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SPATIAL ASSESSMENT OF HEAVY METALS IN DRY DEPOSITION ROAD DUST FLUX AT TATA-NAGAR, JHARKHAND

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ABSTRACT

Road traffic and maintenance induce chronic heavy metal pollution in the atmosphere and roadside soil. A portion of these pollutants could be dispersed into the air or deposited onto soils as a result of wind dispersion. The main objective of this research was to determine the level of Pb, Fe, Zn, Ni, Cd, Cr, and Cu in dust samples collected near industrial, residential, commercial and rural streets in the Jamshedpur city during March- April 2023. The concentrations of heavy metals were analyzed using an inductively coupled plasma-mass spectrometer (ICP-MS). The result shows metal concentrations Pb, Fe, Zn, Ni, Cd, Cr, and Cu are varied from 14.08-145.25 ng/m^3, 129.30-687.09ng/m^3, 51.21-302.01 ng/m^3, 10.08-31.09 ng/m^3, 29.52-165.28 ng/$m^{3,}$ 18.25-68.38 ng/m^3 and 19.39-64.01 ng/m^3 respectively. Overall, the rank of risk contribution to the local environments among the six heavy metals was Fe (375.54) > Zn (180.21) > Cd (98.48) > Pb (76.54) > Cu (41.48) > Cr (40.86) > Ni (18.90). These values were compared with results from various cities/countries world-wide. This study suggests that earth crust and anthropogenic activities such as motor vehicles were the main sources of heavy metal contamination in the study areas.

Keywords: Heavy metals, Vehicle emission, Road dusts, ICP-MS.

INTRODUCTION

Dust particle with an aerodynamic diameter greater than 20µ that have entered into the atmosphere by various process such as wind, movements of vehicles, industrial emission and from fugitive dust. These particles are generally too heavy to remain in suspension in the air for any period of time and fall out of the air over a relatively short distance depending on a combination of various factors such as particle size, density, temperature (of the air and particle), emission velocity or method, ambient wind speed and humidity. These particles are therefore commonly known as dust fall-out. In recent decade the number of vehicles in all over the world has grown rapidly due to fast growing economics as well as urbanization, however due to this economic boom there has been overall decline in the air quality. According to Crutzen et al (2022) the total number of vehicles registered on the year 1951 were 0.3 million which has been increased to 159 million on 2012 a report according to the ministry of road transport and highway India and only in the last decade i.e. from 2002 to 2012 there has been increased of 10.5% vehicles registration in our country.

Huge amount of dust fall in urban areas of India is mainly due to anthropogenic reasons which include conventional and out-dated technology use in mineral based coal-fired industries (Zeb et al., 2019) haphazard road-traffic emissions (Shubhankar, 2016) heavy civil constructions and soil erosion (Mielke et al., 2020). Natural source contribution to dust fall particles are majorly from soil minerals (i.e. oxides of silicon, aluminium, calcium, and iron). The principal polluting source of many trace elements attached to outdoor dust fallout is the petrol driven automobile. Elements identified as Pb, Cd, Cu, Zn, Fe, Cr and Ni originating from the automobile and Lead comes from the lead in petrol, whereas the other element comes from wear and tear on the motor car, such as Zn and Cd from tyre wear. Industrial sources are varied and elements such as Pb, Cd, Cu, Zn, Fe, Cr and Ni have been identified with specific industries (Peterson et al., 2020). A number of materials in urban areas are also contributed to dust fallout from weathering processes.

DUST PARTICULATE MATTERS: TOXIC AND HEALTH EFFECTS

The effect of particulates on human beings is basically due to either intrinsic toxicity of the particle or the interference of the respiratory mechanisms in the body. Dust, composed of coarser particles is known to be potential source of asthma among growing children and about 23% of asthmatic children have been evaluated to be affected by indoor. While smaller particle penetrates to lungs and remains there for a long time (Shubhankar, 2016). A great many carcinogenic substances are found in these particles and may cause scarring of fibrosis of lung lining. The threshold limits value of selected metals pollutants is tabulated in table 1 with its hazardous effects.

Table 1 Source CPCB, TLV- Threshold limit value.

S.No.	Metals	TLV Limits in air (mg/m^3)	Hazardous effects
1	Lead (Pb)	0.15	Suspected carcinogen of lung and kidneys. The major organ system affected are the nervous system, blood system and kidneys.
2	Iron (Fe)	50-100	Potentially toxic in all forms and by all routes of exposure. Inhalation of iron dust results in iron Pneumoconiosis (arc-welder lung). Iron dust also causes massive lung fibrosis, lung cancer.
3	Zinc (Zn)	1.0-5.0	Variable toxicity, but generally low. Exposure of zinc chloride fumes can cause damage to mucous membrane of nasal pharynx and respiratory tract.
4	Nickel (Ni)	1.0	Produces cancer of lung and sinus, pulmonary asthma.
5	Cadmium (Cd)	0.05	Exposure can cause chronic poisoning resulting in death. Chromium and its compounds are highly toxic. It is a carcinogen of lungs, nasal cavity, larynx, stomach.
6	Chromium (Cr)	0.5	Carcinogen of lungs, nasal cavity, larynx, stomach. Hexavalent compounds are more toxic than trivalent compounds.
7	Copper (Cu)	0.05	Inhalation of dust causes pulmonary damage. Poison by intravenous and intra tracheal routes.

AIM AND OBJECTIVE

* To measure metal deposition in four different places in same time in Tata nagar to examine spatial variation of dry deposition flux.
* To measure concentration of Metals and its variation over a period of time.
* To determine the overall total deposition velocity for particulate matter.
* To create a database for further analysis.

STUDY AREA

The study area was Jamshedpur City (Tata Nagar), an urban-industrial environment having a total land area of 18801.6 ha and two major industrial complexes namely 1) Tata nagar Industrial area, 2) Adityapur-Ghamaria Industrial area.

SAMPLING PLAN

Major dust generating sources in the study region has been identified are Industrial area (S-1), Sensitive area (S-2), Commercial area (S-3) and Rural area (S-4). Industrial zone is Adityapur area which is mainly composed of 95% coal-fired Ferro metallurgical industrial units, including metallurgical, chemical & fertilizers, glass & plastics, sponge, Ferro-alloy, casting & rolling and integrated steel plants. Sensitive zone is near to NIT Jamshedpur which is an educational centre. Commercial zone is high traffic zone and near to industrial zone. Rural zone is an Agriculture zone. A representative collection of dust emissions within the identified sampling location has been carried out by installing dust fall collection jars at roof tops of highest building setups, specially located in downwind.

Dust collection Jars (Dimension: diameter – 23 cm; height - 45 cm) with standard specifications described elsewhere (Katz, 1977) have been placed in four positions of a roof top of buildings (height: 20 feet) for a month (March-April, 2023). Total of 20 sample was collected, i.e. once in a week same date at all site. Pooled sampling has been decided to evaluate uncertainties of measurements (Kumsanlas et al 2019). About one litre of double distilled water was put in each sampling Jar and a net sheet (size: 20 mesh) was placed on mouth of the Jars and total dust fallout was measured. Replicate weighing measurements have been done to maintain relative standard deviation within 5%. The dust fall rate was calculated for each site using the following equation (Katz, 1977).

$$\textbf{Dust fall} = W/a \times 30/t$$

Where:

W= Weight analysed

a = Open area of sampling container at top

t = time of exposure days

ANALYSIS

Specialized cleaning and sampling techniques were used during all stages of sample collection to prevent contamination. All containers and samplers used for sampling were cleaned using a dilute liquid soap followed by a hydrochloric acid solution and multiple rinses in ultra-pure, de-ionized (DI) water, following standard protocols (Envirotech, 2000). Dust sampling jars after the sampling immediately transferred to the laboratory. The samplers were washed with double distilled water and filtered using Whatman Filter Paper No. 42 in pre-washed polyethylene bottles. Insoluble and soluble fractions of dust fall samples have been stored at 5 ^{0}C or less until chemical analysis. Insoluble fraction has been divided in four portions. One portion was digested in the Teflon digestion bombs using 10 ml mixture of nitric acid (HNO_3) and hydrogen peroxide (H_2O_2) in a ratio of 3:1. Teflon bombs were then kept in temperature-controlled muffle furnace (Lab tech Model TIC 4000) at 180°C for 6 hrs. (Envirotech, 2000), which is followed by cooling and filtration by using 0.001 M nitric acid. Final volume of the digested sample was made to 25 ml using distilled water. Digested insoluble and soluble fractions of dust fallout were analysed for selected cations (Pb, Fe, Zn, Ni, Cd, Cr and Cu). Selection of chemical species has been decided on the basis of indicator species of selected industrial emissions (CPCB, 2007).

Elemental analysis has been determined using inductive coupled plasma atomic emission spectrophotometer (ICP-AES) (JOBIN-YVON HORIBA ICP Spectrometer Version 3.0) (Montaser and Golightly, 1987).

RESULTS AND DISCUSSION

Dust fallout levels in selected receptor sites belong to different environmentally defined zones [Industrial (S-1), Rural (S-4), Commercial (S-3) and Sensitive (S-2)] have shown figure 1. Many-fold higher concentrations occurred in every receptor site compared to prescribed standards.

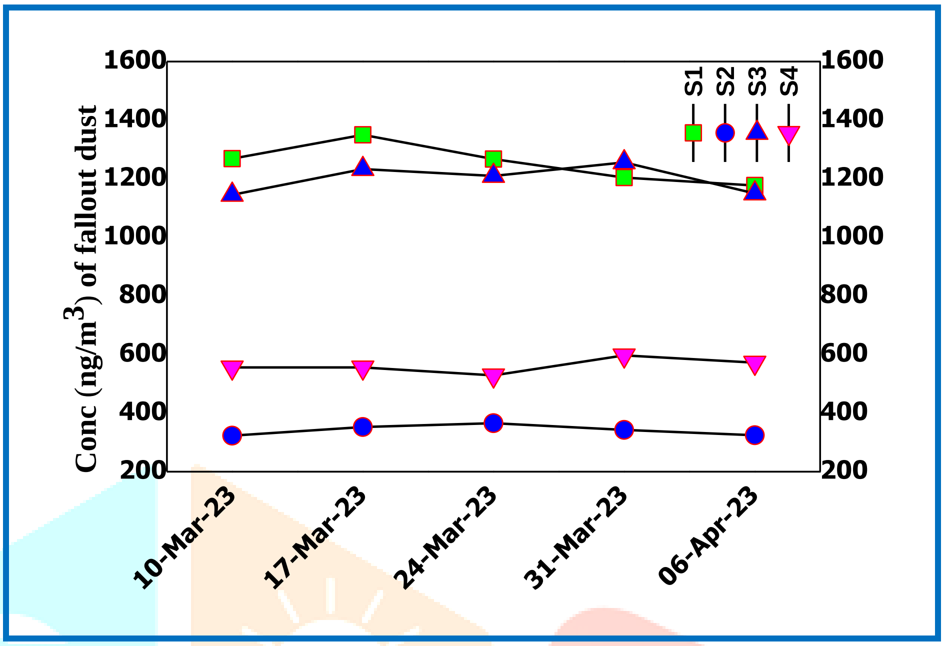

Figure 1 Variability of ambient atmospheric dust fallout at all sampling sites.

The highest average dust fall of 1253.30 ng/m^3/month has been found at S-1, whereas the lowest level of 341.65 ng/m^3/month has been found at S-2. The industrial site S-1 has shown 2-4-fold higher dust fall compared to Site S-2 and S-3. On one of the sampling days i.e. on 17 March 2023 sampling site S-3 has more of dust fallout than S-1 because of local festival which is being celebrated among tribal of this region. Heavy metals species have shown different pattern of occurrence in atmospheric dust fallout. Ni and Cr have shown comparatively low values at all the sampling sites.

From figure 2 Site S-1:

Fe (622.66 ng/m^3) > Zn (251.53 ng/m^3) > Cd (125.99 ng/m^3) > Pb (115.23 ng/m^3) > Cr (57.88 ng/m^3) > Cu (56.88 ng/m^3) > Ni (23.53 ng/m^3).

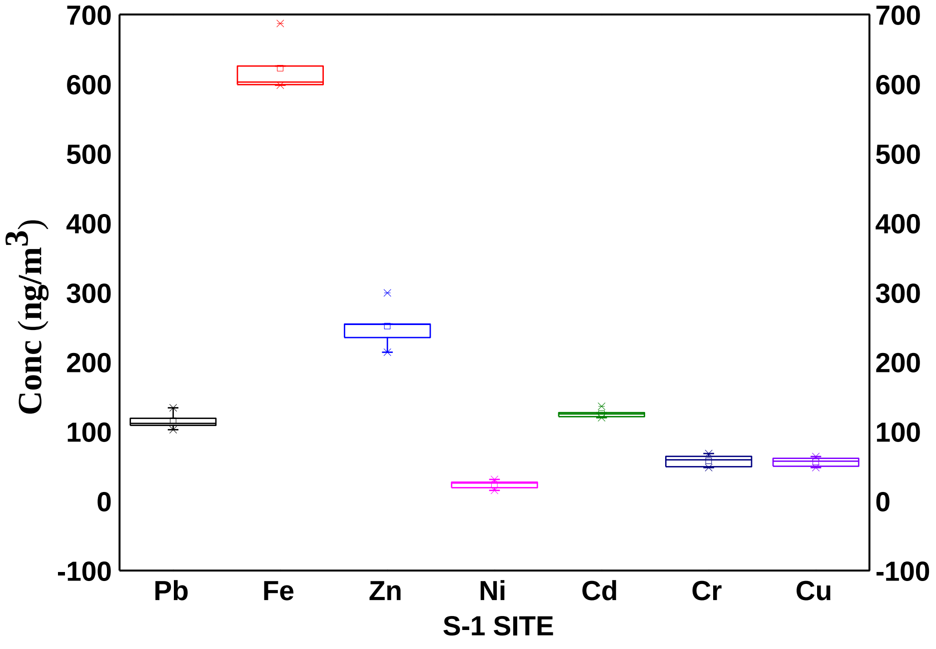

Figure 2 Source compositional profile of dust deposition from site S-1.

From figure 3 Site - 2:

Fe (143.44 ng/m^3) > Zn (65.42 ng/m^3) > Cd (45.34 ng/m^3) > Cu (25.68 ng/m^3) > Cr (24.17 ng/m^3) > Pb (22.96 ng/m^3) > Ni (14.02 ng/m^3).

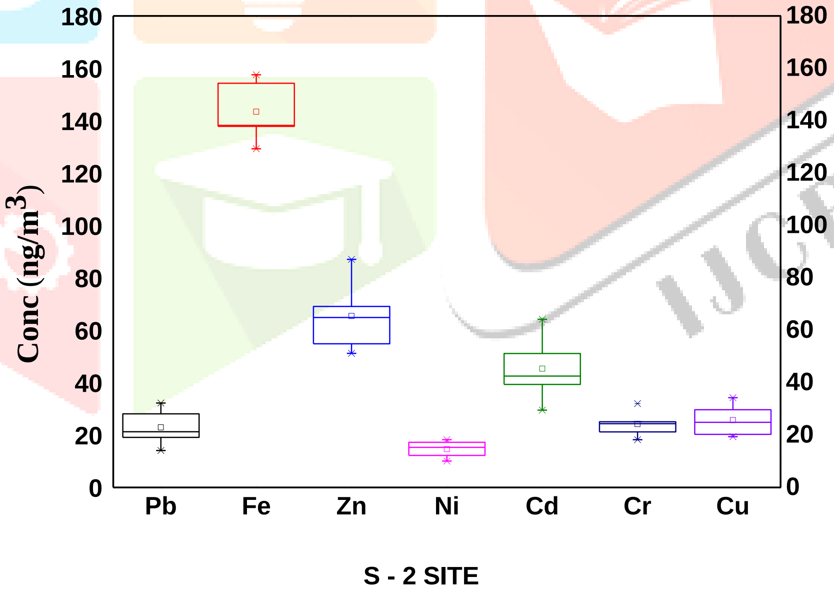

Figure 3 Source compositional profile of dust deposition from site S-2

From figure 4 Site - 3:

Fe (514.81 ng/m^3) > Zn (288.58 ng/m^3) > Cd (159.05 ng/m^3) > Pb (122.42 ng/m^3) > Cr (47.77 ng/m^3) > Cu (44.97 ng/m^3) > Ni (20.88 ng/m^3).

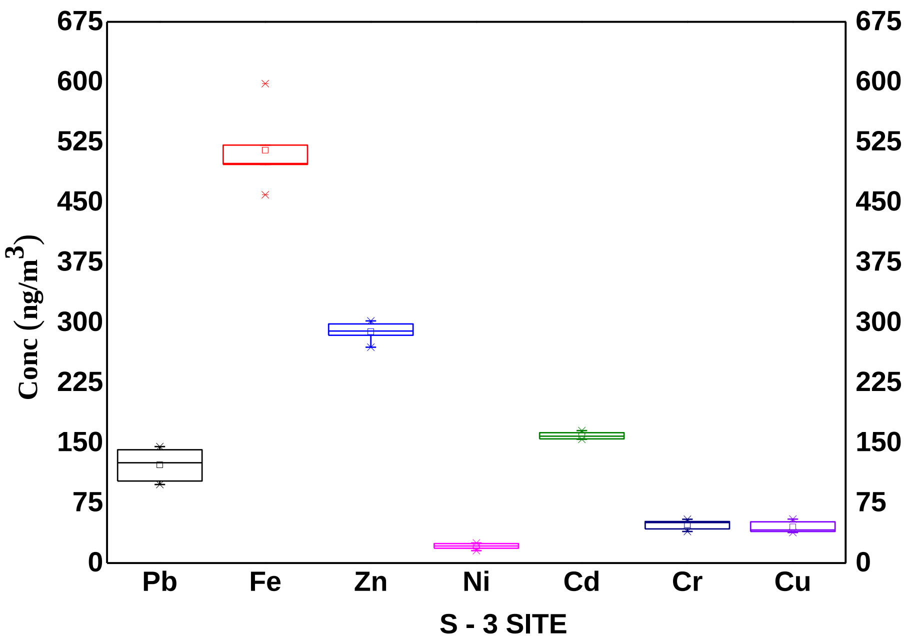

Figure 4 Source compositional profile of dust deposition from site S-3

From figure 5 Site - 4:

Fe (233.27 ng/m^3) > Zn (155.29 ng/m^3) > Cd (63.52 ng/m^3) > Pb (45.66 ng/m^3) > Cu (39.08 ng/m^3) > Cr (33.62 ng/m^3) > Ni (16.32 ng/m^3).

This explained that occurrence of these species is significantly high at sampling site S-1 than at sampling site S-2. Similar pattern has been observed in case of sampling site S-2, S-2 and S-3.

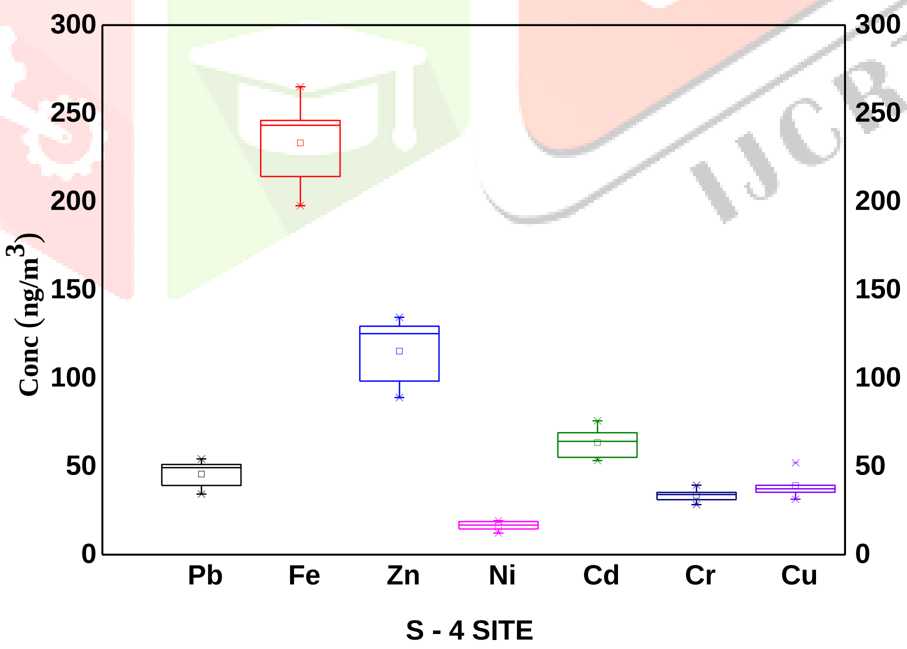

Figure 5 source compositional profile of dust emission from site S-4

Fe shows the maximum concentration in all sampling sites and Ni has minimum concentration at all sampling sites. Fe, Zn, Cd and Zn are the major heavy metal pollutants in urban environment and the primary source of all of them is automobiles. Industries also substantially contribute to heavy metal contaminations in urban centres. Tyre wear as a source of Fe, Zn, Pb, Cr and Ni in roadsides, and wear of brake linings as another source of Ni, Cr and Pb in roadsides (Shubhankar, 2016). Corrosion of bushings, break wires, and radiators also as the source of Cu, Fe, Ni, Cr and Cd. Plants in contaminated roadsides is exposed to heavy metals both in the aerial and underground environments. Therefore, the impact of heavy metals in contaminated environment is more direct on plants than on other organisms.

Table 2 Comparative Study of metals with present study and previous study

Location	Metal Concentration (μg/m³ or ng/m³)							Duration	Reference
	Pb	Fe	Zn	Ni	Cd	Cr	Cu		
Tata Nagar (ng/m³)	14.08 - 145.25	129.30 - 687.09	51.21 - 302.01	10.08 - 31.09	29.52 - 165.28	18.25 - 68.38	19.39 - 64.01	March - April, 23	This study
Madurai (μg/m³)	0.21-1.18	-	-	-	-	-	-	July 05 - June 06	Bhaskar et.al., 2008
Lucknow (ng/m³)	181.57	831.9	311.83	22.06	-	86.16	61.20	March 12	Choudhary et.al., 2013
Rourkela (ng/m³)	-	102.14	41.90	17.44	-	-	-	Jan – Dec 11	Kavuri et.al., 2012
Dhanbad (ng/m³)	-	-	-	0.0075	0.005		-	Dec 08- Jan 09	Dubey et.al 2012
Agra (ng/m³)	1.1	-	0.5	0.9	0.3	-	0.1	May 06 – Mar 08	Kulshrestha et.al., 2009

CONCLUSION

This chapter deals with source contribution of heavy metals at various locations of the study area. Among all trace elements Fe depicted higher concentration due to its origin from earth crust. The main source of pollution in the study area is thus earth crust, air borne soil dust due to the movement of vehicles over unpaved road. Next category of pollution source is industrial activities which lead to fugitive dust emission. Third pollution sources are coming from vehicular exhaust as indicated Pb. The last possible pollution source is other industrial activities which lead to emission of Zn, Fe and Cd. Source contribution estimates for the more complex sources of metals, such as local combustion and long-range transported air pollution. The major cause for elevated concentrations of resuspended dust in ambient environments seems to be the turbulence and tyre stress related to traffic.

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REFERENCES

Bhasker BV, Jeba RRV, Muthusubramanian P, Kesarker AP. (2008). Mwasurement and modelling of respirabale particulate (PM10) and lead pollution over Maduri, india. Air quality and atmos. health. 1: 45-55.

Choudhary P, Singh D, Kumar J and Singh SK. (2013). Assessment of ambient air quality in northern India using air quality index method. Bulletin of environ. and scientific research. 2: (2-3) 12-17.

Crutzen, P.J. and Ramanathan, V., 2022. Atmospheric chemistry and climate in the Anthropocene: Where are we heading? (2004). In Paul J. Crutzen and the Anthropocene: A New Epoch in Earth's History (pp. 47-74). Cham: Springer International Publishing.

Dubey B, Pal AK and Singh G. (2012). Trace metal composition of airborne particulate matter in the coal mines and non-mining area of Dhanbad region, Jharkhand, India. Atmos. pollution research. 238-246.

Envirotech (2000). Background Material for Short Course on Ambient Air Quality and Management. Envirotech Centre for Research and Development, New Delhi. Envirotech publication, New Delhi.

Gogikar, P., Tyagi, B. and Gorai, A.K., 2019. Seasonal prediction of particulate matter over the steel city of India using neural network models. Modeling Earth Systems and Environment, 5, pp.227-243.

Katz M. (1977). Methods of Air Sampling and Analysis, American Public Health Association, USA.

Kavuari NC and Paul KK. (2013). Chemical characterization of ambient PM_{10} aerosol in a steel city, Rourkela, India. Research J. of recent sciences. 2: (1) 32-38.

Kulshrestha A, Satsangi OG, Masih J and Taneja A. (2009). Metal concentration of $PM_{2.5}$ and PM_{10} particles and seasonal variations in urban and rural environmental of Agra, India. Science of total environs. 407: 6196-6204.

Kumsanlas, N., Piriyakarnsakul, S., Sok, P., Hongtieab, S., Ikemori, F., Szymanski, W.W., Hata, M., Otani, Y. and Furuuchi, M., 2019. A cascade air sampler with multi-nozzle inertial filters for PM0. 1. Aerosol and Air Quality Research, 19(8), pp.1666-1677.

Mielke, H.W., Gonzales, C.R., Powell, E.T., Shah, A., Berry, K.J. and Richter, D.D., 2020. Spatial-temporal association of soil Pb and children's blood Pb in the Detroit Tri-County Area of Michigan (USA). Environmental Research, 191, p.110112.

Montaser A and Golightly DW. (1987). Inductive Coupled Plasma in Analytical Atomic Spectrometry, VCH, New York.

Peterson, G.C.L., Hogrefe, C., Corrigan, A.E., Neas, L.M., Mathur, R. and Rappold, A.G., 2020. Impact of reductions in emissions from major source sectors on fine particulate matter–related cardiovascular mortality. Environmental health perspectives, 128(1), p.017005.

Prenner, S., Allesch, A., Staudner, M., Rexeis, M., Schwingshackl, M., Huber-Humer, M. and Part, F., 2021. Static modelling of the material flows of micro-and nanoplastic particles caused by the use of vehicle tyres. Environmental Pollution, 290, p.118102.

Rajouriya, K., Pipal, A.S. and Taneja, A., 2023. Chemical Characterization and Health Risk Assessment of Particulate Matter near National Highway at Urban and Semi-Urban location of Northern India.

Shubhankar B, and Ambade B. "Review on Composition, Emission sources of RSPM, TSPM, Heavy metals and Ions with effect on environment and health." Research Journal of Chemistry and Environment,20 (2016): 10.

Shubhankar, B., Ambade, B, Singh, S.K, and Meshram, S.G. "Characteristics and seasonal variation of Carbonaceous and Water-soluble organic Components in the aerosols over East India." Oriental Journal of Chemistry 32, no. 1 (2016): 523-532.

Shubhankar, B, and Balram A. "A Review on Deposition, Distribution of Polycyclic Aromatic Hydrocarbons in Different Environmental Matrix and Study its Toxicity and Carcinogenic Effect." Asian Journal of Chemistry 28, no. 11 (2016).

Yadav, A.K., Sahoo, S.K., Dubey, J.S., Kumar, A.V., Pandey, G. and Tripathi, R.M., 2019. Assessment of particulate matter, metals of toxicological concentration, and health risk around a mining area, Odisha, India. Air Quality, Atmosphere & Health, 12, pp.775-783.

Zeb, B., Alam, K., Sorooshian, A., Chishtie, F., Ahmad, I. and Bibi, H., 2019. Temporal characteristics of aerosol optical properties over the glacier region of northern Pakistan. Journal of atmospheric and solar-terrestrial physics, 186, pp.35-46.