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Study of Extent and Magnitude of Arsenic in Groundwater in Uttar Pradesh, India

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Abstract

Arsenic occurs in three common allotrops namely metallic grey, yellow and black. Arsenic founds in shallow aquifer of Ganga and Brahmaputra River Basin. Arsenic contamination in groundwater in the Ganga- Brahmaputra basin in India is reported as arsenic contaminated zone. There are seven highly contaminated states namely-West Bengal, Jharkhand, Bihar, Uttar Pradesh (UP), Assam, Manipur and Chhattisgarh in India. Three districts namely Ballia, Gazhipur and Varanasi in UP are contaminated with very high amount of arsenic. In Ballia district 5 out of 17 blocks are highly contaminated and people are suffering by skin disease related to arsenic. The results depicted that extent amount of arsenic is found in eastern part of Ballia District. The objective of this paper is to study the extent and magnitude of arsenic in groundwater for almost all shallow, medium and deep aquifer of Murli Chhapra Block. Results showed 78% samples are contaminated with arsenic. The contamination rate is in decreasing order by going down(shallow>medium>deep aquifers). In the study area more than 80 percent people have their own hand pump ranged between 12mto 25m in shallow aquifer.

Keywords: arsenic contamination; aquifer; water pollution; ground water; health effects

1. Introduction

The arsenic contamination in groundwater of many countries are reported (Smedley and Kinniburgh, 2002; Giang Luu *et al*., 2009; Uddin *et al*., 2006). India, Vietnam, Taiwan, Mexico, Argentina, Hungary, Chile, Romania and most part of USA are showing arsenic contamination in groundwater (Bissen and Frimmel, 2003), which is derived from both natural and anthropogenic sources. Various survey reports clearly indicate that there are 20 arsenic groundwater contamination incidents on our globe till 21st century, of which 5 are from Asia (Ravenscroft *et al*., 2008). The arsenic contamination shows a similar trend in most of the states that the floodplains, particularly banks of rivers originating from Himalayas or Tibet Plateau are highly contaminated (Chakraborti *et al*., 2004; Nickson *et al*., 2005). It proves after getting arsenic reports from different place vis. the Yellow River in China, the Irrawaddy River in Myanmar, the Mekong River in Laos and Cambodia, the Indus River in Pakistan, the Red River in Vietnam and the Ganga-Brahmaputra-Meghna (GBM) River system in parts of Bangladesh and West Bengal in India and (Acharyya *et al*., 1999; Poyla *et al*., 2005; Iqbal, 2001; Berg *et al*., 2001; World Bank, 2007). In India arsenic contamination is concentrated in Ganga and Brahmaputra Plain and due to arsenic concentration all states on it (Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam are showing high arsenic contamination (Chakraborti *et al*., 2004). Brahmaputra (GMB) Plains are announced after 20 year survey that in Ganga River Plain Uttar Pradesh, Bihar, Jharkhand and West Bengal and in Brahmaputra plain Assam are highly arsenic affected states (Chakraborti *et al*., 2004). Arsenic contamination was reported in Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, and Northern India in 1976 (Datta and Kaul, 1976) and in lower Ganga plain (West Bengal) arsenic contamination was discovered in 1984 (Garai *et al*., 1984). In 2006, the arsenic contamination found in three district of Uttar Pradesh (Varanasi, Gazipur and Ballia) (Ahamed *et al*., 2006). Arsenic contamination is reported in all blocks of Ballia district and arsenic concentration is higher in post-monsoon than pre-monsoon and contamination level is more than permissible limit (Ali *et al*., 2012; Namrata *et al*., 2015). According to the Arsenic Task Force (ATF) has been reported that about 1.20 lacks people are affected by arsenic in three blocks of Ballia district namely Reoti, Belahari and Dubahand

(Katiyar and Singh, 2014). WHO guideline as well as the Bureau of Indian Standard (BIS) permissible limits for arsenic in drinking water is 10 μg/L. Presently the Ministry of Rural Development (MHRD) has retained an interim standard of 50 μg/L in India. To determine the arsenic contamination in ground water few investigations have been carried out in the state of Uttar Pradesh, India, (Nickson *et al.*, 2007; Chauhan *et al.*, 2009; Chakraborti *et al.*, 2009; Kumar *et al.*, 2010). The elevated level of arsenic consumption is associated with skin lesions, peripheral vascular disease, hypertension and cancers (Sams II *et al.*, 2007). The injection of arsenic for a several year is a cause of arsenical lesion (Chakraborti *et al.*, 2002) but current study noticed that consumption of arsenic, even at low levels, leads to carcinogenesis. The arsenic exposes is common in poor families through groundwater. In rural part of India filtration of water is difficult and a poor family can't afford its cast. Now many arsenic filters are working based on different technology but by the help of dual treatment method by oxidation- co precipitation -adsorption and filtration by activated alumina is a current technology to filter water with best results (Roy *et al.*, 2014; 2016). The overall objective of this research paper is to determine the extent and magnitude of arsenic in a ground water in Murli Chhapara Block and find out the contamination character in aquifers.

2. Materials and Methods

2.1 Study Area

Ballia district is the eastern most part of the Uttar Pradesh lies between 25°23" and 26°11" north latitude and 83°38" and 84°39" east longitudes (Fig. 1). Its total geographical areas of the district are 2981 sq.km. As per 20011 census district has population 3,239,774 of which 1,672,902 males and 1,566,872 females. Rural population is 2491676 and urban population is 269944. The district has a population density of 1,081 inhabitants per square kilometer. There are 17 blocks in Ballia district. Out of 17, Murli Chhapara is a block in the confluence of Ganga and Ghaghara River. This block is the southeast block of district surrounded by Ganga and Ghaghara from 3 sides. Each and every year this block get flooded and face the problem of water logging. The total area of this block is 168.58 sq. km with population 145,619.

2.2 Sampling

100 samples have been collected from all available current and previous private and public groundwater sources (hand pumps / tube wells / bore wells) used for drinking and cooking purpose by using household

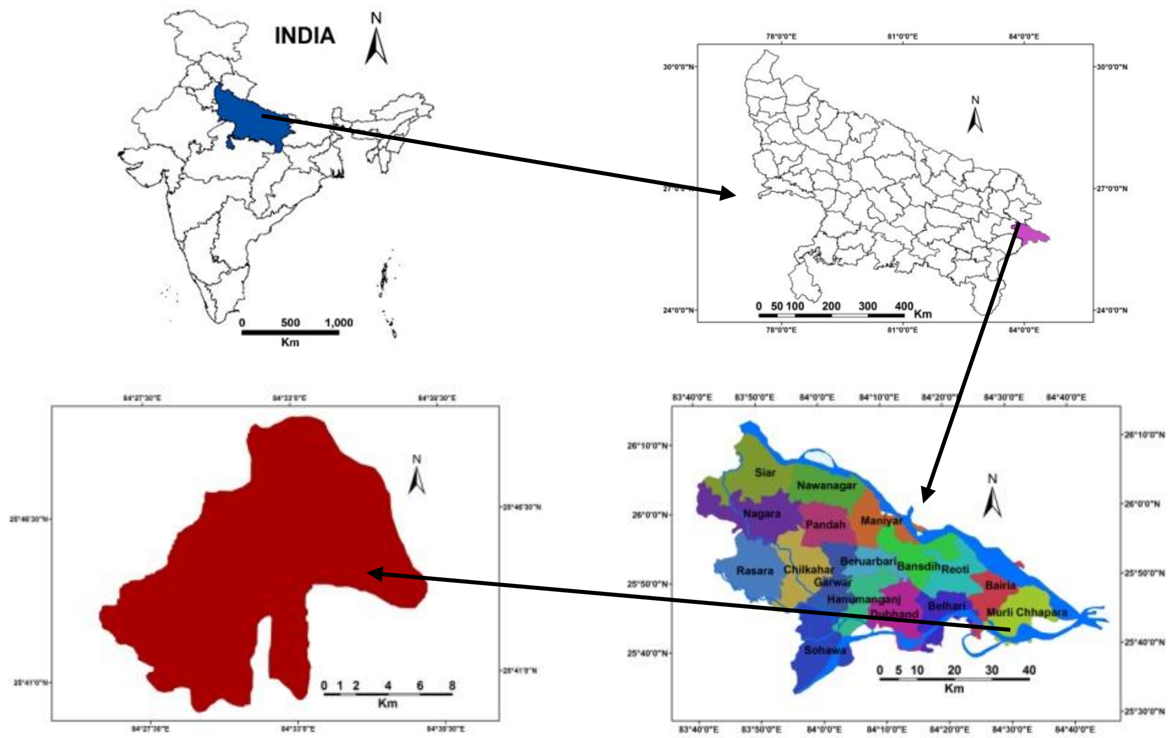

Figure 1. Study area of Ballia district

survey at random from Murli Chhapara block in Ballia district. 60 samples has been collected from shallow aquifer range between 0 to 25 m because in the study area more than 80 percent household have their own hand pump with less than 25 m. depth, 30 samples have been collected from medium aquifer range between 25 m to 90 m because 40 percent household have tube wells and only 10 samples from deep aquifer more than 90 meter deeper because in rural area number of deep bore wells are very low.

2.3 Sample analysis

An attempt has been made to carry out preliminary investigation of the water quality especially arsenic. The analysis had been taken in field with the help of Econo Quick Arsenic Test Kit, Part No. 481298 (Sensitivity: 0, 10, 25, 50, 100, 200, 300, 500, 1000 ppb (μg/L)). Serial Dilution Method has been used for water analysis purpose. The result shows the level of arsenic contamination in groundwater is higher than BIS standard 50 μg/L.

3. Results and Discussion

3.1 Geomorphology and topography of Ballia district

Geologically, Ballia district exposes quaternary sediments which are differentiated into older alluvium and younger alluvium. The older alluvium (Varanasi alluvium) consists of oxidized, brown to yellow colored sediments. The younger alluvium (Holocene alluvium) lies dis-conformably over the Varanasi alluvium and consists of un-oxidized, grey and khaki colored sediments (shown in Fig. 2). The terrain of Ballia is a part of middle Ganga plain, geomorphologically, it is divisible into upland and low land. The upland known as Varanasi plain, occupies Ganga-Ghaghara interfluve with elevation of 57-69 m above mean sea level. This surface is silt to clayey, slopes gently towards southeast (Geological Survey of India). In Ballia district surface water resources provided by Ganga, Ghaghara, Chhoti Saraju and Mangai Rivers. Ganga and Ghaghara Rivers are snow fed perennial rivers. Chhoti Saraju and Mangai Rivers are groundwater fed rivers. Suraha, Basau, Daha and Dah are big tal/lakes

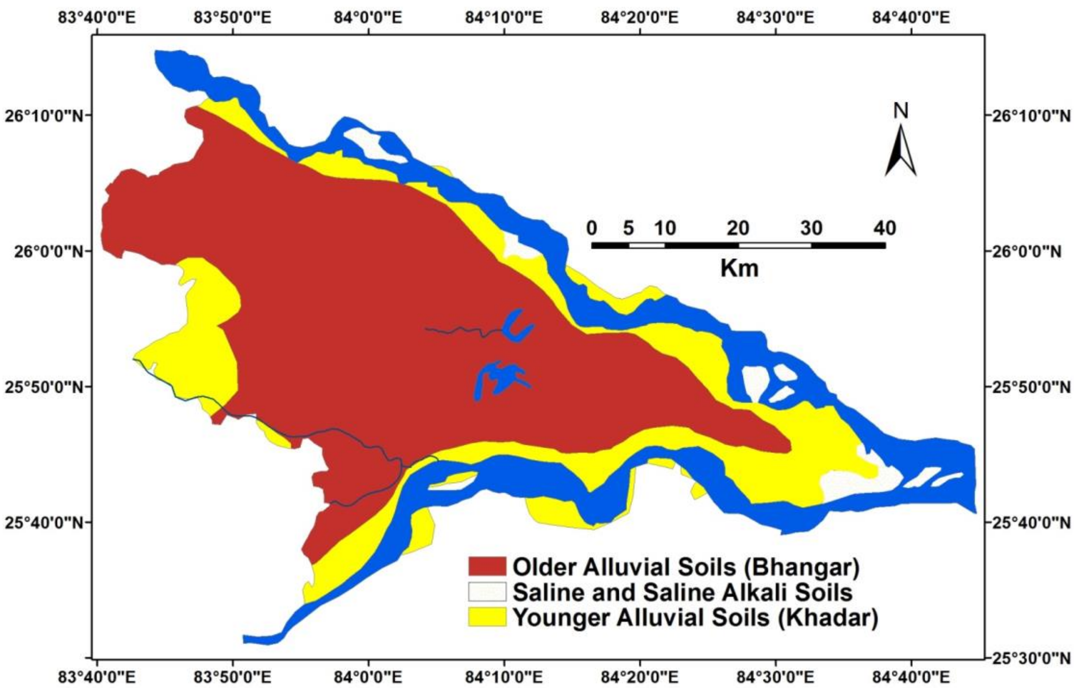

Figure 2. Geomorphology and topography of Ballia district

3.2 Digital Elevation Model (DEM) and slope map of Ballia district

Geomorphological and topographic information was extracted from the 'ASTER GDEM' digital elevation model (DEM), available at 30 m resolution. DEM shows that the western part of the district falls under high elevation range whereas the elevation ranges gradually decrease in eastern part of the district. Arsenic contamination in groundwater and the elevation values have found directly reverse relationship. In high elevation range, the contamination level is low but in low elevation range, contamination level is found to be higher depicted in Fig. 3. The DEM was projected into the UTM coordinate system to develop the raster products of elevation in meter, slope in degrees as shown in Fig. 4, flow accumulation cell values and 'distance to river'. Flow accumulation cell values represent accumulated water flowing into each corresponding down slope cell in a raster image. Slope map of Ballia district shows that the western part of the district is in high slope range and it gradually decreases from west to east part. Due to the decreasing order of slope the groundwater flow, surface water as well as storm water flows according to the slope.

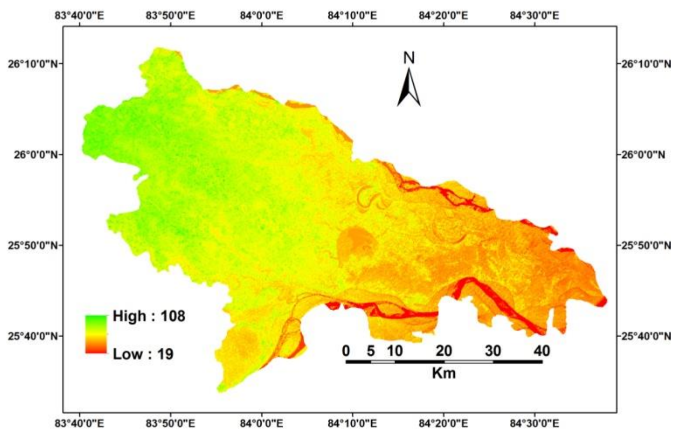

Figure 3. Digital Elevation Model (DEM) of Ballia district

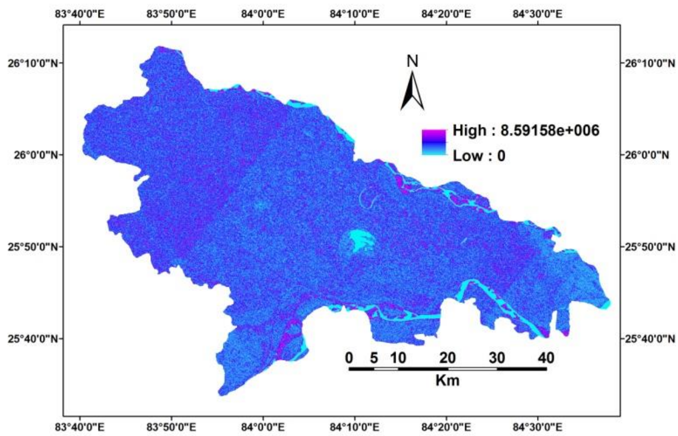

Figure 4. Slope map of Ballia district

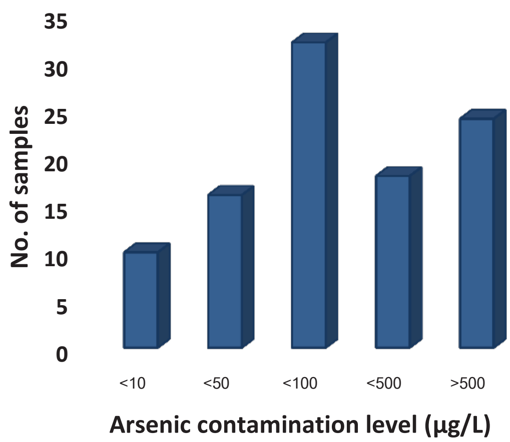

Figure 5. Arsenic level in groundwater of Ballia district

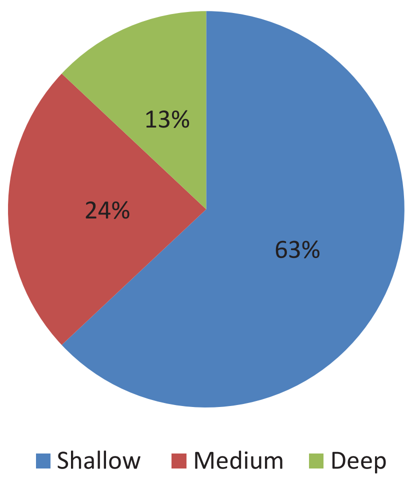

Figure 6. Contamination level in aquifers of Ballia district

After analyzing all samples the result shows that the contamination is very high and only 10 percent samples are under 10µg/Land 16 percent sample are under 50 µg/L prescribed in the Bureau of Indian Standards (BIS) and the remaining 74 percent samples are highly contaminated found to be higher as 50 µg/L. The shallow aquifer is more contaminated than deep aquifer. The selected deep aquifer samples and their results are found to be lesser than 50 µg/L. This area falls in confluence of Ganga and Ghaghara River and this area is constructed by flood plain so its aquifer is rich in arsenic contamination. In this block people are affected by arsenic and they have not any idea to solve it. Government has installed many arsenic filters but no one is working. They are broken and they are abounded by villagers because these filters run after backwash, but no one is there to do it.

After analyzing all water samples the result shows that contamination in aquifer is in decreasing mode reflected in Fig. 5. After going down the rate of contamination is decreasing. So the first aquifer is totally contaminated because this aquifer is constructed by Ganga and Ghaghara River flood plain so the contamination is very high but in second layer of aquifer is less contaminated and in compression than it deep aquifer is safe and the contamination level highlighted in Fig. 6 is found to be very low (less than 10 µg/L) as per BIS standard. Arsenic contamination in aquifers is decreasing with the depth depicted in Fig. 6. First aquifer is highly contaminated and results shows that 63% contamination is concentrated in shallow aquifer. Medium aquifer is less contaminated than shallow aquifer and contamination is only 23%. In deep aquifer contamination is only13% and it is less contaminated than shallow and medium aquifer.

4. Conclusions

In this study arsenic analysis has done to determine the level of arsenic in groundwater. This paper has suggested that in this area the groundwater arsenic contamination is very high and only a little no of hand pumps are safe so people should avoid contaminated water source and share safer water. Discriminate between contaminated and safe hand pumps by painting them with color that anyone can easily understand the condition of hand pump. Villagers should share safe hand pumps water. Eastern Part of Ballia district is famous for vegetables cropping. In this area there is not a single canal so all villagers irrigate their field by groundwater with Jet pump and tube wells. The extraction rate of groundwater is very high and due to withdrawal of excessive amount of groundwater from deep aquifer are causes of infiltration of arsenic in deep aquifer. A huge population is living in arsenic contaminated area are in low socio-economic condition, low educated and are engaged in agricultural farming and physical labour. They are poor and they have not enough money to install a water filter. Surface water is free from arsenic contamination so the use of surface water sources with minor treatment to be a good solution for the villagers.

4.1 Recommendation

- In those areas where arsenic contamination is present in groundwater people should use treated water for drinking and domestic purpose because use of arsenic contaminated water for food preparation, drinking, and irrigation of food crops are great source of threat to human health.
- Government organizations should take part for its mitigation at village level and they should discriminate between high-arsenic and low-arsenic sources by marking at different colors.
- Water Quality monitoring and surveillance should be taken into consideration at village/block level.
- The mass awareness program should be organized to aware people and government should encourage villagers for testing their hand pumps every year with free of cost.
- Government should install arsenic removal units with appropriate technology and therefore a proper sludge management will be needed in an eco-friendly and environmentally safe and finally a proper nutrition facility should be given as high order to avoid less chances of health problem related to arsenicosis problem.

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