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GEOCHEMICAL MAPPING OF HEAVY METALS USING STREAM SEDIMENTS FOR ASSESSMENT OF SOIL CONTAMINATION IN JAIPUR, RAJASTHAN, INDIA

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ABSTRACT

Jaipur is one of the fastest growing capital city in state of Rajasthan, India. City is expanding to cater to the need of increasing population. Jaipur has undergone rapid industrial revolution and urbanization, particularly during the past two decades. City expansion has happened towards eastern and southern parts. This may have increased the amount of heavy metals released into soils. The objective of this study is a targeted investigation for the concentrations and the spatial distribution of As, Cd, Hg, Ni, Cr, Co, Cu, Zn and Pb contamination in soils. The specific goal is to support human health risk assessment in the multisource Jaipur area based on urban soil samples. This study provides important background geochemical values of heavy metals (As, Cd, Hg, Ni, Cr, Co, Cu, Zn and Pb)for Jaipur city for assessment of soil contamination from urban/industrial land use changes. Our results show relatively high values Ni, Cr, and Co near murlipura, jagatpura and sitapura area. These anomalous values are due to anthropogenic causes and cannot be explain by natural geological causes. Cu, Zn, As and Pb shows anomalous high value in and around Murlipura area, which is an industrial area this is due to industrial pollutions relatively lower value are observed near jagatpura which is a predominantly residential area.

Keywords: *Heavy Metals, Geochemical Study, Soil, Jaipur, Rajasthan.*

Introduction

Everything on the Earth is made from one or combination of naturally occurring chemical elements. As the natural processes and anthropogenic activities continuously modify the chemical composition of earth, it is necessary to evaluate and quantify the spatial distribution and abundance of the elements across the earth's surface in a systematic manner. Systematic geochemical mapping is the best method to provide the information about the natural variability of the geochemical background. Geochemical elemental distribution maps are pertinent way for representing the data base from the stream sediment, stream water and soil sample data. These interpolated images at various scales may help in addressing a wide range of environmental problems from local to national scale, this will also aid in identifying potential mineral resources. Current work was under taken to help to understand the geochemical dispersion patterns of various elements on Jaipur city. The geochemical database can be utilized for achieving different purposes in the fields of mineral exploration, land use, agriculture, forestry, management of environment, many aspects of human and animal health, waste disposal etc.

A range of media geochemical sampling includes stream sediments or slope wash, water and soil (top-soil & 'C' horizon) samples have been used for regional geochemical mapping (e.g. Darnley, 1990). In India, National Geochemical Mapping (NGCM) programme was initiated in 2001-2002 field season by the geoscientists of Geological Survey of India to cover entire surface area of the country by systematic geochemical sampling and 68 elements were to be analyzed using inductively coupled plasma mass spectrometry (ICP-MS), Atomic absorption spectrometry (AAS), and X-ray fluorescence (XRF) techniques. The main object of NGCM programme was to generate geochemical elemental baseline data for use in managing and developing natural resources; for application in environmental, agricultural, human health, other social concerns and also to search for hidden mineral deposits (SOP GSI, updated 2014).

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Jaipur has undergone rapid industrial revolution and urbanization, particularly during the past three decades. City expansion has happened towards eastern and southern parts. This may have increased the amount of heavy metals released into soils. The objective of this study is a targeted investigation for the concentrations and the spatial distribution of As, Cd, Hg, Ni, Cr, Co, Cu, Zn and Pb contamination in soils. The specific goal is to support human health risk assessment in the multisource Jaipur area based on urban soil samples.

Study Area

Jaipur the capital of the State of Rajasthan is located in northwestern part of Indian shield. The study area is undulating with linear ridges comprising the northern part while rest of the area is covered with alluvium representing both aeolian and fluvial sediments with isolated hillocks exposed in the northeastern and southeastern parts. The hills around Jaipur and the isolated hillocks in the eastern part are generally made up of hard, resistant quartzite and the peneplain terrain covered with Quaternary sediments. The major drainage in the study area is seasonal rainfed Dhund Nadi which flows southerly. The Amanishia Nala which originates from the western slopes of Jaigarh hills and meets the Dhund Nadi at the southeastern part of the area. The climate of the area is warm humid to semi-arid.

Geologically, the area belongs to the Alwar Group of rocks of the Delhi Supergroup (Palaeo to Mesoproterozoic) (Heron, 1953). The study area constitutes the southern part of the Alwar sub-basin of North Delhi Fold Belt and the rocks exposed in the area comprise metasedimentary rocks with minor intrusive which belong to Alwar Group of the Delhi Supergroup(Gupta et al., 1981; Sinha and Roy 1984). Alwar Group (arenaceous) of rock divided into two formations, the lowermost is Rajgarh Formation and uppermost is Pratapgarh Formation. Massive quartzite, feldspathic quartzite, quartz-biotite-schist etc. are the major rocks occur in the area. The quartzite forming NNE-SSW trending prominent ridge extending from Amer in the north to Jagtapura in the south belong to Pratapgarh Formation (Fig. 1a). The Rajgarh Formation of Delhi Super group occurs in the form of isolated hillocks whereas Pratapgarh Formation of Delhi Supergroup forms the linear ridges (Gupta, 1961; Das and Sinha, 1974).

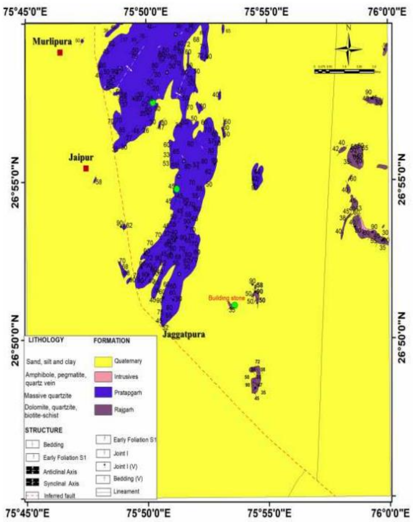

Fig. 1(a) Geological map of toposheet No.45N/13 (Data Source: Geo-Data Division, GSI, WR, Jaipur)

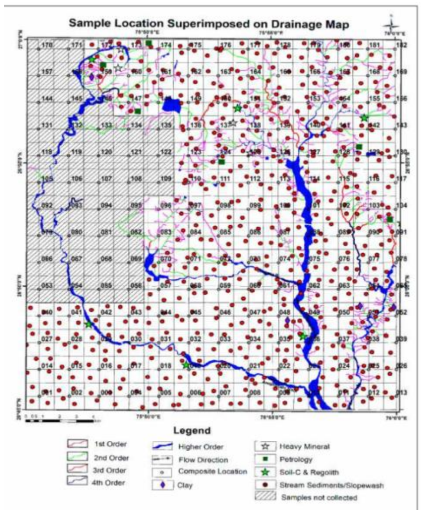

Fig. 1 (b)Sample location map and drainage map with gridding (Data Source: SOI, Toposheet)

Methodology

- **Sampling and Laboratory Analysis**

Geochemical sampling was carried out in toposheet no. 45N/13 on 1: 50,000 scale in Jaipur city and its vicinity, including industrial areas mostly in the middle, eastern and southern part of the city as a part of NGCM Programme in 2017. From the western part of the city sampling was not done due to highly developed settlement area. A total of 555sq km area was covered under geochemical mapping. A total of 555 Nos. of stream sediment/slope wash samples were collected from 1km x 1km grid interval (Fig. 1b). Basic idea is to collect sediment that is representative of the unit cell being sampled. The sample maybe collected from various sites within the unit cell to achieve the best representation (Naz and Bairwa, 2017).

Sample from each stream is to be prepared by compositing five or more sub-samples collected from a stretch of at least 50 meter. This is done to smoothen out any bias at sampling locations. Sample is collected from the stream bed away from the banks to avoid contamination. The bed material is sieved by a 120 (0.125mm) mesh steel sieve and the -120 mesh fraction collected. In case streams are absent from the unit cell slope wash material (0 order stream) is sieved by a 120 (0.125mm) mesh steel sieve and the -120 mesh fraction collected from downslope direction. At each sample location, before sampling, the sampling tools (tubs, spatula, sieves, and brushes) are cleaned thoroughly and proper care had been taken to avoid any metallic tool. At each location the lithology, nature of soil, degree of weathering, sediment mineralogy and sorting is noted in observation sheet. The -120 mesh fraction is collected in polyethylene packets, marked with the unique sample number and transported to camp for compositing.

About 250 gms of sieved material was kept as individual grid reference sample in plastic sun pet container and the remaining 250 gms sample was used for preparing composite stream sediment sample. The processed 500 gms samples were then analyzed at Chemical Division, GSI, NR, Lucknow using, Atomic absorption spectrometry (AAS), and X-ray fluorescence (XRF) techniques.

- **Statistical Data Analysis and Data Representation**

Numerous analytical data were generated from collected samples during geochemical mapping and it is very difficult to understand the significance of these data by just mere observation and come to a conclusion. Here statistics plays an important role to understand the correlation between different elements, elemental dispersion pattern and anomalous concentration of element from background values.

Univariate Statistics Analysis of single variable is known as univariate statistics. The main purpose of univariate analysis is to describe the data and find patterns that exist within it. It can be described with the range, measure of central tendency by various methods, skewness, kurtosis, variance, maximum, minimum and quartiles. Data are also studied using graphs and charts like histogram, cumulative frequency curve and box plot to better understand the behaviour of variable.

Descriptive Statistics The descriptive statistics function of microsoft excel was used to find the number of samples or count (n), minimum value, maximum value, mean, median, mode, standard deviation and skewness. The mean, median and mode values were compared to have a theoretical assessment of the normality in the dispersion of element using data analysis tool of MS Excel, to verify the mode value. The histograms and cumulative frequency curves were prepared for all the received XRF and ICPMS elements to know the distribution pattern of population.

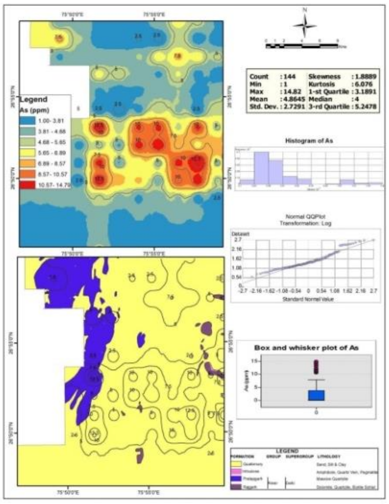

Fig. 2a. Geochemical dispersion pattern of Arsenic (AS)

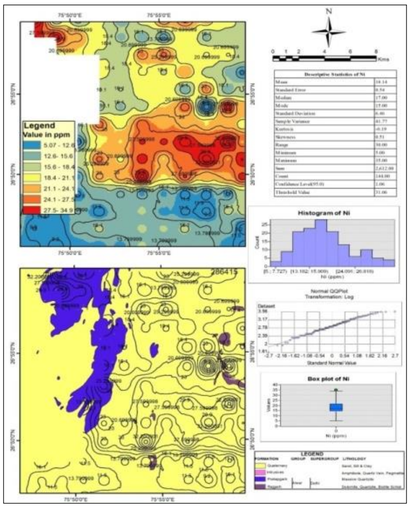

Fig. 2b. Geochemical dispersion pattern of Nickel (Ni)

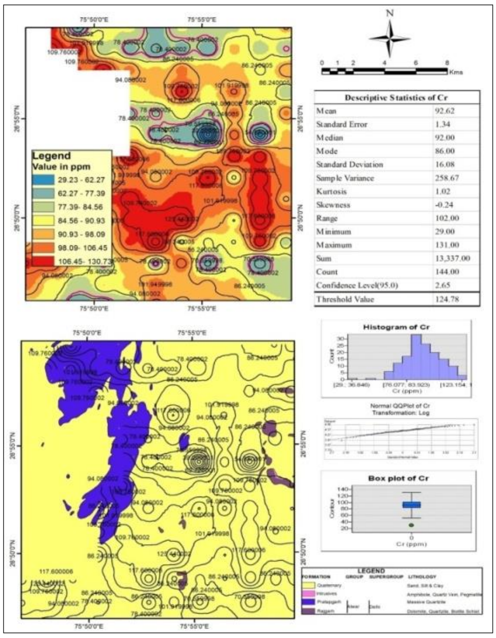

Fig. 2c. Geochemical dispersion pattern of Chromium (Cr)

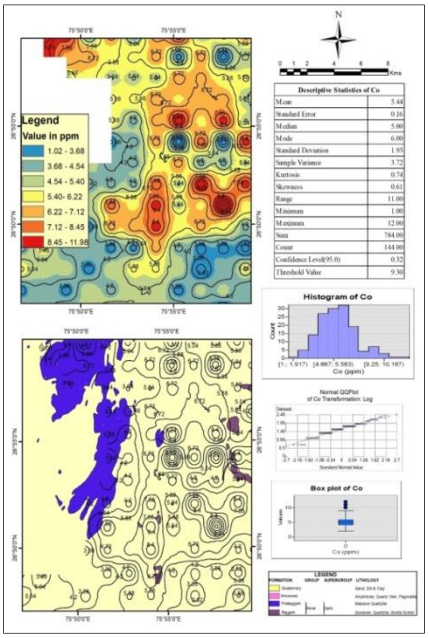

Fig. 2d. Geochemical dispersion pattern of Cobalt (Co)

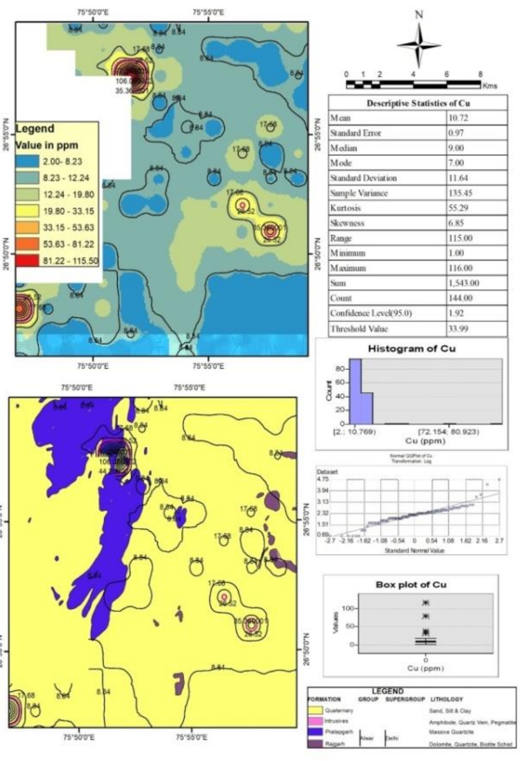

Fig. 3a. Geochemical dispersion pattern of Copper (Cu)

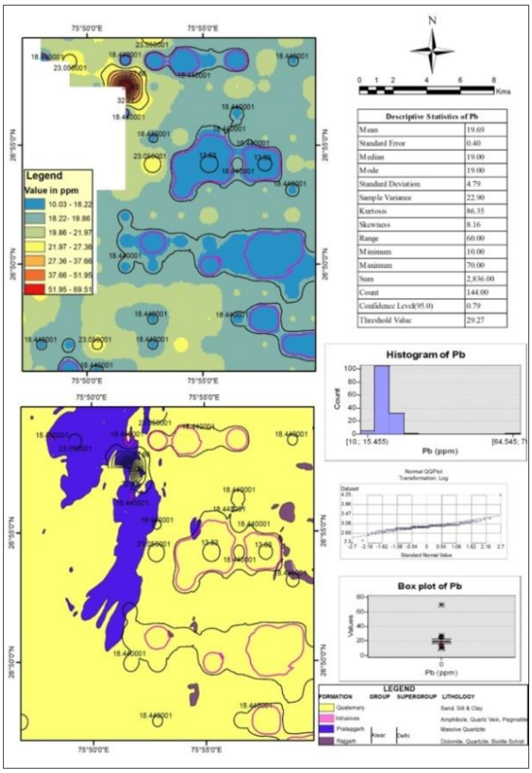

Fig. 3b. Geochemical dispersion pattern of Lead (Pb)

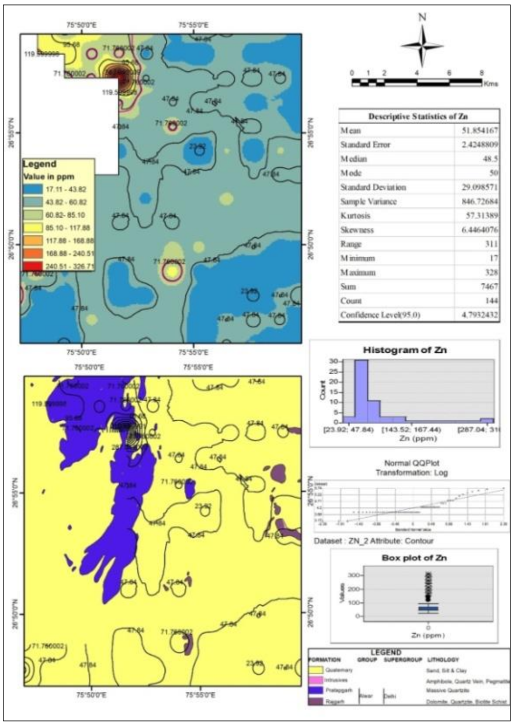

Fig. 3c. Geochemical dispersion pattern of Zinc (Zn)

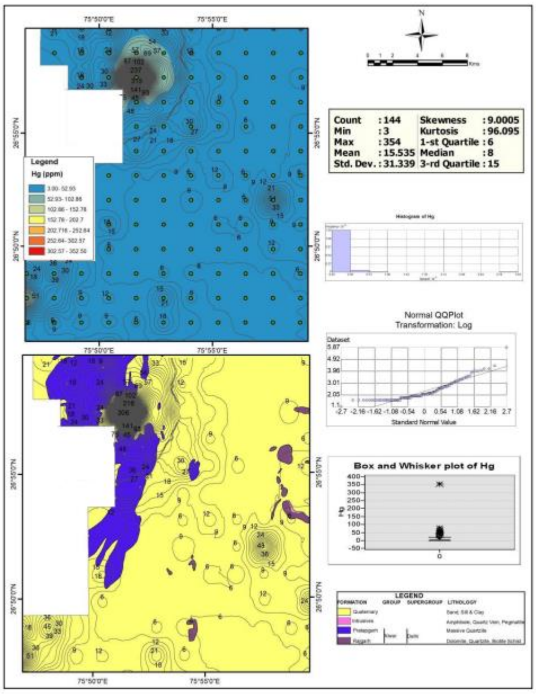

Fig. 3d. Geochemical dispersion pattern of Mercury (Hg)

- **Preparation of Elemental Distribution Pattern Maps**

Interpolation is done using kriging method and contours are generated to create elemental distribution maps on surfer. The contour maps overlays over the Geological map were also prepared in juxtaposition with the element distribution contour maps to bring forward the effect of lithology on the distribution of elements. Geological interpretations of elements the basic statistics of the dataset of 6 elements have been produced. The closeness of mean, median and mode values of the elements suggest that most of them are normally distributed. Multivariate statistics was attempted to study the correlation between individual elements / oxides, by preparing the ―nonparametric‖ correlation matrix. Association of different elements shows that the lithology is principle governing factor, which plays important role in distribution of elements. Taking these facts into consideration, following general interpretation, based on geology, has been done.

Results and Discussion

- **Arsenic (As)**

Statistical data varies from 1 to 14.82 ppm having a range of 13.82. The mean is 4.86, median is 4 with standard deviation of 2.7. The crustal abundance is 4.4ppm and threshold value in the area is 10.2. The frequency distribution graph is asymmetric and positively skewed and with few peakdness. QQ plot of shows normal distribution. There is no anomalous concentration was observed over the data set.(Fig. 2a)

- **Nickel (Ni)**

Ni statistical data varies from 5 ppm to 35 ppm giving a range of 30 ppm in toposheet no. 45N/13. The mean is 18.14 ppm, median 17 with standard deviation of 6.46. The frequency distribution graph is almost symmetric, mesokurtic and slightly positively skewed. QQ plot of shows normal distribution. The crustal abundance is 38ppm and threshold value in the area is 31.06ppm. No anomalous concentration was observed over the data set. The dispersion pattern of Ni is shown in and indicates its maximum concentration over Quaternary sediments in grid no.172 over the quartzite of Pratapgarh Formation near in the Amer RF. Only 10 % of samples shows values above than the crustal abundance. Most of the observations are below crustal abundance (Fig. 2b).

- **Chromium (Cr)**

Statistical data Chromium varies from 29 ppm to 131 ppm with mean values of 92.62 ppm and standard deviation of 16.08. Histogram is almost bell shaped, lecokurtic and shows slightly negatively skewed pattern. The crustal abundance is 80ppm and threshold value in the area is 124.78 ppm. No anomalous concentration was observed in the data set. The dispersion pattern of Cr indicates its maximum concentration, which is more than the continental crust concentration (Annexure-V), in grid no. 152. 163,164,149 value over alluvium and quartzite of Pratapgarh Formation near Siroli (fig. 2c).

- **Cobalt (Co)**

The statistical data of Co varies from 1 ppm to 12 ppm giving a range of 11 ppm. The mean values are 5.44 ppm and standard deviation of 1.93. The frequency distribution graph is almost mesokurtic; symmetric and slightly positively skewed with higher values dominating the right side. From QQ plot it is observed that the data is not normal distributed. Box plot shows few values are occurring outside the outer fence as an extreme outlier, i.e, they are unusual value is present in the data. The crustal abundance is 17ppm and threshold value in the area is 9.30ppm. The anomalous value of Co observed in the southeastern part of the study area (Fig. 2d).

- **Copper (Cu)**

Copper (Cu) values shows very wide variation from 1 ppm to 116 ppm with mean values of 10.72 ppm and standard deviation of 11.64. The crustal abundance is 32 ppm and threshold value in the area is 33.99 ppm. Skewness is 6.85 indicating that the data is positively skewed, peakdness in the data and lower values dominating the data set. QQ plot of shows normal distribution. Box plot shows few values are occurring outside the outer fence as an extreme outlier, i.e, they are unusual value is present in the data Cu in the stream sediments. The anomalous value of copper observed in unit cell no 149 over ferruginised quartzite of Pratapgarh Formation near Siroli (Fig. 3a).

- **Lead (Pb)**

Pb statistical data varies from 10 ppm to 70 ppm with mean values of 19.69 ppm and standard deviation of 4.79 in toposheet no. 45N/13. The crustal abundance is 18ppm and threshold value in the area is 29.27ppm. The frequency distribution graph is almost bell shaped and positively skewed showing few peaks in the data set. QQ plot of shows normal distribution. No anomalous concentration was observed over the data set. The geochemical dispersion pattern of Pbindicates its maximum concentration in grid nos. 175 and 176 over the pegmatitite associated with quartzite of Pratapgarh Formation in the north-west of Amer (Fig. 3b).

- **Zinc (Zn)**

Zn statistical data varies from 17 ppm to 328 ppm giving a range of 311 ppm. The mean is 51.85ppm, median 48.5 ppm with standard deviation of 29.09. The crustal abundance is 70ppm and threshold value in the area is 110.05 ppm. The frequency distribution graph is asymmetric, and positively skewed and lower values dominates the data set with few peakdness. QQ plot of shows normal distribution .There is no anomalous concentration was observed over the data set. The dispersion pattern of Zn indicates its anomalous concentration in grid no 17 over the alluvium near Govindpura Fig. 3c).

- **Mercury(Hg)**

Statistical data varies from 3 to 354 ppm having a range of 351. the mean is 15.60 median is 8 with standard deviation of 31.4. the crustal abundance is 1.55 and threshold value in the area is 21.88. the distribution graph is asymmetric and positively skewed and with few peakdness. QQ plot of shows normal distribution. There is no anomalous concentration was observed over the data set Fig. 3d).

- **Cadmium (Cd)**

Analytical Results of this Element are below Detection Limit.

As seen from the elemental distribution pattern we observed a very good correlation in Ni, Cr, and Co because of quartz muscovite schist of rajgarh fm. Relatively high values are observed near Murlipura, Jagatpura and Sitapura area these anomalous values are due to anthropogenic causes and cannot be explain by natural geological causes.

Cu, Zn, As and Pb shows very less value in the eastern part of study area which is underlain by pratapgarh quartzite but they show anomalous high value in and around Murlipura area, which is an industrial area this is due to industrial pollutions relatively lower value are observed near jagatpura which is a predominantly residential area.

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