Journal of King Saud University – Science 32 (2020) 1106–1110

Contents lists available at ScienceDirect

Journal of King Saud University – Science

journal homepage: www.sciencedirect.com

Original article

Chemical analysis of trace metal contamination in the air of industrial area of Gajraula (U.P), India

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ARTICLE INFO

Article history:
Received 26 June 2019
Revised 9 October 2019
Accepted 20 October 2019
Available online 6 November 2019

Keywords:
PM_{10}
Heavy metals
ICP-MS spectrophotometer

ABSTRACT

Industrial air pollution has emerged as a speeding problem in recent years because of its detrimental effects on human health. The present study was conducted in Gajraula industrial area of India, highly affected by ambient air pollution. Samples of PM_{10} were collected from three different sites (Raunaq Automotives, Indra Chowk and Town Basti) during 2017–2018. Maximum concentration of PM_{10} was observed during winter and the minimum during monsoon season. Heavy metals such as Pb, Cd, Cu, Zn, Cr, Fe, Al and Ni were analysed by ICP-MS. This study concluded that Indra Chowk is affected by high particulate pollution, while its level at Raunaq Automotives was moderate. Town Basti was being considered as less polluted area. Toxic metals are emitted into the atmosphere mainly due to industrial, commercial and agricultural activities. Most of the industrial emissions from Indra Chowk was because of lots of industries in the vicinity and it has been observed that public from this area is suffering from respiratory disorders and other health problems due to exposure of air pollution.

1. Introduction

Industrial, commercial activities and agricultural production are considered as the engines of economic growth. Man, land, and crops are responsible for agriculture revolution (Yubero et al., 2018). Rapid industrialization and urbanization have resulted in widespread pollution of airborne particulate matter (PM) containing various heavy metals with adverse human-health effects. (Srivastva et al., 2012; Park et al., 2015; Liu et al., 2019). Man and nature have always been antithetical and all his invention tampered with keeping on making continuous efforts to conquer nature in order to satisfy his needs (Dappe et al., 2018). The quality of the environment is a datum of grave concern, specifically when the importance of human intervention are clearly manifest (Philip et al., 2017).

The particulate matter could be elementary (particles emitted outright by emission sources) or secondary (particles formed via the atmospheric reaction of gases) (Yubero et al., 2018; EPCA, 2018). The particles vary greatly in size, concentration, composition, depending on age and origin. Particles produced by anthropogenic activities are typically smaller than 10 µm in diameter and in contrast particles of natural origin are mainly in the size range between 2.5 µm to 10 µm. PM_{10} deposit relatively quickly with a lifetime of lower than two days and exposure may lead to adverse responses in the lungs triggering an array of problems in the heart and the lungs. Heavy metals in PM are deemed to be

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.jksus.2019.10.008
1018-3647/

the determining causes of a range of diseases (Akinfolarin et. al., 2017).

Two main anthropogenic sources that pollute the earth and natural air are burning of coal and the corrosion of commercial waste products, which add copper, chromium, lead and galvanized metals (Eroula et al., 2011; IARC, 2013). Burning coal adds Trace metals such as cadmium, nickel, aluminum and iron into the soils and oil burning contributes iron, lead and nickel to the environment. The emission of metal during the transportation of vehicles includes nickel and zinc from tires, aluminum from a catalyst, cadmium, and copper primarily from diesel engines and nickel and zinc from aerosol emission lubricants, which are interceded. The burning of leaded gasoline has been the main source of Pb in the environment. Incineration of municipal wastes generates a valued concentration of Zn, Al, Cu and Fe (Ujowundu et al., 2011). National and International environmental pollution and disease problems continue to rise and the World health organization (Im et al., 2013; WHO, 2013; Pope et al., 2015) reported that 25%-30% of diseases in evolved countries are due to environmental factors. Thus, the objective of this study was to identify the possible source and determination of Particulate Matter PM_{10}, the concentration of Trace Metals (Ni, Zn, Cd, Fe, Al, Cr, Cu and Pb) in respirable dust (PM_{10}) during winter, summer and monsoon season at all sampling sites (Ratna et al., 2007; Ujowundu et al., 2011). In the present study efforts have been made to analyze and determine the present level of Particulate Matter and their trace metal contents in the industrial city Gajraula of Western UP, India, over the one year period, i.e. July 2017–June 2018.

2. Material and methods

Gajraula is an Industrial area and Nagar Panchayat at Amroha district in the western U. P. (India); it is vested on NH-24, 4-lane highway connecting capital of state and country at latitude 28.85 N, longitude 78.23 E and elevation of 257 m (879 feet). According to Indian census, 2011 Gajraula had a population of 55048. Due to the establishment of a large number of industries, there is an urgent need of ambient air pollution monitoring in Gajraula industrial area. Various types of Industries such as chemicals, fertilizers, pesticides, insecticides, sugar plants, paper mills and automobiles are located over here. Now people have started to take serious note of the ill effect of particulate matter, therefore, detailed study and control measures are required to account the ill health effects.

2.1. Site selection

Raunaq Automotive (S1): It is an Automotive Industry and the site is located near NH-24.

Indra Chowk (S2): It is a residential area having commercial activities. A large number of workshop and shops are situated near this site, and the distance of the Gajraula railway station is 500 m.

Town Basti (S3): It is low density agriculture, residential based area and almost free from pollution. It is located in the southern part of the city and around 2 km away from the Railway station.

2.2. Analysis technique of particulate matter (PM_{10})

PM_{10} samples were collected with the aid of Respirable Dust Sampler (RDS) APM-460 NL (Envirotech, New Delhi) at the rate of two samples per week on Whatman glass fiber filter paper-GF-A for 24hrs. (Three shift i.e. 8 h.) with air flow rate of 1–1.5 m^3/min. The distinction in the initial and the final weight of the filter paper gave the total quantity of PM_{10} collected over the 24 h. The value of PM_{10} were reported in $\mu g/m^3$ (CPCB, 2015). Each gravimetric measurements were obtained precisely in a digital balance (Sartorius, Model: TE214S Max = 210 g and d = 0.1 M/g).

2.3. Analysis of trace metal

For trace metal analysis, six samples were taken from each site, select minimum and maximum concentration of PM_{10} in a season. A known portion of the fiber filter paper was covered by particulates digested by nitric acid and Perchloric acid at 140 °C on a hot plate. Residues were then re-dissolved by 0.1 m hydrochloric acid and a blank were also prepared using the same area of unexposed glass fiber filter paper and by treating the same procedure. These were cooled, filtered and makeup to 50 ml by adding with DDW. Concentrations of trace metals have been analyzed in triplicate by ICP-MS (Agilent Instruments-USA) from samples collected for each site (Danadurai et al., 2011).

2.4. Quality control

The quality control, during the investigation, filter paper numbering, Weighing, monitoring, preconditioning, handling, the post weighing and recording was the thrust. For maintaining the quality control all instruments used during monitoring such as balance, spectrophotometer and Respirable Dust Sampler (RDS) were calibrated on regular gap and recorded. The instruments, performance check, temperature, humidity control, data validation and standard monitoring protocol were followed at all stages. The complete analytical procedures were provided by NABL regulation and central pollution control board, New Delhi.

3. Results and discussion

The results show that the seasonal average concentrations of PM_{10} in three different areas in Gajraula city i.e. Industrial area, Commercial area, and Residential area were recorded as 222 μgm^{-3}, 250 μgm^{-3} and 206 μgm^{-3} in winter and 166 μgm^{-3}, 183 μgm^{-3} and 163 μgm^{-3} in monsoon season respectively (Fig. 1). The higher concentration of PM10 was recorded (285 μgm^{-3}) at S2 in the month of June and lower concentration was recorded (145 μgm^{-3}) at S3 in the month of July. The average of all sites exceeded the CPCB National Air Quality Standards (CPCB, 2015).

In the industrial area of Gajraula the concentration of PM_{10} was found to be in the range of 38–439 $\mu g/m^3$. This area is surrounded by many small and big scale of industries along with vehicles, railway and Traffic Emission and many agricultural activities like fuel Burning, leaves burning.

The concentration of PM_{10} was found to be highest at site II in the range of 49–439 $\mu g/m^3$ because it has been identified that this area is surrounded by large scale industries like Jublient Power Plant having many units of boiler and fertilizer plants, etc. Railway station, high traffic density, power generators, power houses and many types of commercial activities like coal burning and dung cake burning (Akshu, 2015).

The minimum concentration of PM_{10} was found at SIII, which is a residential area containing the range of (38–309 $\mu g/m^3$). In the moderate range of pollution concentration of PM_{10} was found in SI surrounded by many small scale industries and a few number of large scale industries. It has been found that all the location (SI, SII and SIII) the quantitative value of PM_{10}. Was above the prescribed standards of air quality (CPCB, 2015) of 100 $\mu g/m^3$ for rural urban and industrial area respectively.

Trace metal such as Pb, Cd, Cu, Zn, Cr, Fe, Al and Ni concentration for the year of 2017–18 was also observed in PM_{10}. Annual mean and ± SD are presented in Table 1 and are reported in ng/m^3. Among the three monitoring sites, the highest concentration of

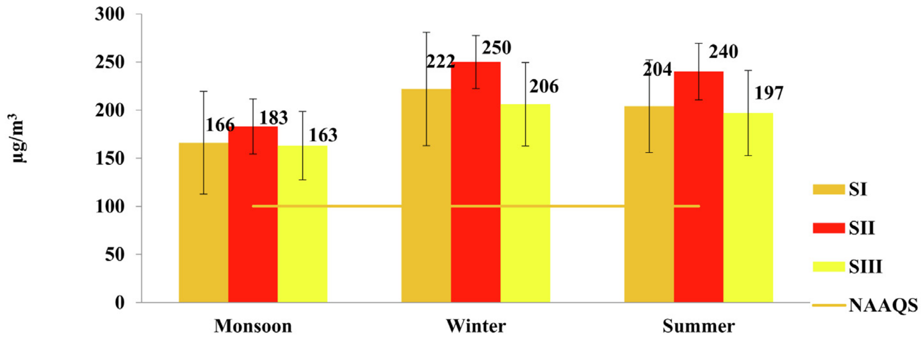

Fig. 1. Seasonal average concentration of PM_{10} at different sites.

Table 1
Concentration of Heavy Metal (ng/m^3) in PM_{10} ($\mu g/m^3$).

Sites	Session	*Ran-ge	Concentration of PM_{10}($\mu g/m^3$)	Concentration of Trace Metal (ng/m^3) in PM_{10}							
				Pb	Cd	Cu	Zn	Cr	Fe	Al	Ni
SI (July 2017 - June 2018)	Monsoon	Min	59	20	1	10	608	32	575	158	13
		Max	256	294	4	15	1594	279	1958	2834	124
	Winter	Min	85	84	3	45	1235	88	815	239	21
		Max	387	478	12	31	1824	819	3142	5042	439
	Summer	Min	42	78	4	34	998	65	716	199	17
		Max	316	341	8	12	1632	508	2896	4795	387
SII (July 2017 - June 2018)	Monsoon	Min	49	29	4	14	615	41	195	169	15
		Max	302	464	10	57	1849	284	2051	2978	127
	Winter	Min	149	84	8	48	918	52	845	245	24
		Max	439	613	13	138	2463	827	3249	5143	454
	Summer	Min	58	62	7	39	816	67	749	207	19
		Max	377	521	12	37	2218	512	2985	4895	422
SIII (July 2017 - June 2018)	Monsoon	Min	56	0	0	4	554	7	219	41	0
		Max	294	39	2	32	1450	114	1724	1342	10
	Winter	Min	81	15	4	18	670	28	621	88	3
		Max	309	172	9	84	2023	219	2924	2954	48
	Summer	Min	38	11	1	11	998	34	515	64	1
		Max	287	142	8	57	1632	207	1624	2815	27

*Minimum (min) and Maximum (max).

Pb (613 ng/m^3), Cd (12 ng/m^3), Zn (2463 ng/m^3), Cr (827 ng/m^3), Fe (3249 ng/m^3), Al (5143 ng/m^3) and Ni (454 ng/m^3) recorded at S2, and Cu (138 ng/m^3)at S1 which falls in industrial and commercial area due to Jubilant life science, Raunaq Automotives and many other kind of industry i.e. such as paper mills, milk Industry, Teva, Sugar industry and traffic density on NH-24 Line Highway as well as railway station.

The density of trace metals lead, cadmium, copper, zinc, chromium, iron, aluminum and nickel was also monitored from these three sites SI, SII and SIII. The concentrations of these metals at three different sites are given in the Table 1. Among these trace metals the concentration of Al found to be higher (5143 ng/m^3) followed by Fe (3249 ng/m^3), Zn (2463 ng/m^3), Cr (827 ng/m^3), Pb (613 ng/m^3), Ni (454 ng/m^3), Cu (138 ng/m^3) and Cd (13 ng/m^3) these trace metals can be arranged in the decreasing order of their concentration (ng/m^3) in the following order aluminum > iron > zinc > chromium > lead > nickel > copper > cadmium (ATSDR, 2008).

The highest concentration of trace metals was found to be highest at SII, because this area is surrounded by Power Plants and heavy emission from industries and vehicular activities. These sources were found to release trace metal loaded fumes in the ambient air. Many other activities like cutting, scraping and finishing of machine tools are the other reason for the increasing of trace metal concentration specially Al, Fe and Zn. Vehicular activities and traffic is the main source for the increasing concentration of Pb. Combustion of carburetor, releases total pollutant Cd in the air. Tyre burning and tyre dust found to release and increases the concentration of Cu, Cd and Pb in the level which is injurious to human health and these trace metals may be categorize as traffic pollutants (Wang et al., 2015).

Correlation coefficient (Table 2) of Trace metal concentration inPM_{10}: The correlation coefficient (r) was calculated from the trace metal density in order to predict the perspective of a common source of PM_{10}. The significant positive correlation was found between Pb with Cr (r = 0.921), Al (r = 0.919) and Ni (r = 0.905), Zn with Fe (r = 0.939) and Al (r = 0.903), Cr with Ni (r = 0.957) and Al (r = 0.932), Fe with Al (r = 0.962), Al with Ni (r = 0.905) and in the year July 2017 to June 2018, respectively. Similarly, moderate positive correlation were found between Pb with Cu (r = 0.531), and Cu with Zn (r = 0.496). It may be due to the industrial and anthropogenic activities like vehicular emission and the burning of industrial activity.

There were also found a nonsignificant correlation between Ni (r = 0.350) in a complete year. On the basis of correlation study, it may be found that lead, cadmium, copper, zinc, chromium, iron, aluminum and nickel were contributed by some common sources, probably by stacking of industries, vehicular, anthropogenic activity and agriculture sources etc (ATSDR, 2008; Aksu, 2015).

The principal component application for factor analysis is to decrease the number of variables. This method focuses on tidiness up the factors. PCA was applied to determine the correlation between pollutants and to calculate the source layout plan of trace metals in PM_{10} (Table 3). The values of PCA that was featured to

Table 2
Correlations analysis between elements concentration in PM_{10} during 2017–2018.

	Pb	Cd	Cu	Zn	Cr	Fe	Al	Ni
Pb	1.000							
Cd	0.847**	1.000						
Cu	0.531*	0.661**	1.000					
Zn	0.868**	0.789**	0.678**	1.000				
Cr	0.921**	0.802**	0.496	0.815**	1.000			
Fe	0.868**	0.807**	0.541	0.939**	0.886**	1.000		
Al	0.919**	0.813**	0.456	0.903**	0.932**	0.962**	1.000	
Ni	0.905**	0.762**	0.350	0.739**	0.957**	0.836**	0.905**	1.000

Table 3
Principal components analysis of PM_{10} for heavy metals at three different sites of Gajraula (2017–2018).

Variables	Factor 1	Factor 2	Factor 3
Pb	0.957	−0.093	0.094
Cd	0.895	0.172	0.264
Cu	0.626	0.758	0.072
Zn	0.932	0.163	−0.294
Cr	0.952	−0.179	0.111
Fe	0.954	−0.044	−0.242
Al	0.966	−0.180	−0.132
Ni	0.908	−0.366	0.173
% Variance	**81.904**	**10.231**	**3.600**
Cumulative %	**81.904**	**92.135**	**95.735**
Sources	**Industrial activities, Anthropogenic activities and road traffic**	**Industrial activities (molding Purpose) and road traffic**	**Agriculture Activity**

cognize ordinary sources of heavy metals with their variance in PM_{10} during an year sampling time. PCA results of trace metals in PM_{10} for last one year exhibited three factors accounting for 99.735% of the collective variance. Factor 1 had high loadings for lead, cadmium, zinc and nickel which explained 81.904% of the entire variance. This factor is allied with Industries and traffic emission (Patil et al., 2004). Thus, factor 1 can be identified as complex sources of industrial activities (such as burning and heating Boiler in Industries, Boiling of Stack and Production on the basis of Acid-Base Reaction) and marching emissions. Factor 2 showing that 10.231% of the total variance and correlated with high loadings on Copper, iron and aluminum. This factor depicts the use of copper and zinc for molding purpose in making Brassware items and other utensils.

Another possible source of Zn and Cu is road traffic (diesel engine and wearing of brakes). Factor 3 explained 3.600% of the total variance mainly derived from the rural activities. Table 3: Principle Component Analysis (PCA) in PM_{10} during 2017–2018. Most of the industrial emissions from IndraChowk (around 500-meter distance industry and traffic interceptions) were attached residential area of the Nagar panchayat and this shows up the urban and rural pop released from the industries.

4. Conclusion

The study carried out to estimate the concentration of various heavy metals in SPM of ambient air in three different site of Gajraula Industrial area. Nevertheless, it was found to have low concentrations of heavy metals except Indra Chowk site. Conclusively, SPM analyses showed the presence of Pb, Cd, Cu, Zn, Cr, Fe, Al and Ni heavy metals. Although the findings on the rate of heavy metal contents are not alarming in this region, regular survey at appropriate intervals should be implemented to monitor the air quality of the Gajraula city as to control pollution from industries, foundries and from other sectors. Further, actions may be taken by educating the industrialists to adapt pollution curtailing methods and also to bring awareness among the common public so as to support and follow pollution control strategies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The author's gratefully acknowledge the financial help provided by UPPCB/CPCB, Ministry of Environment, Forest and Climate Change New Delhi. The authors would like to thank to UPPCB (Uttar Pradesh Pollution Control Board) and also acknowledge the support of the King Khalid University through a grant RCAMS/KKU/011/19 under Research Center for Advanced Materials Science (RCAMS) at King Khalid University, Kingdom of Saudi Arabia. The authors also thankful to Dr. Shivlalsingh (AGSS Laboratory New Delhi), Dr. R.B. Singh (Cardiologist), Charu Gangwar (Project Assistant), Ajay Kumar (Project Assistant), Priyanka Singh (Project Assistant), Mahesh Kumar (Field Assistant), Digvijay Saxena and Sumit Verma (Computer Assistant) for their valuable support and providing sampling facilities at different locations.

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