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Charecterization of Diffuse Chemical Pollution in Satna District of Vindhya Region, India

Tripathi Indra Prasad[1], Kumar M. Suresh[2] and Dwivedi Arvind Prasad[1]
[1] Deptt of Physical Sciences, Faculty of Science and Environment, M.G.C.G.V. Chitrakoot Satna, MP, INDIA
[2]Solid and Hazardous Waste Management Division, National Environmental Engineering Research Institute, Nagpur, MS, INDIA

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Abstract

Concern over agricultural diffuse pollution sources in integrated water and soil quality management has been growing recently[1]. The term diffuse essentially point to this feature of the discharge of such pollution leads which makes them some what difficult to notice, monitor or control. For the study of seasonal variation in inorganic content as well as physico chemical parameters, monitoring was done during summer, rainy and winter season year 2009 to 2011. The parameters like temperature, pH, turbidity, dissolved oxygen (DO) biochemical oxygen demond (BOD), chemical oxygen demond (COD), nitrate, nitrite, chloride, sulphate, phosphate and heavy metals for water analysis and soil temperature, pH, O.C (organic carbon), total nitrogen, phosphorus, exchangeable cation (Na^+, K^+, Ca^{++}, Mg^{++}) and heavy metals for soil analysis have been studied. The study revealed that the water sources in the area are heavily polluted. The heavy metals concentration were found more than the permissible limits during all the seasons. Most of these parameters are correlated with one another. Statistical analysis of the data is presented.

Keywords: Satna district, diffuse pollution, ground water, soil, heavy metals, statistical analysis, Vindhyan region.

Introduction

The focus has been on regulating the point source pollution load from urban and Industrial sources and non-point or diffuse load from agriculture, animal husbandry and rural sources were largely ignored in water quality management. Increasing use of chemicals, fertilizers, pesticides, perfumes, cosmetics, petrochemicals, harm aquatic life and human health. Other chemical in recent years has caused the more diffused chemicals pollution[1].

Satna, also called Shat Nagar or Bhatgarh, city, northeastern Madhya Pradesh state, central India. It is situated on the Tons River, a tributary of the Ganges (Ganga). The city is a road and rail junction and an important distribution centre for agricultural products and cloth fabrics. The grain market in the city is one of the largest in the country. Industries include flour and oilseed milling and cement manufacturing; there is a large cement plant and a thermal power-generating station. Satna has several colleges affiliated with Awadesh Pratap Singh University. Satna's surrounding region was part of the kingdom of Kosala and later became part of Vatsa territory. The Vindhya Pradesh plateau is environmentally very important to understand the rich Indian biodiversity and diffuse chemical pollution. The district of Satna is situated between latitude 23" 12' north and longitude 80" 21' and 81" 23' east in mid northern part of Rewa commissioner's division in Madhya Pradesh State of India.

Heavy metals viz, Cr, Pb, Cd, Ag, Co, Ag, Hg, Ca and Sc are recognized highly toxic and dangers pollutant. However, continuous disposal of industrial effluents on lands leads to percolation of pollutants to the groundwater through seepage and leaching, causing contamination. As a result, farmers in the adjoining areas find the ground water unsuitable for irrigation. Drinking water wells may also get affected. Environmental problems related to industrial effluent disposal on land have been reported from various parts of the country. Disposal on land has become a regular practice for some industries and creates local/regional environmental problems[2-12]. Watershed management for any city requires the estimation of both point and non-point sources of water pollution. An effective land-use planning plays a crucial role in efficient management of water resources of any area. Both diffuse and point source pollution is dependent upon the land use pattern of a city. The total amount of runoff generated from an area depends upon the land use type of that area. High impervious area in a city results in more runoff generation thereby allowing more pollutants to enter into the surface water bodies directly and indirectly. Similarly the point source pollution of water is also dependent upon the landuse pattern of the city. Densely populated city like National Capital Territory (NCT) of India will generate more domestic sewage. Also, urban runoff on percolation results in salinization of the groundwater[13]. The poor quality of surface waters can also be attributed to the runoff generated from both dry and wet weather[14-15]. Different factors contributing to the quality of urban runoff have been studied and it has been concluded that

surface water quality is indeed affected by urbanization and industrialization[16-17].

Satna district comprises of variety of minerals including bauxite shale, laterite, conglomerate, cuartzite, sandstone, coal seams and granite etc. Soils derived from sandstone are generally non – permeable and have no water contents. The water table in sandstone is deeper in general shalis show little percolation of ground water hence has limited retaining and explanation of it. Limestone allows movement of ground water due to the presence of such geology the ground water of study area is highly affected in its quality, the aim of present work is to assess the quality of drinking water of the Satna district by analyzing various inorganic non-metallic constituent and heavy metals present in water[18].

Material and Methods

Twenty sampling locations consisting of bore wells and hand pumps were selected in the study area. Sampling was done during summer, rainy and winter seasons (of year 2009 to 2010). The month of April-May, July-August and December-January, were selected as representative month of summer, rainy and winter seasons respectively. Sampling was done in accordance with grab sampling methods in polyethylene bottles of one liter capacity. To avoid leaching of metals and interaction with the surface wall of the container, bottles were first cleaned with detergent and then with 1:1 HNO_3 for 24 hours. Finally bottles were cleaned and rinsed with the distilled water. During sampling bottles were rinsed two to three times with the sample to be examined before finally filling with it. Samples were collected by immersing the rinsed bottles in river water[19-20]. During sampling from hand pumps and bore wells, the water pumped to waste for about five minutes and sample was collected directly. All the samples were refrigerated at 4^0C in the laboratory[19,21,22], and procedures were followed as per the standard methods[23-25], and different physicochemical parameters like, temperature, pH, turbidity, dissolved oxygen, BOD, COD, nitrate, nitrite, chloride, sulphate, phosphate and heavy metal were analyzed. Twenty soil samples were collected from different location in plastic bags, dried at 60^0C for 48h and fine powder was made with the help of pistil mortar and sieved it with 2mm sieve. The pH of the soil samples was determined with Orion Research Analog pH meter/model 301 according to standard analytical method. Organic matter was determined using the chromic acid oxidation method. Soil samples were analyzed for Ca, mg, K and Na and these minerals were extracted by using ammonium chloride extracting solution methods. The samples were capped and weighed to determine possible acid loss during digestion. The samples were then digested in CEM 2000 microwave digester at 100 ponds per square inch (PSI) for 5.5 min and filtered through Whatman 42 filters and transferred to 100ml volumetric flasks. Samples with weighed loss of greater than 10% were re-digested. The digested samples were analyzed for heavy metals using Atomic Absorption Spectrophotometer. The locations of sampling stations are shown in figure 1.

The coefficient of variation (CV) was determined using the formula.

$$CV = \frac{SD}{Average} \times 100$$

Where CV = coefficient of variation, SD = Standard Deviation

The correlation coefficient 'r' was calculated using the equation

$$r = \frac{\Sigma xy - \Sigma x.\Sigma y}{\sqrt{[n.\Sigma x^2 - (\Sigma x^2][n.\Sigma y^2 - \Sigma y^2)}} \times 100$$

where x and y represents two different parameters.

The t- test (t) was calculated by using the following formula

$$t = \frac{r}{\sqrt{1 - r^2}} \sqrt{n-2}$$

at degree of freedom = n – 2.

Results and Discussion

In the present study ground water and soil samples were collected from Satna district. These water samples were subjected for the analysis of parameters like temperature, pH, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrates, nitrites, sulphates chlorides, phosphates and heavy metals like lead, cadmium, nickel, Iron, chromium and copper. As for as soil samples are concerned physicochemical properties like texture, structure, organic carbon, nitrogen, phosphorus, potassium, sodium, magnesium, and heavy metals were analyzed.

Ground water samples collected from 20 different locations, and analyzed for the physicochemical characteristics, correlation coefficient and heavy metal content in it. The physicochemical characteristics of the ground water sample of Satna during the three seasons are presented in table-1. Heavy metals concentrations in the ground water samples of Satna district in different seasons and average values with their standard deviation are presented in table-2 and 3. The graphical representation of average individual metals concentrations from different location are depicted in figure- 2a and 2b. Same as soil samples collected from 20 different locations, and analyzed for the chemical properties and heavy metal contents in it. The chemical characteristics of soil collected from Satna district for the three seasons are presented in table-4. Metal contents in the soil of Satna with seasons are presented in table-5 and the average metals concentrations are showed in table-6. The graphical representation of average metals concentrations from different locations are depicted in figure- 3a and 3b.

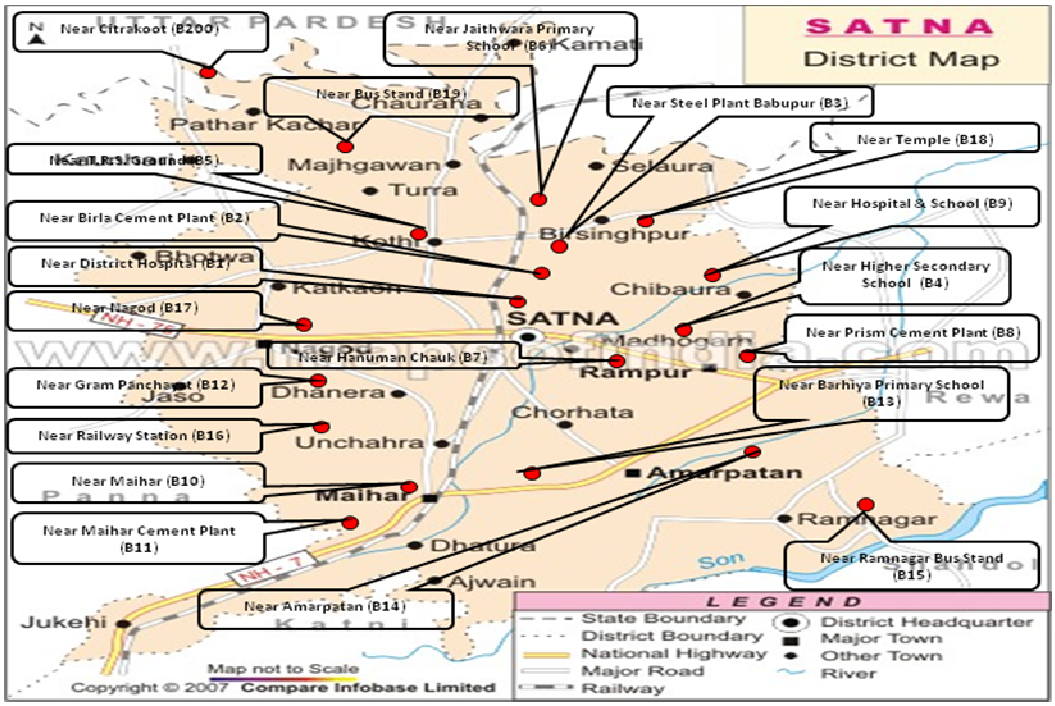

Figure-1
Sampling locations of Satna District

Characteristics of ground water: Ground water samples were collected from twenty different locations in Satna District; the details of the locations are depicted in the figure- 1. The ground water samples were collected during the three seasons (Monsoon, winter and summer) to know the seasonal variation in characteristics. The physicochemical characteristics of the ground water sample of Satna during the three seasons are presented in tables-1.

The mean values of eleven parameters of ground water analysed in 20 stations together with their SD and CV are presented in table- 1. The water temperature averaged 29.6^{0}C which was lower than the average value of ground water of Prism Cement Plant (36.8) and higher than those of Unchara (24.5) at location B20, in Satna District during monsoon season. pH was ranging from 6.6 to 8.1 with an mean value of 7.2 mg/l. WHO (1984) prescribed to desirable limit of pH range between 7 and 8.5 mg/l. The turbidity of water was found to be 1.0 to 10 NTU and the mean value was 2.4 NTU. The value from all the sampling stations within the WHO recommended values (5NTU) except the sampling stations of Kothi region (B5). The mean value of DO in the ground waters of during monsoon season was 3.54 mg/l which was ranged between 1.5 to 7.4 mg/l, The maximum value was recorded in the samples B14 collected from Amarpatan. The mean values of BOD and COD in the ground water of Satna District during monsoon season were 4.06 mg/l and 7.29 mg/l respectively. The BOD and COD values observed in the present study were well within the limit (6.0 mg/l for BOD and 10 mg/l for COD) prescribed by WHO for drinking water. The CV value of temperature (12.6), pH (9.1), COD 15.1 or lower than 50%, there for variation of these parameters are not significant between sampling stations, while turbidity (77.3) and DO (52.5) shows CV value which means of turbidity do not varies from one sampling stations to another stations. In the case of nitrates, nitrites, sulphate, chloride and phosphates, the mean values were recorded as 4.028, 1.972, 3.179, 34.75, 0.860 mg/l and all the results are within the permissible limit. The high CV values of nitrates (84.8), Nitrites (98.3), chloride (68.3) and phosphate (116.7) indicated their significant variation from one station to another.

The correlation coefficient (r) among various water quality parameters are given in table-1. The temperature of ground water in Satna District during monsoon showed positive relationship with pH, nitrates and sulphates and negative relationship with turbidity, dissolved oxygen, BOD, COD, nitrites, chlorides and phosphates. The pH of the ground water showed significant positive relationship between DO, BOD, COD, nitrates, nitrites, sulphates, chlorides and phosphates and negative relationship with turbidity. Turbidity showed all the parameters significant negative relationship.

Dissolved oxygen (DO) showed positive relationship with pH, BOD, COD, nitrites, chlorides, phosphates and negative relationship with temperature, turbidity, nitrates and sulphates. Biochemical oxygen demand (BOD) showed positive relationship with pH, DO, nitrites, chlorides and phosphates and negative relationship with temperature, turbidity, COD, nitrates and sulphate. Chemical oxygen Demand (COD) showed positive relationship with pH, DO, nitrites, chlorides and

phosphate and negative relationship with temperature, turbidity, BOD, nitrates and sulphate.

Nitrates showed significant positive relationship with temperature, pH, BOD, sulphate and negative relationship with turbidity, DO, COD, nitrites, chloride and phosphates. Nitrites in present investigation showed positive relationship with pH, DO, BOD, COD, chloride and phosphate are negative relationship with temperature, turbidity, nitrates and sulphates. The sulphates of the ground water showed significant positive relationship with temperature, pH, nitrates and phosphate and negative relationship with turbidity, DO, BOD, COD, nitrites and chloride. Chloride showed significant positive relationship with pH, DO, BOD, COD, nitrites and phosphate and negative relationship with Phosphate showed significant positive relationship between ground water pH, DO, BOD, COD, nitrites, sulphate and chloride and negative relationship with temperature, turbidity and nitrates.

The present study deals with the various relationship derived statistically by calculation 'r' and 't' among the physico-chemical characteristics the r value was negative 27 times and positive 28 times this showed that positive relationship in the present study.

During monsoon season, correlated different parameter each other statistically which shows great variation negative to positive values for 1% significant value (2.878) and 5% significant value (2.101). In the case of dissolved oxygen and pH, COD and pH, COD and DO and chloride and nitrites we established a correlation ship which were positive and values were 2.559, 2.637, 2.802 and 2.423 respectively, which was greater than 5% significant level. For chloride and nitrates we have found positive value of correlation ship at 15 significant level i,e 3.768 while nitrate and nitrites, sulphate and DO and sulphate and nitrites shows negative relationship i,e -4.070, -4.238 and -3.378 respectively with each other at 1% significant level. It showed that DO, pH, COD, chloride, nitrites, nitrates, temperature, sulphate play major role in the physico chemical characteristics of ground water of satna district during monsoon season.

The mean values of eleven parameters of ground water analysed in 20 station together with their SD and CV are presented in table- 1. The water temperature averaged 23.6^{0}C which was lower than the average value of ground water of Bariha (28.6^{0}C) at location B13 and higher than those of Kothi (15.9^{0}C) at location B20 in Satna District during winter season.

pH was ranging from 5.6-8.6 with an mean value of 7.02, WHO (1984) prescribed the desirable limit of pH range between 7 and 8.5 mg/l. The turbidity of water was found to be 0.5 to 2.0 NTU and the mean value was 1.28 NTU. The mean value of DO in the ground water of Satna District during winter season was 3.535 mg/l respectively. Dissolved oxygen was ranged between 1.4-7.6 mg/l the maximum value was recorded during the winter period in the samples B14 collected from Amarpatan.

The mean values of BOD and COD in the ground water of Satna District during winter season were 4.1 mg/l and 7.65 mg/l respectively. The BOD and COD values observed in the present study were well within the limit (6.0 mg/l for BOD and 10 mg/l for COD) prescribed by WHO for drinking water. The CV values of temperature (13.9), pH (10.3), turbidity (29.0), dissolved oxygen (53.6), BOD (39.5) and COD (12.7) showed that wide fluctuation there for relation of these parameters did not occur between stations. In the case of nitrates, nitrites, sulphates, chloride and phosphate, the mean values were recorded as 3.664, 2.332, 3.090, 33.2, 0.793 mg/l and all the results are within the permissible limit. The phosphates content of water was found to be 0.05-3.7 mg/l. The highest value of 3.7 mg/l was recorded at location B11 while the minimum value 0.05 mg/l was recorded at location B15, as show in table-1. The CV values of nitrates (85.2), nitrites (109.9), sulphates (52.9), chlorides (64.6), and phosphates (133.6) indicated their significant variation from one station to another.

The correlation coefficient (r) among various water quality parameter are given in table-1. The temperature of ground water during winter showed positive relationship with pH, turbidity, DO, BOD, COD, nitrates and nitrites and negative relationship with sulphate, chlorides and phosphates. The pH of the ground water showed significant positive relationship between temperature, turbidity, nitrates and sulphates and negative relationship with DO, BOD, COD, nitrites, chlorides and phosphates. Turbidity showed significant positive relationship with temperature, pH, DO, COD, nitrates, sulphates and phosphate and negative relationship with BOD, nitrites and chlorides.

Dissolved oxygen (DO) showed positive relationship with temperature, turbidity, BOD, COD, nitrites and phosphates and negative relationship with pH, nitrates, sulphates and chloride. Biochemical oxygen Demand (BOD) showed positive relationship with temperature, DO and nitrites and negative relationship with pH, turbidity, COD, nitrates, sulphate, chlorides and phosphates. Chemical oxygen demand (COD) showed positive relationship with temperature, turbidity, DO, nitrates, nitrites, chlorides and phosphates and negative relationship with pH, BOD, and sulphates.

Nitrates showed significant positive relationship with temperature, pH, turbidity, COD, sulphates and phosphates and negative relationship with DO, BOD, nitrites and chlorides. Nitrites in present investigation showed positive relationship with temperature, DO, BOD, COD, chlorides and phosphates and negative relationship with pH, turbidity, nitrates and sulphates.

Sulphates showed significant positive relationship with pH, turbidity, nitrates and phosphate and negative relationship with temperature, DO, BOD, COD, nitrites and chlorides. Chlorides

showed significant positive relationship with COD, nitrites and phosphates and negative relationship with temperature, pH, turbidity, DO, BOD, nitrates and sulphates. Phosphates showed significant positive relationship between turbidity, DO, COD, nitrates, nitrites, sulphate and chlorides and negative relationship with temperature, pH and BOD.

The various relationship derived statistically by calculation 'r' and 't', among the physico-chemical characteristics. The r value was 25 times negative and 30 times positive this showed that positive relationship in the present study.

During winter season we have investigated the different physico chemical characteristics of ground water of satna district and stablised the correlation by using ANOVA statistical software. The table values of 5% significant level were 2.101 and at 1% significant level were 2.878. In the case of BOD and temperature, COD and turbidity, nitrites and BOD and sulphate and nitrites we established a correlationship which were positive and value were 2.235, 2.522, 2.403 and 2.753 respectively, which was greater than 5% significant level. For sulphate and temperature we have found negative value of correlationship at 5% significant level i,e -2.21, while COD and DO we have found 2.943 correlation which slightly greater than 1% significant value. It showed that BOD, temperature, turbidity, nitrites, sulphates, COD, DO play major role in the physico chemical characteristics of ground water of satna district during winter season.

The mean values of eleven parameters of ground water analysed in 20 stations together with their SD and CV are present in table- 1. The water temperature averaged 30.6^0C which was lower than the average value of ground water of Nagod (36.6^0C) at location B17 and higher than those prism Cement Plant (25.1^0C) at location B8 in Satna District during summer season.

pH was ranging from 6.5- 8.1 (mean value of 7.20) and turbidity of water was found to be 0.5 to 1.5 NTU (mean value was 0.995 NTU). The mean value of DO in the ground water of Satna District during summer season was 3.535 mg/l which ranged between 1.0-7.8 mg/l, the maximum value was recorded during the summer period in samples B14 collected from Amarpatan.

The mean values of BOD and COD in the ground water of Satna District during summer season were 3.795 mg/l and 8.045 mg/l respectively. The BOD and COD values observed in the present study were well within the limit prescribed by WHO for drinking water. The CV values of temperature (10.9), pH (6.7), turbidity (35.1), dissolved oxygen (54.8), BOD (42.8) and COD (12.5) showed that wide fluctuation of these factors did not occur between stations. In the case of nitrates, nitrites, sulphate, chloride and phosphates, the mean values were recorded as 3.415, 2.073, 2.6, 34.5, 0.674 mg/l and all the results are within the permissible limit. The phosphates content of water was found to be 0.03 to 3.0 mg/l. The highest value of 3.0 mg/l was recorded at location B15 as Show in table-1 Values of phosphate at Birla cement plant (0.97), Kothi (0.37), Chibaura (0.47), Maihar cement plant (2.11), Amarpatan (0.36) Nagod (1.66) and Birsinghpur (3.0) are higher than the permissibl limit prescribed by WHO and BIS. The high CV values of nitrates (87), nitrites (91.9) chloride (55.3) and phosphates (122.9) indicated their significant variation from one station to another.

The correlation coefficient (r) among various water quality parameter are given in table- 1. The temperature of ground water during summer showed positive relationship with pH, BOD, nitrites and chlorides and negative relationship with turbidity, DO, COD, nitrates, sulphates and phosphates. The pH of the ground water showed significant positive relationship between temperature, DO, BOD, COD, nitrates and phosphates and negative relationship with turbidity, nitrites, sulphates and chlorides. Turbidity showed significant positive relationship with DO, COD, nitrates, sulphates and phosphates and negative relationship with temperature, pH BOD, nitrites and chlorides. Dissolved oxygen (DO) showed positive relationship with pH, turbidity, BOD, COD, nitrites and phosphates and negative relationship with temperature, nitrates, sulphates and chlorides.Biochemical oxygen demand (BOD) in present investigation showed positive relationship with temperature, pH, turbidity, DO, nitrites and negative relationship with turbidity, COD, nitrates, sulphates, chlorides and phosphates. Chemical oxygen demand (COD) in present investigation showed positive relationship with pH, turbidity, DO, nitrates, nitrites, chlorides and phosphates and negative relationship with temperature, BOD and sulphates.

Nitrates showed significant positive relationship with pH, turbidity, COD and sulphates and negative relationship with temperature, DO, BOD, nitrites, chlorides and phosphates. Nitrites in present investigation showed positive relationship with temperature, DO, BOD, COD and phosphates and negative relationship with pH, turbidity, nitrates, sulphates and chlorides. Sulphates of the ground water summer showed significant positive relationship with turbidity, nitrates and chlorides and negative relationship with temperature, pH, DO, BOD, COD, nitrites and phosphates. Chlorides showed significant positive relationship with temperature, COD, sulphates and phosphates and negative relationship with pH, turbidity, DO, BOD, nitrates and nitrites. Phosphates showed significant positive relationship between ground water pH, turbidity, DO, COD, nitrites and chlorides and negative relationship with temperature, BOD, nitrates and sulphate.

The present study deals with the various relationship derived statistically by calculation of 'r' and 't' among the physico-chemical characteristics. The r value was 28 times negative and 27 times positive this showed that negative relationship in the present study.

During summer season correlated between different parameter with each other, statistically which shows great variation negative to positive values for 1% significant value (2.878 and 5% significant value 2.101). In the case of nitrates and turidity, nitrites and nitrates, sulphate and DO and sulphate and nitrites

we stablished a correlation which were positive and values were 2.211, 2.491, 2.631 and 2.102 respectively, which was greater than 5% significant level. Sulphate and temperature shows positive relationship i,e 2.150 which is closer to the 1% significant value. COD and DO were found positive value of co relationship at 1% significant level i,e 3.022. Turbidity and temperature, sulphate and nitrites shows negative relationship i,e -2.866 and -6.146 respectively with each other at 1% significant level. It showed that nitrites, turbidity, temperature, nitrates, sulphates, COD, DO play major role in the physico chemical characteristics of ground water of Satna district during summer season.

The heavy metals concentrations in the ground water samples of Satna District in different seasons and average values with their standard deviations are presented in table- 2 and 3. The lead concentration was recorded maximum during the monsoon season (9.04 ppm) and minimum of 0.046 ppm in summer season. Cadmium concentration was found to be 0.143 ppm, maximum in monsoon and minimum of 0.010 ppm during summer. Maximum concentrations of Nickel, Iron, Chromium and Copper are observed to be 0.041, 2.33, 0.056 and 1.2 ppm, while minimum values were recorded as 0.009, 0.01, 0.013, 0.01 ppm, respectively. The average individual metals concentrations from different locations in Satna District are depicted in figure-2 a and 2b.

Characteristics of soil: Oil samples collected from 20 different locations, and analyzed for the chemical properties and heavy metals contents in it. The chemical properties of the soils collected from Satna District for the three seasons are presented in table- 4, Heavy metals concentrations in the soils of Satna with seasons are presented in table- 5 and the average metals concentrations are showed in table- 6. The maximum concentration of chromium (99.0 mg/kg) and lead (103.0 mg/kg) was observed at sample B_8 and B_2 respectively (figure- 3a and 3b). The maximum concentration of cadmium 24.0 mg/kg was observed at the location B2, while Nikel was found to be 54.0 mg/kg maximum at B_{17} location. The maximum concentration of copper (87.0 mg/kg) was detected at sampling location of B_3 and maximum Iron concentration found to be 180 mg/kg at B_8. All the results were compared with the standards set by bureu of Indian standards (100500 : 1991), world health organization (1994) and SQGL value as given in table-7.

Table-1
Seasonal variation in Physico-chemical characteristics of ground water samples at different locations in Satna District

Parameters		Sampling Locations																						
		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B 11	B 12	B 13	B 14	B 15	B 16	B 17	B 18	B 19	B 20	Mean	S.D	C.V.
Temperature (°C)	Monsoon	30.4	24.5	27.2	33.3	25.5	38.1	33.4	36.8	31.4	31.4	30.3	28.5	29.2	30.1	28.5	29.2	27.3	25.1	27.8	24.5	29.625	3.742	12.6
	Winter	24.4	21.4	17.2	24.7	15.9	23.4	24.5	24.5	23.1	23	22.3	21.9	28.6	31.2	26.3	24	23.4	24.1	24.6	24.6	23.655	3.294	13.9
	Summer	32	29.2	27.3	32.2	35.7	31.7	33.2	25.1	27.5	29.8	25.8	27.2	27.6	32.4	34.2	35	36.6	32	29.8	28.5	30.64	3.355	10.9
pH	Monsoon	7.42	7.16	6.8	6.85	6.62	7.25	7.23	7.06	7.36	8.12	7.9	7.7	7.5	7.8	7.6	8.16	6.61	7.85	7.4	5.23	7.281	0.664	9.1
	Winter	8	6.8	7	8	6.9	6.6	7.3	7.7	6.8	6.3	7.1	5.6	8.6	7.8	6.4	7.3	6.1	6.8	6.5	6.8	7.02	0.728	10.3
	Summer	7.2	6.8	6.5	6.8	7	7	7.4	7.1	7.2	8.1	7.5	6.6	7.82	7.6	7.5	7	7.1	7.4	8.1	6.36	7.204	0.483	6.7
Turbidity (NTU)	Monsoon	1	3	2.5	3	10	2	2	3	2	1.5	2.4	2.1	1.75	2.8	1.9	1.5	2	1.7	1.5	1	2.4325	1.881	77.3
	Winter	0.5	1	1.5	2	1	1.5	1.5	1	2	1	1.6	1	1.2	1.5	1.5	1	1.2	1	1.5	1.1	1.28	0.372	29
	Summer	1	1.5	1	1	1	1.2	1	1	2	1	1	1.2	1	1	1	0.5	0.5	1	0.5	0.5	0.995	0.350	35.1
Dissolved Oxygen	Monsoon	2.3	2.7	2.3	2.6	2.2	1.5	1.7	1.6	6.5	5.5	6.3	4.5	2.2	7.4	6.1	3.2	1.5	4.3	4.2	3.2	3.59	1.885	52.5
	Winter	2.1	2.5	2.1	2.4	2	1.7	1.5	1.4	5.7	5.4	6.5	4.7	2.5	7.6	6.3	3.5	1.7	3.7	4.1	3.3	3.535	1.894	53.6
	Summer	2	2.6	2	2.1	2	2	1.4	1	5.5	4.7	6.8	4.9	2.7	7.8	6.5	3.7	2.1	3.9	4	3	3.535	1.939	54.8
BOD	Monsoon	4.7	4.5	1.2	2.2	3	4.3	4.8	2.6	3.5	3.3	3.4	4.6	5.7	5	6.4	6.7	4.7	4.2	3	3.4	4.06	1.371	33.7
	Winter	4.6	4.4	1.1	2.1	2.7	4	4.6	2.4	3.4	3	3.5	7.4	5.5	5.8	6.3	6.6	4.5	4	2.8	3.3	4.1	1.619	39.5
	Summer	4.3	4	1	2	2.4	3.8	4.4	2.2	3.2	2.8	1.8	7.1	5.3	5.5	6	6.2	4.3	3.8	2.7	3.1	3.795	1.625	42.8
COD	Monsoon	5.7	8	7.2	9	5.8	6.9	6.2	6.1	6.8	9.3	8.5	6.9	6.5	8	8.2	8.1	6.3	8.5	7.7	6.2	7.295	1.106	15.1
	Winter	6.1	8.2	7.5	9.5	6	7.2	7	6.5	8.2	8.8	8.6	7	6.9	8.2	8.5	8.2	6.5	8.7	7.9	7.6	7.655	0.977	12.7
	Summer	6.7	8.6	7.7	9.7	6.2	7.8	7.2	6.7	8.7	9.2	9	7.2	7.1	8.7	9.2	8.6	7.2	9.2	8.3	7.9	8.045	1.011	12.5
Nitrates	Monsoon	1.8	6.5	2.6	3.5	0.6	11.8	9.8	7.5	8	4.2	7.1	0.5	3.5	3.5	3	1.8	4.6	0.01	0.01	0.25	4.028	3.418	84.8
	Winter	ND	4.23	2.15	3.17	0.56	9.87	8.67	8.5	7.27	3.28	6.92	0.2	2	3.5	2	2	4	1	0.1	0.2	3.664	3.122	85.2
	Summer	ND	4.13	1.56	2.89	0.32	8.28	8.21	8.52	7.68	3.33	6.57	0.2	2	3	3	2	2	0.1	0.1	1	3.415	2.973	87
Nitrites	Monsoon	2	0.62	0.23	1.2	0.32	0.3	0.29	2.3	1.1	0.19	0.2	1.2	0.1	5	2.5	5.3	5.2	3.7	5.5	2.2	1.972	1.940	98.3
	Winter	1.98	0.56	0.11	1	0.11	0.28	0.25	1.95	1	ND	0.15	1.7	ND	6.1	3.5	8.3	6.8	4.9	0.5	2.8	2.332	2.565	109.9
	Summer	1.56	0.47	ND	0.97	0.09	0.23	0.22	1.55	0.96	ND	0.08	3.2	0.5	6	4	4.8	5.3	2.8	2	2.6	2.073	1.907	91.9
Sulphates	Monsoon	3.77	4.11	4.17	3.34	2.86	3.65	4.67	3.76	3.68	3.53	4.22	3.45	4.92	1	1.2	2.4	0.7	3.15	3.8	1.2	3.179	1.243	39.1
	Winter	3.54	3.68	6.88	2.65	2.73	3.52	5.26	3.45	3.52	2.68	5.88	3.34	3.66	0.82	0.8	2.2	0.5	2.6	3	1.1	3.090	1.636	52.9
	Summer	3.11	3.44	4	2.54	2.52	3.47	4.52	3.15	3.12	2.55	4.15	2.67	3.15	0.81	0.5	2	0.4	2.3	2.5	1.1	2.6	1.165	44.8
Chlorides	Monsoon	36	37	12	14	29	27	25	34	37	25	19	20	10	8	44	82	12	78	78	68	34.75	23.75	68.3
	Winter	43	40	15	18	33	31	29	38	30	28	21	10	8	8	30	70	6	70	76	60	33.2	21.463	64.6
	Summer	38	43	19	21	38	42	35	43	38	20	28	10	7	5	25	62	23	68	70	55	34.5	19.085	55.3
Phosphates	Monsoon	0.23	1.2	0.32	0.28	0.51	0.12	0.27	0.23	0.62	0.45	3.5	1.9	0.36	0.51	0.06	0.7	2	3.2	0.53	0.22	0.860	1.004	116.7
	Winter	0.11	1	0.11	0.26	0.46	ND	0.14	0.19	0.56	0.37	3.7	0.98	0.27	0.32	0.05	ND	1.89	3.15	0.52	0.2	0.793	1.060	133.6
	Summer	ND	0.97	0.09	0.23	0.37	ND	0.12	0.18	0.47	0.29	2.11	0.85	0.21	0.36	0.03	ND	1.66	3	0.35	0.18	0.674	0.829	122.9

Table-2
Seasonal variation in metals concentration of ground water samples at different locations in Satna District

Metals (ppm)		Sampling Locations																			
		B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**	**B12**	**B13**	**B14**	**B15**	**B16**	**B17**	**B18**	**B19**	**B20**
Lead	Monsoon	0.051	0.582	0.524	0.737	0.809	0.630	0.615	0.875	0.828	0.494	0.226	9.04	0.595	0.600	0.612	0.690	0.662	0.574	0.575	0.687
	Winter	0.036	0.095	0.528	0.748	0.815	0.637	0.627	0.872	0.838	0.512	0.236	9.00	0.598	0.612	0.619	0.698	0.672	0.584	0.587	0.695
	Summer	0.046	0.075	0.359	0.744	0.812	0.632	0.623	0.869	0.791	0.491	0.225	8.95	0.594	0.594	0.610	0.692	0.657	0.671	0.573	0.685
Cadmium	Monsoon	0.033	0.094	0.112	0.086	0.084	0.072	0.104	0.085	0.074	0.098	0.073	0.095	0.070	0.143	0.069	0.084	0.085	0.141	0.079	0.081
	Winter	0.031	0.097	0.010	0.082	0.078	0.067	0.118	0.075	0.059	0.086	0.058	0.093	0.065	0.138	0.065	0.081	0.079	0.137	0.074	0.075
	Summer	0.027	0.086	0.086	0.073	0.068	0.057	0.010	0.068	0.049	0.077	0.047	0.087	0.061	0.133	0.059	0.075	0.073	0.135	0.067	0.065
Nikel	Monsoon	0.023	0.016	0.025	0.019	ND	0.036	0.023	0.017	ND	0.019	0.041	ND	ND	0.026	0.023	0.016	0.017	0.024	0.027	0.013
	Winter	0.018	0.020	0.022	0.028	ND	0.028	0.025	0.021	ND	0.011	0.022	ND	ND	0.032	0.029	0.013	0.009	0.025	0.028	0.016
	Summer	0.022	0.021	0.024	ND	ND	0.032	0.022	0.014	ND	0.018	0.032	ND	ND	0.028	0.027	0.015	0.013	0.023	0.024	0.014
Iron	Monsoon	0.22	0.46	0.53	2.27	0.52	0.49	0.57	0.31	0.55	2.03	0.67	0.09	0.04	0.02	0.07	0.65	0.50	0.47	0.32	0.19
	Winter	0.24	0.51	0.65	2.33	0.63	0.51	0.62	0.45	0.57	2.21	0.71	0.10	0.18	0.25	0.14	0.76	0.88	0.55	0.49	0.24
	Summer	0.21	0.37	0.45	2.21	0.48	0.46	0.52	0.30	0.49	2.00	0.52	0.05	0.03	0.01	0.05	0.52	0.45	0.36	0.24	0.16
Cromium	Monsoon	0.041	0.037	0.017	0.046	0.029	0.035	0.025	0.043	0.024	0.052	0.043	0.025	0.052	0.041	0.018	0.039	0.027	0.047	0.035	0.039
	Winter	0.051	0.039	0.019	0.052	0.019	0.056	0.031	0.045	0.025	0.055	0.052	0.042	0.54	0.051	0.023	0.042	0.018	0.044	0.041	0.040
	Summer	0.043	0.035	0.013	0.047	0.025	0.054	0.023	0.042	0.021	0.049	0.039	0.028	0.055	0.046	0.019	0.038	0.024	0.033	0.032	0.038
Copper	Monsoon	0.04	0.60	0.03	0.02	0.02	0.03	0.03	0.01	0.03	0.02	0.02	0.08	0.03	0.06	0.01	0.20	0.01	0.01	0.01	0.02
	Winter	0.08	0.09	1.00	0.07	0.06	0.80	0.10	0.02	0.20	0.03	0.08	0.03	0.01	0.08	0.04	0.06	0.03	0.02	0.02	0.02
	Summer	0.02	0.08	1.20	0.03	0.05	0.20	0.09	0.06	0.80	0.09	0.04	0.03	0.02	0.20	0.03	0.50	0.05	0.01	0.04	0.01

All the values are expressed in mg/l. **B1**: Near District hospital Satna, **B2**: Near Birla cement plant, **B3**: Near steel plant Babupur, **B4**: Madhogarh, near higher secondary school, **B5**: Near T.R.S ground, Kothi, **B6**: Near Jaithwara primary school, **B7**: Rampur Baghelan, near Hanuman chauk, **B8**: Near Prism cement plant, **B9**: Near Hospital and School, Chibaura, **B10**: Near Maihar, **B11**: Near Maihar cement plant, **B12**: Near Dhanera gram panchayat, **B13**: Near Barhiya primary school, **B14**: Near Amarpatan, **B15**: Near Ramnagar Bus stand, **B16**: Near Unchagra railway station, **B17**: Near Nagod, **B18**: Near temple Birsinghpur, **B19**: Near Majhgawan Bus stand, **B20**: Near Chitrakoot.

Table-3
Average metals concentration in ground water of Satna District

Metals	Sampling Locations																			
	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**	**B12**	**B13**	**B14**	**B15**	**B16**	**B17**	**B18**	**B19**	**B20**
Lead	0.044	0.251	0.470	0.743	0.812	0.633	0.622	0.872	0.819	0.499	0.229	8.997	0.596	0.602	0.614	0.693	0.664	0.610	0.578	0.689
SD (±)	0.008	0.287	0.096	0.006	0.003	0.004	0.006	0.003	0.025	0.011	0.006	0.045	0.002	0.009	0.005	0.004	0.008	0.053	0.008	0.005
Cadmium	0.030	0.092	0.069	0.080	0.077	0.065	0.077	0.076	0.061	0.087	0.059	0.092	0.065	0.138	0.064	0.080	0.079	0.138	0.073	0.074
SD (±)	0.003	0.006	0.053	0.007	0.008	0.008	0.059	0.009	0.013	0.011	0.013	0.004	0.005	0.005	0.005	0.005	0.006	0.003	0.006	0.008
Nikel	0.021	0.019	0.024	0.024	ND	0.032	0.023	0.017	ND	0.016	0.032	ND	ND	0.029	0.026	0.015	0.013	0.024	0.026	0.014
SD (±)	0.003	0.003	0.002	0.006	ND	0.004	0.002	0.004	ND	0.004	0.010	ND	ND	0.003	0.003	0.002	0.004	0.001	0.002	0.002
Iron	0.223	0.447	0.543	2.270	0.543	0.487	0.570	0.353	0.537	2.080	0.633	0.080	0.083	0.093	0.087	0.643	0.610	0.460	0.350	0.197
SD (±)	0.015	0.071	0.101	0.060	0.078	0.025	0.050	0.084	0.042	0.114	0.100	0.026	0.084	0.136	0.047	0.120	0.235	0.095	0.128	0.040
Cromium	0.045	0.037	0.016	0.048	0.024	0.048	0.026	0.043	0.023	0.052	0.045	0.032	0.216	0.046	0.020	0.040	0.023	0.041	0.036	0.039
SD (±)	0.005	0.002	0.003	0.003	0.005	0.012	0.004	0.002	0.002	0.003	0.007	0.009	0.281	0.005	0.003	0.002	0.005	0.007	0.005	0.001
Copper	0.047	0.257	0.743	0.040	0.043	0.343	0.073	0.030	0.343	0.047	0.047	0.047	0.020	0.113	0.027	0.253	0.030	0.013	0.023	0.017
SD (±)	0.031	0.297	0.626	0.026	0.021	0.405	0.038	0.026	0.405	0.038	0.031	0.029	0.010	0.076	0.015	0.225	0.020	0.006	0.015	0.006

Concentrations of metals are expressed in mg/l.

B1: Near District hospital Satna, **B2**: Near Birla cement plant, **B3**: Near steel plant Babupur, **B4**: Madhogarh, near higher secondary school, **B5**: Near T.R.S ground, Kothi, **B6**: Near Jaithwara primary school, **B7**: Rampur Baghelan, near Hanuman chauk, **B8**: Near Prism cement plant, **B9**: Near Hospital and School, Chibaura, **B10**: Near Maihar, **B11**: Near Maihar cement plant, **B12**: Near Dhanera gram panchayat, **B13**: Near Barhiya primary school, **B14**: Near Amarpatan, **B15**: Near Ramnagar Bus stand, **B16**: Near Unchagra railway station, **B17**: Near Nagod, **B18**: Near temple Birsinghpur, **B19**: Near Majhgawan Bus stand, **B20**: Near Chitrakoot.

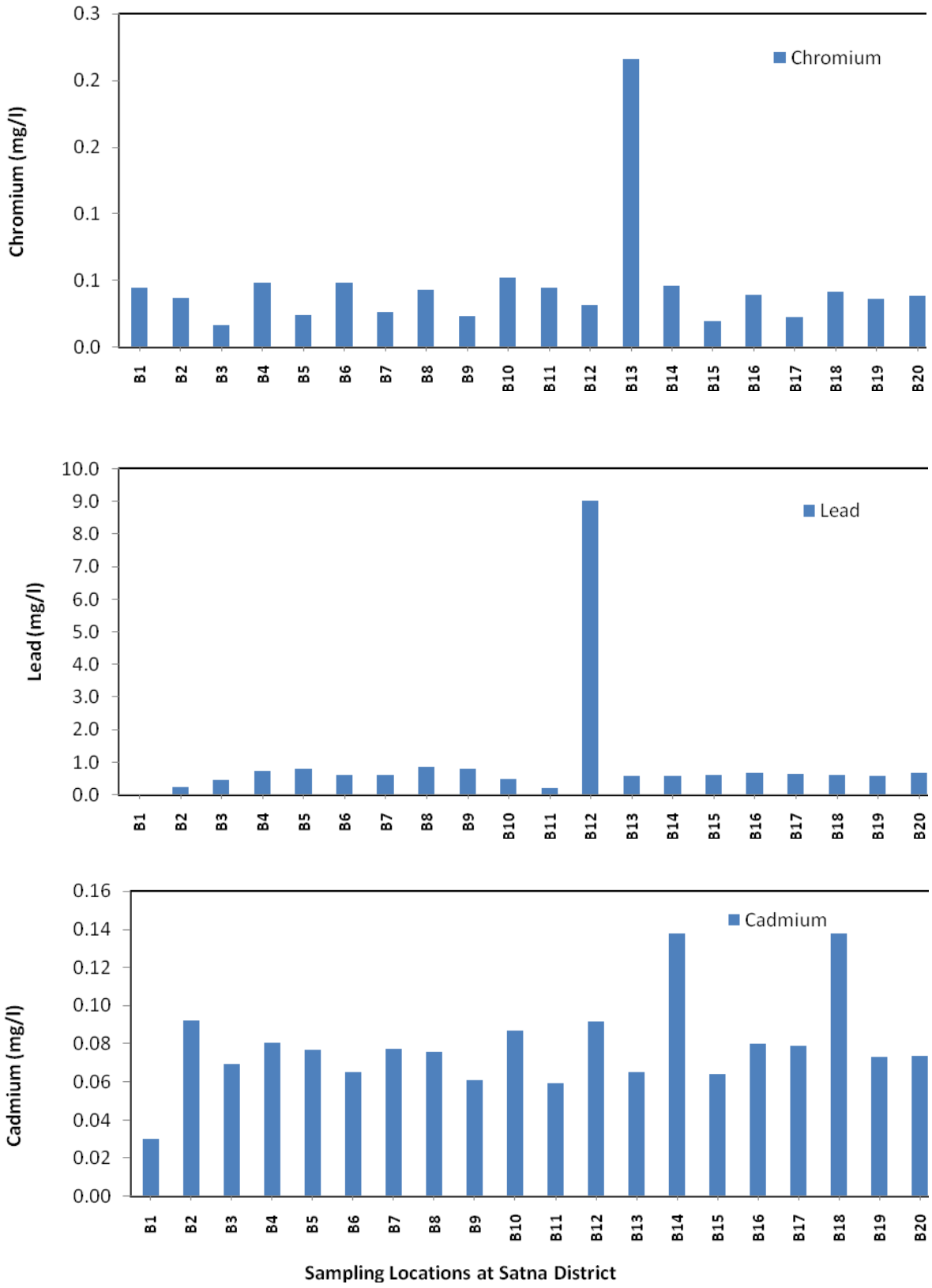

Figure 2a
Metals content in the ground water samples of Satna District

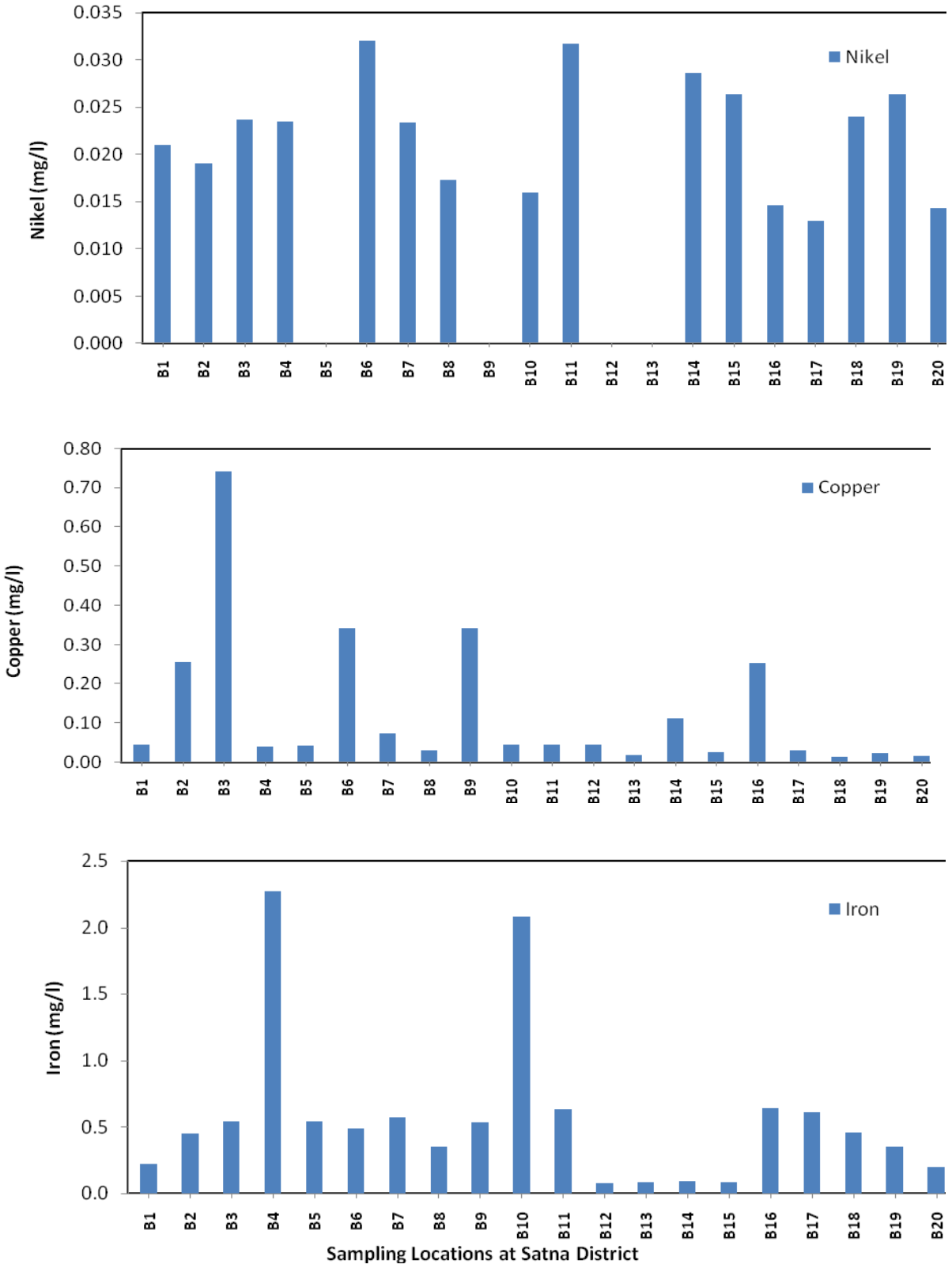

Figure-2b
Metals content in the ground water samples of Satna District

Table-4
Chemical composition of soils collected from different locations in Satna District

		Sampling Locations																			
	SEASONS	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**	**B12**	**B13**	**B14**	**B15**	**B16**	**B17**	**B18**	**B19**	**B20**
O.C.	Summer	2.19	1.58	0.44	0.40	4.19	0.30	0.70	1.50	2.47	1.32	0.79	0.38	0.21	0.25	0.40	0.17	0.50	0.26	0.56	0.24
	Winter	2.15	1.56	0.46	0.42	4.15	0.28	0.68	1.46	2.45	1.35	0.78	0.35	0.25	0.23	0.35	0.19	0.47	0.24	0.59	0.21
	Monsoon	2.13	1.54	0.48	0.47	5.29	0.26	0.66	1.42	2.43	1.37	0.75	0.33	0.28	0.21	0.30	0.21	0.44	0.22	0.61	0.18
N	Summer	24.7	29.0	6.38	11.70	5.17	12.14	28.89	36.44	5.19	17.39	10.49	16.67	14.33	33.39	25.13	15.73	9.59	21.80	16.67	18.22
	Winter	26.2	25.3	791	14.75	5.29	14.37	31.67	37.26	5.43	21.72	11.57	19.27	16.56	37.22	28.03	16.68	9.60	25.39	19.27	21.07
	Monsoon	30.0	24.5	9.64	17.22	5.98	18.46	43.06	42.33	5.57	23.81	12.41	23.64	20.50	43.59	32.00	20.29	9.64	28.47	23.64	24.23
P	Summer	2.0	1.5	0.71	0.82	1.82	0.67	0.52	0.97	0.46	0.67	0.58	0.45	3.44	2.15	0.68	0.85	0.33	0.57	0.26	2.15
	Winter	1.98	1.2	0.57	0.76	0.89	0.62	0.35	0.85	0.46	0.62	0.53	0.45	4.49	2.13	0.66	0.85	0.21	0.58	0.29	2.20
	Monsoon	1.98	1.00	0.65	0.76	0.78	0.65	0.53	1.90	0.50	0.73	0.63	0.49	4.53	2.18	0.65	0.95	0.21	0.63	0.32	2.25
Na^+	Summer	10.3	11.0	7.4	16.1	30.8	23.6	24.3	32.7	15.4	69.8	5.28	10.3	16.1	34.1	18.7	6.34	28.6	37.2	4.25	26.9
	Winter	12.5	14.5	9.5	18.4	32.7	24.3	19.8	34.2	16.9	67.7	5.31	10.7	15.5	31.6	15.4	6.98	24.3	35.9	4.30	28.4
	Monsoon	15.3	18.0	13.0	21.6	35.9	25.9	20.6	35.4	18.3	63.0	5.53	11.4	14.2	28.5	12.3	7.44	19.2	32.7	4.36	32.2
K^+	Summer	33.3	36.4	14.2	15.4	12.25	24.40	31.24	24.7	24.0	5.18	21.82	7.12	5.49	9.89	10.19	19.00	4.90	7.22	13.49	3.29
	Winter	32.7	34.7	13.6	14.2	12.48	27.0	36.92	28.2	28.0	5.15	22.61	7.67	5.22	9.84	10.97	19.57	4.85	7.32	13.96	3.52
	Monsoon	31.5	32.3	12.4	13.1	12.63	27.45	40.00	31.5	32.0	6.19	23.78	7.82	5.60	9.45	11.35	19.49	4.62	7.43	13.98	3.62
Ca^{++}	Summer	18.	19.7	18.8	17.5	15.3	25.0	19.0	16.5	27.0	32.0	35.0	ND	42.0	25.0	35.0	41.7	32.5	43.6	ND	12.3
	Winter	15.2	10.5	12.7	15.3	11.3	43.0	27.0	20.0	32.0	39.0	49.0	ND	22.0	15.0	14.0	18.0	21.7	23.5	ND	8.2
	Monsoon	15.0	7.8	12.5	16.2	13.2	51.0	20.0	24.3	35.1	45.0	52.0	ND	28.0	17.0	16.0	22.3	21.0	19.2	ND	8.0
Mg^{++}	Summer	19.5	15.0	21.0	33.0	39.0	42.0	55.0	35.0	36.0	44.0	27.0	34.0	35.0	51.0	57.0	45.0	39.0	45.2	37.0	ND
	Winter	23.2	16.5	25.2	28.0	42.0	45.0	58.0	38.0	40.0	49.0	30.0	37.5	40.0	54.0	60.0	46.0	42.0	48.5	39.0	ND
	Monsoon	28.0	21.0	28.0	25.0	44.4	48.0	61.0	41.0	44.0	54.0	33.0	40.5	45.0	51.0	63.0	45.0	45.5	51.0	39.0	ND

All the values expressed in mg/kg.

B1: Near District hospital Satna, **B2**: Near Birla cement plant, **B3**: Near steel plant Babupur, **B4**: Madhogarh, near higher secondary school, **B5**: Near T.R.S ground, Kothi, **B6**: Near Jaithwara primary school, **B7**: Rampur Baghelan, near Hanuman chauk, **B8**: Near Prism cement plant, **B9**: Near Hospital and School, Chibaura, **B10**: Near Maihar, **B11**: Near Maihar cement plant, **B12**: Near Dhanera gram panchayat, **B13**: Near Barhiya primary school, **B14**: Near Amarpatan, **B15**: Near Ramnagar Bus stand, **B16**: Near Unchagra railway station, **B17**: Near Nagod, **B18**: Near temple Birsinghpur, **B19**: Near Majhgawan Bus stand, **B20**: Near Chitrakoot.

Table-5
Seasonal variation of metals concentration in soils collected from Satna District in Vindhya Pradesh

HM	**SEASONS**	Sampling Locations																			
		B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**	**B12**	**B13**	**B14**	**B15**	**B16**	**B17**	**B18**	**B19**	**B20**
Cr	Monsoon	50.8	38.8	74.4	37.2	29.7	17.1	57.3	92.5	54.0	62.0	74.5	42.7	39.2	60.2	47.8	53.5	42.0	39.4	18.2	22.7
	Winter	51.2	41.5	75.0	41.5	32.0	17.8	60.0	96.4	55.2	67.3	86.2	39.8	44.5	56.1	39.0	59.4	45.0	41.0	19.0	23.4
	Summer	54.6	44.4	76.6	45.0	32.4	19.0	59.0	106.6	55.4	72.8	105	35.6	52	54	35	62.0	56.2	44.2	19.4	23.8
pb	Summer	47.2	116	21.6	8.2	35.0	48.6	72.8	45.8	5.2	72.8	32.4	23.4	8.0	20.4	48.6	44.8	45.8	16.5	21.6	5.2
	Winter	43.5	104	24.2	14.5	37.5	45.0	68.4	46.4	4.0	68.4	33.2	20.4	10.5	19.6	44.2	39.1	46.2	17.6	23.5	5.0
	Monsoon	30.4	90.0	26.4	19.6	40.6	42.3	63.2	47.8	3.7	63.2	35.0	17.5	12.4	16.7	39.7	37.4	48.0	19.2	25.4	4.9
cd	Summer	12.4	26.6	12.5	10.8	5.2	2.4	8.7	11.0	6.8	10.4	22.6	0.4	1.2	13.0	8.0	8.2	1.6	0.2	10.0	1.2
	Winter	12.4	23.4	13.5	10.0	4.7	2.1	5.1	12.0	7.0	11.0	21.0	0.6	1.0	12.5	8.6	5.4	1.5	0.2	9.3	1.0
	Monsoon	11.5	22.3	12.0	8.4	4.1	1.7	4.2	11.5	6.2	7.2	20.3	0.6	ND	12.0	9.4	3.0	0.8	0.2	7.6	1.7
Ni	Summer	16.4	35.4	33.0	2.8	8.4	ND	13.4	45.6	0.8	19.0	34.4	7.0	3..4	13.4	22.5	44.6	52.4	6.3	37.5	7.5
	Winter	15.2	37.0	29.5	6.0	9.5	ND	16.5	48.0	0.5	26.2	30.0	4.5	3.0	16.5	19.5	40.5	54.2	12.2	40.0	2.5
	Monsoon	12.8	38.2	24.2	8.5	13.2	ND	18.7	49.2	0.2	28.5	27.5	3.1	2.8	18.7	15.8	37.2	55.0	15.4	43.5	11.4
G	Summer	34.6	58.8	92.6	18.6	80.4	16.8	21.8	27.2	0. 4	91.6	54.4	0.6	1.2	16.0	3.5	22.4	4.0	3.6	28.6	2.6
	Winter	32.0	58.0	87.6	20.4	25.8	14.0	19.2	29.0	0.3	84.2	49.2	0.5	1.0	18.1	2.3	18.5	3.5	2.0	27.8	2.0
	Monsoon	29.8	56.5	81.4	19.0	21.2	12.4	17.5	28.2	0.2	75.5	43.4	0.4	0.7	9.4	1.6	14.2	2.8	1.2	27.0	1.0
Fe	Summer	26.0	33.8	131.6	46.2	18.6	90	67.0	191.2	45.8	61.5	93..3	29.4	18.6	49.7	32.0	75.6	64.0	27.0	73.0	28.8
	Winter	23.0	31.0	127	42.3	17.4	72.0	69. 0	180.0	42.3	59.5	91.0	24.0	16.0	47.2	29.0	72.4	61.1	21.0	68.0	26.5
	Monsoon	20.0	29.4	125.2	40.1	16.2	67.0	65.0	168.0	57.5	56.2	89.5	19.0	15.8	46.4	25.7	68.5	57.4	15.4	64.0	24.2

All the values are expressed in mg/kg.

B1: Near District hospital Satna, **B2**: Near Birla cement plant, **B3**: Near steel plant Babupur, **B4**: Madhogarh, near higher secondary school, **B5**: Near T.R.S ground, Kothi, **B6**: Near Jaithwara primary school, **B7**: Rampur Baghelan, near Hanuman chauk, **B8**: Near Prism cement plant, **B9**: Near Hospital and School, Chibaura, **B10**: Near Maihar, **B11**: Near Maihar cement plant, **B12**: Near Dhanera gram panchayat, **B13**: Near Barhiya primary school, **B14**: Near Amarpatan, **B15**: Near Ramnagar Bus stand, **B16**: Near Unchagra railway station, **B17**: Near Nagod, **B18**: Near temple Birsinghpur, **B19**: Near Majhgawan Bus stand, **B20**: Near Chitrakoot.

Table-6
Average Metals concentration in Soils collected from Satna District in Vindhya Pradesh

Metals	Sampling Locations																			
	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**	**B12**	**B13**	**B14**	**B15**	**B16**	**B17**	**B18**	**B19**	**B20**
Cromium	52.20	41.57	75.33	41.23	31.37	17.97	58.77	98.50	54.87	67.37	88.57	39.37	45.23	56.77	40.60	58.30	47.73	41.53	18.87	23.30
SD (±)	2.09	2.80	1.14	3.91	1.46	0.96	1.37	7.28	0.76	5.40	15.39	3.57	6.43	3.15	6.55	4.36	7.48	2.44	0.61	0.56
Lead	40.37	103.33	24.07	14.10	37.70	45.30	68.13	46.67	4.30	68.13	33.53	20.43	10.30	18.90	44.17	40.43	46.67	17.77	23.50	5.03
SD (±)	8.83	13.01	2.40	5.71	2.81	3.16	4.81	1.03	0.79	4.81	1.33	2.95	2.21	1.95	4.45	3.88	1.17	1.36	1.90	0.15
Cadmium	12.10	24.10	12.67	9.73	4.67	2.07	6.00	11.50	6.67	9.53	21.30	0.53	1.10	12.50	8.67	5.53	1.30	0.20	8.97	1.30
SD (±)	0.52	2.23	0.76	1.22	0.55	0.35	2.38	0.50	0.42	2.04	1.18	0.12	0.14	0.50	0.70	2.60	0.44	0.00	1.23	0.36
Nikel	14.80	36.87	28.90	5.77	10.37	ND	16.20	47.60	0.50	24.57	30.63	4.87	2.90	16.20	19.27	40.77	53.87	11.30	40.33	7.13
SD (±)	1.83	1.40	4.43	2.86	2.51	ND	2.66	1.83	0.30	4.96	3.49	1.98	0.14	2.66	3.36	3.71	1.33	4.62	3.01	4.46
Copper	32.13	57.77	87.20	19.33	42.47	14.40	19.50	28.13	0.25	83.77	49.00	0.50	0.97	14.50	2.47	18.37	3.43	2.27	27.80	1.87
SD (±)	2.40	1.17	5.61	0.95	32.93	2.23	2.17	0.90	0.07	8.06	5.50	0.10	0.25	4.54	0.96	4.10	0.60	1.22	0.80	0.81
Iron	23.00	31.40	127.93	42.87	17.40	76.33	66.00	179.73	48.53	59.07	90.25	24.13	16.80	47.77	28.90	72.17	60.83	21.13	68.33	26.50
SD (±)	3.00	2.23	3.30	3.09	1.20	12.10	1.41	11.60	7.96	2.68	1.06	5.20	1.56	1.72	3.15	3.56	3.31	5.80	4.51	2.30

Metal concentrations are expressed in mg/kg.

B1: Near District hospital Satna, **B2**: Near Birla cement plant, **B3**: Near steel plant Babupur, **B4**: Madhogarh, near higher secondary school, **B5**: Near T.R.S ground, Kothi, **B6**: Near Jaithwara primary school, **B7**: Rampur Baghelan, near Hanuman chauk, **B8**: Near Prism cement plant, **B9**: Near Hospital and School, Chibaura, **B10**: Near Maihar, **B11**: Near Maihar cement plant, **B12**: Near Dhanera gram panchayat, **B13**: Near Barhiya primary school, **B14**: Near Amarpatan, **B15**: Near Ramnagar Bus stand, **B16**: Near Unchagra railway station, **B17**: Near Nagod, **B18**: Near temple Birsinghpur, **B19**: Near Majhgawan Bus stand, **B20**: Near Chitrakoot.

Table-7
Standards for Drinking Water and Soil

Water					**Soil**	
Parameter	**BIS (10500 : 1991) mg/l**		**WHO (1994) mg/l**		**Parameter**	**Soil Quality Guide line level mg/kg**
	Desirable	**Permissible**	**Excessive**	**Permissible**		
pH	-	6.5	8.5	6.5		
Turbidity	-	--	10	5.0	Temp.	-
DO	3.0	--	6.0	4.0	pH	-
BOD	-	2.0	--	6.0	O.C.	-
COD	-	--	--	10.0	N	-
Nitrate	100	45	10	10	P	-
Nitrite	-	--	40	10	Na+	62
Sulphate	1000	--	400	250	K+	60
Chloride	1000	250	600	250	Ca++	250
Phosphate	--	--	0.3	0.1	Mg++	30
Lead	0.05	No relaxation	0.01	0.05	Lead	140
Cadmium	0.01	No relaxation	0.003	--	Cadmium	10
Nikel	--	--	--	0.02 mg/l.	Nikel	50
Iron	0.3	1.0	0.3	--	Iron	-
Chromium	No relaxation	0.05	--	0.05	Chromium	64
Copper	1.5	0.05	1.00	--	Copper	63

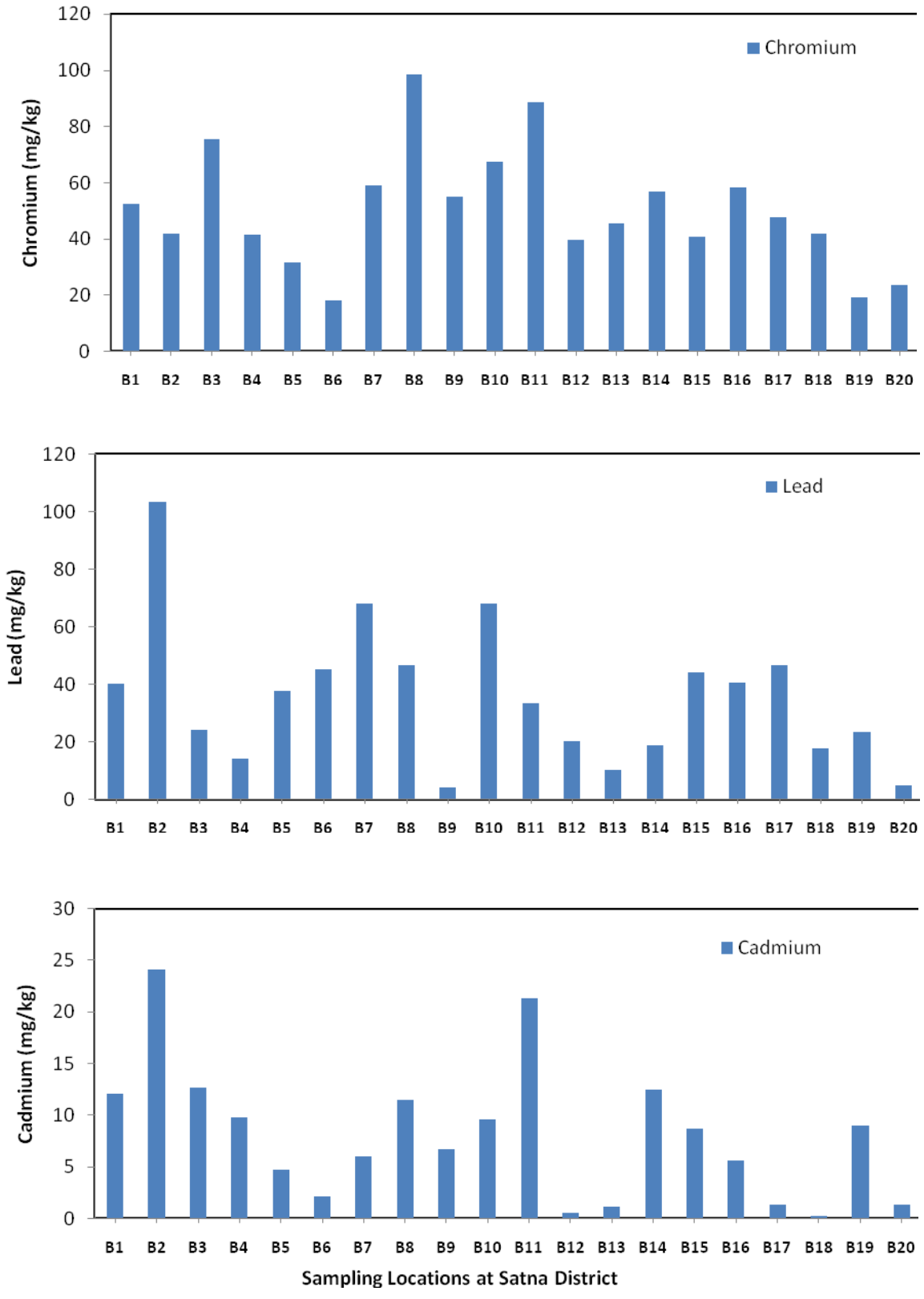

Figure-3a
Metals content in the soils of Satna District

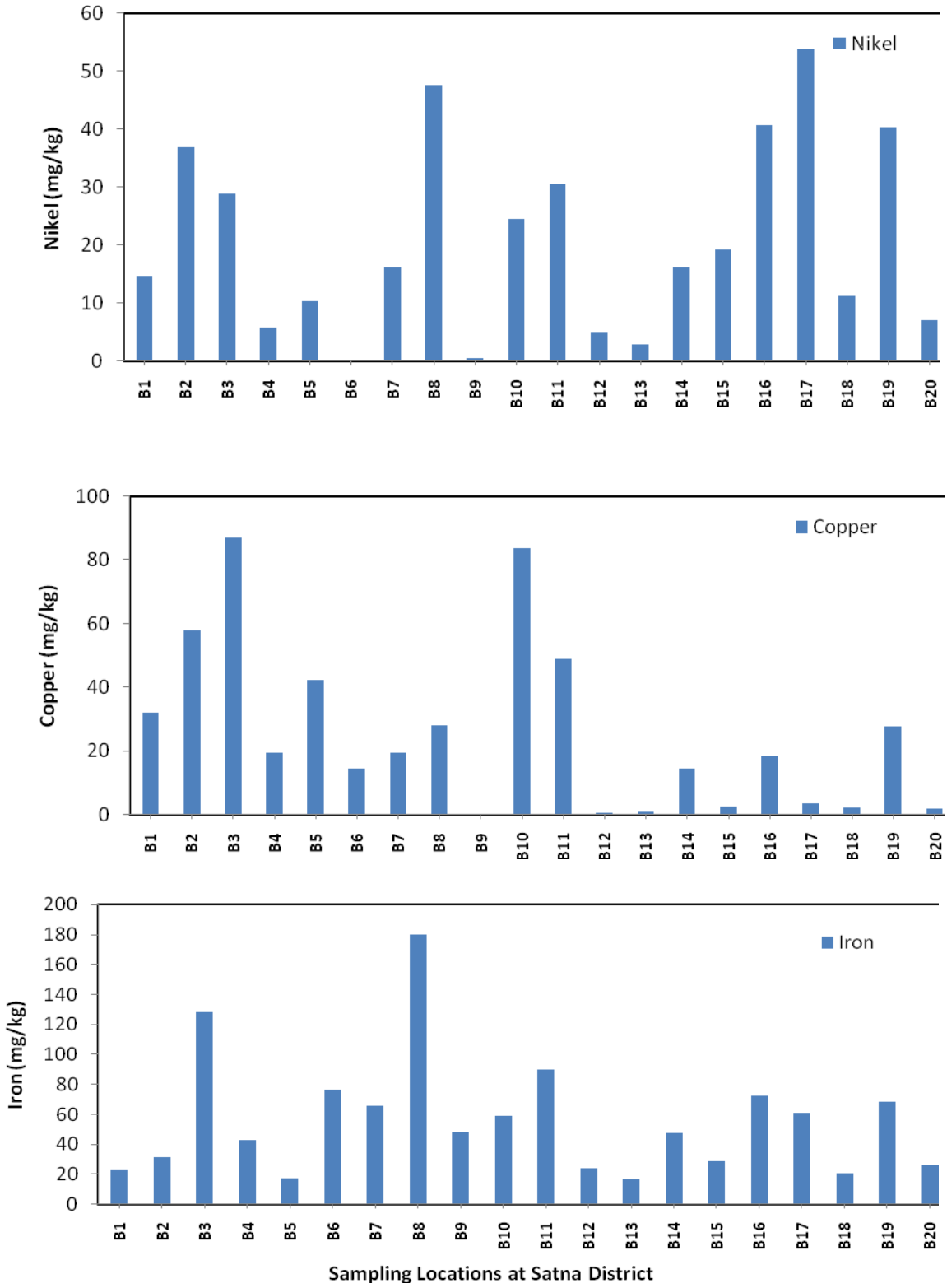

Figure-3b
Metals content in the soils of Satna District

Conclusion

Diffuse water pollution is mainly related to the way we use and manage level and soil. It can affect rivers lakes coal ground water. Unlike point source pollution, we cannot easily control diffuse pollution by issuing licenses or permits[26]. Regulatory approaches have to be more subtle and in many cases need to be well connected to the land use planning systems. The present study reveals that the water samples collected from different location of Satna district. The parameters like pH, DO, BOD, COD, Nitrate, Nitrite, chloride and sulphate were well within the permissible limit, prescribed by WHO. The turbidity of all the water samples within the range of 05 to 10 NTU. The maximum value of turbidity 10 NTU was observed at sampling location of B_5 during the rainy season. The value from all the sampling station within the WHO recommended values (5NTU) except the sampling location of B5 (Kothi region). As for as the phosphates are concerned, maximum concentration of 3.70mg/l was observed in winter season and minimum concentration of 0.01mg/l during the rainy season. The maximum concentration of phosphate (3.70) was recorded at Maihar cement plant (B_{11}). The content of Pb, Cr and Fe in the analyzed water sample more than the permissible limit during all the season, while Ni showed very little seasonal variation and most of the data showed concentration below the permissible limit with slight variation. Copper concentration ranged from 0.01 to 1.20 mg/l and all the results were below the permissible limit set by BIS (1991) as 1.5mg/l. Babupur region of Satna district showed the highest concentration of copper in water. Soil samples collected from 20 different location and analyzed for the chemical properties and heavy metals contents in it. The organic content in these soil are very poor and ranging from 0.17 to 5.29 mg/kg, nitrogen concentration ranging from 5.17 to 43.59 mg/kg and phosphorus concentration ranged from 0.21 to 4.53mg/kg. The content of Pb, Ni and Fe in the analyzed soil samples were below the recommended level, while copper concentration at sampling satation B3, B5 and B10 are higher than the recommended level. The concentration of Cd and Cr in many sample more than the SQGL value.

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References

1. Agarwal G.D., Lunkad S.K., Malkhed T., Diffuse agricultural nitrate pollution of ground waters in India, *Water Science and Tecnology.,* **39(3),** 67-75 **(1999)**

2. Padmaparna Ghosh, Drug abuse: Ranbaxy, Dutch pharma put paid to groundwater, *Down To Earth,* **14(17),** 7-8 **(2005)**

3. Behera Bhagirath and Reddy V. Ratna., *Environment and Accountability: Impact of Industrial Pollution on Rural Communitie, Economic and Political Weekly,* 257-265 **(2002)**

4. Biradar B. S. and Biradar C.B., Groundwater pollution due to improper treatment and disposal arrangements by distillery - A case study. Chapter 36 in Trivedy, R. K. (ed.), "Industry and Environment'' Daya Publications Delhi, **(2002)**

5. Salunke K. J. and Karande S. M., Effect of pulp and paper mill effluent on the seed germination and early seedling growth in Mungbean, Chapter 68 in R. K. Trivedy (ed.) Industry and Environment, Delhi, Daya Publications. **(2002)**

6. Kumar R.D., Senthil and Narayanaswamy .R., Spectroscopic on the heavy metal pollution of the Sugar mill effluents and its impact on groundwater, Chapter 34 in Trivedy, R. K. (ed.). Industry and Environment, Daya Publications Delhi, **(2002)**

7. Barman S. C., Kisku G. C., Salve P. R., Misra D., Sahu R. K., Ramteke P. W. and Bhargava S. K., Assessment of industrial effluent and its impact on soil and plants*, Journal of Environmental Biology.,* **22(4)**, 251-6 **(2001)**

8. Singh G., Bala N., Rathod T.R. and Singh B., Effect of textile industrial effluent on tree plantation and soil chemistry, *Journal of Environmental Biology,* **22(1),** 59-66 **(2001)**

9. Kisku G.C., Barman S.C. and Bhargava S.K., Contamination of Soil and Plants with Potentially Toxic Elements Irrigated with Mixed Industrial Effluent and its Impact on the Environment, *Water, Air and Soil Pollution,* **120(1-2),** 121 – 137 **(2003)**

10. Gowd Srinivasa S. and Kotaiah B., Groundwater pollution by Cystine manufacturing industrial effluent around the factory, *Environmental Geology,* **39(6)**, 679-682 **(2000)**

11. Singh K.P. and Parwana H.K., Groundwater Pollution due to Industrial Wastewater in Punjab State and Strategies for its Control, *Indian Journal of Environmental Protection,* **19(4),** 241-244 **(1998)**

12. Kaushik A., Bala R. Kadyan and Kaushik C. P., Sugar mill effluent effects on growth, photosynthetic pigments and nutrient uptake in wheat seedlings in aqueous vs. soil medium, *Water, Air and Soil Pollution.,* **87(1-4),** 39 – 46 **(1996)**

13. Narwal R.P., Antil R.S., and Gupta A.P., Soil pollution through industrial effluent and its management, *Journal of Soil Contamination,* **1 (3),** 265-272 **(1992)**

14. Ma J., Ding Z., Wei G., Zhao H. and Huang T., Sources Of water pollution and evolution of water quality in the Wuwei Basin of Shiyang River, Northwest China. *Journal of Environmental Management.,* **90,** 1168–1177 **(2009)**

15. Taebi A., Droste L.R., Pollution loads in urban runoff and sanitary wastewater*, Science of the total Environment,* **327,** 175–184 **(2004)**

16. Petersen M.T., Rifai S.H., Suarez P.M., Stein A.R., Bacteria loads from point and non-point sources in an urban watershed, *Journal of Environmental Engineering,* **131,** 1414–1425 **(2005)**

17. Marsalek J., Diamond M., Kok S., Watt E.W. Urban Runoff, The National Water Research Institute, *http://www.nwri.ca/threatsfull/ch11-1-e.html.* **(2002)**

18. Kelsey H., Porter E. D., Scott G., Neet M., White D., Using geographic information systems and regression analysis to evaluate relationships between landuse and fecal coliform bacterial pollution. *Journal of Experimental Marine Biology and Ecology* **298,** 97–209 **(2004)**

19. Jamwal P., Mittal A. K. and Mouchel J. M., Point and non-point microbial source pollution: A case study of Delhi, *Physics and Chemistry of the Earth.* doi:10.1016/j.pce.2008.09.005a **(2008)**

20. Hasan M. Z., Panday S.., Pathak B. N., Bulusu, K..P., Project No-1428, NEERI Nagpur, **(1981)**

21. ICMR Manual of standards of quality for drinking water, ICMR Delhi 2nd ed, **(1975)**

22. NEERI manual on water and waste water analysis, Nagpur **(1988)**

23. WHO, guidelines for drinking water quality, **(1994)**

24. Standard method for the examination of water and waste water, APHA AWWA and WEF, 18th ed. **(1992)**

25. Piper C.S., A laboratory manual of methods for the examination of soil and the determination of the inorganic constituents of plant, Original Edition-1942. Printed in India. Scientific publishers Jodhpur (Raj.) India **(1942)**

26. Sharma V.K, Environmental Chemistry, Goel publishing House, Meerut, **(2000)**

27. Vladimir Novatny, Diffuse pollution monitoring and abatement in the future cities, Keynote paper at the International Workshop on TMDL Monitoring and Abatement Program presented at Konkuk University, Seoul, Korea, on May 16 **(2008)**