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Heavy Metal Status of Soils around Industrial Belts of Samba and Kathua District of Jammu, India

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Effluent borne heavy metals in soil ecosystem can result into phytotoxic levels impair plant growth. Long-term accumulation of toxic metals in soils and their uptake by crop plants has a high potential for phytotoxicity besides entering into the food chain. Soils in both the districts were slightly acidic to neutral. The cation exchange capacity (CEC) was highest in maize wheat production system and least in pasture system in soils of district Samba, and whereas least was observed in rice wheat system in soils of Kathua. Higher organic carbon (OC) % was in the pasture system of district Kathua. The soils of district Samba is mostly sandy loam whereas soils of district Kathua are clay loam. Among the heavy metals, lead (Pb) was found to be slightly higher than the permissible limits (as per European Union standards, 2002) in two locations (Dhiansar RWS-2 and Kartholy RWS-1) representing rice-wheat production system and one location (Dhiansar VS-4) representing vegetable production systems in samba district of Jammu and Kashmir.

Introduction

Soil is considered contaminated when chemicals are present or other changes are imparted in the natural ecosystem which deviates normal composition of soil ecosystem and impairs soil health. Heavy metals in soil is of major significance in relation to their fertility because many of these like zinc (Zn), copper (Cu), and selenium (Si) are essential elements for the normal growth of the plants and living organisms, however, high concentration of these metals become toxic. Other heavy metals like lead and chromium also become harmful at high concentration. Rapid industrial, agricultural and domestic activity has posed a problem for the rational utilization of soils. Industrial inputs and contaminated sewage contribute the metals accumulation in soil which leads to real threat to environment because the metals cannot be naturally degraded like organics and may continue to remain in different parts of food chain. Heavy metal pollution affects all the forms of life including soil microbes, plants and animals, though the degree of toxicity varies for different organisms. Metal contamination may lead to change in the physicochemical conditions of the soil including pH, redox potential and alleviate decomposition of organic matter (Kelly *et al.*, 2003). Soils irrigated with contaminated sewage or effluent had shown higher electrical conductivity (EC), cation exchange capacity (CEC), organic carbon (OC) and clay content but had lower pH and $CaCO_3$ compared to soils irrigated with uncontaminated water (Dheri and Brara, 2007). The Pb (35.30 ppm), Cu (95.30 ppm), Zn (69.0 ppm) and Fe levels in soils of industrial areas in Bangalore was much higher than non – industrial areas, also pH of the soils under study was 6.45 contrast to normal soils (Gowda *et al.,* 2003). With long-term use of sewage waste and effluents, heavy metals can accumulate to phototoxic levels and result in reduced plant growth (Salamasi and Tavassoli, 2005) and yield. Long-term accumulation of toxic metals in soils and their uptake by crop plants has a high potential for phytotoxicity besides entering into the food chain (Dheri and Brar, 2007). Vegetables grown on affected soils have shown elevated concentration of several heavy metals near Amritsar, India (Khurana *et al.,* 2004) and thus confirming their entry into the food chain. There are several reports of high accumulation of Cd in grains of rice, wheat and barley grown on soils irrigated with Cd rich industrial effluents (Garcia *et al.,* 1981; Juwarkar and Sinde, 1986; Pandey, 2006).

Sewage is a rich source of organic and inorganic nutrients for plant growth (Mitra and Gupta, 1999) and is cheaply and freely available to the farmers near big cities without any legal obligation. However, sewage has often high values of temperature, pH, hardness, alkalinity, chemical oxygen demand, total soluble salts, nitrates, nitrites and cations like sodium (Na), potassium (K), calcium (Ca) and magnesium (Mg) (Ghafoor *et al.,* 1995). In addition to these, sewage also contains significant amounts of toxic metals such as arsenic (As), chromium (Cr), cadmium (Cd), copper (Cu), lead (Pb), nickel (Ni), zinc (Zn), cobalt (Co), magnesium (Mg) and iron (Fe) (Ali *et al.,* 1996) and after accumulating in soil, get transferred to vegetables grown on these soils (Malla *et al.,* 2007). The application of wastewater/ effluents to agricultural soils is a useful source of plant nutrients, particularly nitrogen (N) and phosphorous (P) and also organic matter that can potentially improve soil fertility and physical properties (Gibbs *et al.,* 2006). However, in addition to these beneficial effects, effluents often contain appreciable amounts of both organic and inorganic toxic materials. Many organic pollutants, being biodegradable, are less persistent, and presumably have transient and less serious effects as they are eventually metabolized to carbon dioxide and inorganic substances. Among the inorganic chemicals, heavy metals are often present in appreciable quantities, chelated by the organic matter in the effluents. When effluents are applied, the metals enter the soil and get fixed to the soil components. Thus continuous application of effluents tends to accumulate large quantities of heavy metals in soil, which persists there for an indefinite period of time to have long lasting effects in the soil environment. Some metals such as Zn, Cu, Ni, Cr and Co are physiologically essential for plants, animals and microorganisms, whereas others like cadmium (Cd) mercury (Hg) and lead (Pb) have no known biological and physiological functions. However, all these metals may be toxic at higher concentration and may pollute the natural and manmade ecosystems (McGrath *et al.,* 1995; Duffus, 2002).

Long term use of effluents for growing crops and vegetables, may result in the uptake of toxic metals by crop plants, with the chance of their access into the food chain. Physiological and metabolic processes in plants are inhibited because of higher concentrations of heavy metals in soil (Agarwal, 2002). Among heavy metals, Pb shows severe effects on seedling length, inhibits germination and reduces total chlorophyll production and gaseous exchange in leaves (Latif *et al.,* 2008). Similarly, toxic levels of Cr and Ni show strong effects on dry matter production and yield (EPA, 1990). Toxic level of Cd causes structural changes in chloroplast and thus reduces photosynthesis, availability of CO_2, total lipids, glycolipids and neutral lipids, interferes with membrane permeability and ultimately reduces respiration in leaves (Agarwal, 2002). However, metals and plants interact in specific ways depending upon the soil type, plant species, growing conditions and the types of ions (Athar and Masood, 2002). Heavy metals contamination of soil may reduce both crop yield and quality of crop produce when reaches to toxic levels. This problem of heavy metal toxicity may become more severe in future if these soils are fed continuously with untreated industrial effluent/wastes. Therefore, it is important to frame remedial strategies to reduce heavy metals toxicity in soil and for framing such strategies the information about the quantitative heavy metal loads and its relationship with various physico-chemical properties is needed.

Materials and Methods

A comprehensive survey was conducted in order to evaluate soils from different locations near the industrial belts of district Samba and Kathua for heavy metals contamination (Cd, Pb, Ni, Fe and Zn) from industrial/ domestic effluents irrigation. Samba (Map.1) town is situated at 32^0 33' 19.78" N latitude 75^0 06' 35.08" E longitude elevation 1184ft on range Shivalik hills alongside the national highway 1-A on the bank of river Basantar. Kathua district (Map 2) is situated at 320 17' to 320 55' North latitude and 750 70' to 760 16' East longitude. The study area was divided into the two major areas adjoining industrial belts of Samba and Kathua as per cropping system vis-a-vis locations specific; each with four sub locations in order to avoid biasness and to reduce sampling errors. Soil and plant samples were collected from the heavy metal contaminated sites of district Samba and Kathua. Soil samples were processed and passed through 2mm sieve and analyzed for mechanical properties (Piper,1966), pH and electrical conductivity (1:2.5 soil: water ratio), Organic carbon (Walkey and Black 1934), nitrogen (Subbiah and Asija, 1956), phosphorus (Jackson, 1973), Potassium (Jackson, 1973), exchangeable calcium and magnesium (Black, 1965). Simple coefficient of correlation 'r' was worked out between various soil properties and leaf nutrient content as per the standard procedures given by Gomez and Gomez (1984). All the data was analyzed and computed with the help of statistical tool SPSS 16.0 and DTPA-extractable heavy metals Pb, Cd, Cr, Ni, Zn, and Fe by (Soltanpour and Workman, 1979) Atomic absorption spectrophotometer Model-Z2300; Hitachi Japan. One gram oven dried plant samples were digested by Di acid method (Nitric acid and perchloric acid) and are analyzed for heavy metals Pb, Cd, Cr, Ni, Zn, and Fe on Atomic Absorption spectrophotometer.

Results and Discussion

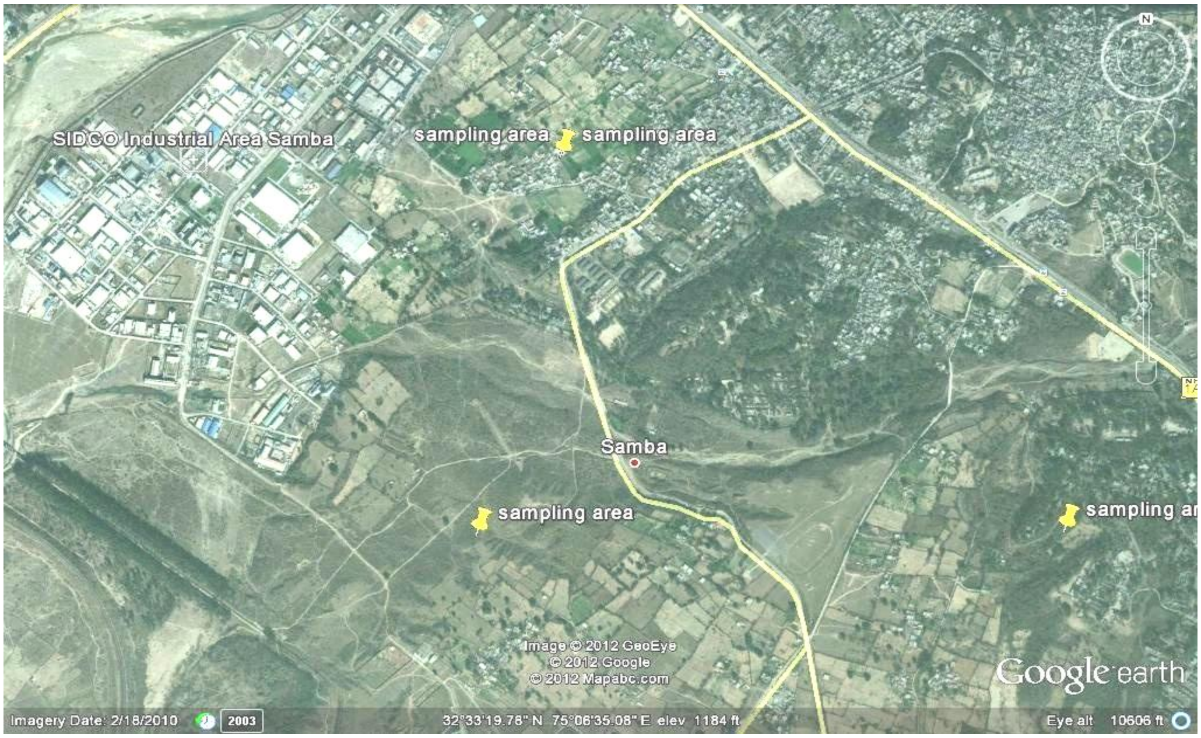
The soils of district Samba are slightly acidic to neutral with pH value ranged from 6.78-7.54 in maize-wheat production system and that of soils under rice-wheat, pasture system and vegetable production system had mean pH 7.03, 6.86 and 6.95 respectively (Table 1) While in Kathua district Maize-wheat production system had the highest mean pH (7.25) and that of rice-wheat, pasture system and vegetable production system had mean pH 6.93, 7.16 and 6.60 respectively (Table 2). The electrical conductivity (EC) showed variability with minimum mean value of 0.08 ds m^{-1} in pasture system and maximum value of 0.13 ds m^{-1} in rice wheat production system in soils of district Samba (Table 1) Electrical conductivity (EC) of soils of district Kathua showed wide range 0.07-0.15 ds m^{-1} in pasture system and range of 0.12-0.21 ds m^{-1} in maize-wheat production system. In rice-wheat production system highest value of EC (0.19 ds m^{-1}) was observed in Taraftujwal (RWS-3) soils and least (0.08 ds m^{-1}) was observed in Taraftujwal (RWS-1) soils (Table 2). Whereas cation exchange capacity (CEC) was lowest in maize-wheat production system and highest in pasture system with mean values 11.12 and 14.5 Cmol kg^{-1} of soil, respectively in soils of district Samba (Table 1). In soils of district Kathua cation exchange capacity (CEC) was highest in pasture system and least in rice-wheat system with mean value 15.46 and 13.32 Cmol kg^{-1} of soil, respectively (Table 2).

A comparison of the mean values for OC in district Samba showed that highest percentage was in the pasture system (0.46 %) followed by vegetable production system (0.42%), followed by rice-wheat production system (0.38%) whereas the least was in the maize-wheat production system (0.36%) (Table 1). While as organic carbon in soils of pasture system of district Kathua showed highest value of 0.47% and least was in the rice-wheat production system (0.35%) (Table 2). The soils of district Samba was sandy loam to sandy clay loam. Based on mean values, the highest clay percentage was found in pasture system with a value of 20.00 % (Table 1). Soils of district Kathua is clay loam to sandy loam. Based on mean values the highest clay percentage was found in rice-wheat production system with mean value of 32.67 % (Table 2).

The Iron (Fe) content in soils of district samba was in the range of 1.28 to 29.21, 1.70 to 26.76, 14.31 to 30.23 and 5.14 to 23.69 µg $g^{-1}$of soil in the surface soil of rice-wheat production system, maize-wheat production system, pasture system and vegetable production system, respectively (Table 3). In the soils of district Kathua iron (Fe) was present in range of 14.68 to 34.79, 0.64 to 19.06, 14.49 to 23.60 and 25.74 to 34.35 µg g^{-1} of soil in the soils of rice-wheat production system, maize-wheat production system, pasture system and vegetable production system, respectively (Table 4). Zinc (Zn) content in soils of district Samba showed the highest mean value in pasture system (1.85 µg $g^{-1}$of soil) followed by maize-wheat production system (0.80 µg $g^{-1}$of soil), rice-wheat production system (0.60 µg $g^{-1}$of soil) and Vegetable production system (0.51 µg $g^{-1}$of soil) (Table 3). In pasture system highest mean zinc (Zn) concentration was 2.14 µg $g^{-1}$of soil, followed by maize-wheat production system (1.06 µg g^{-1} of soil) rice-wheat production system (0.33 µg g^{-1} of soil) and lowest was observed in vegetable production system (0.27 µg $g^{-1}$of soil) (Table 4). Similar reports were reported by Jalali and Sharma (2001) in the soil of Jammu region.

The magnitude of deficiency was related to low organic matter content as well as high calcium carbonate ($CaCO_3$) and pH. The highest value of Lead was observed for rice-wheat production system (383.66 µg $g^{-1}$of soil) at location Kartholy RWS-1, followed by vegetable production system (300.85 µg $g^{-1}$of soil) at location Dhiansar (VS-4) and pasture system (0.659 µg $g^{-1}$of soil) (Table 3). While in the soils of district Kathua mean Lead (Pb) content was found to be maximum in vegetable production system 181.31 µg $g^{-1}$of soil followed by rice-wheat and maize-wheat production system(56.66 and 6.51 µg $g^{-1}$of soil, respectively). Pasture system soils had the lowest Pb content (4.57 µg $g^{-1}$of soil) (Table 4). The results are in line with the findings of Khalid *et al.,* (1990). Cadmium (Cd) was not detected in soils of district Samba but in soils of district Kathua it was observed in two production systems, viz. rice-wheat and vegetable production system varying between (0.78 to 5.11 and 0.0 to 3.8 µg g^{-1} respectively) (Table 4).

Map.1 Satellite image of sampling area (Samba)



Map.2 Satellite image of sampling area (Kathua)

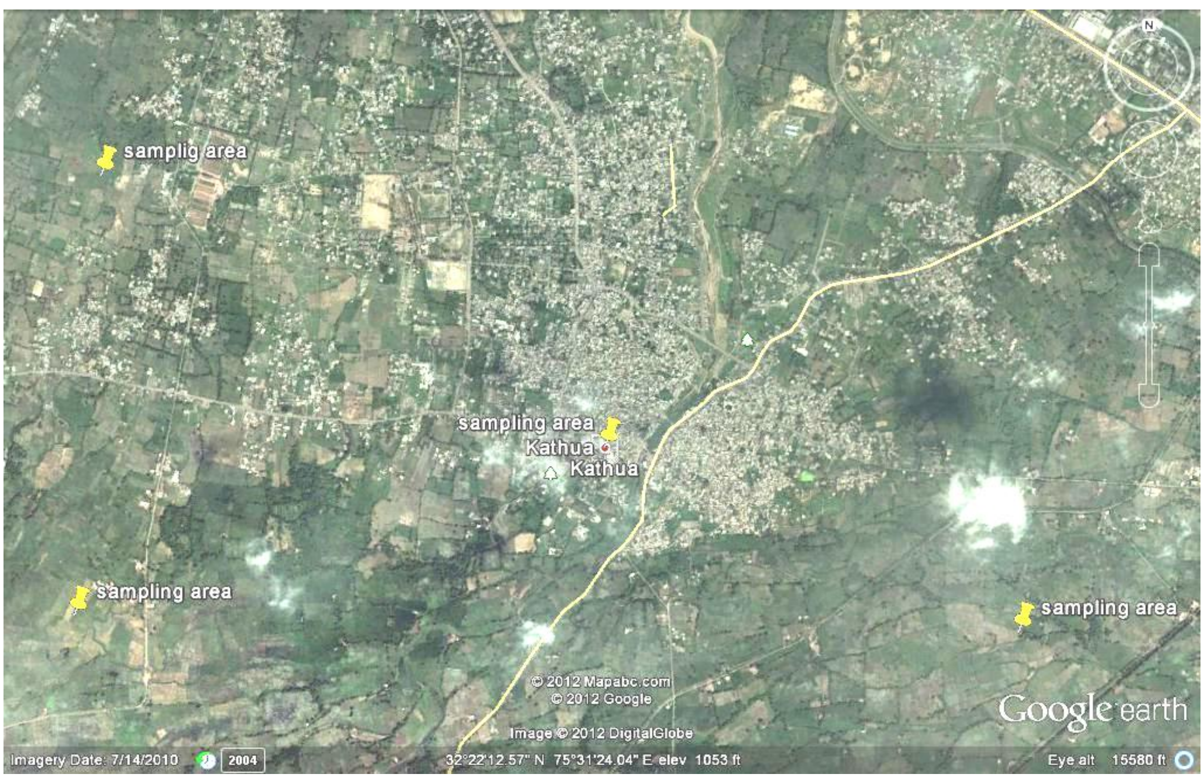


Table.1 Physico-chemical properties of soils under different production systems adjoining industrial areas in district Samba

Location	pH(1:2.5)	EC ds m^{-1}	OC %	CEC Cmol kg^{-1}	Sand %	Silt %	Clay %	Textural class
Rice-wheat production System (RWS)								
Dhiansar RWS-1	6.75	0.10	0.41	11.5	64	14	22	Sandy clay loam
Dhiansar RWS-2	6.68	0.09	0.43	9.72	20	62	18	Silt loam
Dhiansar RWS-3	6.72	0.12	0.39	10.11	68	14	18	Sandy loam
Dhiansar RWS-4	6.94	0.15	0.36	12.07	72	6	22	Sandy clay loam
Kartholy RWS-1	6.84	0.13	0.38	11.5	70	12	18	Sandy loam
Kothay RWS-1	6.85	0.15	0.33	12	50	26	24	Sandy clay loam
Channi RWS-1	7.24	0.13	0.36	14	66	14	20	Sandy loam/sandy clay loam
Tanda RWS-1	7.12	0.17	0.43	14	56	24	20	Sandy loam/sandy clay loam
Tanda RWS-2	7.37	0.14	0.41	9.55	64	22	14	Sandy loam
Tanda RWS-3	7.45	0.13	0.34	10.5	74	14	12	Sandy loam
Tanda RWS-4	7.40	0.17	0.41	10.74	56	26	18	Sandy loam
Range	**6.68-7.45**	**0.09-0.17**	**0.33-0.43**	**9.55-14**	**20.00-74.00**	**6.00-62.00**	**12.00-24.00**	
Mean	**7.03**	**0.13**	**0.38**	**11.48**	**58**	**23.23**	**18.61**	
Maize-wheat production System (MWS)								
Rakh Dhiansar MWS-1	6.84	0.08	0.32	12.5	64	16	20	Sandy loam/sandy clay loam
Tanda MWS-1	7.54	0.09	0.41	10	60	24	16	Sandy loam
Kothay MWS-1	6.78	0.20	0.36	13	54	24	22	Sandy loam/sandy clay loam
Tanda MWS-2	7.44	0.12	0.39	9.12	51	29	20	Sandy loam
Range	**6.78-7.54**	**0.08-0.20**	**0.32-0.41**	**9.12-13**	**51.00-64.00**	**16.00-29.00**	**16.00-22.00**	
Mean	**7.15**	**0.12**	**0.36**	**11.12**	**57.33**	**23**	**19.33**	
Pasture System (PS)								
Kothay PS-1	7.02	0.09	0.42	10.5	68	14	18	Sandy loam
Dhiansar PS-1	6.72	0.07	0.47	9.55	66	16	18	Sandy loam
Dhiansar PS-2	6.84	0.10	0.51	14.5	54	22	24	Sandy clay loam
Range	**6.72-7.02**	**0.07-0.10**	**0.42-0.51**	**9.55-14.5**	**54.00-68.00**	**14.00-22.00**	**18.00-24.00**	
Mean	**6.86**	**0.08**	**0.46**	**11.51**	**62.66**	**17.33**	**20.00**	
Vegetable production system (VS)								
Dhiansar VS-1	6.68	0.14	0.36	10.6	68	14	18	Sandy loam
Dhiansar VS-2	7.11	0.09	0.47	12.4	66	16	18	Sandy loam
Dhiansar VS-3	6.97	0.12	0.43	11.7	63	18	19	Sandy loam
Dhiansar VS-4	7.14	0.15	0.47	10.4	65	14	21	Sandy loam
Range	**6.68-7.14**	**0.09-0.15**	**0.36-0.47**	**10.4-12.4**	**63.00-68.00**	**14.00-18.00**	**18.00-21.00**	
Mean	**6.95**	**0.12**	**0.42**	**11.27**	**65.50**	**15.50**	**19.00**	

Table.2 Physico-chemical properties of soils under different production systems adjoining industrial areas in district Kathua

Location	pH (1:2.5)	EC ds m^{-1}	OC %	CEC Cmol kg^{-1}	Sand %	Silt %	Clay %	Textural class
Rice-wheat production System (RWS)								
Taraftujwal RWS-1	7.2	0.08	0.34	14.52	40	24	36	Loam
Taraftujwal RWS 2	6.81	0.09	0.28	14.75	36	28	36	clay loam
Taraftujwal RWS-3	6.91	0.19	0.41	13.15	42	28	30	clay loam
Taraftujwal RWS-4	6.71	0.16	0.33	12.99	36	28	36	clay loam
Bajwal RWS-1	7.15	0.14	0.39	10.40	52	18	30	loam/sandy loam
Bajwal RWS-2	6.77	0.18	0.39	15.18	44	28	28	clay loam
Range	**6.71-7.2**	**0.08-0.19**	**0.28-0.41**	**10.4-15.18**	**36.00-52.00**	**18.00-28.00**	**28.00-36.00**	
Mean	**6.93**	**0.13**	**0.35**	**13.32**	**41.67**	**25.67**	**32.67**	
Maize-wheat production System (MWS)								
Govindsar MWS-1	6.53	0.21	0.36	15.18	58	20	22	sandy loam/sandy clay loam
Govindsar MWS-2	6.69	0.12	0.46	17.09	56	20	24	sandy loam/sandy clay loam
Govindsar MWs-3	8.03	0.19	0.38	12.12	78	14	8	sandy loam
Govindsar MWS-4	7.74	0.16	0.37	10.37	62	16	22	sandy loam
Range	**6.53-8.03**	**0.12-0.21**	**0.36-0.46**	**10.37-17.09**	**56.00-78.00**	**14.00-20.00**	**8.00-24.00**	
Mean	**7.25**	**0.16**	**0.39**	**13.70**	**63.50**	**17.50**	**19.00**	
Pasture System (PS)								
Kathua PS-1	7.26	0.07	0.49	14.51	72	14	14	sandy loam
Kathua PS-2	7.06	0.15	0.43	15.68	50	18	32	Loam
Kathua PS-3	7.19	0.14	0.51	16.31	44	24	32	Loam
Range	**7.06-7.26**	**0.07-0.15**	**0.43-1.51**	**14.51-16.31**	**44.00-72.00**	**14.00-24.00**	**14.00-32.00**	
Mean	**7.16**	**0.11**	**0.47**	**15.46**	**55.33**	**18.67**	**26.00**	
Vegetable production system (VS)								
Bajwal VS-1	6.52	0.14	0.39	14.53	42	28	30	clay loam
Bajwal VS-2	6.47	0.16	0.43	15.20	38	30	32	clay loam
Bajwal VS-3	6.98	0.11	0.39	14.24	34	30	36	clay loam
Bajwal VS-4	6.35	0.10	0.49	12.23	46	30	24	sandy clay loam
Range	**6.35-6.98**	**0.1-0.16**	**0.39-0.49**	**12.23-15.2**	**34.00-46.00**	**28.00-30.00**	**24.00-36.00**	
Mean	**6.60**	**0.12**	**0.43**	**13.93**	**40.00**	**29.50**	**30.50**	

Table.3 Heavy metals concentration in soils under different production systems adjoining industrial areas in Samba

Location	Heavy metal concentration (µg g^{-1})					Hazardous heavy metal in soil, as per standards referred by European Union Standards, 2002 (EU); FAO standards, 2007 (FS); Awasthi, 2000 (AS)
	Fe	Zn	Cd	Pb	Ni	
Rice-wheat production System (RWS)						
Dhiansar RWS-1	20.46	0.39	ND	1.046	ND	-
Dhiansar RWS-2	25.83	0.76	ND	377.96	ND	Pb (EU)
Dhiansar RWS-3	8.30	0.84	ND	0.358	ND	-
Dhiansar RWS-4	29.21	1.00	ND	4.400	ND	-
Kartholy RWS-1	23.38	0.45	ND	383.66	ND	Pb (EU)
Kothay RWS-1	6.85	0.45	ND	2.12	ND	-
Channi RWS-1	12.01	2.24	ND	2.37	ND	-
Tanda RWS-1	8.28	0.12	ND	ND	ND	-
Tanda RWS-2	1.28	0.10	ND	ND	ND	-
Tanda RWS-3	3.03	0.10	ND	ND	ND	-
Tanda RWS-4	2.24	0.19	ND	ND	ND	-
Range	1.28-29.21	0.100-2.240	ND	0.0-383.66	ND	
Mean	12.806	0.60	ND	70.11	ND	
Maize-wheat production System (MWS)						
Rakh Dhiansar MWS-1	16.92	0.70	ND	ND	ND	-
Tanda MWS-1	13.62	0.34	ND	ND	ND	-
Kothay MWS-1	26.76	2.06	ND	ND	ND	-
Tanda MWS-2	1.70	0.11	ND	ND	ND	-
Range	1.70-26.76	0.11-2.06	ND	ND	ND	
Mean	14.75	0.80	ND	ND	ND	
Pasture System (PS)						
Kothay PS-1	30.23	2.70	ND	ND	ND	-
Dhiansar PS-1	26.98	0.82	ND	0.659	ND	-
Dhiansar PS-2	14.31	2.04	ND	0.358	ND	-
Range	14.31-30.23	0.82-2.70	ND	0.35-0.65	ND	
Mean	23.83	1.85	ND	0.33	ND	
Vegetable production system (VS)						
Dhiansar VS-1	14.40	0.36	ND	0.401	ND	-
Dhiansar VS-2	23.69	0.88	ND	0.745	ND	-
Dhiansar VS-3	5.14	0.37	ND	ND	ND	-
Dhiansar VS-4	12.73	0.43	ND	300.85	ND	Pb (EU)
Range	5.14-23.69	0.36-0.88	ND	0.401-300.85	ND	
Mean	13.99	0.51	ND	75.49	ND	

Permissible limits for soil (µg g^{-1}): Awashti (2000: Cd (3-6); Pb (250-500); Zn (300-600); Ni (75-150) European Union Standards (2002): Cd (3); Pb (300); Zn (300); Ni (75) FAO (2007): Not available; ND: Not detected Nickel (Ni) was not detected in soils of both areas i.e. (Samba and Kathua).

Table.4 Heavy metals concentration in soils under different production systems adjoining industrial area in district Kathua

Location	Heavy metal concentration (μg g^{-1})					Hazardous heavy metal in soil, as per standards referred by European Union Standards, 2002 (EU); FAO standards, 2007 (FS); Awasthi, 2000 (AS)
	Fe	Zn	Cd	Pb	Ni	
Rice-wheat production System (RWS)						
Taraftujwal RWS-1	30.65	0.41	0.780	23.150	ND	-
Taraftujwal RWS-2	33.99	0.45	5.118	1.562	ND	Cd (EU)
Taraftujwal RWS-3	24.14	0.20	ND	0.917	ND	-
Taraftujwal RWS-4	34.79	0.42	ND	0.000	ND	-
Bajwal RWS-1	14.68	0.24	ND	0.616	ND	-
Bajwal RWS-2	28.97	0.26	3.543	313.73	ND	Cd (EU), Pb (EU)
Range	14.68-34.79	0.2-0.45	0-5.11	0-313.73	ND	
Mean	27.87	0.33	1.54	56.66	ND	
Maize-wheat production System (MWS)						
Govindsar MWS-1	6.61	0.43	ND	0.100	ND	-
Govindsar MWS-2	10.23	0.29	ND	0.186	ND	-
Govindsar MWS-3	0.64	1.12	ND	24.480	ND	-
Govindsar MWS-4	19.06	2.40	ND	1.304	ND	-
Range	0.64-19.06	0.29-2.4	ND	0.1-24.48	ND	
Mean	9.135	1.06	ND	6.517	ND	
Pasture System (PS)						
Kathua PS-1	21.19	2.65	ND	2.121	ND	-
Kathua PS-2	14.49	2.43	ND	10.680	ND	-
Kathua PS-3	23.60	1.35	ND	0.917	ND	-
Range	14.49-23.60	1.35-2.65	ND	0.917-10.680	ND	
Mean	19.76	2.14	ND	4.57	ND	
Vegetable production system (VS)						
Bajwal VS-1	33.71	0.33	3.80	355.390	ND	Cd (EU), Pb (EU)
Bajwal VS-2	25.74	0.11	ND	0.659	ND	-
Bajwal VS-3	34.35	0.31	ND	ND	ND	-
Bajwal VS-4	34.27	0.32	ND	369.200	ND	Pb (EU)
Range	25.74-34.35	0.11-0.33	0.0-3.8	ND-369.2	ND	
Mean	32.01	0.27	ND	181.31	ND	

Permissible limits for soil (μg g^{-1}): Awashti (2000: Cd (3-6); Pb (250-500); Zn (300-600); Ni (75-150) European Union Standards (2002): Cd (3); Pb (300); Zn (300); Ni (75) FAO (2007): Not available; ND: Not detected Nickel (Ni) was not detected in soils of both areas i.e. (Samba and Kathua).

Table.5 Heavy metals concentration in plants under different production systems in district Samba

Location	Heavy metal concentration (µg g^{-1})					Hazardous heavy metal in plants, as per standards referred by European Union Standards, 2002 (EU); FAO standards, 2007 (FS); Awasthi, 2000 (AS)
	Fe	Zn	Cd	Pb	Ni	
Rice-wheat production System (RWS)						
Dhiansar RWS-1	4.9	0.01	ND	1.089	ND	Pb (FAO)
Kartholy RWS-1	3.4	0.21	ND	1.734	ND	Pb (FAO)
Range	3.4-4.9	0.01-0.21	ND	1.089-1.734	ND	
Mean	4.15	0.11	ND	1.412	ND	
Maize-wheat production System (MWS)						
Rakh Dhiansar MWS-1	2.9	0.22	ND	0.007	ND	-
Tanda MWS-1	5.4	0.02	ND	0.011	ND	-
Range	2.9-5.4	0.02-0.22	ND	0.007-0.011	ND	
Mean	4.15	0.12	ND	0.009	ND	
Pasture System (PS)						
Dhiansar PS-1	5.1	0.39	ND	0.710	ND	Pb (FAO)
Dhiansar PS-2	3.8	0.91	ND	0.190	ND	
Range	3.8-5.1	0.39-0.91	ND	0.190-0.710	ND	
Mean	4.45	0.65	ND	0.45	ND	
Vegetable production system (VS)						
Dhiansar VS-1	3.2	0.09	ND	0.358	ND	Pb (FAO)
Dhiansar VS-2	4.7	0.12	ND	0.487	ND	Pb (FAO)
Range	3.2-4.7	0.09-0.12	ND	0.358-0.487	ND	
Mean	3.95	0.10	ND	0.423	ND	

Permissible limits in plants (µg g^{-1}): Awashti (2000: Cd (1.5); Pb (2.5); Zn (50.0); Ni (1.5)
European Union Standards (2002): Cd (0.20); Pb (5.0); Zn (60.0); Ni (NA)
FAO (2007): Cd (0.20); Pb (0.30); Zn (NA); Ni (NA); ND: Not detected; NA: Not available

Table.6 Heavy metals concentration in plants under different production systems adjoining industrial areas in district Kathua

Location	Heavy metal concentration (µg g^{-1})					Hazardous heavy metal in plants, as per standards referred by European Union Standards, 2002 (EU); FAO standards, 2007 (FS); Awasthi, 2000 (AS)
	Fe	Zn	Cd	Pb	Ni	
Rice-wheat production System (RWS)						
Taraftujwal RWS-2	5.6	0.01	0.240	0.617	ND	Cd (EU, FAO), Pb (FAO)
Bajwal RWS-2	5.3	ND	0.216	0.358	ND	Cd (EU, FAO), Pb (FAO)
Range	5.3-5.6	ND-0.01	0.216-0.240	0.358-0.617	ND	
Mean	5.45	0.005	0.228	0.487	ND	
Maize-wheat production System (MWS)						
Govindsar MWS-1	0.76	0.007	ND	0.032	ND	-
Govindsar MWS-4	1.4	0.02	ND	0.264	ND	-
Range	0.76-1.4	0.007-0.02	ND	0.032-0.264	ND	
Mean	1.08	0.013	ND	0.148	ND	
Pasture System (PS)						
Kathua PS-1	4.4	0.11	ND	1.021	ND	Pb (FAO)
Kathua PS-2	3.1	0.09	ND	2.876	ND	Pb (AS, FAO)
Range	3.1-4.4	0.09-0.11	ND	1.021-2.876	ND	
Mean	3.75	0.1	ND	2.905	ND	
Vegetable production system (VS)						
Bajwal VS-1	5.8	0.014	1.200	4.185	ND	Cd (EU, FAO), Pb (AS, FAO)
Bajwal VS-3	4.52	0.006	ND	0.659	ND	Pb (FAO)
Range	4.52-5.8	0.006-0.014	0.0-1.200	0.659-4.185	ND	
Mean	5.16	0.01	0.600	2.422	ND	

Permissible limits in plants (µg g^{-1}): Awashti (2000: Cd (1.5); Pb (2.5); Zn (50.0); Ni (1.5)
European Union Standards (2002): Cd (0.20); Pb (5.0); Zn (60.0); Ni (NA)
FAO (2007): Cd (0.20); Pb (0.30); Zn (NA); Ni (NA); ND: Not detected; NA: Not available

Table.7 Pearson's correlation matrix among heavy metals in soil and plant samples of Samba District

		Soil			Plant		
		Fe	Zn	Pb	Fe	Zn	Pb
Soil	Fe	1					
	Zn	-0.129	1				
	Pb	0.330	-0.213	1			
Plant	Fe	0.285	-0.115	-0.325	1		
	Zn	-0.101	0.944**	-0.050	-0.210	1	
	Pb	0.636	-0.293	0.791*	-0.014	-0.173	1

**. Correlation is significant at the 0.01 level (2-tailed) *. Correlation is significant at the 0.05 level (2-tailed).

Table.8 Pearson's correlation matrix among heavy metals in soil and plant samples of Kathua District

		Soil				Plant			
		Fe	Zn	Cd	Pb	Fe	Zn	Cd	Pb
Soil	Fe	1							
	Zn	-0.473	1						
	Cd	0.660	-0.583	1					
	Pb	0.437	-0.466	0.592	1				
Plant	Fe	0.876**	-0.378	0.724*	0.547	1			
	Zn	-0.356	0.829*	-0.451	-0.343	-0.055	1		
	Cd	0.501	-0.421	0.624	0.790*	0.549	-0.275	1	
	Pb	0.213	0.062	0.208	0.487	0.390	0.280	0.740*	1

**. Correlation is significant at the 0.01 level (2-tailed) *. Correlation is significant at the 0.05 level (2-tailed)

Rattan *et al.,* (2005) reported that sewage effluents irrigated plants contained heavy metals below the critical level of phyto toxicity, probably due to the addition of organic carbon (OC) through wastewater in the soil that resulted in less metal accumulation in plant tissues.

Iron (Fe) content in plant samples collected from pasture system of the district Samba showed the highest mean value of 4.45 µg g^{-1} which was 6.74% more than that of maize-wheat production system. Patel *et al.,* (2004) also confirmed that different vegetable crops accumulate invariably high amounts of Fe irrespective of the type of effluents/water used for irrigation indicating the facts of variable uptake as a function of crop species, cultivars and selectivity of elements. Zinc (Zn) content in plant samples of district Samba showed the highest mean value in pasture system (0.65 µg g^{-1}) whereas plant samples from maize-wheat production system, rice-wheat production system and Vegetable production system showed a decrease of 83%, 84.6% in comparison to pasture system.

Zinc is readily available to plants over a fairly wide range of soil conditions. Lindsay (1979) reported required levels of Zn 34-340 ug g^{-1} and 28-39 ug m^{-1} for lettuce and carrot, respectively. Lead (Pb) concentration in plant samples of district Samba showed the highest mean value in rice-wheat system (1.41µg g^{-1}) followed by pasture system (0.45 µg g^{-1}), vegetable production system (0.42µg g^{-1}) and maize-wheat production system (0.009µg g^{-1}). Iron (Fe) content in plant samples from rice-wheat production system showed maximum value of 5.45 µg g^{-1} and least of 1.08 µg g^{-1} in maize-wheat production system (Table 5).

Plant samples from district Kathua, showed the highest Zn in pasture system (0.1 µg g^{-1}) followed by maize-wheat production system (0.013 µg g^{-1}), vegetable production system (0.01 µg g^{-1}) and rice-wheat production system (0.005 µg g^{-1}). Cadmium (Cd) was not detected in plant samples from district Samba but in plant samples of district Kathua it was found in two production systems, rice-wheat and vegetable production system with a mean value (0.22 and 0.6µg g^{-1} of plant). Lead (Pb) in plant samples showed the highest mean value in pasture system (2.9µg g^{-1}) followed by vegetable production system (2.42µg g^{-1}), rice-wheat production system (0.487 µg g^{-1}) and maize-wheat production system (0.148 µg g^{-1}) (Table 6). Due to poor mobility of lead (Pb) in plants it largely remains accumulated in plant roots (Alloway, 1995). Nickel (Ni) was not detected in both the areas of Samba and Kathua.

Coefficient of correlations were carried out to assess the heavy metal content in soil in relation to plants. Among all the metals zinc content in soils of District Samba showed a highly positive significant correlation with respective content in the plant (r= 0.944**) similar results were reported by (Rattan *et al.*, 2005 and Trisha *et al.*, 2013) and lead content in soil also showed a significantly positive correlation with their content in the plant samples.(Table 7). Iron content in soils of district possessed a positively highly significant relation with respective content in the plant(r= 0.876**) like that Lead content in the soil is significantly positive correlated (r= 0.829*) with their content in the plant (Table 8). DTPA-extractable Fe contents were not related to the Fe contents in any of the crops. Failure of DTPA extractant in some cases in the present study may be attributed lesser number of observations and variations in the management practices among the farmers of the study area. Even under controlled conditions, ability of extractants to predict plant available metals depends on the crop species, the metal and extractant used (Hooda *et al.*, 1997). Cd in the soil shows a positive but non-significant relation with Cd content in plants (Table 8). Ayoub, *et al.*, (2011) also reported a positive but non-significant correlation of Cd, Cr and Ni in plant tissues with their total content of these metals in the soils of Dinapur Uttar Pradesh. Accumulation of zinc in the plants is directly related to their content in the soil through absorptions taken place by the roots.

Among the heavy metals, lead (Pb) was found to be slightly higher than the permissible limits (as per European Union standards, 2002) in two locations (Dhiansar RWS-2 and Kartholy RWS-1) representing rice-wheat production system and one location (Dhiansar VS-4) representing vegetable production systems in samba district of Jammu and Kashmir. This can be attributed to the use of contaminated irrigation water from industries. The concentration of Pb was also detected in plant samples, though the concentration was not hazardous as per European Union Standards (EU) but as per Food and Agriculture Organization standards (FAO), 2007, the plant samples from rice-wheat and vegetable system were having Pb concentration more than the permissible limits and this again can be attributed to the effluent coming from the industries which includes paint industry, metal processing plants, Smelters etc. In district Kathua, Lead and Cadmium concentration, above the permissible limits (as per EU standards) was detected in soil, water and plant samples in a few locations representing rice-wheat and vegetable production systems. The content of Pb and Cd which are present may also be ascribed to the continuous application of phosphate fertilizer in these soils (Percival

2003, Han *et al.*, 2000, Assadian 2003, Adriano 2001).

Soils in both the districts were slightly acidic to neutral. The cation exchange capacity (CEC) was highest in maize wheat production system and least in pasture system in soils of district Samba, and whereas least was observed in rice wheat system in soils of Kathua. Higher organic carbon (OC) % was in the pasture system of district Kathua. The soils of district Samba was mostly sandy loam whereas soils of district Kathua were clay loam. Further monitoring methods are needed to characterize microbiological and biochemical soil properties to evaluate the intensity of the soil contamination in industrial belt of Jammu. They are more sensitive and their reaction to soil contamination is faster in comparison with the monitoring of the chemical and physical properties of soil which are manifested after a long time (months to years). Installation of treatment plants for making waste water suitable for irrigation to farmer fields. Astringent measures for installing safe waste disposal machinery for releasing liquid waste from the factories. Regular monitoring of water bodies and canals for different kind of contamination so that the concentration of heavy metals does not exceed the critical limits. Farming community of the areas like Tanda, Bajwal etc. should apply organics for improving microbial activity and reduction of metals toxicity in the soils. Soils irrigated with wastewater should be analyzed for heavy metals concentration. Crops produced from the areas should be monitored for its function for human and animal consumption.

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