SJIF 2012: 2.545

UIF 2013: 1.075

Received on:

25th June 2014

Revised on:

27th June 2014

Accepted on:

27th June 2014

Published on:

1st July 2014

Volume No.

Online & Print

6 (2014)

Page No.

16 to 31

IRJC is an international open access print & e journal, peer reviewed, worldwide abstract listed, published quarterly with ISSN, Free- membership, downloads and access.

GROUNDWATER QUALITY ASSESSMENT IN SOME VILLAGES OF VADGAM TALUKA OF BANASKANTHA DISTRICT, GUJARAT, INDIA, WITH AN EMPHASIS ON STUDY OF FLUORIDE AND ITS EFFECTS

E.R. AGHARIA

DEPARTMENT OF CHEMISTRY,

SVKM's MITHIBAI COLLEGE,

VILE – PARLE (WEST).MUMBAI-400056, INDIA.

Email: mhea22@rediffmail.com

ABSTRACT:

Groundwater quality is a very essential hydrogeochemical investigation. Springs, shallow wells, deep wells and bored tube wells are the main sources of groundwater. The health of people consuming this water is greatly influenced by its quality. Water obtained from different sources is contaminated with a large number of impurities. The present study deals in detail with 15 physico-chemical parameters viz. p^H, total dissolved salts, total alkalinity (as $CaCO_3$) conductivity, total hardness (as $CaCO_3$) M.O. alkalinity (as $CaCO_3$), nitrite, nitrate, sulphate, chloride, fluoride, sodium, zinc, magnesium and calcium as well as 3 microbiological parameters such as total bacterial count at 37^0C, coliform and E. coli tests in four bored tube well samples. Their toxicological and adverse effects, if any, when present beyond the prescribed limits, are also discussed at length. These bored tube well underground waters are obtained from a depth of about 700-800 feet from the surface of the earth in this area having now a scanty rainfall. The daily ingestion of 2 mg fluoride could result in crippling flourosis after 40 years.

The values recommended by Indian Standard Specifications for Drinking Water (IS: 10500: 1993) of Bureau of Indian Standards (BIS), are used for the purpose of comparison of observed values.

KEY WORD: *Groundwater, Bored tube wells, Quality, Fluoride, Water pollution.*

INTRODUCTION:

Water, the most precious gift of God to the nature, is one of the most abundantly substance in nature. Water constitutes about 70% mass of our body. About three fourth of the matter of the earth's crust is formed by water. Water which covers major part of the earth's surface, is an essential component of all animal and vegetable matters. It is of utmost physiological importance in human body, as it has to carry out specific functions. Therefore, pure water is absolutely necessary for healthy living. Water is mostly used for grampanchayat/municipal, industrial and irrigation purposes. Therefore, it is very essential to supply right quality and quantity of water for the above said purposes. It is the basic need for all human beings on the earth and even after this millions of people world over are deprived of this[1].

Groundwater is a good source of fresh drinking water since long time and even today it is a very important source of potable water because of inherent purification by soil. Groundwater constitutes more than 95% of the fresh water available in the world[2].

Nearly 90% of the rural population in India is primarily dependent on ground water and about 25% of the people's need in urban areas is met by groundwater[3]. About 74% of India's population live in villages of which only 86% have access for safe water[4].

It may be noted that 80% of water needs of rural India are met by groundwater and 20% from surface water[4]. Of the estimated total annual amount of water used in India, about 36% of it comes from groundwater. Due to unavailability of surface water at many places, groundwater is the only source of good quality water[3]. Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices[5].

There can be no state of positive health and wellbeing without safe water[4]. As per the WHO estimate, nearly 80% of all the diseases in human beings are caused by water[5]. Harmful effects on humans and aquatic biota are caused due to alteration in physical, chemical and biological characteristics of water. Water borne diseases and water caused health problems are mostly due to inadequate and incompetent management of water resources[1].

Due to rapid population explosion, agricultural developments, urbanization and industrial expansion, the groundwater exploration and development have gained momentum not only in India but also the world over to meet with the increasing demand by the people, resulting into the over exploitation of water resources [3,6]. Surface water sources are more prone to water contamination as compared to groundwater [7]. The quality of water gets deteriorated due to many reasons.

Thus, it is very essential to monitor, control and evaluate the water quality on regular basis. Therefore, the present work is undertaken with the objectives of determination of various physico-chemical characteristics or parameters of water as they are necessary for assessing the suitability of water for various purposes like drinking, domestic, industrial and irrigation and also to discuss their toxicological and adverse effects, if any at length, particularly with an emphasis on effects of fluoride.

MATERIALS AND METHOD:

Profile of the study area:

Vadgam is a Taluka place, situated in Banaskantha District in northern Gujarat, India. Administratively, it is a Taluka, comprising of 110 villages. The population of the Vadgam taluka is around 101025. It is 15 km away from Palanpur, the pre-independence princely state of the Nabob of Palanpur, which today is the main city and the District Centre of the Banaskhantha District. Vadgam is also nearer to another historical city of Siddhpur, the only place for 'Matrushraddha' in India.

The main activities of the people are agriculture, dairy farming, animal husbandary, diamond cutting and to some extent the restaurant and guest house businesses. It is situated near the well known Banas Dairy, Palanpur. Vadgam is a buffer taluka between Banaskantha and Mehsana districts. It is a commercial place for nearby villages. There is an Agricultural Market Yard, primary and high schools, college, village panchayat and milk society in vadgam. There is a big temple of Radha Krishna in Vadgam which also have many other Mandirs or Temples.

Collection of Samples:

The bored tube well water samples from four villages viz. Sherpura (Majadar which henceforth is abbreviated as M.), Bharkawada, Chhapi (Taj Chowkdi or Square which henceforth is abbreviated as T.C.) and Changwada of Vadgam taluka were collected in pre-rinsed sterile polythene bottles and were taken immediately to the laboratory for various physico-chemical analysis. These villages are located within the radius of 4-5 km with Sherpura (Majadar) as a centre.

RESULTS AND DISCUSSION:

All the results / values of various physico-chemical and microbiological parameters are given in Table I.

Taste and Odour:

All water samples had agreeable taste and had no unpleasant odour. These water samples appear to be non-turbid and clear. Water from deep bored tube wells contains no turbidity[8], but it contains more mineral salts, free CO_2, salts of Ca, Mg, Fe, Mn, etc..

p^H :

p^H of all the water samples was observed in the range, of 7.10 to 7.56 with the mean value of 7.39 suggesting the slightly alkaline nature of water The observed values are well within the same desirable and permissible limits of 6.5 – 8.5, beyond this range, the water affects the mucous membrane and / or water supply system. Knowledge of p^H is essential in the selection of coagulants for water purification. p^H in conjunction with total salinity, total alkalinity and temperature is used to determine whether water is corrosive in nature or is having scale forming tendencies[8]. As reported[2], it seems that there is no significant correlation between the incidence of diseases and p^H. p^H of circulating water controls leaching of fluoride from the fluoride bearing material.

Electrical Conductivity (EC):

The electrical conductivity of samples ranges from 761.0 to 2435 μS/cm with the mean value of 1369.25 μS/cm. There is no consistency in the observed values as they vary considerably from one village to the other. Salinity is measured in terms of EC[9]. EC values are useful to know about the pollution and to find out the presence of inorganic dissolved solids and also to know whether water is suitable for irrigation purposes or not [10]. Conductivity is proportional to its dissolved mineral water content. Conductivity of water is an important drinking water quality parameter, as it is significantly correlated with physico-chemical parameters like hardness, total solids, TDS, total suspended solids, chemical oxygen demand, alkalinity, chloride and fluoride[1]. Salinity of groundwater is measured in terms of electrical conductivity and therefore, EC is called salinity factor.

Total Dissolved Solids (TDS):

The total dissolved solids in the study area vary from 520 mg/L to 1770 mg/L with an average value of 967.50 mg/L, showing considerable variations from one sample to another. The maximum value of TDS in the water sample of Chhapi (T.C.) 1770 mg/L followed by that of Sherpura (M.) with the value of 930 mg/L are almost 3.5 and 2.0 times respectively higher than the desirable limit of 500 mg/L, but still they are within the permissible limit of 2000 mg/L in the absence of alternative source.

Beyond the desirable limit, it decreases palatability and may cause gastro-intestinal irritation. All the samples are having TDS values higher than the prescribed or desirable limit. TDS may be considered as an indicator of salinity for classification of ground water. The increase in TDS is mainly due to the increase[2,5,8] in inorganic salts containing carbonates, bicarbonates, sulphates, Ca, chloride, K and other ions and also due to the small amount of organic matter which influences the taste of water. High TDS in water does not mean the water would also have high fluoride content.

Total Alkalinity or T Alkalinity (as $CaCO_3$):

It is the measurement of all species of alkalinity in the water. Alkalinities are classified as T, M and P alkalinities according to the end point of the titration with acid. T alkalinity is the final end point for the alkalinity titration. The total alkalinity (as $CaCO_3$) values in the current study vary from 231.42 mg/L to 558.25 mg/L with the mean value of 382.66 mg/L.

The maximum value of 558.25 mg/L was observed in the sample of Chhapi (T.C.) which is about 2.8 times higher than the desirable limit of 200 mg/L. All the samples have values greater than this limit. Beyond the desirable limit, the taste becomes unpleasant.

M.O. Alkalinity or M Alkalinity (as $CaCO_3$):

M.O. Alkalinity (as $CaCO_3$) values fall in the range of 231.42 mg/L to 558.25 mg/L with the average value of 382.66 mg/L, however there is no maximum limit specified for this.

Alkalinity of water is generally due to the presence of carbonate, bicarbonate and hydroxide ions, but, the first two are, main causes[8]. Higher alkalinity can be attributed to substantial amount of dissolved CO_2 which is the principal source of alkalinity. Alkalinity neutralises acid and it protects[4] water and its life from sudden change in p^H. Alkalinity provides the idea of the nature of the salts present in water. All types of alkalinity are expressed in terms of (as $CaCO_3$). Excess alkalinity in water is harmful for irrigation, which leads to soil damage and reduce crop yields[10]. Alkalinity around 150 mg/L has been found conducive to higher productivity of water bodies[7]. M alkalinity is same as T alkalinity and same holds true in the present study as the values for both these are same in all the samples.

Total Hardness (as $CaCO_3$):

The total hardness in the present study varies from 264 mg/L to 561 mg/L with average value of 390.5 mg/L. Two samples of water from villages Bharkawada and Changwada are having the total hardness value as 264 mg/L each, which is well within the desirable limit of 300 mg/L, whereas the remaining two village are having values higher than this maximum limit. There is no conclusive evidence that hardness affects health [4,7]. Some people who are not used to it may develop digestive upset. It is also observed that in the areas with soft water, cardiovascular diseases have been found to be more common and this is attributed to Mg deficiency [4]. Calcium and magnesium are hardness causing ions. Increased hardness renders water unfit for washing and cleaning purposes. Beyond the desirable limit, it develops encrustation in water supply system and adverse effects on domestic use.

Chloride:

The recommended upper desirable limit of chloride in drinking water is 250 mg/L. In the present study, the chloride concentration is in the range of 82.36 mg/L to 421.50 mg/L with the mean value of 191.39 mg/L. There are considerable variations in these values from one sample to another. The water sample of Chhapi (T.C.) has the highest chloride level of 421.50 mg/L which is about 1.69 times higher than the prescribed limit, whereas, all other values are well within the limit. Beyond the desirable limit, corrosion and palatability are affected. High concentrations of chloride produces salty taste in drinking water.

When chloride values range between 100 to 200 mg/L, there is no health or aesthetic affects, but there is an increase in the corrosion (as mentioned earlier) rate of domestic appliances[11]. Chlorides are often used to remove unwanted taste and odours and to disinfect water[11]. If the water with high chloride is used for construction purpose, this may corrode the concrete[10]. The concentration of chloride in groundwater is high where the temperature is high and rainfall is less[7], as is the case in the current study area. Soil porosity and permeability also plays a key role in building up the chloride concentration [7].

Sulphate:

The sulphate concentrations in the study area varies from 14.41 mg/L to 118.02 mg/L with the mean value of 45.41 mg/L and they all are well within the prescribed desirable limit of 200 mg/L, beyond which it causes gastro-intestinal irritation [11] when present with Mg and Na. There are no health hazards when it is present within the prescribed limit. Presence of sulphates in drinking water impairs taste, however taste impairment is minimal and unnoticeable[4] below the concentration of 250 mg/L. Higher concentration of sulphate in water can cause malfunctioning of the alimentary canal and shows laxative cathartic effects on human beings[7,10].

Nitrite:

Nitrite values in all the samples are <0.01 mg/L for which no IS standard is specified, however R.P. Roy et al. have reported[12] the BIS limit of 0.02 ppm. If nitrite level exceeds its maximum admissible concentration (MAC) of 0.1 mg/L, it can be potentially hazardous to health. Nitrite being unstable compound, is converted into nitrates [4]. Nitrites consumed through leafy vegetation and drinking water are converted into nitrates (as mentioned above) in stomach.

Sodium:

The sodium level in the present study varies in the range of 66.00 mg/L to 380.00 mg/L with the mean value of 177.00 mg/L. There are large number of variations in the observed values. The water sample of Chhapi (T.C.) shows the highest value of 380 mg/L. There is no IS standard specified for this, but R. P. Roy et al. have reported [12] the BIS limit of 30 ppm.

There are no health effects associated with the use of water containing sodium levels of less than 200 mg/L for domestic purpose [11]. But for consumers on a sodium restricted diet, the concentrations between 200 to 400 mg/L are not suitable and levels exceeding this limit are also not good for infants [11]. It is also reported, that sodium concentration exceeding 50 mg/L makes the water unsuitable for domestic use [13].

Zinc:

In the present study, all the water samples show concentration of zinc 0.01 mg/L or even less than this and this is well within the desirable limit of 5 mg/L. Concentrations of zinc beyond this desirable limit can cause astringent taste and opalescence in water. Large excess of zinc can cause vomiting, cramps and renal damage [8].

Calcium:

The present study shows the concentration of calcium in the range of 66.00 to 114.4 mg/L with the average value of 89.3 mg/L. Two villages Sherpura (M.) and Chhapi (T.C.) have values of calcium as

114.4 mg/L and 110.0 mg/L respectively which are higher than the maximum desirable limit of 75 mg/L. Calcium when present beyond this maximum limit, results in encrustation in water supply structure and adverse effects on domestic use. There are no health effects associated with higher levels of calcium in water used for domestic purpose. However, high levels of calcium when present with magnesium usually in the form of $MgCO_3$ and $CaCO_3$ may render water hard[11].

Daily intake of few grams of calcium is essential for man and also necessary for potent growth[8]. For irrigation purpose, it is also desirable in water. However, high calcium contents in water are undesirable for washing, bathing and laundering [8]. Scales and incrustations on utensils are created by high level of calcium. In water, total hardness, magnesium and calcium (the fifth abundant element in nature) are inter-related[7].

Magnesium:

In the current study, the magnesium concentration varies from 23.23 mg/L to 68.64 mg/L with mean value of 40.03 mg/L which is higher than the prescribed desirable limit of 30 mg/L. Samples of Sherpura (M.) with Mg concentration of 44.48 mg/L and that of Chhapi (T.C.) with 68.64 mg/L are 1.48 and 2.9 times respectively higher than the prescribed limit.

Magnesium is also essential for man. But, the higher levels of magnesium salts have laxative effects and also they act as cathartics and diuretics in man [8]. It is the major scale forming cation in industrial water. Magnesium hydroxide as well as magnesium silicate deposits interfere with heat transfer and reduce efficiency [8]. Exceeding values of magnesium indicates the hardness of water. Magnesium usually occurs in lesser concentration than calcium and this is attributed to the fact that the dissolution of magnesium enriched materials is a slow process and that calcium is more abundant in the earth's crust[7] as stated earlier.

Nitrate:

In the present study, water samples shows the concentration of nitrate in the range of 32.24 mg/L to 73.68 mg/L with the mean value of 49.34 mg/L which is higher than the prescribed limit of 45.00 mg/L. In two villages, it is above the desirable limit with the highest values of 73.68 mg/L in the sample of Sherpura (M.). Nitrate is useful as a plant nutrient and moderately toxic. But, the high concentrations of nitrate is possibly having adverse effects on human beings and animals. Methaemoglobinaemia or blue baby disease [3,7,8] in infants is caused by the reaction of nitrate with haemoglobin, the oxygen carrier in blood, causing the lack of oxygen in blood [8]. Due to this, the respiratory and vascular systems are damaged which ultimately leads to suffocation and death known as "nitrate poisoning" [8]. Mainly, the increase in the nitrate level in groundwater is due to the excessive use of nitrogen fertilizers in modern agriculture and this is ultimately responsible for nitrate poisoning. Nitrate possibly wears down body's immune system, while its derivatives may be carcinogenic [3,8], for example, it is linked with stomach cancer in adults. High concentrations of nitrate also causes eutrophication [8]. The increase in the nitrate level in groundwater can also be attributed [8] to domestic sewage, industrial waste or drain passing near by the source. Nitrate in excessive amount can also cause gastro-intestinal tract infections in humans [8]. Even ruminants are susceptible to nitrate poisoning. Further, nitrate may be reduced to nitrite in human system and this may in turn react with organic compounds to form nitrosamines, most of which are known to be carcinogenic [2]. In view of this, WHO guidelines recommend that nitrate concentration in potable water should not exceed 45 ppm [2].

Apart from toxic metals, fluorides and nitrates are health affecting substances, where as other parameters like colour, TDS, turbidity, odour, Fe, Mn, Cu, Zn, Ca and Mg salts etc. are affecting mainly potability of water.

Fluoride:

The determination of fluoride content was done by APHA standard method APHA4500 F-D. All the water samples under present study contains fluoride less than 1 mg/L.

In small quantities, fluorides are essential for man and animals. Fluorides in small concentrations upto 1 ppm or even slightly greater than 1 ppm are generally considered to be beneficial in water, as it improves dental health and prevents the formation of dental cavities, as it being a component part of bones and teeth [8]. It also reduces decaying and missing teeth. This is because the fluoride ion attacks enzymes that produce the acid in the mouth on which the bacteria sit down causing tooth decay[8].

To improve physical comfort with respect to dental caries of the people consuming fluorine poor water, fluorides like NaF are added for fluoridation of water, but recently this has been proved wrong. However, it has been recommended that use of fluoride containing tooth pastes and mouth fresheners protect against dental caries in children [8].

Fluorine, the most electronegative element in the periodic table, is the 13th most abundant element in the earth's crust, where, it exists in the form of fluoride minerals. The fluoride concentrations are classified into four types [13]: low fluoride (<1.00 mg/L), moderate fluoride (1.0 to 1.5 mg/L) high fluoride (1.5 to 3.0 mg/L) and very high fluoride (> 3.0 mg/L).

The prescribed desirable limit of fluoride according to WHO is 1.5 ppm and according to Indian Standards, it is 1.00 ppm. It is reported[14] that in area with warmer climate, the optimal fluoride concentration in drinking water should remain below 1 mg/L while in cooler climates, it could be upto 1.2 mg/L.

Fluorine compounds are poisonous. Excessive fluorides in drinking water causes[8] fluorosis, mental disorder, failure of reproductive system, destroys enamel of teeth and makes the bones brittle. Chronic poisoning of fluorine also causes[8] loss of appetite, cachexia, structural changes in the bone tissues and teeth. It affects joints, kidneys, liver, heart, adrenal glands, testes and thyroid glands and also destroys enzymes involved in metabolism [8].

Excess amount of fluoride in drinking water may cause [8] mottling of teeth or dental fluorosis. Bone fluorosis or crippling effects are observed in case the concentration of fluoride exceeds 1 mg/L. Excess of fluoride causes several diseases like [8] cancer, infertility in women, osteoporosis, arthritis, brain damage, Alzeimer's disease, skeletal fluorosis, non-skeletal fluorosis and twisted limbs. Fluoride damages the Pinea gland. Thus, excess of fluoride is a threat to the public life.

In Gujarat, many villages have the complaint about the quality of water supplied by the Panchayat wells. There are complaints of bad quality of water, which results in dental fluorosis among children and pain in body-joints among elderly people. Food cooked by using this water does not taste good, pulses do not get cooked and tea becomes sour, etc.. Some people have complaints of skin rashes.

An estimated 60 million people in India suffer from fluorosis caused by drinking underground water having excessive natural fluoride. Since last two decades, this underground water from both shallow and deep aquifers are brought to the surface mostly by submersible pumps installed in these tube wells in Rajasthan and Gujarat, resulting into the possibility of increase in leaching [13] of various chemical constituents including fluoride. With progressive decline of groundwater table, more electric power is required to lift the same quantity of water[14]. India's escalating water crisis forces people to hunt for water deeper and still deeper underground, exacerbating the problem. Pumping of water from deeper underground taps older water which is stored since ages and is in contact with rocks and minerals for long, resulting into its more contamination. According to the author, in the study area the underground water which is withdrawn from the depth of about 700-800 feet from the surface of the earth is perhaps the "fossil water or paleowater".

Fossil water or paleowater is groundwater that has remained sealed in aquifer for a long period of time ranging from thousands to even millions of years. Fossil water is a non-renewable resource. Changes in the surrounding geology seal the aquifer off from further relplenish from precipitaton, the water becomes trapped within and is known as fossil water. Fossil aquifers get little or no recharge, whereas, the most aquifers are naturally replenished by infiltration of water from precipitation. In hydrology water mining is defined as the extraction of water from non-replenishing groundwater reserves which are low safe-yield reserves. When water is pumped from a well at a withdrawal rate that exceeds the natural recharge rate (which is very low or zero for a fossil aquifer) the water table drops forming depletion in the water levels around the well. In the study area, the possibility of the underground water at about a depth of 700 to 800 feet as being fossil or paleowater is confirmed by the fact that the large scale exploitation of this groundwater for drinking, irrigation and industrial purpose has led to fall in groundwater tables in Gujarat at a rate of about 3 m/yr through groundwater mining [14] and also due to scanty rainfall there is a zero recharge of this underground water which thus is not naturally replenished. Survey with the farmers in the study area indicates that at a depth of more than 800 feet there is a hard stone layer lacking water.

Fluorine is accumulated in the body even if it is introduced in trace amounts. According to IS standards, the desirable limit for fluoride is 1 mg/L and maximum permissible limit in the absence of alternate source is 1.5 mg/L. Thus according to BIS, the fluoride content in water should be 1 – 1.5 mg/L as levels above or below this could cause dental decay[8]. High concentration of fluoride causes fluorosis and other health problems. But, contrary to this, it is reported [8] that daily ingestion of 2 mg of fluoride could result in crippling skeletal fluorosis after 40 years. Fluorine content of water depends on the soil and varies from 0.5 to 50 ppm. Soft water contains little fluoride, but significant amount may be present in hard water[8].

Fluoride mainly enters the human body through drinking water and secondly through food materials [8] e.g. onions (2.1 ppm), tea leaves (56.0 ppm), carrot (3.4 ppm), potato (1.9 ppm), tomato (1.4 ppm), etc.. 1 mg of fluoride is introduced into body through two cups of tea. Thus the average daily intake of about 2-3 litres of water having fluoride concentration below the desirable limit of 1mg/L and the other fluoride rich food can meet with this requirement and can lead to health problems in a long run. The author completely agrees with this as such cases of fluorosis accompanied by other health problems are observed in the study area as well as the other Talukas of B.K. district and also in the adjacent districts of North Gujarat. Thus, the idea or belief that fluoride within the limits of 1-1.5 mg/L is non-harmful is false and thus it is concluded that even water with this concentration of less than 1 mg/L is a slow poison in a long run.

The occurrence of fluorosis can vary widely among different places having nearly the same concentration of fluoride in drinking water and can be affected by various factors such as climate, individual susceptibility and biological response[8]. Endemic fluorosis is aggravated by the key role played by poor malnutrition. Fluorosis is an irreversible disease which neither allows a person to live nor to die [8] as there is no cure for that. Fluorosis is developed slowly among the people. Thus, fluoride is known as double edged sword [15]. The problem with fluoride in drinking water is that, if it is present then also problems are there and even if it is not present, then also problems are there.

Gujarat is one of the most severely affected states in the country considered to be endemic to fluorosis, where about 18 out of total 24 districts are prone to fluorosis due to high content of fluoride in drinking water[14]. In North Gujarat, the adjacent districts, Mehsana, Patan and Banaskantha (of which the present study area is a small part) are the most affected districts apart from other state districts like Ahmedabad, Amreli, Sabarkantha and Baroda[14].

In Gujarat the NGO's as well as Government health centres and doctors do not like to declare/diagnose fluorosis as such rather they would like to cover fluorosis behind the mask of 'Va' or MSD (Musculo-Skeletal Disease). Thus, the cases of fluorosis are mixed with MSD and recorded as general MSD. Prevalence and severity of fluorosis is increased with age and length of residence in fluoride endemic area[15]. The gestation period of fluorosis is long and less predictable, it may happen that the problem may become all out severe in few years, and by the time State Government becomes alert and active, the situation will be totally out of control and it may be a disaster ahead. Thus, fluorosis in Gujarat is a disaster ahead. Under these circumstances, the Government of Gujarat should take preventive measures for fluorosis, must provide fluoride free water to every village of the state and some kind of rehabilitation for fluorosis affected people and fluorosis should be given priority on war footing. In other states like, Rajasthan, Delhi and Punjab, it is not so. The preventive measures taken by the Government of adjacent state, Rajasthan, should be implemented. The use of domestic defluoridation filters is the short term solution to minimize the fluoride level in drinking water. Villages that are suffering from fluoride problem above the permissible limits are provided with hand pumps attached with AA (activated alumina) filters under the 'Integrated Fluoride Mitigation Programme' initiated by Government of Rajasthan[16]. Public Health and Engineering Department, Government of Rajasthan, provides safe drinking water to those affected villages through Bisalpur project. In Rajasthan, out of the proposed 483 villages and two hamlets, 149 villages, and two hamlets are benefited through 'Fluoride Mitigation Scheme' proposed by the State Government[16].

BIOLOGICAL POLLUTION OF WATER:

Pathogenic bacteria, certain fungi, pathogenic protozoa, viruses, parasites, worms etc. are responsible for biological pollution. Pathogenic bacteria, if present in water are responsible for diseases[8] like cholera, typhoid, dysentry, jaundice, gastroenteritis, etc..

Total bacterial count and E.coli test or/and Coliform test are the two/three important bacteriological examinations or tests.

Total Bacterial Count @ 37^0 C:

In the water samples under study, this parameter is having the values ranging from 2×10^3 to 4×10^4 org/mL. In this test[8], the sample of water and agar is kept in an incubator at 37^0 C for 24 hours. The growth of bacteria in the form of bacterial colonies can be seen and counted. Though there are no IS specifications for this, it is reported[8] that in potable water the total count should not be more 1×10^2 per mL of water.

Coliform group of bacteria are intestinal organisms and some of which are non-pathogenic. The presence of coliform group of bacteria in water is a good indicator of microbiological pollution. In the present study, they are present in the range of 18 to 43 MPN /100mL, indicating that these waters are microbiologically polluted and are not suitable for drinking purpose. In all samples they are present beyond the maximum permissible limit[2,3,8] of 10 MPN/100 mL. Coliforms in excess number may be responsible for the outbreak of a number of water borne diseases [3,12] as mentioned earlier.

Escherichia coli (E. coli):

E.coli is the most common bacteria in the coliform group. The presence of this bacteria in water may indicate the presence of pathogenic bacteria[8]. Ideally E. coli count in 100 mL of any water sample should be zero. The E. coli index[8] (the approximate number of E. coli present in 1 mL of water sample) in potable water should be less than 3 and it should never be more than 10. In the present study, all water samples shows the absence of E. coli.

REMEDIAL MEASURES AND RECOMMENDATIONS:

These waters before being used for potable purpose, should be disinfected in the interest of public health. The ground water resources should be augmented[3] by recharging the ground water aquifer through rain water harvesting and thus reducing the high level of physico-chemical parameters, mainly the high concentration chemical parameters. The main effects of over exploitation of groundwater resources are, depletion in groundwater levels, drying up of the wells and bore wells, increased consumption of energy and deterioration of ground water quality. Under these circumstances, roof top rain water harvesting and recharge of underground water, harnessing of runoff rain water in check-dams, percolation trenches, ponds and underground tanks in villages will help quite a lot. This rain water harvesting will have a number of advantages like rise in groundwater levels, availability of more water, prevention of declining in water levels, less consumption of energy, water quality improvement, etc.. Farmers should be encouraged to use bio-fertilizers instead of using chemical fertilizers like ammonium nitrate responsible for increase in the level of toxic nitrate level in water. Health awareness programme should be initiated among public who should be instructed to use boiled water for drinking. Bacteriological contaminations of water attracts the attention of concerned authority easily as its effects on consumers are rapid, visible and known[4] while chemical contamination of water takes long time to show its effects on consumer's health. We should follow the path of many developing countries in which water borne diseases have been reduced or virtually eradicated and now more attention is being paid to control the chemical pollutants[4]. The use of polluted waters[17] for irrigation in absence of any other alternative fresh water source has produced adverse effects on the soil inhibiting plant growth. At many places, the soil is turning hard and losing its fertility. Crops have either failed to germinate or have reduced yield due to irrigation with polluted water. Factors like depletion in the water table, highly increased non-affordable cost of making bored tube wells, increased costs of materials and seeds required for agriculture, comparatively low yield of the agricultural products, high electricity costs, increased fertilizer costs, division of ancestral land with increase in the number of generations, industrialisation, increased labour cost and lesser availability of labourers due to urban migration, etc. are responsible for destroying of agriculture in villages. The rural economy which is agriculture based has badly shattered. This has considerably affected the socio-economic status of villages leading to the migration of rural people to cities which are already over loaded. This is a serious issue with multiple direct or indirect effects and government should swing into action immediately on priority basis as India is made up of 75-80% villages. The groundwater of this area needs some degree of treatment before drinking and it needs to be protected from contamination so as to prevent adverse health effects on human beings[5].

Regular intake of fluoride rich water seems to be the main cause for high incidence of fluorosis (dental and skeletal). The public awareness should be created through community awareness camps and information about the nutrition, defluoridation techniques at domestic level to prevent fluorosis. Nutritional diet such as calcium and phosphorous rich food should be recommended to those affected with fluorosis, as it decreases rate of accumulation of fluoride in the human body[14].

Water containing increased amount of fluorine should be defluoridated, which is one of the method of purification of water. Water is defluoridated[8] by binding fluoride ion with chemical reagents or by its sorption on various materials such as salts of Al, Mg and H_3PO_4.

For defluoridation, conventional filters such as sand filters can be used at primary level as they are having their own limitations. Nanofilters and nanomebranes are better methods as compared to conventional methods[8] but they are costly. Advanced mechanical filtration like diatom filtering (which cannot remove chemical impurities due to large size pores) and reverse osmosis commonly known as RO (which wastes 60-87% water and is slow) can perform on the nanometric scale[8].

Nanofiltration membrane technology is widely used[8] to remove dissolved salts from salty water, remove micropollutants, soften water and treated waste water. Nanofiltration technologies have emerged as an option[8] that is cheaper as compared to existing water purification technologies in terms of efficiency, maintenance, less energy requirement and no use of any chemicals. But, a fusion of conventional and nanoscience based technologies can ensure safe water without any additional cost [8].

Preventing measures like public awareness for optimal use of water and minimum wastage, providing less expensive water filters (like Activated Alumina Plant and hand pumps fitted with AA filters as mentioned earlier), personal or domestic RO based kitchen filters coupled with UV and ultrasound assemblies or captive demineralization plant which can be on a co-operative basis organized by the villagers, a big defluoridation plant erected by Government, reducing fluoride concentration in ground water by mixing it with river water, a practice adopted in North Gujarat by using Sabarmati river's water through Dharoi Dam and recharge of groundwater by rain water harvesting will help in reducing fluoride from the groundwater. Fluorosis affected victims should be rehabilitated by NGO's and Government authorities.

There is a rise in RO plants as a cottage industry to get safe drinking water (with reduced fluoride, within the permissible limit) in North Gujarat. These plants supply good and safe water to the consumers under packed drinking water.

Water can also be defluoridated by use of powdered corn cobs whose surface is modified by using aluminium chloride[18]. Nalgonda technique[19] can also be used for defluoridation of water. It was found that use of alum with lime indicated good results for minimising the fluoride problem of the villagers. Public awareness may be created with the messages of the type: 'Water is Precious. Save it', 'Jal Hi Jeevan Hai' [Water is Life] etc..

CONCLUSION:

The water in the study area is not suitable for domestic consumption without prior treatment as many parameters are far beyond the desirable limits. Ingestion or this low fluoride containing water at a later age can lead to fluorosis (dental and skeletal) as fluoride even within the desirable limit of 1 mg/L can have toxic effects over a prolonged period. The groundwater quality may deteriorate with passage of time. It may also get reduced in quantity with time and may result in drying up of deep bored tube wells. The author is of the opinion that this water is not suitable even for agricultural purposes. Compared to each other, many parameters in the samples of two villages Sherpura (M.) and Chhapi (T.C.) are very high and the latter having some parameters with highest values.

ACKNOWLEDGEMENT:
The author thanks Principal and Head of Chemistry Department, Mithibai College, for their valuable support. He also thanks his student, Mr. Hem Kothari for his constant help.

REFRENCES:

1. D. K. Sinha, G. K. Rastogi, R. Kumar and N. Kumar, *J. Environ.Sci. and Engg*. 51(2), (2009), 111-114.
2. B. K. Sharma, L. L. Sharma and V. S. Durve, *J. Environ.Sci. and Engg*. 50(2), (2008), 133-136.
3. B. S. Shankar, N. Balasubramanya and M. T. Maruthesha Reddy, *J. Environ.Sci. and Engg*. 50(2), (2008), 97-102.
4. G. Desai, S. Vasisth, M. Patel, V. Mehta and B. Bhavsar, *J. Environ.Sci. and Engg*. 54(3), (2012), 416-419.
5. V. Vishwarkarma and L. S. Thakur, *J. Environ.Sci. and Engg*. 54(4), (2012), 533-543.
6. K. S. Bangar, S. C. Tiwari, S. K. Verma and U. R. Kandkar, *J. Environ.Sci. and Engg*. 50(3), (2008), 179-186.
7. S. Dutta, A. K. Pandey and K. C. Sharma, *J. Environ.Sci. and Engg*. 48(4), (2006), 241-246.

8. B. K. Sharma, Environmental Chemistry, GOEL Publishing House, An Imprint Of Krishna Prakashan Media (P) Ltd., Meerut (U.P.), 13th Edition,(2012), pages 1-404(Unit-4) and pages 1-72(Unit-7).
9. M. K. Sharma and C. K. Jain, *J. Environ.Sci. and Engg*. 48(4), (2006), 271-280.
10. M. L. Sundar and M. K. Saseetharan, *J. Environ.Sci. and Engg*. 50(3), (2008), 187-190.
11. P. Sukdeo, P. Srinivasan and B. Hari, *Current Science*. 106(05), (2014), 739-743.
12. R. P. Roy, J. Prasad and R. Gupta, *J. Environ.Sci. and Engg*. 54(3), (2012), 420-423.
13. A. N. Modi and P. Kumar, *J. Environ.Sci. and Engg*. 54(4), (2012), 510-519.
14. P. Parikh and R. Parikh, *Int. J. of Environ.Sci. and Engg*. 3(2), (2013), 2199-2207.
15. R. Mogra and S. Sharma, *J. Environ.Sci. and Engg*. 51(4), (2009), 273-276.
16. C. Vikas, *J. Environ.Sci. and Engg.* 51(3), (2009), 169-174.
17. J. Rathore, S. Jain, S. Sharma, V. Choudhary and A. Sharma, J. *Environ.Sci. and Engg.* 51(4), (2009), 269-272.
18. H. S. Parmar, J. B. Patel, P. Sudhakar and V. J. Kashy, *J. Environ.Sci. and Engg.* 48(2), (2008), 135-138.
19. A. Sahu and M. M. Vaishnav, J. *Environ.Sci. and Engg*. 48(1), (2006), 65-68**.**

Table I : Results / Values of various physico-chemical and microbiological parameters of groundwater samples with their prescribed limits

Sr. No.	Parameter	Unit	Results of water sample from village				Drinking water Standards as per IS:10500:1993 (Desirable Limit)
			Sherpura (M.)	Bharkawada	Chhapi (T.C.)	Changwada	
1.	pH	-	7.10	7.39	7.51	7.56	6.5 – 8.5
2.	Total Dissolved Solids	mg/L	930.00	650.00	1770.00	520.00	500
3.	Total Alkalinity as ($CaCO_3$)	mg/L	406.00	334.95	558.25	231.42	200
4.	Zinc (as Zn)	mg/L	<0.01	<0.01	0.01	<0.01	5
5.	Calcium (as Ca)	mg/L	114.40	66.00	110.00	66.88	75
6.	Magnesium (as Mg)	mg/L	44.48	23.76	68.64	23.23	30
7.	Sodium (as Na)	mg/L	132.00	130.00	380.00	66.00	Not Specified
8.	Conductivity	µS/cm	1328.00	953.00	2435.00	761.00	Not Specified
9.	Total Hardness (as $CaCO_3$)	mg/L	437.00	264.00	561.00	264.00	300.00
10.	M.O. Alkalinity (as $CaCO_3$)	mg/L	406.00	334.95	558.25	231.42	Not Specified
11.	Nitrite (as NO_2)	mg/L	<0.01	<0.01	<0.01	<0.01	Not Specified
12.	Nitrate (as NO_3)	mg/L	73.68	32.24	48.03	43.42	45.00
13.	Sulphate (as SO_4)	mg/L	31.53	14.41	118.02	17.66	200.00
14.	Chloride (as C1)	mg/L	154.42	107.63	421.15	82.36	250.00
15.	Fluoride (as F)	mg/L	<1.0	<1.0	<1.0	<1.0	1.0
16.	Total bacterial count @ 37^0C	Org/mL	$3 X 10^4$	$2 X 10^3$	$4 X 10^4$	$1 X 10^4$	Not Specified
17.	Coliform	MPN/100 mL	24.00	18.00	43.00	36.00	10
18.	E. coli	-	Absent	Absent	Absent	Absent	Absent