Impact of Industrial Effluent collected from Doaba region on elemental content of soil and its accumulation in crops

NAVDEEP SIDHU*[1] SK MUNSHI[2]
1 Research Scholar, IK Gujral Punjab Technical University, Kapurthala, Jalandhar
2 Department of Biotechnology, PCTE, Baddowal, Ludhiana

ABSTRACT

A study was conducted to analyse the effect of industrial effluent on agricultural soil present near the drains in Doaba region of Punjab. A total of twelve samples of soil and crops were collected from different areas and the physical as well as elemental content in both were estimated .Many collected samples showed a variation in values of physical parameters in case of soil. The results also indicated accumulation of heavy metals in the soil and parts of the crops especially in form of As, Pb, Cd and Ni. The presence of these heavy metals in soil and crops lead to disturbance of ecosystem and health risks.

Keywords: Effluent, heavy metals, soil, crops

1. INTRODUCTION

Industrialization, urbanization and agricultural activities in Punjab (Saxena et al., 2007) have led to a considerable increase in the level of heavy metal in different environmental compartments, especially in soil and crops over the course of recent decades.
Lack of proper environmental planning has lead to discharge of industrial effluents and sewage into natural water bodies. Industrial effluent is considered to be rich in heavy metals and a large amount of other toxic elements. Kabata & Pendias (2001) reported that waste disposal activities are one of most considerable and important source of heavy metal pollution in the environment. Shortage of water has forced farmers to opt for using other sources specifically sewage or waste water for irrigation purposes thereby leading to toxic metal accumulation and contamination in the soils. Health risks as well as food safety issues are one of the major environment concerns presently (Cui et al 2004). Plants are known to have inherent tendency to accumulate heavy metals and toxic elements from the surrounding environment i.e. soil and water used for irrigation (Karatas *et al*. 2006). Leather industry, Tannery, electroplating industry, Food processing, Dairy, auto spare parts, Textile and sports goods industry effluents are a major cause of environmental pollution in Punjab. In Jalandhar and surrounding areas also such types of industries are prevalent and discharge a large volume of effluent daily into drains present in areas namely Kala Sanghian, Jamsher Khas, Basti Bawa Khel, Hamira, Mundh, Chheru and many more. Reports suggest that common effluent treatment plants (CETP) has capacity of treating approximately 1.5 million litres of effluent in one day but the volume generated is more than 5 million litres on daily basis. The drains passing through entire area of Jalandhar carry with them both treated and untreated waste water which is finally dumped into two rivers Sutlej and Beas. Due to lowered water table, shortage of rainfall as well as shortage of power supply for tube wells, the irrigation of crops with the water of these drains becomes a necessity as well as an easy option for the farmers (Khurana & Bansal, 2008). This study was aimed to assess the heavy metal content in soil and its subsequent accumulation into crops in specific areas near drain which have been exposed to heavy metals through all these years.

2. MATERIAL AND METHODS

2.1Study Area

In order to study the effect of industrial effluent on soil and crops, twelve sites were selected in Jalandhar (Punjab) and its surrounding areas falling in Doaba region having direct exposure to open drains. Jalandhar is a hub of industries and deals mainly with leather, textile, electroplating, hand tools, pipe fittings, rubber, dairy etc. The polluted water released from these industries without any treatment along with domestic waste water find its way into respective drains located in the proximity alongside Kala Sanghian, Jamsher Khas, Leather complex, Basti Bawa Khel, Nijjaran, Mundh, Athola, Chehru, Jandiali, Partapura ,Hamira and Hoshiarpur byepass falling under vicinity of Jalandhar area.

2.2Methodology

To determine the pollution potential, soil sample (10-15 cm deep) and crops sample numbering 12 were collected from sewage irrigated soils of the defined area. The soil sample collected from selected agricultural areas falling in domain of Industrial drains was classified according to texture ranging from sandy to loamy sand. The physical-chemical properties of soil, available macro and micro elemental content along with heavy metals content was determined by DTPA method (Lindsay and Norvell, 1978)
From each of the selected field 1Kg soil was collected with help of kurpa after diging for 10-15 cm deep. The sample was collected from near drain, roughly centre and far away from drain so as to collect five random samples. These samples were mixed thoroughly

and a final sample of 500g was taken for analysis. This process was followed for collection of all soil and crop samples. The samples were dried, sieved and stored for further analysis. 10 gm of soil sample was acid digested and total metal estimation was done using inductively coupled argon plasma atomic emission spectrophotometer (ICAP-AES) method (AOAC, 1990).
Similarly, the crop samples Wheat, Rice and Potato were collected from same fields in triplicates and were washed to remove soil or other impurities. Then they were air dried followed by oven drying at 50±5º C temp.

2.2.1 Physical parameters

Physico-chemical analysis of collected soil samples in terms of pH, Electrical conductivity, Organic Carbon and $CaCO_3$ content were carried out.

2.2.2 Metal estimation in crops

For the estimation of total metal accumulation in the roots, shoots and grains of crops, the samples were digested as suggested by Sokkaro and Ohn (1977). Sampling of crops was done from same field twice i.e. pre-flowering stage (vegetative plants) and post-flowering stage (mature plants at harvest stage). The collected plant parts were properly washed and were dried initially by Air drying and then oven dried at 55±5ºC for 24 hrs, grounded and stored in air tight containers. Each oven dried sample (1 g) was digested with 15 ml of Diacid mixture of Nitric acid and Perchloric acid in the ratio 4:1 in a conical flask. The contents were kept overnight for slow digestion and then heated using hot plate at low temperature until about 1 ml of clear, colourless liquid was left. The contents were allowed to cool and transferred with deionised water into a 50 ml volumetric flask after repeated washing and volume was made up to the mark. The digested samples were filtered and stored in air tight containers. The samples were analyzed using ICAP-AES (Inductively coupled argon plasma atomic emission spectrophotometer) method (AOAC, 1990).

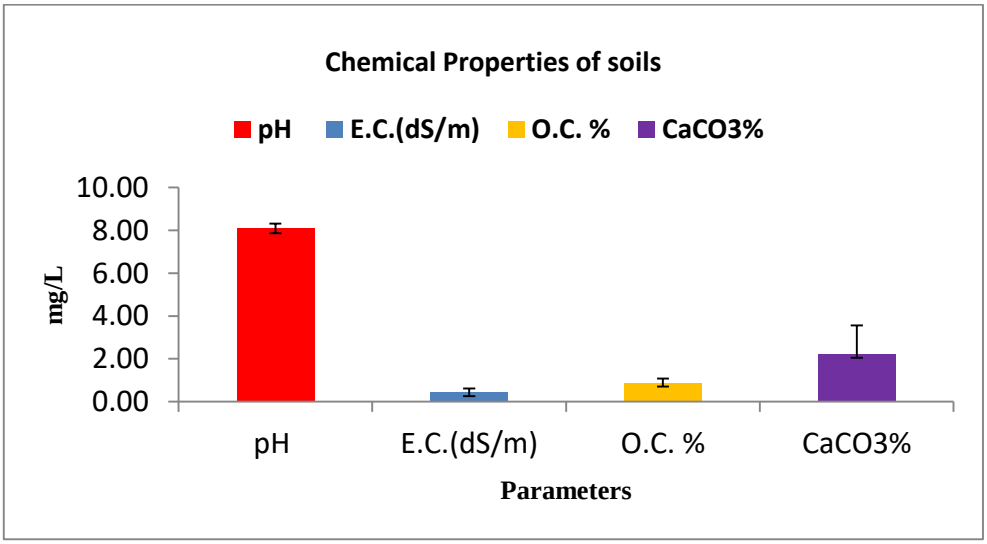
3. RESULTS

3.1 Physical and chemical characteristics of soils

Physico-chemical analysis of collected soil samples in terms of pH, Electrical conductivity, Organic Carbon and $CaCO_3$ content was done to check and correlate it with the values as laid by government regulations. pH of collected soil samples varies between 7.5-8.3.The E.C. ranges between 0.2-0.6; O.C. % falls between 0.52-1.12; $CaCO_3$ value varies between 1.1-6.0
The results are shown in Table 1.1

Table1.1 showing comparison of various physico-chemical parameters of soil samples collected from twelve different areas.

Parameters↓ /Area→	S1	S2	S3	S4	S5	S6	S7	S7	S9	S10	S11	S12	Mean	SD	N
pH	8	8.2	7.5	8.2	8.3	8.2	8.2	8.3	8.2	8	8	8	8.09	0.22	12
E.C.(dS/m)	0.22	0.3	0.25	0.35	0.65	0.65	0.38	0.2	0.55	0.5	0.6	0.6	0.43	0.18	12
O.C. %	0.92	0.7	0.76	0.52	1.07	0.95	0.92	0.81	0.83	0.82	1.22	1.12	0.89	0.19	12
$CaCO_3$%	1.7	1.1	1.3	1.5	6	3	1.92	1.72	1.72	2.22	1.62	3	2.23	1.33	12

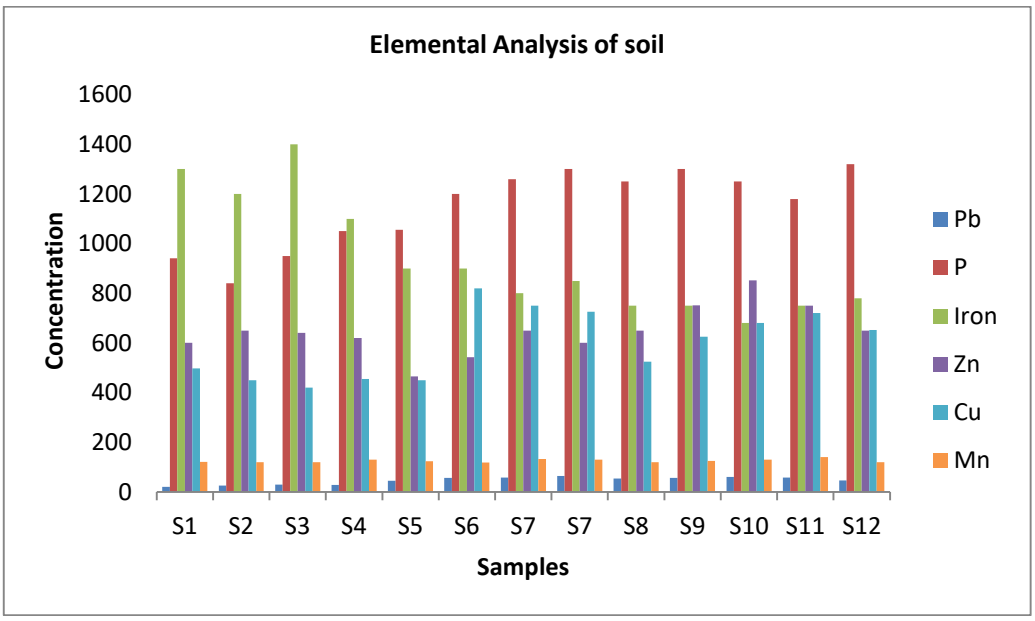


Graph 1.1 showing chemical properties of soil samples collected from twelve different areas.

Metal content was also assessed in case of soil and results are presented in Table 1.2

Table 1.2 showing metal content in soil sample collected from different twelve sites

Elements	S1	S2	S3	S4	S5	S6	S7	S7	S8	S9	S10	S11	S12
Pb	21	25	30	28	45	56	58	64	54	56	60	58	46
P	941	840	950	1050	1056	1200	1260	1300	1250	1300	1250	1180	1320
Iron	1300	1200	1400	1100	900	900	800	850	750	750	680	750	780
Zn	601	650	640	620	465	542	650	600	650	752	852	750	650
Cu	497	450	420	455	450	820	750	725	525	625	680	720	652
Mn	121	120	120	130	123	118	133	130	120	125	130	140	120



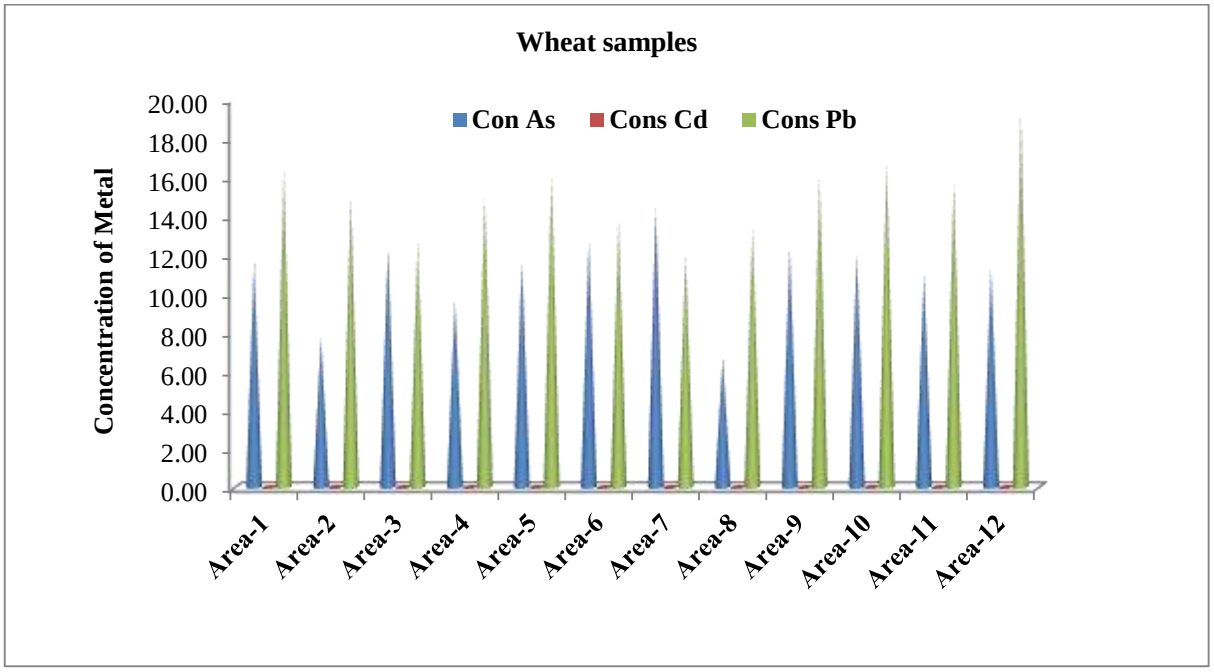
Graph 1.2showing concentration of elements and heavy metals in soil samples

3.2Metal estimation in crops

The estimation of total metal accumulation in the roots, shoots and grains of crops, the samples were digested as suggested by Sokkaro and Ohn (1977).The results are shown in Table 1.3

Table 1.3 showing the concentration of As, Cd and Pb present in the Wheat samples

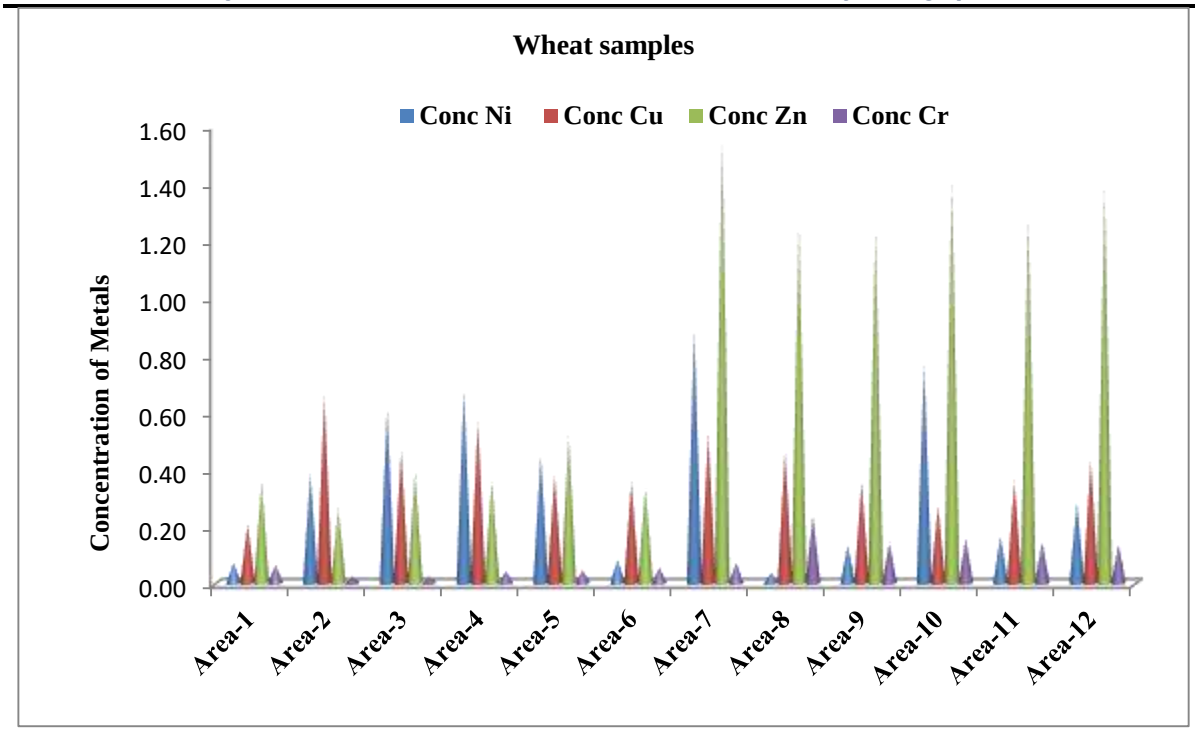
Wheat															
	As					Cd					Pb				
Sr. No.	**R1**	**R2**	**R3**	**Mean**	**SD**	**R 1**	**R2**	**R-3**	**Mean**	**SD**	**R1**	**R 2**	**R3**	**Mean**	**SD**
Area-1	10	13	12	11.67	1.53	0.07	0.08	0.08	0.08	0.01	14	22	13	16.3	4.9
Area-2	5	7	11	7.67	3.06	0.03	0.06	0.07	0.05	0.02	15	12	18	15.0	3.0
Area-3	8	11	18	12.33	5.13	0.06	0.07	0.02	0.05	0.03	13	10	15	12.7	2.5
Area-4	7	12	10	9.67	2.52	0.01	0.08	0.03	0.04	0.04	12	15	18	15.0	3.0
Area-5	8	14	13	11.67	3.21	0.06	0.03	0.02	0.04	0.02	15	18	15	16.0	1.7
Area-6	11	15	12	12.67	2.08	0.05	0.06	0.07	0.06	0.01	10	16	15	13.7	3.2
Area-7	10	18	15	14.33	4.04	0.01	0.09	0.02	0.04	0.04	16	10	10	12.0	3.5
Area-8	9	6	5	6.67	2.08	0.08	0.08	0.02	0.06	0.03	20	12	8	13.3	6.1
Area-9	10	14	13	12.33	2.08	0.02	0.08	0.08	0.06	0.03	12	21	15	16.0	4.6
Area-10	12	14	10	12.00	2.00	0.08	0.02	0.07	0.06	0.03	13	15	22	16.7	4.7
Area-11	10	13	10	11.00	1.73	0.04	0.04	0.03	0.04	0.01	18	14	15	15.7	2.1
Area-12	12	10	12	11.33	1.15	0.02	0.07	0.04	0.04	0.03	18	18	22	19.3	2.3



Graph 1.3showing the Conc. of heavy metals present in the wheat samples

Table 1.4 showing Concentration of Ni, Cu ,Zn & Cr in wheat samples

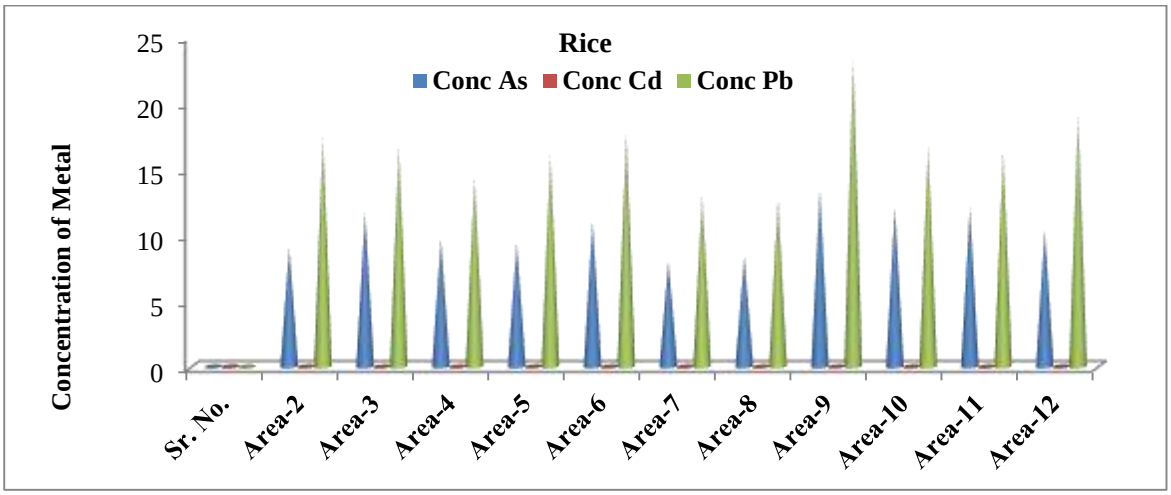
Wheat																				
	Ni					Cu					Zn					Cr				
S.No.	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD
Area-1	0.085	0.095	0.035	0.07	0.03	0.202	0.205	0.208	0.21	0.00	0.322	0.388	0.356	0.36	0	0.042	0.083	0.071	0.07	0.02
Area-2	0.082	0.683	0.385	0.38	0.30	0.651	0.659	0.658	0.66	0.00	0.222	0.278	0.286	0.26	0	0.032	0.031	0.012	0.03	0.01
Area-3	0.885	0.821	0.128	0.61	0.42	0.453	0.473	0.465	0.46	0.01	0.354	0.454	0.359	0.39	0.1	0.013	0.042	0.022	0.03	0.01
Area-4	0.686	0.645	0.689	0.67	0.02	0.659	0.42	0.622	0.57	0.13	0.322	0.375	0.375	0.36	0	0.04	0.048	0.042	0.04	0.00
Area-5	0.595	0.593	0.155	0.45	0.25	0.412	0.313	0.412	0.38	0.06	0.489	0.513	0.548	0.52	0	0.049	0.049	0.042	0.05	0.00
Area-6	0.095	0.083	0.075	0.08	0.01	0.388	0.324	0.358	0.36	0.03	0.301	0.389	0.315	0.34	0	0.108	0.049	0.011	0.06	0.05
Area-7	0.985	0.682	0.985	0.88	0.17	0.524	0.523	0.524	0.52	0.00	1.437	1.212	1.987	1.55	0.4	0.119	0.056	0.042	0.07	0.04
Area-8	0.035	0.039	0.033	0.04	0.00	0.658	0.313	0.412	0.46	0.18	1.214	1.215	1.312	1.25	0.1	0.122	0.108	0.481	0.24	0.21
Area-9	0.065	0.165	0.168	0.13	0.06	0.359	0.312	0.389	0.35	0.04	1.137	1.312	1.258	1.24	0.1	0.119	0.187	0.124	0.14	0.04
Area-10	0.789	0.782	0.721	0.76	0.04	0.298	0.215	0.298	0.27	0.05	1.439	1.237	1.515	1.40	0.1	0.106	0.187	0.183	0.16	0.05
Area-11	0.186	0.121	0.187	0.16	0.04	0.389	0.375	0.312	0.36	0.04	1.437	1.137	1.259	1.28	0.2	0.108	0.184	0.145	0.15	0.04
Area-12	0.285	0.288	0.283	0.29	0.00	0.459	0.412	0.422	0.43	0.02	1.434	1.254	1.432	1.37	0.1	0.109	0.111	0.187	0.14	0.04



Graph 1.4showing the Conc. of heavy metals present in the wheat samples

Table 1.5showing the concentration of As, Cd and Pb present in the rice samples

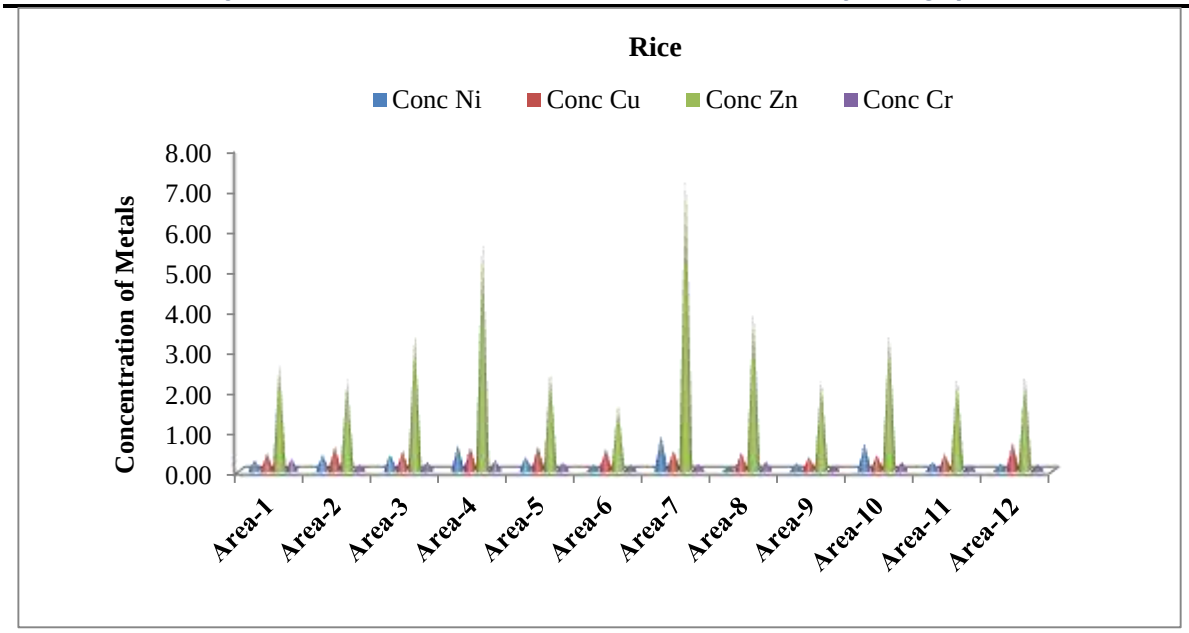
Rice															
	As					Cd					Pb				
Sr. No.	R1	R-2	R3	Mean	SD	R 1	R2	R-3	Mean	SD	R-1	R 2	R-3	Mean	SD
Area-2	9	7	11	9	2.00	0.03	0.06	0.07	0.05	0.02	22	12	18	17.33	5.03
Area-3	8	14	13	11.7	3.21	0.06	0.07	0.02	0.05	0.03	13	17	20	16.67	3.51
Area-4	7	12	10	9.7	2.52	0.01	0.08	0.03	0.04	0.04	17	14	12	14.33	2.52
Area-5	6	9	13	9.3	3.51	0.06	0.03	0.02	0.04	0.02	17	16	15	16	1.00
Area-6	11	10	12	11	1.00	0.05	0.06	0.07	0.06	0.01	19	16	18	17.67	1.53
Area-7	10	8	6	8	2.00	0.01	0.09	0.02	0.04	0.04	16	13	10	13	3.00
Area-8	9	7	9	8.33	1.15	0.08	0.08	0.02	0.06	0.03	20	10	8	12.67	6.43
Area-9	12	15	13	13.33	1.53	0.02	0.08	0.08	0.06	0.03	21	26	23	23.33	2.52
Area-10	12	14	10	12	2.00	0.08	0.02	0.07	0.06	0.03	13	15	22	16.67	4.73
Area-11	11	15	10	12	2.65	0.04	0.04	0.03	0.04	0.01	17	14	18	16.33	2.08
Area-12	14	9	8	10.33	3.21	0.02	0.07	0.04	0.04	0.03	18	15	24	19	4.58



Graph 1.5showing the Conc. of heavy metals present in the rice samples

Table 1.6 showing Concentration of Ni, Cu ,Zn & Cr in Rice samples

Rice																				
	Ni					Cu					Zn					Cr				
Sr. No.	**R1**	**R2**	**R3**	**Mean**	**SD**	**R1**	**R2**	**R3**	**Mean**	**SD**	**R1**	**R2**	**R3**	**Mean**	**SD**	**R1**	**R2**	**R3**	**Mean**	**SD**
Area-1	0.445	0.313	0.056	0.27	0.20	0.802	0.306	0.208	0.44	0.318	1.213	2.388	4.356	2.65	1.59	0.242	0.383	0.271	0.30	0.07
Area-2	0.182	0.683	0.385	0.42	0.25	0.651	0.559	0.658	0.62	0.055	2.218	1.278	3.286	2.26	1.00	0.132	0.135	0.212	0.16	0.05
Area-3	0.885	0.221	0.159	0.42	0.40	0.653	0.398	0.465	0.51	0.132	5.214	3.454	1.359	3.34	1.93	0.313	0.042	0.322	0.23	0.16
Area-4	0.686	0.545	0.689	0.64	0.08	0.759	0.421	0.622	0.60	0.170	6.154	4.375	6.375	5.63	1.10	0.104	0.248	0.442	0.26	0.17
Area-5	0.395	0.518	0.155	0.36	0.18	0.912	0.513	0.412	0.61	0.264	2.219	1.513	3.548	2.43	1.03	0.249	0.149	0.242	0.21	0.06
Area-6	0.195	0.189	0.075	0.15	0.07	0.588	0.724	0.358	0.56	0.185	3.214	0.389	1.315	1.64	1.44	0.108	0.249	0.111	0.16	0.08
Area-7	0.985	0.688	0.985	0.89	0.17	0.524	0.523	0.524	0.52	0.001	8.437	5.212	7.987	7.21	1.75	0.119	0.256	0.142	0.17	0.07
Area-8	0.135	0.139	0.033	0.10	0.06	0.657	0.313	0.412	0.46	0.177	5.214	1.215	5.312	3.91	2.34	0.122	0.108	0.481	0.24	0.21
Area-9	0.265	0.166	0.168	0.20	0.06	0.354	0.319	0.389	0.35	0.035	4.137	1.312	1.258	2.24	1.65	0.119	0.187	0.124	0.14	0.04
Area-10	0.789	0.589	0.721	0.70	0.10	0.198	0.715	0.298	0.40	0.274	3.439	4.237	2.515	3.40	0.86	0.306	0.187	0.183	0.23	0.07
Area-11	0.256	0.125	0.289	0.22	0.09	0.289	0.675	0.312	0.43	0.217	2.437	3.137	1.256	2.28	0.95	0.108	0.184	0.145	0.15	0.04
Area-12	0.115	0.218	0.215	0.18	0.06	0.412	0.812	0.922	0.72	0.268	3.434	1.172	2.43	2.35	1.13	0.209	0.111	0.187	0.17	0.05



Graph 1.6showing the Conc. of heavy metals present in the rice samples

Table 1.7 showing the concentration of As, Cd and Pb present in the potato samples

Potato															
	Conc As					Conc of Cd					Conc of Pb				
Sr. No	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD
Area-1	15	10	18	14.3	4.0	0.04	0.02	0.02	0.03	0.01	18	15	3	12	7.937
Area-2	18	14	16	16.0	2.0	0.05	0.02	0.06	0.04	0.02	12	17	14	14.3	2.517
Area-3	16	18	12	15.3	3.1	0.01	0.03	0.07	0.04	0.03	20	13	16	16.3	3.512
Area-4	17	10	15	14.0	3.6	0.05	0.02	0.02	0.03	0.02	22	20	14	18.7	4.163
Area-5	12	8	16	12.0	4.0	0.03	0.08	0.06	0.06	0.03	16	13	18	15.7	2.517
Area-6	7	14	10	10.3	3.5	0.01	0.02	0.08	0.04	0.04	19	15	19	17.7	2.309
Area-7	18	15	13	15.3	2.5	0.04	0.02	0.02	0.03	0.01	14	10	12	12	2
Area-8	15	12	18	15.0	3.0	0.05	0.06	0.06	0.06	0.01	18	20	11	16.3	4.726
Area-9	13	10	15	12.7	2.5	0.04	0.03	0.05	0.04	0.01	17	12	10	13	3.606
Area-10	10	12	15	12.3	2.5	0.04	0.02	0.02	0.03	0.01	10	8	7	8.3	1.528
Area-11	9	10	15	11.3	3.2	0.06	0.02	0.06	0.05	0.02	14	17	20	17	3
Area-12	16	15	11	14.0	2.6	0.03	0.03	0.07	0.04	0.02	18	13	12	14.3	3.215

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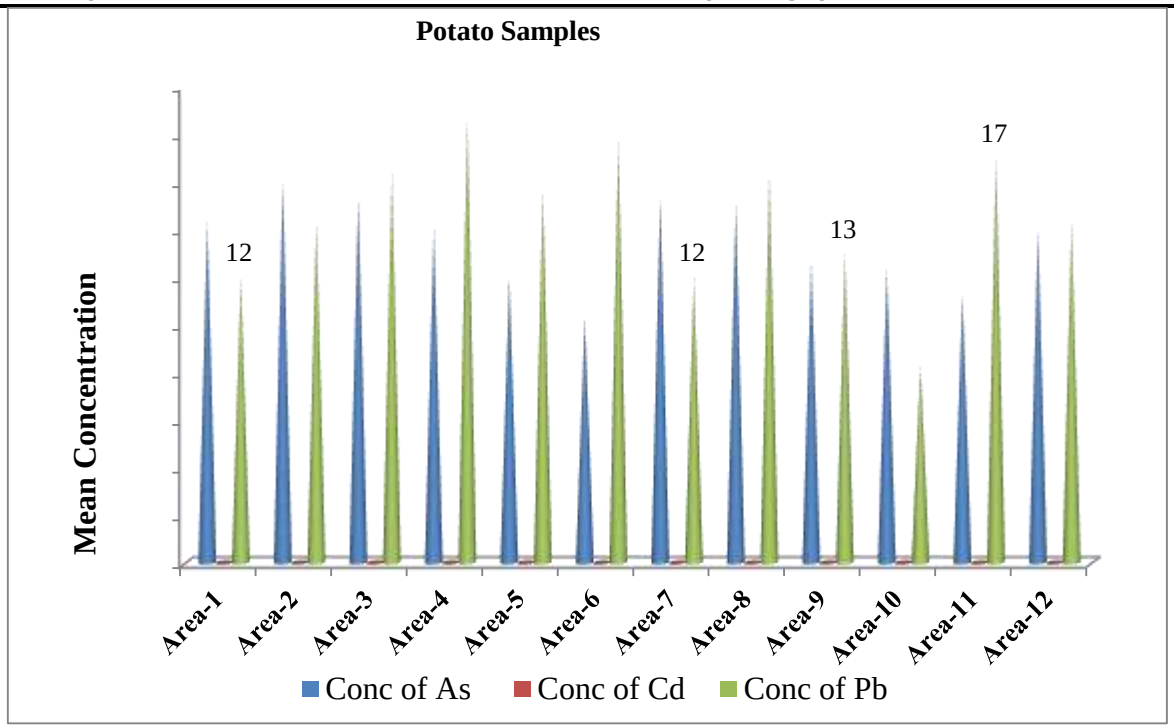
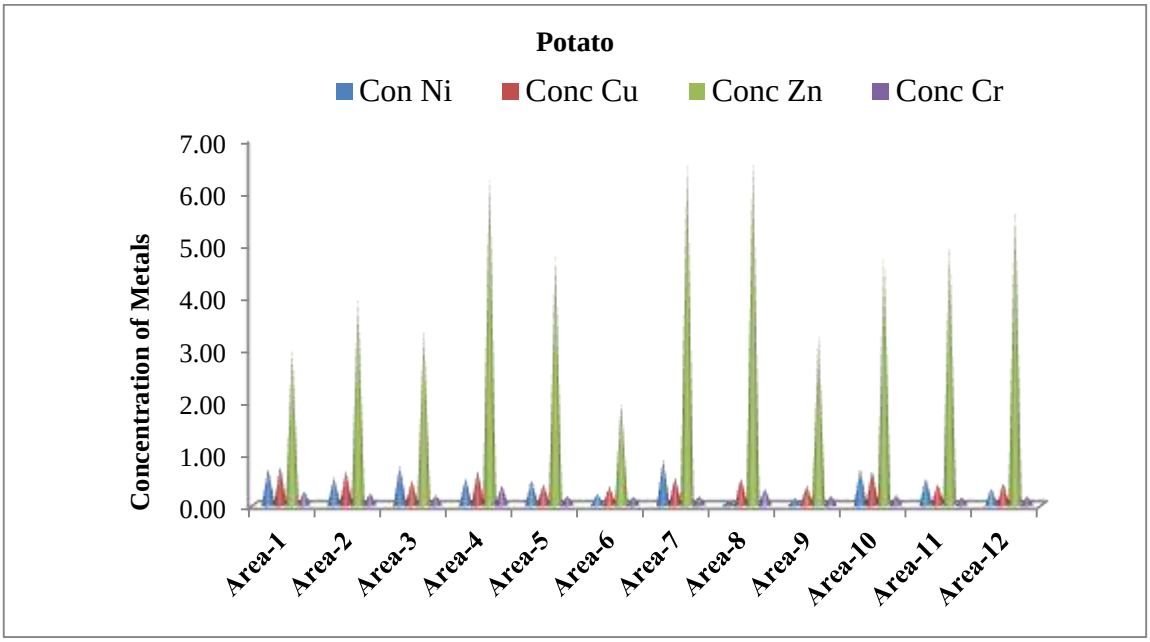


Graph 1.7showing the Conc. of heavy metals present in the potato samples

Table 1.8 showing Concentration of Ni, Cu , Zn & Cr in Potato samples

	Ni					Cu					Zn					Cr				
Sr. No.	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD
Area-1	0.885	0.695	0.533	0.70	0.18	0.902	0.709	0.615	0.74	0.15	1.213	3.388	4.356	2.99	1.61	0.142	0.383	0.271	0.27	0.12
Area-2	0.683	0.683	0.235	0.53	0.26	0.651	0.659	0.658	0.66	0.00	2.218	6.278	3.286	3.93	2.10	0.332	0.135	0.218	0.23	0.10
Area-3	0.785	0.821	0.628	0.74	0.10	0.453	0.598	0.412	0.49	0.10	5.214	3.454	1.359	3.34	1.93	0.213	0.042	0.322	0.19	0.14
Area-4	0.385	0.645	0.523	0.52	0.13	0.759	0.612	0.626	0.67	0.08	6.154	6.375	6.375	6.30	0.13	0.442	0.248	0.442	0.38	0.11
Area-5	0.592	0.593	0.255	0.48	0.19	0.412	0.318	0.478	0.40	0.08	4.219	6.513	3.548	4.76	1.55	0.148	0.149	0.242	0.18	0.05
Area-6	0.198	0.083	0.376	0.22	0.15	0.388	0.347	0.369	0.37	0.02	3.214	1.389	1.315	1.97	1.08	0.115	0.249	0.111	0.16	0.08
Area-7	0.981	0.682	0.912	0.86	0.16	0.512	0.523	0.587	0.54	0.04	8.437	5.212	5.987	6.55	1.68	0.112	0.256	0.142	0.17	0.08
Area-8	0.135	0.039	0.033	0.07	0.06	0.658	0.513	0.412	0.53	0.12	5.214	6.215	8.312	6.58	1.58	0.356	0.108	0.481	0.32	0.19
Area-9	0.065	0.165	0.168	0.13	0.06	0.319	0.512	0.289	0.37	0.12	4.137	4.312	1.258	3.24	1.71	0.216	0.187	0.124	0.18	0.05
Area-10	0.989	0.782	0.321	0.70	0.34	0.789	0.615	0.598	0.67	0.11	5.439	4.237	4.515	4.73	0.63	0.222	0.187	0.183	0.20	0.02
Area-11	0.582	0.121	0.887	0.53	0.39	0.356	0.375	0.512	0.41	0.09	6.437	3.137	5.256	4.94	1.67	0.113	0.184	0.145	0.15	0.04
Area-12	0.285	0.288	0.397	0.32	0.06	0.418	0.412	0.422	0.42	0.01	6.433	5.172	5.43	5.68	0.67	0.209	0.111	0.187	0.17	0.05



Graph 1.8showing the Conc. of heavy metals present in the potato samples

Table 1.9showing Limits of toxic trace elements (mg/kg) in vegetables

	Vegetable type	As	Cd	Pb	Ni	Cr
WHO (2004)	**Leafy vegetables**	0.05	0.2	0.3	0.3	0.5
	Root vegetables	0.05	0.1	0.3	0.3	0.5
	Other vegetables	0.05	0.05	0.1	0.3	0.5

4. DISCUSSION

The chemical analysis of soils from near drain fields indicated that there is many fold metal accumulation in comparison to the Government regulation.The physical and chemical characteristics of soil indicate disturbed soil health due to variation i n almost all the values. In the collected samples elemental content as well as heavy metals Pb, P,Cr, Cu, Cd, Ni, Pb were quite high; with highest being 64,1300,1400,852,820,133 and lowest being 21,840,680,465,420,120 respectively but the level of As in all soil samples was in traces. Heavy metals accumulation were more in the different parts, like leaves, roots, seeds of crops growing in the fields in close proximity to drains in comparison to regulations set by government. Toxic heavy metal depositions was reported at high level in many areas specifically Pb, As and Ni in the collected samples of Wheat, Rice and Potato.In case of Wheat, As was reported to be high in three samples, Pb in five samples but Cd was either slightly higher or almost in acceptable range. For Rice, value of As and Pb was high in most of the samples followed by Cd at the border line. Most of the potato samples were detected to be having high concentration of As and Pb along with borderline limit of Cd. There are reports of heavy metal accumulation in crops by many authors (Liu et al., 2003, McBride, 2003, Cheng et al.2006, Guibin J et al., 2008).

5. CONCLUSIONS

It can be concluded from current study that there is toxic heavy metal accumulation in soil as well as crops irrigated with polluted water. Continuous use of Effluent for irrigation purposes and its availability as such without proper treatment or disposal has lead to change in the natural composition of macro and micro elements as well as accumulation of toxic substances in form of heavy metals. It has been observed that concentration of As, Pb, Ni is more in plants in comparison to soil. Hence these heavy metals pose health hazards for consumers and also disturb the elemental strength of soil leading to decrease in its fertility. The present scenario needs to be controlled and a vigilant check needs to be made by concerned authorities for benefit of environment and to control heath related consequences. The need of hour now is to modify treatment system and maintain continuous monitoring of various parameters important for combating pollution.

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