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ARSENICOSIS- A HYDROLOGICAL PROBLEM OF PATNA

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ABSTRACT

Background- In the present times, arsenic poisoning contamination in the ground water has caused lots of health-related problems in the village population residing in middle Gangetic plain in Bihar, about 16 to 20 districts have been reported to be affected with arsenic poisoning. For the ground water and health assessment, area of Patna district was undertaken which is a flood plain region of river Ganga.

Methods- In this study, Measuring the P^H and hardness by EDTA methods and also did the arsenic estimation of collected sample, their results were analyzed. Furthermore, the correlation between arsenic contamination in ground water with depth and its distance from river Ganga were analyzed. Results are presented as mean ± standard deviation and total variation present in a set of data was analyzed through one-way analysis of variance. The difference among mean values has been analyzed by applying Dunnett's test. The criterion for statistical significance was set at $P < 0.05$.

Result- This study shows novel findings ever done in this area. In the Patna, places like Patna sahib, Marcha-marchi Hathitola, Rampurdiar, Haldiatola, Nayatola and Nala road and Mahadevsthan place were the most affected strips with high-arsenic concentrate ion in hand pumps. Furthermore, a correlation between the arsenic concentration with the depth of the hand pumps and the distance from the river Ganga was also a significant study.

Conclusion- The present study concludes that in Gangetic plain of Patna, there is high contamination of arsenic in ground water in all the strips. Such a huge population is at very high risk leading the village on the verge of causing health hazards among them. Therefore, an immediate strategy is required to combat the present problem.

KEY WORDS - Arsenic contamination, ground water, river, village.

INTRODUCTION

Environmental pollution represents a critical global challenge, with arsenic (As) ranked among the 20 most toxic substances of concern to human health[1A]. Previous studies identify arsenic (As), a naturally occurring metalloid, as a priority pollutant due to its high toxicity and widespread occurrence. The toxicological impact of arsenic is governed by its chemical form and oxidation state, with inorganic As (III) and As (V) in drinking water posing greater risk than organoarsenic compounds. Groundwater arsenic has been reported globally [2–6]. In the Indian context, Chakraborti et al. (1984) first confirmed contamination in the lower Gangetic plain of West Bengal, followed by reports from Bihar in 2002. The Ganga-Meghna-Brahmaputra plain is now recognized as an arsenic-affected region affecting >500 million inhabitants. Official surveys by PHED-Bihar and UNICEF-Bihar list 14 affected districts in Bihar. Epidemiological evidence links prolonged exposure to arsenicosis and other systemic disorders. Naturally occurring arsenic and arsenic-bearing compounds have been documented at low concentrations in geothermal zones[2d].Arsenic is a shiny metalloid that dissolves in water. It is a natural mineral, present in the soil and aquifers, and the concentrations above the safe level in drinking water may cause significant health risks. Prolonged exposure to high arsenic concentrations in drinking water correlates with increased incidence of respiratory disease, dermatoses, hepatopathy, cardiovascular dysfunction, neuropathy, and malignancies[2d].Most arsenic enters water supplies either from natural deposits in the earth or from industrial and agricultural pollution. Arsenic is a natural element of the earth's crust. Although surface water are mostly considered safe for drinking water but groundwater sources are arsenic contaminated in the range of 40 – 140 feet.

Bihar along with few other states of India is facing a severe problem due to arsenic menace in groundwater. Groundwater is the main source of drinking water and it constitutes more than 80 per cent of drinking source in rural

Bihar. The other sources of drinking water are from surface water, dug well, pond and from natural sources (lakes, rivers etc.) and protected dug well. The groundwater sources were considered safe for drinking water but over the past few years, they have reported contamination and pollution problems in its root due to rapid urbanisation, increase in population, industrialisation and excess and uncontrolled extraction of groundwater for irrigation and other purposes.Around 40 percent districts of Bihar have reported arsenic in its groundwater. This comprises more than 67 blocks from 15 districts and covering more than 1600 habitations across the state where arsenic contamination in groundwater exceeds the Bureau of Indian Standard(BIS) limits for safe drinking water of 50 parts per billion (ppb) and more. If we consider the WHO limits of 10 ppb, the coverage area will be much more and the population which is facing the danger of arsenic hazard will be more than the BIS standard limit. It is estimated that more than 13.85 million people could be under the threat of contamination level above 10 ppb/l, out of which more than 6.96 million people could be above 50 ppb/l, against the total population of these area is around 50 million (Ministry of Water Resources, 2010). The actual problem of arsenic menace among the population will be more than the estimate due to increase in affected area after every new survey.

Access to safe water supply is one of the most important factors of health and socio–economic development (Cvjetanovic, 1986). More than 150 million people are affected worldwide by arsenic contamination in 70 countries, out of which 50 million people in Bangladesh and 30 million people in India are at risk (Ravenscroft et al., 2008, 2009). Arsenic is toxic in nature and the excess quantity of its use in drinking water leads to several health hazards. Drinking arsenic contaminated water over a long period results in various health effects including skin problems such as colour changes on the skin, and hard patches on the palms and soles of the feet (WHO, 2010). It also leads to skin cancer, cancer of the bladders, kidney and lung, and diseases of the blood vessels of the legs and feet, and also possibly diabetes, high blood pressure and reproductive disorders (WHO. 2010)

BACK GROUND

Bihar is rich in groundwater resources. In Bihar, annual replenishable groundwater resources, net annual groundwater availability and annual groundwater draft are 29, 27.42, and 10.77 BCM. The stage of groundwater development in Bihar is 39 percent and the annual rainfalls (in mm) are 1232. The per capita water availability is decreasing in both Bihar and India. In 2001, per capita availability of water (in cu. m) was 1950 and 1816 for Bihar and India. It has further decline to 1545 and 1200 (in cu. M) in 2011. The decline in availability of groundwater is due to uncontrolled population growth, excess dependence on groundwater (85 percent), over extraction of groundwater for irrigation, uncontrolled deforestation. This leads to overall water quality problems. But water is becoming increasingly scarce over the years. Uncontrolled growth of population, expansion of irrigation channels and developmental activity are responsible for the decline in water availability problems. It also leads to problems in water quality which affects the health and other problems. The groundwater problems in Bihar have been summarized in Table.

METHODS

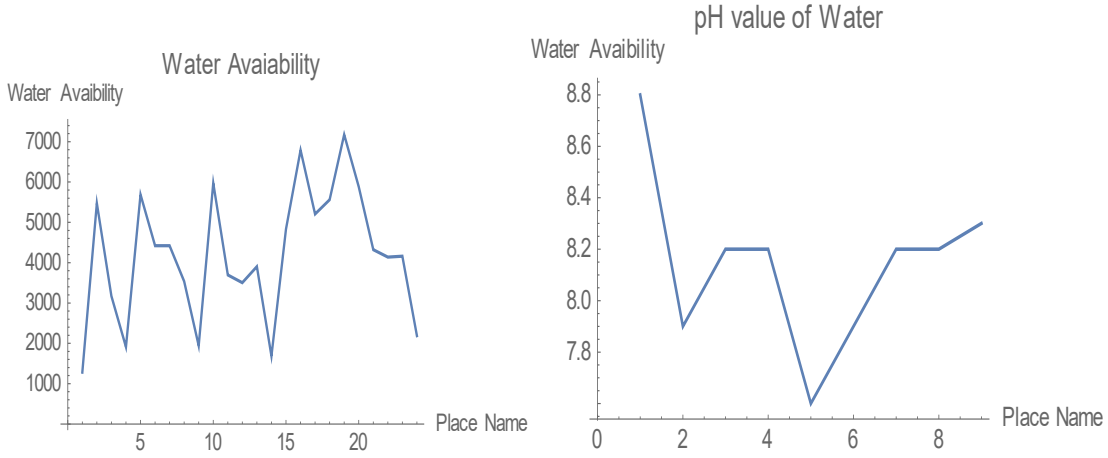
Location- The study was conducted in India in Maner block of Patna district and Patna Sahib area , Patna district of Bihar. The area is a flood plain region of Patna district. The population of the Patna sahib is 2748000 approx in 2026. There are 12621 households in 2025.The area is so large in area that it is divided into four strips – Nala road, railway station road, marchamarchi, and Ramo Patti. Among thesestrips, Marcha-marchi strip acquires the largest part of the patna sahib area. While in Maner block we selected several area like Hathitola village, Rampurdiara, Haldiyatola, Nayatola and Ratantola.

Arsenic analysis and survey- For the collection of water samples, 500 ml polypropylene bottles were utilized and were cleaned and pretreated with hydrochloric acid. Altogether, 150 water samples in duplicates were collected from hand pumps of the households every 50 m of distance in each the village of strips. After the collection, water samples were on spot analyzed utilizing Merckoquant Arsenic Field test kit. Final confirmation was done using Thermo Fisher ultraviolet-visible spectrophotometer through the silver diethyldithiocarbamate method against a blank at 520 nm. For the estimation of the per capita consumption of drinking water through hand pumps by the village people, a survey in all the strips of the village was conducted utilizing a questionnaire method. The questionnaire was filled after proper interrogation with elderly, adults, and youths of the village (2680 people) related to the amount of daily consumption of drinking from their hand pumps, their household hand pump depth, and their health-related problems. Handheld global positioning system receivers with an estimated accuracy of ≈10 m were utilized for the determining the exact location of the area. The correlation between arsenic contamination in ground water with depth and its distance from river Ganga were also analyzed.

Statistical analysis-Statistical analysis was done utilizing statistical software (GraphPad Prism 5), and the values were expressed as mean ± standard error of mean. The difference between the groups were analyzed statistically by one-way analysis of variance using Dunnett's test.

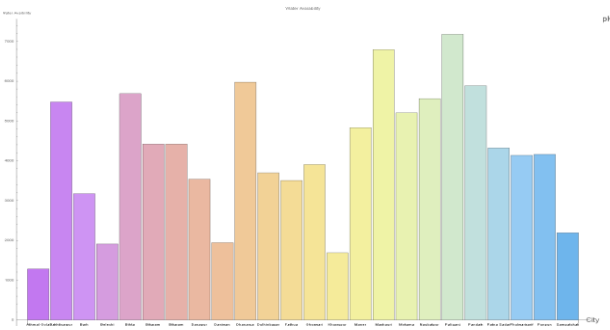
RESULT

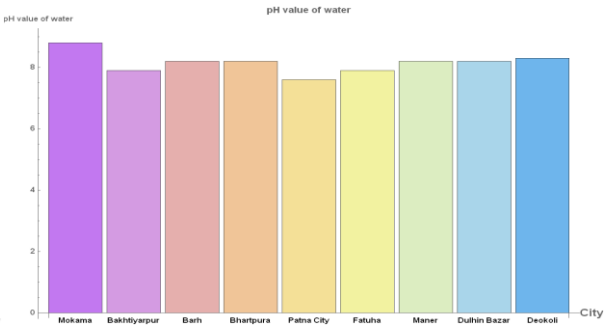
Ground water arsenic contamination in Patna, the Patna sahib area is situated near the vicinity of the river Ganga. The nearest point from Patna sahib that is Gangetic marine drive strip to the river Ganga is hardly 1/2 km. The study also emphasizes that longer the distance from the river, the higher is the arsenic concentration in the ground waters of hand pumps . High prevalence of arsenic contamination in ground water was found after analysis of 150 water samples . The different strips showed different patterns of arsenic contamination in ground water. All the strips showed a unique pattern of arsenic contamination in the groundwater as the middle region of the strips were arsenic free, but their periphery showed severe arsenic contamination in the hand pumps . Among the most severely affected strips were Marchamarchi and Nala road where the arsenic contamination was much higher in most of the analyzed water samples . The Marchamarchi strip showed hand pumps with arsenic contamination between 60 ppb and 300 ppb while other strip showed hand pumps with arsenic contamination between 60 ppb and 400 ppb.

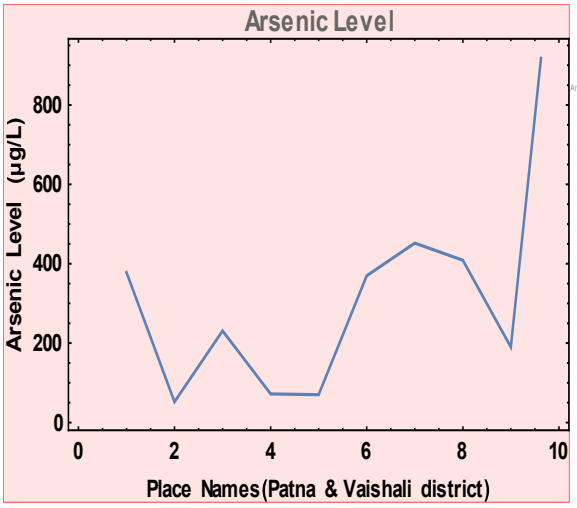


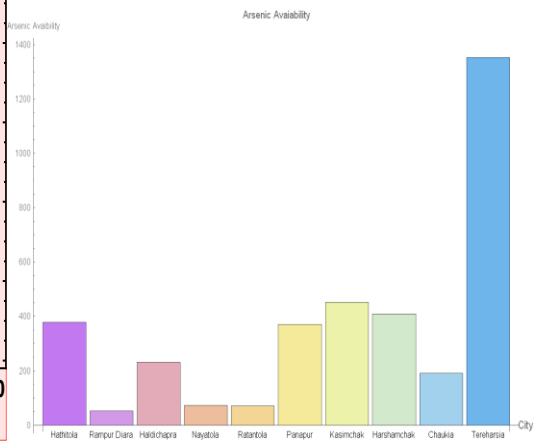
[The water avability and P^H Value of water will be shown in the above graph the water samples are collected from the places Hathitola, Rampurdiar, Nayatola and Nala road.]

Arsenic (atomic number, 33; relative atomic mass, 74.92) has chemical and physical properties intermediate between a metal and a non-metal, and is often referred to as a metalloid or semi-metal. It belongs to Group VA of the Periodic Table, and can exist in four oxidation states: –3, 0, +3, and +5. Arsenite, As^{III}, and arsenate, As^{V}, are the predominant oxidation states under, respectively, reducing and oxygenated conditions (WHO, 2001; IARC, 2004). Arsenic is the 20th most common element in the earth's crust, and is emitted to the environment as a result of volcanic activity and industrial activities. As^{III}, MMA^{III}, and DMA^{III} can induce chromosomal aberrations *in vitro* (Oya-Ohta *et al*., 1996; Kligerman *et al*., 2003). Statistically significant increases in chromosomal aberrations occur only at toxic doses (Klein *et al*., 2007), except as a secondary effect of genomic instability in long-term, low-dose treatment protocols (Sciandrello *et al*., 2004). In the human body, inorganic arsenic compounds are converted to As^{III} and As^{V}. As^{V} is rapidly converted to As^{III}. As^{III} species are more toxic and bioactive than are As^{V} species, both because of the greater chemical reactivity of As^{III}, and because As^{III} enters cells more easily. Many of these effects depend on altered gene expression that can result from genetic and epigenetic effects . Changes in gene expression by As^{III} can also be mediated by the alteration of miRNA patterns (Marsit *et al*., 2006). Some short-term changes in gene expression (e.g. changes in the expression of DNA-repair proteins or DNA methyltransferases) can result in long-term changes. Genome-wide changes in gene expression and signal transduction induced by arsenicals have been reported in several publications (Su *et al*., 2006; Kumagai & Sumi, 2007; Ghosh *et al*., 2008). An analysis of micronuclei induced by As^{III} in human fibroblasts shows that at lower (relatively non-toxic) doses, As^{III} acts as an aneugen by interfering with spindle function and causing micronuclei with centromeres, but at high (toxic) doses, it acts as a clastogen, inducing micronuclei without centromeres (Yih & Lee, 1999). Aneuploidy is seen after treatment with As^{III} concentrations lower than those that cause chromosomal aberrations (Yih & Lee, 1999; Ochi *et al*., 2004; Sciandrello *et al*., 2002, 2004).

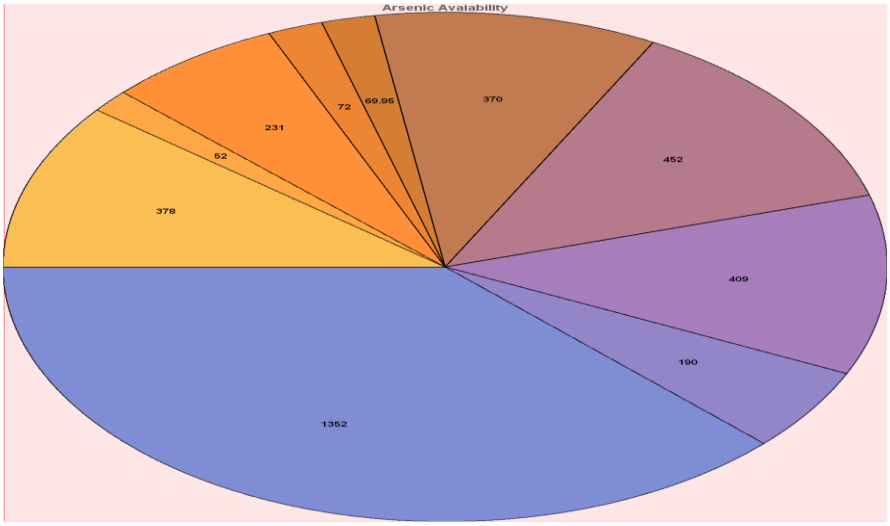








[In Patnna analysis of water samples from Patna Sahib , Marcha Marchi, Nala road while from vaishali samples are collected from Bhagwanpur & Lalganng]



DISCUSSION

Arsenic is found in the natural environment in plenty in the earth's crust and in small magnitudes in rock, soil, water and air and is always present as compounds with oxygen, chlorine, sulphur, carbon and hydrogen on one hand, and with lead, gold and iron on the other (Ministry of Water Resources). It can exist in both organic and inorganic form but inorganic arsenic is more toxic than organic arsenic. Inorganic arsenic compounds are known to be more human carcinogens. Arsenic in element form is insoluble in water and soluble in oxidized form. Countries including Argentina, Bangladesh, Chile, Ghana, Mexico, Mongolia, India, Taiwan, Vietnam, and United States are exposed to arsenic problems because the sources of arsenic are primarily natural rather than anthropogenic or geothermal. Inorganic arsenic of geological origin has been recognised as the main form of arsenic in groundwater. Sparks (2005)

suggested three source of arsenic in soil and aquatic ecosystem. It consists of biogenic, geogenic and anthropogenic sources of arsenic. By and large geogenic sources are responsible for arsenic contamination but anthropogenic activities also cause contamination. The anthropogenic sources of arsenic occur due to human activities. The main source of anthropogenic can be further classified in three categories viz. agricultural, industrial and others. Agricultural sources of arsenic can be from pesticides, herbicides, seed treatment, cattle deep and fertilizer mainly, while industrial sources are from timber treatment, tannery, electro plastic, and paints and chemicals. Other anthropogenic sources are from sewage and smelting. Arsenic is a heavy metal and regarded as a toxic element. Excess of arsenic in drinking water over long run is considered as a human health hazard and leads to different diseases. In extreme cases it leads to an end of human life. Seven states of India have reported arsenic contamination in groundwater and it is increasing at increasing rate (Ministry of Environment and Forest, 2009). Out of reported seven states, Bihar and West Bengal have severe impact of the livelihoods of the stakeholders due to arsenic menace. More than 70 countries are globally affected directly or indirectly with arsenic contamination in drinking water which affects more than 150 million people across the globe. Around middle of the 20th century, arsenic poisoning surfaced in those areas where people ingested arsenic contaminated water. The major affected countries from arsenic poisoning were Argentina, Chile, Mexico, Taiwan, and some part of the United States. In global arsenic scenario, 38 countries are affected more severely at present. At the last quarter of 20th century three Asian countries (Bangladesh, China, and India) came to lime light due to their suffering from groundwater arsenic contamination. The major source of arsenic contamination was contaminated hand tube-wells. As of 2010 September, 13 Asian countries were arsenic affected and the level of arsenic contamination in Asian countries was more severe than the rest of the world. Bangladesh is the worst affected country, as 60 of its total 64 districts have arsenic groundwater contamination above World Health Organization (WHO), 2001 guidelines of 10mg/l for safe drinking in water. In India, flood plains of all the states in Ganga and Brahmaputra rivers are arsenic affected. The first case of arsenic in India was reported in 1976 from Chandigarh, where some patients were suffering from noncirrhotic portal hypertension (NCPH) and later it was found that the water used by patients who suffered from NCPH came from arsenic contaminated tube wells (Ministry of Water Resources, 2010b). In 1982 a patient from North - 24 Parganas district of West Bengal, reported skin lesions which were not like the usual skin diseases and later, similar problems were found in many patients from the same village suffered from such problems in soles of their feet, palms of their hands, ulcers in hands and bodies. It was found that the cause of theses was the excess availability of arsenic in tube wells in drinking water (Ministry of Water Resources, 2010a). Soon after the incident four districts of West Bengal (North 24 Parganas, South 24 Parganas, Nadia, and Murshidabad) were found on arsenic menace in ground water. In 1983, 33 villages of 4 districts were identified, having arsenic contamination. By the end of 2004, 3200 villages of 85 blocks from 9 districts were identified having arsenic contaminated water and by the end of 2008, more than 3417 villages of 111 blocks from 9 districts have reported arsenic contaminated groundwater (Ministry of Water Resources, 2010b). As of 2009, out of 38 districts of Bihar, 57 blocks from 15 districts having total population more than 10 million have been reported to have arsenic groundwater contamination above 50 mg/l (Ministry of Water Resources, 2010a and 2010b, Ministry of Environment and Forest, 2009). Due to the excess arsenic contaminated drinking water, 18 babies were born blind in the Bhojpur district. The demographic survey done by many organisations mainly in Bihar and West Bengal estimated that more than 13.85 million people could be under the threat of contamination level above 10 mg/l, in which more than 6.96 million people could be above 50 mg/l, against the total population of those areas of the order of 50 million (Ministry of Water Resources, 2010b). Live-stock in large number has also been exposed to arsenic contaminated groundwater. In the arsenic affected areas, arsenic contaminated groundwater is also used for agricultural irrigation. This leads to the possibility of arsenic exposure through food chain not only in contaminated areas but also in areas with no contamination due to open market sale of food products. Out of seven states, two states of India namely Bihar and West Bengal are worst affected by arsenic contamination in their groundwater. Altogether more than 40 percent of the people from Bihar and West Bengal are affected by arsenic contamination in groundwater which causes serious threats to the people of the state in health and other hazards which threats to the socio - economic status of the affected people.

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