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STUDY OF SEASONAL VARIATION OF ARSENIC CONCENTRATION IN GROUNDWATER IN GHAZIPUR DISTRICT OF UTTAR PRADESH

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AUTHOR'S CONTRIBUTION

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

It was reported a clear temporal and seasonal variability of as concentrations in different water samples of Ghazipur district of eastern U. P. During post monsoon season as concentration decreases in Samples. A definite relationship exists between the behavior of arsenic and rainfall intensity. Groundwater quality depends on the composition of recharging water, the mineralogy and reactivity of the geological formations in aquifers, anthropogenic activities and environmental conditions that may affect the geochemical mobility of certain constituents. Arsenic concentrations in groundwater of the Kathmandu Valley show a wide range and some of groundwater sources investigated were found to be in elevated levels in some parts of the valley could be due to the nature of the sediments there. The high degree of spatial variability in groundwater quality over short distances indicates that groundwater movement has been limited and is poorly mixed. The higher concentration of arsenic under reduced groundwater environment may be due to Fe/Mn oxides and direct reduction of As(V) into As(III). After an initial increase, arsenic concentration often decreases again as a function of time below water table due to sulfide precipitation, whereas it increases with increasing sulfate concentrations above water table. Under moderately reduced environment (0 to 100 mV), arsenic solubility seemed to be controlled by the dissolution of Fe ox hydroxides. But at highly reduced condition, e.g., at −250 mV, arsenic chemistry is dominated by the formation of insoluble sulfides FeAsS, As, As_2S_3 attenuating concentration of arsenic in the groundwater.

Keywords: Ground water; post monsoon; geochemical mobility; arsenic concentration; spatial variability; anthropogenic activities.

1. INTRODUCTION

1.1 Spatial Distribution of Arsenic

The concentration of arsenic, iron, manganese and ORP (Oxidation- Reduction potential) value vary significantly in Ghazipur groundwater district. The spatial distribution pattern reveals higher values of arsenic, iron and manganese in groundwater of Ballia district. Ghazipur and nearby districts groundwater have lower arsenic concentrations in most of the groundwater wells. The concentration of the arsenic in groundwater of the study area increases from Ghazipur to Ballia districts and showing highest towards doab areas.

Arsenic concentration was relatively lower in Ghazipur district groundwater in comparison with Ballia district groundwater. The spatial distribution of ORP in the groundwater clearly shows most of the groundwater wells have lower ORP value. The variations of elemental concentration are mainly clay

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controlled in both the margin and central parts. There is progressive increase in the finer particles and trace elements towards the central part of the sediments from the northern part which is attributed to decrease in grain size and the concentration of metals in sediments tend to increase in fine grained sediments.

The larger particles in sediments have less surface area available for metal hydroxide coatings to form and adsorb arsenic and less adsorbed arsenic contributes a smaller amount of aqueous arsenic in equilibrium with adsorbed arsenic. Therefore, there is in less potential for release of arsenic through reductive mobilization mechanisms [1-3]. The variation in grain size has role in mobilization of metals in groundwater. Therefore, higher metal concentration is associated with the fine grained sediments in the Ghazipur district groundwater. Furthermore, higher concentrations of metals in Ghazipur district groundwater might be due to the fact that the Ghazipur district groundwater is considered as poorly recharging due to the presence of a thick black clay layer.

Groundwater quality depends on the composition of recharging water, the mineralogy and reactivity of the geological formations in aquifers, anthropogenic activities and environmental conditions that may affect the geochemical mobility of certain constituents [4-6]. Arsenic concentrations in groundwater of the Kathmandu Valley show a wide range and some of groundwater sources investigated were found to be in elevated levels in some parts of the valley could be due to the nature of the sediments there. The high degree of spatial variability in groundwater quality over short distances indicates that groundwater movement has been limited and is poorly mixed. The higher concentration of arsenic under reduced groundwater environment may be due to Fe/Mn oxides and direct reduction of As(V) into As(III) [7-11]. After an initial increase, arsenic concentration often decreases again as a function of time below water table due to sulfide precipitation, whereas it increases with increasing sulfate concentrations above water table. Under moderately reduced environment (0 to 100 mV), arsenic solubility seemed to be controlled by the dissolution of Fe ox hydroxides. But at highly reduced condition, e.g., at −250 mV, arsenic chemistry is dominated by the formation of insoluble sulfides FeAsS, As, As_2S_3 attenuating concentration of arsenic in the groundwater [12-15].

2. MATERIALS AND METHODS

2.1 Ghazipur District (Geographical study)

Ghazipur district is located in alluvial plain of the middle Ganga Valley, lying in the eastern U.P. Geographically it is extended from 25°19' N to 25°54°N Latitude and 83°4' E to 83°58' E Longitude and has an area of 3377 Km^2. This district is a part of the Ganga-Ghaghara Doab so it is strongly flood-prone area. It is bounded in the north-west by Azamgarh district, in the north-east and east by Ballia district, in the west by Jaunpur district and the south by Varanasi district, all in Uttar Pradesh and in south east by Bihar state, from which it is separated by the Karamnasa river. The maximum east-west length of the district is 90 km. District on administrative ground is divided in 5 tehsils, namely Ghazipur, Saidpur, Muhammadabad, Jakhania and Zamania. These tehsils have been further Sub-divided in to 16 development blocks Bhadaura, Bhawarkole, Bimo, Deokali, Ghazipur, Jakhania, Karanda, Kasimabad, Manihari, Mardah, Muhammadabad, Reotipur, Sadat, Saidpur and Zamania. Location of Ghazipur district in the alluvial plain of the Ganga provide a very large fertile land area. Kankar or Limestone is commonly occurs in strata from the upland area to various depths below the surface. Clay is available everywhere suitable for making bricks.

District is surrounded by many rivers, river Ganga is the most important river of Ghazipur district while The Gomti, the Gang, the Mangai, the Saryu and the Karamnasa are its subsidiary water resources. From Saidpur tehsil, The river Ganga enters the district with its north-easterly flow with confluence of the Ganga and Gomti. The Ganga after Saidpur tehsil, takes a sudden turn towards the south-east up to Zamania, where it forms a significant meander by bending towards north-west. The total length of this river from its first point in this district to its exit at Rasulpur is about 120 km. The river Gomti flowing along the southern boundary of Saidpur tehsil separate Ghazipur from Varanasi District. Due to meandering nature of this river, the land along the river Gomati is broken by ravines. The river Ganga enters the district at Saidpur near Naikdih which is a tributary to Ganga and emerge out as a stream in the north of Mainpur. Course of this river is marked by a succession of loops and bends and its direction is east south east. The river Besu enters the district at Gadaipur in the north-west comer of village Bahriabad and its origin in the Deogaon tehsil of District Azamgarh. Besu river forms a channel with Udwanti stream After a short distance from Shadiabad town, the Besu is connected by the Udwanti stream rising in Azamgarh and forms a short boundary of district, finally it move towards the east and ends in to the Ganga on its left bank.

The river Mangai enters Ghazipur district in the north of pargana Shadiabad . It start from Dostpur in Sultanpur district and flowing through Jaunpur and

Azamgarh it enter in district. It moves towards north-east for a long distance and passing through the Muhammadabad pargana then reaches Hata and flowing north-eastward along Lathudih then makes a South-Easterly stream into the Ballia district and finally enters the Saryu or Tons. Then it meets with Ganga. It covers a distance of 99 km The total length in the district Ghazipur. It drains a very large area. The river Bhainsahi forms the northern boundary of Ghazipur district, it originates in the Muhammadabad tehsil of Azamgarh district and after covering a long distance it touches near Jalalabad. After draining a large area of Shadiabad and Pachotar it reaches to Zahurabad and falls in to Saiju river in the town of Bahadurganj. The Saiju river is mostly called as the tons and also as Choti Saryu. It forms a water reservoir of the Tons and the Choti Saiju. The river Karamnasa which means destroyer of pious deeds forms a boundary between Ghazipur district and Bihar. It originate from the Kaimour hills of Bihar and passes through the districts of Mirzapur and Varanasi and flowing towards the north-east forms the boundary of the district separating it from Bihar State. It joins the Ganga near Bara at Chausa where Humayaun was defeated by Sher Shah Suri. It drains a considerable area of the Southern uplands and is fed by several small channels out of which the Eknaiya, joins at Diwaitha.

2.2 Groundwater Arsenic Enrichment in the Middle Gangetic Plain of Ghazipur District (U.P.)

Ghazipur district is located in the eastern alluvial part (classification based on agro-climatic zonation) of the Uttar Pradesh 25°19′ to 25°54′N, 83°4′ to 83°′58′E (Fig. 1). The district is a peneplain intersected by numerous streams. Topography varies due to high banks of the Ganga, Karamnasa, Gomti, and Saryu rivers and the gentle slope from the central watershed towards these rivers. The monsoon during July to September brings nearly 70% of the annual rainfall. The mean annual temperature is 24°C.

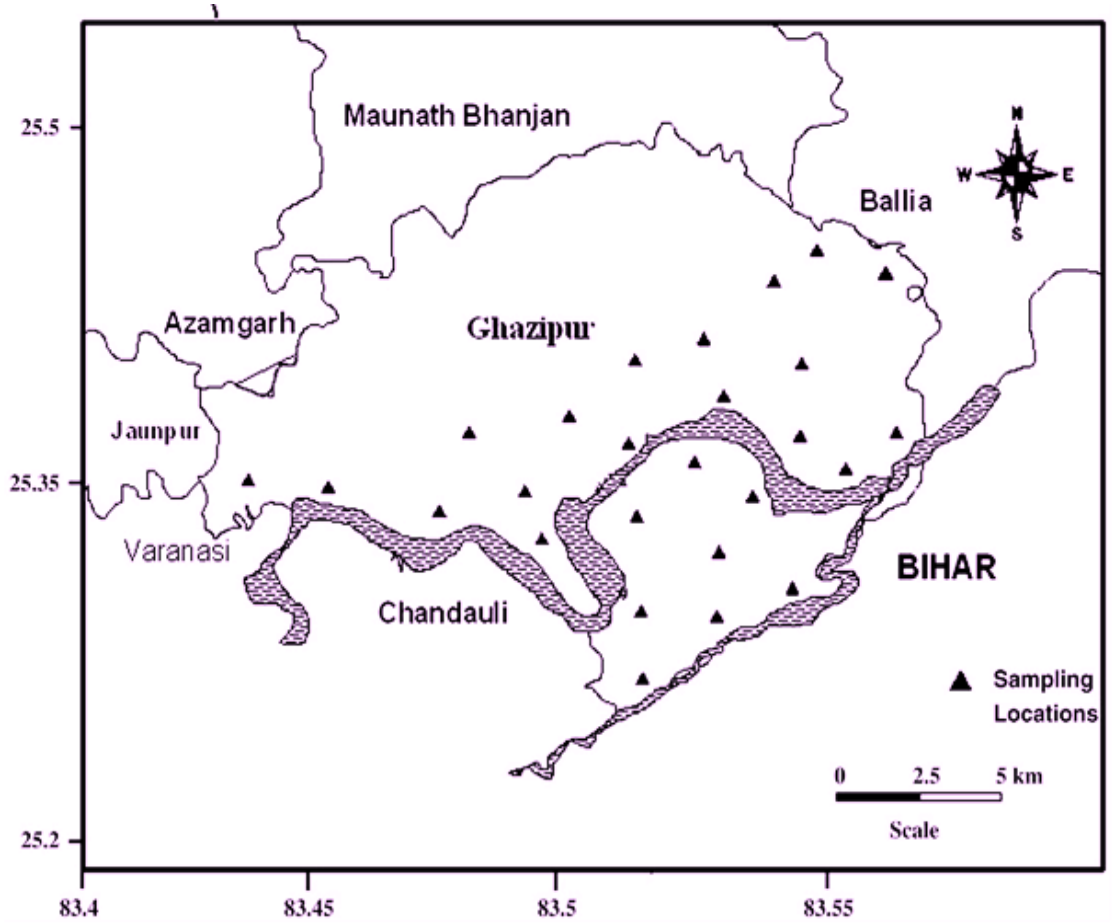

Fig. 1. Map of study area of Ghazipur district in Eastern U. P

3. RESULTS AND DISCUSSION

3.1 Temporal and Seasonal Variability of Arsenic in Groundwater

It was reported a clear temporal and seasonal variability of As concentrations in different samples. During post monsoon season As concentration decreases in Samples. The variability in As concentrations is likely to be associated with the seasonal fluctuations in groundwater recharge and the impact of irrigation drawdown (Mac Arthur et al). Difference in Arsenic concentration during pre and post monsoon seasons is correlated in terms of its concentration. A definite relationship exists between the behavior of arsenic and rainfall intensity. With increasing rainfall intensity rate of dilution increases which minimizes the arsenic concentration in the groundwater [16,17,18,19]. During monsoon period there is considerable decrease in the arsenic concentration. Thus it can be said that there is a strong correlation exists between rainfall condition, dilution effect and arsenic concentration. Contrary to this, during winter season and pre monsoon seasons there is an increase in the concentration which is associated with the decrease in dilution effect.

Table 1. Distribution of arsenic during post monsoon & pre monsoon in block Bhawarkole

Villages in block Bhawarkole	As in ppb	
	Post monsoon	Pre monsoon
Balariya	15	21
Bhawarkole	15	22
Mirzabad	17	21
Bantha	14	22

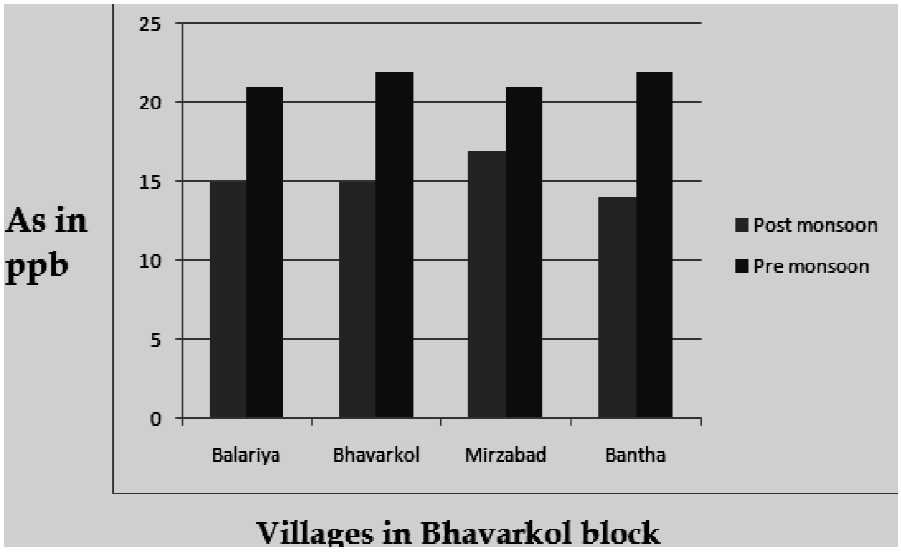

Fig. 2. Histogram diagram of Distribution of Arsenic in Bhawarkole block

Table 2. Distribution of arsenic during post monsoon& pre monsoon in Zamania block

Villages in Zamania block	As in ppb	
	Post monsoon	Pre monsoon
Gahmar	98	170
Phully	34	53
Zamania	24	35

Table 3. Distribution of arsenic during post monsoon & pre monsoon in Reotipur block

Villages in Reotipur block	As in ppb	
	Post monsoon	Pre monsoon
Chochakpur	18	28
Ishopur	15	27
Nawali	17	26
Reotipur	17	27

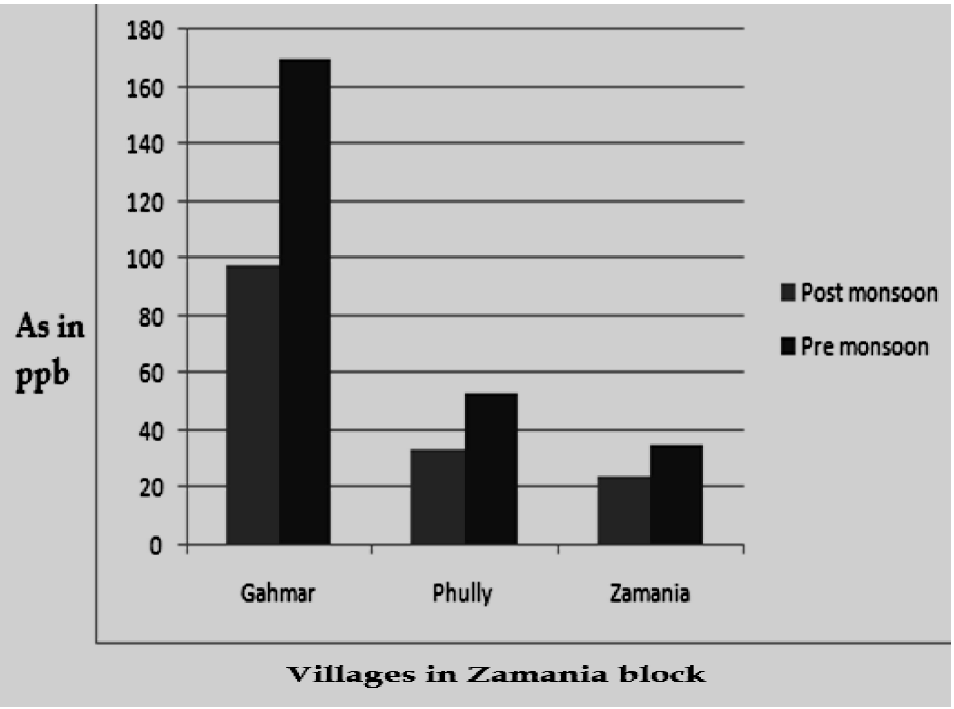

Fig. 3. Histogram diagram of distribution of arsenic in Zamania block

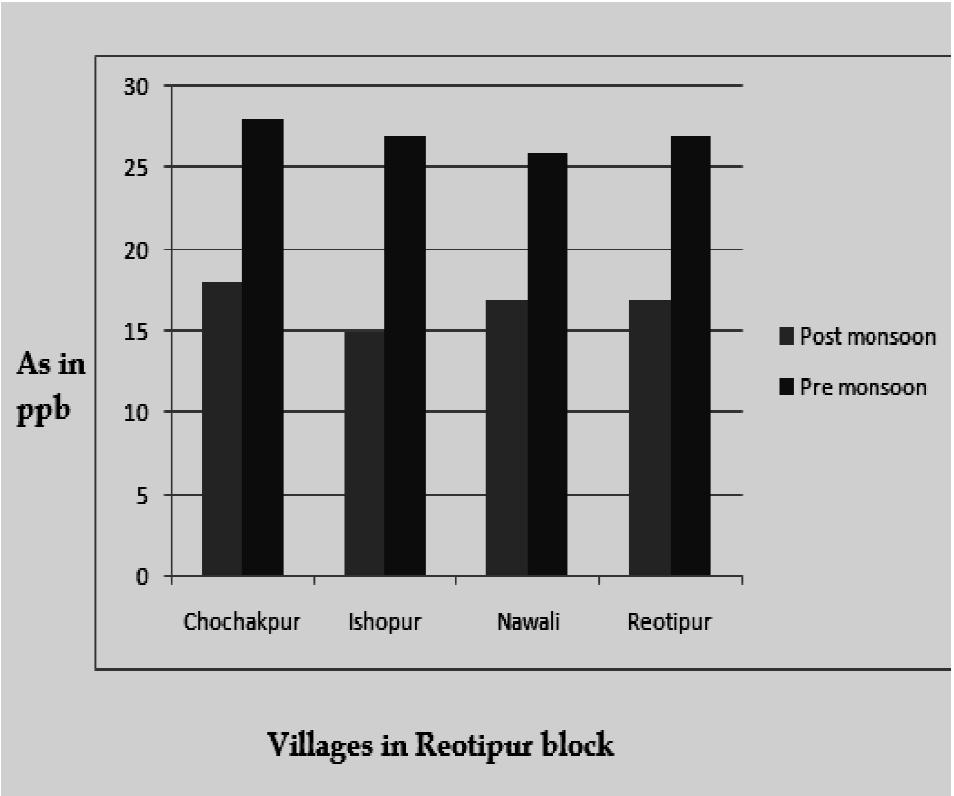

Fig. 4. Histogram diagram of distribution of arsenic in Reotipur block

Table 4. Distribution of arsenic during post monsoon & Pre monsoon in Ghazipur city

Villages in Ghazipur city block	As in ppb	
	Post monsoon	Pre monsoon
Baberi	210	290
Ghazipur city	210	290
Ruhipur	198	287
Rauza	222	290

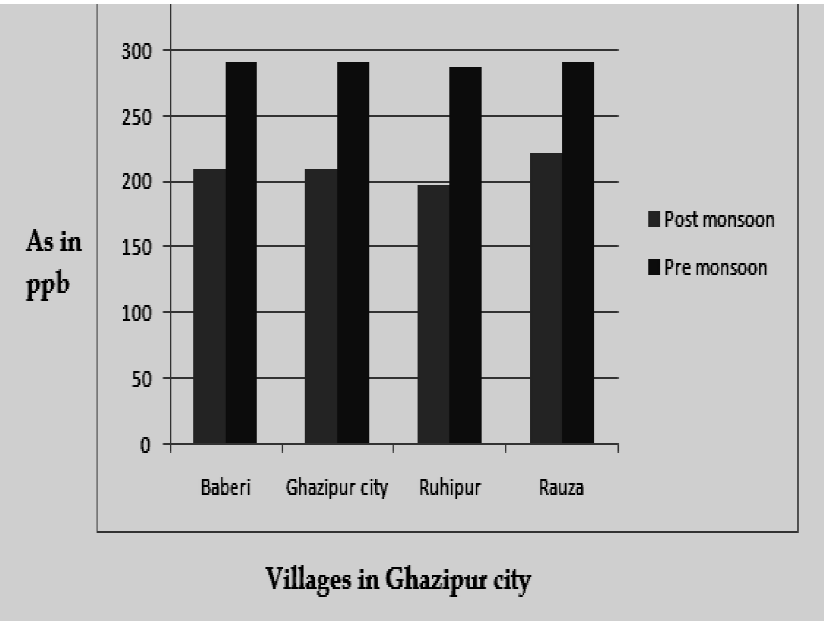

Fig. 5. Histogram diagram of distribution of arsenic in Ghazipur city block

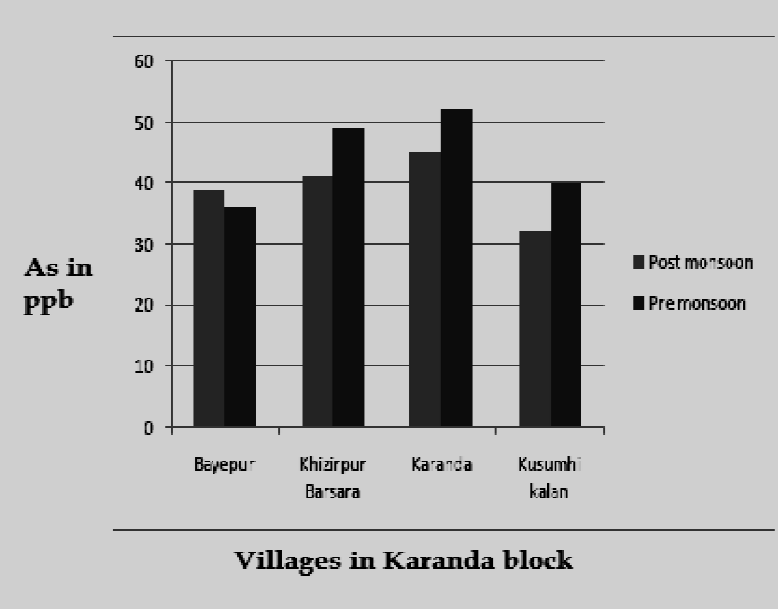

Fig. 6. Histogram diagram of distribution of arsenic in Karanda block

Table 5. distribution of arsenic during post monsoon & pre monsoon in Karanda block

Villages in Karanda block	As in ppb	
	Post monsoon	Pre monsoon
Bayepur	39	36
Khizirpur Barsara	41	49
Karanda	45	52
Kusumhi kalan	32	40

Table 6. Distribution of arsenic during post monsoon & pre monsoon in Mohammadabad block

Villages in Mohammadabad block	As in ppb	
	Post monsoon	Pre monsoon
Daudpur	12	18
Gauspur	12	17
Sukhdehra	14	20
Mohammadabad	18	30

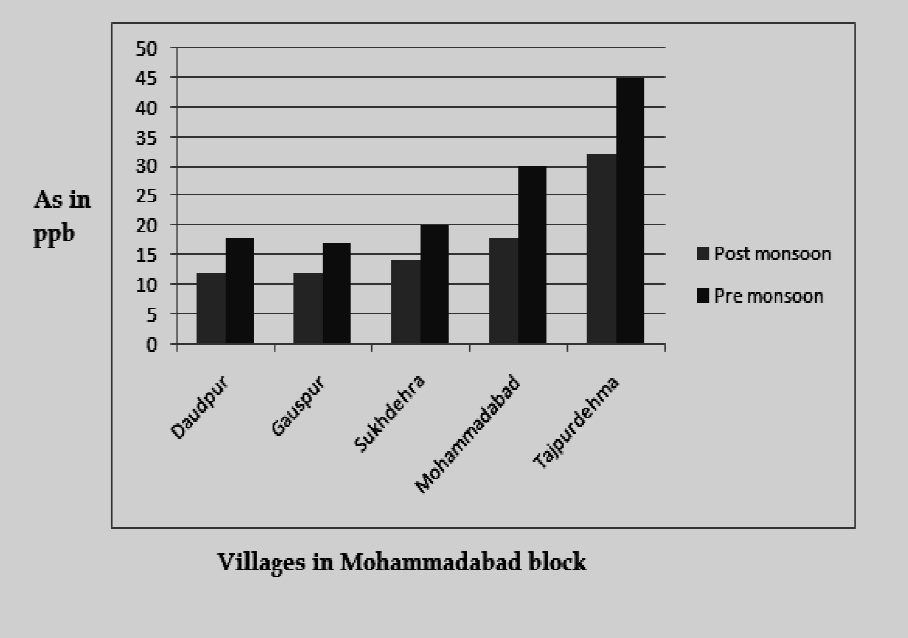

Fig. 7. Histogram diagram of distribution of arsenic in Mohammadabad block

4. CONCLUSION

Each sample shows variation in As concentrations due to seasonal variation. There is decrease in As concentration from pre monsoon to post monsoon season. The cause of variation is change in groundwater level during rainy season and also consumption of groundwater in irrigation process. Arsenic concentration fluctuation during pre and post monsoon seasons is correlated in terms of its concentration. A direct relationship exists between As concentration and average amount of rainfall in rainy season. As concentration decreases with increase in amount of rainfall as it increases rate of dilution of As in water. During monsoon period considerable decrease in the arsenic concentration has been observed. So it is clear that as concentration is strongly related with average rainfall amount and dilution effect .On other side, As concentration increases during winter season and pre monsoon seasons which is due to decrease in dilution effect.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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