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Principal Component Analysis to Assess the Heavy Metal Enrichment in the Urban Soils of Kabini Basin: Emerging Concerns

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Abstract

Heavy metal enrichment in urban soils demarcates a major ecological concern. The emerging industries, settlements and agricultural lands in bank of Kabini River resulted in prominent changes in water and soil geochemistry. In present work, a total of 20 soil samples from Kabini Basin have been checked for trace metals concentration and assessed following multivariate statistical approach. The PCA has been conducted to characterize the trace metals as per the common source of origin. The factors distinguished the heavy metals into 3 components with overall variance of 82.53%. Higher loading of various heavy metals indicates natural and anthropogenic interferences in soil. The baseline data generated from the present study provides the insight over the concentration of heavy metals, which would further be helpful in conservation and management of soil resources of the basin.

Keywords: Heavy Metal, PCA, Urban Soils, Kabini Basin

Introduction

The surface of the Earth is the constant platform for the interactions among geosphere, biosphere, atmosphere and pedosphere. The formation of soil, nutrient cycles, water circulation, transport of radioactive substance are some of the mass and energy driven processes occurring on the Earth at spatial and temporal scales. Soil present in the environment is associated with air, water and rock interface (Facchinelli *et al.*, 2001; Krishnakumar *et al.*, 2022) is more prone to contaminants as the interaction among these components tends to release substances that get adjusted with soil thereby changing its chemistry. Trace elements in soil are natural components of Earth crust. These are important elements of biological community which interact with aquatic environment by various man-made activities (Mohan *et al.*, 2022). The determination of the heavy metals in soils is necessary as it affects the soil fertility and microbial processes, absorption/ desorption processes, disturb the food chain that ultimately leads to health impairment in human beings. Also, the mobilized heavy metals may under gobio-accumulation that may further cause the long- term problems in ecosystem (Krishnakumar *et al.*, 2021).

In present work statistical approach has been used to determine the origin and linkage between various heavy metals along the basin. Principal Component Analysis is one of the widely accepted approaches to estimate the prominent sources of heavy metals in the soil. Therefore, the study seeks to identify the concentration and source of various elements in soil of Kabini Basin.

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Study Area and Geology

The Kabini Interstate Basin extends in the area of 7040 Km^2 through Kerala and Karnataka states between 11°45' to 12°30' latitude and 75°45' to 77°00' longitude. The main water body in the area is Kabini River Basin, which is the east flowing river, originating from the Wayanad district of Kerala having an entire length of 240 Km. The river confluence with the Cauvery River at T.N. Pura in Karnataka. The basin experienced humid to semi-arid conditions with average rainfall of 700 mm/year. The south west monsoon plays a dominant role in defining the precipitation characteristics of the basin. Geologically, the basin area is associated with granites, charnockites, peninsular gneisses, metasediments and metavolcanic rocks *etc*. (Nagaraju and Papanna, 2009). Largely, the basin is occupied by alluvial soils with the sandy loam to clayey loam texture and moderate potash, organic matter and nitrogen (Sarangan., 2022). The downstream side basin area mainly consists of red soil, laterite soil, black soil, alluvo-colluvial soil and brown forest soil (Kumar *et al.*, 2021; Prasanna, 2021).

Material and Methods

Sampling and Analysis

A total of 20 soil samples have been collected from the Kabini River basin during monsoon period September 2021. The sample

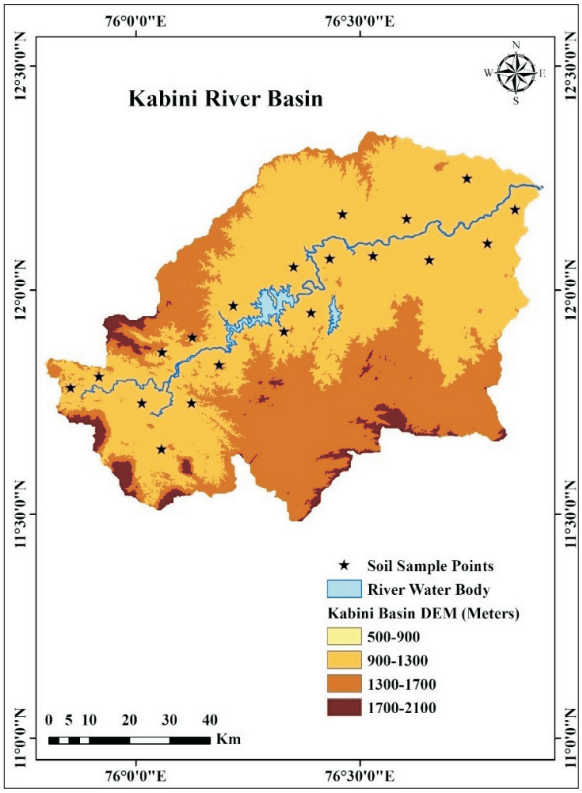

Fig. 1. Location Map of Study Area showing soil sampling locations.

locations (Fig. 1) are identified in such a way to reflect the existing conditions prevailing in the region. The heavy metal values (ranges and average) in soils along the basin are shown in Table 1. The soil samples were brought into the laboratory and dried at 60° C and the samples were homogenized by coning and quartering. The dried samples were crushed using Mortar and Pestle and sieved through with the mesh size of 250mm. Then samples are subjected to X-ray Fluorescence spectrometry (XRF) by using the packing of small aluminum cups with boric acid and the pellets are prepared under hydraulic press (25 tons of pressure) for determination of heavy metals.

Results and Discussion

The Principal Component Analysis (PCA) is a widely used technique that illustrates the inter correlated variable by reducing the dimensionality of data set. The PCA rendered three PCs with eigen value greater than 1 explaining the 82.53%of total variance. As per the scree plot, the data accounts for 3 useful factors since after that eigen value drops below 1 (Fig. 2). The different loading of factors is shown in Table 2 and loading plot of various elements is presented in (Fig. 3).

Table 1: Comparative values of heavy metals in soil near Kabini River Basin (mg/Kg)

Heavy Metals	V	Cr	Ni	Cu	Zn	Rb	Y	Zr	Ba
Max.	592	899	386	149	197	321	66	132	922
Min.	86	123	24	35	43	73	16	68	20
Mean	207.4	439.5	147.8	68.2	133.6	171.3	40.5	102.8	469.4

Table 2: Rotated Component Matrix of significant principal components in soil

Heavy Metals	Components		
	1	2	3
V	0.950	-0.124	-0.042
Cr	0.554	0.738	-0.054
Ni	-0.333	0.873	0.009
Cu	0.422	0.234	0.793
Zn	-0.460	0.337	0.710
Rb	0.197	0.944	0.075
Y	0.904	0.254	0.225
Zr	-0.230	-0.024	0.812
Ba	0.560	0.455	-0.072
Eigen Value	3.755	2.481	1.188
Variance %	41.724	27.571	13.198
Cumulative %	41.724	69.295	82.492

The PC1 accounts for 41.72% of total variance. The factors showing strong correlation include Vanadium, Yttrium, Barium. The basin area is surrounded by several industries such as chemical, textiles, automobiles, cement, oil etc. that discharges large quantity of toxic effluents such as untreated waste water directly to the river, thereby enhancing the metal pollution along the basin (Star of Mysuru, 2021; The Hindu 2019). The presence of Vanadium in soil is largely controlled by parent material, associated pedogenic processes and weathering of ultramafic rocks such as gabbro-anorthosite complexes in the basin (Ramiengar *et al.*, 1978). Moreover, the Vanadium and Barium proximity in the area also highlighted industrial discharge from textile, dyeing, electronics, metallurgy industries etc. (Krishna *et al.*, 2007).The basin is largely occupied with the agricultural sectors, with municipal and industrial waste water. As per the research carried out by (Abhilash *et al.*,

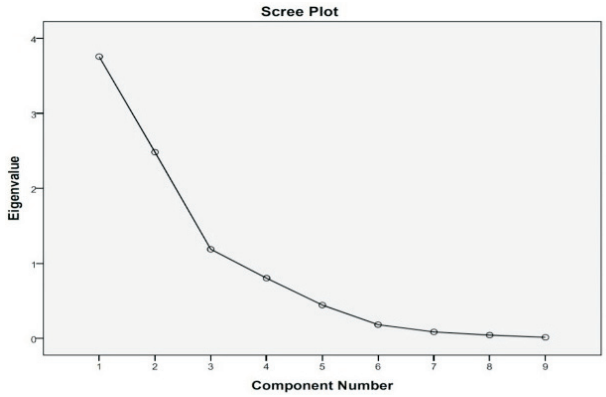

Fig. 2. Scree plot of eigen values

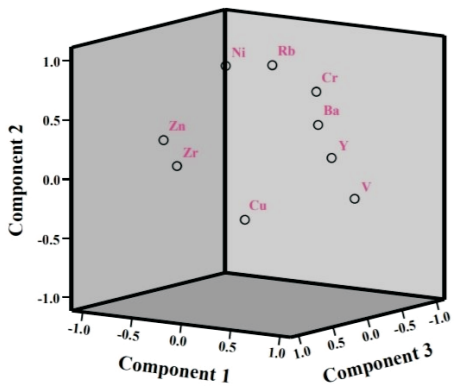

Fig. 3. Loading plot of heavy metals

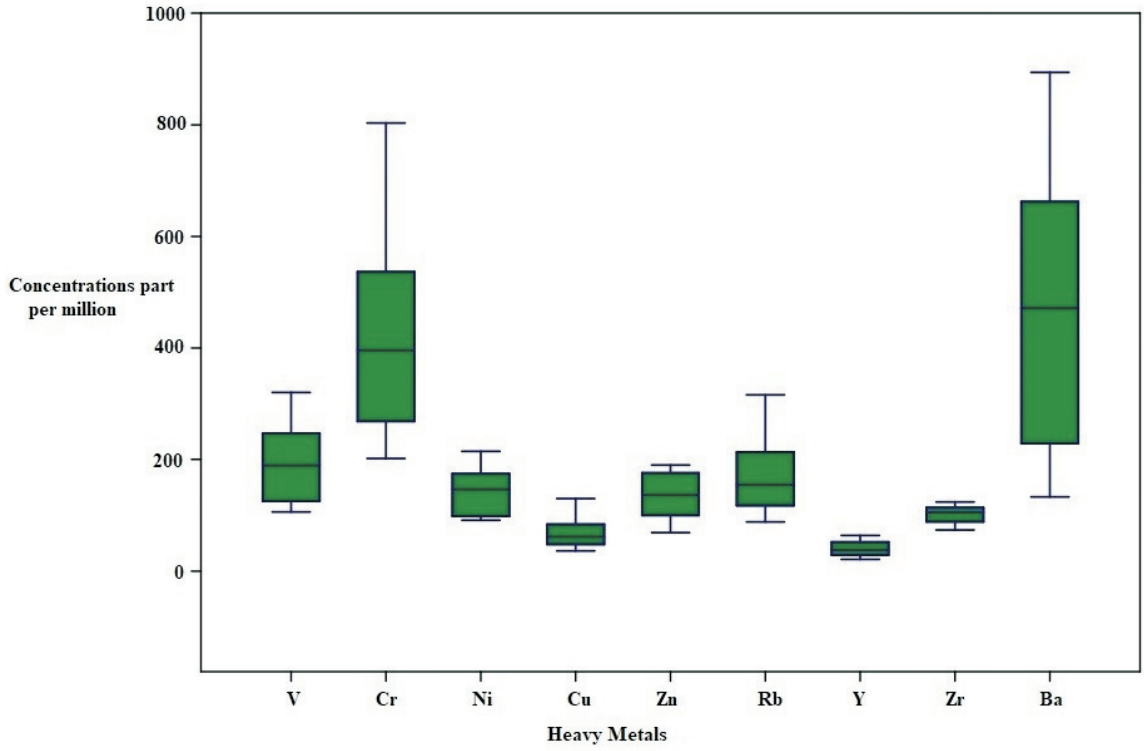

Fig. 4. Box plot for maximum, minimum and average composition of heavy metals

2016), towards the down stretched side of the basin the crops that are irrigated by industrial waste water such as *Coriandrum sativum L*, *Menthalangi folia L*, *Oryza sativa L etc.*, are associated with seasonal heavy metals accumulation. The *P. purpureum* Schumach is one among the prominent crop, that sustained the highest heavy metals such as Cu, Ni, Zn, Fe *etc.* along the basin. Also, the enormous use of pesticides such as carbofuran, organochlorine insecticide such as DDT (Dichloro diphenyl trichloro ethane), endosulfan sulphate also enhances the heavy metals accumulation in soil across the basin (Sharma and Raju, 2013; Devasia, 2013). Yttrium is commonly associated with natural processes such as coal combustion as well as anthropogenic inputs from the nearby agricultural and industrial areas (Kumar *et al.*, 2021). The concentrations of various heavy metals are depicted in the box plot (Fig. 4)**.**

The PC2 accounts about 27.6% of variance with the Chromium, Nickel and Rubidium showing the highest loading. The higher concentration of these elements in the area might indicates the weathering of mafic and ultramafic rocks such as chromiferous serpentinite, pyroxenite, anorthosite etc. (Kierczak *et al.*, 2016; GSI., 2006) and industrial discharge along the basin. Additionally, the geochemistry of different rock types along the basin has been referred from several research studies. The nearby localities are explored by different researchers mainly (Narasimha and Kapfo, 2016; Babeesh *et al.*, 2018). In the present work, V, Ni, Y, Ba are found to have higher values. PC3 accounts for 13.2% of variance with the strong loading of Copper, Zinc and Zirconium. The higher concentration of Cu is attributed to industrial waste water effluents such as the electroplating industries near the basin (Krishnanandan and Srikantaswamy, 2013). Also, the leather tanning, metal plating, cleaning industries significantly resulted in concentration of Zn and Zr that are observed along the basin (Krishna *et al.*, 2007; Hejabi *et al.*, 2010; The Hindu, 2019).

Conclusions

Concentration of various heavy metals in the soils along Kabini River Basin are following the sequence as Ba> Cr> V> Ni> Rb> Zn> Cu> Zr> Y. The results of PCA illustrated the geogenic inputs such as weathering of ultramafic rocks as well as anthropogenic intakes like heavy use of agrochemicals and industrial discharge towards the down stretched side of the basin. The alarmingly increasing concentration of these heavy metals may cause several ecological concerns such as disturbance of food web that may lead to deteriorating human health and may cause chronic illness, kidney disinfection, birth defects *etc.* The study further confirms that increasing concentration of heavy metals is minacious. Therefore, certain conservative and management strategies need to be implemented along the basin to prevent further deterioration of these precious natural resources.

Authors' Contributions

HG: Conceptualization, Analysis, Writing Original Draft. **AK**: Visualization, Supervision, Investigation, Reviewing, Editing, Administration. **AKK**: Analysis, Validation, Investigation.

Conflict of Interest

The authors declare no competing interest.

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References

Abhilash, M.R., Shivanna, S., Doddaiah, S.K. and Krishnegowda, J. (2016). Speciation of Heavy Metals in Municipal and Industrial Wastewater Irrigated Crops of Mysuru City, India - A Comparative Study. Jour. Env. Sci. Comp. Sci. Eng. and Tech., v. 5(2), pp.68-75.

Babeesh, C., Achyuthan, H. and Sajeesh, T.P. (2018). Geochemical Signature of Karlad Lake Sediments, North Kerela: Source area, weathering and provenance. Jour. Geol. Soc. India, v.92, pp. 177-186.

Devasia, M.J. (2013). An investigation on pesticide residue in soil and water with particular reference to Carbofuran in Wayanad District, Kerala. Ph.D. thesis. Mahatma Gandhi University.

Facchinelli, A., Sacchi, E. and Malleri, L. (2001). Multivariate Statistical and GIS-based approach to identify heavy metal sources in soils. Jour. Environ. Poll., v. 114, pp. 313-324.

Geological Survey of India, GSI (2006). Geology and the mineral resources of the States of India. Karnataka and Goa.

Hejabi, A.T., Basavarajappa, H.T., Karbassi, A.R. and Monavari, S.M. (2010). Heavy metal pollution in water and sediments in the Kabini River, Karnataka, India. Internatl. Jour. Environ. Res., v. 4(4), pp. 629-636.

Kierczak, J., Pedziwiatr, A., Waroszewski, J. and Modelska, M. (2016). Mobility of Ni, Cr and Co in serpentine soils derived on various ultrabasic bedrocks under temperate climate. Jour. Geoderma., pp.78-91.

Krishna, A.K. and Govil, P.K. (2007). Soil contamination due to heavy metals from an Industrial area of Surat, Gujarat, Western India. Jour. Environ. Monit. Assessment., pp.263-275.

Krishnakumar, A., Aditya, S.K. and Kannan, N. (2021). Geochemistry and Environmental Implications of Sediments from a Tropical Urban Small Catchment River of South Western Ghats, India. Jour. Geosci. Res., pp. 57-67.

Krishnakumar, A., Aditya, S.K., Krishnan, A.K., Nandakumar, V., Kaliraj, S. and Jose, J. (2022). Establishment of baseline reference geochemical values in tropical soils of Western Ghats: Assessment of Periyar basin with special reference to contaminant geochemistry. Jour. Clean Soil Air Water, 2200382.

Krishnandan,V. and Srikantaswamy, S. (2013). Assessment of impacts by Industries on sediments of Kabini river around Nanjangud Industrial area, Karnataka, India. Internatl. Jour. Scient. Engineer. Res., v. 4(11).

Kumar, S., Zhao, M., Zhang, H., Rahman, Md. A. Luo, C. and Rahman, M.M. (2021). Distribution Contamination status and source of trace elements in the soil around brick kilns. Jour. Chemosphere, 263, pp. 127882.

Mohan, U. and Krishnakumar, A. (2022). Geochemical aspects and contamination evaluation of major, minor and trace elements in the sediments of Kallada River Basin, SW India. Jour. Environment. Sci. Health, pp.1-10.

Nagaraju, D. and Papanna, C. (2009). Hydrogeochemical Studies of Kabini River Basin, Karnataka, India. Jour. Nat. Environ. Poll. Tech., v. 8, pp. 111-118.

Narasimha, K.N.P. and Kapfo, L. (2016). Petrological and geochemical studies of Felsites around Mandya districts Western Dharwar Craton, South India, Karnataka. Internatl. Jour. Geol. Earth Sci., v. 2(1), pp. 63-76.

Prasanna, K.R. (2021). Geographical profile of Mysore district: A detailed analysis. Internatl. Jour. Res. Cul. Soc., v. 5(4), pp.37-41.

Ramiengar, A.S., Chayapathi, N., Raghanandar, K.R., Rao, M.S. and Rao, P.R. (1978). Mineralogy and Geochemistry of a Vanadiferous Titano-Magnetite Deposite and Associated Copper Mineralization in Gabbro-Anorthosites Near Masanikere, Shimoga District, Kapnataka, India. Jour. Develop. Precamb. Geol., pp.395-406.

Sarangan, M.S.S. (2022). Central Groundwater Board Ministry of Jal Shakti. Department of water resources, river development and Ganga rejuvenation government of India,Kerala region. Aquifer mapping and management plan of Wayanad district, Kerala.

Sharma, M. and Raju, N. (2013). Correlation of heavy metal contamination with soil properties of industrial areas of Mysore, Karnataka, India by cluster analysis. Internatl. Res. Jour. Environment Sci., v. 2, pp. 22-27.

Star of Mysore. (2021).Notices to be issued to industries polluting rivers: Environment Minister - Star of Mysore.

The Hindu (2019). No facility for handling waste in Mysuru's Industrial area. (Dated. 21st November)