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Arsenic Contamination of Ground Water of Mohanpur Block of Samastipur District

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ABSTRACT
Arsenic contamination in ground water has been reported from several districts of Bihar including Samstipur. The main aim and objective of the recent work is to identify areas within Samastipur district, where ground water is significantly contaminated by Arsenic. In this present paper we studied about one of the blocks of Samstipur district viz. Mohanpur, lying in the vicinity of river Ganga are significantly affected by Arsenic contamination resulting in severe harmful effects on human health and causing clinical manifestations like, hyperkeratosis, bronchitis, gangrene in limbs and even skin cancer in the long run.
Keywords : Arsenic, Contamination, Water Pollution.

I. INTRODUCTION

Arsenic contamination of ground water is now-a-days a global phenomenon as higher level of Arsenic contamination was reported from various parts of the world including U.S.A., China, Chile, Mexico, Argentina, Thailand, Vietnam, Hungary, Pakistan, Nepal, India & Bangladesh [1-5]. The govt. of India and Bangladesh with the help of foreign agencies in the year 1970s & 1980s took initiative so as to provide the masses with safe drinking water. The majority of the wells for providing drinking water were sunk by UNICEF. Ironically, these wells led to the largest Arsenic contamination crisis in the world. The first case of severe Arsenic poisoning was identified in West Bengal in July 1983. Infact, among various countries of the world, Bangladesh is facing the largest mass poisoning of human population in the history due to Arsenic contamination. It is even beyond the environmental disasters at Bhopal in 1984 and Chernobyl Ukraine (USSR) in 1986. In India, several states are in the grip of Arsenic contamination particularly Odisha, West Bengal, Bihar and Jharkhand. Arsenic calamity in West Bangal is a well-known phenomenon as reported by Dr. D. Chakraborty of the school of Environmental science, Jadavpur University (1991) Kolkata. Arsenic contamination in ground water has been reported from several districts of Bihar including Samstipur.

The main aim and objective of the recent work is to identify areas within Samastipur district, where ground water is significantly contaminated by Arsenic. As reported from various source from several blocks of samstipur district viz. Mohanpur lying in the vicinity of river Ganga are significantly affected by Arsenic contamination resulting in severe harmful effects on human health and causing clinical manifestations like, hyperkeratosis, bronchitis, gangrene in limbs and even skin cancer in the long run.

II. SOURCES OF GROUND WATER POLLUTION BY ARSENIC

Although ground water must be pure if used for drinking purpose but due to Domestic, Agricultural, and Industrial wastes, the ground water becomes highly polluted. Although in natural way soil mantle acts as an adsorbent in adsorbing colloidal particles and soluble ions but still the ground water gets contaminated due to agricultural wastes, domestic wastes, Industrial wastes, Radioactive wastes, Mine spills and run off from rural & urban areas. Arsenic occurs in ground water as a result of mineral dissolution, industrial discharge, or the application of fungicides, insecticides etc.

Among its various compounds, those of As (iii) are the most toxic As (iii) exerts its toxic action by attacking –SH groups of an enzyme, thereby inhibiting enzyme action. The enzymes which generate cellular energy in the Citric Acid Cycle are adversely affected. Arsenic also inhibits enzyme involved in DNA repair and thus responsible for DNA damage.

Singh and Ghosh (SOES, 2012) [2] indicated that there is a very high health risk in the Arsenic contaminated areas in Maner Block of the Patna. As reported by them, the cancer risk and hazard quotient owing to drinking Arsenic contaminated ground water was as high as 192. However, the highest-level of 2182 mg/l of Arsenic was reported in the Buxar distt. of Bihar other Arsenic affected areas of Bihar where the level of Arsenic in drinking Water exceeded 1000 mg/l are Bhojpur, Patna, Samastipur and Bhagalpur districts. More than 50 mg/l of Arenic were detected in Vaishali, Saran Begusarai, Khagaria, Munger and Katihar districts. However, other districts viz. Siwan, Lakhisarai, Darbhanga, Supaul & Kishanganj districts, where Arsenic in drinking water is below C.P.C.B; India's standard of 50 mg/l.

III. REVIEW

Extensive studies have been done on Arsenic removal methods. The important methods have been presented here: -

Metal-based methods

Strong cation-exchange resins, macroporous polymers, chelating resins and biopolymer gels have been used in the preparation of metal-loaded polymers. They are classified here according to that metal. These metal-loaded polymers have then been used to adsorb arsenic [1-3].

Zero-valent iron.

The use of Fe (0) to remove arsenic has been actively investigated by many groups [1]. The surface area exposed plays a major role in both the adsorption kinetics and capacities. Kanel et al. [34, 35] synthesized nanoscale (1–120 nm diameter) zero valent iron (NZVI) for rapid, first order As (III) and As (V) removal (k_{obs} = 0.07–1.3 min^{-1}) This rate was about 1000 times faster than that of micron-sized iron. Batch experiments determined the feasibility of using NZVI for As (III)/As (V)-contaminated groundwater remediation versus initial Arsenic [As (III) or As (V)] concentrations and pHs (pH 3–12). The maximum As (III) adsorption Freundlich capacity was 3.5 mg of As (III)/g for NZVI. Light scattering electrophoretic mobility measurements confirmed a NZVI-As (III) inner-sphere surface complexation mechanism.

Bang et al. utilized zero-valent iron filings for Arsenic remediation. Arsenic removal was dramatically affected by oxygen content and pH [2]. Arsenate removal by Fe (0) filings was faster than arsenite under toxic conditions. Greater than 99.8% of the As (V) was removed whereas 82.6% of the As(III) was removed at pH 6 after mixing for 9 h. When dissolved oxygen was removed by nitrogen purging, less than 10% of the As (III) and As (V) was removed. High dissolved oxygen content and low solution pH increased the iron corrosion rate. Thus, arsenic removal by Fe (0) was attributed to adsorption onto iron hydroxides generated from Fe (O). The As(III) removal rate was higher than that for As(V) when iron filings (80–120 mesh) were mixed with nitrogen-perged arsenic solutions in the pH range of 4–7 [323]. XPS spectra demonstrated As(III) surface reduction to As(0). As (V) was reduced to As(III) with Fe(0) under anoxic conditions, but no As(0) was detected in solution after 5 days. Arsenic uptake by Fe(0) proceeded by electrochemical reduction of As(III) to insoluble As(0) and adsorption of As(III) and As(V) on surface iron hydroxides formed under anoxic conditions. The removal rates of As(V) and As(III) from water were much higher under air than under the anoxic conditions. As(V) removalwas faster than As(III). Adsorption of As(III) and As(V) was rapid on surface ferric hydroxides formed by Fe(0) oxidation by dissolved oxygen.

The potential use of Fe filings to remove monomethyl arsenate (MMA) and dimethyl arsenate (DMA) from contaminated waters was further demonstrated [4]. The affinity of MMA for Fe filings was comparable to that of inorganic arsenate, but lower than that for arsenite. In contrast, less DMA was retained by Fe filings or their corrosion products. The effectiveness of Fe filings was also demonstrated with a field deployment at a U.S. Superfund site where groundwater is highly contaminated with both organic and inorganic As species. Over the course of 4 months, a 3 L cartridge of Fe filings removed >85% of As contained in 16,000 L of groundwater containing 1–1.5 mg/L total dissolved As, ~30% of which was organic As.

Zero-valent iron mechanisms for arsenate removal from drinking water were also investigated by [5-7]. Batch experiments using iron wires suspended in anaerobic arsenate solutions were performed to determine arsenate removal rates as a function of the arsenate solution concentration. Corrosion rates were determined as a function of elapsed time using Tafel analysis. Batch reactor removal kinetics was described by a dual-rate model. Arsenate removal was pseudo-first-order at low concentrations and approached zero-order in the limit of high arsenate concentrations. Arsenate decreased iron corrosion rates as compared to those in a blank 3mM $CaSO_4$ electrolyte solutions.

Arsenate removal kinetics from water by zero-valent iron media was investigated to determine iron corrosion rate effects on the rate of As(V) removal [8]. As(V) removal in columns packed with iron filings was measured over 1 year of continuous operation. As(V) removal on freely corroding versus cathodically protected iron confirmed that continuous generation of iron oxide adsorption sites and As(V) diffusion through iron corrosion products determined the rates. The presence of 100mg/L As(V) decreased the iron corrosion rate by up to a factor of 5 compared to a blank electrolyte solution. However, increased As(V) concentrations (100–20,000 mg/L) caused no further decrease in the iron corrosion rate. Arsenate removal kinetics ranged between zeroth- and first-order versus the aqueous As(V) concentration.

Recently, modified nanosized zero-valent iron (Fe0) particles such as NiFe and PdFe were synthesized by borohydride reduction of nickel and palladium salts on Fe0 particles and used for arsenate removal [33]. Increasing the temperature caused an increase in arsenate removal while competing sorption of phosphate and sulphate inhibited arsenate removal.

IV. EXPERIMENTAL

Location

The area and population of Samastipur situated in middle Gangatic plain are 2,904 km^2 and 4.27 million (Census, 2011), respectively. The climate of the district is tropical monsoon but variations exist due to differences in altitude. The majority of the population depends on farming as its main occupation. Infant mortality is below 60 (per 1000) in the region. The administrative structure of Samastipur district consists of 20 blocks namely Kalyanpur , Warisnagar, Khanpur, Samastipur, Pusa, Tajpur, Morva, Sarairanjan, Patori, Mohanpur, Mohiuddinnagar, Vidyapoatinagar, Dalsingsarai, Ujiyarpur, Bibhutipur, Rosera, Shivajee Nagar, Singhia, Hasanpur and Bithan. Each Block has several Gram Panchayets (GP), which are the clusters of villages. To understand the severity of contamination and consequent health effects in West Bengal, we studied Samastipur district and undertook a detailed surgery in one of the blocks namely Mohanpur. It is shown in Map:-(1).

Physical setting

The large-scle features of the Ganga plain correspond to major climate changes in the late Quaternary [9-11]. The geomorphic surfaces identified in the regional mapping of the quaternary deposits of the Ganga plain are upland interfluves surface (T_2), marginal fan upland surface (MP), mega fan surface (MF), piedmont fan surface (PF), river valley terrace surface (T_1) and active flood plain surface (T_0). A significant aspect of these surfaces is that all of them are depositional surfaces, having a succession of overlying sediments. The Bihar Ganga plain (50-200m above the ASL, and 550-1000 km from the sea coast) shows prominent distinction between T_0, T_1 and T_2 surfaces. The Holocene aggradations, mostly due to rising base level and climate-driven sediment supply are more pronounced here compared with U.P. plain. The Ganga plain foreland basin is a repository of sediments derived from the Himalayas and from Peninsular Craton. The weathered material brought from the Himalaya is deposited in the alluvial plain where they undergo further chemical weathering, mobilizing several anions and cations. In Ganga River sediments As, Cr, Cu, Pb, U, The W, etc., are concentrated significantly [12].

Table-1

Experimental data of water samples collected froms Mohanpur block, Samastipur District.

Name of Village	Arsenic concentration (in mg/L)
Baghra	0.005
Bishunpur Beri	0.03
Chainpur	0.042
Dumari	0.001
Hardarpur	0.041
Hasimpur	0.04
Jalalpur	0.05
Madhopur	0.049
Rajepur	0.059
Sarari	0.01
Shah Alampur	0.061
Shahpur Barat	0.059
Sirsawa	0.052
Pirganj	0.041
Jahangira	0.049
Dharnipatti	0.02

V. MATERIALS AND METHODS

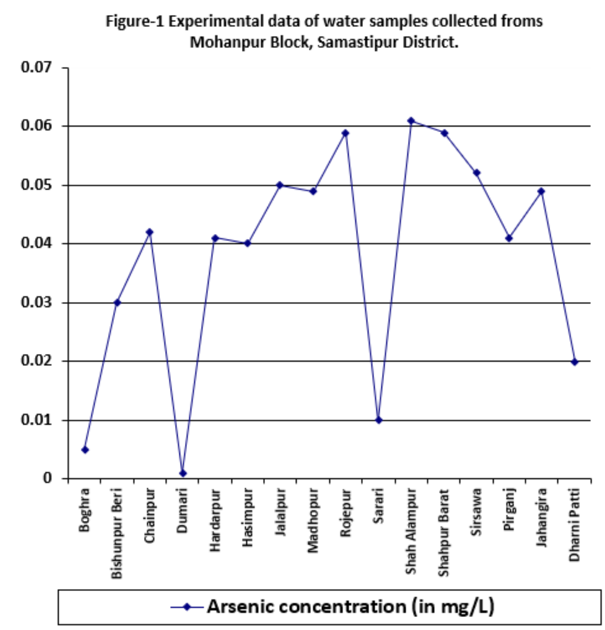
The physic-chemical analysis of groundwater samples collected from these blocks was carried out, according to the standard method (APHA, 2005)[13]. A total of 60 water samples were collected in pre-monsoon season. All the samples were collecting in poly propylene bottles. Before collecting the samples, bottles were through cleaned by 8M HNO_3, followed by repeated washing with deionized water. Adding 1:1 HNO_3 for analysis of arsenic and other heavy elements preserved 1 L of each of the collected water samples. The different physical and chemical parameters were pH, electrical conductivity (EC), turbidity, total dissolved solid (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl^-), fluoride(F^-), iron (Fe), sulphate(SO_4^{2-}), nitrate(NO_3^-) and arsenic (As). The reagents used in the study were all analytical grade reagents and demonized water was used throughout for the reagent preparation. The pH of the water samples was determined in the field at the time of sample collection by using portable pH meter (Merck, India). Fluoride contents were determined by SPANDS method using spectrophotometer (Analytik Jena, Specord-40, Germany), Sullphatae was determined by spectrophotometer method (Analytik-Jena, Specord-40, Germany). Total hardness (TH) of the samples was determined by titrimetric method. The analysis of magnesium and calcium were determined by the method of titration. The concentrations of heavy elements and arsenic in the water samples were determined by atomic absorption spectrometer (Perkin Elmer Analyst 200, USA).

VI. RESULTS AND DISCUSSION

The experimental results relating arsenic concentration of water samples from three blocks namely Mohanpur have been represented in table-(1) and Figure-(1) in the experimental section.

Arsenic - Water contaminated by arsenic is a burning problem affecting the whole world. Arsenic at high concentrations in water can cause skin lesion, cancers, vascular diseases and hypertension and diabetes mellitus (Clarke, 2001). It is observed that drinking water with more than 300μg/L arsenic for several years may cause arsenic skin lesions (Chakraborti *et.al.,* 2002).

Ingestion of inorganic as in an established cause of skin bladder and lung cancer (Berg *et.al.,* 2001, NRC 2001). The results reveal that out of three blocks of Samastipur district of Bihar, Patori block shows maximum (31.28%) groundwater contamination by arsenic followed by Mohanpur block (26.50%). In Mohiuddinnagar block, As of all ground water samples have been found to be in permissible limit of drinking water. In this study an average of 28.93% water samples have arsenic concentration above the permissible limit of 0.05mg/L. the maximum value recorded was 0.072 mg/L in Patori block. The variation of arsenic content indifferent sampling points from different blocks of Samastipur district is shown in figure-(1).



pH

The pH of 90% of the water samples analyzed were within the desirable limit of 6.5 – 8.5 given by WHO standard and most of the samples were slightly alkaline in nature. In this study pH of water samples from, Mohanpur blocks varied from 7.1 to 7.9.

Electrical conductivity and total dissolved solid

The EC, which is highly correlated, with TDS is ranged from 0.55 to 0.87 mmho/cm. Indian standards for drinking water propose no standards for EC, however, the standard for TDS are proposed which are 500 to 2000mg/L. it is seen that TDS of water samples from Mohanpur, varies from 270 to 557. The minimum value recorded is 270 from Mohanpur block.

Turbidity

It is caused by clay organic matter, phytoplankton and other microscopic organisms and makes the water unfit for domestic purposes, food and beverage industries. it is seen that TDS of water samples from Mohanpur varies from 0.7 to 2.9. The maximum value recorded is 209 for Mohanpur block. Turbidity of all samples found to be below the permissible limit 10 NTU.

Total hardness

It is the measure of the capacity of water to precipitate soap. Though hardness is not harmful to health, it has been suspected to be plying some role in heart disease. In this study, total hardness of all samples found to be below the permissible limit 600mg/L for drinking water. It is seen that total hardness of water samples from Mohanpur, block varies from 214 to 322. The minimum values recorded were 214 from Mohanpur block.

Calcium

In order of abundance, it is the fifth element which is commonly present in all water bodies where it usually comes from the leaching of rocks. Calcium is very essential for nervous systems and for formation of bones. In this study calcium concentration of water samples from Mohanpur block varied from 42.3 to 91.5. The concentration of calcium in potable water ranges from 75 to 200mg/L.

Magnesium

Magnesium tolerances by human body are lower than that of calcium. High concentration of magnesium in drinking water gives unpleasant taste to the water. The concentration of magnesium in potable water ranges from 30-100mg/L. In this study magnesium concentration of water samples from Mohanpur block varied from 12.5 to 60.8. The minimum and maximum recorded values of magnesium was minimum 8.42 and maximum 60.8mg/L, in Mohanpur block. The variation of calcium and magnesium content with different sampling point are given.

Chloride

Chloride in excess imparts a salty taste to water and people who are not accustomed to high chloride can be subjected to laxative effects (Ravi Prakash and Krishna Rao, 1989). In ground water it may be contributed from minerals, like apatite, mica and hornblende and also from the liquid inclusion in the igneous rocks (Das and Malik, 1988). In this study chloride concentration of water samples from Mohanpur block varied from 3.7 to 17.9. All samples are found to be below desirable limit 250mg/L. The variations of chloride content with different sampling points are given.

Fluoride

High concentration of fluoride in drinking water can cause an adverse effect on human beings. Continuous consumption of water having high fluoride content can cause diseases, like fluorosis, dental carries and bone diseases (Mariappan *et.al.*, 2005). The concentration ranges observed in the is study were 0.07 to 0.54, 0.11 to 0.8 and 0.11 to 1.05mg/L for Mohanpur block, respectively. The variation of fluoride content with different sampling points.

Iron

Iron is considered to be the most essential element to all organisms. It is present in hemoglobin and myoglobin systems. Presence of iron in water can cause staining laundry and porcelain. It gives stringent taste to water when water contains iron concentration above the permissible limit 1mg/L of drinking water. In this study iron concentration of water samples from Mohanpur block varied from 0.11 to 1.11. The maximum concentration observed was 1.11mg/L, in Mohanpur block. The variation of iron content with different sampling points is presented.

Sulphate

It is the common ion in water. Sulphate can produce bitter taste at high concentration. Sodium and magnesium sulphate exert a cathartic action in human beings. It is also associated with respiratory diseases. The permissible limit and desirable limit of sulphate in drinking is 200 to 400mg/L. respectively.

Nitrate

High nitrate in drinking water may cause methamoglobehemia among infants in which the skin becomes blue due to poor oxygenation of blood hemoglobin. Carcinogenous disease, like nitro-semines result due to higher nitrate in drinking water. It is seen that nitrate of water sample from Mohanpur block varies from 0.5 to 2.5. The minimum value recorded is 0.5 for Mohanpur block. All samples are found to be below desirable limit 45.00mg/L.

VII. CONCLUSION

Analysis of groundwater samples collected from these blocks shows that pH of 90% water samples analyzed were within the desirable limit of 6.5-8.5 given by WHO standard and most of the samples were slightly alkaline in nature. Similarly, TDS, turbidity, TH, Ca^{2+} and Mg^{2+} concentration in the water samples are all within the permissible limit of drinking water SO_4^{2-}, Cl^-, F^-, Fe and NO_3^- content in the groundwater samples from these blocks are also found within the permissible limit for drinking water. From the study it shows that groundwater of the region is contaminated by arsenic. The results reveal that one of block shows maximum (31.25%) groundwater contamination by arsenic followed by Mohanpur block (26.66%). Though the groundwater of the two blocks has been contaminated by arsenic, no symptoms of arsenic poisoning are observed till date. This is most probably due to the presence of As^{5+} in groundwater in high amount as compared to As^{3+}. But in near future, the problem of Arsenicosis may arise and, therefore, speciation of arsenic should be taken into consideration.

VIII. REFERENCES

[1]. Arsenic in ground water in six districts of West Bengal, India. Das Dipankar et.al., Env. Geochem. And Health., 18, (1996) 5-15.

[2]. B.B.Sandwar and A.K. Tiwary, Monthly variation in heavy metal concentrationin Ganga river water in North Bihar region around Barauni Mokameh Industrial complex Poll. Res, 25(4), (2006)P 693-700.

[3]. Water and Waste Water analysis (Manual)-National Environ, Engg. Res. Insitute (NEERI), Nagpur(1984).

[4]. C. Pasha and B. Narayan., Determination of Arsenic in Environment and Biological samples using toluidine blue by simple spectrophotometer method. Bulletin of Eviron, contamin. Toxicol 81, (2008)47-51.

[5]. A.K. Singh., Approaches for removal of Arsenic from ground water of North eastern India current science, vol. 92, June (2007)., no.11 .

[6]. A.K. De. -Environmental Chemistry 4th Edn. New Age International (p) Ltd. New Delhi (2002)., pp 257 & 289.

[7]. ATSDR: Toxicological Profile for Arsenic. U.S. Department of Health & Human Services, Public Health Service Agency for Toxic Substancwas and disease Regdistry(2000)., pp 428.

[8]. CGWB & BARC: Studies on Arsenic Pollution of Groundwater using isotopic and geochemical methods in Arsenic in Bhojpur. Distt. of Bihar, India Central ground water Board, Mid Eastern region, Patna (2009)pp 49.

[9]. D. Saha; Arsenc ground water contamination in part of middle Ganga plain Bihar. Current Sci, Vol. 97 (2009)pp. 753-755.

[10]. C. Kumar.; Status and Mitigation of Arsenic Contamination in ground water in India. The international journal of earth & Environmental Sciences (IJEES) 1(1) (2015):1-10.

[11]. S.K. Singh and A.K. Ghosh;Health risk assessment due to ground water Arsenic contamination: children are at high risk. Human and Ecological Risk Assessment, An International Journal, 18(4) (2012):751-766.

[12]. A. K. Singh; Arsenic and fluoride in ground water: An emerging problem in North-Eastern India. Presented in an International Conference on ground water for sustainable development: Problem, Perspectdives and challenges (eds Ramanathan et.al.) Abstn. Vol. New Delhi(1-4 February 2006).

[13]. D. Chakrabarti. et.al., Arsenic gdround water contramination in Middle Ganga plain Bihar India: a future danger? Environ. Health per4specitves, 111, (2003)pp 1194-1201.

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