quality of drinking water of some major residential areas of Tumkur town with reference to Human welfare" 15-16 MRp14-15/KATU008/UGC SWRO 4th February 2015 is a bonafide record of research work carried out by me during the year 2015-2017.

I further certify that the work presented in the report is original and carried out according to the plan in the proposal and guidelines of the University Grants Commission.

Principal Investigator

ACKNOWLEDGEMENT

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I'm grateful and thankful to my family members, my parents, husband and children without whose support this work would not have been possible.

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Principal Investigator

INTRODUCTION

The quality of water is vital concern for mankind since it is directly linked with human welfare. The present investigations involve the analysis of Physico-Chemical parameters of drinking water supply to the residents of Tumakuru town and evaluate its suitability for drinking with respect to BIS guide lines. Unsafe drinking water accounts for mortality and susceptibility to water borne microbial infectious diseases due to improper management and environmental degradation. Poor quality of water affects badly the plant growth and human health (Subba Rao, 2005, WHO 1992, Karanth 1997).

The main aim of this study was to carry out tests on different physico-chemical parameters of water samples collected from different locations of Tumakuru town and to recommend whether it is suitable for drinking and domestic purpose.

The surface water system is an important source of water for human activities and it is under severe environmental stress as a consequence of developmental activities. Freshwater resource is at a faster rate of deterioration day by day and is now a global problem. (Singh Abujam et al., 2010).

Water quality is a measure of its suitability for human consumption, irrigation, recreation, pisciculture and other purposes. Water quality of surface water and ground water is affected directly or indirectly by the leachates from farm fields, discharge of domestic waste, washing of animals, cloths and decaying of flora in the water body, (Shivanna et al., 2015). It is a critical factor affecting human health and welfare. Water meant for drinking must therefore meet quality standards. Water quality is essentially described according to its Physical, Chemical and biological characteristics (Rafiullah Khan et al., 2012). To assess that, monitoring of these parameters is essential to identify magnitude and source of any pollution load.

WQI has been regarded as one of the most effective way to assess the quality of water and is communicated on the basis of calculated water quality indices (Pradhan et al; 2001). WQI is defined as a rating reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of suitability of water for human consumption. It is a single number like a grade that express the overall water quality at a certain area and time based on several water quality parameters.

A water quality index is a means to summarize a large amounts of water quality data into simple terms (ex: Excellent, good, poor, very poor, unsuitable for drinking) for reporting to management and public in a consistent manner .

The requirement of water to all organisms from micro organisms to human being is a serious challenge because all water resources are polluted due to unplanned urbanization and industrialization, (Rajagopal 2010).

Physico-chemical characteristics are highly important with regard to the occurrence and abundances of species. Discharge of urban, industrial and agricultural wastes have increased the quantum of various chemicals that enter the receiving water body which considerably alter physico-chemical characteristics, (Kiran.B.R.2010).

World health organization survey has revealed that 1.2 billion people all over the world do not have access to pure and safe drinking water. Unsafe drinking water accounts for mortality and susceptibility to water borne microbial infectious diseases due to improper management and environmental degradation. Lack of awareness, unscientific methods of waste disposal, improper water management and negligence damaged not only the aquatic systems but also its biological composition . According to W H O [1984] 30% to 40% of human diseases occurred due to impurities of water. World Health Organization at a regional meeting at Delhi in November 1979 called for protected water supply covering 100% of population and effective sanitation covering 80% of urban and 50% of the rural population.

Inadequate management of water resources directly or indirectly resulted in the degradation of hydrological environment, (Karanth 1989). Any change in physico-chemical characteristics of water not only alters its quality, but also disturbs aquatic environment and ecological balance. Therefore a periodical monitoring of water quality is necessary to take appropriate steps for water resource management practices.

The world's total quantity of water is estimated to be about 1.36 x108 million hectare meters. About 97.2% of this water is contained in the oceans as salt water and only about 2.8% is available as fresh water on the earth. Out of the 2.8% of fresh water, around 2.2% is available as surface water and the rest (0.6%) is available as ground water. Out of the 2.2% of available fresh water, around 2.15% is in glaciers and ice caps. Out of the remaining 0.05% of fresh water, 0.01% is available in lakes and streams and the remaining 0.04% is in the other forms. In the 0.6% of stored ground water, only about 0.25% can be extracted economically with the available drilling technology and the remaining is at greater depth of the earth's crust.

Contamination of ground water resource poses a substantial risk to local resources user and the natural environment. Heavy metals designate a group of elements that occur in natural system in minute concentration and when present in sufficient quantities are toxic to living organisms (Verma et al., 1995). The behavior of trace metals in ground water is complicated and is related to geochemical process. In elemental condition, some metals are essential for normal functioning of the human body, while others are non essential (Shivashankaran et al., 1997).

As the people here purely depend on ground water resource mainly for drinking purpose, the most important source of organic matter in waters are disposals of municipal sewage, industrial waste waters, urban and rural run off and detritus formed by indigenous primary and secondary products. The municipal sewage consists of mainly of human excreta and other organic matter (rout et al 2001), average raw sewage contains usually 1% solids which remains both suspended and dissolved, out of these 70% are of organic matter in nature and remainder are in organic forms, of the organic constituents 65% are nitrogenous (mainly proteins) 25% are carbohydrates and 10% are fats (Tebbut, 1977).

India has presently the sewer facilities for about 2% of its population (Rao, 1981) and the sewage generated in class I –cities gets some kind of treatment for only 25% of the total volume. Industrial waste waters are important sources of organic pollutions of different nature (Sharma et al.,2002).

The BOD of urban' runoff is highly variable its residues as high as 7700mg/l have been reported in certain areas (Mason;1981) the excreta of aquatic animals also contains several refractory organic compounds, though there trace causes mainly aesthetic problems; recently it has been found that some of them can produce chloroform or other halo methane's in water (Sawyer and McCarty, 1978).

The sodium content of ground water is a function of weathering sodium plagioclase from bed rock followed by exchange of calcium Ca^{+2} for sodium on the surface newly formed clays minerals. In addition ground water contains large amount of sodium rock and soil. The common source of sodium levels in the ground water are erosions of salt deposits and sodium bearing rock minerals, Due to brackish water of some aquifers, salt water intrusion in to wells in coastal areas, infiltration of surface water contaminated by road salts, irrigation, sewage effluents and land fills precipitation, leaching through soils high in sodium. (Clarke ; 1924).

OBJECTIVES:

1. To know the physio-chemical properties of drinking water.
2. To know and understand biological components of ground water.
3. To find the inter-relationship between various physico-chemical characteristics and inturn to understand the impact of these physico-chemical factors on biological components.
4. In case water is found not fit for drinking purpose, to suggest the remedies to reduce the pollution load.

Review of Research and Development in the Subject:
International status and National Status:

In India, more than three million people get affected or die of enteric diseases every year. The menace of water borne diseases and epidemics still threatens the wellbeing of a population, particularly in developing countries. Thus, the quality as well as quantity of clean water supply is of vital significance for the welfare of mankind. It is therefore necessary that the quality of water be monitored at regular intervals.

The disposal of huge quantities of solid waste by open dumping leads to environmental degradation. The solid waste is dumped in low lying areas which come in contact with groundwater or rainwater resulting in generation of leachate that contains organic and inorganic substances. This also contributes to the contamination of groundwater **(Vogi et al, 1985)**.

Lakshmanan et al, (1986) have investigated the drinking water quality with respect to nitrate and fluoride concentration in twin cities of Hyderabad and Secunderbad.

Higher level nitrate concentration has been reported in dug wells and shallow tube wells penetrating the alluvial aquifers of the Indo-Gangetic plain which is an intensively cropped and irrigated area **(Handa, 1994)**.

Rai and Sharma (1995) reported on the microbial quality of ground water utilized for drinking in the rural areas of northwest Uttar Pradesh.

Madhusudhana Reddy (1995) studied hydro geoenvironment of industrial polluted zones in Visakhapatnam area and found ground water with total dissolved solids, total hardness, total alkalinity, calcium, magnesium, chloride, sulfate, Fe, Mn, Cu, Pb and Cd in excess of ISI recommended values due to the impact of industrial effluents. These high values can be deleterious to the health of human beings and thus corrective measures are necessary.

Weathering of rocks contribute carbonate and bicarbonate salts. In areas of non-carbonate rocks, the HCO_3^- and CO^-_3 originates entirely from the atmosphere and soil CO_2, whereas in areas of carbonate rocks, the rock itself contributes approximately 50% of the carbonate and bicarbonate presence **(Chapmann, 1998)**.

Calcium and magnesium are essential for normal human growth. It has been found in several epidemiological investigations in the USA and European countries that drinking water hardness i.e., concentration of calcium and magnesium is inversely associated to cardiovascular mortality in particular and adult mortality in general **(Sonneborne et al, 1983)**. These investigations have revealed that the presence of calcium and magnesium in the drinking water supplies might prove beneficial to humans. Magnesium is common in natural water as Mg^{2+} and along with calcium, contributes to water hardness. Magnesium arises principally from the weathering of rocks containing ferromagnesium minerals and from some carbonate rocks. Magnesium occurs in many organo-metalic compounds and inorganic matter, since it is an essential element for living organisms **(Sawyer et al, 1978; Kannan, 1991)**.

A high profile of fluoride in groundwater has been observed in 4.6% of geographical areas of Karnataka **(Sumalatha et al, 1999).** Sporadic incidence of high fluoride content in groundwater has been reported from India, China, Sri Lanka, West Indies, Spain, Holland, Italy, Mexico, North and South American countries. In India, its occurrence in top aquifer system is endemic to many places in Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Rajasthan, Punjab, Haryana, Bihar and Kerala **(Sumalatha and Ambica, 1999)**.

Sharma (2001) carried out the analysis of the groundwater in an industrial town, Bhilwara of Rajasthan and established a significant positive correlation between electrical conductivity and physico-chemical parameters like chloride, magnesium, nitrate and total dissolved solids and suggested to detect the valid parameters for monitoring the groundwater quality in industrial towns instead of complete water analysis, as such key parameters also give insights into hydrochemistry and geology of the area concerned.

Elango et al, (2004) have studied the hydro geochemistry and made quality evaluation along the groundwater path in Hankendi Plain at Turkey and found that chemically the groundwater is potable and suitable for both domestic and agricultural purposes.

Adediji and Ajibade (2005) studied quality of well water in Ede Area of South western Nigeria and concluded that the well water in Ede area contain free carbon dioxide but no free acids as indicated by the pH value of all the samples analysed. Potassium was the most abundant dissolved cation in the water which has been attributed to abundance of total dissolved solids.

Wayde et al, (2008) studied potability status of ground water in Maharashtra and found that the ground water samples showed higher concentration of physico-chemical parameters in rainy and summer season. Furthermore, it was noted that prescribed permissible limit had not been exceeded in any of the samples.

Kasar et al, (2009) conducted bacteriological examination of drinking water in different public places of Aurangabad district, Maharashtra with reference to coli forms and the detection and confirmatory test for E.coli was made by most probable number (MPN) method. The most probable number (MPN) of coli forms in case of water samples collected from cinema theatres, railway station and bus stand ranged between 26-220 coli form per 100 ml and contributed to water diseases.

Mahananda et al, (2010) investigated the physico-chemical parameters of surface and ground water of Bargarh district, Orissa and found a high positive (0.7) correlation between sodium and TDS and high positive correlation between temperature and fluoride (0.724) of dug well.

Subroto Dutta et al., (2010) studied the status of ground water quality in Masuda Tehsil of Ajmer district, Rajasthan during summer season and found that the chloride concentration ranged from 43mg/l to 1010 mg/1. The data revealed that 44% samples had chloride within permissible and 20% exceeded the limit. Sulphate varied from 1 mg/l to 900 mg/l.

Karthikeyan et al, (2012) studied the ground water of lower Vellar watershed, Cuddalore, Tamil Nadu and found pH values between 4.47 and 9.46. Electrical conductivity ranged from 500 to 6710 μmhos/cm.

Study Area:

Tumakuru is an industrial city located in Karnataka State. Since 28th August 2010, it has been declared a corporation. It is at a distance of 70 km north west of Bengaluru along NH-206.

Geography:

Tumkur is located at 13.34° N, 77.1° E. It has an average elevation of 822 m (2696 feet) and an area of 48.60 Sq.Km. It is at Longitude of 77° 05' 00"and latitude 13° 20' 19".

Demographics:

As of 2011 census Tumkur had a population of 3,05821 with Kannada being commonly spoken. The chief crops of Tumkur are coconut millet, rice, pulses, areca nut and oil seeds and industries making cotton clothes, woolen blankets, ropes, HMT watches, Wipro, TVSE etc.

Transportation:

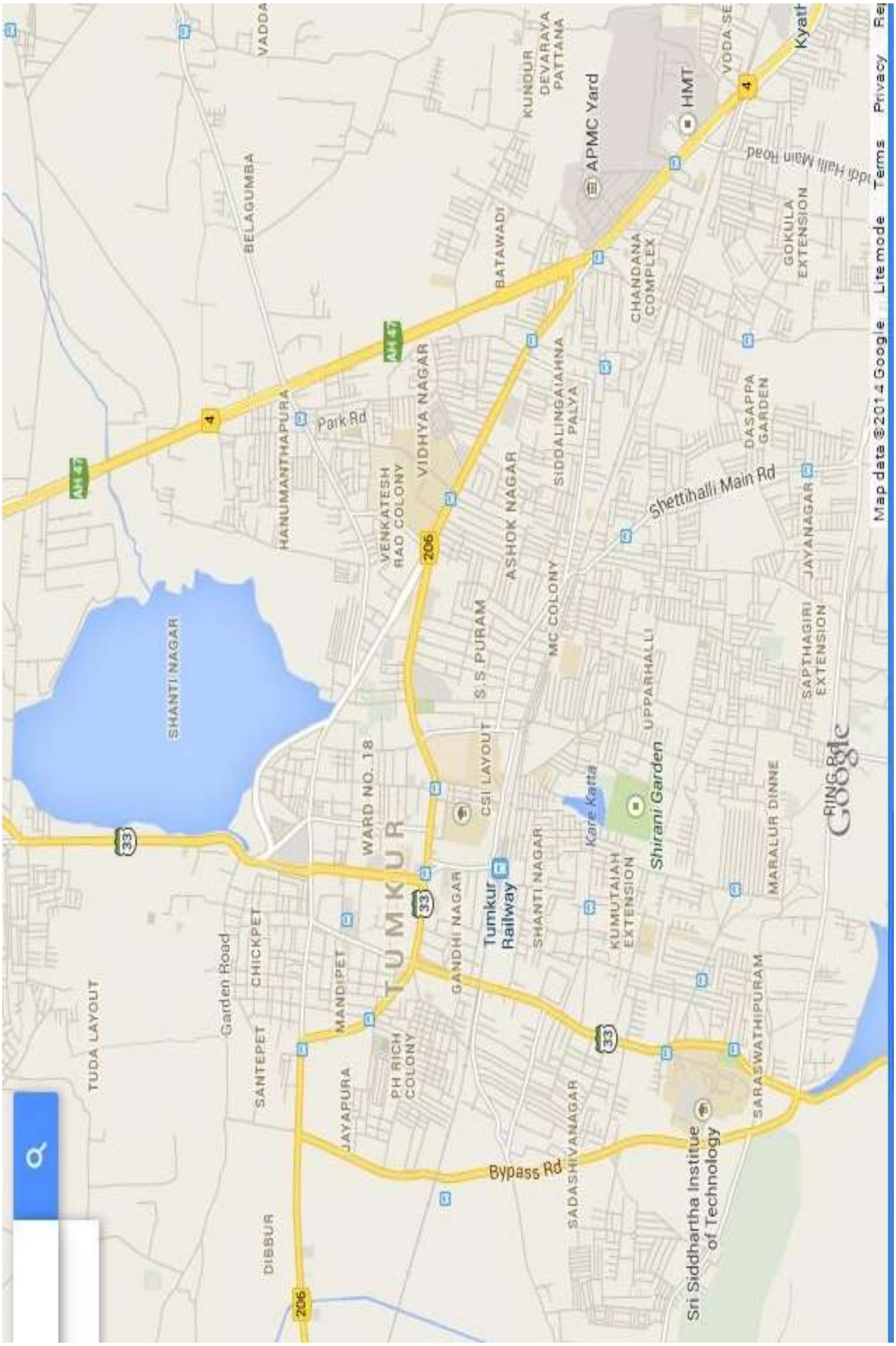
Karnataka state road transport corporation (KSRTC) has a divisional office situated in Tumkur city. It is well connected to Bengaluru and other cities in the state by KSRTC buses. Two national highways NH-4 and NH-206 pass through this city. It is well connected by rail Bangalore – Hubli main line. The nearest airport is Bengaluru international airport about 80 kms from the city.

Physiography:

Tumkur is located 70 km from Bangalore. 48.60 sq.km in area, with an average rainfall of 670 mm, temperature varies11°C in winter and 38° C during summer.

CORPORATION WATER SAMPLING LOCATIONS IN TUMKUR TOWN

Sample No.	Sample sites
1	Siddaganga Extension
2	Chickpet
3	S.S. Puram
4	Vidyanagar
5	Batawadi
6	Upparahalli
7	CSI Layout
8	Jayanagara
9	Gokula Extension
10	Maralur
11	Saraswathipuram
12	Shanthi Nagar
13	Sadashivanagar
14	P.H. Colony
15	Mandipete



TUDA LAYOUT
SHANTI NAGAR
BELAGUMBA
VADDA
Garden Road
CHICKPET
SANTEPET
DIBBUR
HANUMANTHAPURA
Park Rd
MANDIPET
JAYAPURA
PH RICH COLONY
WARD NO. 18
TUMKUR
VENKATESH RAO COLONY
VIDHYA NAGAR
GANDHI NAGAR
CSI LAYOUT
S.S.PURAM
ASHOK NAGAR
BATAWADI
KUNDUR
DEVARAYA PATTANA
Tumkur Railway
SHANTI NAGAR
MC COLONY
SIDDALINGAIAHNA PALYA
SADASHIVANAGAR
Bypass Rd
Kare Katta
KUMUTAIAH EXTENSION
APMC Yard
UPPARHALLI
Shirani Garden
CHANDANA COMPLEX
HMT
Shettihalli Main Rd
Sri Siddhartha Institute of Technology
SARASWATHIPURAM
MARALUR DINNE
DASAPPA GARDEN
JAYANAGAR
SAPTHAGIRI EXTENSION
GOKULA EXTENSION
VODA SE
RING Rd
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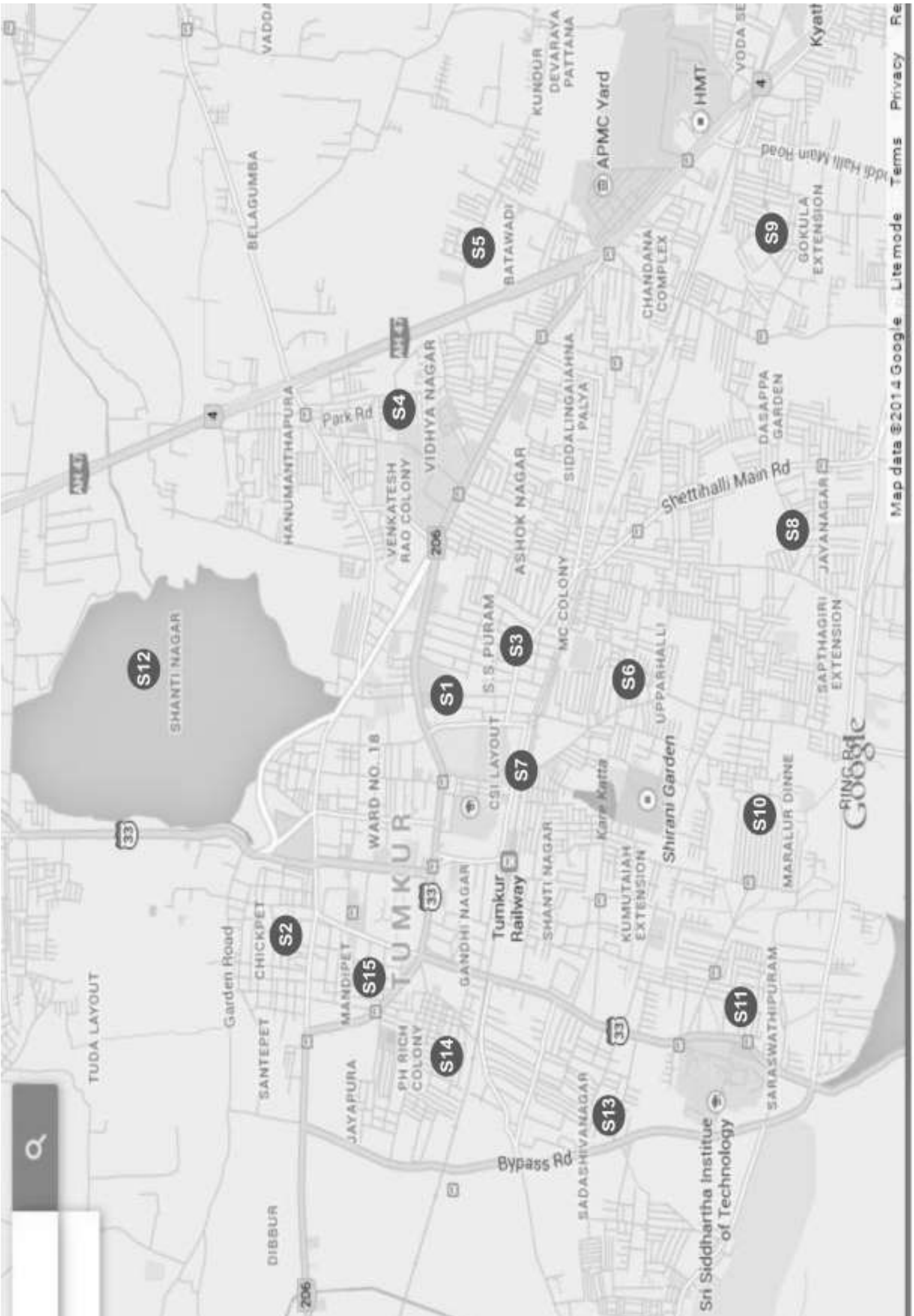
TABLE OF SAMPLE LOCATIONS AS IN THE MAP

S1	Siddaganga Extension	Near Siddaganga High School
S2	Chickpet	Near Kavitha Metal Stores
S3	S.S. Puram	Near Mahathma Gandhi Park
S4	Vidyanagar	4th Cross
S5	Batawadi	Behind Mirji Petrol Bunk
S6	Upparahalli	Behind Mosque
S7	CSI Layout	Near Govt. First Grade College
S8	Jayanagar	Near Main Road
S9	Gokula Extension	Behind Railway Track
S10	Maralur Dinne	Main Road
S11	Saraswathipuram	Near Navagraha Vana
S12	Shanthinagar	Near Water Tank
S13	Sadashivanagar	Near Yasin Masjid
S14	P.H. Colony	Near Vivekananda School
S15	Mandipete	Near Christian Street



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TUDA LAYOUT
SHANTI NAGAR
BELAGUMBA
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Park Rd
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SAPTHAGIRI EXTENSION
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PH RICH COLONY
JAYAPURA
DIBBUR
Bypass Rd
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MATERIALS AND METHODS:

Water samples from 15 sampling locations in Tumakuru city were collected on a monthly basis during the study period in 2 ltr cleaned and dried polythene cans with necessary precautions. All the chemicals used were of AR grade. Double distilled water was used for the preparation of reagents and solutions.

The parameters like temperature and pH were measured on the spot using water analyser kit. Samples were immediately transferred to the laboratory. The parameters like total alkalinity, total hardness, calcium, magnesium, chloride and dissolved oxygen were analysed following the standard methods of APHA (2006) and Trivedi and Goel (2006). Some parameters like sulphates, nitrates, iron etc. were analysed using spectrophotometer and flame photometer.

RESULTS AND DISCUSSION:

Water quality data of corporation tap water samples collected during the study period are tabulated in the table.

Temperature:

Temperature is an important factor which controls the chemical reactions and also plays an important role in the metabolic activities of the organism.

While conflicting theories have floated about for years as to the best temperature for drinking H_2O, here's the one that holds the most water. Cold water passes through your stomach faster, which means your intestines absorb it quicker and you'll rehydrate quicker. In the present study, temperature range from a minimum of 28.5°C to a maximum of 29.85° C.

pH:

The pH is an important index of acidity or alkalinity and the concentration of hydrogen ion in a water sample.

In general, water with a pH < 7 is considered acidic and with a pH > 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5. Alkalinity is a measure of the capacity of the water to resist a change in pH that would tend to make the water more acidic. The measurement of alkalinity and pH is needed to determine the corrosivity of the water.

The pH of pure water (H_2O) is 7 at 25°C, but when exposed to the carbon dioxide in the atmosphere this equilibrium results in a pH of approximately 5.2. Because of the association of pH with atmospheric gasses and temperature, it is strongly recommended that the water be tested as soon as possible. The pH of the water is not a measure of the strength of the acidic or basic solution and alone does not provide a full picture of the characteristics or limitations with the water supply. In the present study the pH varied between 6.94 to 8.42 and were found to be within the prescribed limits of BIS.

Alkalinity:

Alkalinity is a measure of the capacity of water to neutralize acids or hydrogen ions. Alkalinity can sometimes be refereed as "Carbonate hardness". Alkalinity acts as a buffer if any changes are made to the water's pH value. The Alkalinity in the water will help keep the water's pH stabilized. The drinking water and all water should have a pH of 7 meaning that it is neutral. High alkalinity is good to have in our drinking water because it keeps the water safe for us to drink. Most alkalinity in surface water comes from calcium carbonate ($CaCO_3$) that come from rocks and soil. Limestone contains high level of calcium carbonate. The process is enhanced if the rocks and soil have already been broken up before entering the water. The dissolved minerals get into the water through construction and other processes. In the present study the alkalinity varied between a minimum of 31 mg/l to a maximum of 220 mg/l.

Magnesium and Calcium:

The World Health Organization says that "there does not appear to be any convincing evidence that water hardness causes adverse health effects in humans". In fact, the United States National Research Council has found that hard water actually serves as a dietary supplement for calcium and magnesium.

Some studies have shown a weak inverse relationship between water hardness and cardiovascular disease in men, up to a level of 170 mg calcium carbonate per litre of water. The World Health Organization has reviewed the evidence and concluded the data was inadequate to allow for a recommendation for a level of hardness. In addition, hard water, particularly very hard water, could provide an important supplementary contribution to total calcium and magnesium intake. The health effects of hard water are mainly due to the effects of the salts dissolved in it, primarily calcium and magnesium. To a large extent, individuals are protected from excess intakes of calcium by a tightly regulated intestinal absorption mechanism through the action of 1, 25-dihydroxy-vitamin D, the hormonally active form of vitamin D. Although, calcium can interact with iron, zinc, magnesium, and phosphorus within the intestine, thereby reducing the absorption of these minerals. On the other hand, the major cause of hypermagnesemia is renal insufficiency associated with a significantly decreased ability to excrete magnesium. Increased intake of magnesium salts may cause a change in bowel habits (diarrhea). Drinking-water in which both magnesium and sulfate are present in high concentrations (~250 mg/l each) can have a laxative effect. Laxative effects have also been associated with excess intake of magnesium taken in the form of supplements, but not with magnesium in the diet. In the present study, the calcium levels varied between a minimum of 14.8296 mg//l and a maximum of 65.7312 mg/l. And the magnesium levels varied between a minimum of 55.725 to a maximum of 352.4926 mg/l.

Chloride:

Chloride is one of the most common anions found in tap water. Although chlorides are harmless at low levels, well water high in sodium chloride can damage plants if used for gardening or irrigation, and give drinking water an unpleasant taste. While the tolerance range is 250 - 1000 mg/l, high chloride content can cause high blood pressure in people. It can also have a laxative effect on people who are not accustomed to it. Over time, sodium chloride’s high corrosivity will also damage plumbing, appliances, and water heaters, causing toxic metals to leach into your water. In the present study, the chloride content varied from a minimum of 35.5 to a maximum of 253 mg/l.

Nitrate:

Nitrates and nitrites are a major constituent of fertilizers and have been used for many years in lawn treatments. Without the addition of these, crops would deplete nitrogen from soil. Unfortunately, when nitrogen fertilizers are used, they can get into wells and contaminate them. Nitrates and nitrites from these fertilizers also seep into groundwater, especially shallow wells.

Nitrites are cause for concern in infants under 6 months of age and farm animals. They affect the blood's ability to carry oxygen. Nitrites get into the body when nitrates are ingested, both from food and water, and nitrate reducing bacteria in an infant's digestive tract converts the nitrate to nitrite. Once the nitrite enters the blood stream and binds to the hemoglobin, oxygen cannot be carried, and "blue-baby" syndrome (bluish tint to skin due to lack of oxygen) occurs, as well as shortness of breath, increased sensitivity to illness, heart attacks, and possibly death by asphyxiation. However, as the infant ages, stomach acid becomes stronger, and bacteria that cause the conversion of nitrate to nitrite are reduced. Older children and adults generally do not have a problem with nitrates. In the present study the nitrate content varied from a minimum of 0.1 to a maximum of 1.2 mg/l.

<u>Sulphate</u>:

Sulfate minerals can cause scale buildup in water pipes similar to other minerals and may be associated with a bitter taste in water that can have a laxative effect on humans and young livestock. Elevated sulfate levels in combination with chlorine bleach can make cleaning clothes difficult. Sulfur-oxidizing bacteria produce effects similar to those of iron bacteria. They convert sulfide into sulfate, producing a dark slime that can clog plumbing and/or stain clothing. Blackening of water or dark slime coating the inside of toilet tanks may indicate a sulfur-oxidizing bacteria problem. Sulfur-oxidizing bacteria are less common than sulfur-reducing bacteria. In the present study the sulphur content varied from a minimum of 6.5 to a maximum of 47 mg/l.

<u>Sodium</u>:

The sodium content of ground water is a function of weathering sodium plagioclase from bed rock followed by exchange of calcium Ca^{+2} for sodium on the surface newly formed clays minerals. In addition ground water contains large amount of sodium rock and soil. The common source of sodium levels in the ground water are Erosions of salt deposits and sodium bearing rock minerals, Due to brackish water of some aquifers, salt water intrusion in to wells in coast areas, infiltration of surface water contained by road salts Irrigation sewage effluents and land fills precipitation , leaching through soils high in sodium. In the present study the sodium content showed a variation from a minimum of 7.5 to a maximum of 90mg/l.

<u>Potassium</u>:

Potassium reacts rapidly and intensely with water to form a colorless potassium hydroxide solution. Potassium is useful in human body, and the total amount in our bodies lies between 110g and 140g. Red blood cells and brain tissue contain the highest amount of potassium in our bodies. The vital functions of potassium in our bodies include its role in nerve stimulus, muscle contractions, blood pressure regulation and protein dissolution.

Intake of a number of potassium compounds is harmful to our health. For example at higher concentration, potassium chloride interferes with nerve impulses, which of course affects the functioning of the body and mainly the heart. Potassium alum causes stomach complaints and nausea at even concentration as low as 2 g. potassium carbonate and potassium dichromate is lethal, while potassium nitrate causes severe intoxication. In the present study, the potassium levels varied from a minimum of 0 to a maximum of 6.5 mg/l.

Dissolved oxygen:

When BOD levels are high, dissolved oxygen (DO) levels decrease because the oxygen that is available in the water is being consumed by the bacteria. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive. In the present study, the dissolved oxygen content varied between 9.05 to 11.2 mg/l.

Iron:

Iron is necessary for our health. The most well-known role that iron plays in human nutrition is in the formation of the protein hemoglobin, which transports oxygen to all cells of the body. Iron is also used in cellular metabolism and is found in many of the body’s enzymes. Low iron stores in the body can lead to iron deficiency, anemia and fatigue and can make you more susceptible to infections.

Some segments of the population are more at risk than others for iron deficiency. In particular, women, children, the elderly, and non-Caucasians are more likely to be iron-deficient than men, although anyone can be iron-deficient.

It is possible that drinking water that is high in iron may be beneficial, as it adds small amounts of iron to your diet. However, drinking water that contains iron may help mediate iron deficiency symptoms. In the present study, the iron content varied between a minimum of 0.005 to a maximum of 0.045 mg/l.

Fluoride:

Water fluoridation is the controlled addition of fluoride to a public water supply to reduce tooth decay. Fluoridated water has fluoride at a level that is effective for preventing cavities; this can occur naturally or by adding fluoride. Fluoridated water operates on tooth surfaces: in the mouth, it creates low levels of fluoride in saliva, which reduces the rate at which tooth enamel demineralizes and increases the rate at which it remineralizes in the early stages of cavities. Typically a fluoridated compound is added to drinking water, a process that in the U.S. costs an average of about $1.04 per person-year. Defluoridation is needed when the naturally occurring fluoride level exceeds recommended limits. In 2011 the World Health Organization suggested a level of fluoride from 0.5 to 1.5 mg/L (milligrams per litre), depending on climate, local environment, and other sources of fluoride. In the present study, the fluoride content varied between a minimum of 0.03 to a maximum of 0.42 mg/l.

Table : Average values

Sl. No.	Temp °C	pH	T. acidity	T. alkalinity	TH	Ca^{+2}	Mg^{+2}	Cl^-	NO_3	SO_4^-	Na^+	K^+	Do	Fe^{+2}
S1	22.7	7.47	17	91	194	44.8	131.4	95.5	1.2	40	42.4	BDL	9.6	BDL
S2	22.25	7.7	22	118	190	38.4	55.7	99.5	0.1	34.5	59.5	4.5	11.1	0.035
S3	31.7	8.03	19	115	345	57.3	317.5	24.5	0.75	45.5	78.5	2	9.35	0.01
S4	28.9	7.07	27	142	337	61.3	352.4	25.3	0.3	47	90	6.5	11.35	0.02
S5	28.8	7.58	14	31	144	63.3	142.7	85	0.2	6.5	34	1.5	10.85	0.045
S6	28.7	7.85	21	98	384	77.7	251.8	194	0.05	32	80	1.5	11.2	0.015
S7	28.75	7.5	17	135	226	43.6	184.2	94.5	0.4	41	60.5	3	9.05	0.04
S8	28.85	6.94	15	112	283	51.3	204.2	109	0.55	14	38.5	1	10.55	0.03
S9	28.5	7.4	19	86	198	40.9	165	80	0.55	34	41	0.5	9.1	0.035

S10	28.5	8.4	29	152	315	65.7	226.6	171	0.1	23	71	0.5	9.2	BDL
S11	28.5	8.4	27	220	178	34.4	170	66.5	0.35	21	30	BDL	8.5	0.045
S12	28.55	7.8	17	65	91	19.6	66.7	36.5	0.2	26.5	12.5	1	10.4	0.015
S13	28.55	8.1	28	62	96	22.4	68.8	57.5	0.4	33	7.5	1	9.6	BDL
S14	28.55	8.2	14	48	71	14.8	66.7	35.5	0.5	24.5	8	1	9.35	0.015
S15	28.55	7.8	30	49	87	15.6	78.3	44.5	0.35	24.5	10	2	9.95	0.01

All values are in mg/l except temperature and pH.

Bureau of Indian Standards
Drinking Water - Specification for some of the important parameters
IS 10500 - 2012 (Second revision)

S.No.	Characteristic	Unit	Requirement (Acceptable Limit)	Permissible limit in the absence of alternate source
1	Total Dissolved Solids (TDS)	Milligram/litre	500	2000
2	Colour	Hazen unit	5	15
3	Turbidity	NTU	1	5
4	Total Hardness	Milligram/litre	200	600
5	Ammonia	Milligram/litre	0.5	0.5
6	Free Residual Chlorine	Milligram/litre	0.2	1.0
7	pH	--	6.5-8.5	6.5-8.5
8	Chloride	Milligram/litre	250	1000
9	Fluoride	Milligram/litre	1.0	1.5
10	Arsenic	Milligram/litre	0.01	0.05
11	Iron	Milligram/litre	0.3	0.3
12	Nitrate	Milligram/litre	45	45
13	Sulphate	Milligram/litre	200	400
14	Selenium	Milligram/litre	0.01	0.01
15	Zinc	Milligram/litre	5.0	15.0
16	Mercury	Milligram/litre	0.001	0.001
17	Lead	Milligram/litre	0.01	0.01
18	Cyanide	Milligram/litre	0.05	0.05
19	Copper	Milligram/litre	0.05	1.5
20	Chromium	Milligram/litre	0.05	0.05
21	Nickel	Milligram/litre	0.02	0.02
22	Cadmium	Milligram/litre	0.003	0.003
23	E-Coli or Thermotolerant coliforms	Number/ 100 ml	NIL	NIL

Note: Please refer to BIS standard IS-10500-2012 (second revision) for other parameters.

Indian Standard

DRINKING WATER — SPECIFICATION

(Second Revision)

1 SCOPE

This standard prescribes the requirements and the methods of sampling and test for drinking water.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 TERMINOLOGY

For the purpose of this standard the following definition shall apply.

3.1 Drinking Water — Drinking water is water intended for human consumption for drinking and cooking purposes from any source. It includes water (treated or untreated) supplied by any means for human consumption.

4 REQUIREMENTS

Drinking water shall comply with the requirements given in Tables 1 to 4. The analysis of pesticide residues given in Table 3 shall be conducted by a recognized laboratory using internationally established test method meeting the residue limits as given in Table 5.

Drinking water shall also comply with bacteriological requirements (*see* **4.1**), virological requirements (*see* **4.2**) and biological requirements (*see* **4.3**).

4.1 Bacteriological Requirements

4.1.1 *Water in Distribution System*

Ideally, all samples taken from the distribution system including consumers' premises, should be free from coliform organisms and the following bacteriological quality of drinking water collected in the distribution system, as given in Table 6 is, therefore specified when tested in accordance with IS 1622.

4.2 Virological Requirements

4.2.1 Ideally, all samples taken from the distribution

Table 1 Organoleptic and Physical Parameters
(*Foreword* and *Clause* 4)

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternate Source	Method of Test, Ref to Part of IS 3025	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	Colour, Hazen units, *Max*	5	15	Part 4	Extended to 15 only, if toxic substances are not suspected in absence of alternate sources
ii)	Odour	Agreeable	Agreeable	Part 5	a) Test cold and when heated b) Test at several dilutions
iii)	*p*H value	6.5-8.5	No relaxation	Part 11	—
iv)	Taste	Agreeable	Agreeable	Parts 7 and 8	Test to be conducted only after safety has been established
v)	Turbidity, NTU, *Max*	1	5	Part 10	—
vi)	Total dissolved solids, mg/l, *Max*	500	2 000	Part 16	—

NOTE — It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.

Table 2 General Parameters Concerning Substances Undesirable in Excessive Amounts
(*Foreword* and *Clause* 4)

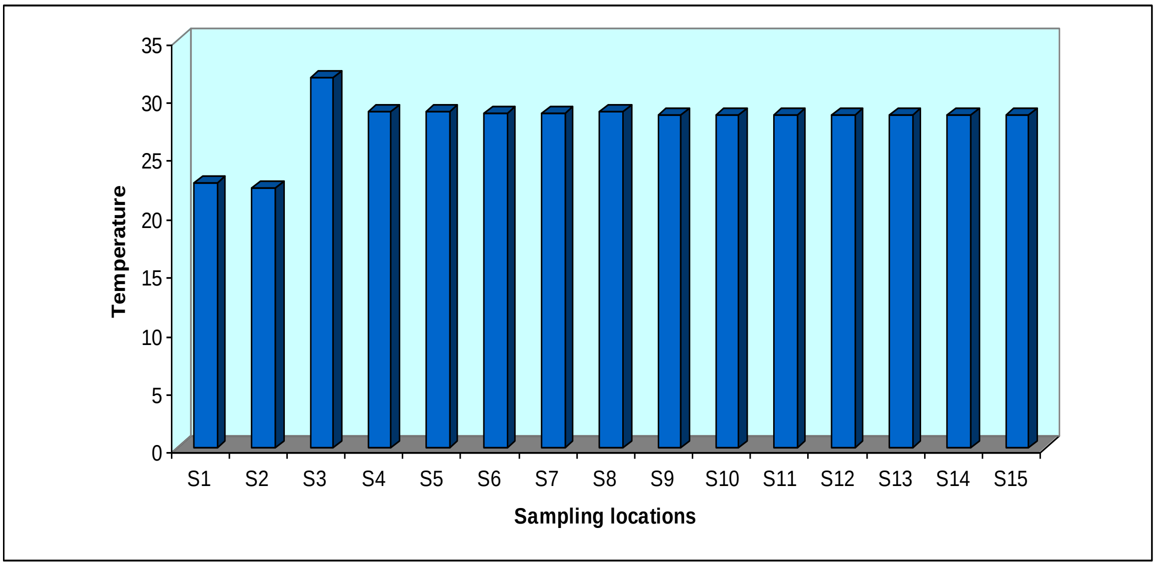
Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternate Source	Method of Test, Ref to	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	Aluminium (as Al), mg/l, *Max*	0.03	0.2	IS 3025 (Part 55)	—
ii)	Ammonia (as total ammonia-N), mg/l, *Max*	0.5	No relaxation	IS 3025 (Part 34)	—
iii)	Anionic detergents (as MBAS) mg/l, *Max*	0.2	1.0	Annex K of IS 13428	—
iv)	Barium (as Ba), mg/l, *Max*	0.7	No relaxation	Annex F of IS 13428* or IS 15302	—
v)	Boron (as B), mg/l, *Max*	0.5	1.0	IS 3025 (Part 57)	—
vi)	Calcium (as Ca), mg/l, *Max*	75	200	IS 3025 (Part 40)	—
vii)	Chloramines (as Cl_2), mg/l, *Max*	4.0	No relaxation	IS 3025 (Part 26)* or APHA 4500-Cl G	—
viii)	Chloride (as Cl), mg/l, *Max*	250	1 000	IS 3025 (Part 32)	—
ix)	Copper (as Cu), mg/l, *Max*	0.05	1.5	IS 3025 (Part 42)	—
x)	Fluoride (as F) mg/l, *Max*	1.0	1.5	IS 3025 (Part 60)	—
xi)	Free residual chlorine, mg/l, *Min*	0.2	1	IS 3025 (Part 26)	To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be minimum 0.5 mg/l
xii)	Iron (as Fe), mg/l, *Max*	0.3	No relaxation	IS 3025 (Part 53)	Total concentration of manganese (as Mn) and iron (as Fe) shall not exceed 0.3 mg/l
xiii)	Magnesium (as Mg), mg/l, *Max*	30	100	IS 3025 (Part 46)	—
xiv)	Manganese (as Mn), mg/l, *Max*	0.1	0.3	IS 3025 (Part 59)	Total concentration of manganese (as Mn) and iron (as Fe) shall not exceed 0.3 mg/l
xv)	Mineral oil, mg/l, *Max*	0.5	No relaxation	Clause **6** of IS 3025 (Part 39) Infrared partition method	—
xvi)	Nitrate (as NO_3), mg/l, *Max*	45	No relaxation	IS 3025 (Part 34)	—
xvii)	Phenolic compounds (as C_6H_5OH), mg/l, *Max*	0.001	0.002	IS 3025 (Part 43)	—
xviii)	Selenium (as Se), mg/l, *Max*	0.01	No relaxation	IS 3025 (Part 56) or IS 15303*	—
xix)	Silver (as Ag), mg/l, *Max*	0.1	No relaxation	Annex J of IS 13428	—
xx)	Sulphate (as SO_4) mg/l, *Max*	200	400	IS 3025 (Part 24)	May be extended to 400 provided that Magnesium does not exceed 30
xxi)	Sulphide (as H_2S), mg/l, *Max*	0.05	No relaxation	IS 3025 (Part 29)	—
xxii)	Total alkalinity as calcium carbonate, mg/l, *Max*	200	600	IS 3025 (Part 23)	—
xxiii)	Total hardness (as $CaCO_3$), mg/l, *Max*	200	600	IS 3025 (Part 21)	—
xxiv)	Zinc (as Zn), mg/l, *Max*	5	15	IS 3025 (Part 49)	—

NOTES

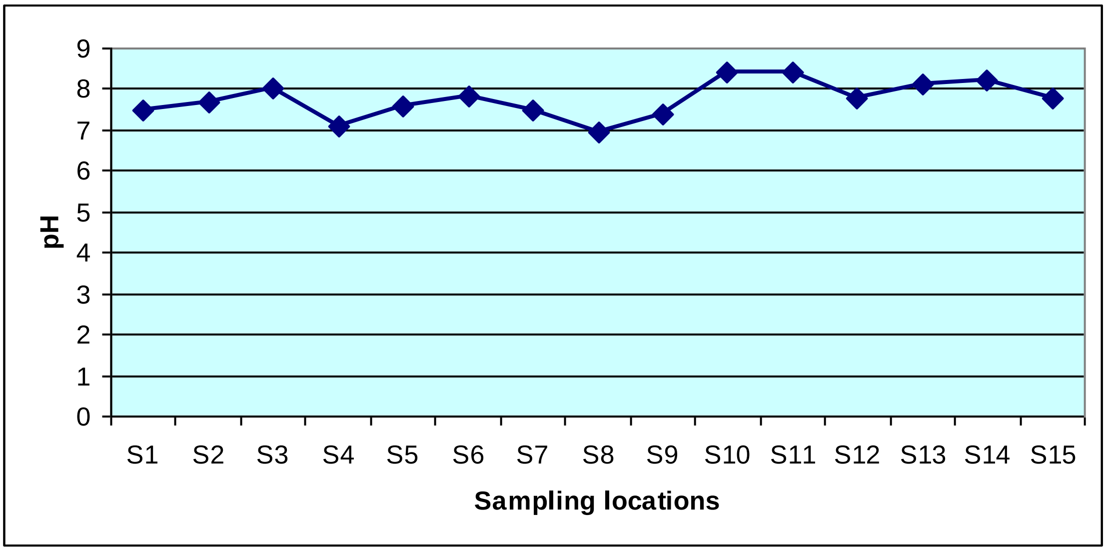
1 In case of dispute, the method indicated by '*' shall be the referee method.

2 It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.

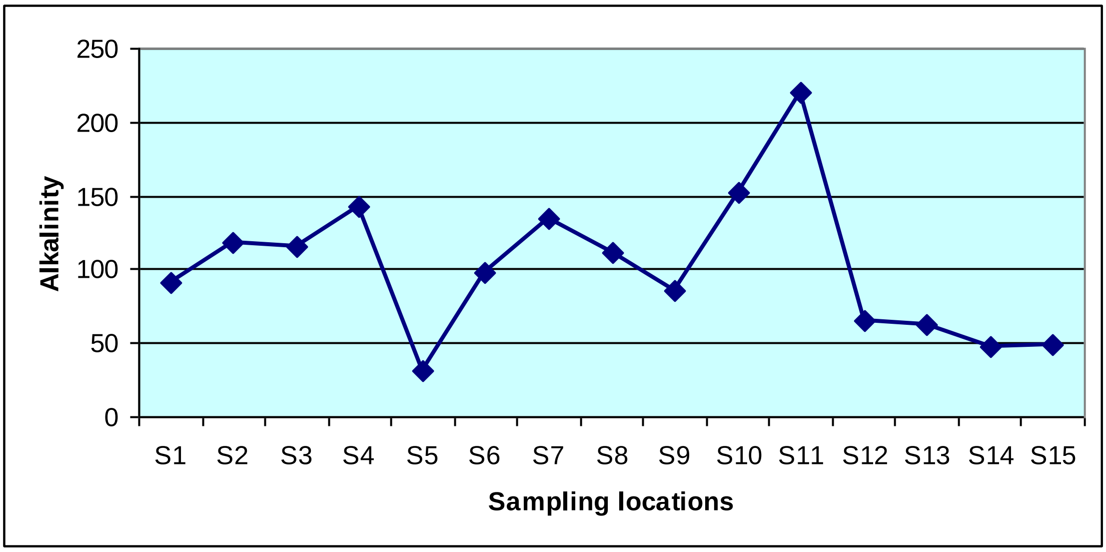
Graph showing temperature variation



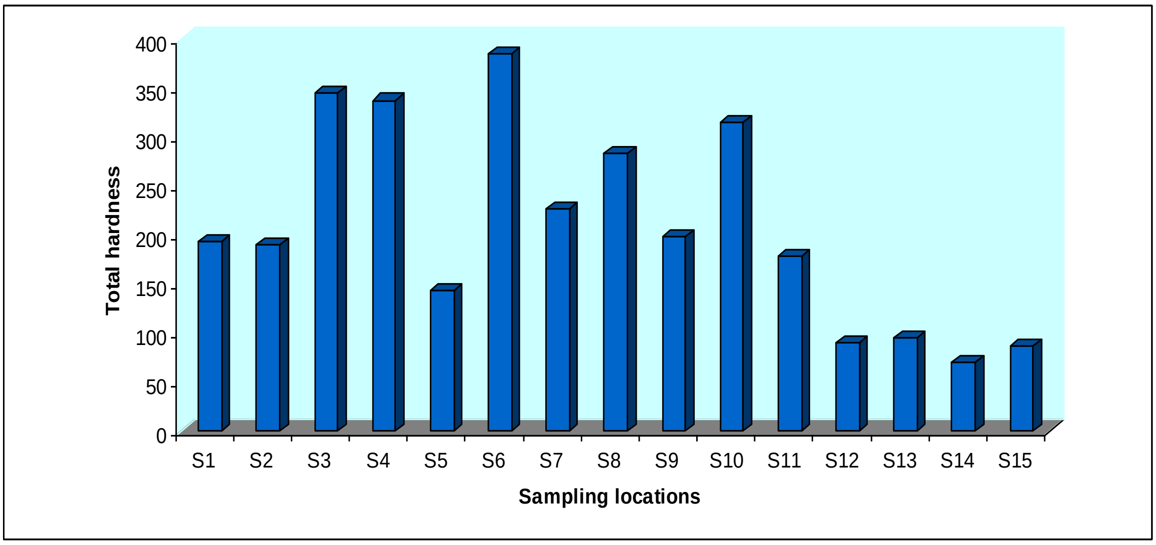
Graph showing pH variation



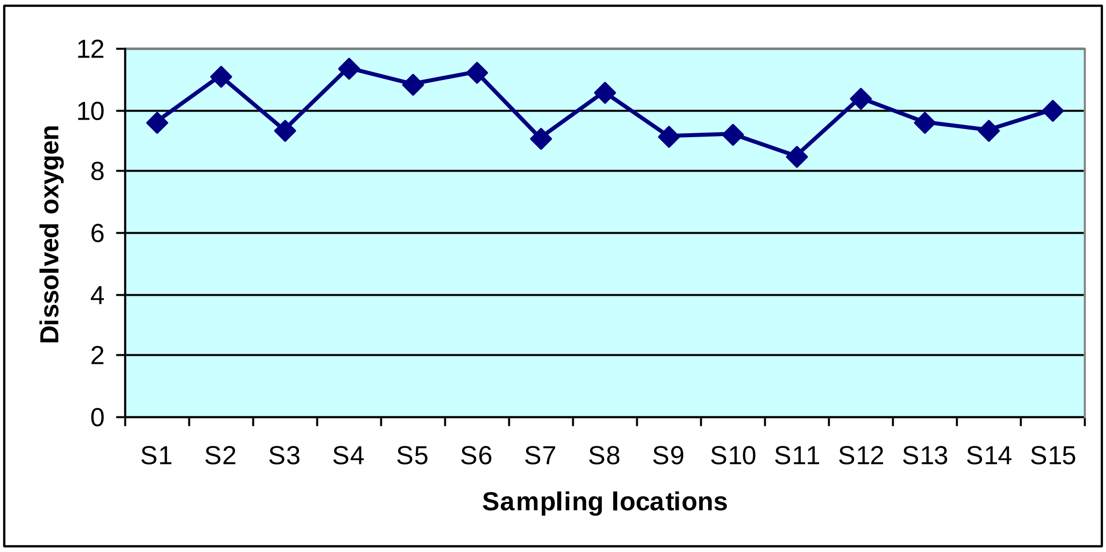
Graph showing alkalinity variation



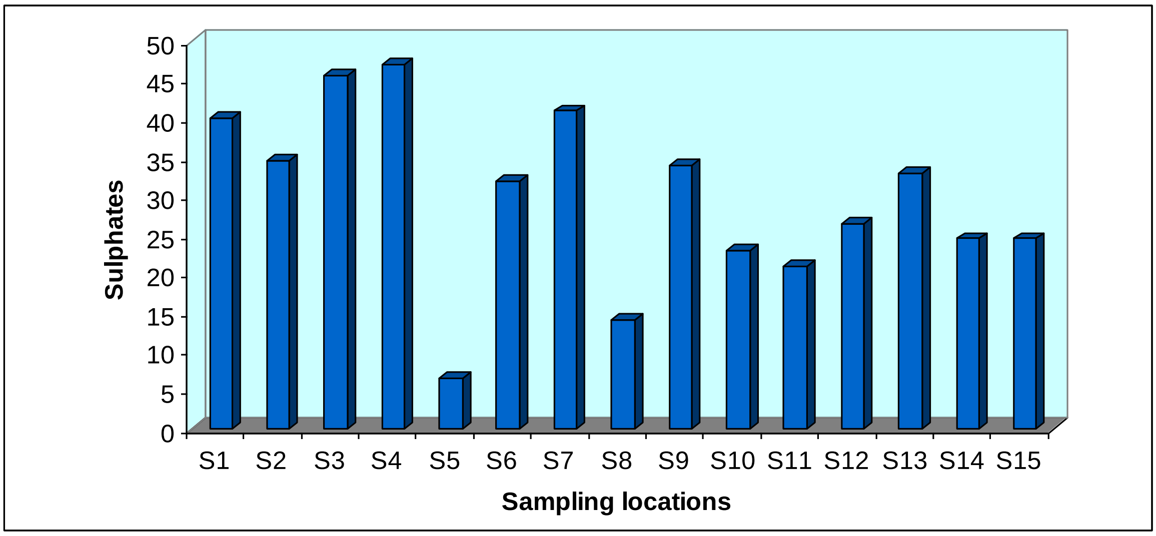
Graph showing variations in total hardness



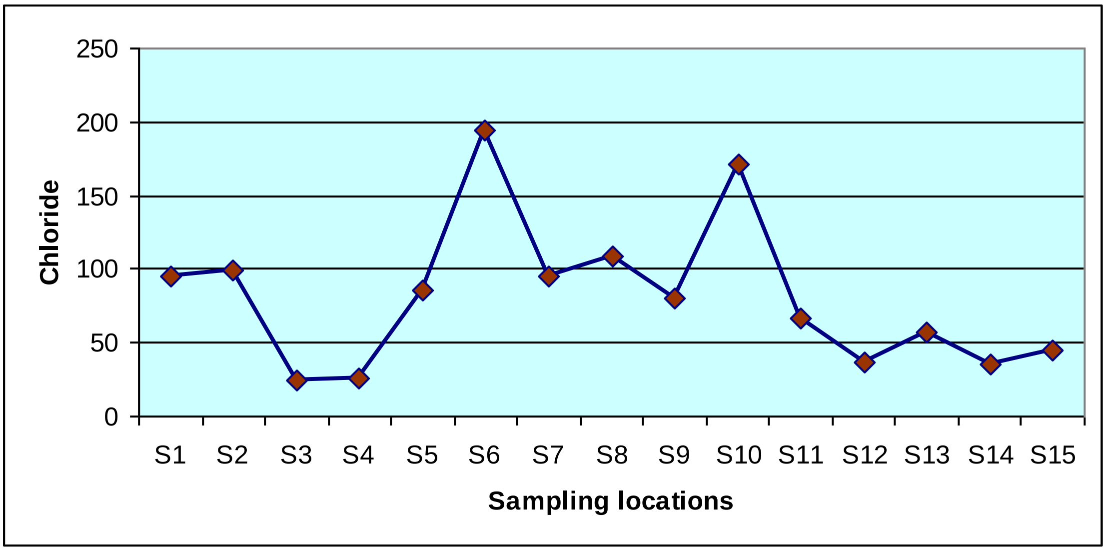
Graph showing variations in dissolved oxygen



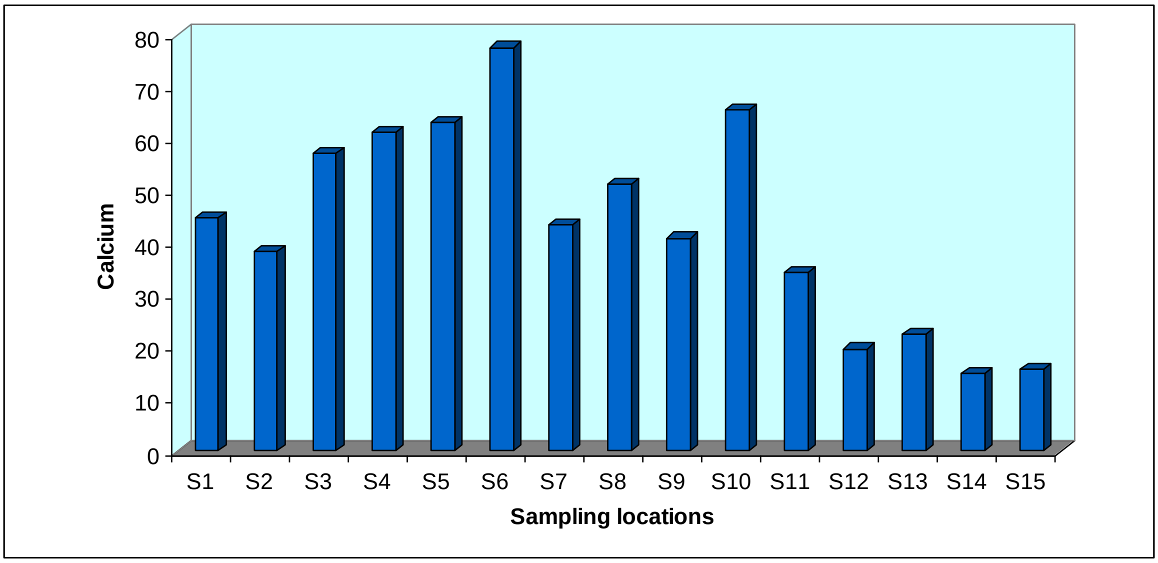
Graph showing variations in sulphates



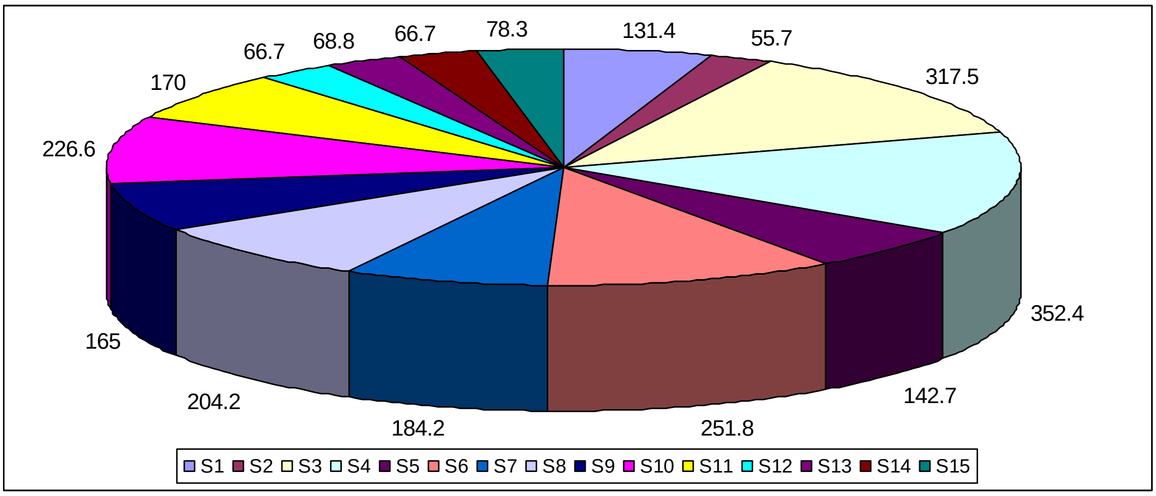
Graph showing variations in chloride



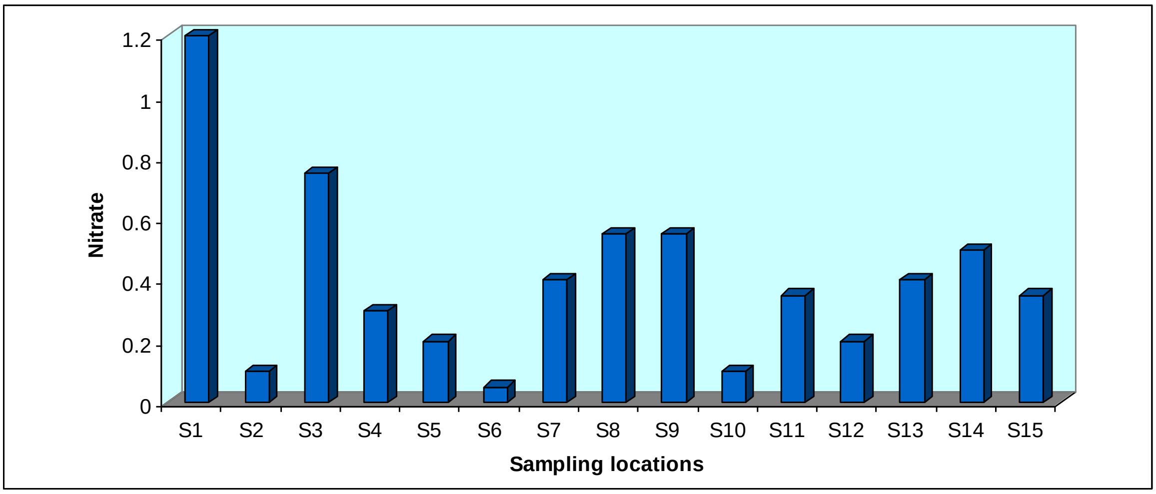
Graph showing variations in Calcium



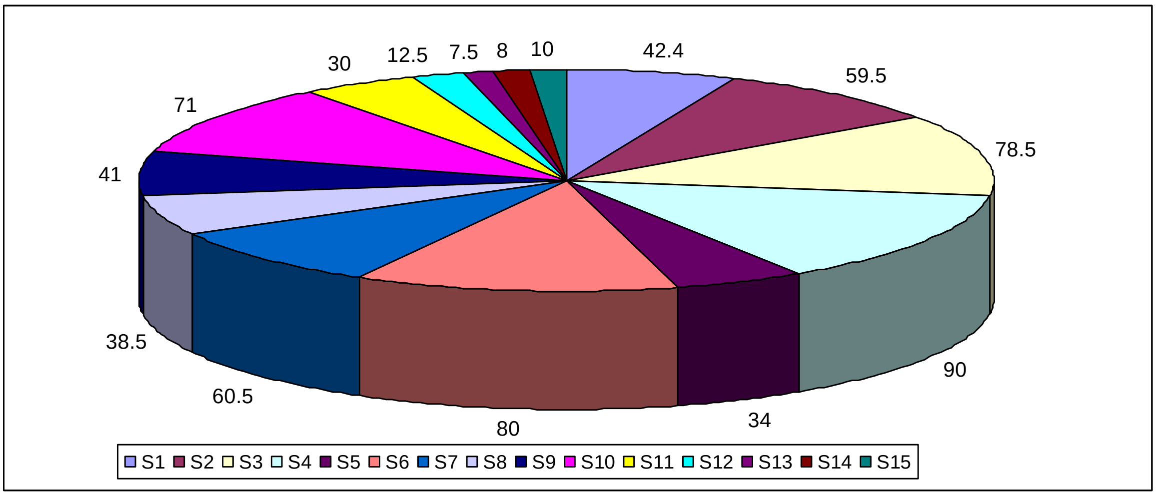
Graph showing variations in Magnesium



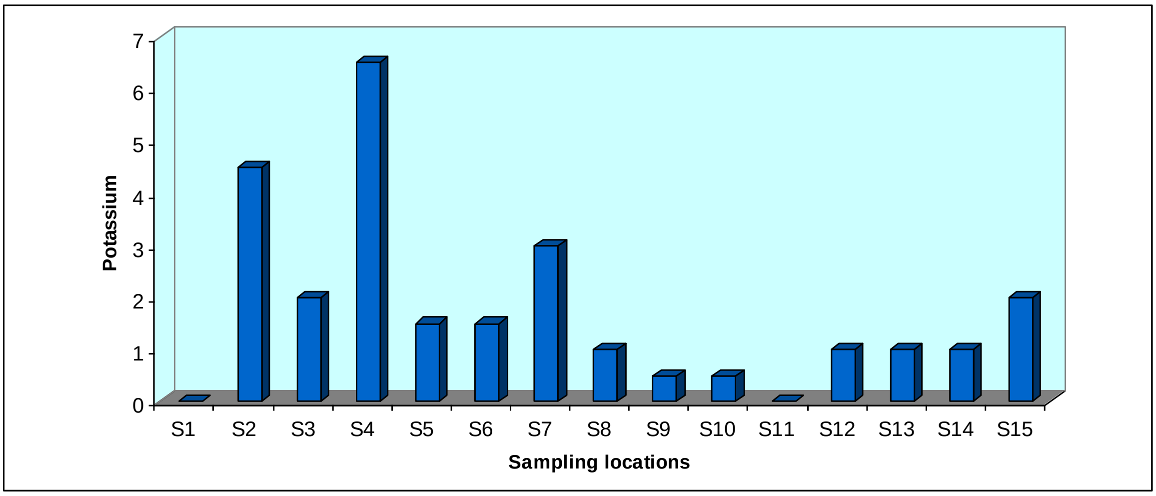
Graph showing variations in Nitrate



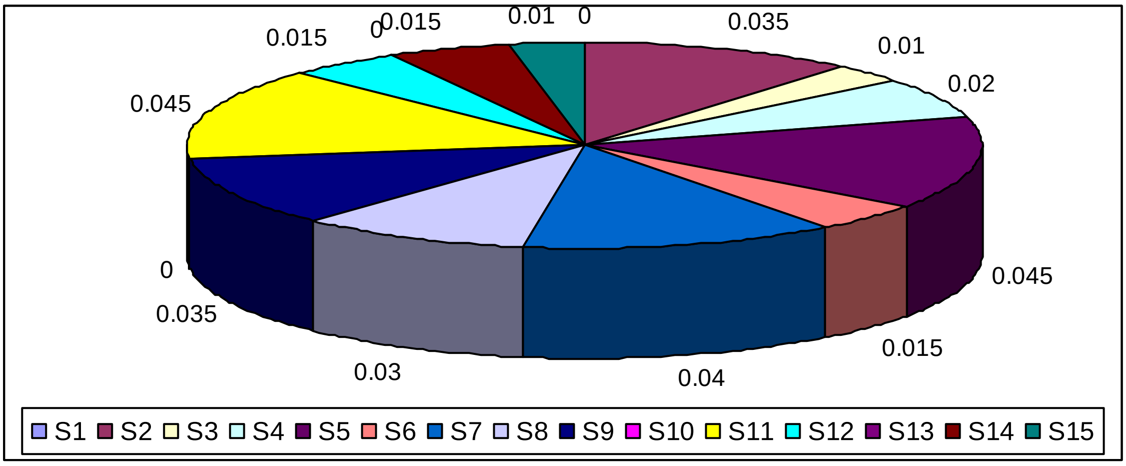
Graph showing variations in Sodium



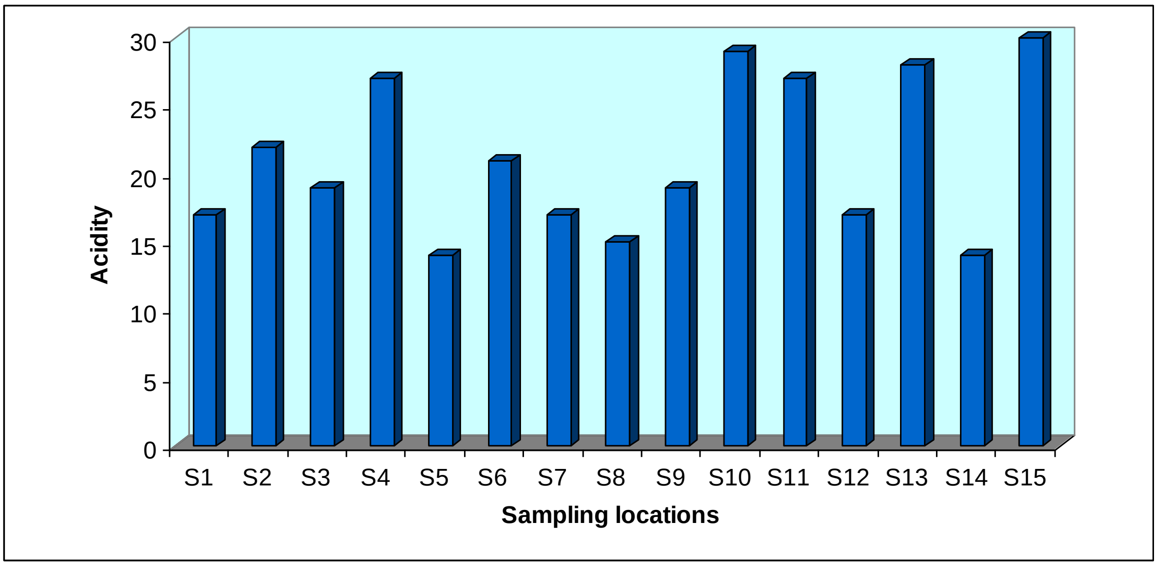
Graph showing variations in Potassium



Graph showing variations in Iron



Graph showing variations in acidity



SAMPLE STATION - LOCATION

S1 - Siddaganga Extension

S2 - Near Kavitha Metal Store, Chickpet

S3 - S.S. Puram

S4 - 4th Cross, Vidyanagara

S5 - Batawadi

S6 - Upparahally

S7 - CSI Layout

S8 - Jayanagara

S9 - Gokula Extension

S10 - Maraluru Dinne

S11 - Saraswathipuram

S12 - Shanthi Nagar

S13 - Sadashivanagar

S14 - P.H. Colony

S15 - Mandipete

Summary of the findings:

After the investigation which was a strenuous but rewarding exercise, The drinking water quality of the study areas of Tumkur town was assessed.

In the present study the investigation of the quality of drinking water supplied by Corporation to these areas was done by collecting the water samples of these areas and testing them for various parameters.

The physical parameters like temperature, pH and alkalinity were well within the acceptable limits prescribed by the BIS.

Investigation for the hardness of water revealed that it was well within the prescribed BIS limits. Investigation of the chemical parameters like calcium, magnesium, chloride, nitrate, sulphate, dissolved oxygen and iron showed that these were well within the acceptable limits.

It was observed that most of the middle class people in these study areas were dependent on corporation water supply for drinking and domestic purposes. As very few had bore wells.

During winter and rainy season, water was adequately supplied by Hemavathy tank and during summer season when the frequency of Hemavathy water supply decreased, people depended on bore well water.

The present study shows the quality of water during different seasons. It can be inferred that the quality of water is quite good. The water can be used for domestic as well as small industry purposes.

This investigation is useful for water supply department to control the pollution load and fulfill suggested remedies.

Conclusions:

1. The present investigations reveals that corporation water was slightly alkaline.
2. Overall quality of corporation water was well within the BIS standards.
3. Water is fit for drinking and domestic purpose.
4. Regular attention should be given to maintain the status of water by treatment not to pollute.
5. Water was free of fluoride toxicity.
6. Other trace elements were found to be below detectable limits.
7. Water was free of E.coli contamination.

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Future Plans:

The author wishes to continue the work, extend this study for a larger area and work towards a Ph.D degree.