J. Ind. Geophys. Union (July 2018)
v.22, no.4, pp: 436-443

Assessment of urban pollution from heavy metals concentration in road dust in Greater Hyderabad Municipal Corporation (GHMC), Telangana State, India.

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ABSTRACT

Greater Hyderabad Municipal Corporation (GHMC) is witnessing fast urbanization characterized by rapid urban sprawl, population growth, infrastructural construction, industrialization and motorization, which is leading to environmental degradation, placing human health at risk. Presently, heavy metals in road dusts are used as proxies to illustrate environmental changes of GHMC area. In this study 307 dust samples were collected along the roads of GHMC in one season of the year 2014.Further, measurements like Magnetic susceptibility(χ), Anhysteretic remanent magnetization (ARM) and Isothermal Remanent Magnetization (IRM), on these samples have revealed high concentration of magnetic minerals like magnetite and hematite in the urban road dust. The results indicate increasing trends, though not steady, in traffic and industry contributed pollution. Regular measurement and monitoring of these pollution markers in different seasons and for longer periods can help understand area-wise ill-effects of the present trend of urbanization and therefore guide the city planners and rulers.

Key words: Environmental Magnetism, Urbanization, Traffic, Road dust, GHMC.

INTRODUCTION

The problem of urban soil contamination is drawing the attention of city administrators and gaining more importance in solving air pollution. The problem of urban soil contamination with heavy metals is due to rapid industrialization and urbanization. The modernization of industry and the presence of intensive human activities in urban areas have exacerbated the problem of heavy metal contamination in urban soils (Sun et al., 2010). In soil, the total ferrimagnetic component may include primary minerals such as titanomagnetites with geological origins, secondary minerals such as magnetite and maghemite derived through chemical and bacterial processes or produced during burning, and contaminitating polluting dusts containing magnetic spherules (Thompson and Oldfield 1986). In urban areas, pollutants are mainly due to vehicle emission, industrial wastes, the sedimentation of dust and suspended substances in the atmosphere, the combustion of coals and the dry and wet precipitation of other pollutants (Sun et al., 2010). The concentration of these pollutants containing heavy metals vary significantly in urban soils and cause detrimental hazards to human health as it can be easily ingested into human bodies from suspended dust or by direct contact (Madrid et al., 2002; Wang and Yong, 2005). The composition and quantity of chemical matrix of road dust are indicators of Environmental pollution, which results in development of different elements and the high concentration of these elements becoming toxic. Metals such as Pb or Cr, may be tolerated by the ecosystem in low concentration, but become harmful in higher concentrations (Allowayand Ayres 1997; Nriagu 1988).

Hyderabad, the capital city of Telangana State and a major political, industrial and economic center in India, has an area of 650km^2 and has population over 8.7 million. Greater Hyderabad Municipal Corporation (GHMC) is a planned extension of older Hyderabad Municipal Corporation, by adding surrounding municipal corporations.This extension has added some advantages and some disadvantages due to various reasons.One can call GHMC as a newly structured urban conglomeration of importance. It comprises an industrial system strengthened by the presence of organised supporting departments complete with all the facilities.It is planned to give priority to automobile, petrochemical , mechanical processing, electronic, pharmaceutical, aviation, metallurgy, building materials industries, to name a few. Thus it has become absolutely necessary to study the pollution caused by the road dust that has increased phenomenally since the recent past. The main objectives of this study are (1) to determine the concentration and distribution of heavy metals in road

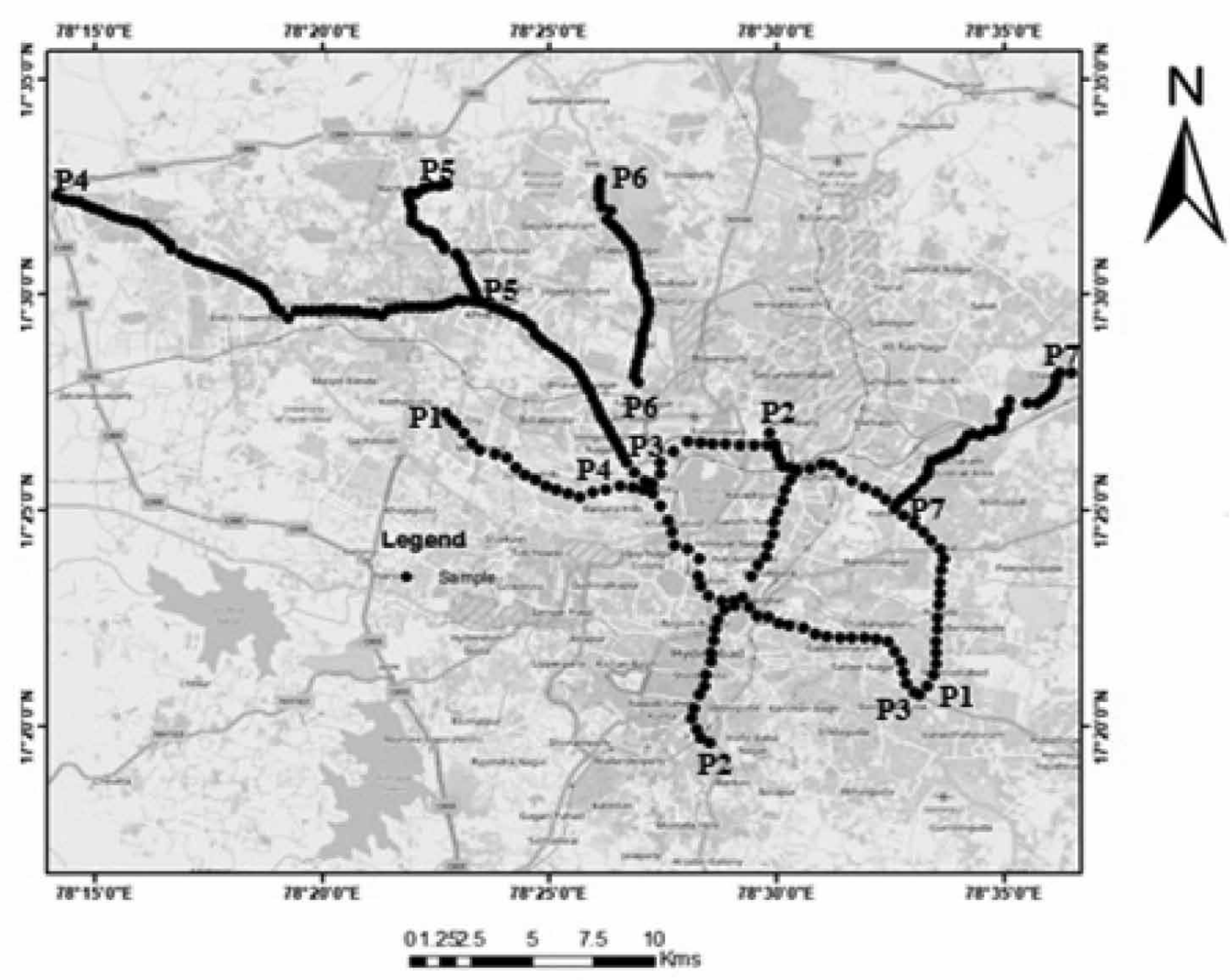

Figure 1. Location Map of the Study Area.

dust of GHMC; (2) to identify the varieties and sources of heavy metals in samples; and (3) to assess the heavy metal grain size in dust samples.

STUDY AREA

The Hyderabad being capital city of Telangana State has several roads, scattered all over the city to meet the transportation needs of the population. Out of these, there are seven major roads which pass through important junctions connected to industrial, academic, scientific labs etc. These roads due to heavy traffic generates considerable air pollution in the city affecting human health. In view of this phenomenal growth of air pollution the entire GHMC area is identified as the study area. The study was carried out along the major roads in the GHMC. Hyderabad produces around 4,500 tonnes of solid waste daily, which is transported from the waste collection points to the dumpsite in Jawaharnagar. Disposal is managed by the Integrated Solid Waste Management project, which was started by the GHMC in 2010. Rapid urbanisation and increased economic activity has also led to increased industrial waste, air, noise and water pollution, which is monitored and regulated by the Telangana Pollution Control Board (TPCB). The contribution of different sources to air pollution in 2006 was: 20–50% from vehicles, 40–70% from a combination of vehicle discharge and road dust, 10–30% from industrial discharges and 3–10% from the burning of household rubbish. This is further exacerbated by inadequately treated effluent discharged from industrial treatment plants polluting the water sources of the city.The GHMC is a city with many and newly emerging industries coupled with high infrastructural development and road construction activities. It has major road and rail links for transporting agricultural produce, textiles and leather goods and wood products. The city has shown tremendous growth in terms of population, infrastructure and traffic density during the last five to six years. Figure 1 presents the map of Telangana State showing the sampling locations in GHMC.

Table 1. Environmental Magnetic Parameters in GHMC

Profile No.		χ_{lf} (10^{-8} m^3 kg^{-1})	$\chi_{fd\%}$,	SIRM (10^{-5} Am^2·kg^{-1})	χ_{ARM} (10^{-8} m^3·kg^{-1})	χ_{ARM}/SIRM (10^3m.A^{-1})	SIRM/ χ_{lf} (10^3m.A^{-1})	χ_{ARM}/χ_{lf},	S_{-300mT}	SOFT (10^{-5}Am^2·kg^{-1})
P1	Max.	1087.48	10.67	6996.73	3552.33	0.95	8.76	5.63	103.81	1872.78
	Min.	224.48	0.04	620.31	12.68	0.003	0.70	0.01	88.73	4.71
	Average	564.16	1.56	3412.56	686.78	0.20	6.20	1.14	95.04	310.57
P2	Max.	868.26	8.70	7060.31	2987.82	0.54	10.27	3.44	105.41	1682.36
	Min.	253.70	0.15	984.07	60.21	0.03	3.01	0.16	82.95	35.19
	Average	467.26	1.92	3049.09	550.24	0.16	6.45	1.08	98.13	322.03
P3	Max.	870.32	7.75	4605.85	1719.03	0.75	7.31	4.69	105.42	483.39
	Min.	288.03	0.11	1185.25	11.18	0.004	3.24	0.02	93.93	47.30
	Average	500.68	2.00	2641.31	335.24	0.13	5.34	0.73	98.67	270.99
P4	Max.	1022.67	9.33	7851.33	2731.74	0.87	13.06	5.79	142.25	1229.65
	Min.	127.96	0.03	900.79	31.38	0.01	2.36	0.08	88.78	2.60
	Average	432.51	1.95	3214.20	512.53	0.16	7.42	1.21	97.63	235.47
P5	Max.	535.89	11.43	3840.72	1582.50	0.68	8.67	4.35	100.58	390.87
	Min.	83.83	0.44	588.89	75.32	0.05	3.07	0.21	94.15	5.13
	Average	305.43	5.14	1837.70	412.83	0.21	6.12	1.41	96.43	151.69
P6	Max.	1283.11	3.73	10296.45	4698.98	0.62	10.81	5.77	101.78	1059.40
	Min.	287.91	0.01	562.24	68.68	0.02	0.63	0.12	86.24	16.06
	Average	691.87	1.58	5010.65	1371.68	0.26	7.49	2.06	97.02	322.51
P7	Max.	1417.41	10.43	9575.80	2735.30	0.71	8.67	2.44	102.73	6643.98
	Min.	338.16	0.05	1057.73	114.58	0.02	0.74	0.12	75.78	53.46
	Average	886.69	2.08	5504.49	615.13	0.12	6.35	0.68	96.93	1016.02

P1- LB nagar to Shilparamam, P2-Jublee Bus Station to Falaknuma, P3- LB nagar to Ameerpet, P4- Ameerpet to Patancheru, P5- Miyapur X road to Bachupally, P6- Balanagar to Suraram X road, P7- Habsiguda to Cherlapally.

Laboratory Analysis

The 307 road dust samples have been collected dividing the entire GHMC area into 7 profiles (P1-P7) during December 2013 and February 2014 (Winter Season) from major traffic hotspots as indicated in figure 1 with personal protection. The samples have been collected on the road using a clean broom with dust pan and a plastic packer. On each pickup sample at regular interval of 0.25km distance has weighed between 100g to 150g. The samples have been collected in a new plastic zip cover and properly labeled for later packing. These samples have been wrapped in thin polythene films and packed firmly in pre-weighed standard non-magnetic (styrene) cubic sample holders of 10 cc volume. Magnetic mineral composition in road dust samples have been determined using a magnetic susceptibility (χ) implement.The mineral composition of 1gr samples has been determined using a dual frequency (470 and 4700 Hz) Bartington Instrument`s MS2 sensor and frequency dependent magnetic susceptibility (χ fd%) implement. The anhysteretic remanent magnetization (ARM) is studied by a DC bias field,superimposed over peak alternating (decaying) field of 100 mT using the Molspin Alternating Field Demagnetizer. The isothermal remanent magnetization (IRM) acquisition and its backfield demagnetization curves have been measured with the pulse magnetizer, where the applied field has been progressively increased up to 1 Tesla at room temperature.

RESULTS

The magnetic measurement results of the dust samples are summarized in Table 1. The evaluated magnetic parameter low field susceptibility (χ_{lf}), Satturation isothermal remanent magnetization (SIRM), SOFT [{(SIRM-IRM$_{-20mT}$)/2}/mass] and χ_{ARM} (ARM susceptibility) are along the 7 profiles P_1-P_7. The details are presented in Table 1 as maximum, minimum and average level values to explain their variation on each profile.The profile along a road reflects the concentration of magnetic materials in the sample, while $\chi_{fd\%}$, χ_{ARM}/χ, χ_{ARM}/SIRM, SIRM/χ, S_{-300mT} (backward remanence) are related to the grain size and the type of the magnetic materials in the sample (Li et al., 2010). The Table 1 shows value of Magnetic susceptibility (χ_{lf}).It varies from 83.83×10^{-8} to 1417.41×10^{-8} $m^3{\cdot}kg^{-1}$ (average 533.84×10^{-8} $m^3{\cdot}kg^{-1}$) and the SOFT from 2.60×10^{-5} to 3544.06×10^{-5} $Am^2{\cdot}kg^{-1}$ (average 324.11×10^{-5} $Am^2{\cdot}kg^{-1}$), indicating the different types and concentrations of magnetic material in the study area. The range of ARM/SIRM is (0.003~ 0.95) $\times10^{-5}$ $m{\cdot}A^{-1}$ (average 0.18×10^{-5} $m{\cdot}A^{-1}$) and the range of χ_{ARM}/χ is 0.01~5.79 (average 1.18). These parameters show the diversity and similarity of road dust in GHMC.

Distribution of Magnetic Mineral Content

The statistics of magnetic parameter details (Table 1) shows that the magnetic susceptibility (χ) varies in the Hyderabad city of GHMC area. The maximum values of χ along the P1-P7 (1087.48, 868.26, 870.32, 1022.07, 535.89, 1283.11, 1417.41×10^{-8} $m^3{\cdot}kg^{-1}$), and the minimum values along the P_1-P_7 (224.54, 253.70, 288.03, 127.96, 83.83, 287.91, 388.16×10^{-8} $m^3{\cdot}kg^{-1}$) shows the variation details. The SIRM and χ_{ARM} show the point distribution. The maximum and minimum values of SIRM along the P1-P7 (6996.73, 7060.31, 4605.85, 7851.33, 3840.72, 10296.45, 9575.80×10^{-5} $Am^2{\cdot}kg^{-1}$), (620.31, 984.07, 1185.25, 900.79, 588.89, 562.24, 1057.73×10^{-5} $Am^2{\cdot}kg^{-1}$) and χ_{ARM} is (3552.33, 2987.82, 1719.03, 2731.74, 1582.50, 4698.98, 2735.31×10^{-8} $m^3{\cdot}kg^{-1}$), (12.68, 60.21, 11.18, 31.38, 75.32, 68.68, 114.58×10^{-8} $m^3{\cdot}kg^{-1}$) respectively.The variation in these parameters like χ, SIRM and χ_{ARM} are contoured and presented in Figure 2 (a,b,c), respectively. The result clearly shows that variation is different along each profile.

Types of Magnetic Mineral

To explain the magnetic nature of road dust the back-field demagnetization (B/mT) curves have been drawn between the IRM/SIRM.The collected road dust samples of seven profiles at different fields have been utilised for this study (Figure 3). The result shows that all the samples have a remanence coercivity less than 50 mT, indicating that the dominant magnetic mineral is magnetically soft and magnetite-like component. However, there are differences in the curves obtained from the dust samples. The curves of samples P_1 21, P_2 23, P_3 13, P_4 83, P_5 3, P_6 14 and P_7 31 show a rapid rise below 100mT, reaching 80% SIRM at a magnetic field of 100 mT, and reaching nearly saturation of remanence at 300 mT.The S_{-300mT} has also gone beyond 20%, indicating that the magnetically soft but hard mineral is the dominant magnetic mineral. Further it is noticed that in the entire area of GHMC the road dust particles with more magnetically soft and hard components are present. However, hard particles are more in percentage than the soft in the area ,which is due to contribution from heavy traffic and presence of high level of industrial confluence.

Similarly, the linear correlation between SIRM and χ, SOFT and SIRM (Figure 4) also indicates significant presence of the magnetic properties of the road dust samples. The result exhibited in the figure 3 indicates that the dust samples are dominated by ferromagnetic minerals.

Grain Size of Magnetic Mineral

In the present study the evaluated parameters of the road dust reflect the characteristics of magnetic material with different grain size. To explain this the King plot graph is plotted (from Table 1)for the samples collected in GHMC area (King et al., 1982). The results show that the samples are of 1-5μm in size.This in turn suggests that most of the magnetic domain is a combination of pseudo-single domain (PSD) and multidomain (MD) (Figure 5). χ_{ARM}/SIRM (Figure 5a) shows the relative content of SD and PSD, the higher the ratio value the more the concentration of SD and PSD (Li et al., 2010). Analysis of the χ_{fd}% and χ_{ARM}/SIRM could semi-quantitatively interpret the magnetic mineral grain size. Further, to study the domain of the samples, the Dearing-plot (Figure 5b) is plotted between ARM/SIRM and χ_{fd}%.It indicates that the domain size of the road dust in GHMC area is mainly a composition of PSD and MD. Besides the low χ_{fd}%, could also indicate the low concentrations of super paramagnetic (SP) particles in the samples (below 75%) (Dearing et al., 1997).

DISCUSSION AND CONCLUSIONS

The evaluated magnetic parameters from road dust samples of GHMC area are χ, SIRM and $\chi_{ARM.}$ They indicate the high concentration of magnetic minerals in the samples. Compared to the dust particles caused by natural factors, the samples of street dust consist mainly of coarse MD and PSD grains, due to high level of concentration of industries coupled with anthropogenic pollution caused by heavy traffic, building materials and road friction. The χ, SIRM and χARM values of samples of road dust are higher. However, the values of χARM/SIRM and χARM/χ are lower in the area (Table 1). This variation could be due to the magnetic enhancement in dust samples created by heavy traffic and high concentration of industrial belt. The study shows that degree of pollution changes in an area with traffic and other factors, which contribute and generate the dust.

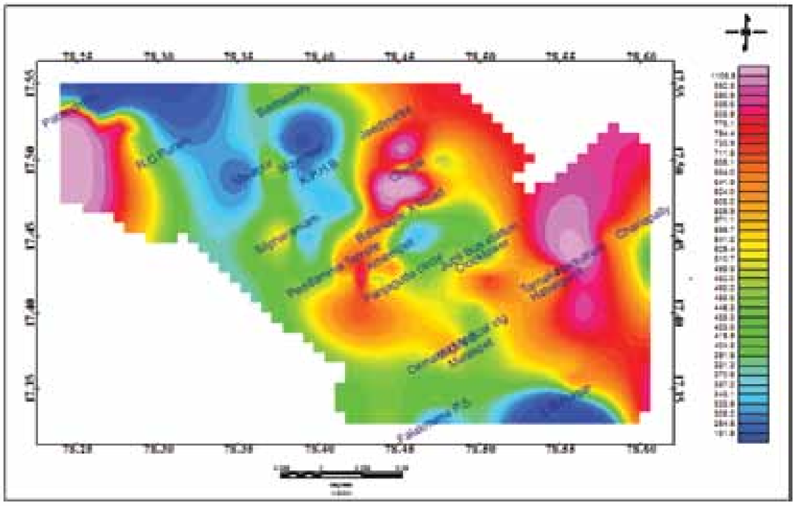

Figure 2(a). Contour map of χ (10^{-8} $m^3 \cdot kg^{-1}$).

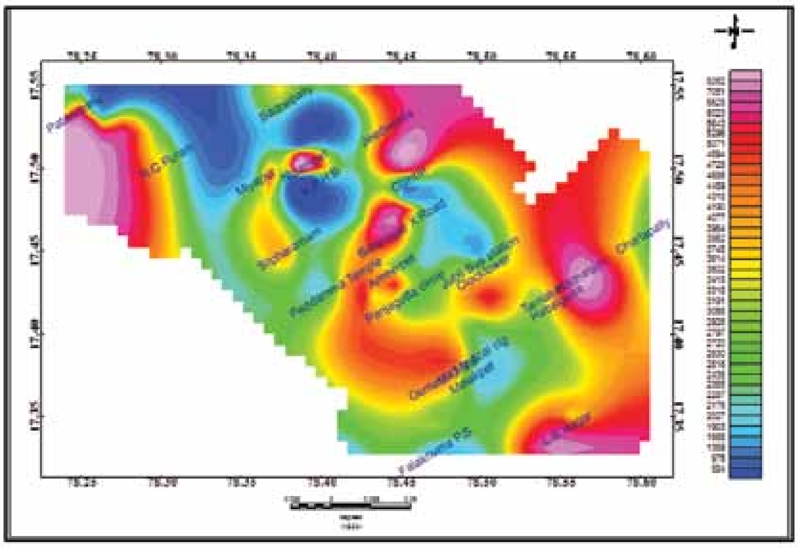

Figure 2(b). Contour map of SIRM (10^{-5} $Am^2 \cdot kg^{-1}$).

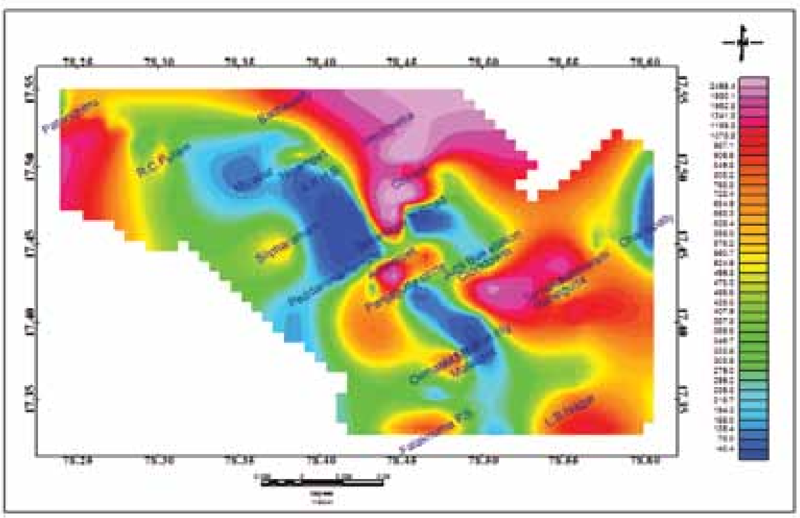

Figure 2(c). Contour map of χARM (10^{-8} $m^3 \cdot kg^{-1}$).

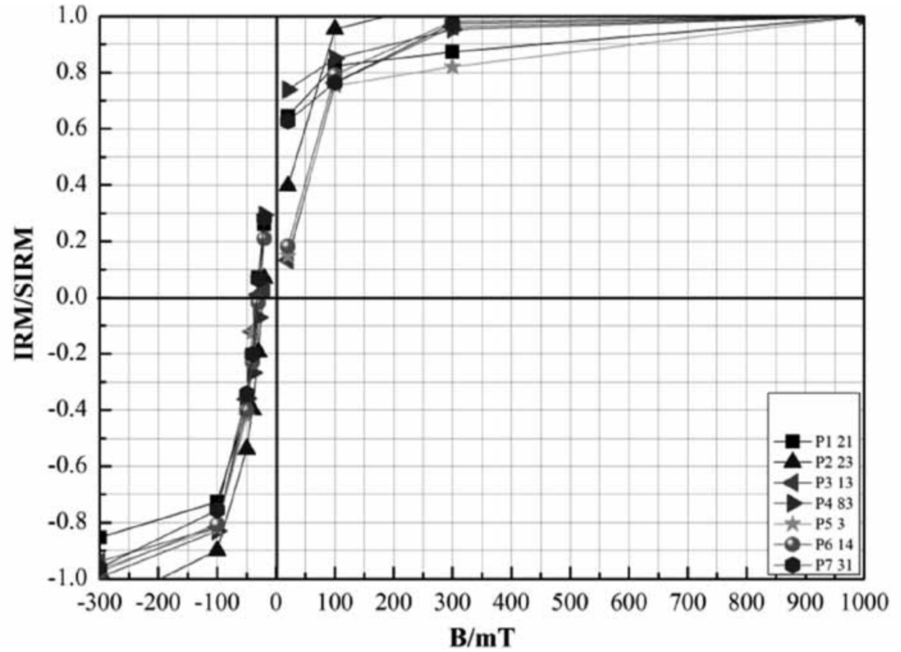

Figure. 3. IRM acquisition curves of typical road-dust samples.

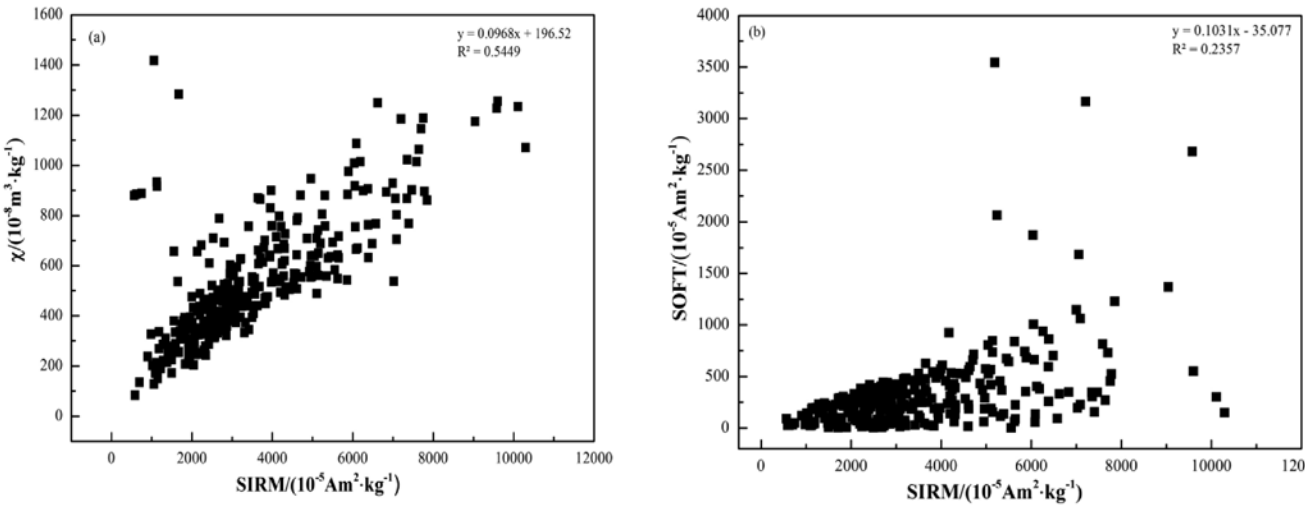

Figure 4. Bi-plots of different magnetic parameters in road-dust samples showing correlation between χ and SIRM; (b) correlation between SOFT and SIRM.

From the Table 1, the χ value of road dust sample in GHMC area exhibits an amount ferromagnetic mineral content with high magnetic nature. The results of Figure 2, show that the values of χ, SIRM and χ_{ARM} are different. This indicates the degree of pollution in the area. The χ presents a regional distribution related to the strength of heavy traffic and industries. The SIRM and χARM present the distribution related to both the level and type of heavy traffic and industrial area. Thus the pollution distribution can be known by the analysis of χ, SIRM and χ ARM.

The study reveals: 1) Ferromagnetic minerals dominate the magnetic properties of the samples. 2) The value of the magnetically soft and hard mineral component in samples of profiles P_1 21, P_2 23, P_4 83, P_5 3, P_6 14 and P_7 31 are from heavy traffic and high concentration of industries in the GHMC. This may result the degree of pollution levels related to traffic density. Thus, the specific technique of magnetic methods used in the present study is significantly effective in studying pollution created by the dust along heavily used roads.

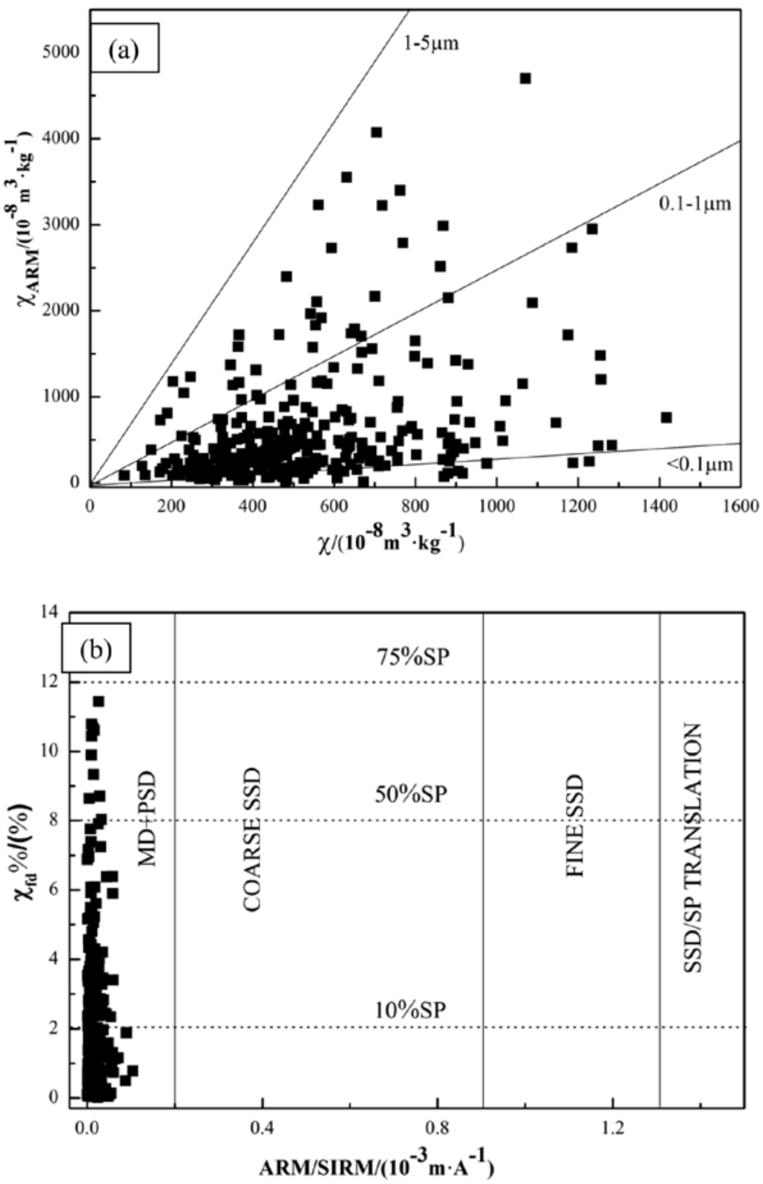

Figure 5: (a) King plot exhibitingcorelation between χ_{ARM} and susceptibility, and (b) Dearing plot exhibiting corelation between χ_{fd} and ARM/SIRM.

The magnetic mineral content in road dust samples of GHMC area, is related to traffic density and presence of industrial corridor. The magnetic measurement thus, could be used as a potential tool for identifying the zones of pollution and classifying the causative sources. Adoption of this technique could be used by the GHMC in monitoring the civic development and urbanization.

ACKNOWLEDGMENTS

We are grateful to CSIR-UGC for providing funds to do the research, and we acknowledge to Dr.K.S.Krishnan Geomagnetic Research Laboratory (KSKGRL), Allahabad for utilizing laboratory facilities. We are thankful to Prof.B.V.S.Murthy for his encouragement and guidance.We are indebted to Dr.P.R.Reddy for systematic reviewing and apt editing.

Compliance with Ethical Standards

The authors declare that they have no conflict of interest and adhere to copyright norms.

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Received on: 1.12.17; Revised: 22.2.18; Accepted on: 30.4.18