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LEAD CONTAMINATION ASSESSMENT IN THE SOIL OF KOTA CITY

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ABSTRACT

The current study has been designed to assess the level of soil contamination from the heavy metal lead in Kota city, India. Soil samples from different zones that include: Industrial zone, Commercial zone, Residential zone and Agricultural zone have been collected. Each zone includes two to three locations. Samples have been collected during the months from April to July 2017.Soil samples have been analyzed for total lead concentration. Pb concentrations have been analyzed using Flame Atomic Absorption Spectrophotometer (FAAS). Results have been compared to the levels of the control site, their ratio showing the metal pollution index. Highest Metal Pollution Index was found in Industrial zone while least was in Residential zone. It was concluded from the study that high metal pollution index has been a growing ecological concern especially for urban area such as Kota city.

KEYWORDS: Lead, flame atomic absorption spectrophotometer, control site, Metal Pollution Index (MPI).

INTRODUCTION

The two causes generating soil pollution are anthropogenic (man-made) causes and natural causes. Soil acts as a natural sink for contaminants, by accumulating and sometimes concentrating contaminants that end up in soil from various sources. If the soil is contaminated, homegrown vegetables and fruits may become polluted too. This happens because the plants along with water extract most of the soil pollutants present in the soil every time they feed. There are a large variety of pollutants that could poison the soil. One of the most common and problematic soil pollutant is Lead (Pb).

Lead is a very well known non-biodegradable toxic metal in the environment and now, it has become a global health issue. The varying degree of lead concentration in soil has a great significance because of its toxicity to living organisms. The environmental burden with heavy metals is that they are non-degradable and most of them have toxic effect on living organisms when they exceed a certain concentration level in soil.[1] Soils become contaminated by the accumulation of heavy metal lead through lead based exterior paint, auto tailpipe emissions from vehicles burning lead gasoline, bio-solids and manures, pesticides, fertilizers, metal mining, commercial products such as automotive batteries, cosmetics etc. Industrial emissions are also source of soil contamination in certain areas.

The chemical composition of soil, particularly its metal content is environmentally important because the concentration of toxic metals can reduce soil fertility can increase input to food chain, consequently leading to the accumulation of such toxic metals in food stuffs, thereby endangering human health.

While lead poisoning knows no age boundaries, most at risk from exposure to lead are children between the ages of six months to six years. This is because they most commonly engage in hand-to-mouth activities through which lead can be ingested.

METHODOLOGY

Description of Study Area – Kota city, which is an educational as well as industrial hub, is located in the southeast direction of Rajasthan. It is located around 250 kilometres south of the Rajasthan state’s capital, Jaipur. It is situated on the banks of Chambal River. It is one of the major industrial cities and the third most populous city of Rajasthan according to the 2011 census. The comparatively rocky, barren and elevated land in southern part of city descends towards a plain agricultural land in the north. The major type of soil in Kota is black soil.

Soil Sampling – Following are the places (marked by yellow star) from where the samples have been collected. (Fig. 1).

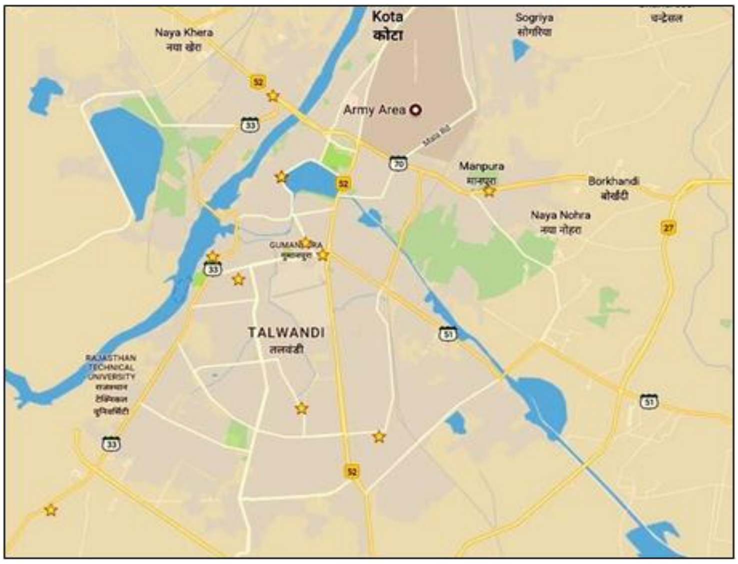

Fig. 1: Sampling sites (marked by yellow star) shown on the map of Kota city.

Table 1: Geography of Sampling Sites In Kota.

Nomenclature	Location	Latitude	Longitude
IS 1	Nayapura	25.199925	75.839558
IS 2	RIICO	25.131138	75.862747
IS 3	Kishorepura	25.116270	75.790740
CS 1	Geeta Bhawan	25.183614	75.841339
CS 2	Aerodrome Circle	25.167735	75.850381
RS 1	Pratap Nagar	25.162907	75.831842
RS 2	Mahaveer Nagar	25.136792	75.845907
RS 3	Ballabhnagar	25.170311	75.846718
AS 1	Borkheda	25.180655	75.887066
AS 2	Nayagaon	25.116270	75.790740

Analysis of Soil Samples

Preparation of soil samples for determination of Pb

1. First of all, the composite sample brought to the lab was uniformly mixed and thereafter double sieved through two sieves of 106 µ, below which pan was attached.
2. The sieved sample was collected in the pan and taken into the clean petridish. The petridish has been put in the oven at 105°C temperature for the removal of moisture.
3. After moisture removal, 1 gram of sample was weighed using weigh machine (accurate upto four decimals) and put into the beaker. 30 ml of HCl was added and kept on the hot plate, so as to dissolve the metals, until the solution remained half of the original.
4. Later the remaining half solution was taken out and allowed to cool. Afterwards, 10 ml of HNO3 was added to the solution and kept again on the hot plate. Again when then the solution was left half of it, was taken out, added 100 ml distilled water and put it on the

hot plate again.

5. Later when the solution remained less than half of original, it was allowed to cool and then filtered in the 100 ml volumetric flask using Whatman filter paper no. 42. After filtering the solution, distilled water was added so as to make up to 100 ml in the volumetric flask.

In some samples, the above-prepared solution was further diluted as the total lead concentration exceeded the detection limit of AAS instrument. The procedure of diluting solution 5 times the original is as follows: Take 10 ml prepared solution from volumetric flask and add 40 ml distilled water to make up to 50 ml. This makes 5x-diluted solution so as to get the concentration of metal within the instrument's detection limit.

Determination of Pb

1. The total Pb concentration in soils has been determined by using Flame Atomic Absorption Spectrophotometer (AAS), make of VARIAN, model number Spectra 55B.
2. AAS instrument was turned ON and so air compressor and acetylene gas too.
3. The air pressure was kept at 6-kg/cm^2 and acetylene gas pressure at 15 kg/cm^2 at the outlet of cylinder.
4. The instrument was standardized using Cu solution of 1, 2, 3, 4 and 5 ppm respectively.
5. Calibration was done with different concentrations of Pb.
6. Putting the thin pipe into the samples tested the digested samples.
7. Observed value of Pb was shown in the LCD display.
8. The values of Pb were given in parts per million (ppm).
9. These values have been converted into mg/kg by the following formula:

$$\frac{\text{Concentration of Pb (in ppm) x 100}}{\text{Weight of soil sample (in grams)}}$$

Metal Pollution Index (MPI) – The quantification of contamination/pollution index has been derived by adopting the contamination/pollution index of metals in soil.[1]

The index value represents the ratio of the heavy metal content measured in the soil through chemical analysis to the reference value obtained from the control soil.

$$\text{MPI} = \frac{\text{Concentration of metal in soil}}{\text{Reference soil (control)}}$$

Table 2: Interval of Contamination/Pollution Index Of Heavy Metals In Soil And Its Significance.

MPI	Significance	Remark
< 0.10	Very slight contamination	No negative effect on soil, plant and environment
0.10 - 0.25	Slight contamination	No negative effect on soil, plant and environment
0.26 - 0.50	Moderate contamination	No negative effect on soil, plant and environment
0.50 - 0.75	Severe contamination	No negative effect on soil, plant and environment
0.76 - 1.00	Very severe contamination	No negative effect on soil, plant and environment
1.1 - 2.0	Slight pollution	Will pose negative effect on soil, plant and environment
2.1 - 4.0	Moderate pollution	Will pose negative effect on soil, plant and environment
4.1 - 8.0	Severe pollution	Will pose negative effect on soil, plant and environment
8.1 - 16.0	Very severe pollution	Will pose negative effect on soil, plant and environment
> 16.0	Excessive pollution	Will pose negative effect on soil, plant and environment

Source: Environmental Burden of Heavy Metal Contamination Levels in Soil from Sewage Irrigation Area of Geriyo Catchment, Nigeria", *Civil and Environmental Research*, Vol. 6, No. 10, 2014.[1]

RESULTS AND DISCUSSSION

Assessment of Pb contamination in soil.

Table 3: Metal Pollution Index of Nayapura (Industrial Zone).

Location:	**Nayapura**		
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	43.34	46.69	0.93
May	75.05		1.61
June	39.89		0.85
July	34.50		0.74

Major source of lead in Kota city is the industrial emission through the Kota Super Thermal Power Plant. The prominent direction of its plume is in the Northeast direction. Nayapura lies in the N-E direction of the Kota city as per geographical map. Also, it is one of the entrances to the city, which also forms one of the busiest routes of the city.

Among the four months, highest metal pollution index was found in the month of May. Such value of MPI represents the soil as slightly polluted. It will affect the soil, plants growing on such a soil and its nearby environment.

Table 4: Metal Pollution Index of Riico Industrial Area.

Location:	RIICO Industrial Area		
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	1288.74	192.50	6.69
May	1328.72		6.90
June	1484.41		7.71
July	1467.66		7.62

High MPI (shown in Table 4) during the month of July can be possibly due to precipitation that results in deposition of airborne lead due to industrial and vehicular emissions.

High MPI value in this region is possibly because of presence of battery work industries in this area. Such high MPI shows soil heavily polluted with lead that will consequently affect plants grown on such soil and its nearby environment. High MPI significantly affects health of workers, children and women of reproductive age.

Table 5: Metal Pollution Index Of Kishorepura (Industrial Zone).

Location:	Kishorepura		
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	51.94	70.96	0.73
May	99.00		1.40
June	129.53		1.83
July	63.63		0.90

MPI value (shown in Table 5) for the month of April represents severe lead contamination of Kishorepura soil, which can be rendered as harmless. During the months of May and June, slight pollution is observed in this region, which can be harmful to the plants, soil and the environment.

Table 6: Metal Pollution Index Of Soil Near Geeta Bhawan (Commercial Zone).

Location:	Geeta Bhawan		
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	95.66	65.49	1.46
May	93.07		1.42
June	69.16		1.06
July	68.72		1.05

MPI values (shown in Table 6) for all months are greater than 1, thereby stating that the soil is polluted. High traffic volume, congestion is probable causes of high value of lead in the topsoil. MPI range from 1 to 2 denotes the soil pollution as slight. This pollution can be harmful to the population living near such polluted soil.

Table 7: Metal Pollution index of aerodrome circle (commercial zone).

Location: Nayapura			
Month	**Pb in surface soil**	**Pb in reference soil**	**MPI**
April	43.34	46.69	0.93
May	75.05		1.61
June	39.89		0.85
July	240.5		5.15

High MPI values (shown in Table 7) are observed in this region of the commercial zone. This may be due to high traffic and congestion throughout the year, which allows coarse particles of lead to settle alongside roads. Such high values of MPI show moderate pollution of soil. This pollution shall cause negative effect on the plants, soil and surrounding environment of soil.

Table 8: Metal Pollution Index Of Pratap Nagar (Residential Zone).

Location: Pratap Nagar			
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	67.96	56.82	1.20
May	61.53		1.08
June	40.23		0.71
July	46.60		0.82

MPI values (shown in Table 8) for the months of April and May are greater than 1, stating that the soil is slightly polluted and will be harmful for biotic environment. MPI value of June shows severe contamination of soil whereas MPI value of July shows very severe contamination. However, in both months i.e. June and July, no such negative effect shall occur on soil and its nearby environment.

Table 9: Metal Pollution index of mahaveer nagar (residential zone).

Location: Mahaveer Nagar			
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	41.52	40.85	1.02
May	40.25		0.99
June	25.55		0.63
July	20.85		0.51

MPI values (shown in Table 9) except for the month of April do not indicate soil pollution. April month shows MPI value 1.02 which represents the soil as slightly polluted. The month of May represent the soil as very severely contaminated, while the month of June and July represent it as severely contaminated.

Table 10: Metal pollution index of ballabh nagar (residential zone).

Location:	Ballabh Nagar		
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	58.52	56.85	1.03
May	52.82		0.93
June	44.92		0.79
July	32.70		0.58

The MPI value (shown in Table 10) for this region during the month of April shows that the soil is slightly polluted hence could be harmful to the biotic life and their environment. While in May and June the soil is very severely contaminated and in July it is severely contaminated.

Table 11: Metal Pollution Index of borkheda (agricultural zone).

Location:	Borkheda		
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	33.11	38.77	0.85
May	28.98		0.75
June	31.59		0.81
July	25.86		0.67

MPI values (shown in Table 11) of April and June indicate very severe contamination of soil while MPI values of May and July indicates severe contamination of the soil. All the above MPI values are not harmful, thus the lead concentration in the Borkheda region won't affect the soil, plants and the environment.

Table 12: Metal Pollution Index Of Nayagaon (Agricultural Zone).

Location: Nayagaon			
Month	**Pb in surface soil (in mg/kg)**	**Pb in reference soil (in mg/kg)**	**MPI**
April	46.79	33.98	1.38
May	43.58		1.28
June	36.34		1.07
July	28.62		0.84

Highest value of MPI (shown in Table 12) if found during the month of April (MPI = 1.38). Such value could be probably because of soil being eroded by heat waves during the month. Lowest MPI has been recorded during the month of July. Low MPI could have been due to runoff of rainwater. MPI values for the months of April, June and July is greater than 1, representing the soil as slightly polluted. MPI value of July month is less than 1, showing the soil as very severely contaminated soil.

CONCLUDING REMARKS

MPI Results

In the Industrial zone, IS 1 and then IS 3 highest follow MPI value of IS 2. Total lead concentration of IS 2 is far higher than any other location sampled in the city. Such high MPI value is very harmful to biotic life. In Commercial zone, MPI value of CS 2 is greater than CS 1, i.e. CS 1 < CS 2, which states that CS 2 is more polluted. In the Residential zone, the MPI values can be arranged as: RS 2 < RS 3 < RS 1. This shows that RS 1 is has highest MPI while RS 2 has the lowest. In the Agricultural zone, AS 1 < AS 2 i.e., MPI of AS 2 has been found to be higher than AS 1.

In order of decreasing MPI values, the zones can be arranged as Industrial Zone > Commercial Zone > Agricultural Zone > Residential Zone.

The Pb contamination of soil of Kota city is expected due to both geogenic and anthropogenic pollution. The coal burning in KSTPS is assumed as a major anthropogenic inventory for the Pb contamination in the soil. There is a need of proper repair and maintenance of all type of vehicles, light or heavy, both. This may help in containing the amount of lead present in the soil. Compulsory PUC for the vehicles may ease the task for the authorities and would keep the vehicles in check.

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