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Heavy Metals Pollution in Groundwater of Ghaziabad district, Western Uttar Pradesh, India: Groundwater quality constraint

Siraj Ahmad*, Shadab Khurshid, Mashkoor Khan
Department of Geology, Aligarh Muslim University, Aligarh-202002, UP, India
E-mail: sirajalig05@gmail.com

Abstract- A present study to analyze the groundwater samples of the Industrial belt of Western Uttar Pradesh i.e., pH, total dissolved solids (TDS), Electrical conductivity (EC), manganese (Mn), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), lead (Pb) and zinc (Zn). The concentration of heavy metals in thirty six groundwater samples of the study area is determined by using Atomic Absorption Spectrometer (AAS). The result of heavy metals indicate that manganese, cadmium, chromium, iron, nickel and lead are exceeding the permissible limit excepting copper and zinc as per Bureau of Indian Standard [2] as well as World Health Organization [21]. The spatial distribution maps are showing heavy metal concentrations which indicate the geogenic and anthropogenic source. High concentrations of heavy metals show that it was noticeable rise in chemical composition and likely to have its origin dissolution/precipitation processes supported by rainfall and anthropogenic activities, indiscriminate use of fertilizers/pesticides and disposal of waste and sewage, release of reactive pollutants into the atmosphere by industries. Hence this work is of massive public benefit in terms of prevailing human health hazard in the study area.

Keywords- Heavy metals, Groundwater quality, Pollutant, Electrical Conductivity (EC).

1. INTRODUCTION

Groundwater is one of the most important precious fresh water resources which are used for the various purposes like domestic, irrigation and industries etc. It plays an important role in our daily life. It is also important source of drinking water throughout the world. India is a fastest developing country it plays an important role in rise the economic growth of the country [15]. The deterioration of water quality in the study area is due to unsystematic anthropogenic activities such as unplanned increase of industrialization, urbanization and haphazard disposal of domestic, industrial and agricultural effluents have led to serious environmental concerns on the deterioration of groundwater quality [17]. Several studies have been conducted for the assessment of groundwater quality and risk caused by heavy metals such as Fe, Mn, Ni, Cu, Cr, Cd, Pb and Zn which is present in different countries like India, Pakistan, China, Bangladesh and other countries [9,11,12,14]. Analysis of heavy metal concentrations in groundwater is particular in rapidly growing urban and industrial areas which are critical for the making of policies aimed at reducing pollution level and improvement of water quality. The concentration of these elements increases due to waste disposal, atmospheric deposition, use of fertilizers and pesticides and application of sewage sludge in arable land [5,22,10].

Ghaziabad district is one of the fastest growing cities and major industrial hub in Western Uttar Pradesh, India. It is a highly polluted city due to various types of industries including electroplating, metal processing, textiles, lead reprocessing units, chemicals and ceramics pesticides etc. Groundwater contaminations are increasing due to the anthropogenic activities. For this, we need to more investigation for struggle the issue and fulfill the current and future potable water demand. Insufficient of potable water in the Indian metropolitan cities including National Capital Region (NCR) is a major environmental concern and requires scientific attention to combat the problem. The water samples were collected to the analysis of Cu, Cr, Cd, Ni, Fe, Pb, Zn and Mn. These studies are mainly focused on groundwater quality assessment due to the improper disposal of industrial waste effluents and lack of treatment plant. Hence, it's imperative to carry out the increase of pollution in the belt of the Yamuna Sub-basin.

2. MATERIALS AND METHODS

2.1. Study area

The present study area is located in Ghaziabad district of Western Uttar Pradesh. It has a total area of 1933.3 km^2. It is situated between latitude 28°26' to 28°54' N and longitude 77°12' to 78°13' E (Fig.1) and is underlain by Quaternary sediments. It is drained by Yamuna and Ganga river and their tributaries namely Hindon and Kali river. It has the highest density of population in the state of Uttar Pradesh with 3971 persons per square km. The rate of increase in population between 2001 and 2011 is 41.30% and total population of the city in 2011 is 4,681,645 [4]. The rapid population growth is mostly due to its industrial development and closeness to Delhi, the capital of India. Major land uses in the city are primarily industrial, residential and commercial. Agriculture holds a little share in the main city and is dominated in the peri-urban area of the district. The climate of this region is semi-arid with high variation between summer and winter season and temperature conditions in summer are (up to 43°C) while in winter (up to 3°C).

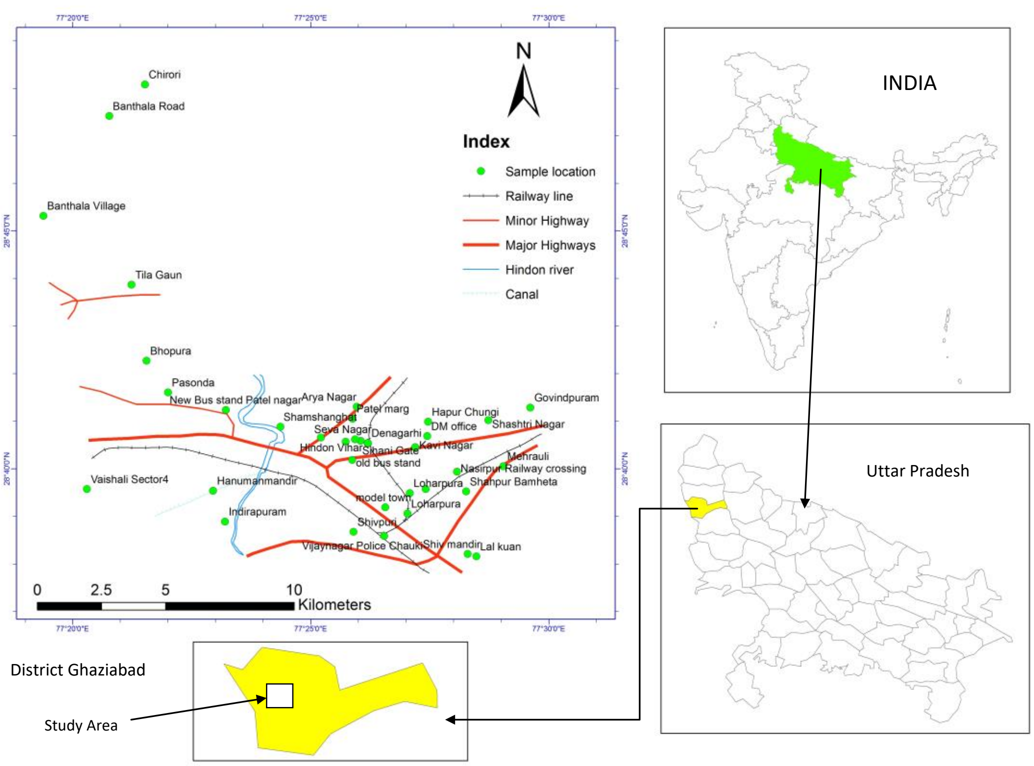


Fig.1. Map showing the sampling locations in Ghaziabad district

2.2. Sampling and analysis

Thirty six groundwater samples were taken from the hand pumps, bore wells in Ghaziabad district during pre and post-monsoon seasons (2016). The sampling area is selected near commercial and industrial sites. The samples were collected in one liter pre-washed plastic polyethylene bottles for analysis of the heavy metals. Prior to collecting the samples, the wells were duly pumped to get the rid the water. The location of each site was recorded by Global Positioning System (GPS). The samples were analyzed for pH, EC and it is measured by a portable digital water analysis kit. Total dissolved solids (TDS) were determined from EC multiplied by 0.64 [3]. To assess the groundwater quality and extent of pollution, groundwater samples were collected to find out the concentration of heavy metals.

The groundwater samples has been analyzed by the methods prescribed by [1] and the concentration of heavy metals like Cu, Cr, Cd, Ni, Fe, Pb, Zn and Mn, is determined by Atomic Adsorption Spectrometer (AAS). The heavy metals were analyzed at the department of Botany, AMU, Aligarh. The study aimed to analyze heavy metals geochemistry from the groundwater and determining the natural background levels of heavy metals as a guide for future pollution and examining the groundwater quality as per Bureau of Indian Standard (BIS) as well as World Health Organization [21] for drinking water. Spatial distribution maps deciphering different zones of heavy metals concentration in groundwater of the study area by using surfer 14.

3. RESULTS AND DISCUSSION

The chemical parameters of the groundwater like pH, TDS and EC is statistically analyzed and the results are compared with drinking water suitability standards of [21,2] are given in Table 1. The pH values varied from 7.5 to 8.8 with an average of 8.25, indicating slightly alkaline in nature in pre-monsoon and 6.4 to 7.9 with an average of 7.26, indicating slightly acidic to slightly alkaline in nature during post-monsoon. Electrical conductivity (EC) varied widely from 300to 3600 µS/cm with (mean value 1258 µS/cm); 300to 3500 µS/cm with (mean value 1366 µS/cm) in pre and post-monsoon seasons respectively. The higher EC values contribute to higher salinity. The total dissolved solids (TDS) values of water samples in the study area vary between 192 mg/l to 2304 mg/l with an average value of 805.33 mg/l and192 mg/l to 2240 mg/l with an average value of 874.67 mg/l in pre and post-monsoon seasons respectively, indicating most of the groundwater samples are undesirable limit (Table 1).

The statistical results of the heavy metals analysis of the thirty six groundwater samples in pre and post-monsoon seasons are summarized in Table 1. During pre-monsoon, the mean concentration of Mn, Cd, Cr, Cu, Fe, Ni, Pb and Zn of the entire samples were shown by 0.12, 0.51, 0.27, 0.14, 0.11, 0.24, 0.26 and 0.23 mg/l respectively. The mean concentration of Mn, Cd, Cr, Cu, Fe, Ni, Pb and Zn in the post-monsoon season shows 0.17, 0.92, 2.19, 0.19, 1.40, 9.35, 2.45 and 0.44 mg/l. In the pre-monsoon season, the concentrations of the heavy metals are found lower as compared to the post-monsoon season. On an average basis in groundwater the heavy metals showed following order Cd>Cr>Pb>Ni>Zn>Mn>Fe in pre-monsoon season (2016), While during the post-monsoon season the order of increasing as Ni>Pb>Cr>Fe>Cd>Zn>Cu>Mn.

The correlation matrix between two or more variables in groundwater of the study area has been discussed to find a predictable relationship. It is used for the measurement of the strength and statistical significance of the relation between two or more water quality parameters. The values of correlation coefficients are listed in Table 2. The positive correlations are found between Fe with Cr and Pb with Cu in pre-monsoon season and Zn with Ni in post-monsoon season (2016).

Table 1: Statistical summary of chemical parameters in the groundwater samples of the study area

Parameters		pH	EC	TDS	Mn	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Pre-monsoon, 2016	**Min**	7.5	300	192	0.01	0.01	0.1	0.02	0.05	0.13	0.12	0.05
	Max	8.8	3600	2304	0.27	0.97	0.51	0.37	0.20	0.32	0.48	0.84
	Mean	8.25	1258	805	0.12	0.51	0.27	0.14	0.11	0.24	0.26	0.23
	SD	0.30	657	420	0.06	0.31	0.11	0.08	0.04	0.04	0.09	0.22
Post-monsoon, 2016	**Min**	6.4	300	192	0.00	0.38	0.81	0.00	0.99	1.89	0.00	0.15
	Max	7.9	3500	2240	0.42	1.36	5.28	0.51	2.27	14.93	6.21	0.80
	Mean	7.2	1366	874	0.17	0.92	2.19	0.19	1.40	9.35	2.45	0.44
	SD	0.34	724	463	0.09	0.20	0.93	0.19	0.30	3.16	1.28	0.14
WHO	**2012**	6.5-8.5	750	500	0.01	0.003	0.05	2.00	0.30	0.07	0.01	3.00
BIS	**2012**	6.5-8.5	1000	500	0.03	0.003	0.05	2.00	0.30	0.02	0.01	5.00

Table 2: Correlation Coefficient Matrix of heavy metals in the study area

Elements	Mn	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Pre-monsoon, 2016								
Mn	1.00							
Cd	0.32	1.00						
Cr	0.07	-0.13	1.00					
Cu	-0.01	-0.03	-0.01	1.00				
Fe	-0.09	-0.16	0.59	0.04	1.00			
Ni	-0.05	-0.17	0.20	-0.13	0.32	1.00		
Pb	-0.29	-0.09	-0.03	0.58	0.00	-0.14	1.00	
Zn	0.24	0.13	-0.14	0.07	0.04	-0.05	-0.18	1.00
Post-monsoon, 2016								
Mn	1.00							
Cd	0.01	1.00						
Cr	0.17	0.25	1.00					
Cu	-0.22	-0.23	0.13	1.00				
Fe	0.03	-0.24	-0.45	0.16	1.00			
Ni	0.00	0.34	0.40	0.14	-0.32	1.00		
Pb	-0.15	0.23	0.21	0.24	-0.10	0.05	1.00	
Zn	0.06	0.37	0.49	-0.01	-0.44	0.60	0.22	1.00

4. Heavy metals geochemistry in groundwater of the study area

Status of heavy metals in groundwater of the study area has been discussed with respect to [21,2]. It is observed that Mn, Cd, Cr, Ni and Pb in pre-monsoon season are in higher concentration than the permissible for drinking water while Mn, Cd, Cr, Fe, Ni and Pb in the post-monsoon also found in higher concentration than the level of drinking water in most of the groundwater samples of the study area.

4.1. Manganese (Mn)

The concentration of Mn ranged from 0.01 to 0.27 mg/l and 0.0 to 0.42 mg/l in pre and post-monsoon seasons, the prescribed permissible limit is 0.01 mg/l prescribed by [21]. The high concentration of Mn is observed in south and north-west part of the study area in pre and post-monsoon (Fig.2a-b). The concentration of Mn is exceeding the permissible limits in 61% of groundwater samples in pre-monsoon and 78% groundwater samples are higher than permissible limits [21] in post-monsoon season. [8] proposed higher concentration of manganese (Mn) in Ghaziabad district due to more electroplating and manufacture of batteries etc. Manganese (Mn) may promote iron bacteria in groundwater.

4.2. Cadmium (Cd)

Cadmium concentration ranges from 0.01 to 0.97 mg/l and 0.38 to 1.36 mg/l in pre and post-monsoon seasons, the highest permissible limit of Cd for drinking is 0.003 mg/l as per [21]. The highest concentration of cadmium is observed in south of the study area in both monsoon periods (Fig.2c-d). All groundwater samples exceeded the permissible limit of [21] standard limits in both monsoon seasons. Cadmium is a cumulative environmental pollutant and its exposure to the body results damage of the Kidney, arteriosclerosis, cancer etc. [16,7]. The concentration of cadmium in groundwater samples may be attributed to the runoff from the agricultural sector where pesticides as well as cadmium phosphatic fertilizer are being used [19].

4.3. Chromium (Cr)

The concentration of Cr values varied from 0.10 to 0.51 mg/l and 0.81 to 5.28 mg/l in pre and post-monsoon seasons. All groundwater samples of the study area exceeded the permissible limit in pre and post-monsoon seasons as per [21,2] i.e., 0.05 mg/l. The highest concentration of Cr is observed in north-east part of the study area (Fig.2e-f). High concentration of Cr in groundwater may cause ulceration of nasal septum and dermatitis [18].

4.4. Copper (Cu)

The concentration of copper values range from 0.02 to 0.37 and 0.0 to 0.51 mg/l in pre and post-monsoon seasons. The highest permissible limit is 2 mg/l presented by [21,2]. The concentration of copper is under the permissible limit in all groundwater samples (Fig.2 g-h). Copper is an essential element, concentrated in several enzymes, its presence in trace concentrations is essential for the formation of hemoglobin [19].

4.5. Iron (Fe)

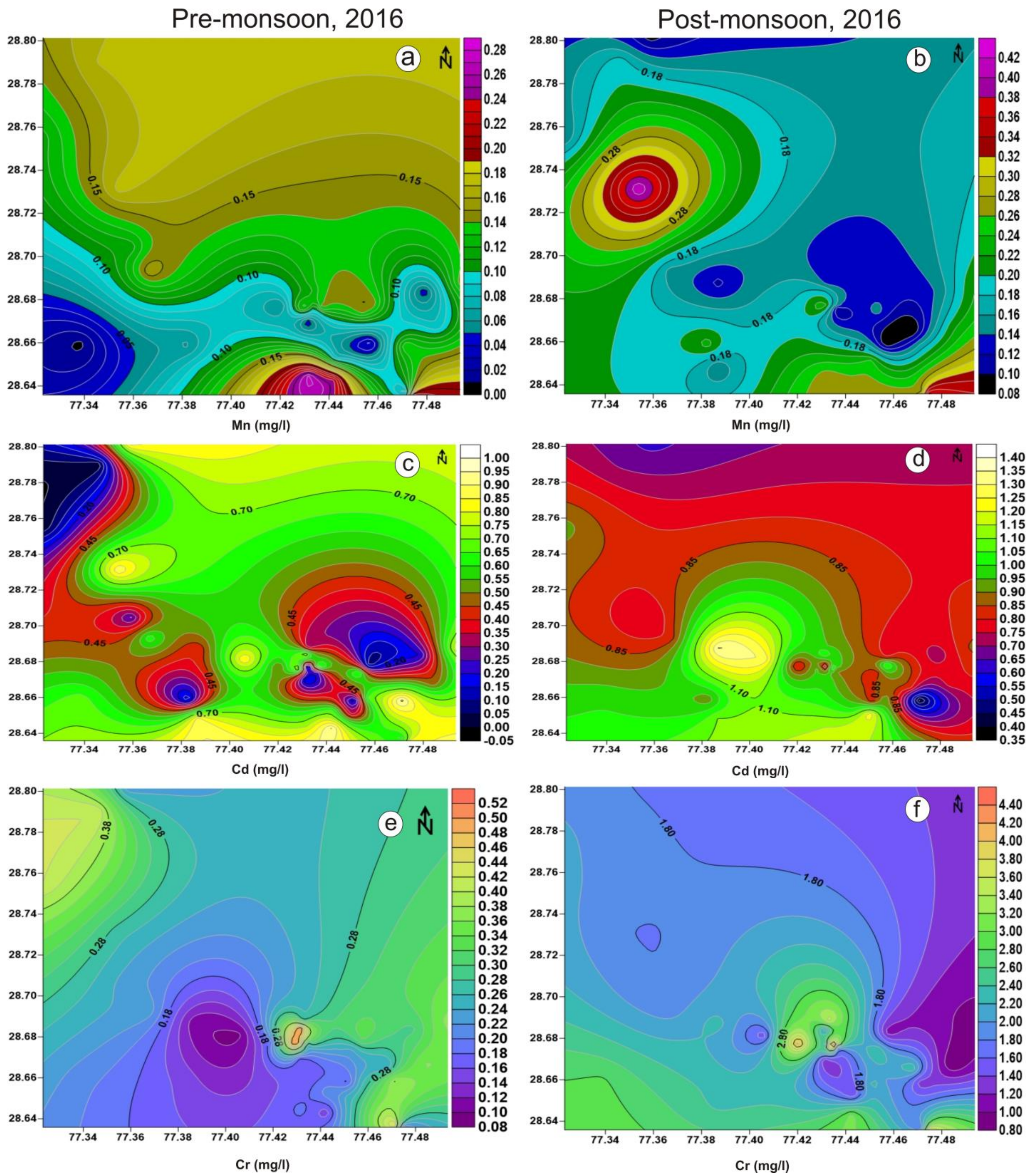
The concentration of iron (Fe) ranges from 0.05 to 0.20 mg/l and 0.99 to 2.27 mg/l in both monsoon periods. The highest permissible limit of iron observed in all the groundwater samples of post-monsoon, the permissible limit is 0.3 mg/l as per [21,2] (Fig. 2i-j). The highest concentration of iron is found in north-east part of the study area. The higher concentrations of iron may cause toxic effect to human health. Iron is essential element in human body [13]. The higher concentration of iron causes bad taste, discoloration, turbidity and staining [6,20].

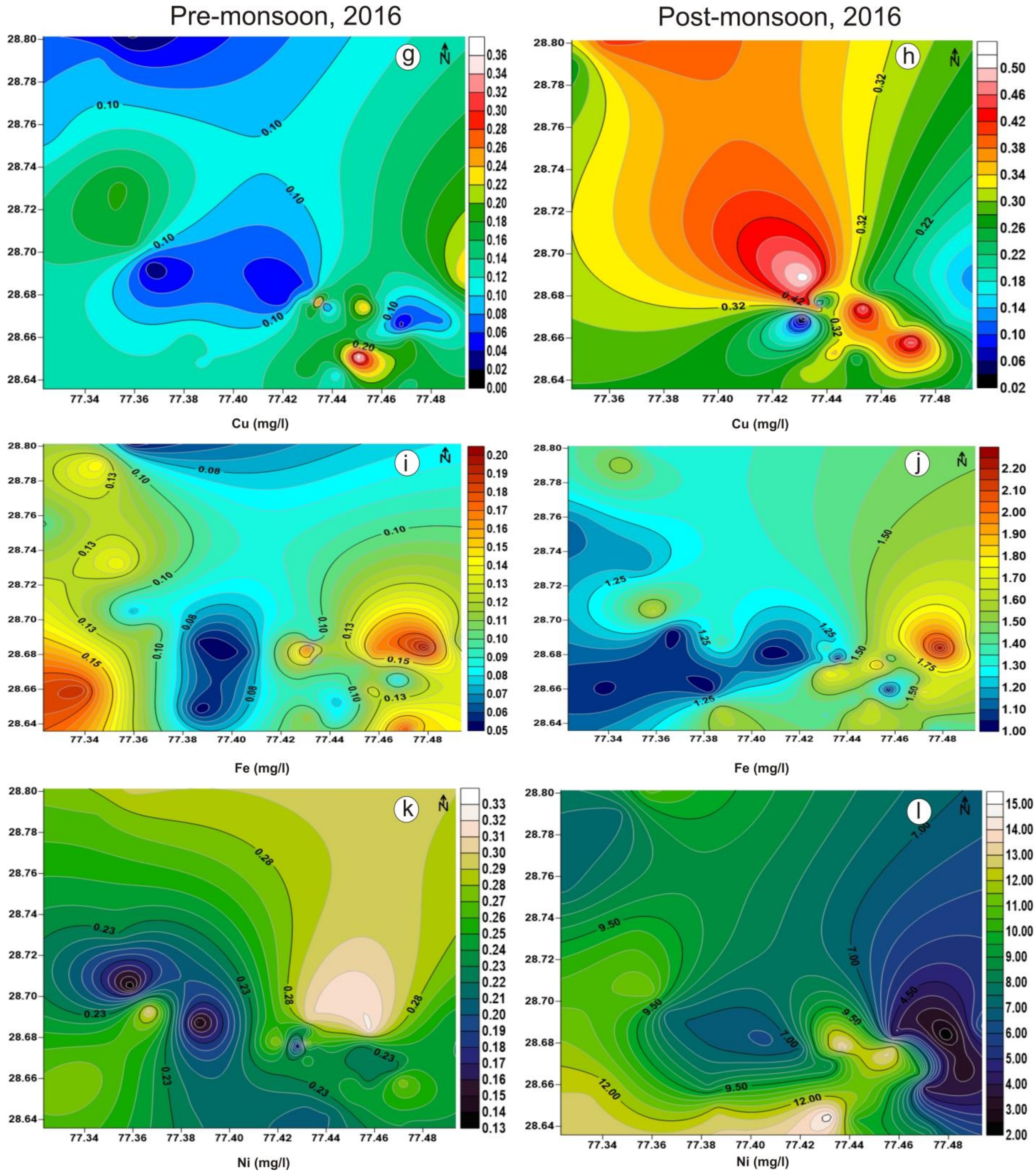
4.6. Nickel (Ni)

A nickel concentration range from 0.13 to 0.32 mg/l and 1.89 to 14.93 mg/l in pre and post monsoon seasons, the highest permissible limit is 0.07 mg/l as per [21]. The highest concentration of nickel in the study area is observed in north-east part of the study area. The concentration of nickel is highest the permissible limit in all groundwater samples. Nickel is present in a number of enzymes in plants and microorganism [19]. The primary source of nickel in drinking water is leaching from metals in contact with drinking water such as pipes and fitting.

4.7. Lead (Pb)

The concentration of lead (Pb) ranges from 0.12 to 0.48 mg/l and 0 to 6.21mg/l, the highest permissible limit as per [21,2] i.e., 0.01 mg/l in both monsoon periods. The concentration of lead is found over the permissible limit in all the groundwater samples. Lead concentration in natural waters increases mainly through anthropogenic activity [7]. The possible sources of lead in groundwater are diesel fuel consumed extensively in farms land, discarded batteries and paint. Lead is also used in some pesticides. Lead is toxic to the central and peripheral nervous system causing neurological and behavior effects.




Pre-monsoon, 2016
Post-monsoon, 2016
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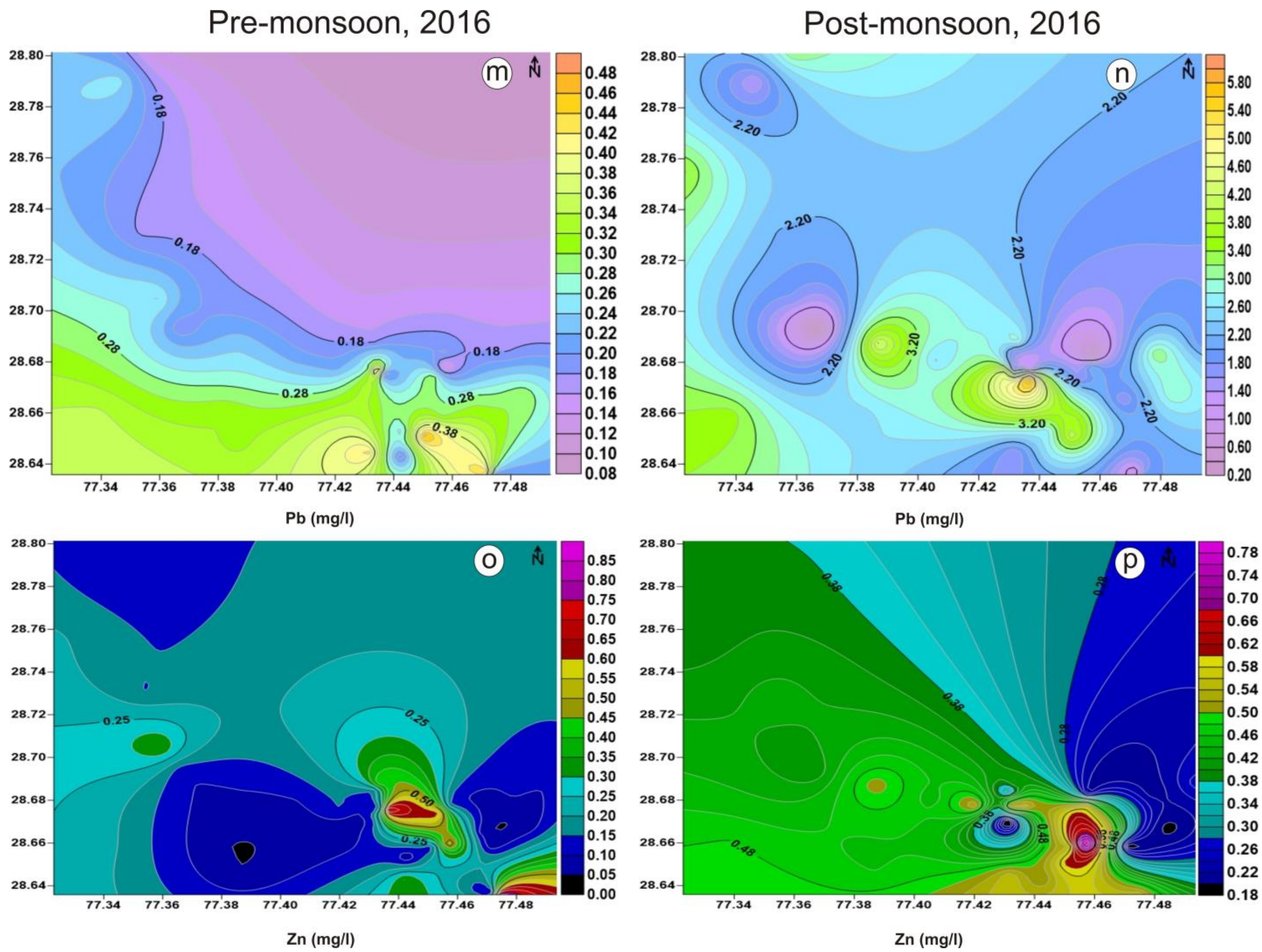

Fig. 2 (a-p). Spatial distribution maps of Mn, Cd, Cr, Cu, Fe, Ni, Pb and Zn in groundwater of the study area during pre and post-monsoon, 2016.

4.8. Zinc (Zn)

Zinc (Zn) concentration in the study area varies from 0.05 to 0.84 mg/l and 0.15 to 0.80 mg/l in pre and post-monsoon periods. The values of zinc in all the groundwater samples are found under the permissible limit (3.0 mg/l) as per [21] (Fig.2 o-p). The groundwater samples are clearly indicating the zinc deficiency in the study area and may leads to dwarfism, dermatitis and loss taste. Chronic dose of zinc increases the risk of anemia, damage of pancreas, lowers down High Density Lipoprotein (HDL) cholesterol levels and raises Low Density Lipoprotein (LDL) cholesterol levels which may enhance the symptoms of Alzheimer’s disease [11].

5. CONCLUSIONS

The present study examined the groundwater samples of the study area are slightly alkaline in nature in pre-monsoon and slightly acidic to slightly alkaline in nature in post-monsoon 2016 and also examined the values of all heavy metals in Ghaziabad district. The concentration of Mn, Cd, Cr, Ni, Fe and Pb are higher the permissible limit as per [21]. The spatial distribution maps decipher heavy metals concentration viz., geogenic and anthropogenic origin. Groundwater is getting contaminated at an alarming due to the influence of rapid urbanization and industrialization in the last few decades. Hence there is a need for regular groundwater quality monitoring to assess pollution from time to time for taking appropriate management measures in time to mitigate the intensity of pollution activity. So groundwater should be recharge through rainwater harvesting and improper disposal effluents of industries and domestics.

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