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Neelam Baghel
Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, College of Agriculture, Raipur, Chhattisgarh, India

Dr KK Sahu
Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, College of Agriculture, Raipur, Chhattisgarh, India

RK Banwasi
Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, College of Agriculture, Raipur, Chhattisgarh, India

Satyendra Patley
Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, College of Agriculture, Raipur, Chhattisgarh, India

Correspondence
Neelam Baghel
Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, College of Agriculture, Raipur, Chhattisgarh, India

Evaluate the arsenic content in different soil types of Ambagarh Chowki block in Rajnandgaon district, Chhattisgarh

Neelam Baghel, Dr KK Sahu, RK Banwasi and Satyendra Patley

Abstract
A micro level investigation was conducted in the As affected 10 villages of Ambagarh chowki block, Rajnandgaon district, Chhattisgarh, to evaluate the As content in different soil types.. After analysing 100 samples of different soil types from different villages, it is revealed that during pre-monsoon season, in *Vertisols*, arsenic content varied from 3.92 to 7.63 mg kg^{-1} with mean value of 5.34 mg kg^{-1}. In *Alfisols*, it varied from 3.70 to 6.58 mg kg^{-1} with mean value of 5.07 mg kg^{-1} and in *Inceptisols*, As content varied from 2.25 to 5.19 mg kg^{-1} with mean value of 4.13 mg kg^{-1}. In post-monsoon season, in *Vertisols*, As content varied from 3.52 to 6.49 mg kg^{-1} with mean value of 4.88 mg kg^{-1}. In *Alfisols*, it varied from 2.65 to 5.30 mg kg^{-1} with mean value of 4.46 mg kg^{-1} and in *Inceptisols*, As content varied from 1.90 to 4.87 mg kg^{-1} with mean value of 3.70 mg kg^{-1}. In the soils of studied area, As content was below 10 mg kg^{-1}, which is lower than the global average of soil As 10 mg kg^{-1} and also less than the soils permissible limit for As 20 mg kg^{-1} by environmental guideline. It was found that in *Vertisols*, the concentration of As was high as compared to *Alfisols* and *Inceptisols*. Seasonal variation in As content was also found and the concentration of As in soil during pre-monsoon season is higher than in post-monsoon season.

Keywords:-*Vertisols*, *Alfisols*, *Inceptisols*, Arsenic, permissible limit.

Introduction
Arsenic (As) is a ubiquitous element that ranks 20th among the most abundant elements in the earth's crust. Its atomic number is 33, and the atomic weight is 74.92. As is a redox-sensitive element, which exists mainly in four oxidation states, + V (arsenate), + III (arsenite), 0 (arsenic), and – III (arsine). Unlike other toxic elements (Pb, Cu, and Co), As occurs as cation (positively charged ion) and oxyanion (negatively charged ions with oxygen) species. It can occur in the environment both in organic and inorganic forms. Inorganic forms usually associate with many minerals and other elements, especially oxygen, sulfur, and chlorine, while organic forms associate with carbon and hydrogen. The most important inorganic species are arsenate As (V) and arsenite As (III), while the most important organic species are monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA). The toxicity of As is mainly dependent on the forms of As. Inorganic As species are more toxic to living organisms than organic forms.

As occurs naturally in soil and minerals and it therefore may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching. Volcanic eruptions are another source of As. As may enter the environment during the mining and smelting of these ores. Small amounts of As also may be released into the atmosphere from coal-fired power plants and incinerators because coal and waste products often contain some As. As cannot be destroyed in the environment. It can only change its form, or become attached to or separated from particles. It may change its form by reacting with oxygen or other molecules present in air, water, or soil, or by the action of bacteria that live in soil or sediment.

The immediate and long term impact of using arsenic contaminated water for irrigating paddy soils is a burning concern as As can transfer from water to soil. Meharg and Rahman (2003) [9] predicted that soil As levels could be raised by 1 µg/g per annum due to irrigation with As-contaminated water. Alam and Sattar (2000) [1] observed that As contained in soils was positively correlated with As content in water. In a study Ahsan *et al.* (2008) [2] reported that As rich irrigation water can increase the As level in agricultural soil up to five times than the normal soil. In the unaffected areas, where irrigation water contained little As (< 1 µg/L),

As concentrations of rice field soils ranged from 1.5 to 3.0 mg/kg whereas the agricultural soil contains arsenic up to 436 µg/L where irrigated with As rich groundwater (Saha and Ali, 2007) [12].

Materials and Methods

Studied area

The study has been conducted in As affected ten villages (Atergaon, Biharikala, Dhadutola, Jadutola, Joratarai, Kaudikasa, Mangatola, Sangli, Sonsaytola, and Telitola) in Ambagarh Chowki block, Rajnandgaon district. In all these areas, the level of As in ground water is frequently exceeding World Health Organization (0.01 mg l^{-1}) permissible water limits (WHO 1992) [14].

Sample collection

Soil samples were collected for the study from farmer's field irrigated with the As contaminated water and transferred to airtight polyethylene bags during pre and post monsoon seasons. 100 of soil samples from adjacent field to the selected irrigated tube wells were collected for the study.

Sample prepration

Soil samples were collected at a depth of 0-15 cm. After collection, the soils were dried for 7 days and massive aggregates were broken by gentle crushing and passed through 2.0 pore sized mm sieve. The unwanted materials such as dry roots, grasses, hard stones were removed and the soil was made homogeneous. The processed soil samples were analyzed in the laboratory for the study.

Sample Digestion

Soil sample were digested heating block digestion procedure (Rahman *et al*. 2007) [10]. About 0.5 g of the sample was taken into clean dry digestion tube and 5 ml of concentrated HNO_3 was added to it. The mixture was allowed to stand over night under fume hood. In the following day, the digestion tubes were placed on a heating block and heated at 60 ^{0} C for 2 h. The tubes were then allowed to cool at room temperature. The soil samples 3 ml of concentrated H_2SO_4 was added in addition to 2 ml of concentrated $HClO_4$. Then the tubes were heated at 160 ^{0}C for about 4-5 h. The heating was stopped when the dense white fume of $HClO_4$ was emitted. The content was then cooled, diluted to 50 ml with de-ionized water and filtered through Whatman No. 42 filter paper and finally stored in polyethylene bottles. Prior to sample digestion all glass good were washed with 2% HNO_3 followed by rinsing with de-ionized water and drying.

Sample analysis

The total arsenic of the digested soil samples were analyzed by the flow injection hydride generation atomic absorption spectrophotometer (FI-HG-AAS, Perkin Elmer PinAAcle 900F) using external calibration through arsenate as standard (Welsch *et al*. 1990). The optimum HCl concentration was 10% v/v and 0.4% $NaBH_4$ produced the maximum sensitivity. For each sample three replicates were taken and the mean values were obtained on the basis of calculation of those three replicates.

Results and Discussion

Arsenic status in soil types

The data pertaining to status of total As concentration in soil types of Ambagarh Chowki block under investigation are summarized in table-3.1 figure-3.1 and 3.2.

Data given in table-3.1 after analyzed the samples in pre-monsoon season concluded that in concentration of As varied from 2.25 to 7.63 mg kg^{-1} with mean value of 4.99 mg kg^{-1} in the study area. The data of As concentration in *Vertisols* showed that As varied from 3.92 to 7.63 mg kg^{-1} with mean value was 5.34 mg kg^{-1}. The highest concentration of As value were recorded 7.63 mg kg-1 in Joratarai-1 followed by 6.91 mg kg^{-1} in Kaudikasa-1 and lowest concentration of As value were recorded 3.92 mg kg^{-1} in Sangli-1 followed by 4.01 mg kg-1 in Dhadutola-2. In *Alfisols* As varied from 3.70 to 6.58 mg kg^{-1} with mean value was 5.07 mg kg^{-1}. The highest concentration of As value were recorded 6.58 mg kg^{-1} in Kaudikasa-1 followed by 6.91 mg kg^{-1} in Joratarai -2 and lowest concentration of As value were recorded 3.72 mg kg^{-1} in Biharikala-1 followed by 3.81 mg kg^{-1} in Sangli-2 and in *Inceptisols* arsenic varied from 2.25 to 5.19 mg kg^{-1} with mean value was 4.13 mg kg^{-1}. The highest concentration of As value were recorded 5.19 mg kg^{-1} in Sonsytola-1 followed by 5.09 mg kg^{-1} in Magatola-2 and lowest concentration of As value were recorded 2.25 mg kg^{-1} in Magatola-1 followed by 3.19 mg kg^{-1} in Biharikala-2.

Data given in table-3.1 after analyzed the samples in pre-monsoon season concluded that in concentration of As varied from 1.90 to 6.49 mg kg^{-1} with mean value of 4.48 mg kg^{-1} in the study area. The data of As concentration in *Vertisols* showed that As varied from 3.52 to 6.49 mg kg^{-1} with mean value was 4.88 mg kg^{-1}. The highest concentration of As value were recorded 6.49 mg kg^{-1} in Joratarai-2 followed by 6.07 mg kg^{-1} in Sonsaytola-1 and lowest concentration of As value were recorded 3.52 mg kg^{-1} in Atergaon-1 followed by 3.62 mg kg^{-1} in Sangali-1. In *Alfisols* As varied from 2.65 to 5.30 mg kg^{-1} with mean value was 4.46 mg kg^{-1}. The highest concentration of As value were recorded 5.30 mg kg^{-1} in Telitola-2 followed by 5.25 mg kg^{-1} in Sonsaytola -2 and lowest concentration of As value were recorded 2.65 mg kg^{-1} in Atergaon-1 followed by 3.40 mg kg^{-1} in Jadutola-2 and in *Inceptisols* As varied from 1.90 to 4.87 mg kg^{-1} with mean value were 3.70 mg kg^{-1}. The highest concentration of As value were recorded 4.87 mg kg^{-1} in Kaudikasa-2 followed by 4.70 mg kg^{-1} in Joratarai-2 and lowest concentration of As value were recorded 1.90 mg kg^{-1} in Biharikala-2 followed by 2.11 mg kg^{-1} in Magatola-1.

Table 1: Concentration of Arsenic in types of soils of different villages in Ambagarh Chowki block during pre and post monsoon seasons.

Name of Villages	Pre-monsoon season (mg kg^{-1})			Post-monsoon season (mg kg^{-1})		
	Vertisols	*Alfisols*	*Inceptisols*	*Vertisols*	*Alfisols*	*Inceptisols*
Atergaon-1	4.85	4.31	-	3.52	2.65	-
Atergaon-2	4.77	5.15	-	4.78	4.83	-
Biharikala-1	4.56	3.70	3.19	4.13	3.65	3.05
Biharikala-2	5.10	4.83	3.76	4.83	4.59	1.90
Dhadutola-1	4.18	4.30	-	3.93	4.09	-
Dhadutola-2	4.01	3.96	-	3.76	3.81	-
Jadutola-1	5.37	5.01	-	5.04	4.83	-
Jadutola-2	4.39	4.47	-	4.31	3.43	-
Joratarai-1	7.63	6.19	4.19	5.73	5.10	3.65
Joratarai-2	6.51	6.46	4.12	6.49	6.05	4.70
Kaudikasa-1	6.91	6.58	4.71	6.03	4.95	4.65
Kaudikasa-2	6.73	6.43	4.98	6.07	5.11	4.87
Magatola-1	4.98	5.00	2.25	4.25	4.39	2.11
Magatola-2	5.65	5.29	5.09	5.33	5.11	3.84
Sangli-1	4.25	4.36	-	3.62	3.56	-
Sangli-2	3.92	3.81	-	3.90	3.70	-
Sonsaytola-1	5.69	5.87	5.19	5.36	5.13	4.58
Sonsaytola-2	6.13	5.77	4.36	6.10	5.25	4.15
Telitola-1	5.19	4.75	-	4.67	4.72	-
Telitola-2	5.87	5.33	-	5.78	5.30	-
Range	3.92-7.63	3.70-6.58	2.25-5.19	3.52-6.49	2.65-5.30	1.90-4.87
Overall range	2.25-7.63			1.90-6.49		
Mean	5.34	5.07	4.13	4.88	4.46	3.70
Overall mean	4.99			4.48		
Total Samples	20	20	10	20	20	10

In general, all of the different soil types contained <10 mg kg^{-1} of As and As which range below the maximum acceptable limit for agriculture soil of 20 mg kg^{-1} as recommended by the European Community (EC) So we concluded that in the different soil types of studied area As is not present in toxic level.

Concentration of As in *Vertisols* exceeded as compared with *Alfisols* and *Inceptisols* is due to the mobilization and attenuation of As in the fine and coarse soil fractions (Lombi *et al.*, 2000; Bhattacharya *et al.*, 2002; Cai *et al.*, 2002; Sadiq, 1997) [8, 3, 6, 11]. Sediments with finer texture usually contain more As than sediments with coarser texture (Khan 2003) [7]. According to Lombi *et al.* (2000) [8], the coarse textured soils are likely to yield a higher fraction of readily mobile As, while As in the fine textured soils is relatively immobile, but can be released upon changes in the subsurface geochemical environment.

A slightly changes in mean value of concentration of As (0.43-0.61 mg kg^{-1}) were observed during pre and post monsoon seasons. The concentration of As in post-monsoon season mean values 4.88, 4.46 and 3.70 mg kg^{-1} were slightly less as compared to pre-monsoon season mean values 5.34, 5.07 and 4.13 mg kg^{-1}in *Vertisols, Alfisols* and *Inceptisols,* respectively. It may be due to in pre-monsoon season dry period and evaporation arsenic accumulated more in soil and in post monsoon season As leached out from the soil. Biswas *et al.* (2014) [5] also found same results in As concentration soil in endemic regions of West Bengal reported that ranged from 5.82 to 9.72 mg kg^{-1} in summer season and 5.01–7.34 mg kg^{-1} in winter season. Semal *et al.* (2010) [4] also found same results concentration of As in soil was little higher in pre-monsoon than post-monsoon season in Gangetic Delta of West Bengal. Bhattacharya *et al.* (2010) [4-13] found similar results mean value of As 0.47 mg kg^{-1} in pre-monsoon season as compared to 0.36 mg kg^{-1} in post-monsoon season.

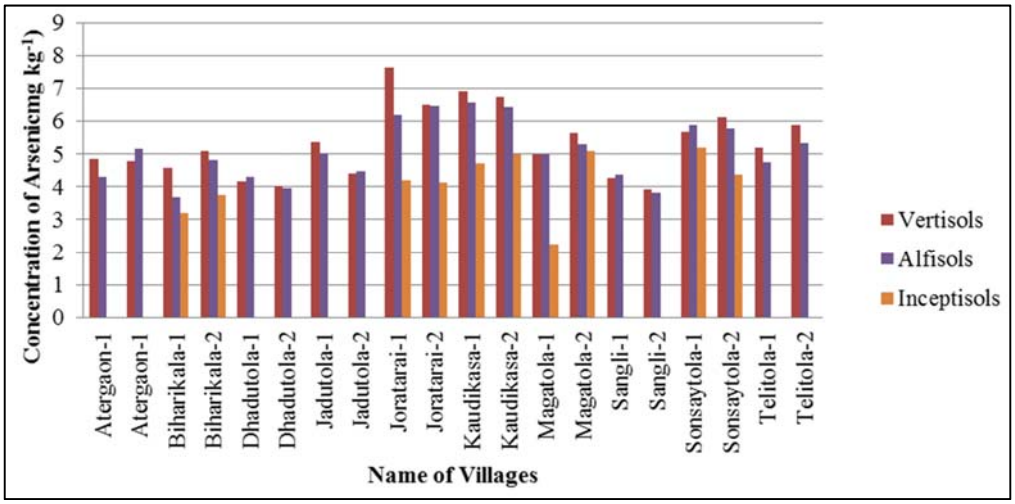

Fig 1: Concentration of As in types of soils of different villages in Ambagarh Chowki block during pre-monsoon season

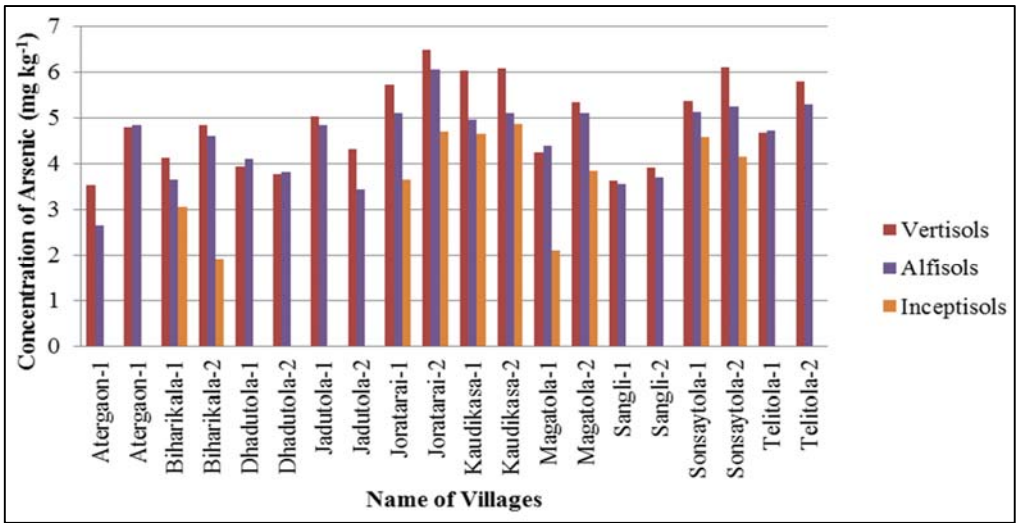

Fig 2: Concentration of As in types of soils of different villages in Ambagarh Chowki block during post-monsoon season.

Conclusion

The research findings showed that all the samples of soil contained <10 mg kg^{-1} of As which range below the maximum acceptable limit for agriculture soil of 20 mg kg^{-1} as recommended by the European Community (EC). Concentration of As in *Vertisols* (7.63 mg kg^{-1}) exceeded as compared with *Alfisols* (6.58 mg kg^{-1}) and *Inceptisols* (5.19 mg kg^{-1}) because of mobilization and attenuation of As in the fine and coarse soil fractions. So, we concluded that in the different soil types of studied area As is not present in toxic level.

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