



Physico-Chemical Characteristics of Soil in Shahdol District of Vindhya Plateau

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ABSTRACT

Soil samples were collected from 5 Tahsil, 2 Industrials Place, 6 Crop field and 7 Villages in Shahdol District. The soil characterization was carried out for physico-chemical parameters like Temperature, pH, particle size distribution (Sand, Silt, Clay), organic carbon (OC), Nitrogen (N), Phosphorus (P), Exchangeable Cation (Na⁺, K⁺, Ca⁺⁺, Mg⁺⁺) and heavy metal like Lead, Chromium, Copper, Iron, Nickel, Copper etc. Conventional analytical methods were employed for the determination of these physico-chemical parameters while heavy metals in the soil samples were analyzed using atomic absorption spectrometer. In the present study Mg⁺⁺ was not detected in five sampling stations (E2, E5, E12, E15 and E17). Pb and Cu were found within the recommended level during all the seasons. Statistical analysis was used in this work.

Keywords: Diffuse pollution, Heavy Metals, Soil, Statistical analysis, Shahdol District, Vindhya Plateau.

INTRODUCTION

The present distribution of metals in the soil can serve as an indication of time, history, and extent of pollutants discharged in the area. Assessing the problems caused by contaminated soils typically involves soil chemistry as well as laboratory and field studies to fully assess the extent and significance of any adverse environmental effects [1]. The toxic metals entering the ecosystem may lead to geoaccumulation, bioaccumulation and biomagnification. Where trace metals are necessary for functioning of biological systems, their deficiency or excess can lead to a number of disorders. [2]

The monitoring of contamination of soils by heavy metals the environmental protection agency of the United States [3] recommends the determination of total contents in soils, extracted with concentrated nitric acid [4]. A quantification of the contamination index for soil in dump sites of both vicinities (agbor/Abraka) shows that the soils are highly contaminated in some of the metals studied and therefore constitutes a major health risk to the local population. These metals may pose a danger to human and aquatic life [5]. Horizon

wise soil samples were analyzed for various physical and chemical properties [6]. Available N, P, K and DTPA extractable Fe, Mn, Zn and Cu were estimated for surface and sub surface soils [7].

Concern over pollution sources in integrated soil quality management has growing recently. The term diffuse essentially point to this feature of the discharge of such pollution loads which makes them somewhat difficult to notice, monitor or control. The Vindhya Pradesh plateau is environmentally very important to understand the rich Indian biodiversity and diffuse chemical pollution. The great Vindhyan range extends generally from west to East and scraps at most of its length towards. Shahdol district is situated in the northeastern part of the Madhya Pradesh provinces of India. Because of the division of the district on 15-08-2003, the area of the district remains 5671km². It is surrounded by Anuppur in the southeast, Satna and Sidhi in the north and Umaria in the west. The district extends 110 km from east to west and 170 km from north to south. This district is situated between 22^o38'N latitude to 24^o20'N latitude and 30^o28' E longitude to 82^o12' E longitude. The district is also a division. Some of the district in this division are Anuppur and Umaria. District Shahdol is very rich in its mineral resources. Minerals found in district are coal, fire clay, ochers and marble. Sohagpur coalfield contributes a major part in the revenue of the state. The Virateshwar Temple in Sohagpur Vangana is the most important tourist destination of Shahdol and structural masterpiece. A large number of researchers have been carried out studies on soil in many part of the country, but a little work has been done for Shahdol District of Vindhya Pradesh. The aim of this study was to examine the physico-chemical properties and heavy metal level in soil of Shahdol District. In the present study diffuse chemical pollution of soil in the Shahdol District was investigated this includes 5 Tehsil (Shahdol, Jaisinghnagar, Beohari, Pushparajgarh, Sohagpur) , 2 Industrial Place (Khamria Mince and Coal Mince), 6 Crop Field (Sidi, Atariya, Pakariya, Suida, Mantola and Kotma) and 7 Villages (Karwa, Jhajauli, Chilpa, Karki, Kanaoudi, Bodari, Redsa).

MATERIALS AND METHODS

In the present work we are intended to find out the diffuse chemical pollution in Shahdol District on the basis of Tehsil, crop field and Villages. Total 20 places were selected for this study i.e Shahdol, Sohagpur, Karwa, Jhajauli, Chilpa, Jaisinghnagar, Atariya, Redsa, Karki, Kanaoudi, Sidi, Beohari, Mantola, Kotma, Suida, khamria mince, Pakaria, Bodri Pushparajgarh and coal mines of district. Sampling was done during rainy, winter and summer season (of year 2009 to 2010) the month of July and August, December and January and April and May were selected as representative month of rainy, winter and summer season respectively. Twenty soil samples were collected from different location in plastic bags, dried at 60^oC for 48h and fine powder was made with the help of pistil mortar and sieved it with 2mm sieve. Various physico-chemical parameter of each location were analyzed by different technique [8-10]. Heavy metals were analyzed by atomic absorption spectrometer [11]. The locations of sampling stations are shown in figure 1.

RESULTS AND DISCUSSION

Physico-chemical characteristics of Soil: The variation of temperature in this district was observed to be 28.64^oC minimum to 42.28 maximum and pH values was ranged from 6.4 to 8.4. Highest pH was observed (8.4) at sampling location E20 (Coal Mince area) during monsoon season while the minimum value 0.01 mg kg⁻¹ was recorded at location E10 (Kanaoudi) as show in table-1. Singh *et al*, 2010 [12] Studied physico-chemical and hydraulic characteristics of soils of major sub group of Eastern India and reported the pH concentration of soil varied from 5.7-8.3.

Maximum percentage of Sand, Slit and Clay are observed to be 92.5, 37.0 and 50.7 percent while minimum values were recorded as 21.4, 1.3, 5.0 %, respectively. Tripathi *et al*, 2014 [13] studied soil of Umaria district and found 17.3 – 92.6% sand, 0.4 – 39.3% slit and 5.4 – 50.2 % clay.

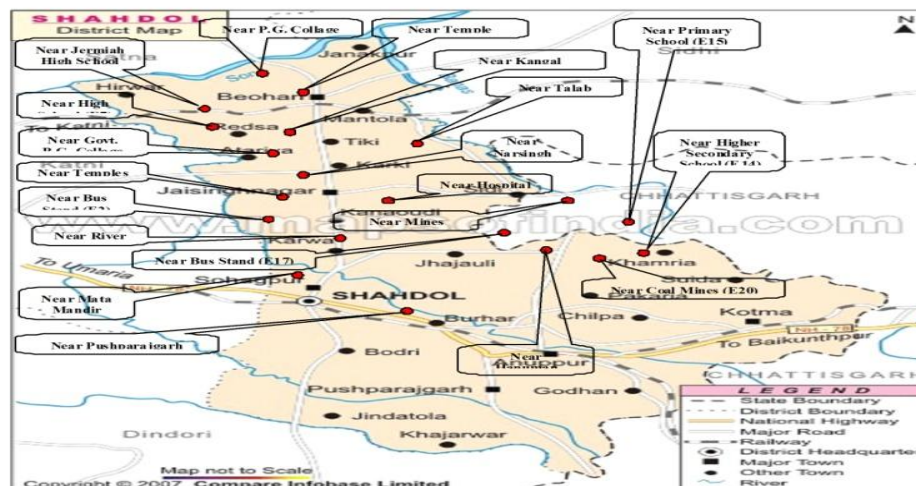


Figure 13: Sampling locations of Shahdol District

Table 1. Physical characteristics of Soli collected from Shahdol District in Vindhya Pradesh

	SEASONS	Sampling Locations									
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Temp °c	Summer	36.82	37.00	29.06	33.65	31.05	42.12	27.42	35.24	33.20	37.00
	Winter	24.46	22.85	21.42	17.21	17.29	24.15	16.84	17.25	22.71	24.74
	Monsoon	30.42	31.47	24.57	25.92	27.49	33.00	28.15	28.16	26.34	33.35
PH	Summer	8.0	8.1	7.5	7.0	7.5	8.0	7.6	7.3	7.6	7.0
	Winter	8.0	8.0	7.6	6.5	7.6	7.0	7.5	6.8	7.5	6.7
	Monsoon	7.0	7.7	8.0	7.3	8.0	6.7	7.4	6.5	7.4	6.4
Sand %	Summer	44.4	37.3	29.7	45.8	47.0	63.7	47.2	25.5	32.8	56.8
	Winter	41.6	35.9	33.2	50.2	38.2	76.7	48.5	28.6	41.1	59.6
	Monsoon	43.6	28.6	79.2	48.0	34.5	76.9	45.2	30.4	39.2	64.4
Silt %	Summer	26.3	12.7	36.1	3.9	14.2	3.9	14.9	24.9	27.8	11.6
	Winter	25.2	17.7	36.6	1.3	14.0	5.4	16.9	22.5	31.2	10.6
	Monsoon	12.3	22.5	8.1	2.7	10.9	5.6	14.9	24.6	20.9	10.4
Clay %	Summer	29.3	50.0	34.2	50.3	38.7	32.4	37.9	49.6	39.5	31.5
	Winter	33.2	46.5	30.2	48.5	47.8	17.9	34.6	48.9	27.7	29.8
	Monsoon	44.1	48.9	12.7	49.3	54.7	17.5	39.9	45.0	39.9	25.2

Table-1 continued

	SEASONS	Sampling Locations									
		E11	E12	E13	E14	E15	E16	E17	E18	E19	E20
Temp °c	Summer	28.95	31.51	32.04	35.54	33.16	28.64	39.71	29.36	38.57	42.28
	Winter	15.94	23.46	17.95	21.87	23.41	21.43	23.63	17.95	25.16	24.25
	Monsoon	25.59	38.15	26.43	27.54	31.25	35.48	33.42	25.14	30.17	38.00
PH	Summer	6.6	7.9	6.2	7.9	7.1	7.6	7.2	7.5	7.5	8.0
	Winter	6.5	7.8	5.8	7.8	7.0	7.8	7.4	7.6	7.4	8.2
	Monsoon	6.7	7.5	5.6	7.5	6.9	8.0	7.6	7.7	7.1	8.4
Sand %	Summer	59.0	42.5	65.2	50.4	30.4	30.7	66.7	92.5	35.6	34.0
	Winter	68.4	42.6	58.6	55.1	32.8	27.0	66.7	74.3	34.3	33.0

	Monsoon	62.7	47.4	77.1	59.0	37.5	32.1	21.4	73.1	33.4	44.0
Silt %	Summer	7.4	17.5	23.4	25.3	18.9	23.4	13.6	2.00	30.8	36.0
	Winter	6.8	15.3	24.0	14.9	27.8	25.3	17.6	14.3	15.1	37.0
	Monsoon	9.4	14.8	13.5	10.1	36.5	25.0	41.3	7.0	22.0	29.0
Clay %	Summer	33.6	40.0	11.4	24.4	50.7	45.9	19.7	5.0	33.6	30.0
	Winter	24.9	42.2	17.4	30.1	39.5	47.7	15.7	11.4	50.6	31.0
	Monsoon	27.9	37.8	9.4	30.9	30.2	43.0	37.3	19.9	44.6	27.0

E1: Near river, Shahdol, **E2:** Near Sohagpur bus stand, **E3:** Karwa near temple, **E4:** Near hospital, Jhajauli, **E5:** Near Hanuman temple, Chilpa, **E6:** Near Jaisinghnagar Govt. P.G. College, **E7:** Near Atariya High school, **E8:** Near Jermiah high school, Redsa, **E9:** Near Kangal Mandir, Karki, **E10:** Kanaoudi near Narsingh Mandir **E11:** Sidi, near talab, **E12:** Beohari near P.G. College, **E13:** Mantola near Temple **E14:** Near Higher Secondary School, Kotma, **E15:** Near primary school, Suida, **E16:** Near Khamria Mines, **E17:** Near Pakaria bus stand, **E18:** Bodri mata Mandir, **E19:** Near Pushparajgarh, **E20:** Near Coal Mines.

The organic matter was low in soil samples and they ranged from 0.09 to 0.72 mg kg⁻¹. Since all samples contained very low amounts of organic matter, this result is consistent with other finding of earlier studies on Shahdol soil. Majeed *et al*, 2013 [14] Studied toxicity of heavy metal and microbial analysis of soil samples collected from the area around Zliten Cement Factory and reported organic carbon are found to be 0.11 to 0.25 g.

Nitrogen was recorded in the range of 2.83 to 41.81mg kg⁻¹, the lowest value was observed during monsoon seasons at location E15 (Suida) while the highest value was found in summer season at location E2 (Sohagpur Bus Stand). Phosphorus concentration range between 0.13- 1.5mg kg⁻¹. The maximum concentration of phosphorus (1.5) mg kg⁻¹ was detected at sampling location of D5. Sahoo *et al*, 2010 [15] Carried out characterization classification and evaluation of soils of Langol Hill, Manipur for rational land use planning and found phosphorus concentration 0.41 to 2.89 mg kg⁻¹.

Exchangeable Cation (Na⁺, K⁺, Ca⁺⁺, Mg⁺⁺): The exchangeable cation concentration in the soil samples of Shahdol district in different seasons are presented in table-2 and figure 2. The maximum concentration of sodium cation (Na⁺) 54.2 mg kg⁻¹ was detected at sampling location of E3 (Karwa) and maximum potassium cation (K⁺) concentration found to be 39.29 mg kg⁻¹ at location E7 (Atariya) during same (Summer) seasons while minimum concentration of sodium cation (Na⁺) 14.0 mg kg⁻¹ was observed at sampling location E5 (Chilpa) and minimum potassium cation K⁺ concentration detected to be 4.6 mg kg⁻¹ at location E14 (Kotma) during monsoon seasons. Maximum concentration of calcium (Ca⁺⁺) and magnesium (Mg⁺⁺) are observed to be 143 and 62.0 mg kg⁻¹, while minimum values were recorded as 8.0, 20.0 mg kg⁻¹, respectively. Dwivedi *et al*, 2013 [16] Carried out assessment of soil and ground water quality in Rewa district of Vindhya plateau and reported Na⁺, K⁺, Ca⁺⁺, Mg⁺⁺, are found to be 14.19 to 68.0, 2.0 to 55.0, 16.5 to 200, 12.7 to 41.5 mg kg⁻¹ respectively.

Table 2. Chemical composition of soils collected from different locations in Shahdol District

	SEASON S	Sampling Locations									
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
OC	Summer	0.42	0.50	0.37	0.34	0.25	0.43	0.27	0.54	0.40	0.27
	Winter	0.4	0.47	0.33	0.33	0.22	0.41	0.21	0.51	0.37	0.24
	Monsoon	0.38	0.44	0.30	0.32	0.20	0.39	0.23	0.48	0.34	0.21
N	Summer	32.57	41.81	31.87	18.18	36.10	10.49	35.60	23.81	36.78	38.31
	Winter	31.00	37.57	30.62	21.93	32.47	12.41	32.47	21.72	34.09	36.60
	Monsoon	26.82	33.99	29.30	24.16	28.28	12.47	36.10	17.39	26.11	35.14
P	Summer	0.30	0.44	1.0	0.38	0.29	0.19	0.40	0.76	0.25	0.38
	Winter	0.28	0.42	1.2	0.35	0.25	0.18	0.37	0.73	0.22	0.49

	Monsoon	0.34	0.46	1.5	0.40	0.21	0.22	0.34	0.70	0.28	0.59
Na+	Summer	34.2	36.4	54.2	35.2	20.0	40.5	26.0	39.4	39.0	22.5
	Winter	32.5	32.0	50.1	34.5	16.0	36.2	28.0	38.5	42.5	19.6
	Monsoon	32.0	26.0	45.0	31.0	14.0	33.0	29.1	36.2	45.1	18.2
	Average	32.9	31.4	49.7	33.5	16.6	36.5	27.7	38.0	42.1	20.1
	Summer	22.89	6.23	ND	19.38	21.89	12.90	39.29	22.8	6.28	26.4
K+	Winter	23.80	5.53	ND	15.14	19.51	11.89	36.48	24.6	5.14	24.28
	Monsoon	24.03	5.26	ND	13.68	15.71	10.33	32.89	28.5	4.56	22.8
	Average	23.5	5.6	ND	16.0	19.0	11.7	36.2	25.3	5.32	24.4
	Summer	26.0	33.5	44.3	52.0	ND	79.0	85.2	69.0	114	98.0
Ca++	Winter	25.3	31.0	36.0	57.3	ND	73.0	67.3	80.0	84.0	94.2
	Monsoon	31.2	35.2	41.0	60.0	ND	72.0	73.5	70.0	75.3	92.0
	Average	27.5	33.2	40.4	56.4	ND	74.6	75.3	73.0	91.0	94.7
	Summer	34.0	39.0	ND	39.0	ND	62.0	57.0	40.0	52.0	55.0
Mg++	Winter	29.0	36.0	ND	36.0	ND	59.0	55.0	38.0	48.0	52.0
	Monsoon	26.0	34.5	ND	34.5	ND	56.0	53.0	34.3	44.0	49.0
	Average	29.6	36.5	ND	36.5	ND	59.0	55.0	37.4	48.0	52.0

Table.2 continued

	SEASON S	Sampling Locations										Soil Quality Guide line level mg/kg
		E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	
OC:	Summer	0.22	0.38	0.21	0.09	0.43	0.49	0.21	0.39	0.20	0.66	--
	Winter	0.25	0.33	0.21	0.12	0.44	0.45	0.19	0.35	0.23	0.69	
	Monsoon	0.28	0.28	0.23	0.14	0.46	0.41	0.18	0.31	0.26	0.72	
N	Summer	34.92	4.60	7.67	35.14	3.86	4.67	39.19	30.31	7.87	32.45	--
	Winter	31.62	5.29	8.91	36.60	3.35	5.29	28.44	31.56	6.78	34.13	
	Monsoon	31.90	5.60	7.52	38.31	2.83	5.96	24.14	32.11	5.77	34.47	
P	Summer	0.29	0.32	0.25	0.16	0.13	0.44	0.22	0.19	0.30	0.25	--
	Winter	0.32	0.28	0.26	0.19	0.16	0.42	0.19	0.13	0.24	0.25	
	Monsoon	0.35	0.24	0.28	0.21	0.17	0.46	0.16	0.22	0.18	0.30	
Na+	Summer	40.0	27.1	35.0	46.0	32.0	22.1	20.4	34.0	51.0	25.4	62
	Winter	36.0	28.5	34.2	40.2	34.2	20.3	16.2	30.5	49.2	27.2	
	Monsoon	35.0	32.0	32.4	35.0	35.4	18.5	14.0	27.1	48.5	31.0	
	Average	37.0	29.2	33.8	40.4	33.8	20.3	16.8	30.5	49.5	27.8	
K+	Summer	9.6	36.4	24.0	8.2	ND	28.5	9.53	13.68	16.6	25.4	60
	Winter	13.6	34.5	21.6	7.21	ND	26.2	7.08	14.4	18.4	27.3	
	Monsoon	14.5	32.2	19.4	4.6	ND	24.4	5.9	15.2	19.2	28.8	
	Average	12.5	34.3	21.6	6.67	ND	26.3	7.5	14.4	18.0	27.1	
Ca++	Summer	125	93.5	ND	143	138	53.0	55.0	39.0	13.0	11.8	250
	Winter	95.0	81.2	ND	128	115	85.0	47.0	73.0	12.8	8.0	
	Monsoon	87.0	69.0	ND	119	102	87.0	45.0	32.0	18.2	18.0	
	Average	102.3	81.2	ND	130.0	118.3	75.0	49.0	48.0	14.6	16.2	
Mg+	Summer	51.0	ND	30.0	45.0	ND	39.0	ND	52.0	34.0	38.0	30
	Winter	49.0	ND	25.0	41.0	ND	36.0	ND	47.0	30.0	35.0	

Monsoon	46.0	ND	20.0	39.0	ND	33.0	ND	45.3	26.0	32.0	
Average	48.6	ND	25.0	41.6	ND	36.0	ND	48.1	30.0	35.0	

E1: Near river, Shahdol, **E2:** Near Sohagpur bus stand, **E3:** Karwa near temple, **E4:** Near hospital, Jhajauli, **E5:** Near Hanuman temple, Chilpa, **E6:** Near Jaisinghnagar Govt. P.G. College, **E7:** Near Atariya High school, **E8:** Near Jermiah high school, Redsa, **E9:** Near Kangal Mandir, Karki, **E10:** Kanaoudi near Narsingh Mandir, All the values are expressed in mg/kg, ND=Not detected. **E11:** Sidi, near talab, **E12:** Beohari near P.G. College, **E13:** Mantola near Temple, **E14:** Near Higher Secondary School, Kotma, **E15:** Near primary school, Suida, **E16:** Near Khamria Mines, **E17:** Near Pakaria bus stand, **E18:** Bodri mata Mandir, **E19:** Near Pushparajgarh, **E20:** Near Coal Mines.

All the values are expressed in mg/kg, ND=Not detected.

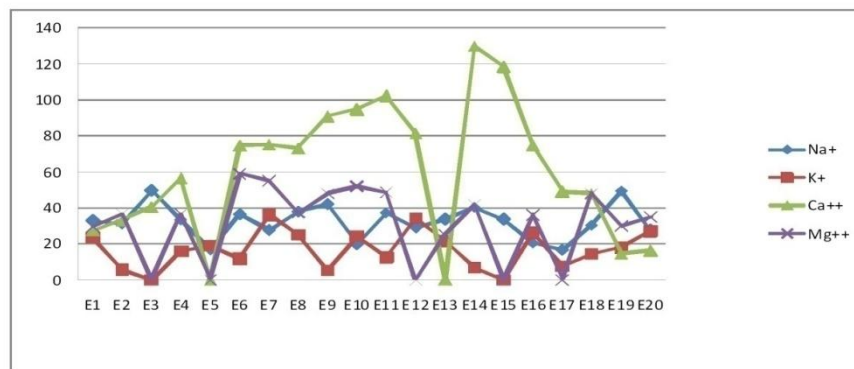


Figure-2 Exchangeable Cation in Soil of Shahdol District

Heavy Metals: The heavy metals concentration in the soil samples with their average and standard deviations are presented in table- 3, 4 and figure- 3. The Lead and Copper of all the soil samples collected from different location were showed in the range of 4.6-87.8 and 0.1-34.4 mg kg⁻¹, and all the samples were below the recommended level (140 mg kg⁻¹ for Lead and 63 mg kg⁻¹ for Copper) prescribed by SQGL (P.K. Govil *et al*, 2008) [17] value. The maximum average concentration of Lead 68.0 mg kg⁻¹ was observed at the location E5 (Chilpa) while average Copper was found to be 33.0 mg kg⁻¹ maximum at E6 location (Kotma).Cadmium concentration ranged between 0.5-17.2 mg kg⁻¹, with average value 16.0 mg/kg. In Shahdol District Cadmium was found to be in alarming concentration and 50% of the samples had their concentration higher than the 10 mg kg⁻¹. The maximum concentration of Cadmium 17.2 mg/kg was observed at the location E20 (Coal Mince Area). Masto *et al*, 2008 [18] studied sewage irrigated soil Delhi and reported cadmium concentration 0.035 to 0.091 mg kg⁻¹. The Nickel of all the soil samples are within the range of 0.3 to 59.4 mg kg⁻¹. The maximum value of Nickel (59.4 mg kg⁻¹) was observed at sampling location of E6 (Jaisinghnagar) during the winter season. The values from all the sampling stations with in the (SQGL) recommended values (50 mg kg⁻¹) except the sampling station of E8 (Jaisinghnagar). Rakesh Kumar *et al*, 2010 [19] studied vertical and topographical distribution of Cobalt, Nickel and Lead in rotation to soil characteristics in different agro climatic zones of Jharkhand and found Nickel concentration 113 to 294 mg kg⁻¹. The Iron content was found to from 10.8 to 203.3 mg/kg. The minimum concentration of Iron was found to be 11.0 mg kg⁻¹ at location E10 (Kanaoudi), while maximum concentration of Iron 203.3 mg kg⁻¹ was observed at the location B11 (Chilpa). Shivkumar *et al*, 2012 [20] studied physico-chemical profile of soil along the banks of Amaravathi River Bank in Karur areas of Tamil Nadu and reported Iron Content range between 9.85 to 6.14 ppm kg⁻¹. The range of Chromium concentration were 107.0 mg kg⁻¹ to 1.6 mg kg⁻¹, the highest concentration of Chromium were observed soil source of location E1 (96.4 mg kg⁻¹) and E20 (107.0 mg kg⁻¹) of Shahdol District. Patnaik *et al*, 2013 [21] studied physico-chemical and heavy metal characterization of soil from Industrial belt of Cuttack, Orissa and reported chromium concentration range between 4.82 to 16.48 ppm kg⁻¹. Tripathi *et al*, 2013

[22] Carried out characterization of diffuse chemical pollution in Satna district of Vindhya region and found chromium content between 17.1 to 106.6 mg kg⁻¹.

Table 3. Seasonal variation of metals concentration in soils collected from Shahdol District in Vindhya Pradesh

HM	SEASONS	Sampling Locations									
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
cr	Summer	96.4	66.6	18.4	6.6	22.2	53.8	17.8	9.0	18.0	8.8
	Winter	69.0	54.1	18.1	5.8	21.5	55.0	15.3	8.7	17.8	7.2
	Monsoon	65.1	49.4	17.2	5.2	20.0	62.2	14.9	8.5	16.5	6.4
pb	Summer	21.6	67.6	43.0	87.8	66.8	41.2	4.6	36.6	14.5	29.5
	Winter	24.5	65.4	39.2	33.7	68.0	43.6	5.2	32.5	16.4	26.7
	Monsoon	25.4	63.2	36.5	29.5	70.1	45.0	6.8	37.6	16.0	24.5
cd	Summer	15.8	12.2	2.2	0.8	1.4	15.0	ND	12.2	0.6	13.8
	Winter	15.4	12.5	2.0	0.7	1.5	16.4	ND	11.9	0.6	15.7
	Monsoon	16.0	13.0	1.5	0.5	1.3	15.0	ND	9.5	ND	14.8
NI	Summer	36.6	49.6	6.3	4.0	ND	57.6	3.0	16.8	1.0	13.0
	Winter	40.1	43.0	12.2	3.8	ND	59.4	5.2	12.4	0.8	10.2
	Monsoon	44.2	37.5	15.4	3.4	ND	60.2	6.4	8.7	0.5	7.0
cu	Summer	16.0	31.2	1.0	2.0	21.0	32.2	0.8	0.4	21.2	0.00
	Winter	12.1	28.4	0.7	0.8	19.3	28.4	0.6	0.2	16.5	0.00
	Monsoon	9.4	25.6	0.3	0.5	17.5	24.7	0.3	0.1	12.6	0.00
Fe	Summer	35.4	73.0	43.9	53.3	203.3	ND	29.6	24.0	17.0	15.8
	Winter	34.6	69.0	38.1	51.2	188.0	ND	26.0	23.0	15.4	13.2
	Monsoon	33.0	64.2	33.0	48.0	178	ND	23.2	21.0	13.0	11.0

Table 3. continued

HM	SEASONS	Sampling Locations										Soil Quality Guide line level mg/kg.
		E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	
cr	Summer	4.8	54.2	9.8	17.2	5.6	9.6	21.4	9.4	45.0	107	62
	Winter	4.5	55.6	9.5	17.0	3.4	12.4	24.5	7.9	41.5	95.4	
	Monsoon	4.3	55.2	9.0	16.7	1.6	16.5	28.2	7.1	37.2	93.8	
pb	Summer	14.8	61.0	42.6	19.4	7.3	22.4	22.4	12.4	48.6	61.4	140
	Winter	12.6	62.6	45.5	15.5	8.5	25.1	21.5	13.8	46.4	62.0	
	Monsoon	11.6	65.0	49.2	12.4	10.0	27.0	20.7	17.2	43.8	64.5	
cd	Summer	3.4	15.6	4.2	12.8	3.2	7.2	15.8	7.8	13.2	17.2	10
	Winter	3.2	11.5	4.5	8.7	2.5	4.4	13.6	7.4	13.2	14.4	
	Monsoon	3.0	10.0	4.7	7.2	2.2	2.0	13.2	6.7	12.8	13.5	
NI	Summer	0.6	40.2	16.4	24.6	ND	9.4	18.2	39.4	34.2	22	50
	Winter	0.3	43.0	12.7	19.2	ND	6.3	21.4	42.5	30.6	16.2	
	Monsoon	0.2	49.0	11.0	14.0	ND	5.5	23.5	45.0	24.5	10.5	
cu	Summer	23.4	34.6	26.4	33.0	23.8	2.4	2.6	1.2	33.8	28.2	63
	Winter	23.0	32.0	27.0	34.2	21.5	2.0	1.8	1.0	28.2	30.0	
	Monsoon	21.5	29.8	26.7	31.4	18.0	1.5	1.4	0.8	23.6	27.8	

Fe	Summer	53.8	39.8	21.0	79.8	45.7	43.9	70.9	54.4	ND	194	--
	Winter	49.5	37.2	18.4	73.5	42.1	40.0	68.4	51.3	ND	189	
	Monsoon	47.2	34.5	14.5	72.0	39.0	37.1	65.6	49.7	ND	183	

E1: Near river, Shahdol, **E2:** Near Sohagpur bus stand, **E3:** Karwa near temple, **E4:** Near hospital, Jhajauli, **E5:** Near Hanuman temple, Chilpa, **E6:** Near Jaisinghnagar Govt. P.G. College, **E7:** Near Atariya High school, **E8:** Near Jermiah high school, Redsa, **E9:** Near Kangal Mandir, Karki, **E10:** Kanaoudi near Narsingh Mandir, **E11:** Sidi, near talab, **E12:** Beohari near P.G. College, **E13:** Mantola near Temple, **E14:** Near Higher Secondary School, Kotma, **E15:** Near primary school, Suida, **E16:** Near Khamria Mines, **E17:** Near Pakaria bus stand, **E18:** Bodri mata Mandir, **E19:** Near Pushparajgarh, **E20:** Near Coal Mines.

All the values are expressed in mg/kg, ND=Not detected.

Table 4. Average metals concentration in soils of Shahdol District in Vindhya Pradesh

Metals	Sampling Locations									
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Chromium	76.83	56.70	17.90	5.87	21.23	57.00	16.00	8.73	17.43	7.47
SD (±)	17.06	8.89	0.62	0.70	1.12	4.54	1.57	0.25	0.81	1.22
Lead	23.83	65.40	39.57	50.33	68.30	43.27	5.53	35.57	15.63	26.90
SD (±)	1.99	2.20	3.27	32.51	1.67	1.92	1.14	2.70	1.00	2.51
Cadmium	15.73	12.57	1.90	0.67	1.40	15.47	ND	11.20	0.60	14.77
SD (±)	0.31	0.40	0.36	0.15	0.10	0.81	-	1.48	0.00	0.95
Nickel	40.30	43.37	11.30	3.73	ND	59.07	4.87	12.63	0.77	10.07
SD (±)	3.80	6.06	4.62	0.31	-	1.33	1.72	4.06	0.25	3.00
Copper	12.50	28.40	0.67	1.10	19.27	28.43	0.57	0.23	16.77	0.00
SD (±)	3.32	2.80	0.35	0.79	1.75	3.75	0.25	0.15	4.31	0.00
Iron	34.33	68.73	38.33	50.83	189.77	ND	26.27	22.67	15.13	13.33
SD (±)	1.22	4.41	5.45	2.67	12.74	-	3.21	1.53	2.01	2.40

Table 4. continued

Metals	Sampling Locations									
	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20
Chromium	4.53	55.00	9.43	16.97	3.53	12.83	24.70	8.13	41.23	98.73
SD (±)	0.25	0.72	0.40	0.25	2.00	3.47	3.40	1.17	3.91	7.20
Lead	13.00	62.87	45.77	15.77	8.60	24.83	21.53	14.47	46.27	62.63
SD (±)	1.64	2.01	3.31	3.51	1.35	2.31	0.85	2.47	2.40	1.64
Cadmium	3.20	12.37	4.47	9.57	2.63	4.53	14.20	7.30	13.07	15.03
SD (±)	0.20	2.90	0.25	2.90	0.51	2.60	1.40	0.56	0.23	1.93
Nickel	0.37	44.07	13.37	19.27	ND	7.07	21.03	42.30	29.77	16.23
SD (±)	0.21	4.50	2.76	5.30	-	2.06	2.67	2.81	4.90	5.75
Copper	22.63	32.13	26.70	32.87	21.10	1.97	1.93	1.00	28.53	28.67
SD (±)	1.00	2.40	0.30	1.40	2.92	0.45	0.61	0.20	5.11	1.17
Iron	50.17	37.17	17.97	75.10	42.27	40.33	68.30	51.80	ND	188.67
SD (±)	3.35	2.65	3.27	4.14	3.35	3.41	2.65	2.39	-	5.51

E1: Near river, Shahdol, **E2:** Near Sohagpur bus stand, **E3:** Karwa near temple, **E4:** Near hospital, Jhajauli, **E5:** Near Hanuman temple, Chilpa, **E6:** Near Jaisinghnagar Govt. P.G. College, **E7:** Near Atariya High school, **E8:** Near Jermiah high school, Redsa,

E9: Near Kangal Mandir, Karki, **E10:** Kanaoudi near Narsingh Mandir, **E11:** Sidi, near talab, **E12:** Beohari near P.G. College, **E13:** Mantola near Temple, **E14:** Near Higher Secondary School, Kotma, **E15:** Near primary school, Suida, **E16:** Near Khamria Mines, **E17:** Near Pakaria bus stand, **E18:** Bodri mata Mandir, **E19:** Near Pushparajgarh, **E20:** Near Coal Mines. Concentrations of metals are expressed in mg/kg, ND=Not detected.

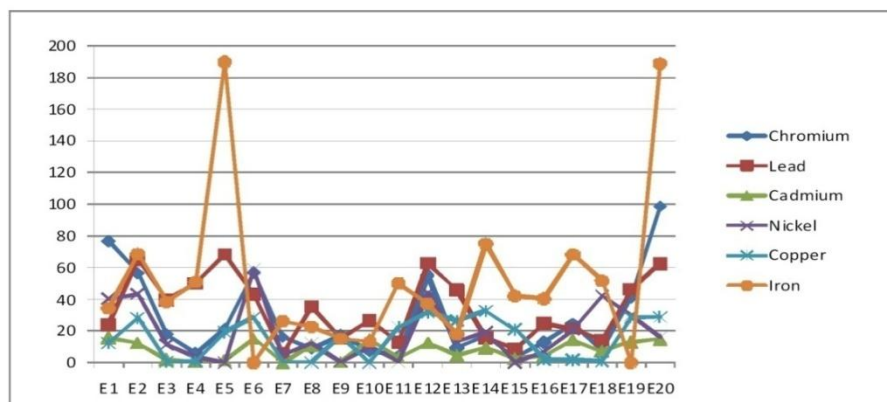


Figure-3 Metal content in Soil of Shahdol District

APPLICATIONS

Shahdol soil is much more useful and significant for future researchers.

CONCLUSIONS

The present study is aimed to evaluate the soil of Shahdol district, Vindhya Plateau. The values of different physico-chemical parameters i.e. temperature 28.64°C–42.28°C, pH 6.4–8.4, Sand 21.4–92.5, Silt 1.3–37.0, and Clay 5.0–50.7% (particle size distribution), organic carbon 0.09 to 0.72 mg/kg, nitrogen 2.83–41.81, phosphorus 0.13–1.5 mg/kg, (Exchangeable cation) Na^+ 14.0 to 54.2, K^+ 4.6 to 39.28 mg/kg, Ca^{++} 8.0 to 143 mg kg^{-1} , Mg^{++} 20–60 mg kg^{-1} and heavy metals concentration in soil i.e. Pb- 4.6–87.8, Cu- 0.1 to 34.4, Cd- 0.5 to 17.2, Ni- 0.3 to 59.4, Fe- 10.8 to 203.3 and Cr- 1.6 to 107 mg kg^{-1} in soil of Shahdol district were found. The Lead and Copper of all the soil samples were below the recommended level (140 mg kg^{-1} for Lead and 63 mg kg^{-1} for copper) prescribed by SQGL value. Iron content was observed at sampling station E5 and E20 and chromium concentration at sampling location E1 and E2 are higher than the recommended level as a SQGL value. The nickel concentration from all the sampling stations within the (SQGL) recommended values (50 mg kg^{-1}) except the sampling station of E6 (Jaisinghnagar), Shahdol district. 50% of the samples had cadmium concentration higher than the recommended level during all the seasons. The high values are indicative of anthropogenic inputs, either due to excess of agricultural, industrial and mining activities.

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