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Assessment of Drinking Water Quality in Different Small Tea Gardens of Sonitpur District (Assam), India

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ABSTRACT

With the apparent exception of water, tea (Camellia Sinensis) is the most widely consumed beverage in the world. Although tea is grown commercially in over 35 countries, world production (about 75%) is largely concentrated in a few countries like India, China, Sri Lanka, Kenya, Indonesia, and Argentina. About 60% of tea production in India is produced in Assam itself. The tea gardens (62 large tea gardens and 207 registered small tea gardens), including Asia's largest tea garden Monabari located in the district Sonitpur of Assam, is one of the most important features of economy. However the use of pesticides for effective pests control and artificial agrochemicals used for the growth and rate of production has generated a lot of concern relating to public health and environmental pollution like water etc. Polluted water is the cause for the spread of epidemics and chronic diseases in human beings. So assessment and monitoring of the drinking water sources located in the small tea garden areas are utmost necessities. A total of 45 numbers of water samples were collected from different water sources like ring wells, ponds, drains and tubewells of Sonitpur district to study the different water quality parameters like pH, EC, TDS, TH, TA, Ca, Mg, F^-, Cl^-, PO_4^{3-}, NO_3^- and SO_4^{2-}. Data were subjected to normal distribution analysis (NDA) to find out the distribution pattern of the water quality parameters and correlation analysis was carried out to study the interrelationship between different parameters.

Key Words: Water quality, Small tea gardens, Agrochemicals, Contamination, Sonitpur district.

INTRODUCTION

India, the largest producer and consumer of tea in the world, accounts for around 28% of world production and 13% world trade [1] . The major driving force behind the country's tea sector development is the prospect of eastern India's tea industry, particularly of Assam which not only produces around 53% of the country's total production, but also creating employment opportunities [1] .There are about 2500 small tea gardens in Assam today adding to the State’s total production by more than 50 million kg [1]. In Assam the tea is cultivated in Brahmaputra and Barak valley covering the area 2,29,843ha, The big gardens are under multinational companies as well as the small tea gardens are under small tea growers. Assam tea is still earning around 50 per cent of the foreign exchange earned by India's tea industry [1]. The tea gardens (73 large tea gardens and 207 registered small tea gardens), including Asia’s largest tea garden Monabari located in the district Sonitpur of Assam, is one of the most important features of economy. However for the growth and increase rate of tea production and to control the pests, a large number of artificial agrochemicals and pesticides respectively are used in the tea gardens [2]. They spray their gardens with increasing amount of fertilizers- containing phosphate and nitrates. As a result the soil and water of the tea garden areas are contaminated by pollutants and the quality soil and water become degraded [3]. The excess fertilizers eventually will find their way in to pools and ponds and wells [4]. Animal wastes also contribute to phosphate and nitrate in runoff water [4]. The main responsibility of eutrophication is phosphate and nitrate. The nitrate in drinking water can cause methemoglobinemia in infants. In numerous studies, exposure of high levels of nitrate in the drinking water has been linked to a variety of effects ranging from enlargement of thyroid to 15 types of cancer and two kind of birth defects an even hypertension [5]. Research shows a definite relationship between increasing rates of stomach cancer with increasing nitrate intake [6]. Agriculture is a major source of nitrogen loss to the environment [7]. Two major scientific bodies recently named N pollution as one of the Earth’s “preeminent problems” and cite insufficient public awareness as an obstacle to managing it [8]. Modern agriculture practice, which involves the application of fertilizer coupled with pesticides, contributes the fluoride to the ground water, which increasing incidence of fluorosis in recent days. The main sources of fluoride intake into human and animal system are water and food having high levels of fluoride. The main anthropogenic sources are industrial plants, manufacturing hydrofluoric acid, superphosphate, brick, thermal power plant etc [9]. It is considered as one of the minor constituents of natural waters, but it is an important parameter in ascertaining the suitability of water for potable purposes. Intake of 1mg/l per day is very much essential for healthy growth of teeth, but level higher than the permissible limit of 1.5mg/l is dangerous to health. Fluoride contamination of ground water has now become a major geo-environmental issue in many parts of the world due to its toxic effects even if consumed in trace quantities. Fluoride in ground water poses a great problem in most of the states of India [10]. Fluoride concentration in ground water of India varies widely ranging from 0.01ppm to 48ppm [11]. A high fluoride content in drinking water sources have been observed in 15 states of India [12]. Sever contamination of fluoride in ground water of Karbi Anglong and Nagaon districts of Assam, India and its manifestation in the form of fluorosis have been reported recently [13]. Deficiency of fluoride leads to dental caries and higher concentration leads to dental and skeletal fluorosis. Fluorosis was first reported from India in the year 1937. Fluoride also circulates in blood and effects nerves and heart. Fluoride reduces secretion of thyroid gland by affecting iodine in the body which may lead to monogolism. Apart from these, excess fluoride intake will also cause gastro intestinal problems like loss of appetite, nausea, vomiting, pain in abdomen, intermittent diarrohea, muscular weakness, excessive thirst etc [14]. High fluoride intake over a period of time can cripple one for life [15]. According our literature review, there has been no published report concerning the nitrate, phosphate and fluoride contaminants in drinking water sources in the small tea gardens of Sonitpur district. The objective of the present detailed survey based study was to determine the contamination of pH, electrical conductivity (EC), total dissolve solid (TDS), total hardness (TH), total alkalinity (TA), calcium (Ca), magnesium (Mg), chloride (Cl^-) and sulfate (SO_4^{2-}) , phosphate (PO_4^{3-}), nitrate (NO_3^-) and fluoride (F^-) in the different drinking water sources in the tea garden areas of Sonitpur district of Assam. Thus the current article would help to fling light on the water quality especially relating to the above mentioned parameters in one of the important tea garden areas of Sonitpur district of Assam, India.

MATERIALS AND METHODS

Study area

The district Sonitpur, (second largest district of Assam after Karbi Anglong in area.) which is taken as study area is located in the north east part of Assam. The total area of Sonitpur district is 5103 sq. km and lies 100 meters above the mean sea level . It is surrounded by Arunachal Pradesh in north, the Brahmaputra river and Morigaon, Nagaon, Jorhat and Golaghat districts in south, Darrang district in the west, Lakhimpur district in the east and Sonitpur district is located north bank of river the Brahmaputra within 26°2 and 26°6 N latitude and 92°2 and 93°5 E Longitude . The study site containing 15 number small tea gardens namely C.R.(Chitra Ranjan), A.S.(Adymoni Sarmah), R.P.(RamPrasad), G.D. (Gobinda Dahal), S.P.(Susil Payeng), S.G.(Santanu Goswami), R.U.(Rishiraj Upadhya), D.U.(Dilip Upadhya), B.B.(Bul Bul), B.D.(Bhatri Day), R.S.(Ratul Saikia), Jamuna tea garden, Manjeet tea garden, Shiva tea garden, and Trinayan tea garden are located in between mighty river Brahmaputra and Himalayan foothills of Arunachal Pradesh. Tropical semi evergreen, moist deciduous, riverain forest, grassland, agricultural land and tea gardens are the main features of the study area.The temperature ranges from 7°C in January to as high as 38°C in May. The district falls in the Sub-Tropical climatic region, and enjoys Monsoon type of climate. Summers are hot and humid, with an average temperature of 29° C. The annual rainfall in the district is 2393mm. The climatic conditions of this area are very suit for the tea cultivation. It is interesting to note that the Monabari tea estate, the biggest tea garden in Asia is situated in Sonitpur district. According to the estimate of 2004, in Sonitpur district itself, there are 62 large tea gardens and 207 registered small tea gardens covering an area of 497.57 hectares and based on this a numbers of small tea industries are growing day by day. The location map of Sonitpur district is shown in figure 1.
(figure 1).

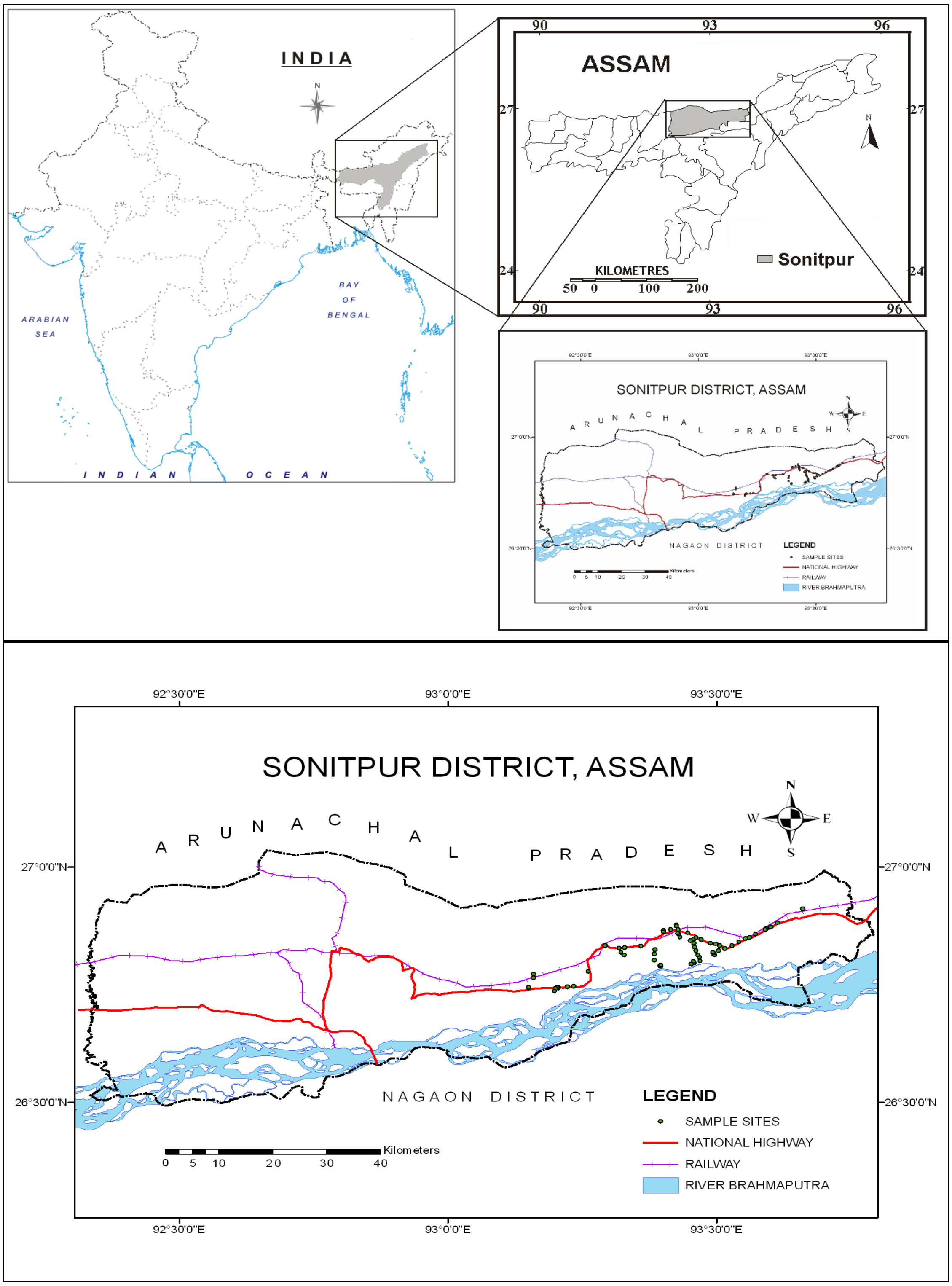

Figure 1. location map of Sonitpur District

Sampling methodology

A total of 45 water samples were collected from different locations of 15 small tea gardens of Sonitpur district. The sources of the water samples were shallow tubewells (hand tubewell, Tara pump, and mark tubewell), ring well, ponds and drains of the tea garden areas. The tubewells are mainly installed by the factory owners. Water samples were collected following the standards methods collection. Tubewell were operated at least 10 minutes before collection to flash out the stagnant water inside the tube and to get fresh ground water. The water samples were collected in clean 1L Poly propylene bottles and stored in an ice box .

Sample analysis

The collected samples were analyzed for the parameters, viz. pH, EC, TDS, TA TH, SO_4^{2-}, Ca, Mg, F^-, Cl^-, PO_4^{2-} and NO_3^-. pH of the samples was measured at the site of collection by using the Pocket pH meter (Merck, India), previously standardized by pH 4, 7, and 9 standard buffer solutions (procured from Merck, India). After determination of pH, 1:1 HNO_3 solution was added to each of the water samples collected (to make pH < 2.0), and the samples were carried to the laboratory for further analysis. E.C, TDS, TH, SO_4^{2-}, Ca, and Mg contents were determined by standard method [16]. The instruments were calibrated and standardized before carrying out the analysis. TH, Ca and Mg were determined by ethylene diamine tetraacetic acid titrametric methods. SO_4^{2-}content present in the water samples were analyzed turbidimetrically at 450 nm using a UV–spectrophotometer (SPECORD 40, Analytic Jena, Germany). F^- contents were determined by SPADNS method [17] SPADNS [2-(p-sulphophenylazo)-1, 8-dihydroxy-3,6-naphthalein disulphonate was obtained from E-Merck and SRL. Cl^- contents were determined by argentometric tritrametric method [18] . Phosphate was determined by molybdenum blue method [19] . Nitrate contents were determined by spectrophotometric method [20] . All the reagents were of analytical grade and were purchased from Merck, India, which were prepared freshly at the time of analysis.

RESULTS AND DISCUSSION

The average results (table 1) of the physico-chemical parameters viz. pH, EC, TDS, TA TH, SO_4^{2-}, Ca, Mg, F^-, Cl^-, PO_4^{2-} and NO_3^- of the water samples collected from the small tea gardens of Sonitpur district were discussed below in detail.

pH

pH is a term used universally to express the acidic and basic nature of a solution. In general the pH of natural water is within the range 6.5 to 8.5. The guideline value of pH in drinking water set by WHO/BIS is 6.5 to 8.5 [21]. In this study, the minimum pH was observed at 6.0 in a sample of ring well of Trinayan tea garden and maximum pH was observed at 8.21 in a sample of hand tubewell (depth 40 feet) of S.P tea garden. The most of the water samples in the study area were found to be acidic in nature. This may be due to use of fertilizers like ammonium sulphate and super phosphate in agriculture [22].

Table 1: Minimum, maximum and average concentration of the water quality parameters of small tea gardens of the study area

Sl. No.	Parameters	Min. (ppm)	Max. (ppm)	Average (ppm)	WHO limit (ppm)	BIS limit (ppm)
1.	pH	6.0	8.21	6.80	6.5- 8.5	6.5-8.5
2.	EC	180	991	570.44	750	-
3.	TDS	115	634	363.28	1000	500
4.	TH($CaCO_3$)	104.63	369.73	215.13	300-600	300-600
5.	Ca^{2+}	15.2	96.2	43.48	75-200	75-200
6.	Mg^{2+}	10.54	58.1	25.7	30-100	30-100
7.	TA	43	360	167.33	200	200
8.	F^-	0.1	5.6	1.29	1.0-1.5	1.0-1.5
9.	Cl^-	11.3	149.99	59.9	250	250
10.	PO_4^{3-}	B.D.L	1.14	0.2	-	-
11.	NO_3^-	0.14	12.86	2.49	50	45
12.	SO_4^{2-}	0.94	15.0	7.53	200-400	200-400

E.C is in µS/cm, and all other parameters are in ppm; B.D.L- Below detectable limit. W.H.O-World Health Organization, BIS- Bureau of Indian Standard.

Electrical conductance (EC)

EC is a measure of water capacity to convey electric current due to presence of dissolved substances in water . USPH recommended permissible limit for EC is 300 µS/cm. In the present study the values of EC were ranges from 180 µS/cm to 991 µS /cm. The minimum and maximum values were observed at 300 µS/cm and 991 µS/cm respectively in one samples of hand tubewell of each of the two small tea gardens namely R.P and Jamuna tea garden. High value of EC indicating the presence of high amount of dissolved inorganic substance in ionized form. Nutrient enrichment due to fertilizers may enhance TDS and it, in turn, increase the EC since these two parameters are directly related to each other) [23].

Total dissolved solids (TDS)

TDS indicates the salinity behavior of water. TDS content is usually the main factor, which limits or determines the use of ground water for any purpose [24]. Water containing more than 500ppm of TDS is not considered desirable for drinking water supplies. In the present study values of TDS were found to be varied from 115ppm to 634 ppm. The minimum value 115ppm was recorded in a sample of R.P tea garden and the maximum value was recorded at 634 ppm in a sample of Jamuna tea garden. Nearly 13% samples were exhibited TDS values outside the permissible limit 500 ppm [25]. The high value of TDS may be due to the leaching of ions from the tea garden soils and rocks and also from the agricultural fields.

Total hardness (TH)

Hardness is the property of water which prevents the lather formation with soap and increased the boiling points of water. In the current study the values of hardness were exhibited a minimum of 104.63 ppm to maximum 369.73 ppm in the study area. Hardness is mainly depends upon the amount of Ca and Mg salts or both. Though the hardness is not harmful to health, it has been suspected to be playing some role in heart disease. The minimum value of TH was recorded at 104.63 ppm in a sample of R.P tea garden and maximum value was observed at 369.73 ppm in a sample of Jamuna tea garden. Overall 13% of the total collection of the water sample was found to have TH values above the WHO/BIS limit for drinking water. The presence of dissolved salts and minerals in the soil of the tea gardens may enhance the concentration of TH in the tea ground water of the study site. At the same time the agrochemicals applied in the tea gardens directly or indirectly might affect the concentrations of a large numbers of inorganic chemicals in ground water which effect the concentration of TH in water [26].

Total Alkalinity (TA)

The alkalinity of water is its capacity to neutralize acids. Most of the alkalinity of natural water is caused by bicarbonates, carbonates and hydroxides. In the present study, the minimum and maximum alkalinity ware recorded at 43 ppm and 360 ppm respectively in one sample of each of the two tea gardens namely C.R. and R.S respectively. 31% samples of the total collection from the study site had TA value above the drinking water guideline value (200ppm) of WHO/BIS. It may also be noted that in polluted waters, other negative ions like PO_4^{3-}, NO_3^- may contribute to alkalinity.

Calcium and Magnesium (Ca and Mg)

Ca and Mg are directly related to hardness. In fact 98% ground water of the world are dominated by Ca and bicarbonate ions due to lime stone weathering in the catchments and underground water beds. Calcium is very essential for nervous systems and for formation of bones. In this study the observed values of Ca concentration were ranges from 15.2 ppm to 96.2 ppm. However only 6.66% of samples of total collection had Ca concentration above the drinking water guideline value (75ppm) of WHO/BIS. Although the sources of Ca in water samples mainly due to the lime stone weathering, the prolonged agrochemicals activities prevailing in the tea gardens may also directly or indirectly augment the mineral dissolution in ground water [26]. In the present study it was noticed that the concentration of Mg was comparatively lower than the concentration of Ca. Mg tolerances by human body are lower than Ca. High concentration of Mg in drinking water gives unpleasant taste to the water. Present study revealed that the concentration range of Mg in the water samples collected from the tea garden areas of Sonitpur district were varied from 10.54 ppm to 58.10 ppm. The minimum value was recorded at 10.54 ppm in a sample of R.U. tea garden and the maximum value was recorded at 58.10 ppm in a sample of S.G tea garden. Almost 33.3% samples of total collection had Mg concentration above the WHO/BIS guideline value (100ppm) for drinking water.

Fluoride (F^-)

High concentration of F^- in drinking water can cause an adverse effect on human beings. Continuous consumption of water having high F^- content can cause diseases, like fluorosis, dental carries and bone diseases [27]. In the present study the concentration of F^- in water samples of the tea garden areas of the study site were ranges from 0.10 ppm to 5.60 ppm. The minimum value was observed at 0.1 ppm in a sample of Trinayan tea garden area and the maximum value was recorded at 5.6 ppm, found in a sample of S.P. tea garden. The high amount of F^- present in water may due to leaching and weathering of rocks like fluorspars, rock phosphate and phosphites. From the survey in the tea garden areas it was found that the presence of high amount of F^- in few water samples of the tea garden areas may due to use of synthetic agrochemicals. Modern agriculture practice, which involves the application of fertilizer coupled with pesticides, contributes F^- to ground water [28]. In some small tea garden areas the concentration of F^- in the water sources were found below the desirable limit (1.0ppm) of WHO/BIS. This may be due to dilution of water by rain [29]. Overall almost 49% samples of the study area had F^- contents more than WHO/BIS guideline value for drinking water. The presence of F^- in high amount in the ground water of Darrang district adjuscent to Sonitpur district (study area) [30]. and Nagaon and Karbianlong district [13]. were also been reported. It is interesting that the entire fluoride-affected region is in the same geological set-up [31]. It seems more appropriate that rocks rich in F^- minerals have contributed to the enriched F^- content of ground water during the course of weathering of rock types fluorspars, rock phosphate and phosphites.

Chloride (Cl^-):

Cl^- occurs in all types of waters. People accustomed to higher chloride in water are subjected to laxative effects . The chloride contents normally increases as the mineral contents increases [32] . The range of Cl^- concentration in water samples of the tea garden areas of the study site were ranges from 11.3 ppm to 149.99 ppm. The minimum (11.3 ppm) and maximum concentration (149.99 ppm) of Cl^- in the study site were recorded in one sample of each of C.R. and R.P. tea garden respectively. Study revealed that 100% samples of total collection were within the WHO/BIS guideline value (250ppm) for drinking water. In natural waters, the probable sources of Cl^- comprise the leaching of chloride-containing minerals (like apatite) and rocks with which the water comes in contact, inland salinity and the discharge of agricultural, industrial and domestic waste waters [33] . Agricultural application of K as a plant nutrient commonly results in Cl^- contamination of recharging shallow groundwater [13]

Phosphate (PO_4^{3-})

Phosphate in natural water mostly ranges between 0.005 ppm to 0.020 ppm [34] . Phosphate may occur in groundwater as a result of domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water. Its content in present investigation ranges from below detectable levels to 1.14 ppm. The maximum value 1.14 ppm is found in Trinayan tea garden. The United States Public Health Standards limit for phosphates in drinking water is 0.1 ppm [35]. From this examination it was found that 46.7% of water samples had PO_4^{3-} above permitted level of USPHS. Use of phosphate as fertilizer in tea gardens perhaps contributed the phosphate in drinking water sources. In tea gardens of sonitpur district, Assam application of synthetic Fertilizers is a common practice [2].

Nitrate (NO_3^-)

NO_3^- from chemical fertilizers used in the plantation and fields can be transported into the drinking water sources either vertically or horizontally with the rainwater during rainy season. Ground water can also be contaminated by sewage and other wastes and other wastes rich in nitrates. The NO_3^- content in the water samples of the study area varied from 0.14 ppm to 12.86 ppm. The minimum value (0.14 ppm) and maximum value (12.86ppm) of NO_3^- were recorded one sample of each of the tea gardens namely B.D. and R.S. respectively. Study reveals that none of the samples exceeds the permissible limit (45ppm) of WHO/BIS for drinking water which may be due to soil type of the garden areas. Being loosely bound to soils, nitrate is expected to be more in runoff and hence its concentration increases during rainy season [27]. Nitrogen fertilizers applied to fields are the primary source of NO_3^- in shallow ground water. Nitrogen fertilizers not used by crops can be carried to the underlying aquifers by water percolating through the soil [36]. Problem with nitrate leaching are often associated with the excess use of fertilizers and high in rainfall areas, or with irrigation on sandy soils, and sometimes with large feedlot operation [37].

Sulphate (SO_4^{2-})

SO_4^{2-}, the common ion in water can produce bitter taste at high concentration. SO_4^{2-} salts of Na and Mg may exert a cathartic action in human beings. It is also associated with respiratory diseases. SO_4^{2-} occurs naturally in waters as a result of leaching from gypsum and other common minerals. SO_4^{2-} form soluble and insoluble salt with various cations. In the current study the observed value of SO_4^{2-} concentration were ranges from 0.94 ppm to 15ppm. Minimum value was found in a water sample of R.U. tea garden and maximum value was found in a sample of S.P. tea garden. Study revealed that 100% samples collected from the tea garden areas of Sonitpur district were all within the permissible limit (400ppm) of WHO/BIS for drinking water. The lower sulphate value in the drinking water samples of the region could be due to the reason that SO_4^{2-} may easily precipitates and settles to the bottom of the sediments of the river [38].

Statistical analysis

Interrelationship studies between different variables are very helpful tools in promoting research and opening new frontiers of knowledge. The study of correlation reduces the range of uncertainty associated with decision making. The numerical values of correlation coefficient (r) for 12 parameters examined here in this study were given in table 2.

Table2: Correlation of different water quality parameters in some of the small tea gardens of study site

	pH	E.C	T.D.S	T.H	T.A	Ca	Mg	F	Cl	PO4	NO3	SO4
pH	1											
E.C	-.017	1										
T.D.S	.038	.920**	1									
T.H	-.305*	.321*	.270	1								
T.A	-.063	.797**	.753**	.444**	1							
Ca	.456**	.299*	.208	.832**	.518**	1						
Mg	-.014	.217	.231	.784**	.182	.308*	1					
F	.658**	-.078	-.047	-.280	-.051	.330*	.109	1				
Cl	-.055	.016	-.050	.031	.027	.180	.146	-.006	1			
PO4	-.161	.109	.148	.076	.082	.116	.000	-.141	-.210	1		
NO3	-.166	.545**	.522**	.202	.559**	.289	.021	-.029	-.068	.145	1	
SO4	-.018	.345*	.375*	.140	.231	.033	.205	.072	.071	.038	.172	1

**Correlation is significant at the 0.05 level (2-tailed).*
***Correlation is significant at the 0.01 level (2-tailed)*

The high positively correlated values were found between TDS and EC (0.920), EC and TA (0.797), TDS and TA (0.753), TH and Ca^{2+} (0.832), TH and Mg^{+} (0.784), pH and F^{-} (0.658), some moderate correlation was observed between EC and NO_3^{-} (0.545), TDS and NO_3^{-} (0.522), TA and NO_3^{-} (0.559), TA and Ca^{2+} (0.518), pH and Ca^{2+} (-0.456) some weak correlations were also observed between TDS and Mg (0.217), EC and PO_4^{3-} (0.109), whereas pH show negative correlation with all parameters except TDS and F^-. F^- showed negative correlation with all parameters except pH. The positive correlation between conductivity and alkalinity is because the properties of conductivity are governed by the characteristics of the constituents inorganic salts dissolved in water. At the same time samples data were subjected to statistical treatment using normal and Gaussian distribution statistics. Some more statistical estimates derived from the normal distribution were also made in the present study for analysis the water quality data which were given in table 3.

Table3: Normal distribution statistics for pH, EC, TDS, TH, TA, Ca^{2+}, Mg^{2+}, F^-, Cl^-, PO_4^{3-}, NO_3^-, and SO_4^{2-} in some of the small tea gardens of the study site

	pH	EC	TDS	TH	TA	Ca^{2+}	Mg^{2+}	F^-	Cl^-	PO_4^{3-}	NO_3^-	SO_4^{2-}
Mean	6.80	570.44	363.30	215.13	167.33	43.48	25.90	1.29	59.90	0.20	2.49	7.53
Median	6.87	540.00	347.20	198.17	172.00	42.23	25.00	0.98	54.98	0.09	1.15	6.58
Mode	6.92	540.00	148.20	104.63	172.00	48.10	23.20	1.50	54.98	0.00	0.23	4.17
Std. Deviation	0.40	2.07	137.40	71.93	82.07	18.79	10.18	1.27	28.40	0.25	3.58	3.61
Variance	0.16	4.31	18880	5175.3	6736.9	353.3	103.67	1.61	806.82	0.06	12.84	13.07
Skewness	0.54	0.053	0.04	0.58	0.38	0.85	0.75	2.23	0.74	1.69	2.08	0.34
Std. Error of Skewness	0.35	0.354	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Kurtosis	2.32	-.574	-.70	-.43	-.52	0.78	0.91	4.83	0.71	2.94	3.01	-.60
Std. Error of Kurtosis	0.695	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.695	0.69	0.69
Range	2.21	811.00	521.50	265.10	317.00	81.00	47.56	5.50	138.69	1.14	12.72	14.06
P25%	6.50	425.00	265.28	163.65	100.00	28.77	18.56	0.52	36.33	0.015	0.49	4.72
P50%	6.87	540.00	347.20	198.17	172.00	42.23	25.00	0.98	54.98	0.09	1.15	6.58
P75%	7.03	730.00	466.82	266.82	211.00	54.75	31.60	1.50	84.92	0.31	2.23	9.90

Sample variance (r^2): Sample variance is given as the square of the standard deviation (r).
Kurtosis: Kurtosis is an indicator of the relative sharpness or flatness of the peak compared to normal distribution. Positive kurtosis indicates a sharp distribution while negative kurtosis indicates a flat one.

Skewness: A measure of the symmetry of the distribution. The normal distribution is symmetric, and has a skewness value of zero. A distribution with a significant positive skewness has a long right tail. A distribution with a significant negative skewness has a long left tail. As a rough guide, a skewness value more than twice its standard error is taken to indicate a departure from symmetry.

Percentile (P_i): Percentile at 25%, 50%, 75% were calculated. P_i at 25% is called first quartile, at 50% second quartile and at 75% third quartile. P_i is also known as the cumulative probability function which lies in the range $0 < P_i < 1$ for i= 1,…..,n.

CONCLUSION

A comprehensive statistical analysis of water parameter of small tea gardens of Sonitpur district, Assam has been carried out with special reference to pH, EC, TDS, TH, TA, Ca, Mg, F^-, Cl^-, PO_4^{3-}, NO_3^- and SO_4^{2-}. Statistical observations showed that all these parameters exhibited an asymmetric distribution with a long asymmetric tail on right of the median. The width of the third quartile was consistently found to be more than the second quartile for each parameter. Difference between mean and median in each case, except Mg high standard deviation and positive kurtosis in most of the cases indicate that the distribution of water parameters in the water samples of the study area was widely off normal. Wide data range in each case indicates the presence of extreme values in the form of outliers, which were likely to bias the normal distribution statistics . In the present situation, these drinking water sources are not safe for use in the tea garden community which may lead to poor drinking water quality. The continuous and uncontrolled use of different chemicals in the tea gardens areas of this region may increase the pollution rate which may lead to cause an adverse health effects to the tea garden community. The only way to get rid of such health problems may be use of organic agrochemicals in place of synthetic agrochemicals in the tea gardens for better productivity and growth rate. For the same awareness and training programs should be conducted for the NGO's and the local people for the sustainable management of drinking water sources.

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