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Innovation The Research Concept

Nitrate, Phosphate, Fluoride, Iron, Zinc, Nickel and Coliform Bacteria Contamination of Drinking Water in Hojai District, Assam, India

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Abstract

Water is the most essential commodity for the entire living system on the earth. Water pollutants are increasingly contaminating groundwater. The study reports the quality of drinking water in Hojai district, Assam, India in three seasons i.e. pre-monsoon, monsoon and winter season over a three years period from 37 different sources in 20 locations. The 37 sources includes 20 tube wells, 13 are ring wells, 4 are supply water. The nitrate concentration was found from .2mg/l to 12.3 mg/l in all sources. In four tube wells and six ring wells the concentration of nitrate have been found beyond WHO standard (10mg/l) and unfit for human consumption. Considering all seasons mean values of some sources of water studied in the present work were found to contain phosphate at higher concentration levels than the limit of WHO (0.1mg/l) and thus not to be absolutely fit for used as drinking water. In the certain areas of Hojai District are unsuitable for drinking purpose due to high fluoride contamination in groundwater. Excessive ingestion of fluoride through drinking water causes fluorosis. This disease is wide spread in certain part of Hojai District . In all sources, the iron contents were found to be higher than the WHO limits (0.3mg/l). The study shows that ground water were considerably polluted due to high concentration of zinc and nickel metals beyond the permissible limits of WHO drinking water standard in these region. The high concentration of these in groundwater may cause serious diseases in human being and disturb metabolic function by consumption of such contaminated water. The microbial investigations have shown presence of E. Coliform organism and faecal coliforms in all sources underground water samples and are highly contaminated and unfit for drinking purpose.

S. Kumar
Associate Professor & Head,
Department of Chemistry,
Rabindranath Tagore University,
Hojai, Assam, India

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Introduction

Water is essential for the survival of any form of life. Increasing industrial activities, rapid progress in Science and Technology, human activities, use of various chemicals in agriculture etc. are the factors threatening the very quality of the life sustaining aquatic system. Moreover, the geology of soil also determine the presence of the chemical substances and their concentrations in water. Quality of water particularly that used for drinking is very much influenced by these substances. The pollutants often do not show immediate effect on human health unless they enter into the body in substantial amounts. However, prolonged exposure to the chemicals even in very low concentration causes accumulation of them and they begin to show adverse effects. Sewage, industrial wastes and wide array of synthetic chemicals pollute considerable part of this limited quantity of water. The menace of water-borne diseases and epidemics still threatens the well-being of population, particularly in underdeveloped and developing countries. Thus the quality as well as the quantity of clean water supply is of vital significance for the welfare of mankind. The present study reports the quality of groundwater from a large number of locations of the Hoja district, Assam has been found to be affected with nitrate,phosphate,fluoride, iron,zinc,nickel and coliform bacteria contamination. People are affected by an peculiar disease in which the neck-movement is limited, spinal cord and joints are stiffened, legs are bifurcated and teeth are moulted in certain areas of Hojai district area. Hojai, district is situated in the central Brahmaputra valley zone of the state of Assam. It is located between 92.45°E to 93°E latitude and between 26°E to 26.5°E longitude at an altitude of 44.3° from the main river level. Hojai district has a total area of 1224 sq.km. with a population of 9.31lakh as per 2011 census (Source : Office of the district l Statistical Officer, Sankardev Nagar, Hojai district). The most widely used source of drinking water in the Sub-division is tube wells and ring wells. The urban water scheme is inadequate and can supply water only in some locations in Hojai town. A large section of the people even in urban areas have to depend on ring wells and tube wells for their water needs. There is no large and medium industries in Hojai district area and the water sources are under tremendous pressure only due to high density of population.

Aim of the Study

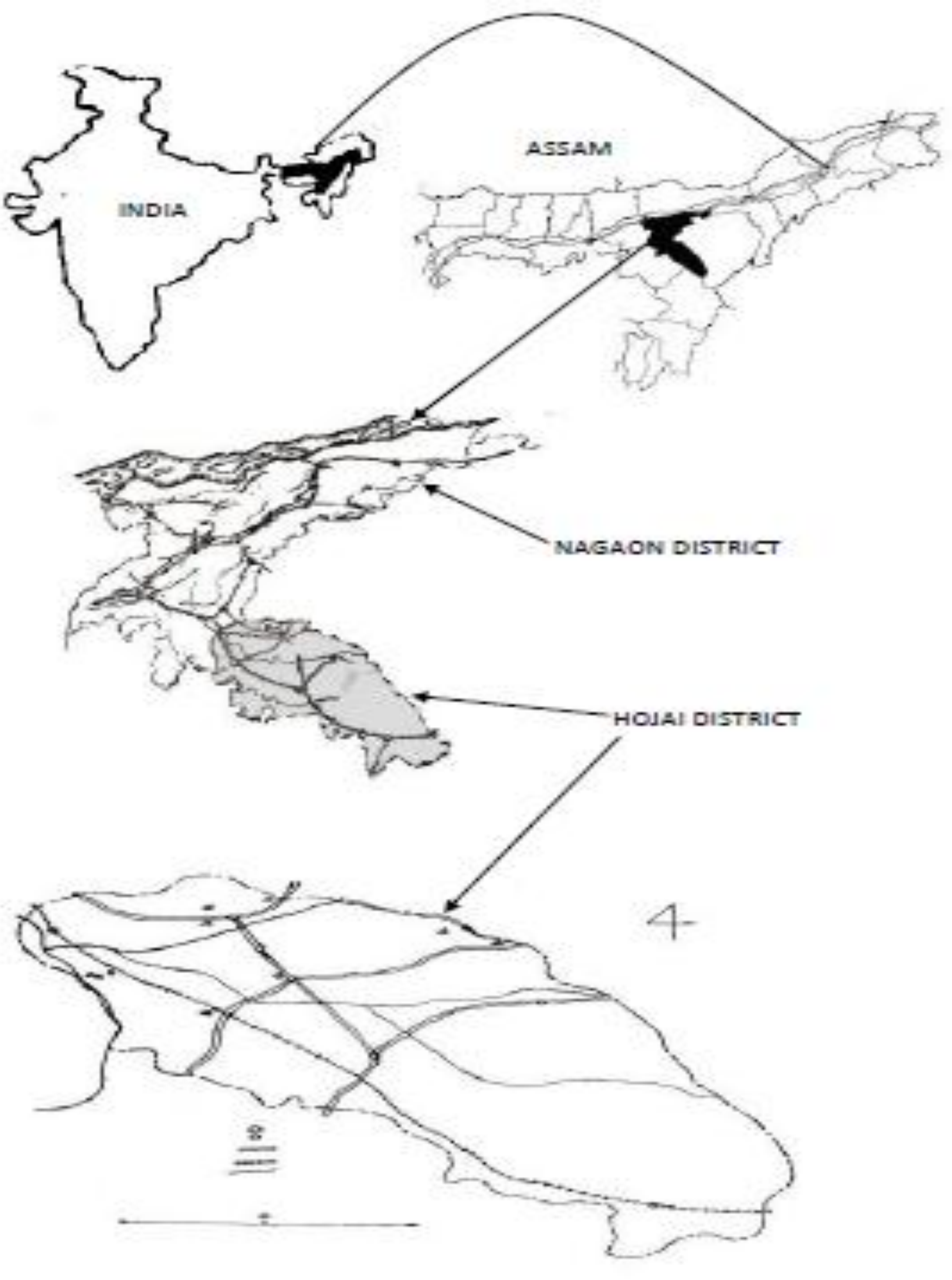
The aim of the study is to alart the people of Hojai district and not of consume polluted water by estimation of No_3-, $Po^{3-}_{4,}$, F^-, Fe^{2+}, Zn^{2+}, Ni^{2+} and Coliform bacteria.

Materials and Method

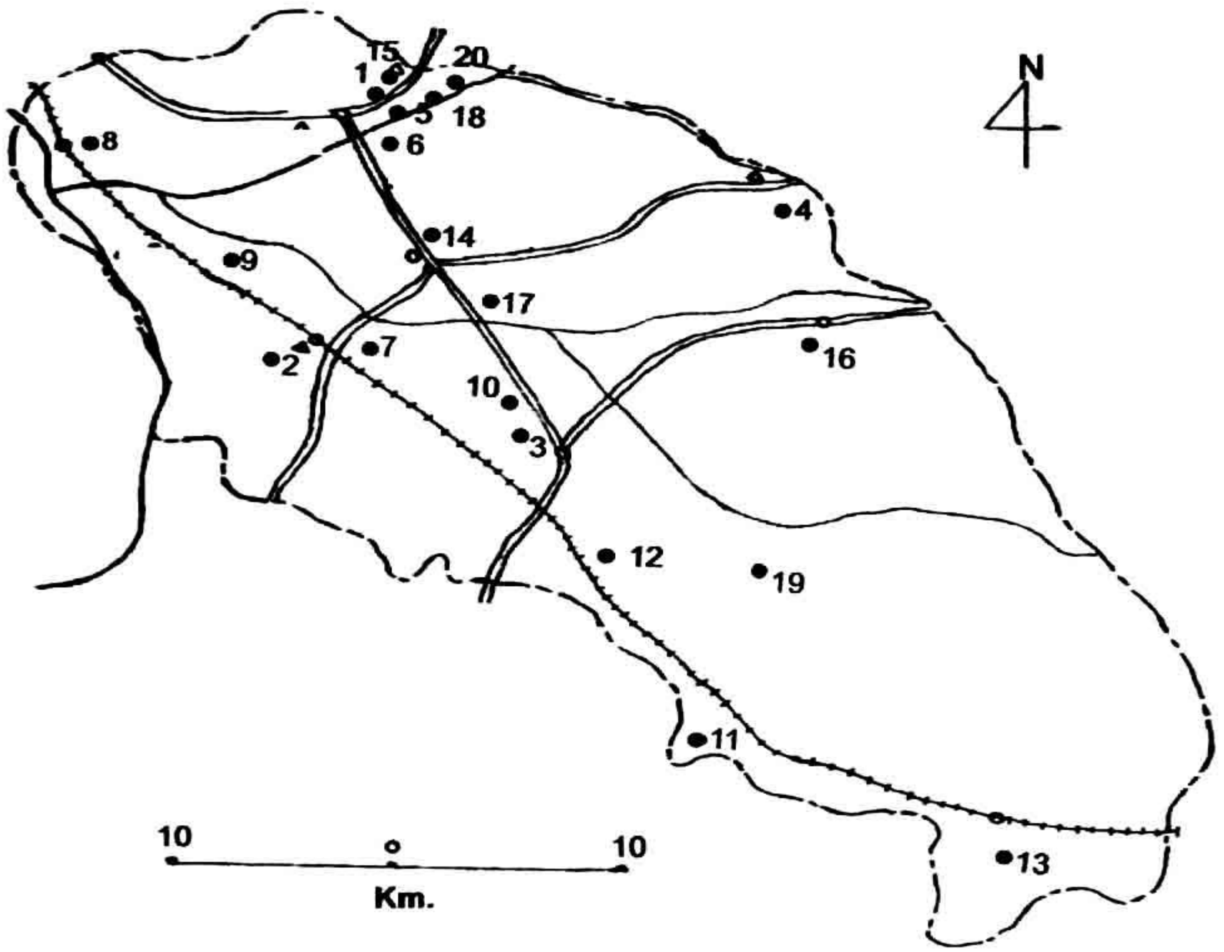
The groundwater samples were collected in three seasons viz. Pre-monsoon season (February-May), Monsoon season (June-September) and Winter (October-January) starting from Feb2018 to Jan,2020. Water samples were collected in pre-cleaned polythene containers of 5 liters capacity from 37 different sources in 20 locations. The 37 sources includes 20 tube wells (from TW1 to TW20),13 are ring wells (from RW1 to RW13), 4 are supply water (from S1 to S4). Locations of the sampling station in Hojai district area are shown in the Map No 1 and Map No. 2.Nitrate-nitrogen was determined by using UV-spectrophotometric technique (Hitachi 3210) by measuring the absorbance of the phenol-disulphonic acid nitrate complex at 410 nm. The amount of phosphate in the water samples were determined by stannous chloride method. Molybdophospharic acid, produced by the action of phosphate with ammonium molybdate reagent, is reduced by stannous chloride to intensely coloured molybdenum blue. The colour intensity is measured photometrically at 690 nm and compared with a calibration curve.The analysis of fluoride was carried out standard procedure (APHA,1995). Fluoride was determined spectrophotometrically by the SPADNS method.The concentration of the iron in water samples were estimated by phenanthroline method. Ferrous iron chelates with 1,10 - Phenanthroline at 3.2 to 3.3 to form an orange-red complex. The intensity of this colour is proportional to the iron content in the sample and the later was read on a UV - spectrophotometer (Hitachi 3210) operating the instrument at 510 nm in photometry mode calibrating against a standard and a blank.Zinc and nicel were estimated using Atomic Absorption Spectrophotometer (Perkin Elmer Model 2380) at the Regional Sophisticated Instrumentation Centre, Shillong with air acetylene flame and standards prepared in triple distilled water.Microbiological examination of water enjoy a special status in studying the water quality. In this examination the Most Probable Number (MPN) indices of total coliform organisms as well as faecal coliforms were determined using the multiple tube fermentation technique. The fermentation was carried out in an incubator (SICO, India) at 350.5^{o}c for total coliforms and at 440.5^{o}c for faecal coliforms.

The average values of nitrate, phosphate, fluoride, iron, zinc, nickel in mg/l and coliform bacteria in MPN/100 in three seasons viz. Pre-monsoon season monsoon season and Winter for three years starting from Feb,2018 to Jan,2020. are given in the Table: 1

LOCATION OF STUDY AREA HOJAI DISTRICT



HOJAI DISTRICT, LOCATION OF SAMPLING STATIONS



1. AKASHIGANGA (TW1)
2. AMTOLA (TW2, RW1)
3. BHALUKMARI (TW3)
4. DEBASTHAN (TW4)
5. DIKHARUMUKH (TW5)
6. DOBAKA (TW6, RW2, S1)
7. HOJAI TOWN (TW7,RW3,S2)
8. JAMUNAMUKH (TW8)
9. JUGIJAN (TW9, RW4)
10. JURAPUKHURI (TW10)
11. KARIKHANA (TW11, RW5)
12. LANKA (TW12, RW6, S3)
13. LUMDING TOWN (TW13, RW7,S4)
14. NILBAGAN (TW14, RW8)
15. NIZ PARAKHOWA (TW15, RW9)
16. NO.1 KAKI (TW16, RW10)
17. SANKARDEV NAGAR (TW17, RW11)
18. TAPAJURI (TW18, RW12)
19. UDALI (TW19, RW13)
20. URDHAGAON (TW20)

Source of Water Sample :
TW : Tube Well, RW : Ring Well, S : Supply Water.

Map 3.1 Locations of the sampling station in Hojai District area.

Table:1 The average values of nitrates, phosphates, fluorides, iron, zinc, nickel in mg/l and coliform bacteria in MPN/100 in three seasons for three years.

Sl. No.	Sampling Sources	Nitrates (mg/l)	Phosphates (mg/l)	Fluorides (mg/l)	Iron (mg/l)	Zinc (mg/l)	Nickel (mg/l)	Coliform Bacteria (MPN/ 100 ml)
1	TW1	5.33	0.39	5.40	8.05	2.35	0.012	354.0
2	TW2	7.24	0.37	0.27	5.16	7.02	0.017	0.0
3	TW3	4.93	0.23	0.46	5.98	1.39	0.008	19.7
4	TW4	5.39	0.34	2.49	9.42	1.58	0.040	30.7
5	TW5	1.72	0.29	7.73	3.70	0.69	0.012	390.7
6	TW6	3.62	0.42	2.24	8.71	1.42	0.016	517.3
7	TW7	1.39	0.30	0.47	10.51	3.15	0.053	612.0
8	TW8	3.25	0.23	1.80	7.10	2.12	0.000	16.0
9	TW9	5.51	0.28	1.90	9.87	1.64	0.013	0.0
10	TW10	2.88	0.26	0.38	3.41	2.94	0.013	408.0
11	TW11	2.74	0.28	0.60	10.27	1.04	0.008	12.3
12	TW12	1.85	0.32	0.67	14.58	1.41	0.014	12.3
13	TW13	2.37	0.21	0.41	6.03	2.85	0.000	0.0
14	TW14	3.79	0.57	2.03	7.89	1.44	0.031	0.0
15	TW15	6.94	0.39	15.48	9.19	2.13	0.040	768.7
16	TW16	3.52	0.28	0.60	5.69	1.22	0.000	15.7
17	TW17	2.45	0.25	0.40	5.85	1.14	0.000	0.0
18	TW18	2.92	0.44	11.27	10.81	2.45	0.015	248.0
19	TW19	3.27	0.42	0.53	16.46	2.74	0.015	13.0
20	TW20	2.87	0.34	3.26	6.88	1.95	0.017	357.3
21	RW1	6.80	0.38	0.34	6.97	1.45	0.03	443.3
22	RW2	3.64	0.64	5.96	4.48	1.93	0.01	1716.3
23	RW3	2.18	0.28	0.43	15.46	1.47	0.05	1690.7
24	RW4	5.36	0.20	0.50	6.79	1.70	0.04	294.7
25	RW5	5.28	0.31	0.36	3.07	0.97	0.01	634.0
26	RW6	2.79	0.36	0.48	9.13	1.93	0.02	340.0
27	RW7	2.19	0.15	0.43	4.02	1.54	0.01	197.7
28	RW8	4.92	0.19	3.42	8.58	1.53	0.02	2995.0
29	RW9	6.27	0.27	8.21	4.91	5.42	0.04	7080.0
30	RW10	5.23	0.24	0.49	4.11	0.85	0.00	466.3
31	RW11	4.74	0.33	0.28	3.87	1.05	0.02	819.0
32	RW12	3.71	0.25	5.78	7.27	2.05	0.01	2904.7
33	RW13	4.67	0.22	0.48	10.98	1.67	0.06	544.3
34	S1	1.71	0.37	1.19	1.24	1.89	0.03	166.3
35	S2	1.24	0.36	0.67	1.49	1.53	0.02	211.5
36	S3	0.86	0.38	0.48	1.45	1.14	0.01	487.7
37	S4	0.94	0.25	0.45	1.26	0.82	0.01	0.0

Results and Discussion

Nitrate

The nitrate-N contents of water samples were found from 0.4 mg/l to 12.3 mg/l in tube wells, 0.5 mg/l to 12.2 mg/l in Ring wells and 0.2 mg/l to 3.8 mg/l in supply water. The contents of nitrate was found 12.3 mg/l from the sampling point Amtola (TW2) and 12.2 mg/l was observed in Doboka (RW2). The present study did not recorded any all season average concentration of NO_3-N above the permissible limit of 10 mg/l. But the higher concentration of nitrate i.e. more than 10 mg /l is found in six ring wells from the sampling points Amtola (RW1), Jamunamukh (RW4), Karikhana (RW5), No.1 Kaki (RW10), Sankardev Nagar (RW11) and Udali (RW13), four tube wells from sampling points Akashiganga (TW1), Amtola (TW2), Debasthan (TW4) and Niz-Parakhowa (TW15) in monsoon seasons. The high value of nitrate in our study area may be due to municipal wastewater, excessive application of nitrogenous fertilizer manure and irrigation, leakage from septic tanks, human and animal waste contamination, inflow of domestic wastes along with groundwater recharge in monsoon seasons. WHO has recommended an amount of 10 mg/l in drinking water. Nitrate, although not harmful as such, may be converted to dangerous nitrite in the body by certain bacteria which reacts with the haemoglobin of red blood cells inhibiting their capacity to carry oxygen. Infants, particularly upto six months of age are more susceptible to this condition as then gastric juices have low P^H, for which a suitable environment is created for the bacteria that convert nitrate to nitrite. Thus, excessive nitrate may affect infants adversely causing methemoglobinemia or “Blue baby disease”. Besides blue baby disease, nitrate leads to potential formation of carcinogenic nitrosamine.

Phosphate

The phosphate values recorded in this study were found to be fluctuated from 0.05 mg/l and 0.9 mg/l in tube wells, 0.06 mg/l and 1.2 mg/l in ring wells, 0.09 mg/l and 0.52 mg/l in supply water. The phosphate concentration .9mg/l was observed from tube well (TW14) in Nilbagan location. Among the ring wells thehighest phosphate concentration, 1.2mg/l was found in RW2 from Doboka location in monsoon season. WHO has recommended 0.1 mg/l of phosphate in drinking water. Considering all seasons mean values of some sources of water studied in the present work were found to contain phosphate at higher concentration levels than the limit of WHO and thus not to be absolutely fit for used as drinking water sources. Dhembare et.al., (1998) had reported that phosphate, if consumed in excess, may produce phosgene gas in the gastrointestinal tract on reaction with gastric juice which can lead even to death of consumers. Phosphate may occasionally stimulate excessive or nuisance growth of algae and other aquatic plants, as it is a plant nutrient. Algal growth imparts undesirable taste and odour to water making it aesthetically unpleasant and interferes with water treatment.

Fluoride

The fluoride concentration in the groundwater samples were observed from 0.1mg/l to 16.2mg/l in tube wells, 0.16mg/l to 10mg/l in ring wells and .2mg/l to 1.6mg/l in supply water. The highest fluoride contents(16.2mg/l) was recorded in the tube well located at Niz-Parakhowa(TW15). The next highest value(12mg/l) was observed in the tube well at Tapajuri(TW18). In the present investigation fluoride content of water(all season average concentration) for the tube wells located at Akashiganga(TW1), Debasthan (TW4), Dikharumukh (TW5), Doboka(TW6), Jamunamukh(TW8), Jugijan (TW9), Nilbagan(TW14), Niz-parakhowa(TW15), Tapajuri(TW18), Urdhagaon(TW20) and that of ring well of Doboka(RW2), Nilbagan(RW8), Niz-parakhowa(RW9) and Tapajuri(RW12) was observed to contain fluoride more than the WHO's guideline level of 1.5mg/l. Moreover in the areas of Dikharumukh (TW5), Niz-parakhowa (TW15),Tapajuri (TW18) and Urdhagaon(TW20) the appearance of fluoride (more than 10mg/l) in the water level has reached an alarming proportion. There is no industrial establishments like smelter plant, power plant, thermal power stations, fertilizer corporation etc. in this area with abilities of producing fluoride contents in groundwater. The fluoride contamination occurs naturally in the water samples of ground water in some areas may due to weathering of fluoroapatite rocks (Sax, 1974; Shrivastava, 1995). Fluoride causes dental fluorosis if present in excess of 1.5 mg/L and skeletal fluorosis beyond 3 mg/L if such water is consumed for about 8 to 10 years (Nawlakhe and Buluse, 1989). In the present study it is seen that 607 habitations were found to affected by dental fluorosis and skeleton fluorosis. The fluoride cause non-skeletal fluorosis (Susheela, 1984, 1985).The results of the initial survey in fluoride affected area indicates that 75% of the population of the village was affected by the skeletal fluorosis. The physical appearance and some symptoms of skeletal fluorosis patient were observed to be curvature of arms and legs and stiffness in joints and spinal cord. The other usual complains were the stiffness of the vertebral column and the pain in the neck movement. The situation of fluoride effected area is fast deteriorating and more and more people particularly children and women becoming victims of the danger fluorosis disease. The fluoride may be removed from water by adsorption method, ion exchange method, precipitation method and miscellaneous methods (Kilder and Bhargava 1988, Ministry 1993).

Iron: The Iron concentrations of the samples were found to extent over the ranges, from 2 mg/l to 23.2 mg/l in tube wells, 1.6 mg/l to 20.1 mg/l in ring well and 0.50 mg/l to 2.60mg/l in supply water. The highest concentrations of iron (23.2 mg/l) was observed in the tube well (TW19) at Udali. The lowest concentration of iron (.50 mg/l) was recorded in supply water (S1) of Doboka Town. The average iron contents of all the types of sampling sources exceeded the permissible limit **.**3 mg/l according to WHO. Thus most of the water sources in the present study area were found to be unfit for use as drinking water sources with respect to this metallic constituents. Further iron was found to be heterogeneously distributed in the groundwater of the present study area. The iron contents of the tube wells and the ring wells are found to be higher due to soil origin, rocks, clays soils natural organometallic or humic compound etc. Iron, in small amounts is an essential element for health as it is a constituent of a number of biologically significant proteins. But very high intakes may lead to hemochromatosis resulting in tissue damage due to accumulation of it. Iron at excessively high concentrations has been reported to interfere with metabolism of phosphorus. Even though iron is an essential trace element for both animal and plants, its presence imparts an objectionable taste to water and it stains clothes and plumbing fixtures. Iron is also associated with constipation and other problems. In the present work iron contents of water samples collected during the monsoon period were found to be generally high indicating that the rain and storm water runoff add to the iron input of all the sources.

Zinc

The zinc concentrations of the samples were found to extend over ranges from 0.35mg/l to 10 mg/l in tube wells, 0.32 mg/l to 8mg/l in ring wells and .33 mg/l to 2.9 mg/l supply water. The high concentration of Zinc (10 mg/l) was observed from the tube well located at Amtola (TW2). This may be due to the pipes and pumps used for the purpose and moreover due to the soil type of this area. A child requires 0.3 mg/l of Zinc per every kilogram of body weight, a deficiency of which may cause retardation of growth (Train, 1979). According De, (1983) zinc at concentration above 5.0 mg/l cause undesirable astringent taste and an opalescence in alkaline water. The low toxicity of this trace metal and efficient homeostatic control mechanism make chronic zinc toxicity from water an unlikely hazard in man. But excessive intake of zinc may cause symptoms such as vomiting, dizziness and lake of muscular co-ordination (WHO, 1984).

Nickel

The concentrations of nickel were found to fluctuate in between ND to 0.06 mg/l for tube wells, ND to 0.07 mg/l for ring wells and ND to 0.03 mg/l for supply water. (ND= Not detectable) The highest concentration (.07 mg/l) of Ni was detected in the ring well (R13) at Urdhagaon. Next the concentration of nickel (0.06 mg/l) was observed in the tube well, located Hojai Town (TW7); in addition of this a number sources i.e. three tube wells (TW4, TW14 and TW15), five ring wells (RW1, RW3, RW4, RW9 and RW13), two supply points (S1 and S3) have been identified with average nickel concentrations at higher levels compared to the normal limit of WHO guideline i.e. 0.02 mg/l. The cause of presence of higher concentration of nickel may be natural because there is no other possible sources of this metal in the present study area. Adverse effects of inorganic water soluble Ni-compounds occur in human through skin contact which causes dermatitis on skin contact with humans and nickel compounds have also been responsible for causing respiratory tract irritations and asthma in industrial workers through inhalation (Fishbein, 1991). Certain nickel compounds have been shown to be carcinogenic in animal test. Soluble nickel compounds, however, have not been regarded as carcinogenic either to animals or the human (WHO, 1994).

Microbiological Examination

The measured most probable number (MPN) indices of coliform organisms ranges lie between 7 to 1002 MPN/100ml in tube wells, 128 to 9500 MPN/100mlin ring wells and NIL to 720 MPN/100ml in supply water. The faecal coliform organism in surface water are - Escherichia coli (85%), Citrobacter freundir (3.5%), Enterobacter cloacae (17%), Klebsiella oxyloea (0.8%), Citrobacter diversus (0.8%) and 5.2% unidentified. In the present work it was found that the coliform organisms were present in excessive amounts in all the water samples except supply water. The degree of contamination with coliform of drinking water in our study area was low in case of supply water compared to other sources. Moreover water of tube wells have found lower coliform compared to ring well. Thus tube wells are successful as a source of drinking water in many parts of India. They yield water which bacteriologically safe. (Park,1994). The values of coliform bacteria is considerably high in ring well, this may be due to improper waste disposal, the presence of unlined sewages and sanitary condition .It is also evident that the moderate temperature during October (post monsoon) favoured the growth of coliforms organisms. Rhenheimr (1985) have found higher coliform during winter. Positive confirmatory test for E. Coli as the predominant coliform organism in most of the sampling points indicate the contamination to be faecal in origin. The presence of coliform bacteria in the water sources from sewage and faeces of animals from various sources, which is undesirable for human consumption. Their presence also indicate the possibilities of occurrence of pathogenic organisms in the water sources. (MSS , 1979; NAS 1977 and Clark et. al.; 1977) According to WHO (1993) guideline the number of coliform organism and number of faecal coliforms per 100 ml should be nil in the drinking water so in the present study drinking water from all the sources in contaminated with E. Coliform organism and faecal coliforms and unit for drinking purpose.

Conclusion

The tube well water in the present study area could not be recommended for direct consumption due to the higher concentration of nitrate, phosphate, fluoride, iron, zinc and nickel. Moreover most of tube well water was found to be contaminated with coliform organism and faecal coliform contents. The concentration of nitrate were observed to be significant. The average phosphate contents also recorded higher concentration levels compared to the maximum permissible limit laid down by WHO for drinking water. The concentration of fluoride were alarming as in eight tube wells water the concentration of fluoride was found more than 10mg/l. Fluorosis is currently incurable however it can be prevented if diagnosed at an early stage. The only way to prevent this disease is to stop the consumption of fluoride contaminated water. According to available statistical data (PHE, Diphu Sub-division 2000) at least 20000 children and young people are in the grip of fluorosis in Assam. As prevention is the only known solution, massive health education is the need of the hour. Treatment of water is required before using the water for drinking purpose. At the same time drinking water may be supplied from the nearby village through pipe line to this twin fluoride affected area in Hojai district. Iron contents of the tube well water were recorded to be higher in the range 10mg/l- 85mg/l. Zinc contents of two tube well water samples were also found to be higher water samples were also found to be higher than the WHO limit. The concentration of nickel were also not satisfactory in tube well water from potability consideration. The high fluoride concentration were recorded in the ring wells which is of serious concern. The nitrate contents of the ring well water were found to be high and crossed the WHO's maximum permissible limit. Average phosphate concentrations which were recorded to be higher than the stipulated limit for drinking water were found to be responsible for degrading the quality of ring well water for drinking purpose. The iron content in the ring wells is higher than permissible limit so ring well water was found to be unfit from potability consideration. Zinc and nickel concentration was higher in comparison to WHO' limit. The quality of ring well water was not found to be fit for drinking due to coliform organisms and faecal coliforms contents.

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