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Arsenic in Surface Waters: A Report from River Ganga and its Tributary Jamania at Bhagalpur, Bihar, India

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Abstract

An investigation has been carried out to examine the arsenic pollution status of River Ganga & its tributary Jamania during pre-monsoon period of 2017 at Bhagalpur, Bihar (India). Altogether 17 water samples from different sampling sites along with their geo co-ordinates have been investigated for the value of arsenic using FTK test as well as spectrophotometer method. Throughout the study, arsenic value ranged from 10.69 ppb to 55.92 ppb. Out of the 17 water samples, the values of arsenic in 13 samples were from 20ppb to 54.1ppb. The concentration levels of arsenic in all the 17 river water samples and 2 public water supply samples (source: river water) in the present study were found above from the permissible limit of WHO (2008) and BIS (2004-2005) standards for drinking which is 10 ppb (part per billion).

Keywords: Arsenic pollution; Surface water; Jamania; River Ganga; Bhagalpur.

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1. Introduction

Arsenic is a constituent of over 300 minerals and is commonly found in non-ferrous ores such as copper, lead, zinc, gold and uranium. Arsenic is a primary constituent of certain ores (for example the copper mineral enargite) and occurs as a trace impurity in others [1]. Arsenic is a natural constituent of the earth's crust and is the 20th most abundant element. The average concentration of arsenic in the continental crust is 1–2 mg/kg [2, 3]. Arsenic is released in the environment through natural processes such as weathering and volcanic eruptions, and may be transported over long distances as suspended particulates and aerosols through water or air. Arsenic emission from industrial activity also accounts for widespread contamination of soil and groundwater environment [4, 5]. Many authors have reported arsenic emissions to the atmosphere on global, regional and local scales [6, 7]. Once introduced into the atmosphere, arsenic may circulate in natural ecosystems for a long time depending on the prevailing geochemical environments [8, 9]. Arsenic can be present in soils, air and water as a metalloid and as chemical compounds of both inorganic and organic forms [10, 11]. Unsafe water, in combination with inadequate sanitation and hygiene, still contributes to the deaths of some 842 000 people every year, representing 58% of deaths caused by diarrhoea. About 361 000 of these deaths occur in children aged under 5 years (12). Safe water supplies are essential not only for health, but also for people's livelihoods, economic growth and development. Water quality issues are a major challenge that humanity is facing in the twenty-first century. Due to its prime importance, the several studies on surface water quality have been assessed in different countries such as India, China and Nepal (13, 14, 15, 16). In recent years, with the continuous development of urbanization and industrialization, the total amount of available water resources is decreasing [17], especially in the semi-humid and arid water shortage areas [18,19]. Over the past few decades, river flows have continued to decline, especially in developing countries such as China and India, due to climate change and human activities [20]. Therefore, the sustainable development of human society and ecosystem needs to study the river water quality under the influence of natural and human activities [21]. In addition, water quality assessment is an important link in the study of aquatic ecological environment quality and is the basis for the protection and rational development and utilization of river water resources [22].

2. Materials and Methods

2.1 Study Area

Bhagalpur town is situated on the southern bank of River Ganga at 85^0 59' East Longitude and 25^0 15' North Latitude. Jamania, a smaller channel of River Chanan, from Nathnagar – Champanagar (3 km west of Bhagalpur) onwards flows along the Bhagalpur town parallel to main Ganga and ultimately meets in River Ganga near Vikramshila Bridge, Barari in Bhagalpur. The surface land is plain and river flows from west to east separating north and south Bhagalpur. Active braided channels, meanders, and oxbow lakes, which result from dynamic hydrological processes occurring within a low gradient alluvial plain, characterize the geomorphology of the River Ganga in this area (Figure 1 and 2).

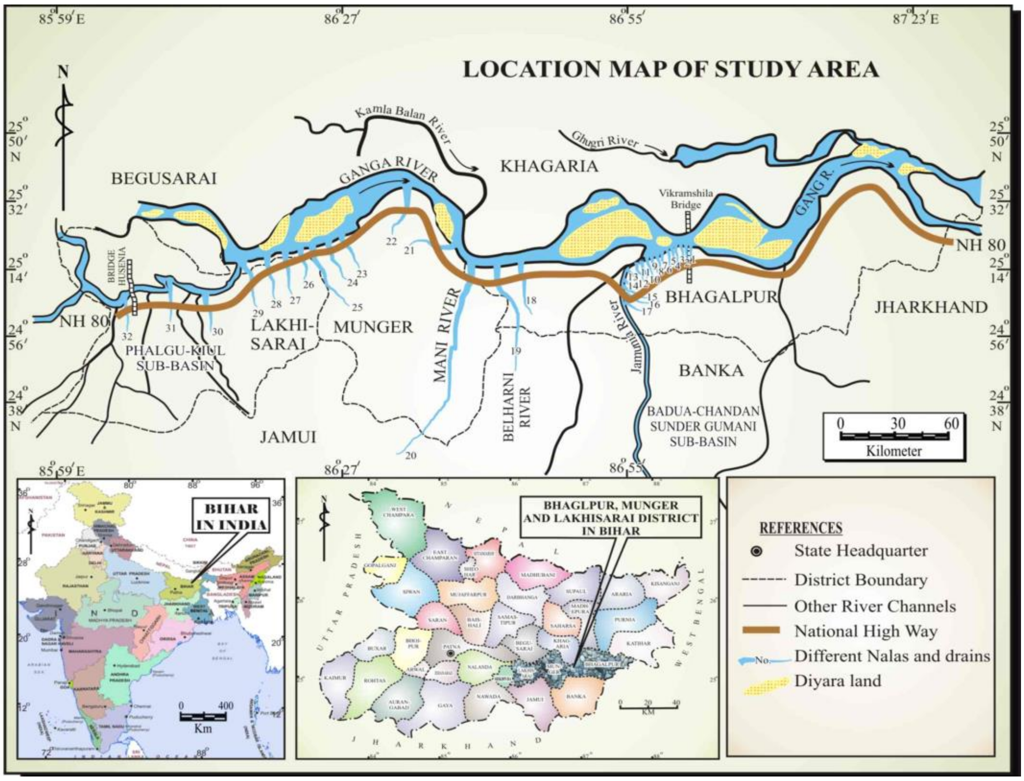

Figure 1

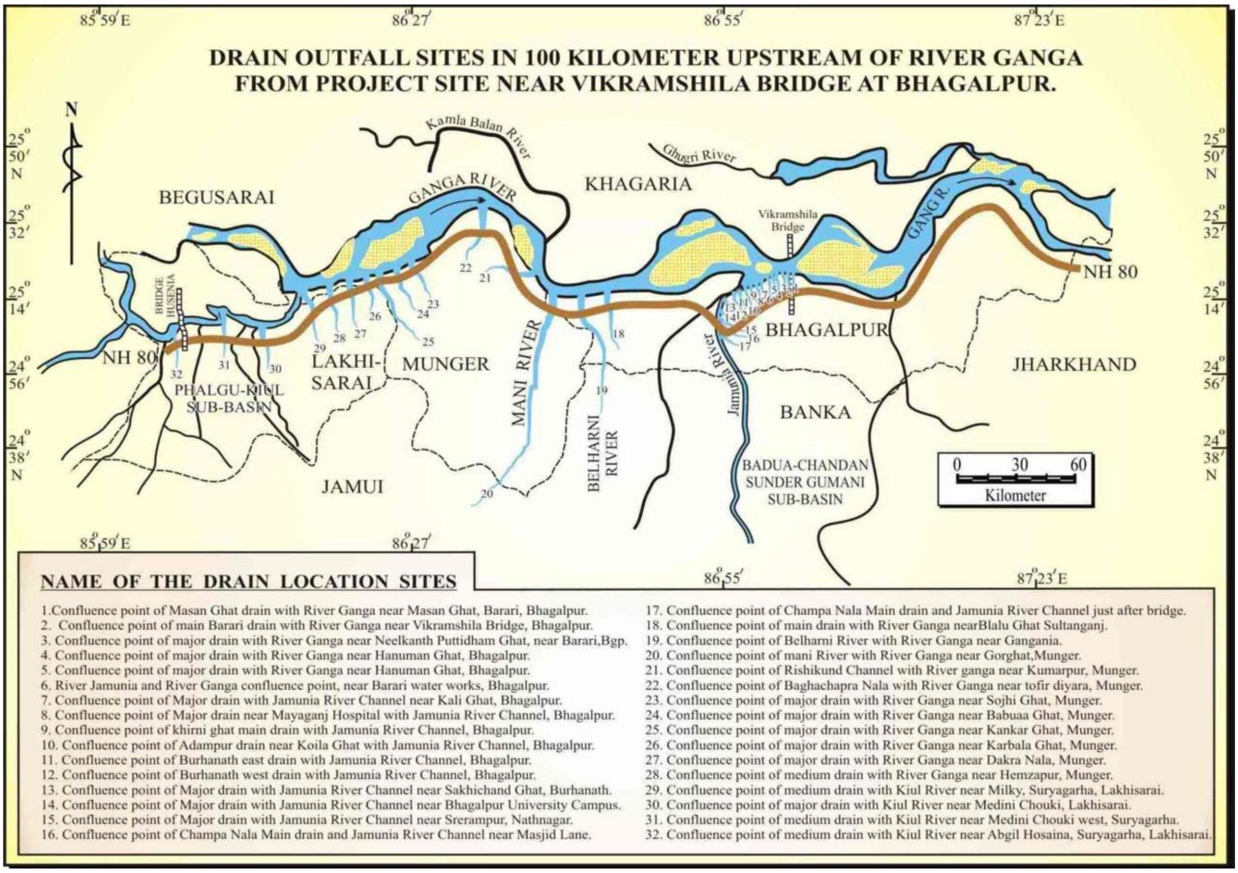

Figure 2

2.2 Methodology

For analysis of arsenic in river waters, water samples were collected in pre-monsoon period of 2017 from 17 sampling sites in a longitudinal distance of 10.5 km downstream from Champanala Bridge to Vikramshila Bridge. These sampling sites were located between 25° 14’ 28” - 25° 16’ 11” N Latitude and 86° 55’ 21” - 87° 00’ 54” E Longitude on the southern bank of Jamania channel and River Ganga. The water sample collection sites are the points where major drains from town meet either Jamania channel or River Ganga. Water samples were also collected for analysis of arsenic from five public water supply tap points, 3 in Barari and 1 each in Khanjerpur and Adampur locality. The source of public water supply in Bhagalpur town is river water and intake well is installed in the confluence zone of Jamania channel and River Ganga, 9.88 km downstream from Champanala Bridge. Water samples were analyzed for arsenic by analyzing the water samples with the help of spectrophotometer in the Environmental Biology Laboratory of T. M. Bhagalpur University. The overall analysis was done following the standard methods [23, 24].

3. Results and Discussion

All the results obtained during the study are depicted in table 1 and figure 4.The analysis results indicated that the concentration of arsenic in river waters ranged from 10.69 ppb – 55.92 ppb. The maximum concentration of arsenic was found at the confluence point of Jamania channel and River Ganga. Out of 5 public water supply tap points, only two tap points, one each in Barari (51.06 ppb of As) and Khanjerpur (236.47 ppb of As) locality were found contaminated with arsenic, remaining three tap point sources had arsenic below detection limit (BDL). The concentration levels of arsenic in all the 17 river water samples and 2 public water supply samples (source: river water) in the present study were found above from the permissible/desirable (safe) limit [25, 26]. Similar results have been obtained in the Yamuna River (range: 32 – 64 ppb, mean: 51 ppb). From the results, it is obvious that the river water quality with respect to arsenic is not satisfactory. Various anthropogenic activities, such as use of phosphate fertilizers and arsenical pesticides in floodplain agriculture, washing of clothes using detergents, sewage drains opening into the river, discharge of effluents from loom industry, brick making near the river bank, immersion of idols painted with chemical paints into the river, hospital wastes channelized directly to the river etc. may be possible reasons for arsenic in river water. The results are also correlated in the light of possible health hazards from arsenic in river water and public water supply sources above the safe limits of WHO and BIS Standards for drinking. Long term exposure to elevated level of arsenic in surface waters may cause serious health hazards. The random survey and interviews of some families settled in the flood plains of Jamania channel and River Ganga revealed that the people were mostly suffering from arsenical skin lesions, and children and women were often more susceptible to the adverse effects of arsenic than adult males. Some people were found to have *Keratosis* on their palms and soles and some with *Melanosis* on their body parts including face and neck. White and black transverse bands across the finger and toe nails in women were also documented (Figure 3).

Site no. 1&2-water after dying and bleaching of the yarn

Site no.10&11-Hospital Wastages being dumped in jamunia nala & sites of idols immersion

Sample sites no. 12-15-Disposal of domestic wastage and others

Melanosis (1st Stage) Developed in both the legs of a 1 year old child

Middle Stage-Keratosis is the middle stage of Arsenicosis developed at fonehand, hand, legs and nails of a body

Keratosis 3rd stage-Symbolises parts of body start developing gangrene & cancer

Figure 3: Victims of arsenicosis found in the study area.

Table 1: Arsenic profile of Jamania Dhar, a perennial channel flowing through the city and meeting the Mainstem of River Ganga near Barari, Bhagalpur, Bihar (May-June, 2017)

	Sites where drain meets the river channel / river channel meets the River Ganga	**As FTK (ppb)**	**As Spectro (ppb)**	**Distance (km) from Champanala bridge (downstream)**	**Geo-Coordinates**
1.	Confluence point of Champa Nala main drain (downstream)and Jamania River channel just after bridge	20+	43.76	0.00	N25° 14' 28" E86° 55' 21"
2.	Confluence point of Champa Nala main drain with Jamania River channel near Masjid Lane, Nathnagar	10+	34.48	0.06	N25° 14' 33" E86° 55' 27"
3.	Confluence point of Major drain with Jamania River channel near Srerampur, Nathnagar	BDL	10.69	1.41	N25° 15' 03" E86° 55' 45"
4.	Confluence point of Major drain with Jamania River channel near Bhagalpur University campus	30+	54.1	4.91	N25° 15' 07" E86° 57' 37"
5.	Confluence point of Major drain with Jamania River channel near Sakhichand Ghat, Budhanath,Bhagalpur	BDL	16.41	6.41	N25° 15' 17" E86° 58' 22"
6.	Confluence point of Budhanath West drain with Jamania River channel, Bhagalpur	40+	51.67	6.46	N25° 15' 18" E86° 58' 28"
7.	Confluence point of Budhanath East drain with Jamania River channel, Bhagalpur	30+	50.45	6.51	N25° 15' 21" E86° 58' 32"
8.	Confluence point of Adampur Main drain near Koila Ghat with Jamania River channel, Bhagalpur	30+	51.67	7.76	N25° 15' 38" E86° 59' 14"
9.	Confluence point of Khirni Ghat Main drain with Jamania River channel, Bhagalpur	BDL	10.89	9.01	N25° 15' 48" E86° 59' 43"

10.	Confluence point of Major drain near Mayaganj Hospital with Jamania River channel, Bhagalpur	40+	48.02	9.76	N25° 15' 54" E87° 00' 03"
11.	Confluence point of Major drain with Jamania River channel near Kali Ghat, Bhagalpur	20+	48.02	9.83	N25° 15' 58" E87° 00' 08"
12.	River Jamania and River Ganga confluence point,(east wards) near Barari Water works, Bhagalpur	30+	55.92	9.88	N25° 16' 04" E87° 00' 19"
13.	Confluence point of Major drain with River Ganges near Balu Ghat, Bhagalpur	BDL	13.37	9.93	N25° 16' 11" E87° 00' 44"
14.	Confluence point of Major drain with River Ganges near Hanuman Ghat, Bhagalpur	10+	46.2	9.96	N25° 16' 10" E87° 00' 87"
15.	Confluence point of Major drain with River Ganges near Neelkanth Putlidham Ghat, near Barari, Bhagalpur	30+	51.06	10.00	N25° 16' 11" E87° 01' 01"
16.	Confluence point of Main Barari drain with River Ganges near Vikramshila Bridge, Bhagalpur	10+	21.88	10.5	N25° 16' 11" E87° 01' 37"
17.	Mainstem of River Ganga, near Vikramshila Bridge	20+	23.7	10.5	N25° 16' 14" E87° 00' 54"

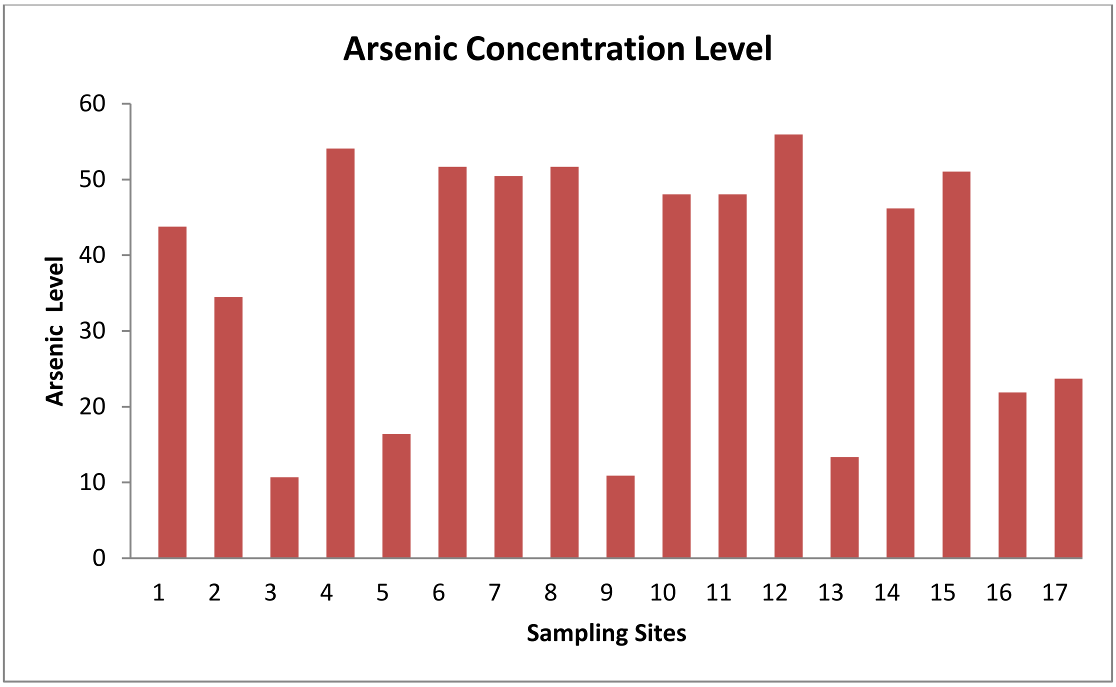

Figure 4: Arsenic Concentration Level

4. Conclusion

Altogether 17 sample sites along with their geo co-ordinates for each sample sites the value of arsenic in FTK test and spectrophotometric test have been detected from the sample water. Out of the 17 sample sites 13 sites are such whose FTK and spectrophotometric value are 20^{+} & 10^{+} ppb and 43.76 ppb and 34.48 ppb are due to dying and bleaching of the silk yarn prevalent in the ward no. 26 and 27 through which these two canals pass. As Bhagalpur city is famous for silk; hence dying and bleaching are major activities. The owner of the company uses such chemicals which are restricted in that country from which they import it. Same is the condition of sample sites no. 4, 6, 7 and 8 but the condition become more critical due to use of pesticides, insecticides as well as tanning of the animal skins as their residuals are directly poured into the canal passing through that locality. As in tanning of skins various types of chemicals are used by them. As sample sites no. 6 and 7 along the southern margin of the Jamunia nala brick making is also in practice. All these human activities add to the concentration of arsenic. Sample sites no. 11 and 12 are sites where waste products of JLN Medical College hospitals are directly dumped in it. Sampling site no. 12 (kali ghat) is the sites of immersion of idols during Durga Puja and Kali Puja. The presence of arsenic in sample sites number 14 and 15 are due to the discharge of fertilizers, pesticides, insecticides and domestic wastes along with amount of arsenic being brought down by the Jamunia canal from the upstream positions. Due to confluence of River Ganga with Jamunia canal at sample sites number 16 and 17 the amount of arsenic is not very high due to mixing of fresh water of Ganga river.

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5. Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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