COMPARATIVE STUDY OF SOME SPECIFIC CONTAMINANTS IN THE AIR AND RAIN WATER AT BHILAI, CHHATTISGARH

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KEY WORDS

Atmospheric pollution, Major and Trace elements, F S 240 AAS, Spectrophotometer

ABSTRACT

The aim of this Paper is analytical studies of contaminants at particular sampling site which is free from any near source effect and to develop correlation between metals and human health, air and rain water pollution and correlation between toxic and heavy metals with environment. 24 hours samples were collected twice every month by a high volume sampler on a glass micro fiber filter paper. The particulates collected from November 2006 to October 2008 were extracted employing an automatic digestion system.

The atmospheric concentrations were determined in these samples by Fast Sequential FS 240 AAS, Spectrophotometer 106. Some more equipment were also used for some specific ions like turbidity meter, ion selective electrode meter, flame photometer, wourtzet method for sulphate, fluoride, sodium, potassium, arsenic respectively.

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In this paper we found by Enrichment calculation that high enrichment of Aluminium, Iron and Zinc in air and simultaneously Zinc and sulphate found in rain water samples. To Inspite of there are number of work in the field of various analytical challenges. These challenges stem from the fact there exist great uncertainty about the adsorption and complexation behaviour of elements and compounds in the environment. This paper proposes to carry out a special study on the pollutants and risk assessment of natural or anthropogenic contaminants in air and rain water of the industrial locations of Bhilai-Durg region.

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INTRODUCTION

Word "environment" is used describing "natural" environment and means the sum of all living and non-living things that surround an organism. Environment includes all elements, factors, and conditions that have some impact on growth and development of certain organism.Our environment is polluting progressively by human activities. Environmental pollution has become a global issue and it is creating by pollutats. A pollutant is a waste material that pollutes air, water and soil. Three factors determine the severity of a pollutant: its chemical nature, the concentration and its persistence.

Here we are discussing various pollutants in terms of trace elements. Trace elements is commonly used to describe substances which cannot be precisely defined but most frequently occur in the environment in concentration of a few ppm or less but they become very toxic at a little higher levels. 25 elements detected in living organisms that seem to be highly essential for the higher animals and humans. This includes the metals and non-

metals both. But its concentration must be right its less supply leads to deficiency, optimum supply helps in healthy growth over supply leads to toxicity and even eventual death to the organism.

Study of the some trace pollutants of the atmosphere concerns mainly with the toxic elements. The word toxic stands for relatively mobile elements (viz. As, Be, Cd, Co, Cr, Cu, Hg, Mn, Ni , Pb, Sb, Sn, Te, Tl, V, Zn) for which values are reported at levels, considered as harmful to the nature and the life (Wood et al 1974, Galloway et al 1982) had carried out a good review and assessment on the trace metals in the atmospheric deposition.

In recent years, atmospheric particulate aerosols have been under intense consideration. They have been suggested to be responsible for possible climatic effect due to their capability to modified the solar or terrestrial infrared radiation (SCEP, 1970), possible modification of cloud processes (Parungo et al. 1982), other environmental effects such as visibility reduction, acidic precipitation and the transport of pollutants from industrial regions to remote and pristine areas (Marshall et al. 1986, Wolff et al. 1986, Swietlicki et al. 1996). Water bodies are also known to be effected by the atmospheric deposition of the trace elements from urban areas (Nguyen et al. 1990 Keeler and Pirrone 1996). Measurement of trace elements in particulate aerosols is of immense importance for toxicological, environmental and occupational health studies. There have been extensive studies in the temperature climate mid- latitudinal countries to measure the trace composition of the particulate and size fractioned aerosols (Lee et al. 1994) gives a good general review of such studies. A close relationship between the trace metal composition of particulate matter and the fixation of the SO_2 in the form of gypsum on limestone has been experimentally demonstrated (Rodrigueznavarro and Sebastian, 1996). However, the

long term effect of the presence of the trace elements in air and their subsequent deposition is still not very clear. Uncontrolled emissions from electric Arc furnaces are also reported to pollute the environment (Pandey et al. 2007). However, the sampling locations were optimized in this work and one such site was chosen which is supposed to give the most representative and averaged pollution levels in the study area.

A lot of studies have been done in the field of contamination of rain water and air (Bernard et al 1956, 1977, 1975, 1985, 1983, Burg et al 1976, Honikel 2004, D'Surney etal 2005, Himer etal 2011). The atmospheric pollutants were washed out with precipitation (Patel et al **2009).** The source of trace metals in rain water can be either natural (crustal weathering, bubble ejection from sea water, volcanism and methylation reactions) (Duce and Hoffman 1976) or anthropogenic (Duce et al., 1976: Mackenzie et al., 1979).

Lead concentration in the air and rain water was found to be much higher than reported for other regions of the world (Polkowska et al 2001, Steinnes et al 2006, Ridame et al 1999, Lacerda et al 2004, Jackson et al 2004). The trace metals particularly iron, manganese and copper have been held responsible for the catalytic activity of the rain-water (Manoj et al., 2000). The twin cities of Bhilai-Durg are one of the most developed industrial cities in Chhattisgarh. The first environmental survey of Bhilai-Durg twin cities was done by Pandey et al. 1998. Anthrapogenic effects are a valuable resource of pollutants in rain water (lara et al 2001, Patel et al 2009) and ambient air. The trend and type of elements present in air have not varied much in last 10 years (Pandey et al 2010).

Toxic metals are metals that form poisonous soluble compounds and have no biological role, i.e. are not essential minerals, or are in the wrong form.

Heavy metals are toxic, but some heavy metals are essential, have a low toxicity, and some are non-toxic. Radioactive metals shows radiologicals and chemical toxicity. For example metals in an oxidation state Chromium(III) is an essential trace element, but chromium(VI) is a carcinogenic nature.. Decontamination for toxic metals is different from organic toxins: because toxic metals are elements, they cannot be destroyed. Toxic metals can bioaccumulate in the body and in the food chain. Therefore, a common characteristic of toxic metals is the chronic nature of their toxicity. Various industries are responsible for environmental pollution due to presence of toxic metals their in effluents they attack on specific organ (Dara 2008).

MATERIAL AND METHODS

Description and demographic details of site

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 of 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 urban air in this city.

Study area and sampling site

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. The Bhilai Institute of Technology is located in

this premises and one of the building was used as sampling location. The size fractionated sampling device was kept on the roof at a height of 10 meter.

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 monsoon 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.

Sample collection

Air sampling

Air sampling was carried out at Bhilai institute of technology Bhilai house Durg. The station was selected keeping the population density and wind directions under consideration in order to obtain a representative sample. The location was not directly affected by the industrial or vehicular emissions. The High volume sampler at BIT (Durg) (sampling station) was kept on the rooftop at a height of about 10 meter in order to reduce the likelihood at larger particulate collection. Ambient air samples were collected using high volume air samplers during a 24-h period. Sampling was carried out from November 2006 to October 2008 at least twice in each month at location. The frequency of sampling was somewhat less during the rainy season. The samples were collected on what man glass micro fiber filter papers GF/A 20.3 X 25.4 c.m. After loading the filter papers were kept in desiccators and weighed on a digital

electronic balance. Rain water on an episodic basis has also been collected during the study period.

Rain Water sampling

Rain water sampling (44 rain water samples) was carried out at Bhilai institute of technology Bhilai house Durg. After filtration it was collected in sampling bottles for analysis of its various parameters using different equipments (pHmeter, conductivity meter, titration method, turbiditymeter, Varian FS 240 AAS (figure 1) and spectrophotometer 106).

Analytical Procedure

Sampling of ambient air for particulate was done as per Indian standard 1S: 5182 (part IV)-1973. Air was drawn into the covered housing of HVS with RPM (Respirable particulate matter) attachment at a flow rate of 1-m^3/min. The equipment was capable of size fractionated collection in two size ranges i.e. above and below 10 micrometers. The larger particles were collected in a cyclone and the smaller fractions were captured through the filter paper. Glass fiber filters was equilibrated in desiccators containing silica gel after sample collection and weighed on a pre calibrated electronic balance. The mass concentration of suspended particulate matters in µg/m^3 was computed by measuring the mass of collected particles and volume of the air sampled. Total particulate loaded glass fiber filters were extracted using a standard hot extraction procedure using concentrated nitric acid and hydrochloric acid (aquaregia). Filter papers having particulate samples were digested by aquaregia on a hot plate in beaker cover with watch glasses. After complete digestion of particulate they were made up by 1:1 HCl in 50 ml voluetric flask.

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RESULTS AND DISCUSSION

Yearly average concentration of pollutants in rain water and air

Yearly average results of different parameters of different month's rain water analysis showing below by graphical representation. This result is compared with result of air analysis during this sesson. With the help of statistical analysis we have analyse number of major and toxic contaminants. The result shows in table-1, figure 2, 3 and 4 which indicates that Aluminium shows its higher concentration in air but its presence is very small in rain water, SO_4^{--} is very high in rain water but it is present in very small amount in air, position of Zinc is also very valuable in air but it is also found in rain water, Iron condition is high in air as compared to rain water, Sodium and potassium are high in air, but Cadmium is representing its high concentration in rain water, Copper position is also high in air as compared to rain water. Though all elements are showing that own valuable presence in rain water however fluoride, and Chromium are not appering its presence in rain water. It is very interesting that Pb shows high concentration in rain water in month of January (off rainy season) whereas it is totaly absent in rain water of remaining month of year (including rainy season). Its average position is high in rainwater than air samples.

The observation of literature data confirms a decrease of Cd, Cu and Pb concentrations in rain waters from the beginning of the nineties. On the other hand, no sharp evolution has been observed for zinc concentrations. The comparison between heavy metals concentrations, always ranked as [Zn]>> [Pb] >> [Cu]>> [Cd] (Deboudt et al 2004). Higher enrichment found in rain compared to atmospheric particulate for certain metals (Cd, Cu, Ni, Pb, Zn,) Duce et al., 1976; Buat menard and chesselet, 1979; Chen and Duce 1983).

Rain water contains particulates from airborne dust. The amount of particulates varies greatly based on the weather. A sample from a brief intense storm after a dry period gave us more particulates than a sample taken in the middle of several days of rain.

Comparision of Aluminium in rain water and air

During analysis we found that Aluminium is in higher concentration in air as compaired to rain water (Figure 5). It is most probably found in excess concentration in month of march, april november and december however it is neglisible in rain water sample. The largest source of airborne aluminium containing particulate in the form of silicates, oxides, and hydroxides is the flux of dust from soil and the weathering rocks.

. Anthrapogenic releases are in the form of air emission, waste water effluent and solid waste primarly associated with industrial processes. The behaviour of aluminium in the environment depens upon its coordination chemistry and the characterstics of the local environment espicially pH. Aluminium has a stronger attraction for fluoride in an acidic environment compaired to other inorganic ligands. Due to this reason fluoride also posse's higher concentration in air as compaired to rain water. There are varying levels of aluminium in the atmosphere, depending on the location of the sampling site, meterological condition and the level of industrial activity or traffic in the area.

Comparision of Iron in rain water and air

During monthly analysis of air and rain water we found that Iron is in high concentration in air samples in month of July as well as in march but it is about to none in rain water samples of whole year (Figure 6). The concentration of Iron is high in air because of industrial and anthrapogenic impact.

Iron makes up 5% of the earth's crust by weight and ranks next to oxygen, silicon and aluminium in abundance. Its abundance is much higher in areas occupied by iron ore and laterite. Despite that, iron content of rainwater, surface water and groundwater is usually very low owing to its insolubility under conditions of alkalinity and oxidising

(aerobic) conditions prevailing in most natural environments(test report by Dr. R. Jagadishwara Rao AP 517502, India 2008).

During rainfall very fine particles get mobilized with the run-off. Iron is only soluble in water under acidic conditions as Fe^{2+}. The pH in the test results is almost neutral, which definitively does not allow iron to be present as dissolved species (test report by Dirk Walther (not verified) on 2008). Iron in the water sample should present in an insoluble form (by Leela Iyengar (not verified) 2008.

Oxygen present in the air converting soluble ferrous iron into insoluble ferric iron leading to high turbidity owing to high suspended solids. These all conditions are responsible for lowering the iron content in rain water as compare to air samples.

Comparision of Sulphate in rain water and air

Monthly variation of sulphate in air and rain water shows that it is very high in month of march and april (off rainy season), it was also very high in all samples of rainy season (Figure 7). It is not in very high concentration in air samples. Because SO_3 rapidly combines with moisture and quickly washed out the atmosphere by rain and settle out as an aerosol so in rain water SO_4^{--} is high as compared to air (Johnstone 1958). Sulfate is one of the major dissolved components of rain. So SO_2, SO_4^{--} mass in clean dry air is as small as compaired to annual emission from anthropogenic sources.

Comparision of Copper in rain water and air

The concentration of copper in air is almost high as compared to rain water (figure 8) showing that in month of april (off rainy season) in starting summer copper is high in rain water as well as in june month which is starting rainy season. In air analysis we found that copper is high in all months of year but it is totally absent in

month of august and september. Its position is very high in air samples in month of december.

Copper is a very common substance that occurs naturally in the environment and spreads through the environment through natural phenomena. Copper can be released into the environment by both natural sources and human activities. Copper enters the air, mainly through release during the combustion of fossil fuels. Copper in air will remain there for an eminent period of time, before it settles when it starts to rain.

Examples of natural sources are wind-blown dust, decaying vegetation, forest fires and sea spray. Copper is often found near mines, industrial settings, landfills and waste disposals. Usually water-soluble copper compounds occur in the environment after release through application in agriculture.

Comparision of manganese in rain water and air

On analysis of manganese in air and rain water we found that it is not very high in samples of ambient air but its valuable presence is found in all samples of rain water of whole year figure-9. Because wet deposition is an important source of soluble, stable Manganese in rain water.

Comparision of Arsenic in rain water and air

Arsenic is present in ground water system and in rain water in minimum range of concentrstion. It occurs in phosphate rock used to make fertilizer and detergent and may thus end up in both rural and urban waterways**.** During analysis we found that the concentration of Arsenic is high in rain water samples specialy in month of march, june, august and september (figure 10) but it is not present in samples of air because it is heavy metalloid and very similar to the phosphorus so it is soluble in water and

found in high concentration in rain water as compaired to air (K B Asthana 3^{3d} edition).

Comparision of lead in rain water and air

Lead is emitted by automobile exhaust. It is heavy metal and present in air in extremely small mean particle size (0.02µm) and is soluble in water. On analysis we found (figure -11) that generally lead is not found in rain water samples but it was very high in month of january, its concentration is high in month of june and july air samples. Whereas it is totally absent in remaining month of year.

Due to it size it is early accumulated in air and found in high concentration in air samples but in off rainy seasons in month of january lead is high in rain water due to its precipitation dissolving in water because it is present as a particulate matter in environment.

Comparision of Zinc in rain water and air

Zinc found in air samples as well as in water samples. its concentration is very high in air samples in month of july. It is also present in air samples of april month. Figure -12 showing the presence of zinc in rain water samples in month of february and november. Industries release dust containing higher levels of zinc into the air. Eventually, the zinc dust will settle out onto the soil and surface waters. Rain and snow also can remove zinc dust from the air. High levels of zinc in the soil, water and air are often found along with high levels of other metals like lead and cadmium. Most of the zinc in lakes, rivers and streams does not dissolve, but settles to the

bottom. Insolubility of zinc in water gives its low concentration in rain water as compaired to air.

Comparision of Nickel in rain water and air

Nickel caused mainly due to nickel carbonyl which is highly formed when finely devided nickel is emitted into an atmosphere containing CO. NiCO is also formed in to tobacco smoke. Nickel is a compound that occurs in the environment only at very low levels. Nickel is released into the air by power plants and trash incinerators.

Analysis of Nickel shows **(**Figure-13) that presence of nickel is very high in rain water samples of june, july, august, september, february , march and april. But its presence is not very high in air samples of all months of year it is only found in air samples of february and march month. It is present in excess in air when atmosphere having high Carbon monooxide (K B Asthana 1990 3 rd edition). So we conclude that this area has not contain much amount of CO and we found higher Ni concentration in rain water as compaired to air.

Comparision of Cadmium in rain water and air

Graphical representation shows that cadmium posses its valuable presence in rain water sample of whole months of year. During analysis of air samples it is found that cadmium is totally absent in all air samples but it is found in very little amount in month of june (figure 14). In this month rain water sample also give high concentration of cadmium. Higher Cd in urban areas due to urban actvity, transportation and combustion acticities. Ambient air cadmium concentrations have been generally estimated as extreely low and may range from 0.1 to 5.0 ng/m^3 in rural aeas, from 2 to 15.0 in urban areas and from 15.0 to 150 ng/m^3 in industrial areas

(WHO 1992, OECD 1994). Greater variations are quoted for the cadmium contents of rainwater, fresh waters, and surface waters in urban and industrialised areas. Levels from 10 ng/L to 4000 ng/L have been quoted in the literature depending on specific location and whether or not totals cadmium or dissolved cadmium is measured (WHO 1992.

Comparision of chromium in rain water and air

On analysis of air samples it is found that chromium posses very high concentration in month of july, its concentration is also high in air samples of october and march month however its valuable presnce is available in most of the month of year (figure 15). It is totally absent in samples of august and september. when we talk about Chromium in rain water samples it is totally absent in all samples of rain water. Chromium enters the air, water and soil in the chromium (III) and chromium(VI) form through natural processes and human activities. Through coal combustion chromium will also end up in air and through

Waste disposal chromium will end up in soils. Most of the chromium in air eventully settle and end up in waters or soils.

CONCLUSION

Measurement of trace elements in aerosols is of immense importance for toxicolgical, environmental and occupational health studies. Discussion of the results of this yerlong study with some reported results in india and other parts of the world, it emerges that the Bhilai air is strikingly contaminated from some specific contaminants like Aluminium, Zinc, Iron, Sodium, Potassium and rain water contaminated from Sulphates, Nickel, Manganeese. The elemental composition of

particulate aerosols at this city is clearly affected by anthrapogenic activities especially transport and industrial activities.

While it is impossible to make any definite conclusion on the nature of rainwater and air through out the India. But this analysis provides significant information about rainwater and air composition in the central east india Bhilai Durg region.

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Figure 1. AA 240FS (fast sequential atomic absorption spectrometer).

Table 1. Average concentration of contaminants in air and rain water samples

yearly average of pollutants	Rain water(ng/l)	Air(ng/m^3)
Cd	32.85	0.3104
Cu	5.833	60.688
Zn	124.58	1059.62
Cr	0	3.5466
Mn	143.4	3.851
As	12.2	0.0258
Fe	0.0159	233.038
Al	7.225	1923.2
Na	844	354
K	780	437
Pb	15	5.25
SO4--	6805	69.2
Ni	387	41.34

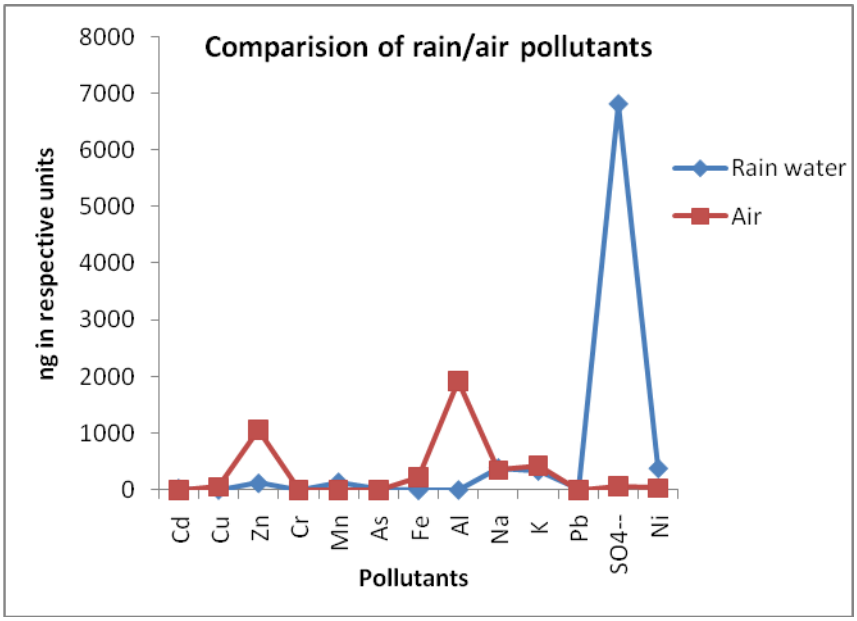

Figure 2. Yearly distribution of air and rain water contaminants

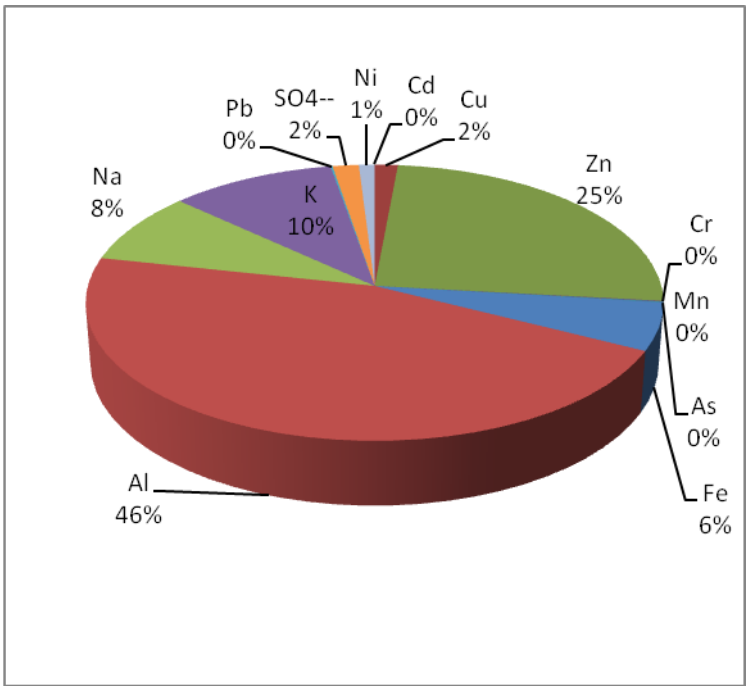

Figure 3. Yearly distribution of pollutants in air

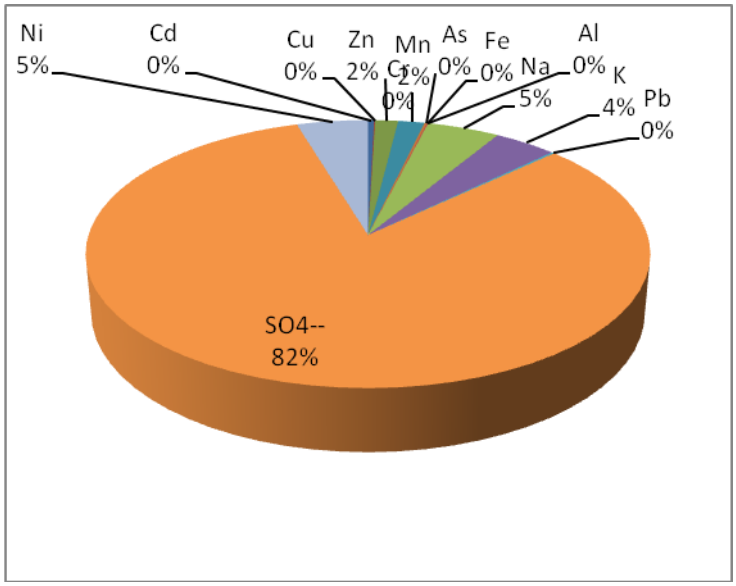

Figure 4. Yearly distribution of pollutants in rain water

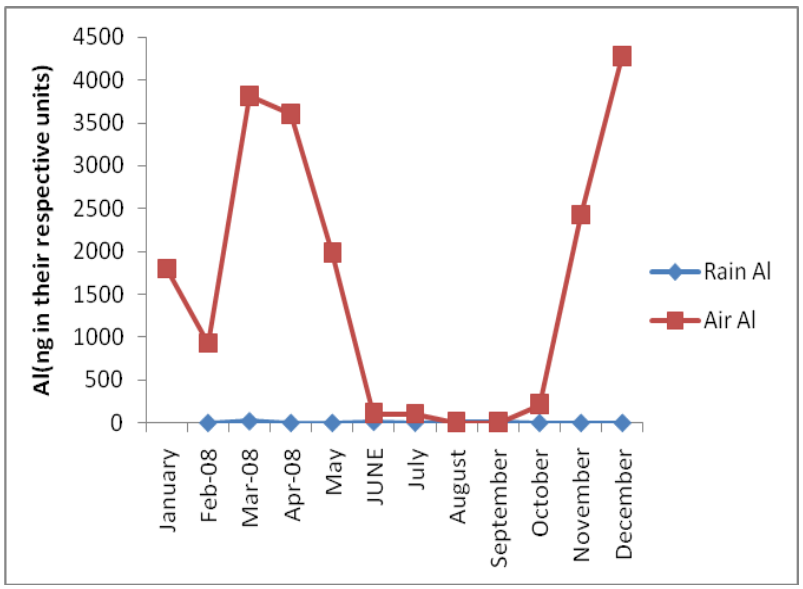

Figure 5. Monthly Variation of Aluminium in rain water and air

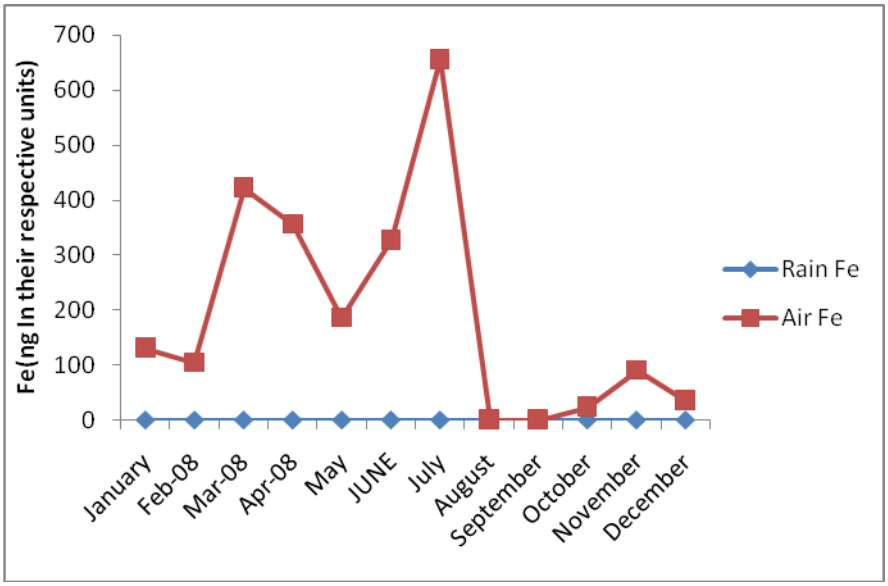

Figure 6. Monthly Variation of Iron in rain water and air

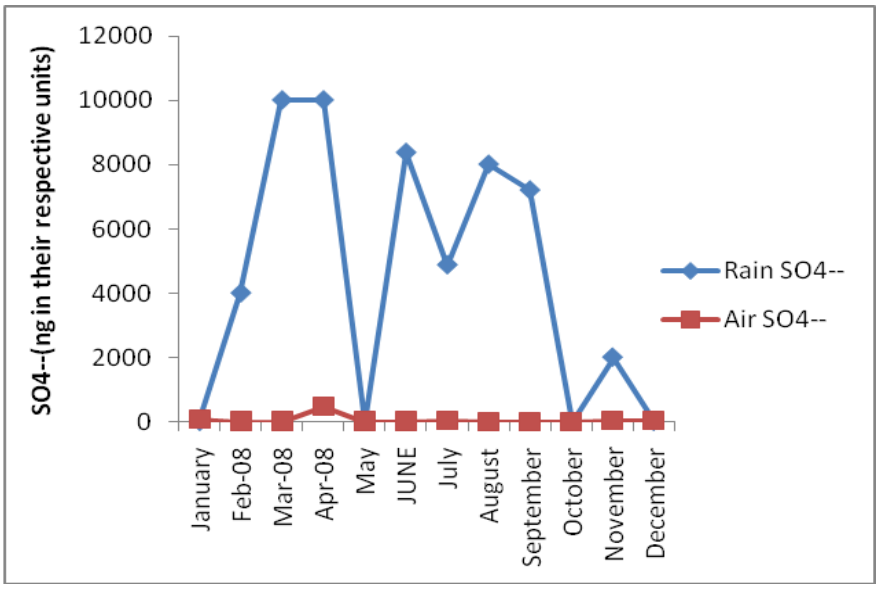

Figure 7. Monthly Variation of Sulphate in rain water and air

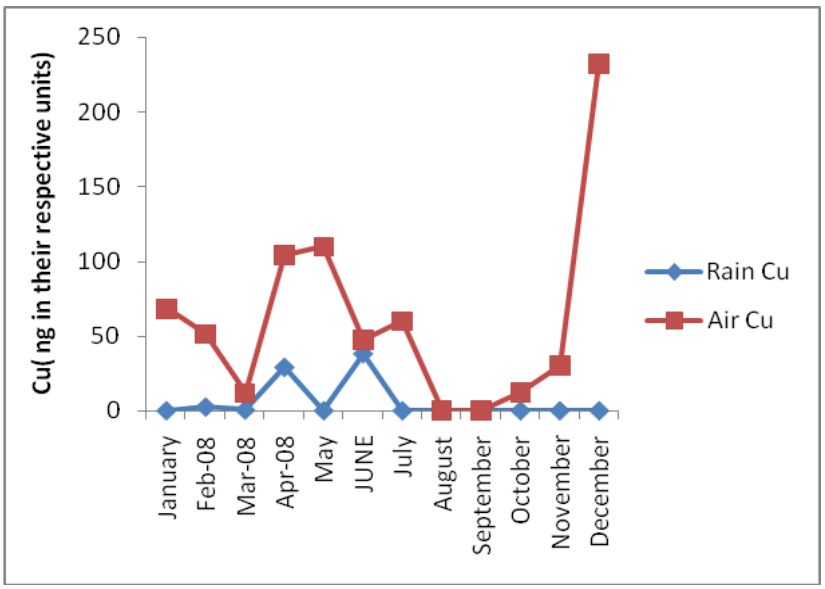

Figure 8. Monthly Variation of copper in rain water and air

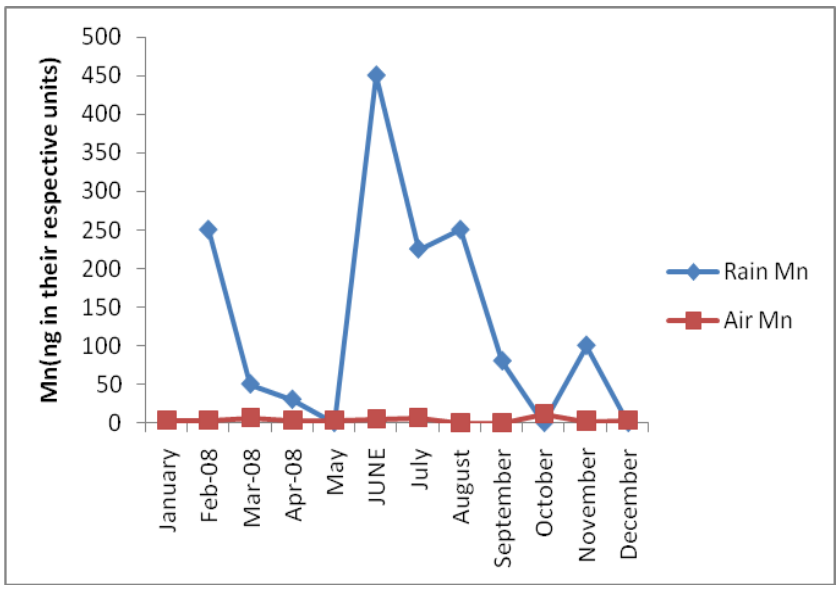

Figure 9. Monthly Variation of manganese in rain water and air

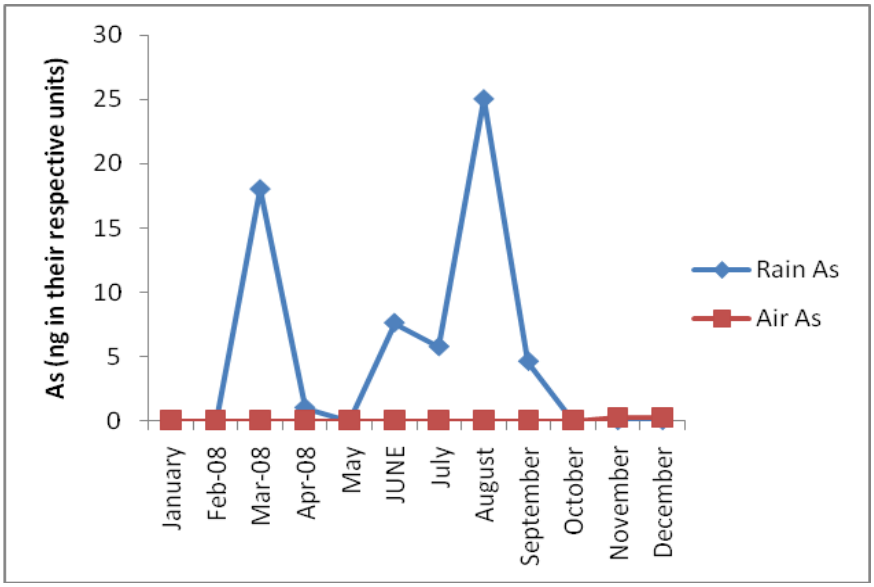

Figure 10. Monthly Variation of Arsenic in rain water and air

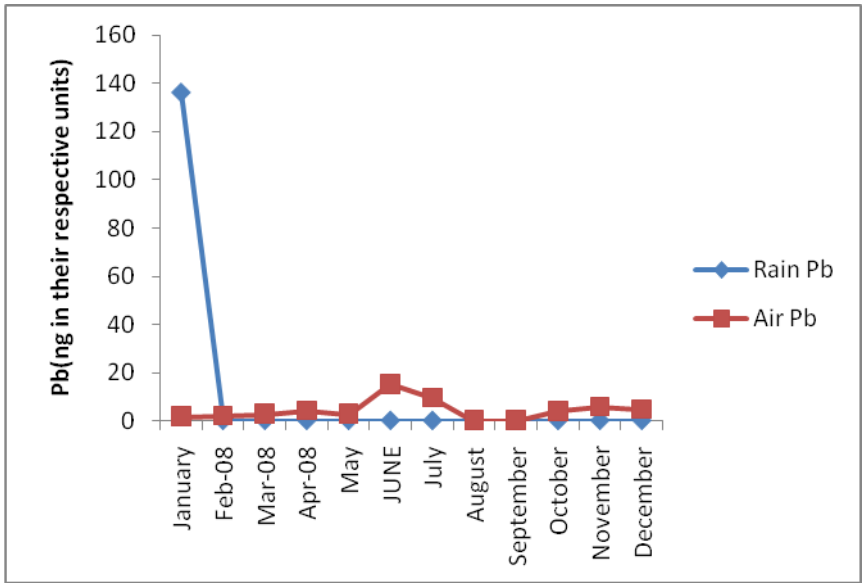

Figure 11. Monthly Variation of lead in rain water

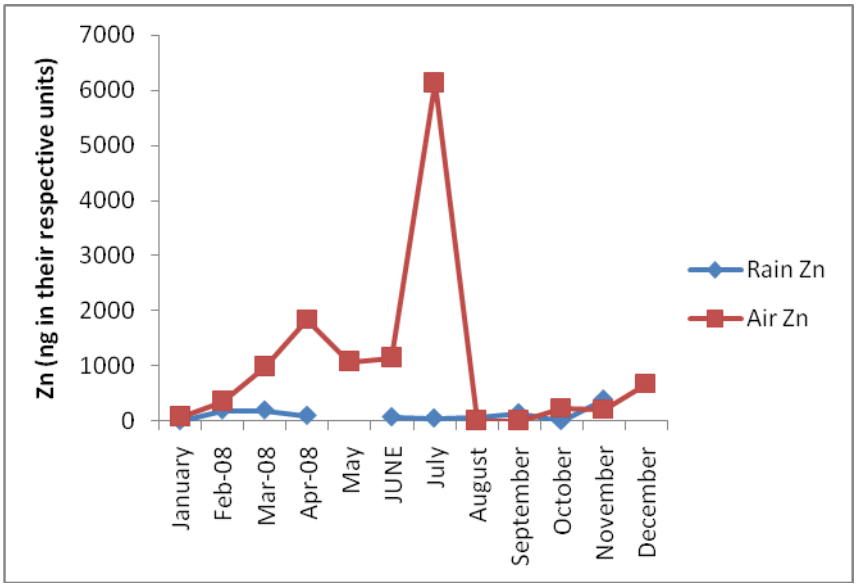

Figure 12. Monthly Variation of Zinc in rain water

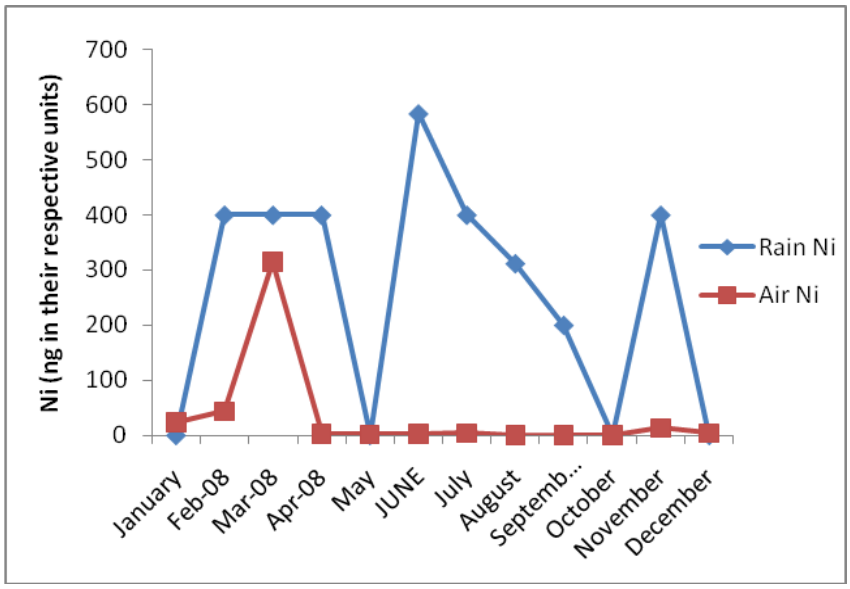

Figure 13. Monthly Variation of Nickel in rain water

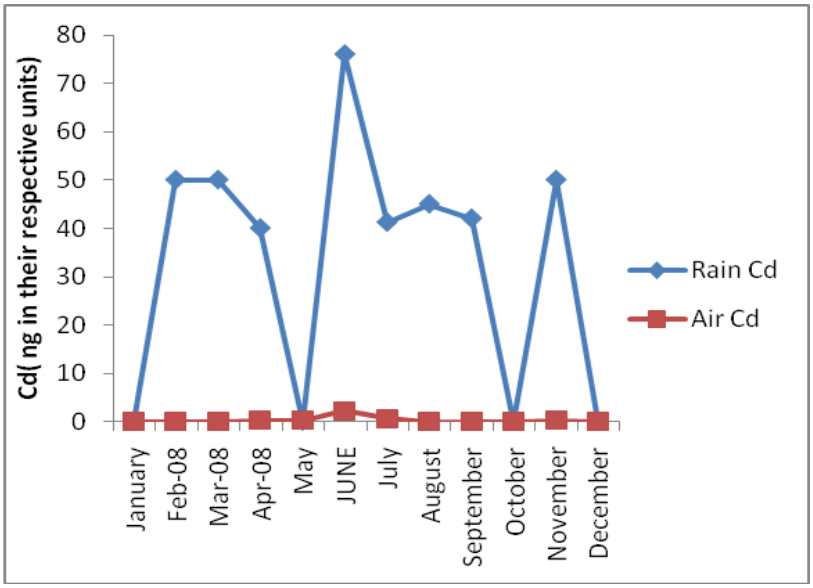

Figure 14. Monthly Variation of Cadmium in rain water

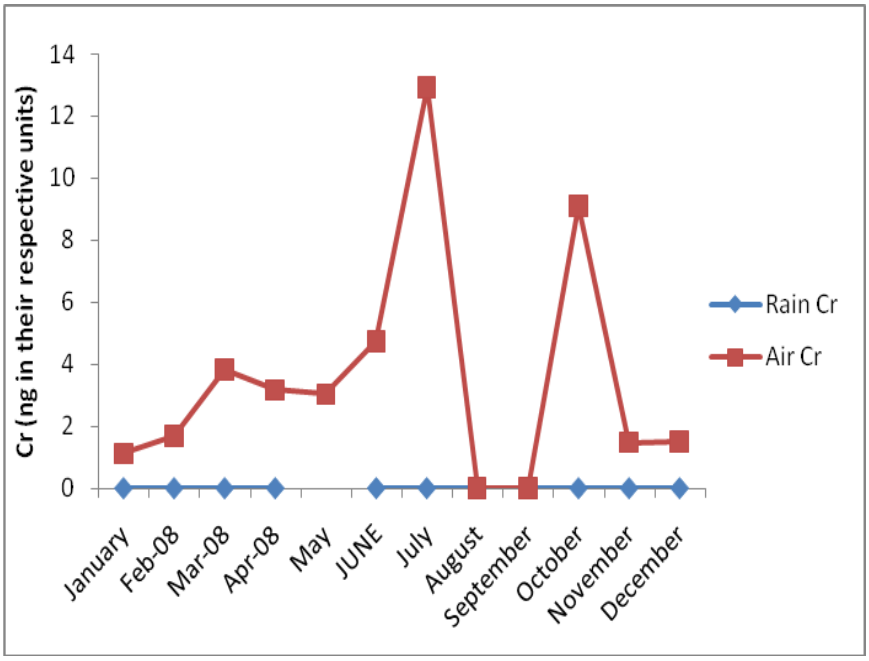

Figure15. Monthly Variation of chromium in rain water