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Arsenic concentration in drinking and irrigation water of Ambagarh Chowki Block, Rajnandgaon (Chhattisgarh)

Vivek Kumar Singhal, Anurag, GR Rathiya and Thaneshwar Kumar

Abstract
The environment of Ambagarh Chowki, Rajnandgaon, has reported the high levels of arsenic by many researchers. Long term use of arsenic-contaminated irrigation water could result in arsenic accumulation in the soil and could reach to toxic level of crops. So, keeping it in view the present study was conducted in Ambagarh Chowki block of Rajnandgaon district (Chhattisgarh) to assess the arsenic concentration in water. Water samples were collected from thirteen arsenic contaminated village's *viz*. Metepar-Gaulitola, Kaudikasa, Joratarai, Atergaon, Pangri-Keshitola, Biharikala, Arajkund, Jadutola, Magatola, Sangli, Telitola, and Sonsaitola of block Ambagarh Chowki, district Rajnandgaon during pre and post monsoon season of the 2016. The research results showed the arsenic content in hand pumps water was ranged from 18.80 to 230.10 µg L^{-1} in pre monsoon season and 17.60-230.30 µg L^{-1} in post monsoon season and found much above the WHO recommended arsenic limit (0.01 mg L^{-1}) for drinking water. Arsenic concentration in tube well water varied from 15.2-329.40 µg L^{-1} in pre monsoon season and 14.10-330.50 µg L^{-1} in post monsoon season. Tube well samples of Metepar-Gaulitola-1, Metepar-Gaulitola-2, Metepar-Gaulitola-3, Arajkund-2, Arajkund-3, Biharikala-3, Pangari-Keshitola-1, Pangari-Keshitola-2, Pangari-Keshitola-3, Atargaon-1, Atargaon-3, Sangali-1, Sangali-2, Sangali-3, Telitola-1, Joratarai-2, Jadutola-1, Jadutola-3, Dhatutola-1, Dhatutola-2, Dhatutola-3, Mangatola-1, Mangatola-2, Mangatola-3 and Sonsoitola-3 were only found under the permissible limit (0.10 mg L^{-1}, FAO) for irrigation. In surface water sources (pond and well), arsenic content varied from 1.90-9.20 µg L^{-1} in pre monsoon and 1.90-8.10 µg L^{-1} in post monsoon season.

Keywords: arsenic, water sources, WHO

Introduction
Arsenic (As) is a highly toxic and carcinogenic metalloid, generally found in a small amount in all rocks, soils, water, air and biological tissues. Arsenic naturally occurs as sulphides and as complex sulphides of iron, nickel and cobalt. Its inorganic arsenic forms are generally highly phytotoxic and is of great environmental concern due to its presence in groundwater and soil. It is widely distributed in the environment, originating either from soil parent material or from discharge on to land as a result of human activities. Arsenic is the constituent of earth's crust which can enter into the environment *viz*. hydrosphere, lithosphere and atmosphere, through two possible source channels: anthropogenic and natural activities. Extensive use of lead arsenate and copper arsenite in pesticides called 'arsenicals' and rodenticides can be responsible for arsenic contamination (Navarro *et al*., 1993 and Sikdar and Banerjee, 2003) [23, 33]. Arsenic contamination in groundwater can also be caused due to dumping of untreated discharge and hazardous waste materials from industries (Pandey *et al.*, 1998 and Chatterjee and Banerjee, 1999) [25]. It can also be released in ground water through natural processes, such as weathering and leaching from rock and the constituent minerals, sediment transportation and deposition (Nicolli *et al*., 1989 and Acharyya *et al*., 1999) [3], and anthropogenic activities including coal mining and its combustion (Belkin *et al*., 2000 and Sahu, 2002) [7, 28].

Arsenic contamination of surface and groundwater's occurs worldwide and has become a socio-political issue in several parts of the globe. A large number of water bodies around the world are reported to have arsenic contamination levels at concentrations above 50 µg L^{-1}. The most noteworthy occurrences are located in parts of Argentina, Bangladesh, Chile, China, Hungary, India (West Bengal), Mexico, Romania, Taiwan, Vietnam and parts of the USA, and SE Asia (Sampson *et al.*, 2008) [29].

The situation of arsenic toxicity in India is alarming with reports of severe health problems among the populations of various states including West Bengal, Bihar, Assam, Chhattisgarh, *etc.* (Chowdhury *et al*., 2000; Acharyya, 2002 and Jain, 2002) [2, 16]. The high concentration of arsenic in groundwater has been reported from the Bengal Delta Plains (BDP) in West Bengal and Bangladesh (Saha and Chakrabarti, 1995 and Dhar *et al*., 1997) [27, 15]. More recently, problems have also been found in the states of Arunachal Pradesh, Assam, Bihar, Nagaland, Manipur, Mizoram, Meghalaya, Tripura, and Uttar Pradesh (Mukherjee *et al*., 2006) [20].

The environment of Ambagarh Chowki, Rajnandgaon, India has high levels of arsenic (Patel *et al.*, 2005 and Shukla *et al.*, 2010) [24, 30]. The groundwater arsenic contamination in the Ambagarh Chowki block situated in the Rajnandgaon district of the state of Chhattisgarh was first reported by Chakraborti *et al.* (1999) [10]. Groundwater samples from 146 sites, Public Health Engineering Department (PHED) tube wells and dug wells in 22 villages of this block were analyzed. Arsenic concentration in tube well water was elevated above the WHO guideline by a factor of more than 10 with concentrations reaching 520 µg L^{-1}, whereas in the dug wells (general depth less than 50 m) arsenic concentrations were as high as 880 µg L^{-1}. Medical study in that village indicated 42 percent of adults and 9 percent of children are suffering from arsenical skin lesions. Also, epidemiological studies indicated high concentrations of arsenic in urine, hair and nail in respective 89, 75 and 91 percent of the village population. In the same area, *i.e.*, at village Kaudikasa, district Rajnandgaon, Chhattisgarh, Central India, an extensive study on the groundwater arsenic over a period of 3 years has been conducted (1998–2000) based on the monitoring of arsenic concentrations in hand pumps and dug wells in the region.

Arsenic contamination in groundwater at variable concentration levels occurs at small patches in the Ambagarh Chowki block of Rajnandgaon district. Tube well waters are affected by high concentrations of arsenic in some areas confined to N–S trending Dongargarh–Kotri rift zone which exposes the early Proterozoic metavolcanic rocks and co-magmatic granite. In the Ambagarh Chowki area, there is a rocky basement covered by alluvium, colluvium, and soil. Tube wells tap groundwater in the fracture system in bedrock. Previous studies (Pandey *et al.*, 1999 and Deshpande *et al.*, 2010) [24, 14], mentioned panning for gold in the area and the presence of mine dumps around Bodal, which are located close to Kaudikasa, village where severe As–contamination occurs. It was assumed that these factors may have some connection to the source of arsenic in groundwater. Some works also postulated that water in the principal river Shivnath, which flows through the arsenic affected groundwater area, might be contaminated. Thus, Raipur, the capital city of Chhattisgarh state and townships like Rajnandgaon and Drug, located downstream, are likely to be at risk (Pandey *et al.*, 1999) [24]. Later studies (Acharyya *et al*., 1999 and Acharyya, 2002) [2, 1] found that As pollution of groundwater is restricted to small isolated patches at village scale, and the Sivnath river water has arsenic concentration below 0.010 mg L^{-1}. The Chhattisgarh basin, located to the east of the Dongargarh rift zone, and exposing mid-late Proterozoic platform-type clastic and carbonate sediments, is totally free of arsenic contamination. Recent investigations (Pandey *et al.*, 2006; Deshpande *et al*., 2010 and Shukla *et al.*, 2010) [24, 30, 14] in the Kaudikasa, Rajnandgaon, Chhattisgarh, found elevated concentrations of arsenic in the wells located in acid volcanic rocks, close to shear zones as well as in granites. So, present study has been carried out to determine the arsenic concentration in water sources of Ambagarh Chowki block, Rajnandgaon.

Table 1.1: Safe limit of arsenic

Organization/Country	Concentration of As	References
1. Drinking water		
WHO	0.01 mg L^{-1}	Chakraborti *et al.*,(2009) [10]
Indian standard/BIS	0.05 mg L^{-1}	Chakraborti *et al.*,(2009) [10]
EU	0.01 mg L^{-1}	Matchullat (2000)
Netherlands	0.01 mg L^{-1}	Ahsan and Del valls (2011)
Germany	0.01 mg L^{-1}	Ahsan and Del valls (2011)
Bangladesh	0.05 mg L^{-1}	Ali *et al.* (2005)
Nepal standard	0.05 mg L^{-1}	Pradhan *et al*. (2010)
2. Irrigation water		
FAO	0.10 mg L^{-1}	Bhattacharya *et al.* (2009)

Materials and Methods

96 water samples were collected from arsenic affected villages (*viz.* Metepar, Gaulitola, Arajkund, Kaudikasa, Biharikala, Pangari, Keshitola, Atargaon, Sangali, Telitola, Joratarai, Jadutola, Dhatutola, Mangatola and Sonsoitola) of Ambagarh Chowki block in pre and post monsoon season of the year 2016. GPS based water sample has been collected from different water sources such as hand-pump, tube-well, pond and well *etc*. (Fig. 1.0). Out of the total, 27 samples were taken from hand-pump, 41 from tube-well and 28 from surface water sources (pond and well). Hand pump water has been used as drinking purpose, while tube well and surface water sources were used for irrigating the crops. The collected water samples were filtered with 0.45 µ Millipore filter paper then acidified with 10 drops concentrated HNO_3 and stored in 250 ml plastic bottles for the further analysis. pH, EC as well as arsenic content were analyzed from these samples. Arsenic content was determined by atomic absorption spectroscopy (AAS) using vapour generation assembly (VGA) as method described by Behari and Prakash, 2006.

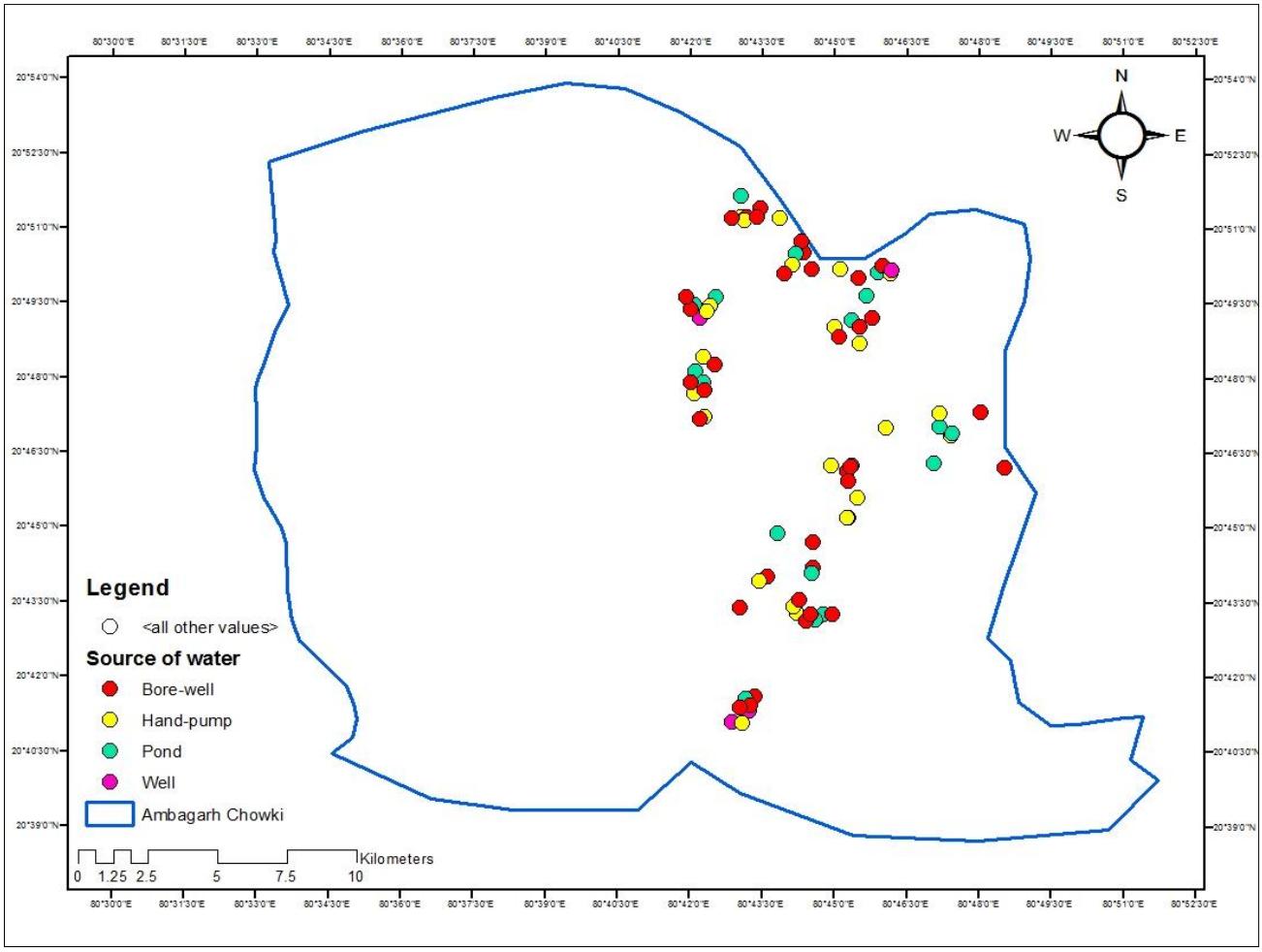

Fig 1: Location of water samples collected from Ambagarh Chowki, Rajnandgaon

Results and Discussions

pH values of water samples

The water of the study area was reported slightly acidic to neutral in reaction with pH range of 6.38-7.54 in pre-monsoon and 6.30-7.48 in post monsoon season (Table 2.0). In pre monsoon season, 3.13, 93.75 and 3.13 per cent samples were observed slightly acidic, neutral and saline in reaction, respectively. But in post monsoon analysis, only 3.13 per cent samples showed slightly acidic nature, while rests 96.87 per cent were found neutral.

In pre-monsoon season, pH values of hand-pump water were ranged from 6.46-7.52 with mean of 7.10 and most of them (92.60 %) were found neutral in nature. Further, pH of tube well water varied from 6.38-7.54 and 90.24 per cent samples were reported neutral reaction. While in surface water sources (pond and well), pH values were ranged from 6.70-7.30 with mean value of 7.09. In case of post monsoon water samples analysis, almost same trend has been noticed. pH of hand-pump, tube well, and surface water samples were ranged from 6.43-7.48, 6.30-7.40 and 6.65-7.30, respectively. Almost 96 per cent of hand pumps water, 95 per cent of tube well and all surface water were noticed under neutral pH range. The results of the present investigation are also in corroboration to the findings of Patel *et al.* (2016) [24]. They reported that pH of village Kaudikasa village water samples were ranged from 6.9-7.6 with the mean value of 7.3.

EC values of water samples

The EC values of water samples of Ambagarh Chowki block are presented in Table 3.0. The water of study area was reported moderately saline (0.25 to 0.75 dS m^{-1}) in nature. In pre monsoon season, EC values ranged from 0.24-0.68 dS m^{-1} with the mean of 0.38 dS m^{-1} while in post monsoon season, it ranged from 0.23-0.66 dS m^{-1} with the mean of 0.37 dS m^{-1}.

In pre monsoon season, EC of hand pump water varied from 0.25 to 0.58 dS m^{-1} with the mean of 0.38 dS m^{-1}, in tube well water it varied from 0.30-0.68 dS m^{-1} with mean of 0.40 dS m^{-1} and in surface water samples it varied from 0.24-0.52 dS m^{-1} with mean of 0.37 dS m^{-1}. All the ground water samples (hand pump and tube well) and 96.40 percent of surface water samples were found under moderate EC range (0.25 to 0.75 dS m^{-1}). In post monsoon season, EC values were ranged from 0.24-0.57, 0.28-0.66 and 0.23-0.52 dS m^{-1} in hand pump, tube well and surface water samples, respectively. 96.30 percent of hand pump water samples, 100 percent of tube well water samples and 96.40 percent of surface water samples were reported moderate salinity.

As per the BIS standards for drinking water within the permissible limit of 1.5 dS m^{-1} and irrigation water with EC readings less than 0.75 dS m^{-1} are generally suitable. Most of water samples were found suitable for drinking as well as irrigation purpose. The moderate EC value of village Kaudikasa was also observed by Patel *et al.* (2016) [24] and ranged from 180 to 472 µS cm^{-1} with mean value of 316 µS cm^{-1}.

Arsenic concentration in water

The village wise data of arsenic concentration in water are presented in Table 4.0. Arsenic concentration in water sample varied from 1.90 to 329.40 µg L^{-1} in pre- monsoon season and 1.90 to 330.5 µg L^{-1} in post monsoon season.

Arsenic concentration in water during pre monsoon season

In pre monsoon season, arsenic concentration in hand pump water (drinking water) was ranged between 18.80 to 230.10 µg L^{-1} with mean value of 88.01 µg L^{-1}. The highest arsenic concentration (230.10 µg L^{-1}) was reported in sample Kaudikasa-2 followed by Biharikala-1 (167.40 µg L^{-1}). The minimum arsenic content in hand pump water (18.80 µg L^{-1}) was noticed in sample Metepar-Gaulitola-1. All the samples were found above the permissible limit of WHO (10 µg L^{-1}) for drinking purpose.

In tube well water the arsenic concentration ranged between 15.2-329.40 µg L^{-1} with mean value of 106.51 µg L^{-1}. Sample Kaudikasa-2 recorded higher value of arsenic with 329.40 µg L^{-1} followed by Biharikala-1 (241.00 µg L^{-1}). Further, minimum arsenic concentration (15.20 µg L^{-1}) was noted in Metepar-Gaulitola-2. According to FAO, the permissible limit of arsenic for irrigation water is 100 µg L^{-1}. So, Metepar-Gaulitola-1, Metepar-Gaulitola-2, Metepar-Gaulitola-3, Arajkund-2, Arajkund-3, Biharikala-3, Pangari-Keshitola-1, Pangari-Keshitola-2, Pangari-Keshitola-3, Atargaon-1, Atargaon-3, Sangali-1, Sangali-2, Sangali-3, Telitola-1, Joratarai-2, Jadutola-1, Jadutola-3, Dhatutola-1, Dhatutola-2, Dhatutola-3, Mangatola-1, Mangatola-2, Mangatola-3 and Sonsoitola-3 were only found under the permissible limit and rest tube well samples were not suitable for irrigation.

In case of surface water sources (pond and well), arsenic concentration was ranged from 1.90-9.20 µg L^{-1} with mean value of 4.04 µg L^{-1}. Higher value of arsenic concentration (9.20 µg L^{-1}) in surface water was found in Kaudikasa-3. While minimum arsenic concentration (1.90 µg L^{-1}) was registered with sample Metepar-Gaulitola-2. All sources of surface water were found suitable for drinking as well as irrigation.

Arsenic concentration in water during post monsoon season

The data presented in Table 4.0 shows that arsenic concentration in hand pump water ranged from 17.60-230.30 µg L^{-1} with mean value of 85.15 µg L^{-1}. Sample Kaudikasa-2 recorded the higher arsenic concentration of 230.30 µg L^{-1} which was followed by Biharikala-1 (161.40 µg L^{-1}) and Pangari-Keshitola-1 (144.30 µg L^{-1}). The lower value of arsenic concentration (17.60 µg L^{-1}) was found in Metepar-Gaulitola-1. All the samples were found above the permissible limit of WHO (10 µg L^{-1}) for drinking purpose.

In tube well water samples, arsenic concentration ranged from 14.10-330.50 µg L^{-1} with mean value of 107.51 µg L^{-1} (Fig. 4.3). Higher value of arsenic (330.50 µg L^{-1}) was observed with sample Kaudikasa-2. While, the minimum arsenic concentration (14.10 µg L^{-1}) was noticed in Metepar-Gaulitola-2. The results also showed that water samples of Metepar-Gaulitola-1, Metepar-Gaulitola-2, Metepar-Gaulitola-3, Arajkund-2, Arajkund -3, Biharikala-3, Pangari-Keshitola-1, Pangari,-Keshitola-2, Pangari-Keshitola-3, Atargaon-1, Atargaon-3, Sangali-1, Sangali-2, Sangali-3, Telitola-1, Joratarai-2, Jadutola-1, Jadutola-3, Dhatutola-1, Dhatutola-2, Dhatutola-3, Mangatola-1, Mangatola-2, Mangatola-3, Sonsoitola-2 Sonsoitola-3 and Sonsoitola-4 were only found suitable for irrigation.

In post monsoon season, surface water has arsenic range of 1.90-8.10 µg L^{-1} with mean of 4.01 µg L^{-1}. The higher value of arsenic (8.10 µg L^{-1}) was found in Kaudikasa-3 followed by Kaudikasa-2. Further, lower value of arsenic (1.90 µg L^{-1}) was registered with Pangari—Keshitola-3. All surface water sources were found suitable for drinking as well as irrigation.

These finding are in general agreement with the experimental results reported by Mukherjee *et al.* (2006) [20] and Patel *et al.* (2017) [25]. Deshpande *et al.* (2010) [14] reported that in Chowki block the Kaudikasa village was found highly affected and showed highest arsenic concentration of 1.89 mg L^{-1}. The most common sources of arsenic in the natural enviroment are volcanic rocks especially acid volcanic rock, volcanic ash and specially their weathering products, marine sedimentory rocks, coal, coal ash, petroleum, hypothermal ore deposits and associated geothermal water (Korte and Fernando, 1991). Arsenic associated with sediment particles can be a major source of arsenic contamination. Major ore minerals of arsenic are Arsenopyrite (FeAsS), Orpiment (AsS_3), Realgar (AsS) and Lollingite ($FeAs_2$). The source of arsenic affecting the Rajnandgaon district is located in granites that have pegmatite intrusions likely generated by hydrothermal activity. It is found that geochemical mobility of arsenic in nature depends on oxidation state of arenic and associated element (Masson and Moore, 1982) [19].

It was also reorted that arsenic concentartion in surface water source was found very low as compared to ground water sources. The main reasons responsible for the low concentration level of arsenic is the high affinity of arsenic to oxide mineals especially iron oxides/hydroxides. In addition to geochemical factors, microbial agents can influences the oxidation state of arsenic in water, and can mediate the methylation of inorganic arsenic to form organic arsenic compounds. Microorganism can oxidize arsenite to arsenate; reduce arsenate to arsenite or even arsine (AsH_3) (Chetia *et al.*, 2010) [12]. The trend in arsenic concentration in water samples was almost same in pre and post monsoon analysis. There was no any change found in arsenic content over seasonal variation. Similar views in the direction of present findings were also expressed by Thundiyil *et al.* (2007) [32].

Conclusion

It can be concluded that arsenic content in the hand pumps water were found above the safe limit concentration (0.01 mg L^{-1}) which is harmful to human health and threatening the lives of people living in those villages. The most vulnerable villages to arsenic contamination were Kaudikasa, Biharikala, Sonsaitola, Arajkund, Jaoratrai and Atargaon. It was also found that in the analyzed water concentrations of arsenic differed slightly across the sites. The detected concentrations of Arsenic at Kaudikasa village were observed maximum in all the analyses.

Table 2.0: pH values of different water samples of Ambagarh Chowki, Rajnandgaon

pH range	Numbers and percentage of samples							
	Pre-monsoon season of 2016				Post-monsoon season of 2016			
	Ground water		Surface water	Total	Ground water		Surface water	Total
	Hand-pump	Tube-well	Pond/well	samples	Hand-pump	Tube-well	Pond/well	samples
Strongly acidic (< 5)	00	00	00	00	00	00	00	00
Moderately acidic (5.0-6.0)	00	00	00	00	00	00	00	00
Slightly acidic (6.0-6.5)	1(3.70)	2(4.88)	00	3(3.13)	1(3.70)	2(4.88)	00	3(3.13)
Neutral (6.5-7.5)	25(92.60)	37(90.24)	28(100)	90(93.75)	26(96.30)	39(95.12)	28(100)	93(96.87)
Saline (> 7.5)	1(3.70)	2(4.88)	00	3(3.13)	00	00	00	00
Range	6.46-7.52	6.38-7.54	6.70-7.30	6.38-7.54	6.43-7.48	6.30-7.40	6.65-7.30	6.30-7.48
Mean	7.10	7.16	7.09	7.11	7.11	7.13	7.04	7.09
Total number of samples	27	41	28	96	27	41	28	96

*Percentage of samples given in bracket

Table 3.0: EC values of different water samples of Ambagarh Chowki, Rajnandgaon

EC range (dS m^{-1})	Numbers and percentage of samples							
	Pre-monsoon season of 2016				Post-monsoon season of 2016			
	Ground water		Surface water	Total	Ground water		Surface water	Total
	Hand-pump	Tube-well	Pond/well	samples	Hand-pump	Tube-well	Pond/well	samples
Low (< 0.25)	00	00	1(3.60)	1(1.04)	1(3.70)	00	1(3.60)	2(2.08)
Medium (0.25-0.75)	27(100)	41(100)	27(96.40)	95(98.96)	26(96.30)	41(100)	27(96.40)	94(97.92)
High (0.75-2.25)	00	00	00	00	00	00	00	00
Very high (> 2.25)	00	00	00	00	00	00	00	00
Range	0.25-0.58	0.30-0.68	0.24-0.52	0.24-0.68	0.24-0.57	0.28-0.66	0.23-0.52	0.23-0.66
Mean	0.38	0.40	0.37	0.38	0.36	0.38	0.36	0.37
Total number of samples	27	41	28	96	27	41	28	96

*Percentage of samples given in bracket

Table 4.0: Status of Arsenic concentration in water samples of Ambagarh Chowki, Rajnandgaon

Name of village	Arsenic content μg L^{-1}					
	Pre-monsoon of 2016			Post-monsoon of 2016		
	Hand-pump	Bore-well	Pond/well	Hand-pump	Bore-well	Pond/well
Metepar, Gaulitola 1	18.80	19.10	2.20	17.60	18.10	2.40
Metepar, Gaulitola 2	--	15.20	1.90	--	14.10	2.10
Metepar, Gaulitola 3	--	18.00	--	--	16.60	--
Arajkund 1	97.50	149.10	5.40	81.20	148.20	5.30
Arajkund 2	63.40	71.20	4.30	59.90	71.20	4.30
Arajkund 3	--	84.00	3.30	--	81.00	3.50
Kaudikasa 1	143.21	231.30	6.10	141.11	221.10	5.70
Kaudikasa 2	230.10	329.40	6.40	230.30	330.50	6.90
Kaudikasa 3	--	156.20	9.20	--	149.80	8.10
Kaudikasa 4	--	216.20	--	--	200.10	--
Kaudikasa 5	--	126.20	--	--	220.10	--
Biharikala 1	167.40	241.00	3.20	161.40	238.20	3.10
Biharikala 2	92.20	190.10	4.10	87.20	282.20	4.30
Biharikala 3	--	72.30	--	--	68.80	--
Pangari, Keshitola 1	146.20	59.20	3.10	144.30	54.00	3.30
Pangari, Keshitola 2	68.21	51.70	3.60	67.60	51.00	4.10
Pangari, Keshitola 3	43.20	30.30	2.10	41.20	27.90	1.90
Atargaon 1	54.50	75.20	2.10	54.70	75.40	2.60
Atargaon 2	98.40	147.40	3.10	90.40	143.10	3.90
Atargaon 3	--	80.20	--	--	88.20	--
Sangali 1	70.20	37.80	3.40	69.10	36.90	3.20
Sangali 2	60.20	23.50	3.20	55.90	21.80	2.40
Sangali 3	--	93.20	--	--	88.20	--
Telitola 1	91.90	98.70	3.20	90.40	95.10	3.20
Telitola 2	64.30	143.20	5.30	63.30	133.00	5.40
Joratarai 1	85.00	154.00	03.30	78.00	146.00	02.78
Joratarai 2	102.00	67.00	02.20	97.00	60.00	02.10
Joratarai 3	--	183.00	06.20	--	170.00	04.70
Jadutola 1	72.30	48.20	6.20	70.10	47.20	6.00
Jadutola 2	80.20	159.90	--	78.20	153.50	--
Jadutola 3	--	80.30	--	--	78.30	--
Dhatutola 1	72.10	73.90	2.30	71.10	70.00	2.30
Dhatutola 2	53.90	47.80	--	51.90	42.70	--
Dhatutola 3	--	54.20	--	--	50.50	--

Mangatola 1	88.30	60.10	4.10	86.70	68.90	4.20
Mangatola 2	52.40	92.00	5.30	51.70	90.40	5.50
Mangatola 3	--	83.20	--	--	70.10	--
Sonsoitola 1	81.20	221.30	05.30	83.60	210.30	05.50
Sonsoitola 2	134.20	100.10	3.10	134.10	96.10	3.50
Sonsoitola 3	45.20	81.10	--	41.20	80.20	--
Sonsoitola 4	--	101.20	--	--	99.40	--
No. of sample	27	41	28	27	41	28
Range	18.80-230.10	15.2-329.40	1.90-9.20	17.60-230.30	14.10-330.5	1.90-8.10
Mean	88.01	106.51	4.04	85.15	107.51	4.01

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