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Alarming Danger of Arsenic in Groundwater of Jabalpur, Madhya Pradesh, India

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***Abstract*: Jabalpur is a major trading and industrial centre, manufacturing and processing industries especially household and small scale engineering industries also contributes to the city's economy, though marginal. Chief industries are textile, telephone parts, furniture, building materials, ammunition and military hardware. Whether these industries contribute contamination in groundwater or not is the subject of special emphasis of this study. Heavy metals are kept under environmental pollutant category due to their toxic effects on plants, animals and human being. The main focus of this paper is to find out the presence and concentration of toxic elements especially arsenic.**

***Keywords*: Arsenic, Groundwater, Jabalpur, Water quality.**

1. Introduction

Groundwater quality in a region is largely determined by natural processes such as litho logy, groundwater velocity and quality of recharge water, rock-water interactions and interactions with other types of aquifers.

Groundwater contamination occurs when the contaminants loaded on the ground surface exceed the detoxification capacity of the soil, bypass the protective soil horizons and reaches to the groundwater table and leads to poor drinking water quality, high clean-up cost, loss of water supply. The rate of depletion of water level and deterioration of groundwater quality is issues of immediate concern. Water quality if not adequately managed can serve as serious limiting factor to the future economic development and to the public health which will results in enormous long- term cost to the society (Pius et. al 2012).

Arsenic is the 20th most abundant element in the earth crust known as poison and human carcinogen. It is 33rd element in the periodic table and exists in the metallic state in nature in three allotropic forms and in several ionic forms. Arsenic is one of the most important heavy metals causing disquiet from both ecological and individual health standpoints (Hughes et al., 1988). It has a semi metallic property, is prominently toxic and carcinogenic, and is extensively available in the form of oxides or sulphides or as a salt of iron, sodium, calcium, copper, etc. (Singh et al., 2007). Arsenic is the twentieth most abundant element on earth and its inorganic forms such as arsenite and arsenate compounds are lethal to the environment and living creatures. Humans may encounter arsenic by natural means, industrial source, or from unintended sources. Drinking water may get contaminated by use of arsenical pesticides, natural mineral deposits or inappropriate disposal of arsenical chemicals.

2. Location of the Area

The area selected for the present research work forms the administrative unit of Jabalpur block. Investigated area is located at latitude N23^{0}06'38"-23^{0}10'31" and longitude E79^{0}49'31":80^{0}00'00". It lies in the survey of India top sheet no.55M/16, covering 120 square km area, 410m above sea level and nestles in the lap of the Narmada basin.

Jabalpur is a Tehsil in the Jabalpur District of Madhya Pradesh. According to Census 2011 information total area of Jabalpur is 1,147 km². Jabalpur has a population of 13,70,673. The normal annual means maximum and minimum temperature of Jabalpur District is 35^{0} C and 18.3^{0}C respectively. The average annual rainfall of Jabalpur is 54.6 inches.

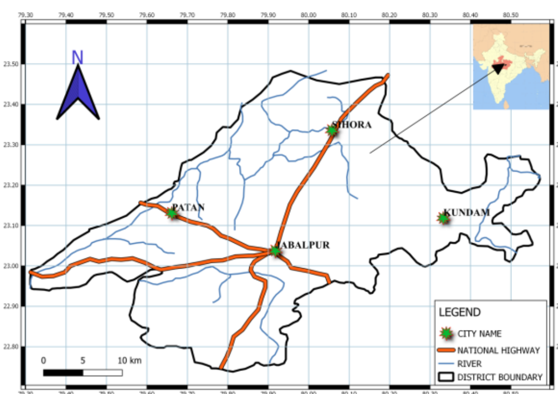

Fig. 1. Map 1 – Location map of Jabalpur

3. Geogology

Jabalpur is considered as a museum of geology because the litho logical formations are ranging in age from Precambrian to Recent.

The litho-Stratigraphy succession of Jabalpur and surrounding area is given by GSI published work is as follows:

Table 1
General geological succession of Jabalpur and surrounding area.

Age	Super Group/Group/ Formation	Lithology
Quaternary /Recent		Alluvium along Narmada river and its tributaries
Upper Cretaceous to Palaeocene	Deccan Trap	Basalt
Upper Cretaceous	Lameta Group	Sandstone, Shale, Mark, impure cherty Limestone
Lower Cretaceeous to permo-carboniferous	Gondwana Super Group	Sandstone, Clay, Shale, Conglomerates in basal part.
Meso to Neoproterozoic	Vindhyan Super Group	Essential Sandstone, shale and limestone
Palaeoproteriozoic	MadanMahal Granite	Pink porphyritic and non-porphyritic granite
Archean to Palaeoproterozoic	Mahakoshal Group	Acid, Basic intrusive, conglomerate, quartzite, quartz-mica schist, chertbreccias, dolomitic marble with chert and quartzite bands, amphibolites, phyllite, metabasalt, quartz -schist, banded haematite quartzite and amphibolite.

4. Materials and Methods

The collection of water samples in present investigation is not confined to the city area only. But large number of samples was collected from different bore wells within the residential area and also through the surrounding of the area selected for the study (Table 2). The sampling points were confined to the bore wells, PHE (Public Health Engineering) water supply, and tube wells used for drinking purposes. For present study, 22 samples of ground water have been considered.

The water samples were collected in narrow mouthed, pre washed and sterilized polyethylene bottle of 1-2.5 litres of capacity after flushing out the tube wells for minimum 10 minutes to get the fresh groundwater. The samples are collected up to the top, without leaving any space so as to prevent the premature release of dissolved gases during the transit period. Samples were prepared with and without preservatives as per norms.

The results obtained were elevated in accordance with the drinking water standards prescribed as WHO, EPA (Table 3). Toxic elements arsenic is determined in the samples by Atomic Spectrophotometric methods.

Table 2
Chemical analysis data for pH and arsenic (mg/l) in groundwater

Number of samples	Arsenic	pH
1	<0.05	7.6
2	<0.05	7.3
3	<0.05	7.4
4	0.03	7.9
5	0.021	7.1
6	<0.05	7.6
7	<0.05	7.53
8	0.043	7.63
9	0.03	7.52
10	0.03	7.58
11	<0.05	7.55
12	0.03	7.43
13	<0.05	7.46
14	<0.05	7.42
15	0.02	7.26
16	0.02	7.3
17	<0.05	7.72
18	<0.05	7.6
19	0.01	8.3
20	<0.05	8.2
21	<0.05	8.28
22	<0.05	8.26

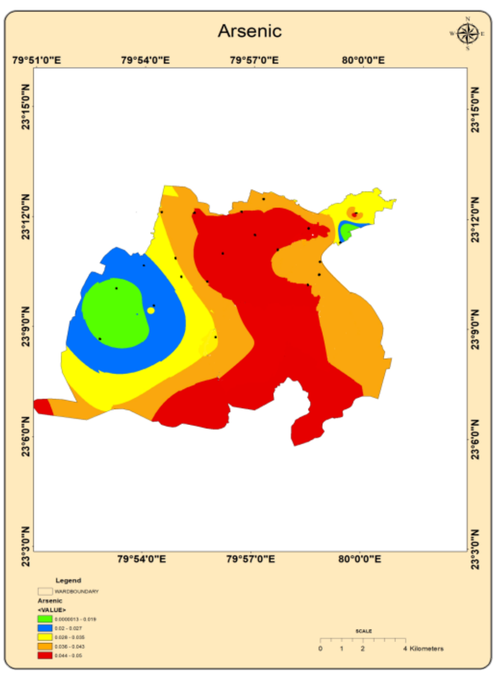

Fig. 2. Map-2 Zonation map of arsenic contamination

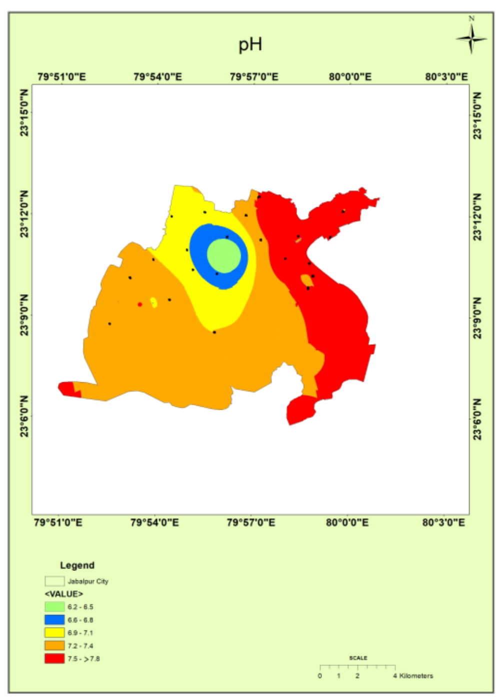

Fig. 3. Map-3 pH values measured in the area have been shown by different colours

Table 3
Drinking water standards for arsenic

S. No.	Organization	Maximum contamination Level	Unit
1	WHO (2011)	0.01	mg/L
2	EPA (2006)	10	ppb

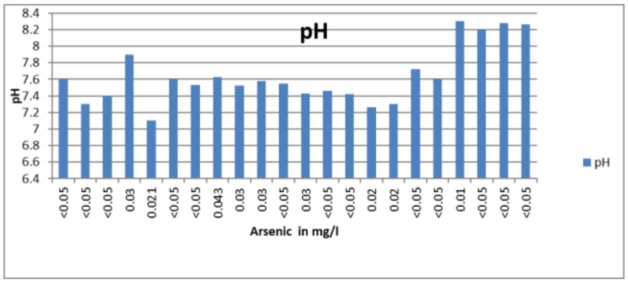

Fig. 4. Plot-1 portray graph of pH against arsenic

5. Mechanism of Arsenic Toxicity

The possible methods of exposures to arsenic are contact, ingestion and inhalation. Ingestion of contaminated drinking water is the predominant source of significant environment exposure globally. Absorbed arsenic passes to bloodstream and distributed to organs/ tissues after first passing through the liver. Once absorbed, arsenic rapidly combines with globin portion of haemoglobin and therefore localises in the blood within 24hours. Arsenic redistributes itself to the liver, kidney, spleen, lung and gast-intestinal tract, with lesser accumulation in muscle and nervous tissue.

After accumulation of small dose of arsenic, it undergoes methytation mainly in the liver to monomethylarsonic acid and di- methylarseenic acid which are excreted along with residual inorganic arsenic in the urine.

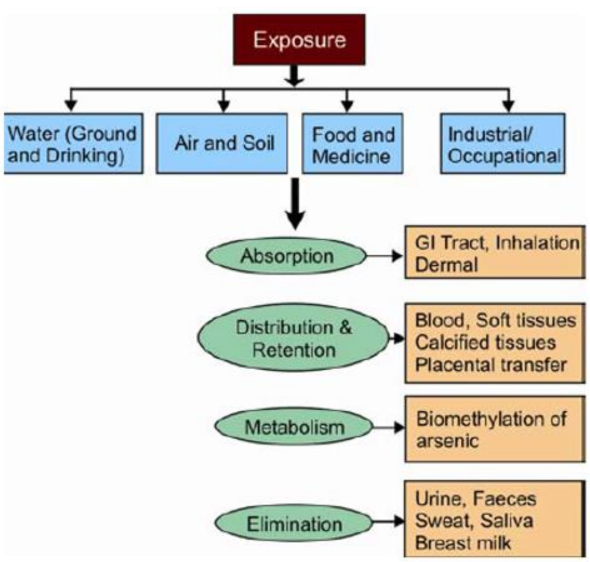

Fig. 5. Major routes of exposure and various in the metabolism of arsenic

6. Result and Discussion

Water whose composition usually mirrors the composition of adjacent rocks can vary from one rock to another and also within aquifers along its flow paths. pH plays an important role in solubility/release of elements from parent rock to groundwater. Elements solubility could be strongly affected by small changes in pH values. In alkaline condition, concentration of arsenic is reported in the groundwater.

The concentrations of arsenic in groundwater which are in between 0.04-0.05 mg/l are occupying large area in the North and along Narmada. These belts show the exposure of population to higher end of elevated level. Away from these two areas one in North & other in South in Narmada the arsenic content gradually decreases to below 0.01 mg/l in West and East part of the Jabalpur. However, the source of contamination cannot be ascertained despite the fact that most of the large defence industries are situated in this high and elevated arsenic zone or at its periphery.

It is not possible to assign these industries as source of arsenic in groundwater as the area is very large and the decrease in arsenic content from high and elevated level i.e. between 0.04-0.05mg/l to lower concentration is very gradual. A lithological source may be the candidate as source supplier may be basalt, granite, lameta, gondwana shale and sandstone.

Table 4
Range of heavy metal concentration (ppm) in igneous and sedimentary rocks (cannon et al., 1978)

S. No.	Metal	Rock	Range
1	Arsenic	Basalt	0.2-10
		Granite	0.2-13.8
		Shale and Clay	1-17
		Limestone	0.1-8.1
		Sandstone	0.6-9.7

Following reasoning has been made for deciphering the source candidate,

1) *Granite being the source:* The area has two outcrops of granite, one is in the SW, another is NE area. The NE area does run across the high and elevated arsenic content zone but, the area down North of Madan Mahal Granite is safest in terms of arsenic content. Therefore, granite does not seem to be responsible for arsenic contamination.
2) *Gondwana Shale & Sandstone:* Partially run over the high and elevated arsenic content zone but, Gardha area completely situated on Gondwana Shale and is the softest area in terms of arsenic content. Hence, the Gondwana shale & sandstone do not seem to be contributing to arsenic level.

The remaining two candidates i.e. basalt and underlying Lameta formation are possible candidate for arsenic level elevation because these two forms the watershed which extends over the zone of high and elevation of arsenic content. Arsenic in drinking water is a global treat to human health Unicef 2008, WHO-2010 a guideline value of 0.01 mg/ l is given to it by the WHO-2011 (Table-3). Arsenic had been found to cause a number of disorders such as hyper & hypo pigmentation, peripheral neuropathy, skin cancer, bladder & lung cancer and peripheral vascular disease (WHO 2010). Although, arsenic contaminations occur in surface water, it is more common in groundwater (Unicef 2008); where arsenic remain tightly bound to sediments under geological condition the dissolved level may remain very low until release by the parent rock due to weathering at deep depth (Oyem H. H, et.al 2014).

7. Conclusion

The general arsenic content of Jabalpur can be said to have elevated level of concentration i.e. between 0.01-0.05mg/l that means the area of Jabalpur is in low but sustain stress of arsenic in groundwater. The range between 0.01-0.05mg/l is not beyond the tolerable limit but still it is considered as elevated concentration. From the study we can conclude that basalt and lameta formation are seem to be the contributing source for arsenic in groundwater.

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