



ISSN: 0975-833X

Available online at <http://www.journalcra.com>

International Journal of Current Research
Vol. 11, Issue, 09, pp.6998-7002, September, 2019

DOI: <https://doi.org/10.24941/ijcr.36624.09.2019>

INTERNATIONAL JOURNAL
OF CURRENT RESEARCH

RESEARCH ARTICLE

PM₁₀ BOUND HEAVY METALS IN AMBIENT AIR ATMOSPHERE AROUND MANDIDEEP INDUSTRIAL AREA, MADHYA PRADESH, INDIA

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ARTICLE INFO

Article History:

Received 11th June, 2019
Received in revised form
25th July, 2019
Accepted 19th August, 2019
Published online 30th September, 2019

Key Words:

Ambient Air, Industrial Area, PM₁₀
Bound Heavy Metals, Lead (Pb),
Nickel (Ni), Arsenic (As).

ABSTRACT

The release of toxic, harmful metals in to ambient air by natural forces, man and other animal has become a great threat to ambient environment of developing countries, which increasing in positive correlation to urbanization and industrialization. Heavy metals in ambient air mostly associated with the particulate matter. This study reveals PM₁₀ bound heavy metals in ambient air atmosphere around Mandideep industrial area, Madhya Pradesh, India. The study of PM₁₀ bound heavy metals i.e. Chromium (Cr), Manganese (Mn), Copper (Cu), Zinc (Zn), Cobalt (Co), Cadmium (Cd), Iron (Fe), Lead (Pb), Nickel (Ni) and Arsenic (As) has been done. Among of all heavy metals mainly there metals i.e. Pb, Ni, Pb were reported as pollutants in National Ambient Air Quality Standards 2009. Lead (Pb) was found within standard limit (0.5 µg/m³) at all monitoring locations, Nickel (Ni) was found exceeded at monitoring location A8 (101 ng/m³) but within standard limit (20 µg/m³) at all other monitoring locations and Arsenic (As) was found within standard limit (6 µg/m³) as per National Ambient Air Quality Standards 2009 at all monitoring locations around Mandideep.

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Citation: Reeta Kori, Alok Saxena, Harish Wankhade, Asad Baig, Ankita Kulshreshtha, Saket Mishra and Smriti Sen. 2019. "PM₁₀ Bound Heavy Metals in Ambient Air Atmosphere around Mandideep Industrial Area, Madhya Pradesh, India", *International Journal of Current Research*, 11, (09), 6998-7002.

INTRODUCTION

Environmental air pollution is a major hazard facing the world today. There is an increasing awareness of the fact that a clean environment is necessary for smooth living and the better health of human beings [Bhaita, 2011]. The ecological equilibrium of the earth is endangered by the chemical process industries as most industries continue to spew chemical toxicants into the environment [Chaudhary, 2017, Vailshery, 2013; Lave, 2013; McMichael, 2000; Mayer, 1999]. Metal air pollution is an emerging risks factor for stroke in developing countries, since pollutants concentration are highest [Andersen, 2011]. The cases of cancer is also under the rise in developing countries, since the rate of exposure to traffic related air pollutants is unavoidable owing to bad roads and higher vehicles [Gehring, 2010]. Heavy metal associated with atmospheric particles may accumulate in human being via inhalation, respiratory deposition, which may cause adverse effects on human health such as neuropathies symptoms, increased blood pressure and anaemia symptoms, kidney

Damage, increase the risk of lung and renal [Vamvakas, 1993; Ewan, 1996; Abernathy 1999; Laden, 2000; Damek-Poprawa Kampa, 2008; Ning, 2010; Fang, 2010]. Main anthropogenic sources of heavy metals are various industrial sources such as present and former mining activities, foundries & smelters, and diffuse sources such as combustion, traffic, piping etc. major activities emitting heavy metals in the air are organic & inorganic petro-chemical processing, steel & metal foundries, motor vehicles, fertilizers, other industrial activities such as glass, cement, asbestos manufacture, textile mills and steam generation power plants. Other sources include wind transport from road dust, incineration of municipal refuse and sewage sludge. The burning of wood in fireplaces, campfires, leaf burning and rubbish incineration also may contribute heavy metals to the air. Heavy metals are defined variously by their different properties, such as atomic number, atomic weight, toxicity and density. Based on these many definitions, the meaning of a heavy metal can be summarized as a metal or metalloid with biological importance is hazardous and accumulates in animals or plants [Suvarapu, 2013]. The major metals or metalloids from the point of view of environmental research based on their toxicity and biological importance are chromium (Cr), lead (Pb), mercury (Hg), cadmium (Cd), arsenic (As), copper (Cu), manganese (Mn), nickel (Ni), zinc (Zn) and silver (Ag) [Hogan, 2010]. Regarding the properties

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of heavy metals, most have high densities. The International Agency for Research on Cancer (IARC) has classified heavy metals into three categories based on their studies on the carcinogenicity of these metals on humans. Group 1 metals and/or metalloids are proven carcinogens to humans. Group 2A compounds are probably carcinogens and group 2B compounds are possibly carcinogens. Group 3 compounds are non-carcinogens to humans. Regarding the carcinogenic nature of heavy metals and/or metalloids, As & its compounds, Cd & its compounds, hexa valent Cr and metallic Ni & its compounds are group 1 carcinogens for humans through the inhalation, ingestion routes of exposure are associated with cancers of the lung, liver, nose and kidney [IARC, 2012]. Inorganic Pb compounds [IARC, 2006] are listed as group 2A, with metallic Pb [IARC, 2015] methyl mercury [IARC, 1993] listed as group 2B carcinogens. Metallic Cr, trivalent Cr metallic Hg and organic Pb compounds are listed as group 3 compounds [IARC, 1990]. Diffuse pollution of the environment by heavy metals is a major environmental problem world-wide.

An important input pathway is the atmospheric deposition of industrial, traffic, and household emissions [Schulin, 2007]. In Romania, gasoline was leaded until 2008 and traffic was therefore certainly an important source for lead. The risk of heavy metal contamination is pronounced in the environment adjacent to large industrial complexes. Many cases of particularly severe metal pollution by atmospheric deposition have been reported from areas surrounding nonferrous metal smelters in many countries [Steinnes, 2000; Kabala, 2001; McMartin, 2002; Martley, 2004]. Therefore study of PM₁₀ bound heavy metal in ambient air around Mandideep industrial area is important for health concern.

METHODOLOGY

Study Area: Mandideep is an industrial area and municipality in Goharganj subdistrict of Raisen district in the Indian state of Madhya Pradesh. Mandideep is 23 km from Bhopal and came into existence in late 1970s.

Table 1. Monitoring Locations around Mandideep Industrial Area

S.N	Code	Monitoring Locations	Monitoring Points
1	A 1	Block 2	Near St Chavara, H. S. School, New Satlapur Mandideep
2	A2	Block 5	Near M/S Bansal Extraction & Exports Pvt, Ltd Mandideep
3	A3	Block 6	Near M/S Bhaskar Industry, Mandideep
4	A 4	Block 7	Near M/S Proctor & Gamble, Mandideep
5	A 5	Block 8	Near M/S Mahindra Steel Service Centre, Mandideep
6	A 6	Block 9	Near M/S Dawat Food Industry, Mandideep
7	A 7	Block 11	Near M/S TMTL (Eicher Tectors), Mandideep
8	A 8	Block 12	Near M/S HEG, Mandideep
9	A 9	Block 13	Near M/S Lupin Ltd, Mandideep
10	A 10	Block 14	Near M/S Vardhman Yarns, Mandideep
11	A 11	Block 16	Near Lalit Gitanjali Makan Hospital, Mandideep
12	A 12	Block 17	Near AKVN, Mandideep
13	A 13	Block 18	Near M/S Crompton & Greaves (Transformer div.), Mandideep

Remark -Block 1,3,4,10,15,19,20 are no monitoring zones

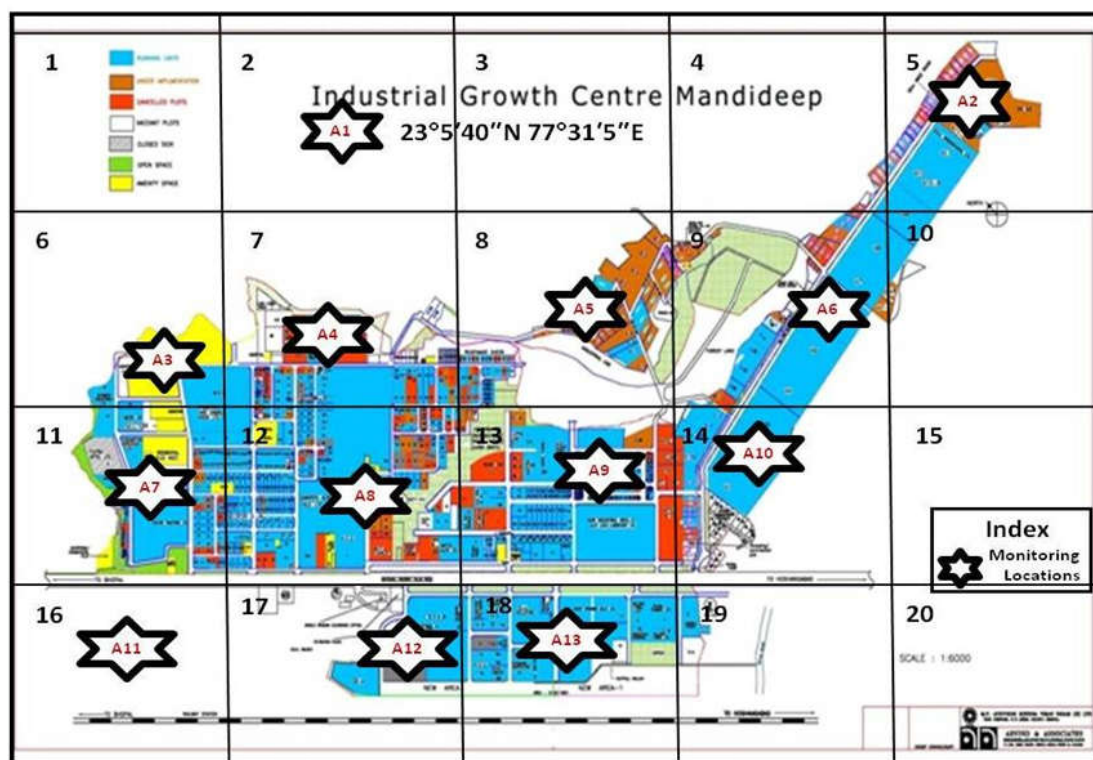


Figure 1. Monitoring Location around Mandideep Industrial Area

Table 2. Metal Concentration in Ambient Air around Mandideep Industrial Area

S.N	Analytes	NAAQS	Unit	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13
1	Cr	-	µg/m ³	0.006	0.018	0.003	0.003	0.004	0.009	0.004	0.005	0.005	0.007	0.051	0.003	0.003
2	Mn	-	µg/m ³	0.06	0.061	0.075	0.101	0.081	0.038	0.085	0.059	0.095	0.064	0.052	0.023	0.023
3	Cu	-	µg/m ³	0.035	0.034	0.036	0.023	0.027	0.02	0.042	0.024	0.025	0.034	0.041	0.033	0.033
4	Zn	-	µg/m ³	0.019	0.014	0.015	0.023	0.011	0.013	0.014	0.012	0.059	0.012	0.003	0.017	0.017
5	Co	-	µg/m ³	0.017	0.003	0.004	0.006	0.004	0.004	0.005	0.002	0.005	0.005	ND	0.003	0.003
6	Cd	-	µg/m ³	0.004	0.001	0.003	0.026	0.004	0.001	0.005	0.003	0.006	0.002	0.002	0.002	0.002
7	Fe	-	µg/m ³	0.586	0.593	0.776	0.635	0.717	0.658	0.684	0.423	0.816	0.588	0.206	0.351	0.351
8	Pb	0.5	µg/m ³	0.158	0.176	0.071	0.087	0.173	0.047	0.229	0.19	0.187	0.123	0.157	0.063	0.063

Remark: ND (Not Detected)

Table 3. Ni and As Metal Concentration in Ambient Air around Mandideep Industrial Area

S.N	Analytes	NAAQS	Unit	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13
1	Ni	20	ng/m ³	ND	11	17	14	7	8	3	101	8	7	8	3	3
2	As	6.0	ng/m ³	ND	4.179	0.711	0.44	2.28	0.723	1.328	0.211	1.117	0.446	0.96	ND	0.318

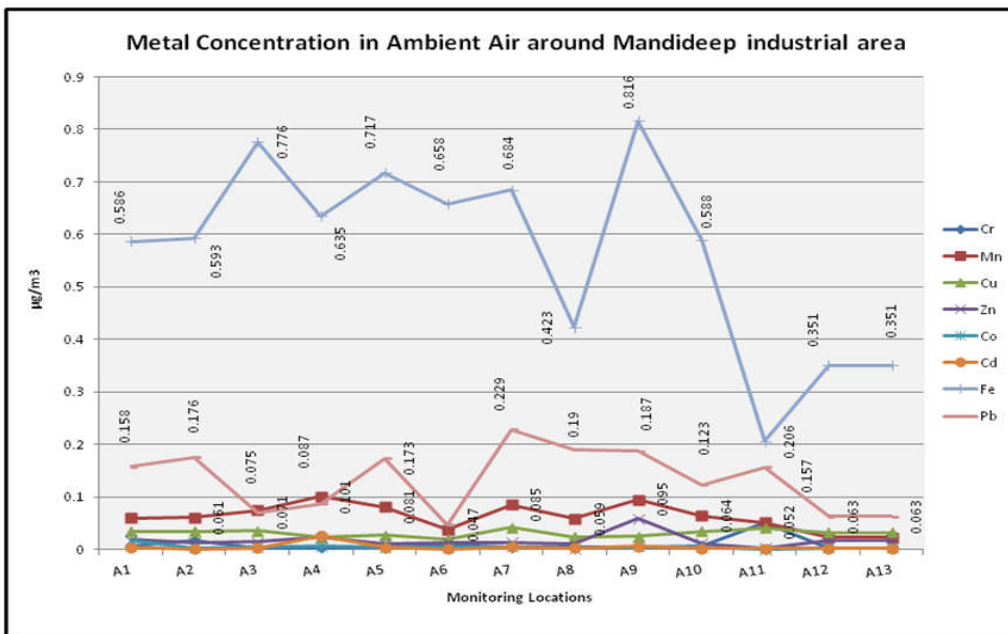


Figure 2. Metal concentration in ambient air around Mandideep Industrial area

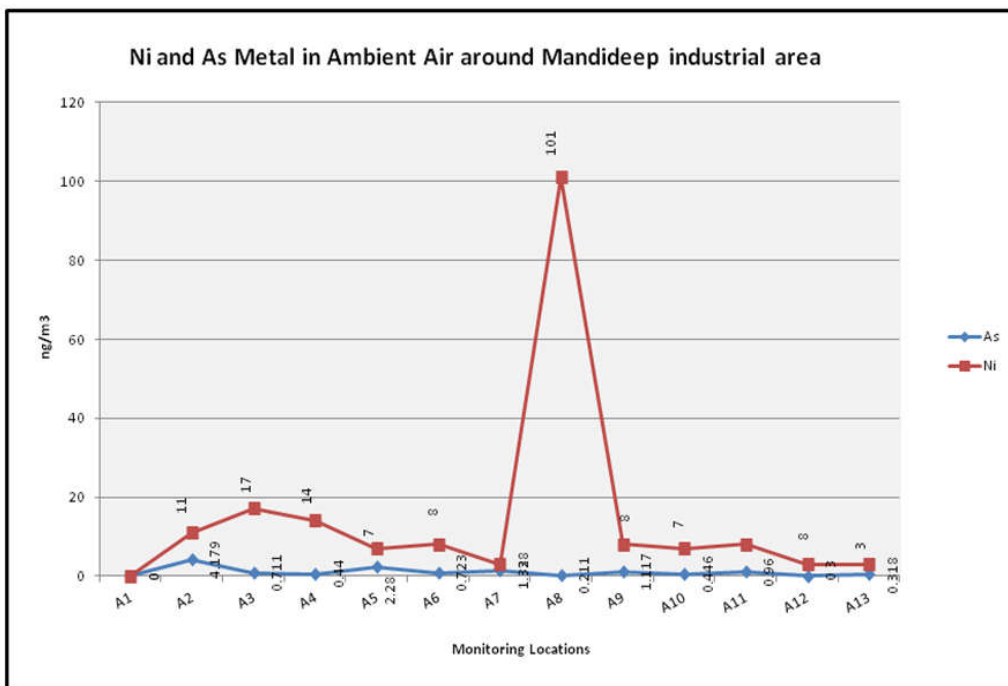


Figure 3. Ni and As concentration in ambient air around Mandideep Industrial area

It is situated between the latitude 22° 47' & 23° 33' north and the longitude 77° 21' & 78° 49' east. It is bounded in the west by Sehore District, in the north by Vidisha District, in the east & southeast by Sagar District, in the south by Hoshangabad and Sehore districts [<https://en.wikipedia.org/wiki/Mandideep>].

Monitoring Locations: Mandideep industrial area were divided in to 20 Blocks in which 13 blocks were selected for this study and other 7 blocks have open area around was no monitoring blocks. Total thirteen locations were selected for ambient air is depicted in table no 1 and figure no 1.

Monitoring: Ambient air was drawn through a size-selective inlet of the dust sampler Envirotech APM-460 and EPM 2000 (8 X 10 in) filter paper used according to guideline followed by Central Pollution Control Board [Guidelines for the Measurement of Ambient Air Pollutants Volume-I, Central Pollution Control Board].

Analysis: For analysis, the collected sample on EPM 2000 filters extracted by hot plate procedure extraction. Cut a 1" x 8" strip or half the filter from the 8" x 10" exposed filter using a stainless steel pizza cutter. Place the filter in a beaker using vinyl gloves or plastic forceps. Cover the filter with the extraction solution (3% HNO₃ & 8% HCl). Place beaker on the hotplate, contained in a fume hood and reflux gently while covered with a watch glass for 30 min. Do not allow sample to dry. Remove the beakers from the hot-plate and allow to cool. Rinse the beaker walls then wash with distilled water. Add approximately 10 ml reagent water to the remaining filter material in the beaker then allow to stand for at least 30 min. Transfer the extraction fluid in the beaker to a 100 ml volumetric flask or other graduated vessel. Rinse the beaker of any remaining solid material with distilled water and add the rinses to the flask. Dilute to the mark with distilled water (Type I) water and shake. The final extraction solution concentration is 3 % HNO₃/8% HCl. The filtered sample is now ready for analysis [Guidelines for the Measurement of Ambient Air Pollutants Volume-I, Central Pollution Control Board].

Analysis of digested samples by AAS: Analysis of acid digested samples was carried out with the help of Atomic Absorption Spectroscopy (AAS). Digested samples were aspirated into the flame, using nebulizer and concentration of element (µg/ml) in the sample was obtained. Concentration of heavy metals in the atmosphere of selected sites was determined using the following relation:

$$C = (M_s - M_b) \times V_s \times F_a / (V \times F_t)$$

Where,

C = Concentration of metal in µg /m³, M_s = Metal concentration in µg/ml, M_b = Blank concentration in µg/ml, V_s = Total volume of extraction in ml, F_a = Total area of exposed filter in cm², V = Volume of air sampled in m³, F_t = Area of filter taken for digestion in cm².

RESULTS AND DISCUSSION

The observed concentration of PM₁₀ bound heavy metals µg/m³ and ng/m³ in ambient air is depicted in table 2 and table 3 respectively. In figure 2, observed concentration of PM₁₀ bound

heavy metals i.e. Cr, Mn, Cu, Zn, Co, Cd, Fe, Pb in µg/m³ is showing that, all heavy metal found in micro level. Lead (Pb) was found within standard limit (0.5 µg/m³) as per National Ambient Air Quality Standards 2009 at all monitoring locations around Mandideep. In figure 3, observed concentration of PM₁₀ bound heavy metals i.e. As, Ni in ng/m³ is showing that, Nickel (Ni) was found exceeded at monitoring location A8 (101 ng/m³) but within standard limit (20 µg/m³) as per National Ambient Air Quality Standards 2009 at other monitoring locations around Mandideep. Arsenic (As) was found within standard limit (6 µg/m³) as per National Ambient Air Quality Standards 2009 at all monitoring locations around Mandideep.

Conclusion

The study of PM₁₀ bound heavy metals i.e. Cr, Mn, Cu, Zn, Co, Cd, Fe, Pb, Ni, As has been done. Among of all heavy metals mainly there metals i.e. Pb, Ni, Pb were reported as pollutants in National Ambient Air Quality Standards of India (2009). Presence of higher concentration of PM₁₀ bound heavy metals in ambient air may cause harmful effect on environment around Mandideep but not higher concentration of heavy metals was found during this study span.

Acknowledgement

The authors acknowledge the help received from authorities of monitoring institutions and industries. We also thankful to the Chairman and Member Secretary, Madhya Pradesh Pollution Control Board, Bhopal, Madhya Pradesh, India for encouragement of study work with kind permission to publish this paper.

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