STUDY OF RAIN WATER COMPOSITION IN BHILAI, CENTRAL INDIA (CHHATTISGARH).

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ABSTRACT

In the framework of urban environmental control, it is necessary to know the effect of different types of pollutants on air and water quality. The precipitation is the main factor of water circulation, so it can contribute to the pollutants transportation from atmosphere into the soil and surface water. Data presented on the chemical composition of rain water collected at a sampling site Bhilai (India) from June 2007 to June 2008. Rain water samples were alkaline with an average pH 6.61. Only two case of acidic rain water recorded at Bhilai with pH < 5.5. Concentration of SO_4^{--} and Cl^- were balanced by higher concentration of Ca^{++}, K^+ and Na^+. So the pH remained approximately alkaline side. In this paper we present the results of the analysis of annual and monthly variation of the rainwater quality.

KEY WORDS

Rain water composition, anions, cations, pollutants.

INTRODUCTION

The rain is a basic component that plays a governing role in the hydrological cycle. The aim of our study is to understand the chemical composition of rain water of Bhilai. We analysed our samples for three

anions Chloride, Sulfate, Nitrate, including Cations Calcium, Magnecium, Sodium and Potassium. Except these contaminants we also analysed some specific parameters like pH, hardness, Conductivity, alkalinity, TDS in all 43 collected rain water samples. The purpose of this study is to investigate the variations in concentration of rain water components in rainy and non rainy season. A lot of studies have been done about composition of rain water of particular sites of all over the world. Diurnal variation of rain water in Coastel site in north carolina (Avery et al. 2001), a long term study on chemical composition of rain water at semiarid region dayalbag was conducted by (Ranjit kumar et al. 2002), anthrapogenic influence of rain water composition in the piracicaba river basin, southeast Brazil by (Lara et al., 2001) in northest Urugvey the study of rain water has been done by Zunckel et al. 2003, pollutants in rainwater runoff in Korea (Kim et al 2005). Rainwater shows a marked enhancement of H^+ and a corresponding decrease in NH_4^+ relative to aerosols (Harisson et al 1983). Rain water chemical is depending on degree and characters of the territary urbanization, relevence of pollution sources. As a result many chemical species present in to the rain water.

STUDY AREA

Description and demographic details of study area

The twin cities of Bhilai-Durg are a part of the Durg district of Chhattisgarh state. There are a large number of industries located in this twin city with a large production capacity. One large integrated steel plant, refractory plant, host of metal working industries, cement mills, chemical industries, and a large number of small scale industries in diverse area of operation are located here.

The population (above 1,000,000) and a large volume of transport activities through and in the area and large number of industries are responsible for ever increasing pollution load on rain water in this city. The sampling site was chosen as Bhilai House located at the threshold of Durg city beside the NH-6 or grand eastern highway GE road in Chhattisgarh state in India. The whole establishment is spread in 0.28 sq. Km area.

Meteorological details of site

Bhilai has a typical tropical mansoon climate with very hot summer heavy rains and moderate cold in winters. During the study period, a maximum temperature of 47.5^0C was recorded in May and the lowest temperature of 12.5^0C was in January. Maximum rain fall and relative humidity have been noticed in the mansoon season from June to September. Lower atmospheric pressures and consequently higher wind speed (>21-61 Km/h) have been observed in the summer- rainy season (May – September).

The meteorological data also shows that the most predominant wind direction in south- west (17%) and west (14%) during the rainy season: north-east (12%) and north (9%) during the rest of the year. Percentage of calm has been noted on 32% days of the year.

MATERIALS AND METHODS

Sample collection

Rain Water sampling and analytical procedure

Rain water samples were collected in polyethylene sampling bottles. All the samples were filtered in order to separate solid suspended matter with a filter paper. The recovered particulate matter was analysed with various equipment.

All sampling bottles were washed and dried before sample collection and kept closed, clean, and in absence of light inside a cupbord. 43 rain water samples were collected from June 2007 to June 2008 at Bhilai.

For analysis of various parameters of these samples different equipments (pHmeter, conductivity meter, titration method, turbiditymeter, Varian FS 240 AAS and spectrophotometer 106) were used.

Chemical analysis

The pH measurements were carried out as soon as the samples were collected with pH meter. The pH meter was calibrated before every measurement using standard buffer solution of pH 4.00 and 7.00 (SCFI

2000a). The conductvity was measured wirh an electric conductivitymeter. Conductivitymeter was used after calibration with KCl standard solution (SCFI, 2000b).

An aliquot of each sample was used for the determination of major ion concentration. The cations Na^+ and K^+ were determined by Flame photometer whereas Ca^{2+} and Mg^{2+} by titration method. The anions Cl^- , SO_4^{--} and NO_3^- ions were determined by titration method, turbiditymeter, and spectrophotometric determination respectively. All solutions were prepared double distilled water with standard solution prepaired by dissolution of 99% purity analytical grade salts.

In Bhilai especially during spring season the rain water was slightly acidic, as a result of vehicles emissions, nearby various industrial plants. All the high values of ions were due to anthropgenic sources, including urban transport and loss of green plants and organic sources, such as soil and sea water.

The samples tended to have high concentration of chloride because of the sea vicinity. So we could easily conclude that chloride is arising from sea salts.

The result of sulphate and even chloride concentration had big variation. Wind speed amount of rainfall and some other meterological condition such as local winds might cause abnormally values.

The analysis of the samples suggested that low pH of rain water determined the vapour salts to decompose in ions.

The analysis also revealed their sources. Anthropogenic emission (industrial plant, transport, and use of fossil fuels), sea salt compoent, (especially Cl^- , SO_4^{--}) construction component (particulate matter, solid building wastes) etc (Alina Barbulescu 2010). The combustion process in motor engines also generates NOx, So both SOx and NOx determine the pH of rain. SO_3 rapidly combines with moisture and quickly washed out the atmosphere by rain and settle out as an aerosol and in rain water SO_4^{--} is high as compared to air.

RESULT AND DISCUSSION

Quantity of rain

Total 43 rain water samples were collected. The largest number of monthly events occurred in June (11) July (8) and August (8), followed by September (5), November (1), February (2), March (2), April (1) and June 08 (5). No rain events were observed in month of October, December and January .The month of May were considered the dry season.

Study of Variation in pH

The pH of individual precipitation events ranged from 5.15 - 8.28 with both acidic and alkaline range. In this study the mean pH value was 6.61, which is higher than the widely accepted background rain pH of 5.6 (Charlson and Rhode, 1982). The result is quite similar than other site of india.The pH of natural rain water is controlled by dissolved CO_2 due to interaction between water droplets and carbon di oxide. Figure 1 showes variation of mean pH. The highest precipitation acidity 6.02 found in spring season samples especialy in period of March and April.

The frequency distribution of pH is shown in Figure- 2. Only 4.5% of 43 rain samples showed a pH below 5 - 5.5 indicate that acidity is not common in rain fall of Bhilai. The abundance of pH from 6 – 8 (above acidic range) with 93% of 43 rain water samples indicates the presence of alkaline substance in the rain water (Hu et al 2003).

Acidic precipitation has been reported in different parts of the world. In Mexico previous studies recorded pH values range from 4.54 and 4.58 (Gracea et al 2006 and Bravo et al 2006) reported an acidic nature of rain. Other studies of Mexico, Greece, India pH ranging from 6.58 -7.2 (Lara et al 2010,Nastos et al 2007,Chandra et al 2005, Khemani et al 1985, Saxena et al 1996) reported an alkaline range. Other study of Ankara, Turkey, reported alkaline pH values due to high $CaCO_3$ loading from alkaline soil (Topcu et al

2002). Thus the mean pH of 6.61 for Bhilai rain samples likely reflects a strong impact on alkaline soil dust on rain water composition.

Study of Chemical composition

The variation of monthly mean concentration of major inorganic ions and SD of rain water is illusterated in Table - 1. Figure 3, 4, 5, and 6 representing the variation in mean concentration of cations. It can be ordered in descending order as $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$, with values ranging from 75 to 0.4 mg/l. The order of anion mean concentration (Figure 7, 8, 9) was $Cl^{-} > SO_4^{--} > NO_3^{-}$ with values ranging from 19.13 to 1.429 mg/l.

The high concentration of cations Na^{+} and K^{+} found in month of March may be due to the small event of rainfall. In every rain fall Ca^{2+} and Mg^{2+} were maximum. The smaller amount of rainfall is expected to produce higher concentration of chemical species in rain water due to removal of suspended particles by wet deposition (Chandra et al 2005). During October, December, January no rain was found in Bhilai. On the other hand the concentration of anion icreased during Februery (Cl^{-}), March, April (SO_4^{--}, NO_3^{-}) may be due to the prevailing meterological condition in Bhilai that do not allow complete dispersion of NO_2 and SO_2(INGEI 2002).

Figure 10, 11, 12 are the representative chart showing the variation of special characterstic (Alkalinity, conductivity, TDS) in rain water samples. Alkalinity is measured by a double titration. Maximum Alkalinity of rain water found in month of February but in month of November, March and April it was very low. Average alkalinity of whole year was found 41.25 ppm. mean Conductivity of rain water samples was maximum in the month of Ferbuary (non rainy season) but it was minimum in the month of August and September. Average value of Conductivity of whole year was found 0.057 ms. Maximum TDS was also found in month of February but it was very low in samples of month of August. Mean value of TDS of whole year was found 81.19 ppm. The reason of lowering these properties was

precipitation.Whereas higher values in month of february depends upon it was non rainy season and the frequency of rain was low.

Comparision with other selected site

Table -2 shows mean concentration in rain water for present study and other results reported for different selected site of India and worldwide. The pH of present study 6.61 is similar to pH 6.78 Tirupati India (Chandra et al 2005) 6.58 Monterrey Maxico (Lara et al 2010) and lower than Athence 7.2 (Nastos et al 2007). This may be due to the latter region having a high load of suspended alkaline atmospheric particles. It is higher than other region of Maxican city 4.5 (Garacia 2006, and Bravo 2006).

In this study Anions were lower than other site but Cl^- concentration was higher than Maxican city whereas it was lower than Athence, the concentration of NO_3^- was lower than all sites but the concentration of SO_4^{--} was similar to El Tajin however it was lower than all samples of different sites.

Correlation matrix

To find out the effect of pollutants in the atmosphere and how these ions are associates with the possible sources of pollutants and the gaseous reaction occuring in the atmosphere the correlation between ions was calculated for all samples are given in table - 3. A significant positive correlation (>0.5) were observed between TDS with conductivity and Chloried, conductivity with Chloried, Potassium with Sodium and Magnecium with Chloried indicating there origin from similar sources whereas significant negative correlation (> - 0.5) were observed between pH and nitrate, calcium with conductivity and TDS indicating the oxides of nitrogen are responsible lowering the pH.

CONCLUSION

The study of the chemical composition of rain water was during June 2007- June 2008 reveals the following conclusion.

In the studied case, the rain water is typically alkaline revealing that the acidity is being neutralized. An average value of annual rainwater pH was 6.61, perhaps due to neutrilization. Only 4.5% of the 43 rain

samples showed a pH between 5 – 5.5. Whereas 93% samples had pH from 6 – 8 because of high loading of Ca ions in the form of $CaCO_3$ comes from various Sources. Chemistry of rain water is dominated by Ca^{2+}, Mg^{2+}, and SO_4^{--}. The principal cations and anions in decresing order, are $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$ and $Cl^{-} > SO_4^{--} > NO_3^{-}$. The presence of Salphate and nitrate ions in water is due to especially to anthrapogenic influence. The monthly variation in ionic deposotion is influenced by rate and quantity of rain fall and concentration of other ionic species. No very strong and specific correlation was found between various ions of rain water.

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Table 1 – pH and major ionic chemistry of rainwater over Bhilai, India.

Constituents(mg/l)	Minimum	Maximum	Average	SD
pH	6.02	7.06	6.61	0.378
Conductivity (ms)	0.031	0.1188	0.057	0.029
TDS	15.998	59.4	81.19	14.08
Alkalinity	35	52.5	41.25	4.96
Sulphate	2	10	6.049	2.84
Chloride	9.925	39.704	19.13	10.156
Nitrate	0.5	1.9	1.429	0.499
Ca^{++}	40	75	57.76	10.76
Mg^{++}	20	62	39.49	17.77
K^{+}	0.2	4.7	1.02	1.43
Na^{+}(ppm)	0.3	5.2	1.23	1.18

Table 2 - Mean concentration of major ions in rain water(mg/l) from different reagions

location Site	pH	Cl^-	NO_3^-	SO_4^{--}	Ca^{++}	K^+	Mg^{++}	Na^+
Present study Bhilai, India	6.61	19.13	1.429	6.049	57.76	1.02	39.49	1.23
Lara et al 2010, Monterrey, N.L. Mexico	6.58	17.61	19.36	44.73	243.26	28.67	60.58	98.46
Garacia et al 2006, Estado de Mexico	4.54	10.2	26.8	56	7.67	5.27	3.53	1.84
Bravo et al 2006, E l Tajin, Veracruz, Mexico	4.58	13.82	11.61	6.87	5.98	3.08	0.039	12.17
Nastos et al 2007,Athence, greece	7.2	342.5	45.2	173.2	342.5	24.2	3.1	108.1
Chandra et al 2005, Tirupati, India	6.78	34.45	42.33	135.12	156.521	38.05	60.85	36.39

Table 3 – Correlation between different parameters of rain water

	PH	Cond. (ms)	TDS	Cl-	Ca++	Mg++	Alkalinity	SO4--	Na+	K+	NO3-
PH	1										
Cond.(ms)	-0.12	1									
TDS	-0.12	**0.99**	1								
Cl-	0.33	**0.61**	**0.61**	1							
Ca++	0.32	**-0.55**	**-0.55**	-0.32	1						
Mg++	0.46	0.44	0.43	0.63	-0.38	1					
Alkalinity	0.21	-0.28	-0.26	-0.08	0.19	-0.21	1				
SO4--	-0.49	-0.33	-0.33	-0.18	0.5	-0.42	-0.02	1			
Na+	-0.51	-0.09	-0.09	-0.22	0.00	-0.32	0.05	0.43	1		
K+	-0.51	-0.14	-0.14	-0.25	-0.01	-0.34	0.12	0.43	**0.98**	1	
NO3-	**-0.68**	0.37	0.38	-0.09	-0.17	-0.26	0.11	0.34	0.37	0.29	1

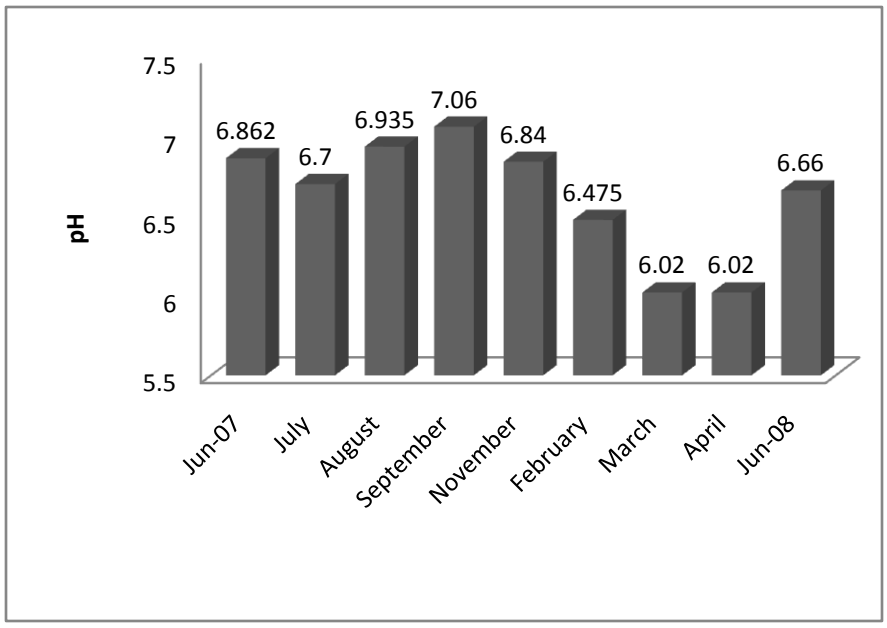

Figure-1 Monthly variation in pH of rain water

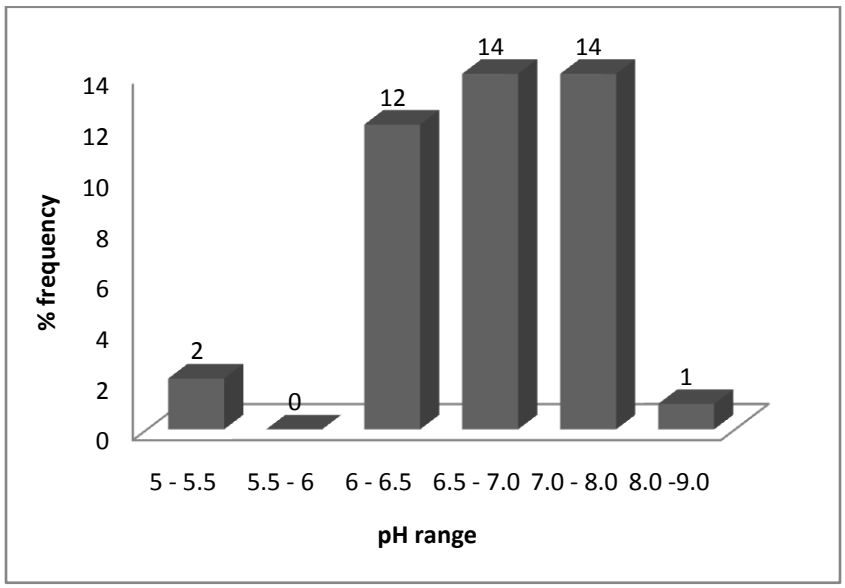

Figure-2 Frequency of pH in different samples

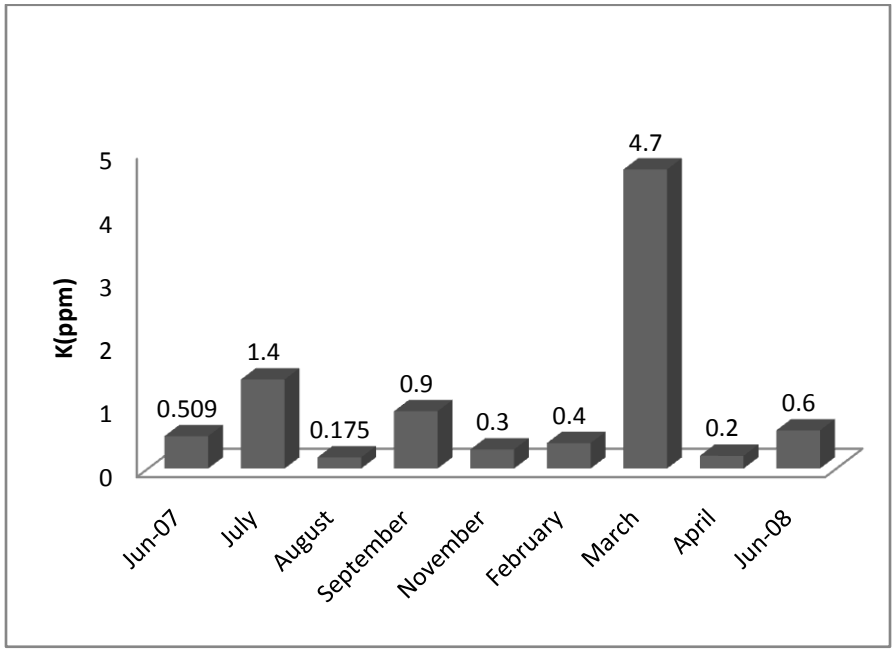

Figure- 3 Monthly variation in K^+ of rain water

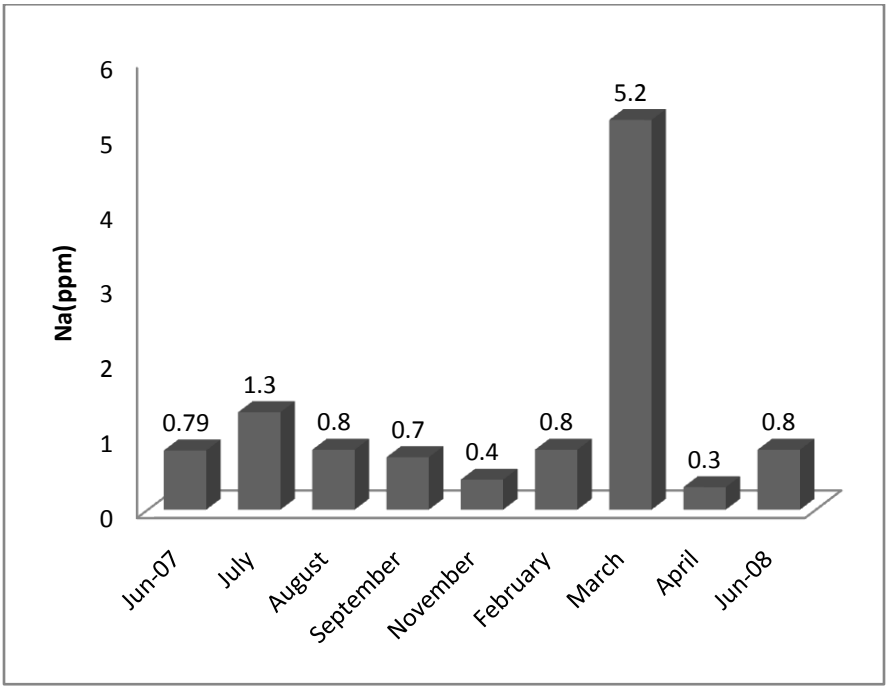

Figure-4 Monthly variation in Na^{+} of rain water

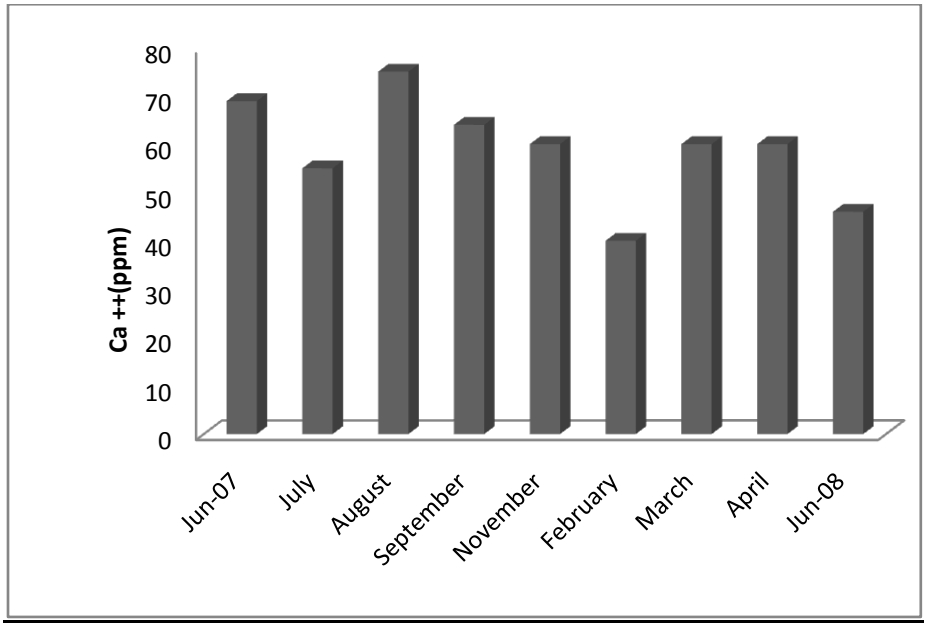

Figure - 5 Monthly variation in Ca^{++} of rain water

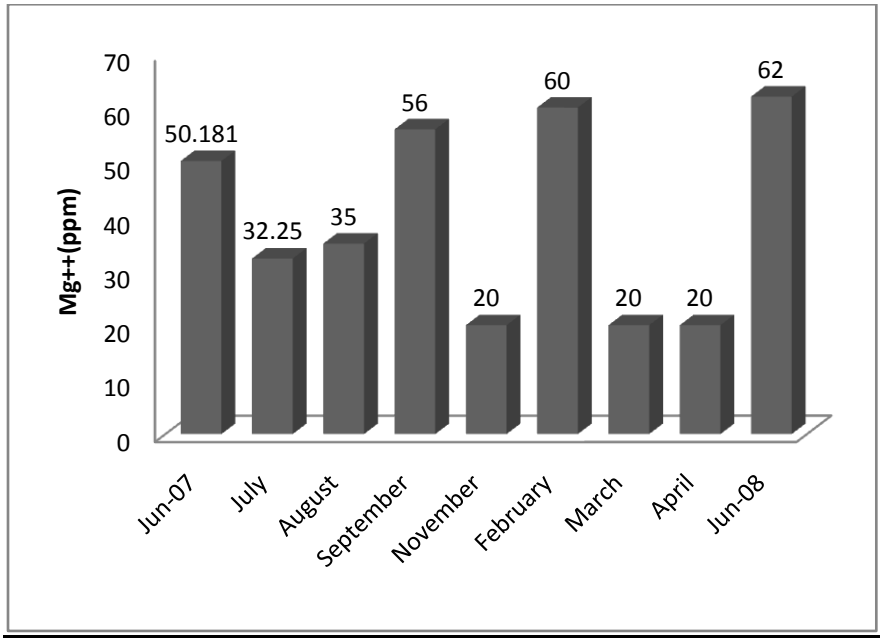

Figure- 6 Monthly variation in Mg^{++} of rain water

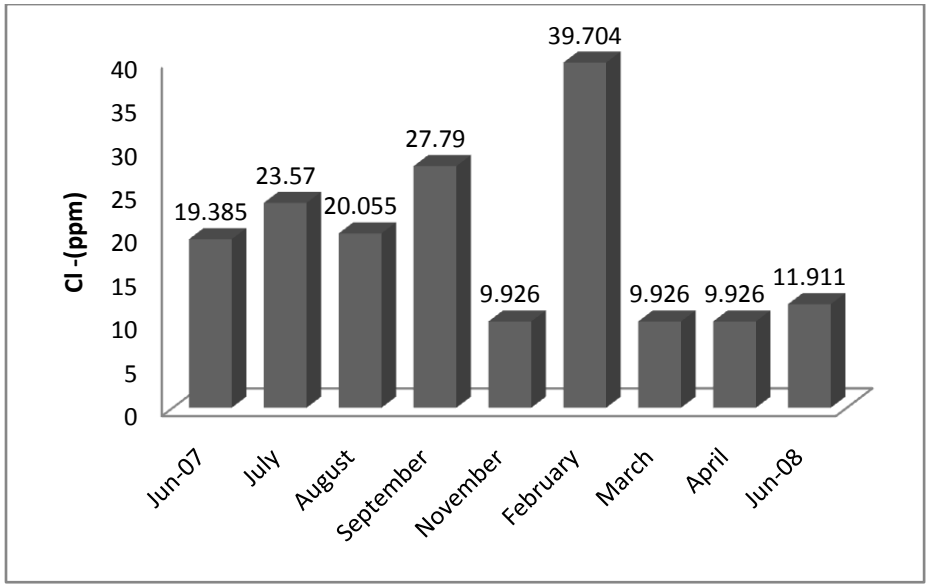

Figure- 7 Monthly variation in Cl ¯of rain water

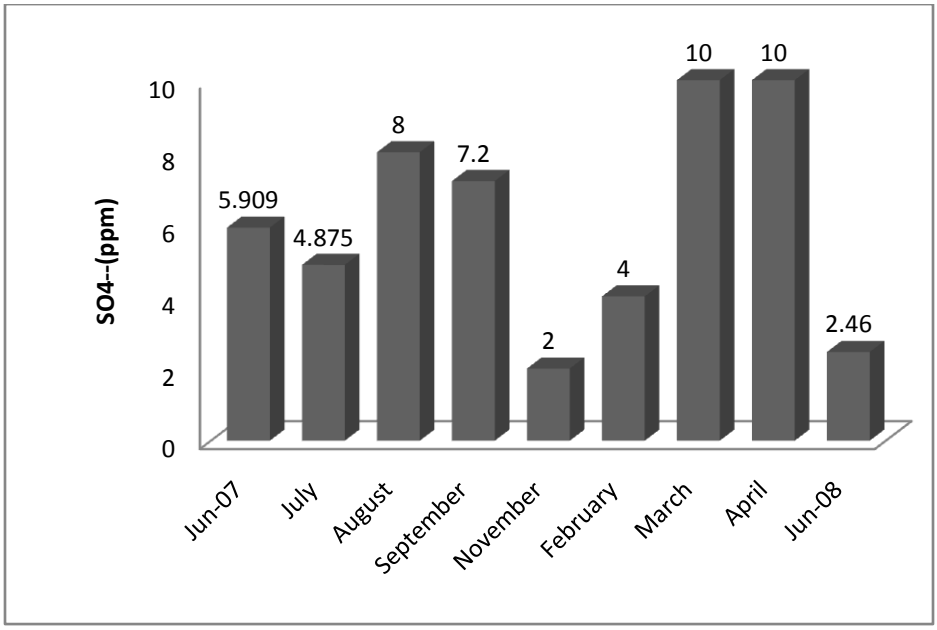

Figure- 8 Monthly variation in SO_4^{--} of rain water

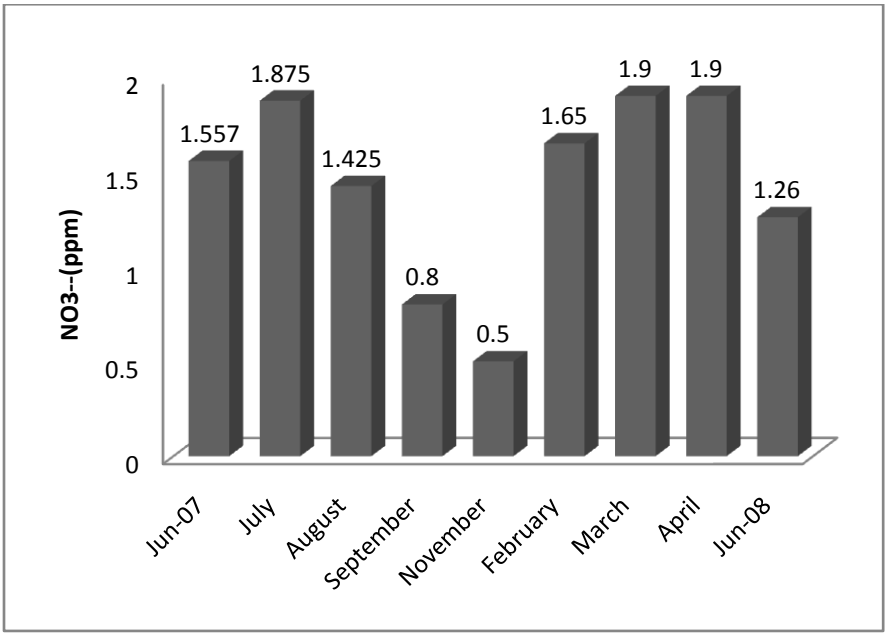

Figure – 9 Monthly variations in NO_3^- of rain water

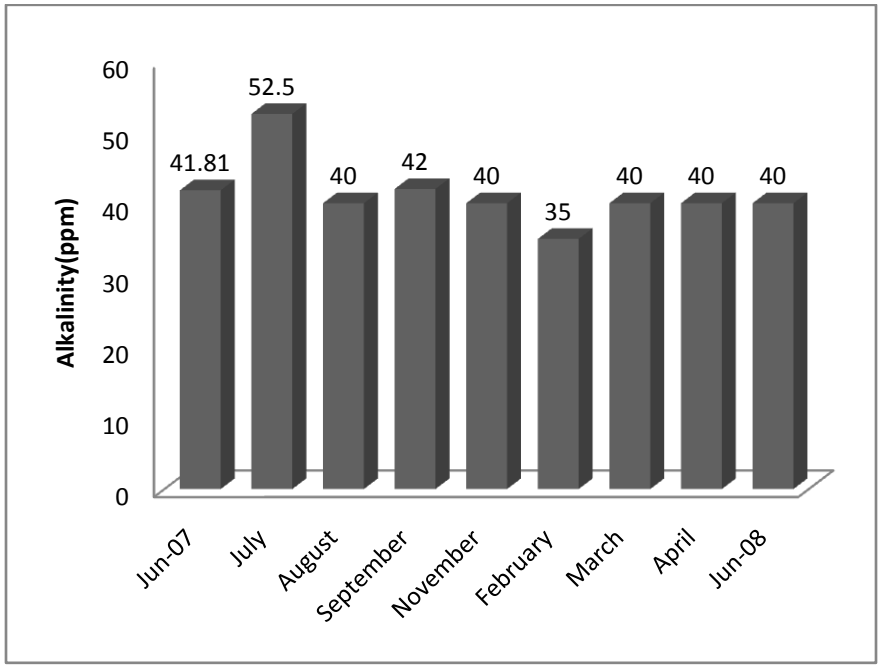

Figure - 10 Monthly variations in alkalinity of rain water

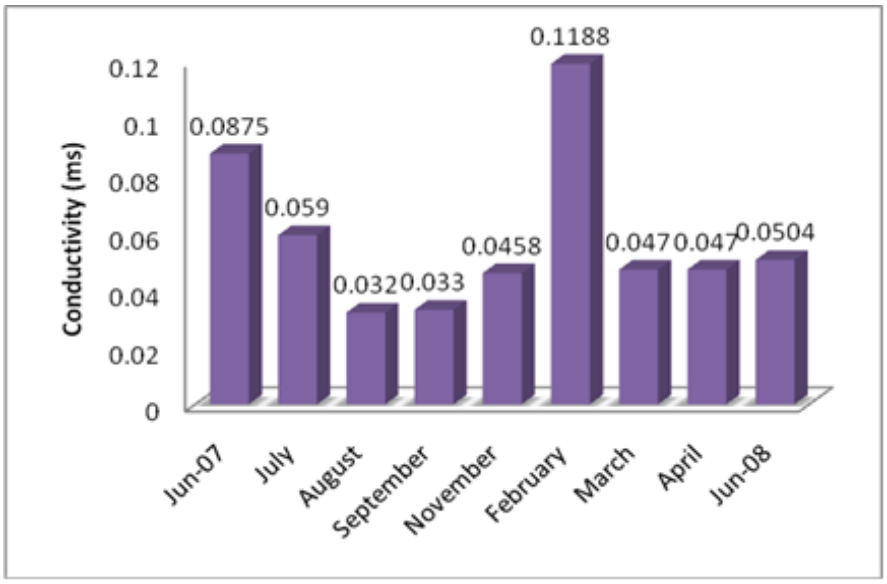

Figure - 11 Monthly variations in Conductivity of rain water

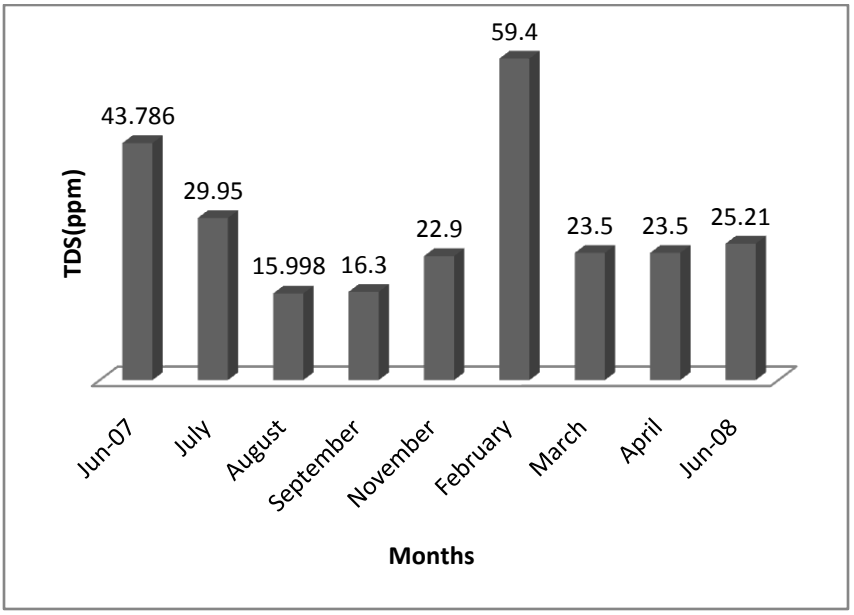

Figure - 12 Monthly variations in TDS of rain water