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ESTIMATION OF DRINKING WATER QUALITY PARAMETERS IN DIFFERENT WATER SOURCES OF NORTH LAKHIMPUR TOWN, ASSAM, INDIA

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ABSTRACT

Water is supreme crucial part of human and animal life. Contaminated water is biggest problem in the world. In this study 42 numbers of drinking water samples were collected from 14 wards of North Lakhimpur town and have been analyzed for some drinking water quality parameters like pH, fluoride (F^-). iron (Fe), arsenic (As), lead (Pb) and mercury (Hg). The result showed that pH, F^- Fe, As, Pb and Hg ranged from 6.4 to 7.5, 0.02 to 0.64 mg/l, 0.033 to 1.17 mg/l, BDL to 0.0018 mg/l, 0.015 to 0.146 mg/l, and 0.0001 to 0.00559 mg/l respectively. All the measured parameters were within the standard drinking water quality values of WHO except Fe and Hg content. The concentration of Fe was found higher than the standard limit value of WHO (0.3 mg/l) in 33.33% of the analysed sampling stations and the concentration of Hg was found higher than the standard limit value of WHO (0.001 mg/l) in 21.43% of the analysed sampling stations. In general the present investigation found that the maximum parameters were not at a level of pollution.

KEY WORDS : Water, pH, Fluoride, Iron, Arsenic, Lead, Mercury, Contamination

INTRODUCTION

Water is one of the most important and most precious natural resources. It is essential in the life of all living organisms from the simplest plant and microorganisms to the most complex living system known as human body (Onifade *et al.,* 2008). Access to safe drinking water is key to sustainable development and essential to food production, quality health and poverty reduction. Safe drinking water is essential to life and a satisfactory safe supply must be made available to consumers (Ackah *et al.*, 2012). Water is thus becoming a crucial factor for development and the quality of life in many countries. In individual arid areas it has even become a survival factor (Eddy *et al.,* 2007). Therefore, water intended for human consumption must not contain pathogen germs or harmful chemicals; because water contaminated with microorganisms is the cause of epidemics (Balbus, 2002). That is good drinking water is not a luxury but one of the most essential requirements of life itself (Ajewole, 2005). However, developing countries, like Ethiopia, have suffered from a lack of access to safe drinking water from improved sources and to adequate sanitation services (WHO, 2006). The WHO revealed that 75% of all diseases in developing countries arise from polluted drinking water (WHO, 2000). Therefore; water quality concerns are often the most important component for measuring access to improved water sources. Acceptable quality shows the safety of drinking water in terms of its physical, chemical and bacteriological parameters (WHO, 2004). International and local agencies have established parameters to determine biological and physicochemical quality of drinking water (Havelaar *et al.,* 2001). The problems associated with chemical constituents of drinking water arise primarily from their ability to cause adverse health effects after prolonged periods of exposure, of particular concern are contaminants that have cumulative toxic properties, such as heavy metals and substances that are carcinogenic (DEWO, 1989). In West Bengal, India and Bangladesh, it is estimated that 100 million people in arsenic-affected areas are potentially at risk from groundwater arsenic contamination above the WHO guideline value of 10 μg/L Chakraborti *et al.,* 2010; Bunnell *et al.,* 2007). Eroded sediments and varied inputs of human activities like mining, pesticides, pharmaceuticals, etc. are thought to be the common sources of arsenic. Chronic arsenic exposure is detrimental to human health being associated with cancer of the skin, lung, liver, urinary bladder, and kidney (Buragohain *et al.,* 2020; Xia *et al.,* 2009) and other diseases, including cardiovascular and peripheral vascular diseases, diabetes, peripheral neuropathies, portal fibrosis, and adverse birth outcomes (Das *et al.,* 2007). Arsenic is a ubiquitous element found in the soil and rocks, natural waters and organisms that mobilizes through a combination of natural process and anthropogenic activities. Weathering, microbial metabolism and volcanic eruptions are some of the natural process through which ground water can be contaminated by arsenic. Anthropogenic activities like mining, combustion of fossil fuels, use of arsenical pesticides, herbicides and crop desiccants and agricultural additives for livestock are also responsible for exaggerating the arsenic in soil and groundwater. Though researches have made advancement in understanding the distribution, occurrence and mobilization of arsenic in groundwater on a global scale, on regional extent it is still poor and lacks proper knowledge and information. Most people of North East India are primarily dependent on dug-well, pond and naturally occurring spring water (Mohan *et al.,* 2020; Buragohain, 2018). Fluoride a naturally occurring mineral, is essential in small quantities for proper growth and maintenance of teeth and bones in humans. However, its excess consump-tion causes irreversible damage to teeth and bones, a phenomenon known as dental and skeletal fluorosis (Hassan *et al.,* 2020; Raj *et al.,* 2017). Fluoride contamination in groundwater is widespread especially in China, India, Nigeria, South America (Andes and western Brazil) and Africa (Rift valley zone), northwest Iran, Pakistan, Kenya, and Sri Lanka (Jeong, 2001). High fluoride in groundwater has been reported from nineteen states in India with fluoride contamination in groundwater resources being widespread, intense, and alarming (Jeong, 2001; Narsimha *et al.,* 2017). In India, the excessive presence of fluorides in groundwater is noticed in nearly 177 districts covering 20 states, affecting more than 65 million people, including 6 million children. The problem of excessive fluoride in groundwater in India was first reported in 1937 in the state of Andhra Pradesh. Telangana State is one of the fluoride affected states in the country and is considered to be endemic to fluorosis (Das *et al.,* 2003). Current review emphasized the elevated level of fluoride concentrations in the groundwater and associated potential health risk globally with a special focus on Assam, North East India (Sharma, *et al.,* 2011; Saikia *et al.,* 2011; Dutta *et al.,* 2010; Lahkar, *et al.,* 2015; Rasool *et al.,* 2017). Natural sources are connected to various types of rocks and to volcanic activity. Agricultural (use of phosphatic fertilizers) and industrial activities (clays used in ceramic industries or burning of coals) also contribute to high fluoride concentrations in ground water (Brunt *et al.,* 2004). The WHO guideline value for fluoride in drinking water is 1.0 mg/l. Above 1.0 mg/l mottling of teeth may occur to an objectionable degree. Concentrations between 3 and 6 mg/l may cause skeletal fluorosis. Continued consumption of water with fluoride levels in excess of 10 mg/l can result in crippling fluorosis. High concentration of fluoride for extended time period causes adverse effects of health such as skin lesions, discoloration, cardiovascular disorders, dental fluorosis and crippling skeletal fluorosis (Gaoa *et al.,* 2013; Buragohain, 2018). Mercury is current in the surroundings in a numerous forms as well asfundamental mercury (HgO), inorganic mercurous (Hg^{+})s and mercuric (Hg^{2+}) salts and as organic compounds (e.g. methyl-, ethyl and phenyl-mercury); everystructure possesses diverse physicochemical property and toxicity profile. Mercury and its compound are increasingtoxin and in little quantity are dangerous to human health. Mercury compound are consider extremely contaminatedmainly for effect on the nervous system, kidney, and skin; in addition, inhalation of mercury can source shocking acute toxicity to the lung (Verma *et al.,* 2018). Forms of Occurrence of Iron and Manganese in Water Iron and manganese occur in dissolved forms as single ions (Fe^{2+}, Mn^{2+}) or in undissolved higher forms mainly as $Fe(OH)_3$ or $Mn(OH)_4$, respectively. They can also be present in colloid form (bound to humic substances). The form of their occurrence depends on oxygen concentration, solubility of Fe and Mn compounds in water, pH value, redox potential, hydrolysis, the presence of complex-forming inorganic and organic substances, water temperature, and water composition (e.g. CO_2 content). Adverse effects of higher Fe and Mn concentrations in drinking water are - iron (II) and manganese (II) ions are oxidized to higher forms in a water distribution system and this results in the formation of hydroxide suspensions causing undesirable turbidity and colour of water, the presence of iron and manganese bacteria in water supply system causes change in water quality (smell) and bacterial growth in pipes and in the case of the occurrence of iron (II) and manganese (II) ions at the consumer's point, iron and manganese are oxidized and precipitated under suitable conditions - e.g. in washing machines, boilers, etc (Barloková *et al.*, 2010).

Unfortunately the public due to the less sensitization and limited knowledge about the quality of these water sources in North Lakhimpur town of Assam has continued to use them for drinking and cooking purposes. The study therefore aimed at ascertaining the quality of selected drinking water sources (tube wells, ring wells and tap water) in North Lakhimpur town of Assam with various human activities. The main aim of this study was to study different water quality parameters of water samples collected from different sites of North Lakhimpur town and to recommend the whether it is potable or not. The major water quality parameters considered for the examination in this study are pH, fluoride, iron, arsenic, lead and mercury.

MATERIALS AND METHODOLOGY

Profile of the study area

The study area, Lakhimpur district (Fig. 1) lies on the North East corner of Assam and at the North Bank of the mighty river Brahmaputra. The district lies between 27.597' Northern latitude and 94.737' Eastern longitude and covers an area of 2277 Sq km out of which 2257 Sq km is rural and 20 sq km is urban. The area is characterized by a temperature range of 24°C-33°C and with an average humidity of 82%. The annual rainfall of the district is 1551.3 mm per year (Statistical Hand Book, Assam, 2017).

Sampling information and Analysis

A total of 42 drinking water samples were collected randomly from different water sources 14 wards of

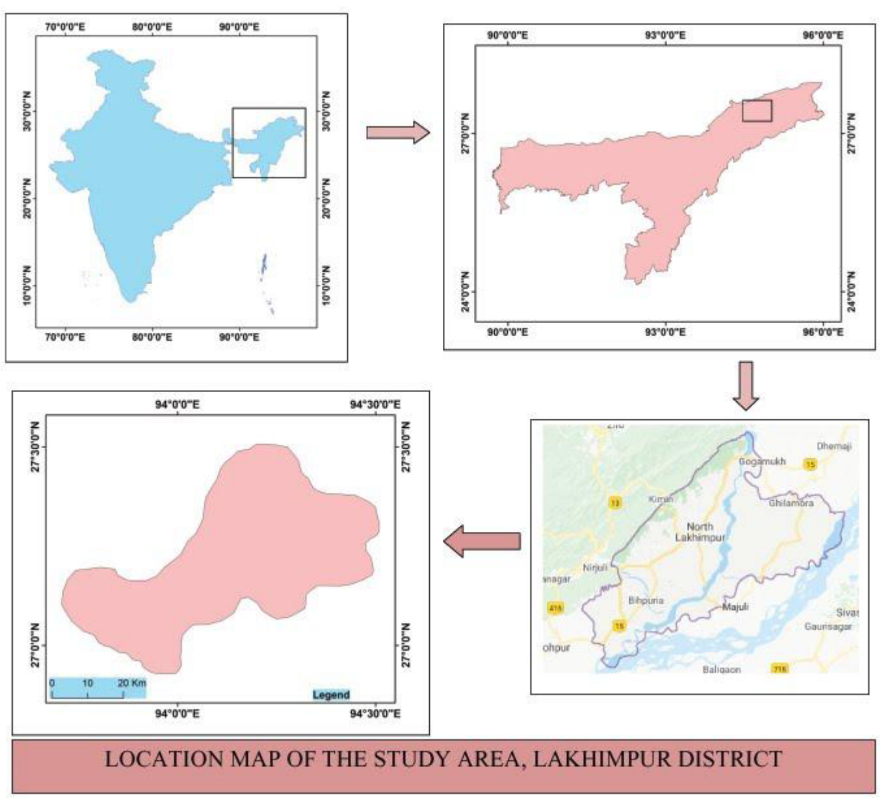

Fig. 1. A cross sectional view of the study area

North Lakhimpur town with three samples from each ward (Table 1). The sampling was done during dry season in the year 2020. Samples were collected in clean and sterile one-litre polythene cans to obtain a composite sample, 1:1 HNO_3 solution was added to each of the water samples (to make pH <2.0) and stored in an ice. The water pH was measured using digital pH meter (Model-802, SYSTRONICS, India). Fluoride contents were determined by SPADNS method. SPADNS (2-(*p*-sulphophenylazo)-1,8-dihydroxy-3,6- naphthalein disulphonate) was obtained from E-Merck and SRL. Iron contents were measured by phenanthroline method by using a UV-visible spectrophotometer (ELICO SL-159) at 510 nm. Arsenic, lead and mercury contents were done by using Atomic Absorption Spectroscopy (Model-ice3500 by Thermo scientific) with Flow Injection Analyze Mercury Hydride Generation System (Model FIAS-100) as per the standard procedures at 193.7 nm, 283.3 nm and 279.5 nm wavelength respectively (Eatson *et al.*, 2005).

RESULTS AND DISCUSSION

The experimental findings of the experimental data are summarized in Table 1 and the distribution of pH, fluoride, iron, arsenic, lead and mercury in water sources of the study area have been presented in Figure 2-7.

Hydrogen Ion concentration (pH): It is an important parameter which is important in evaluating the acid-base balance of water. Also it is the indicator of acidic or alkaline condition of water status. The permissible limit of pH in drinking water is 6.5 to 8.5 (WHO, 2017). As shown in Fig. 2 the pH range found in the investigation is 6.4 to 7.5. In three sampling stations it was found weakly acidic (pH = 6.4), slightly below minimum pH range as prescribed by WHO. The overall result indicates that the water sources are within the desirable and suitable range. Basically, the pH is determined by the amount of dissolved CO_2, which forms carbonic acid in water. pH of ground water can also be lowered by organic acids from decaying vegetation, or the dissolution of sulfide minerals. The slight basic nature of the bore well water may be mainly due to the limestone basin of the all the locations (Werkneh *et al.*, 2015).

Fluoride (F^-)

The fluoride content in the analyzed samples was found to vary from 0.02 to 0.64 mg/l. All the

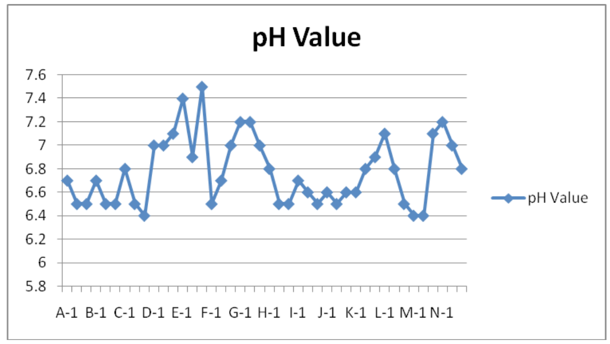

Fig. 2. Distribution of pH

samples analysed, the fluoride concentration in water was less than 0.7 mg/l as prescribed by WHO (0.7-1.5 mg/l) may cause dental carries. Fluorides are released into the groundwater mostly through water–rock interaction by various fluoride-bearing minerals. Fluorite (CaF_2) is the sole principal mineral of fluorine occurring in nature, and is commonly found as an accessory in granitic genesis. Fluorine is also abundant in other rock-forming minerals like apatite, micas, amphiboles, and clay minerals (Narsimha *et al.*, 2017). Fluoride contamination of groundwater is an alarming problem on a global scale. In several parts of the world, biogeochemical processes have resulted in dissolution of naturally occurring fluoride into groundwater. Dissolution of fluorite (CaF_2) and/or fluorapatite (FAP) $[Ca_5(PO_4)_3F]$, pulled by calcite precipitation, is thought to be the dominant mechanism responsible for groundwater fluoride contamination. However, in the absence of any significant anthropogenic sources in the study area, the basic cause for the excess fluoride content seems to be geogenic in origin. Climate and tectonic factors may also play some part in affecting the fluoride concentration of the groundwater. The interaction of the fluoride-bearing minerals with water and aquifer is likely to be an important factor; since the decomposition,

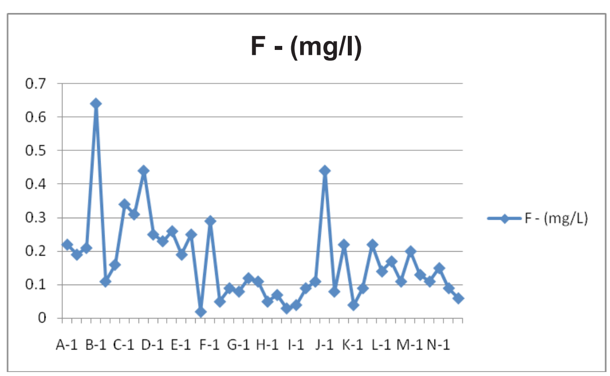

Fig. 3. Distribution of fluoride

Table 1. Results of water quality parameters (wardwise) in the study area

Ward No	Sample No	Sampling location	Sample Source	pH Value	F^- (mg/l)	Fe (mg/l)	As (mg/l)	Pb (mg/l)	Hg (mg/l)
1	A-1	Jatia Vidalaya	RW	6.7	0.22	0.39	BDL	0.146	0.00149
	A-2	Mid Town Hospital	TaW	6.5	0.19	0.26	BDL	0.039	0.00432
	A-3	St. Marys' High School	TaW	6.5	0.21	0.15	BDL	0.019	0.000404
2	B-1	Choudhury Nursing Home	TaW	6.7	0.64	1.04	0.0011	0.038	0.00037
	B-2	Nakari LP School	TaW	6.5	0.11	0.19	BDL	0.032	0.00559
	B-3	Uttar Nakari LP School	TW	6.5	0.16	0.13	BDL	0.020	0.0022
3	C-1	Govt. Boys HS School	TaW	6.8	0.34	0.73	BDL	0.027	0.0019
	C-2	Panindra Vidyalaya	TaW	6.5	0.31	0.88	0.0018	0.019	0.0012
	C-3	N.C. Nursing Home	TaW	6.4	0.44	1.17	BDL	0.028	0.00099
4	D-1	Academy HS School	TaW	7.0	0.25	0.14	BDL	0.025	0.00062
	D-2	Ahuchual Gaon LP School	TaW	7.0	0.23	0.52	BDL	0.029	0.00055
	D-3	Madhab Ram Gogoi LP School	TaW	7.1	0.26	0.18	BDL	0.031	0.0014
5	E-1	Chetia Gaon LP School	RW	7.4	0.19	0.18	BDL	0.026	0.0026
	E-2	Gogoi Enterprise	TaW	6.9	0.25	0.18	BDL	0.022	0.00015
	E-3	Rahdhala LP School	TaW	7.5	0.02	0.51	BDL	0.031	0.0002
6	F-1	NL Girls' HS School	TaW	6.5	0.29	0.26	BDL	0.022	0.00066
	F-2	Old Hospital	TaW	6.7	0.05	0.28	BDL	0.015	0.00021
	F-3	Lakhimpur Commerce College	TaW	7.0	0.09	0.25	BDL	0.031	0.00092
7	G-1	Veterinary Hospital	TaW	7.2	0.08	0.45	BDL	0.034	0.00179
	G-2	Puja Hotel	TaW	7.2	0.12	0.62	BDL	0.035	0.0017
	G-3	State Bank of India	TaW	7.0	0.11	0.27	BDL	0.035	0.0001
8	H-1	Gani Hazarika Market	TaW	6.8	0.05	0.39	BDL	0.043	0.00044
	H-2	Genius Academy	TW	6.5	0.07	0.26	BDL	0.040	0.00050
	H-3	Saibaba LP School	TaW	6.5	0.03	0.42	BDL	0.040	0.00067
9	I-1	Panchanan Dewalai	TaW	6.7	0.04	0.22	BDL	0.038	0.0019
	I-2	Mitali Hotel	TaW	6.6	0.09	0.20	BDL	0.041	0.0015
	I-3	Bazar Patti LP School	TaW	6.5	0.11	0.13	BDL	0.038	0.0004
10	J-1	Kali Mandir	TaW	6.6	0.44	0.19	BDL	0.048	0.00080
	J-2	Gupi Nagar LP School	TaW	6.5	0.08	0.21	BDL	0.049	0.0020
	J-3	Radha Krishna LP School	TaW	6.6	0.22	0.46	BDL	0.045	0.00502
11	K-1	Hira House	TaW	6.6	0.04	0.14	BDL	0.051	0.0005
	K-2	Electricity Office	TaW	6.8	0.09	0.11	BDL	0.041	0.0051
	K-3	Surjya Cenema Hall	TaW	6.9	0.22	0.21	BDL	0.046	0.0010
12	L-1	Ajiz Boruah HS School	TaW	7.1	0.14	0.21	BDL	0.055	0.00062
	L-2	IBM Academy	TaW	6.8	0.17	0.12	BDL	0.047	0.0009
	L-3	Ma-Lakhi Hotel	TaW	6.5	0.11	0.04	BDL	0.043	0.00033
13	M-1	Ghose Hotel	TaW	6.4	0.2	.033	BDL	0.044	0.00051
	M-2	Sarada Hotel	TaW	6.4	0.13	0.11	BDL	0.050	0.0014
	M-3	Rodali Hotel	TaW	7.1	0.11	0.15	BDL	0.047	0.0010
14	N-1	North Lakhimpur College	TaW	7.2	0.15	1.01	BDL	0.044	0.0007
	N-2	Royal Treat Nursing Home	TaW	7.0	0.09	0.22	BDL	0.041	0.0002
	N-3	Agriculture Office	TaW	6.8	0.06	0.13	BDL	0.060	0.0001

RW: Ring Well; TW: Tube Well; TaW: Tap Water;

dissociation and dissolution are the main chemical processes for the occurrence of fluoride in groundwater (Dutta *et al.,* 2010).

Iron (Fe)

The iron content in the analyzed samples was found to vary from 0.033 to 1.17 mg/l. On careful observation of experimental data, it can be seen that the all the analysed samples show higher iron concentration than WHO drinking water standard (0.3ppm). Higher concentrations of iron in tube wells of the area may be due to the soil origin and uses of old rotten iron pipes. The presence of high concentration of iron in water sources give an objectionable odor and are not suitable for drinking, food processing and other reliable activities.

Groundwater of Barpeta district, Assam, India was highly contaminated with arsenic. The quality of the water was found to be alkaline with elevated amount of iron, manganese and lead (Jain *et al.*, 2018). The iron contamination of tea garden belt of Darrang district of Assam, India was found to be higher concentration in tube wells of the area. The presence of iron bacteria in water sample provides such condition. The iron bacteria derive energy from the oxidation of Fe (II) to Fe (III) and luster on the water surface and deposit a slimy coating on the piping during the process. A strong correlation of arsenic and iron was observed in ground water samples of Golaghat district of Assam (India) and study suggested that arsenic mobilization in groundwater may be due to As-Fe bearing minerals (Chetia *et al.*, 2010).

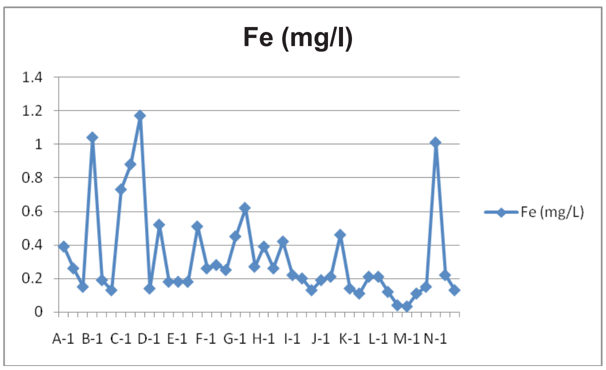

Fig. 4. Distribution of iron

Arsenic (As)

The observed values of concentration for arsenic content in the water samples ranges from BDL to 0.0018 mg/l and all the results lies in permissible limit set by WHO (0.01 mg/l). Long term exposure to As contaminated water may lead to various diseases such as conjunctivitis, hyperkeratosis, hyperpigmentation, cardiovascular diseases, disturbance in the peripheral vascular and nervous

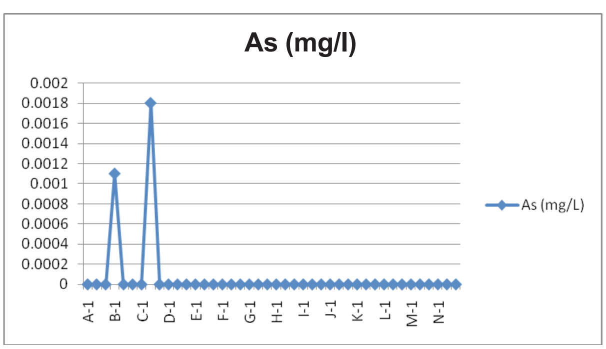

Fig. 5. Distribution of arsenic

systems, cancer of the skin, lung, liver, urinary bladder and kidney skin, gangrene, leucomelonisis, nonpitting swelling, hepatomegaly and splenomegaly (Jack *et al.*, 2003).

Lead (Pb)

Lead concentration results are summarized in Table 1. The lead content in the analyzed samples was found to vary from 0.015 to 0.146 mg/l and all the results lies in permissible limit set by WHO (0.2 mg/l). When present in tap water, lead particles might pose a significant public health threat. This is because the presence of chloride, warm temperature, low pH and mild agitation inside the human stomach may render a significant fraction of particulate lead bioavailable once ingested. Under the experimental conditions, up to 66% of the particulate lead dissolved in simulated gastric fluid after 48 hours. The completed sample collections and datasets are intended to provide insight into those water infrastructure components and processes (such as source-water corrosivity, treatment, plumbing, and so forth) that might influence human exposure to chemical and microbial contaminants at the residential tap. Conducted in collaboration with colleagues and stakeholders from academia, public health agencies, and water utilities, this work can contribute to the foundational understanding of potential associations between human-health effects and drinking-water exposures at the tap (Triantafyllidou *et al.*, 2009).

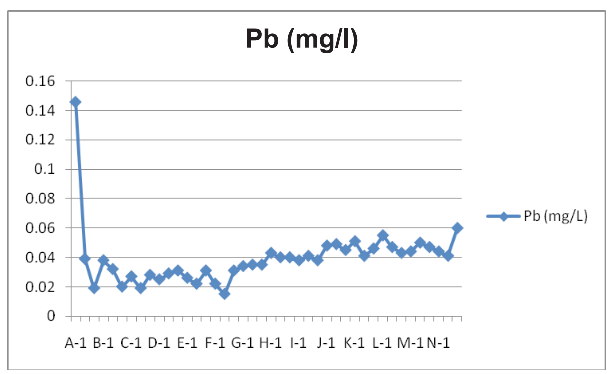

Fig. 6. Distribution of lead

Mercury (Hg)

The mercury content in the analyzed samples was found to vary from 0.0001 to 0.00559 mg/l and all the results lies in permissible limit set by WHO (0.001 mg/l). Frequently in individual contact to mercury is cause through outgassing of mercury since dental amalgamation, intake of infected fish, or occupational experience. The mainly ordinary appearance of natural mercury is methylmercury, which be the maincause of natural mercury establish in the ecosystem. Mercury a liquid metal which is also called as quicksilver. The level of mercury contamination in various water bodies. This contaminated water issued mainly for drinking and agriculture purpose. The major source of mercury contamination may be natural, industrial, sewage, agricultural, medical products, sediments, cement plants and fly ashes etc. Mercury is a highly poisonous metal which is mostly found in environment. The overdose toxic effect of mercury onthyroid gland, gastrointestinal tract, neurological, reproduction and sometime which may lead to death (Verma *et al.,* 2018).

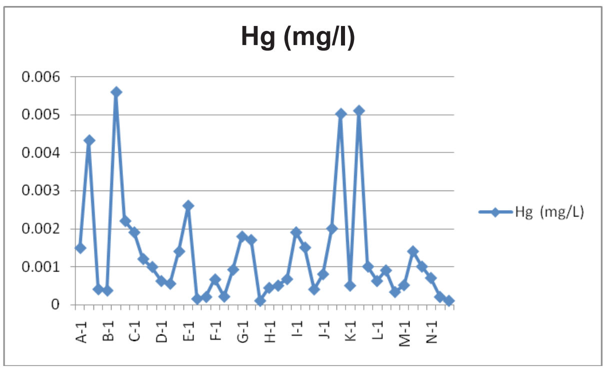

Fig. 7. Distribution of mercury

CONCLUSION

The paper aimed to assess the drinking water quality used in all the 14 different wards of North Lakhimpur town, Assam with respect to different water quality parameters. The result obtained during study was compared with WHO standards. Potable water is water safe enough to be consumed by humans or used with low risk of immediate or long term harm. The study assessed the evolution of water quality in tap water from a groundwater source of North Lakhimpur town. In the present investigation it was found that all the parameters (except iron) were not at a level of pollution. But all the analysed samples showing exceeding amount of iron concentration, it is safe to say that North Lakhimpur town has an alarming condition with respect to iron as far as drinking water quality goes. The concentration of Fe in water in the area is not suitable for food processing, dyeing, bleaching and many activities. The Fe content of the area may cause bacterial activity (redort diseases) but it has no adverse effect in agricultural plants. The presence of these "iron bacteria" which derive their energy from the oxidation of Fe (II) to Fe (III) can also cause a rotten egg odour in the water and sheen on the water surface and in the process deposit a slimy coating on the piping. Fe is contained in a number of biological significant proteins as haemoglobin and cytochromes. Although Fe has got little concern as a health hazard but is still considered as a nuisance in excessive quantities. Long time consumption of drinking water with a high concentration of Fe can lead to liver diseases (hemosiderosis). Fe deficiency caused anemia. It has also been reported that children have been known to develop Fe toxicity by higher Fe intake symtomized by fatigue, anorexia, dizziness, nausea, vomiting, headache, weight loss, shortness of breath and possibly a graying colour to the skin. High concentration of Fe in water is not suitable for processing of food, beverages, ice, dyeing, bleaching and many other items. Water with high concentration of the Fe when used in preparation of tea and coffee, interacts with tanning giving a black inky appearance with a metallic taste. Therefore, the inhabitants of North Lakhimpur town contribute their part by reducing or avoiding usage of pesticides, replacing old iron pipes with new plastic pipes, etc. Furthermore, the government can also bring about some regulations in manufacturing and usage of pesticides, pipes, etc. in order to improve drinking water quality and create public awareness via media. The mitigation strategy for the problem in the area might be specific to the location, taking into consideration the geomorphological variations and socioeconomic conditions. Again, cost-effective, user friendly technologies providing pure water are required to counter the serious health hazards due to consumption of contaminated water. A long-term environmental planning and integrated research is essential to mitigate the danger of such poisoning. A wholistic approach involving medical practitioners, scientists, and social workers will need to work coherently to find out a solution that can lessen sufferings of the humanity and making a provision for safe drinking water. Moreover it is suggested that North Lakhimpur Municipality Board should therefore ensure proper sanitation and water safety plans for these drinking water sources to avoid further contamination from the human activities.

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