



E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP2: 95-97

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National Conference on Conservation Agriculture (ITM University, Gwalior on 22-23 February, 2018)

Assessment of arsenic content in water and soils of arsenic affected villages of Ambagarh Chowki block

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Abstract

Samples of water and soil were collected and analyzed for arsenic content from ten arsenic contaminated villages viz. Kaudikasa, Joratarai, Atergaon, Biharikala, Arajkund, Jadutola, Magatola, Sangli, Telitola, and Sonsaytola of block Ambagarh Chowki, district Rajnandgaon. The As content in different samples of water sources viz. Hand Pumps for drinking purpose, was ranged 0.03 to 0.75 mg L⁻¹ with mean value of 0.32 mg L⁻¹ found much above the (WHO) [1] recommended As limit (0.01 mg L⁻¹ for drinking water). The concentration of arsenic in tube well and pond water for irrigation purpose were also varied 0.08 to 0.49 and 0.01 to 0.29 mg L⁻¹, with the mean value of 0.29 and 0.09 mg L⁻¹, respectively. Among all the tube well samples only one sample of village Atargaon-2 (0.08 mg L⁻¹) was found under the permissible limit (0.10 mg L⁻¹, FAO, 1985) [2] for irrigation purpose. The concentration of arsenic in pond water (0.09 mg L⁻¹) was lower than the tube well water (0.29 mg L⁻¹) in affected villages of Ambagarh Chowki. The As distribution in the three soil orders namely *Vertisols*, *Alfisols* and *Inceptisols* was varied over the ten villages were ranges 2.05-8.48 mg kg⁻¹. All the soil orders were recognized under the permissible limits given by FAO (50 mg kg⁻¹). The maximum concentration 8.48 mg kg⁻¹ of arsenic was recorded in village Kaudikasa-1 and the minimum 2.05 mg kg⁻¹ in village Arajkund-1.

Keywords: Arsenic, Ambagarh Chowki, Vertisol, Alfisols, Inceptisols.

Introduction

The name Arsenic is derived from the Greek word *arsenikon*, which means yellow orpiment, a metalloid is omnipresent in the environment in both organic and inorganic forms, the most common form being arsenopyrite. Inorganic forms of arsenic namely arsenite and arsenate show more toxicity in humans than their organic counterparts. Arsenic is commonly referred to as "king of poisons and poison of kings" because it is potent, discreet, easily available, odorless and tasteless; hence it can be easily camouflaged in food [Hughes *et al.*, 2011] [3].

The arsenic contamination in ground water is now a major environmental hazard and threat in many countries of the world. The drinking water intake of 0.1 mg L⁻¹ is considered highly elevated and a major health threat. In addition to drinking waters, food crops have also been considered as important pathways for As intake by humans [Stone, 2008] [4]. Arsenic is found to be cumulative in living tissue, once ingested by any organism it is passed out of the organism very slowly. The exposure to higher As concentrations can cause several diseases including Arsenicosis, cancers, hyperkeratosis, restrictive lung diseases, and ischemic heart diseases in human being [Chakraborti *et al.*, 2004] [5]. Chronic As poisoning through drinking water can show dermatological symptoms and melanosis (change pigmentation).

Ambagarh-Chowki area of district Rajnandgaon in Chhattisgarh is rocky with thin alluvium, colluviums and soil cover. Thus tube-wells, tap, groundwater in the fracture system are in the bedrocks. The degree of arsenic contamination in groundwater in this area varies from place to place. Four villages namely, Kaurikasa, Sonsaytola, Joratarai and Jadutola are the most affected. Some tube-wells in other affected areas record arsenic concentration over 50 µg L⁻¹ and it often reaches about 100 µg L⁻¹, whereas dug-well water has As concentration 10 µg L⁻¹ [Acharyya *et al.*, 2005] [6].

Material Method Studied area

Ten arsenic contaminated villages (*i.e.* Atargaon, Kaudikasa, Joratarai, Arajkund, Sangali, Biharikala, Mangatola, Jadutola, Sonsaytola and Telitola) of block Ambagarh chowki in

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Sample Collection

GIS based soil samples were collected at a depth of 0-15 cm from the farmer's field and two representative samples of water from the sources of irrigation and drinking water from tube wells, ponds and hand pumps were taken from each of the selected villages in the *monsoon* season of 2016-17.

Sample Digestion and Sample analysis

Soil samples were digested separately with heating block digestion procedure by [Rahman *et al.* 2007] ^[7] and analyzed using Atomic absorption spectrophotometer along with VGA (PinAAcle 900F, PerkinElmer), using external calibration through arsenate as standard by [McLaren *et al.* 1998] ^[8].

Results and Discussion

Water analysis

The village wise data of arsenic concentration in drinking and irrigation water of the study area presented in the table 1 showed that the concentration of As in water samples of the study area varied 0.004 to 0.75 mg L⁻¹ with mean value of 0.23 mg L⁻¹.

The highest concentration 0.75 mg L⁻¹ of arsenic in the hand pump was recorded in village Kaudikasa-1 followed by 0.64 mg L⁻¹ in Kaudikasa-2 and lowest concentration 0.03 mg L⁻¹ of arsenic was recorded in village Arajkund-1. All the samples were found above the permissible limit of WHO (0.010 mg L⁻¹) for drinking purpose. The data of As concentration in various irrigation sources varied from 0.08 to 0.49 mg L⁻¹ with the mean value of 0.29 mg L⁻¹. The highest concentration 0.49 mg L⁻¹ of As in tube well water was recorded in Kaudikasa-2 followed by 0.48 mg L⁻¹ in Jadutola-1 and the lowest concentrations 0.08 mg L⁻¹ of As value were recorded in Atargaon-2. Maximum number of samples identified not suitable for the irrigation purpose. The data on concentrations of As in pond water were recorded maximum 0.29 mg L⁻¹ in Jadutola-2, followed by 0.23 mg L⁻¹ in Kaudikasa-2 and minimum value 0.01 mg L⁻¹ was recorded in Arajkund-1. The data on concentration of As in water showed that the occurrence of high As concentration in ground water (hand pumps and tube wells) of Ambagarh Chowki block.

The results of the present investigation are also corroborated by [Deshpande, *et al.* 2010] ^[9], [Charaborti, *et al.*, 2003] ^[10], [Acharyya *et al.*, 2005], [Chetia *et al.*, 2010] ^[11], [Ali *et al.* 2010] ^[12].

Table 1: Distribution of As in Drinking water (Hand pump) and Irrigation water (Tube wells and Pond water) water of block Ambagarh Chowki.

Name of villages	Arsenic (mg L ⁻¹)		
	Drinking water	Irrigation water	
	Hand Pumps	Tube wells	Ponds
Atargaon-1	0.06	0.10	0.02
Atargaon-2	0.18	0.08	0.08
Kaudikasa-1	0.64	0.47	0.03
Kaudikasa-2	0.75	0.49	0.23
Joratrai-1	0.60	0.18	0.03
Joratrai-2	0.33	0.13	0.01
Arajkund-1	0.03	0.14	0.07
Arajkund-2	0.19	0.27	0.07
Biharikala-1	0.15	0.35	0.11
Biharikala-2	0.19	0.38	0.14
Sangli-1	0.08	0.13	0.06
Sangli-2	0.20	0.32	0.03
Mangatola-1	0.46	0.36	0.04
Mangatola-2	0.51	0.41	0.06
Jadutola-1	0.59	0.48	0.22
Jadutola-2	0.36	0.39	0.29
Sonsaitola-1	0.45	0.47	0.11
Sonsaitola-2	0.56	0.42	0.06
Telitola-1	0.05	0.13	0.06
Telitola-2	0.08	0.18	0.03
Range	0.03-0.75	0.08-0.49	0.01-0.29
Overall range	0.01-0.75		
Mean	0.32	0.29	0.09
Overall mean	0.23		
Total Samples	20	20	20

Soil analysis

Distribution of Arsenic in surface soils of Ambagarh Chowki block is summarized in Table 2. From the data retrieved, concentration of arsenic in soil of studied areas was found to be lower than other arsenic affected soils in India.

The results reveal that arsenic content in the examined samples differed slightly within villages as well as within soils. The values of arsenic concentration in the soil samples were found between 2.05-8.48 mg kg⁻¹. Among the different soil orders the highest mean arsenic concentration was found in *Vertisols* (4.586 mg kg⁻¹) followed by *Alfisols* (3.418 mg kg⁻¹) and *Inceptisols* (2.62 mg kg⁻¹). The value of arsenic

concentration in *Vertisols*, *Alfisols* and *Inceptisols* was observed in the ranges 2.85-8.48, 2.08-5.423 and 2.05-3.59 mg kg⁻¹, respectively. All the soil orders were found under the permissible limits given by FAO (50 mg kg⁻¹).

The data of village wise distribution of As in the soil samples showed that the highest concentrations 8.48 mg kg⁻¹ As were recorded in village Kaudikasa-1 followed by 6.76 mg kg⁻¹ in Kaudikasa-2 and the lowest concentration were recorded 2.05 mg kg⁻¹ in village Arajkund-1. All the villages were found under the permissible limits given by FAO (50 mg kg⁻¹).

The variation of arsenic content in different soil orders might be associated with the local differences in parent materials

(e.g. As-bearing minerals), farm management practices (e.g. use of arsenical pesticides), continental inputs (e.g. dry and wet deposition) and other biogeochemical activities [Ahmad *et al.*, 2015] ^[13]. The accumulation of arsenic in *Vertisols* of village Kaudikasa showed slightly high arsenic concentration compared to other villages, this may be due to various climatic and geomorphic condition of the area, such as rainfall, runoff, rate of infiltration and the ground water level [Bhattacharya *et al.*, 2002] ^[14]. Build up of As in soil associated with the use of As contaminated irrigation water has been shown to lead to elevated levels of As in soil solution [Mehrag and Rahman 2003] ^[15]; [Van Green *et al.* 2006] ^[16]; [Dittmar *et al.* 2007] ^[17].

Table 2: Total Arsenic status in soils of block Ambagarh Chowki.

Name of villages	Sample no.	(Arsenic mg kg ⁻¹)		
		<i>Vertisol</i>	<i>Alfisol</i>	<i>Inceptisol</i>
Atargaon	1	5.07	4.28	-
	2	4.89	3.73	-
Kaudikasa	1	8.48	3.15	-
	2	6.76	4.46	-
Joratrai	1	4.06	3.71	2.25
	2	-	3.85	-
Arajkund	1	2.90	2.69	2.05
	2	2.85	-	-
Biharikala	1	4.26	3.15	2.85
	2	-	3.24	-
Sangli	1	3.06	2.08	-
	2	3.22	2.95	-
Mangatola	1	3.13	2.92	2.36
	2	-	2.86	-
Jadutola	1	3.29	2.57	-
	2	3.15	2.36	-
Sonsaitola	1	6.39	5.42	3.58
	2	6.44	-	-
Telitola	1	5.81	4.07	-
	2	4.14	3.98	-
No. of samples		17	18	05
Range		2.85-8.48	2.08-5.42	2.05-3.59
Overall range		2.05-8.48		
Mean		4.58	3.41	2.62
Overall mean		3.81		
Total samples		40		

Conclusions

It can be concluded from the data of the study of water, soils and rice plants of arsenic contaminated area of Ambagarh Chowki block of Rajnandgaon district, Chhattisgarh, that arsenic content in the water of hand pumps were found under the concentration (0.01 mg L⁻¹) harmful to human health, threatening the lives of people living in those villages. Further accounting for the soil types (*i.e.*, *Vertisol*, *Alfisol* and *Inceptisol*), there is relative differences in content of arsenic. Comparatively slightly higher concentration was found in *Vertisol*. Reason being subtle, correlate well with the general expectation that finer grained soils would result in elevated arsenic concentrations relative to coarse grained soils. The most vulnerable villages to As contamination were observed Kaudikasa, Jaoratrai and Jadutola. It was found that in the analyzed soil, water and plant samples, concentrations of arsenic differed slightly across the sites. The detected concentrations of As at Kaudikasa village were observed maximum in all the analyses.

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