Environment Conservation Journal, 21 (3): 155-164, 2020
ISSN 0972-3099 (Print) 2278-5124 (Online)
DOI: https://doi.org/10.36953/ECJ.2020.21319
https://www.environcj.in/

Assessment of the soil quality of Haridwar Uttarakhand India: A comparative study

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Received: 10.08.2020 **Revised: 01.11.2020** **Accepted: 23.11.2020**

Abstract

The present study aims to compare the quality of soil of different region of Haridwar with reference to physicochemical and heavy metal parameters. To fulfill the objectives of present study, soil sampling was performed in forest (control site), industrial, residential and agricultural areas in and around Haridwar. Soil samples were analyzed for different physicochemical and heavy metal parameters. Values of all the studied soil parameters were found highest (an increase of 32% in temperature (16.63 to 21.64^{0}C), 121% in soil moisture (13.05 to 28.39%), 29.02% in soil porosity (37.56 to 49.03%), and 19.6% in the water holding capacity (36.22 to 43.58%), 74.18% in conductivity (0.25 to 0.40 µMhos/cm), and 203.78% in chloride (16.67 to 53.97mg/gm)) at the industrial area in comparison to other sites. During the course of the study, an increasing trend in all the parameters at all the sites was observed this may be due to the dumping of industrial solid waste and effluent. Although no negative impact was observed on the soil quality but continuous dumping will results in harmful impacts due to the accumulation of pollutants. Therefore there is a need for safe and proper disposal and utilization techniques to manage the enormous quantity of industrial waste. All the heavy metals (such as copper (0.050 to 0.055mg/gm), manganese (0.232 to 0.242mg/gm), nickel (0.035 to 0.036mg/gm), lead (0.039mg/gm), and iron (1.19 to 1.22) were found in higher concentration during the study period while cadmium was found absent during the study period.

Key Words: ***Accumulation, Soil porosity, Threshold value, Water holding capacity***

Introduction

Soil is a thin veneer that covers most of the earth's surface. Different natural forces acting on natural material result in the formation of upper layer of the soil; it is classified into different horizons based on morphology, physical and chemical properties, composition, and biological characteristics (James *et al.,* 2014). In most cases, solid waste added to soil primarily affect chemical properties of soil such as pH and fertility and it depends on the loading rates of dumps. With the increasing population and industrial growth, the need for power has increased manifold (Raja *et al.,* 2015). For the last two decades, the rapid growth of industrialization and urbanization has created a negative impact on the environment which is due to industrial, municipal, and agricultural wastes having a large number of pesticides, insecticides, fertilizer residues, fly ash, heavy metals, etc. In the 21st century, practices such as agriculture, mining, logging, housing, solid waste dumping and wastewater discharge increased to such an extent that their impacts in forms of deteriorated air quality, soil quality, loss of biodiversity, and water quality can be seen (Bharti and Kamboj, 2018). pH of soil, concentration of organic matter, conductivity and valency of ions affects the accessibility of soil nutrients to plants (Jiang *et al.,* 2009). Physical, chemical and micro-biological properties along with interaction of microbial flora and fauna present in the soil affect the quality of soil (Papendick and Parr, 1992). Due to less availability of fresh water and deep water table, farmers show their increased interest in irrigation with partially treated or untreated wastewater, which is a threat to the soil quality (Bougnom *et al.,* 2020; Zhang and Shen, 2019). Irrigation with wastewater increased the amount of pollutants in

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slowly by the process of accumulation. These accumulated pollutants when transferred in the tissues of plants affects the plants and as well as crops and forest ecosystem to a large extent (Courault *et al.,* 2017; Kumar *et al.,* 2019; Sarwar *et al.,* 2019). Although irrigation with wastewater is a sustainable way but it needs utmost for the protection of soil quality. The Soil must be managed and protected carefully for the most beneficial use in the future therefore the present study is aimed to assess soil quality affected by the disposal of industrial waste in different areas of Haridwar. In the present study a comparison of soil of forest area, industrial area, residential area, and agricultural area was performed.

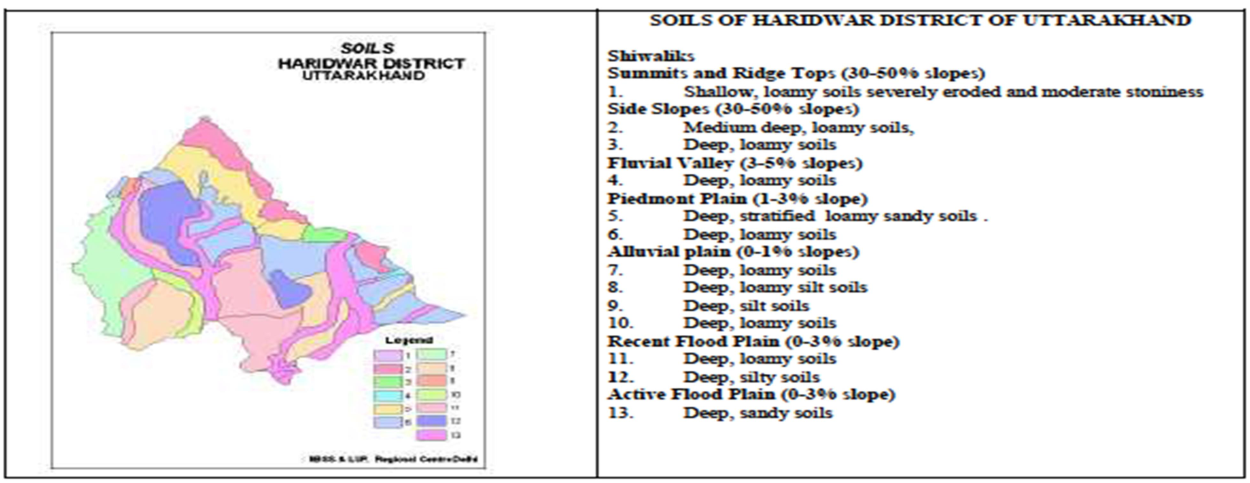
Materials and Methods

For the present study, soil samples were collected monthly from different sampling sites during January 2013 to December 2014 in morning hours. The samples were taken in polyethene from each location. The analysis of soil samples were performed following the standard methods of Singh *et al.* (1999) and Trivedi and Goel (1986). Soil profile of Haridwar region is given in figure 1 (http://agricoop.nic.in/sites/default/files/haridwar.pdf).

Soil sampling sites Industrial area Haridwar

a) **Forest areas (SS1) -** The sample were collected from the forest area of Haridwar. This site is considered as control site.
b) **Residential area (SS2) -** This site is the residential area of Haridwar. Sampling was performed at two points and then a composite sample was prepared.
c) **Industrial area (SS3) –** This site is situated near the SIDCUL area Haridwar. Sampling was performed at three points and then a composite sample was prepared.
d) **Agricultural field (SS4) -** This site is agricultural area located around Haridwar city. Sampling was performed at five points and then a composite sample was prepared.

Figure 1. Soil profile of Haridwar region (http://agricoop.nic.in/sites/default/files/haridwar.pdf)



Results and Discussion

The Physicochemical parameters of the soil of all the four sites are presented in the Table 1 to 8 for both the year (2013 and 2014) and the average values are given in table 9. During the whole study period, minimum average temperature was found 16.42^{o}C±1.79 for the first year in the soil of the Control site (SS1) while maximum average temperature was found 21.75^{o}C±0.74 for the second year in the soil of the Industrial area (SS3) and the average values of temperature was found 16.63^{o}C ±0.30, 18.93^{o}C ±0.11, 21.64^{o}C ±0.16, and 20.55^{o}C ±0.83 at SS1, SS2, SS3, and SS4 respectively. Temperature was found maximum at the industrial area site (21.64^{0}C±0.16) while minimum was found at the control site (16.63^{0}C±0.30). In literature no study was found regarding temperature change in the soil. During the whole study period, minimum average pH was found 7.53±0.45 for the first year

Table 1. Study of physicochemical parameters of Soil at Control site (Forest area) during 2013-2014

Month↓ Year →	Parameters													
	Temperature (ºC)		pH		Soil Moisture (%)		Porosity (%)		Water Holding Capacity (%)		Conductivity (µMhos/cm)		Chloride (mg/gm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Nov	14.3	14.8	7.2	7.3	11.26	11.07	37.8	38.5	35.7	35.6	0.208	0.277	15.12	15.27
Dec	14.2	13.9	7.3	7.7	11.02	10.87	38.5	39.6	35.6	34.3	0.176	0.218	15.07	14.97
Jan	13.7	13.2	7.1	6.9	12.02	11.35	39.6	37.5	34.5	36.6	0.218	0.247	14.90	15.54
Feb	14.0	13.8	6.9	7.0	12.72	12.07	37.5	34.9	36.6	37.2	0.231	0.234	15.41	16.87
Mar	17.0	17.7	7.2	7.3	13.00	12.89	34.9	36.4	37.2	37.4	0.234	0.254	16.86	17.01
Apr	17.1	18.5	7.1	7.7	14.25	13.74	36.4	34.7	36.2	34.7	0.254	0.258	17.01	17.46
May	18.0	18.7	7.6	8.3	14.84	14.26	34.7	35.6	36.7	38.9	0.247	0.270	17.45	18.08
Jun	18.2	18.5	8.1	8.2	14.99	14.77	35.6	36.2	38.9	36.8	0.270	0.256	18.09	18.17
Jul	18.2	18.6	8.0	8.1	14.86	14.54	36.2	34.7	36.8	37.8	0.256	0.274	17.58	17.54
Aug	17.5	18.9	8.1	8.0	13.74	13.96	34.7	36.4	37.8	34.8	0.274	0.278	16.97	17.72
Sep	17.5	17.7	7.9	7.8	12.86	13.12	36.4	37.1	36.5	39.0	0.278	0.281	16.80	17.14
Oct	17.3	17.8	7.9	7.6	12.15	12.74	37.1	37.8	39.4	34.7	0.281	0.208	16.41	16.63
Average ±SD	**16.42 ±1.79**	**16.84 ±2.22**	**7.53 ±0.45**	**7.66 ±0.46**	**13.14 ±1.39**	**12.95 ±1.36**	**36.62 ±1.55**	**38.5 ±1.52**	**36.83 ±1.37**	**35.6 ±1.704**	**0.244 ±0.032**	**0.255 ±0.024**	**16.47 ±1.09**	**16.87 ±1.08**

Table 2. Heavy metals analysis of Soil at Control site (Forest area) during 2013-2014

↓Month Year →	Parameters													
	Cu (mg/gm)		Cd (mg/gm)		Mn (mg/gm)		Ni (mg/gm)		Pb (mg/gm)		Cr^{+6} (mg/gm)		Fe (mg/gm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Nov	0.037	0.041	0.00	0.00	0.243	0.245	0.036	0.035	0.033	0.036	0.040	0.043	1.96	1.98
Dec	0.032	0.035	0.00	0.00	0.233	0.236	0.033	0.036	0.032	0.035	0.038	0.039	1.95	1.98
Jan	0.030	0.032	0.00	0.00	0.246	0.245	0.027	0.035	0.031	0.035	0.035	0.038	1.89	1.99
Feb	0.034	0.035	0.00	0.00	0.267	0.258	0.025	0.036	0.030	0.036	0.038	0.042	1.92	1.93
Mar	0.030	0.033	0.00	0.00	0.212	0.241	0.034	0.038	0.028	0.031	0.032	0.037	1.89	1.88
Apr	0.025	0.030	0.00	0.00	0.226	0.230	0.026	0.029	0.029	0.031	0.026	0.029	1.79	1.88
May	0.027	0.028	0.00	0.00	0.247	0.245	0.030	0.032	0.030	0.032	0.025	0.028	1.95	1.92
Jun	0.031	0.030	0.00	0.00	0.217	0.227	0.032	0.030	0.032	0.035	0.035	0.034	1.79	1.88
Jul	0.034	0.038	0.00	0.00	0.234	0.236	0.025	0.032	0.030	0.033	0.034	0.038	1.87	1.88
Aug	0.033	0.035	0.00	0.00	0.220	0.231	0.023	0.029	0.027	0.035	0.032	0.034	1.96	1.97
Sep	0.032	0.033	0.00	0.00	0.222	0.235	0.027	0.034	0.029	0.032	0.031	0.034	1.87	1.89
Oct	0.027	0.030	0.00	0.00	0.241	0.244	0.040	0.041	0.030	0.036	0.034	0.038	2.07	1.98
Average ±SD	**0.031 ±0.003**	**0.033 ±0.004**	**0.00 ±0.00**	**0.00 ±0.00**	**0.234 ±0.016**	**0.239 ±0.009**	**0.030 ±0.005**	**0.034 ±0.004**	**0.030 ±0.002**	**0.034 ±0.002**	**0.033 ±0.005**	**0.036 ±0.004**	**1.91 ±0.077**	**1.93 ±0.047**

Table 3. Study of physicochemical parameters of Soil at the residential area site during 2013-2014

Month↓ Year →	Parameters													
	Temperature (ºC)		pH		Soil Moisture (%)		Porosity (%)		Water Holding Capacity (%)		Conductivity (µMhos/cm)		Chloride (mg/gm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Nov	18.6	18.5	7.4	7.8	15.61	15.87	38.3	40.5	39.2	41.5	0.208	0.218	16.08	16.17
Dec	18.3	18.2	7.3	7.5	15.32	16.34	38.5	39.7	38.8	40.2	0.177	0.197	16.75	16.56
Jan	18.1	18.3	7.4	7.6	16.19	16.86	36.9	38.6	37.4	39.2	0.168	0.175	16.84	16.78
Feb	18.5	18.4	7.4	7.3	16.46	17.33	37.2	38.2	36.8	37.6	0.157	0.167	16.90	16.86
Mar	18.7	18.7	7.5	7.5	17.06	17.71	38.2	39.4	38.6	39.3	0.167	0.182	16.94	17.16
Apr	19.1	19.4	7.3	7.4	17.34	18.06	39.2	41.2	40.1	41.4	0.173	0.194	17.04	17.64
May	19.2	19.8	7.6	7.8	18.23	18.54	37.8	39.2	39.8	41.1	0.178	0.238	17.25	18.07
Jun	19.5	20.1	6.9	7.3	18.74	18.89	38.2	38.7	39.7	40.7	0.174	0.224	17.78	18.25
Jul	20.0	20.0	8.1	8.0	19.19	18.79	34.7	35.8	40.2	42.5	0.210	0.215	18.06	17.89
Aug	19.5	19.7	8.4	8.5	18.32	17.87	38.9	38.5	41.2	43.5	0.230	0.235	17.84	17.53
Sep	18.0	18.1	7.8	7.9	17.79	17.14	39.4	39.8	41.4	42.6	0.225	0.232	17.31	17.17
Oct	18.7	18.3	8.1	8.4	16.45	16.72	37.4	39.6	40.4	41.3	0.236	0.230	16.85	16.91
Average ±SD	**18.85 ±0.62**	**19.0 ±0.78**	**7.56 ±0.419**	**7.75 ±0.39**	**17.83 ±1.25**	**17.49 ±1.01**	**37.89 ±1.266**	**39.10 ±1.35**	**39.47 ±1.394**	**40.91 ±1.65**	**0.192 ±0.028**	**0.209 ±0.025**	**17.14 ±0.55**	**17.25 ±0.64**

Table 4. Heavy metals analysis of Soil of at the residential area site during 2013-2014

Month↓ Year →	Parameters													
	Cu (mg/gm)		Cd (mg/gm)		Mn (mg/gm)		Ni (mg/gm)		Pb (mg/gm)		Cr^{+6} (mg/gm)		Fe (mg/gm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Nov	0.050	0.057	0.00	0.00	0.245	0.231	0.038	0.044	0.037	0.039	0.057	0.051	0.980	0.920
Dec	0.045	0.051	0.00	0.00	0.243	0.234	0.027	0.036	0.035	0.041	0.053	0.046	1.032	0.997
Jan	0.040	0.048	0.00	0.00	0.231	0.225	0.036	0.032	0.028	0.032	0.051	0.044	1.075	0.984
Feb	0.038	0.036	0.00	0.00	0.218	0.219	0.026	0.031	0.034	0.037	0.056	0.051	0.965	0.875
Mar	0.051	0.054	0.00	0.00	0.256	0.239	0.028	0.032	0.027	0.033	0.052	0.043	0.992	0.911
Apr	0.035	0.048	0.00	0.00	0.254	0.241	0.037	0.042	0.028	0.029	0.048	0.039	0.985	0.889
May	0.054	0.049	0.00	0.00	0.234	0.242	0.032	0.038	0.034	0.041	0.043	0.036	0.993	0.911
Jun	0.037	0.047	0.00	0.00	0.241	0.251	0.038	0.039	0.032	0.039	0.049	0.047	0.997	0.924
Jul	0.038	0.041	0.00	0.00	0.234	0.236	0.035	0.031	0.037	0.045	0.042	0.038	1.087	1.002
Aug	0.047	0.055	0.00	0.00	0.265	0.253	0.029	0.037	0.031	0.042	0.048	0.044	0.967	0.907
Sep	0.045	0.051	0.00	0.00	0.251	0.245	0.034	0.039	0.029	0.034	0.052	0.046	0.939	0.912
Oct	0.037	0.043	0.00	0.00	0.265	0.250	0.032	0.037	0.035	0.043	0.054	0.048	1.073	0.995
Average ±SD	**0.043 ±0.006**	**0.048 ±0.006**	**0.00 ±0.00**	**0.00 ±0.00**	**0.245 ±0.014**	**0.239 ±0.010**	**0.033 ±0.004**	**0.037 ±0.005**	**0.032 ±0.004**	**0.038 ±0.005**	**0.050 ±0.005**	**0.044 ±0.005**	**1.007 ±0.048**	**0.936 ±0.046**

in the soil of the Control site (SS1) while maximum average pH was found 8.14±0.24 for the second year in the soil of the Industrial area (SS3) and the average values of pH was found 7.60±0.09, 7.66±0.13, 8.04±0.15, and 7.86±0.11 at SS1, SS2, SS3, and SS4 respectively. pH was found maximum at the industrial area site (8.04±0.15) while minimum was found at the control site (7.60±0.09). pH was found higher than the available literature (Shah, 2014; Kumar *et al.,* 2020). A high range of pH was observed by Shah (2014) and Bharti and Kamboj (2018). During the whole study period, minimum average moisture was found 12.95%±1.36 for the second year in the soil of the Control site (SS1) while maximum average moisture was found 28.63%±1.10 for the second year in the soil of the Industrial area (SS3) and the average values of moisture was found 13.05±0.13, 17.66±0.24, 28.39±0.35, and 23.88±0.61 at SS1, SS2, SS3, and SS4 respectively. Bharti and Kamboj (2018) studied the soil moisture in 2018 and found less soil moisture. High moisture in the industrial area may be due to the covering of the ground surface and addition of solid waste which increase the moisture due to leachate.

During the whole study period, minimum average porosity was found 36.62%±1.55 for the first year in the soil of the Control site (SS1) while maximum average porosity was found 50.32%±1.30 for the first year in the soil of the Agricultural area (SS4) and the average values of porosity was found 37.56±1.33, 38.50±0.86, 48.32±0.83, and 49.03±1.83 at SS1, SS2, SS3, and SS4 respectively. Soil porosity was found maximum at the agricultural site (50.32%±1.30) while minimum was found at the control site (36.62%±1.55). In literature no study was found regarding porosity change in the soil. High porosity at agricultural site is the indicator of good soil heath at that site during the study period. During the whole study period, minimum average water holding capacity was found 35.60%±1.70 for the second year in the soil of the Control site (SS1) while maximum average water holding capacity was found 44.57%±1.13 for the second year in the soil of the Industrial area (SS3) and the average values of water holding capacity was found 36.22±0.87, 40.19±1.02, 43.58±1.41, and 41.74±1.20 at SS1, SS2, SS3, and SS4 respectively. Water holding capacity (WHC) was found maximum at the industrial area site (43.58±1.41) while minimum was found at the control site (36.22±0.87). Negligible variation was found from results obtained by Bharti and Kamboj (2018).

During the whole study period, minimum average conductivity was found 0.192µMhos/cm±0.028 for the first year in the soil of the Residential area (SS2) while maximum average conductivity was found 0.425µMhos/cm±0.063 for the second year in the soil of the Industrial area (SS3) and the average values of conductivity was found 0.25±0.01, 0.20±0.01, 0.40±0.03, and 0.37±0.00 at SS1, SS2, SS3, and SS4 respectively. Electrical Conductivity (EC) was found maximum at the industrial area site (0.40±0.03) while minimum was found at the control site (0.20±0.01). Soil contamination reduces the conductivity of the soil may be due to binding of ions with pollutant. In all the recent literature a high conductivity was observed. During the whole study period, minimum average chloride was found 16.47mg/gm±1.09 for the first year in the soil of the Control site (SS1) while maximum average chloride was found 54.48mg/gm±1.19 for the second year in the soil of the Industrial area (SS3) and the average values of chloride was found 16.67±0.28, 17.20±0.08, 53.97±0.73, and 20.94±3.17 at SS1, SS2, SS3, and SS4 respectively. Chloride was found maximum at the industrial area site (53.97±0.73) while minimum was found at the control site (16.67±0.28). In literature no study was found regarding chloride change in the soil. Chlorides in the soil increase the salinity of the soil which results in the decreased fertility of the soil. During the whole study period, minimum average copper was found 0.031mg/gm±0.003 for the first year in the soil of the Control site (SS1) while maximum average copper was found 0.077mg/gm±1.19 for the second year in the soil of the Industrial area (SS3) and the average values of copper was found 0.03±0.00, 0.05±0.00, 0.07±0.00, and 0.06±0.00 at SS1, SS2, SS3, and SS4 respectively. Copper (Cu) was found maximum at the industrial area site (0.07±0.00) while minimum was found at the control site (0.03±0.00) with an average value of 50.0mg/Kg. Copper was found in higher concentration during the study as compared to recent literature due to the impact of industrial discharge (Kumar *et al.,* 2020; Shah, 2014; Kumar and Chopra, 2015).

Table 5. Study of physicochemical parameters of Soil at industrial area site during 2013-2014

Month↓ Year →	Temperature (ºC)		pH		Soil Moisture (%)		Porosity (%)		Water Holding Capacity (%)		Conductivity (μMhos/cm)		Chloride (mg/gm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Nov	21.0	21.1	7.8	7.8	26.12	26.56	47.5	49.2	42.5	44.6	0.354	0.371	52.90	52.81
Dec	20.7	21.5	7.9	8.3	27.41	27.23	48.9	49.4	41.3	43.2	0.336	0.348	52.56	52.78
Jan	21.5	21.4	7.6	8.1	27.62	27.94	45.4	47.3	41.3	44.1	0.346	0.351	52.14	53.35
Feb	20.9	20.7	8.1	8.4	27.74	28.17	46.4	48.2	42.1	45.2	0.314	0.373	52.67	54.02
Mar	21.5	21.4	7.5	7.9	28.03	28.94	48.3	49.5	41.7	42.6	0.348	0.379	52.36	54.62
Apr	21.9	22.0	7.9	8.1	29.11	29.57	49.2	49.0	42.4	44.7	0.351	0.384	53.04	55.13
May	22.2	22.5	7.8	7.8	29.42	29.91	47.4	48.7	42.1	43.8	0.403	0.498	53.89	55.86
Jun	22.5	23.6	7.8	7.9	29.91	30.12	47.6	49.2	41.6	43.7	0.362	0.514	54.46	56.55
Jul	21.9	22.0	8.4	8.5	28.84	29.71	47.7	48.5	43.4	46.2	0.435	0.471	54.88	55.68
Aug	21.9	21.6	8.2	8.4	28.43	28.96	48.6	49.2	44.4	45.1	0.516	0.484	54.64	54.71
Sep	21.4	21.4	8.0	8.2	27.86	28.37	46.4	48.2	43.6	46.2	0.414	0.478	54.18	54.41
Oct	21.0	21.8	8.1	8.3	27.16	28.08	49.4	50.4	44.6	45.5	0.416	0.451	53.71	53.89
Average ±SD	**21.53 ±0.56**	**21.75 ±0.74**	**7.93 ±0.25**	**8.14 ±0.24**	**28.14 ±1.06**	**28.63 ±1.10**	**47.73 ±1.23**	**48.90 ±0.79**	**42.58 ±1.15**	**44.57 ±1.13**	**0.383 ±0.056**	**0.425 ±0.063**	**53.45 ±0.96**	**54.48 ±1.19**

Table 6. Heavy metals analysis of Soil at industrial area site during 2013-2014

Month↓ Year →	Cu (mg/gm)		Cd(mg/gm)		Mn (mg/gm)		Ni (mg/gm)		Pb (mg/gm)		Cr^{+6} (mg/gm)		Fe (mg/gm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Nov	0.070	0.080	0.00	0.00	0.245	0.256	0.056	0.047	0.064	0.054	0.076	0.081	1.056	1.060
Dec	0.073	0.083	0.00	0.00	0.242	0.240	0.057	0.045	0.045	0.046	0.070	0.076	1.037	1.045
Jan	0.068	0.078	0.00	0.00	0.234	0.248	0.043	0.038	0.043	0.049	0.079	0.078	1.086	1.083
Feb	0.070	0.075	0.01	0.00	0.242	0.242	0.039	0.032	0.055	0.051	0.080	0.086	0.998	0.984
Mar	0.063	0.068	0.00	0.00	0.234	0.252	0.047	0.041	0.052	0.052	0.082	0.081	0.996	0.995
Apr	0.072	0.082	0.00	0.00	0.245	0.278	0.049	0.042	0.049	0.049	0.081	0.083	1.067	1.074
May	0.071	0.074	0.01	0.00	0.230	0.267	0.045	0.044	0.053	0.053	0.078	0.075	1.038	1.073
Jun	0.071	0.081	0.00	0.00	0.252	0.256	0.048	0.045	0.045	0.047	0.076	0.082	0.975	0.983
Jul	0.073	0.076	0.00	0.00	0.238	0.238	0.040	0.042	0.047	0.039	0.070	0.074	1.138	1.173
Aug	0.075	0.078	0.00	0.00	0.233	0.265	0.042	0.046	0.042	0.041	0.071	0.075	1.067	1.098
Sep	0.072	0.080	0.00	0.00	0.245	0.257	0.052	0.042	0.041	0.043	0.081	0.089	1.189	1.167
Oct	0.070	0.074	0.00	0.00	0.240	0.249	0.043	0.045	0.042	0.040	0.078	0.076	1.084	1.082
Average ±SD	**0.071 ±0.003**	**0.077 ±0.004**	**0.002 ±0.004**	**0.00 ±0.00**	**0.240 ±0.006**	**0.254 ±0.012**	**0.047 ±0.006**	**0.042 ±0.004**	**0.048 ±0.007**	**0.047 ±0.005**	**0.077 ±0.004**	**0.080 ±0.005**	**1.060 ±0.061**	**1.068 ±0.062**

Table 7. Study of physicochemical parameters of Soil at Agricultural area site during 2013-2014

Month↓ Year →	Parameters													
	Temperature (ºC)		pH		Soil Moisture (%)		Porosity (%)		Water Holding Capacity (%)		Conductivity (µMhos/cm)		Chloride (mg/gm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Nov	19.2	21.0	7.9	7.8	23.01	24.21	49.5	47.5	42.5	41.2	0.343	0.344	20.17	22.90
Dec	18.9	19.8	7.8	7.9	22.98	23.86	50.9	48.9	40.4	39.4	0.332	0.325	20.98	22.96
Jan	18.6	19.6	7.5	7.6	22.81	23.63	48.4	45.4	41.3	38.6	0.334	0.334	21.56	23.47
Feb	19.0	20.1	8.0	8.1	23.52	24.48	49.4	46.4	42.1	39.1	0.304	0.302	21.90	23.88
Mar	19.2	20.3	7.4	7.5	23.69	24.72	52.3	48.3	41.7	41.1	0.312	0.332	19.11	22.36
Apr	19.2	20.6	7.3	7.9	23.84	24.91	51.2	49.2	42.4	41.5	0.332	0.334	19.54	22.67
May	20.5	21.6	7.6	7.8	23.96	25.16	49.4	47.4	42.1	39.8	0.378	0.387	19.80	22.91
Jun	21.7	22.8	7.5	7.8	24.15	25.39	49.6	47.6	41.6	41.8	0.356	0.356	20.07	23.16
Jul	21.4	22.5	8.2	8.4	24.06	24.61	49.7	47.7	43.4	40.7	0.429	0.428	20.62	23.76
Aug	21.0	22.1	8.0	8.2	23.69	24.34	51.6	48.6	44.4	42.6	0.498	0.502	20.97	23.87
Sep	20.7	21.6	8.2	8.0	23.15	23.36	49.4	46.4	43.6	43.4	0.400	0.402	20.41	23.56
Oct	20.1	21.2	8.0	8.1	22.55	23.04	52.4	49.4	45.3	41.5	0.389	0.400	19.84	22.61
Average ±SD	**19.96 ±1.07**	**21.14 ±1.05**	**7.78 ±0.31**	**7.93 ±0.25**	**23.45 ±0.53**	**24.31 ±0.72**	**50.32 ±1.30**	**47.73 ±1.23**	**42.58 ±1.15**	**40.89 ±1.44**	**0.367 ±0.053**	**0.371 ±0.056**	**18.70 ±0.87**	**23.18 ±0.52**

Table 8. Heavy metals analysis of Soil at the Agricultural area site during 2013-2014.

Month↓ Year →	Parameters													
	Cu (mg/gm)		Cd (mg/gm)		Mn (mg/gm)		Ni (mg/gm)		Pb (mg/gm)		Cr^{+6} (mg/gm)		Fe (mg/gm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Nov	0.055	0.065	0.00	0.00	0.201	0.244	0.048	0.036	0.061	0.034	0.071	0.065	0.856	0.960
Dec	0.069	0.064	0.00	0.00	0.212	0.234	0.038	0.035	0.040	0.037	0.067	0.066	0.736	0.945
Jan	0.060	0.068	0.01	0.00	0.202	0.233	0.029	0.028	0.042	0.038	0.068	0.058	0.787	0.883
Feb	0.049	0.056	0.00	0.00	0.212	0.226	0.020	0.023	0.051	0.043	0.067	0.074	0.897	0.884
Mar	0.044	0.054	0.00	0.00	0.219	0.226	0.031	0.031	0.048	0.041	0.065	0.068	0.796	0.895
Apr	0.059	0.076	0.00	0.00	0.216	0.237	0.028	0.032	0.043	0.040	0.066	0.069	0.867	0.874
May	0.049	0.066	0.00	0.00	0.229	0.256	0.023	0.034	0.050	0.042	0.056	0.065	0.838	0.973
Jun	0.060	0.076	0.00	0.00	0.224	0.243	0.027	0.035	0.042	0.041	0.065	0.075	0.675	0.783
Jul	0.045	0.056	0.00	0.00	0.217	0.227	0.038	0.032	0.041	0.023	0.045	0.064	0.738	0.973
Aug	0.054	0.048	0.00	0.00	0.203	0.222	0.033	0.036	0.038	0.034	0.034	0.062	0.567	0.998
Sep	0.067	0.061	0.00	0.00	0.198	0.243	0.025	0.032	0.040	0.032	0.056	0.079	0.689	1.067
Oct	0.044	0.056	0.00	0.00	0.189	0.225	0.021	0.035	0.032	0.031	0.056	0.064	0.884	0.882
Average ±SD	**0.055 ±0.009**	**0.062 ±0.008**	**0.00 ±0.002**	**0.00 ±0.00**	**0.210 ±0.01**	**0.235 ±0.01**	**0.030 ±0.008**	**0.032 ±0.004**	**0.044 ±0.008**	**0.036 ±0.004**	**0.059 ±0.011**	**0.067 ±0.006**	**0.778 ±0.099**	**0.926 ±0.074**

During the whole study period, minimum average cadmium was found 0.00 mg/gm±0.00 for the second year in the soil of all the sites while maximum average cadmium was found 0.01 mg/gm±0.00 for the first year in the soil of the SS3 and SS4 and the average values of cadmium was found 0.00±0.00 at SS1, SS2, SS3, and SS4 respectively. During the whole study period, minimum average manganese was found 0.210mg/gm±0.01 for the first year in the soil of the Agricultural area (SS4) while maximum average manganese was found 0.254mg/gm±0.012 for the second year in the soil of the Industrial area (SS3) and the average values of manganese was found 0.24±0.00, 0.24±0.00, 0.25±0.01, and 0.22±0.02 at SS1, SS2, SS3, and SS4 respectively. Manganese (Mn) was found maximum at the industrial area site (0.25±0.01) while minimum was found at the control site (0.22±0.02). Mn value was also found in higher concentration during the study period form all the recent observed literature clearly showing the impact of industrial solid and liquid waste dumping.

Nickel is an essential micronutrient for thwe growth of plants. Nickel absorption takes place through active and passive diffiusion and endocytosis (Ahmad and Ashraf, 2011). During the whole study period, minimum average nickel was found 0.030mg/gm±0.005 for the first year in the soil of the Control site (SS1) and Agricultural area (SS4) while maximum average nickel was found 0.047mg/gm±0.006 for the first year in the soil of the Industrial area (SS3) and the average values of nickel was found 0.03±0.00, 0.04±0.00, 0.04±0.00, and 0.03±0.00 at SS1, SS2, SS3, and SS4 respectively. Nickel was present in less quantity as at the study no source of nicekl was observed in the study area. Maxiumu quantity of the nickel was found at Agricultural area (SS4) which is a bad indicator for the agicultural production as the excess quantity of nickel affects the absorption of nutrientrs by plants (Ahmad and Ashraf, 2011). During the whole study period, minimum average lead was found 0.030mg/gm±0.002 for the first year in the soil of the Control site (SS1) while maximum average lead was found 0.048mg/gm±0.007 for the first year in the soil of the Industrial area (SS3) and the average values of lead was found 0.03±0.00, 0.04±0.00, 0.05±0.00, and 0.04±0.01 at SS1, SS2, SS3, and SS4 respectively. Toxicity of chromium depends on its oxidation states. Cr^{+6} is more dangerous and mobile than Cr^{+3}. During the whole study period, minimum average chromium was found 0.033mg/gm±0.005 for the first year in the soil of the Control site (SS1) while maximum average chromium was found 0.080mg/gm±0.005 for the second year in the soil of the Industrial area (SS3) and the average values of chromium was found 0.03±0.00, 0.05±0.00, 0.08±0.00, and 0.06±0.01 at SS1, SS2, SS3, and SS4 respectively. Maximum values of Cr was found in industrial area may be due to dumping of industrial area waste in the soil (Oliveira, 2012). Toxicity of Cr may be reduced with the help of oxidation with iron, vanadium, sulphydes, and organic materials (Cary, 1982).

During the whole study period, minimum average iron was found 00.778mg/gm±0.99 for the first year in the soil of the Agricultural area site (SS4) while maximum average iron was found 1.931mg/gm±0.47 for the second year in the soil of the Residential area (SS2) and the average values of iron was found 1.92±0.01, 0.97±0.05, 1.06±0.01, and 0.85±0.10 at SS1, SS2, SS3, and SS4 respectively. Iron (Fe) was observed in less concentration during the study period as compared to the results obtained by Kumar *et al.* (2020) and Shah (2014) while higher concentration was observed as compared to the results obtained by Kumar and Chopra (2015). Minimum concentration at agricultural area may be due to utilisation of iron by the crops as it is essential component of plant growth and required for the functioning of various enzymes.

Conclusion

The physicochemical properties of the soil studied were observed affected may be due to different anthropogenic activities. During the course of study an increasing trend in all the parameters was observed. Although all the parameters studied during the study were found within the prescribed limit but the day to day increase in the anthropogenic activities is a threat to the health of soil. When the results were compared with the results obtained in recent literature, most of the parameters were found in higher concentration but a reduction in all the parameters was observed. In agricultural fields an increasing trend of heavy

Table 9. Showing the comparison of results obtained at different locations

Parameters/ Study site	Control site (Forest area)	Industrial area site	Residential area site	Agricultural area site	AVG (in mg/gm)
Temperature (ºC)	16.63±0.30	18.93±0.11	21.64±0.16	20.55±0.83	19.43
pH	7.60±0.09	7.66±0.13	8.04±0.15	7.86±0.11	7.79
Soil Moisture (%)	13.05±0.13	17.66±0.24	28.39±0.35	23.88±0.61	20.67
Porosity (%)	37.56±1.33	38.50±0.86	48.32±0.83	49.03±1.83	42.81
Water Holding Capacity (%)	36.22±0.87	40.19±1.02	43.58±1.41	41.74±1.20	38.42
Conductivity (μMhos/cm)	0.25±0.01	0.20±0.01	0.40±0.03	0.37±0.00	0.31
Chloride (mg/gm)	16.67±0.28	17.20±0.08	53.97±0.73	20.94±3.17	27.41
Cu (mg/gm)	0.03±0.00	0.05±0.00	0.07±0.00	0.06±0.00	0.05
Cd (mg/gm)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
Mn (mg/gm)	0.24±0.00	0.24±0.00	0.25±0.01	0.22±0.02	0.24
Ni (mg/gm)	0.03±0.00	0.04±0.00	0.04±0.00	0.03±0.00	0.04
Pb (mg/gm)	0.03±0.00	0.04±0.00	0.05±0.00	0.04±0.01	0.04
Cr (mg/gm)	0.03±0.00	0.05±0.00	0.08±0.00	0.06±0.01	0.06
Fe (mg/gm)	1.92±0.01	0.97±0.05	1.06±0.01	0.85±0.10	1.21

metals was observed in recent literature showing a threat to agricultural ecosystem. Therefore continuous monitoring of agricultural land around dumping sites is also required to safeguard the health of people as the translocation of all these pollutants in vegetables can affect the heath of peoples. There is need to increase the awareness among the farmers to make them aware about the use of required quantity of irrigation form the wastewater in the fields.

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