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Heavy Metal Analysis in Agricultural Soils in Godavari River Basin of Rajahmundry Region, East Godavari District, Andhra Pradesh, India.

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Abstract

There are many sectors that are using chemicals and increase their production to meet the needs of people in the world. The domestic, industrial, agriculture, medical and recent technological applications effluents consist of heavy metals that have high density than water and are raising the concerns of potential effects on the environment and also human. The soil samples are collected from Godavari river basin near Rajahmundry in East Godavari district, Andhra Pradesh, to assess the levels of Ni, Fe, Cr, Cu, Zn, Co, Pb, Cd & As to calculate soil PERI. Pearson's correlation matrix, Contamination factor, Coefficient variations are used for evaluate contamination of pollutants & ecological risk, based on results the accumulation efficiency is very different in soils; most of the samples have high concentration. Contamination factors of heavy metals are in moderate contamination (1 ≤ 3), but the Cd shows as considerable contamination (3 ≤ 5) in Aalamuru-S5, Korumilli -S7 and Kulla-S8 soils samples. The coefficient variation was observed as (CV > 0.36) high variation in heavy metal (Cd > Cu > As > Fe > Co > Zn > Pb > Ni > Cr). Based on results the toxic concentrations are gradually increases in the soil samples due to over usage of chemical fertilizers and may be accumulated into crops, leads to ecological risk, finally agricultural soil are contaminating by heavy metals in our study area.

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Introduction

Heavy metals are naturally occurring elements that have a high atomic weight and a Soil is a resource in the environment that supports agricultural practices. Additionally, acted as a filter to eliminate contaminants in water that seeps into ground water aquifers that are crucial for agricultural activities, carbon storage, and water regulation.[1] the crop

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productivity and soil fertility will be increased by using fertilizers, necessary for supplying sufficient nutrients and ensuring fruitful harvests.[2] the over utilization of fertilizers in agricultural fields, leads to the contamination[3,4&5] this contamination increases the soil pollution and toxic levels,[6&7] these are inorganic,[8] naturally, with high atomic weight, the density greater than 5g/cm^3.,[9] these may occur naturally in soils and used to manufacture fertilizers, these fertilizers are made with heavy metals, agricultural activities are the source to depositing residues into soils.[10 &11] These metals are contaminated the soils & adversely affect the ecosystem, when migrated into groundwater and taken up by flora & fauna through bio accumulation and biomagnifications. It results a great threat to ecosystems, and risk to management of soils,[12,13&14] Heavy metals could be harmful to all living things when polluted soils are used for crop production,[15,16,17 & 18] land formation is severely hampered by intense agriculture and other human activities, which also cause the biosphere's pollution to rise.[19]

The organization for Toxic Substances and Disease Registry (TSDR) (2007) states that among the heavy metals like arsenic, cadmium (Cd), lead & mercury have negative consequences on health,[3, 4,5,16 &17] accurate predictions of metal content in soil are crucial.[15,18&19] As per results of air deposition, roots may cling to crop surfaces and take up heavy metals from the soil,[20 &21] various studies were assessed on concentration & bioaccumulation of heavy metals caused by agricultural practices, excessive pesticide or fertilizer use,[22] these are leached and not degradable,[23,24,25&26] because contaminated plants can cause cancer and chronic diseases,[26] metals like copper, zinc, nickel, and manganese, all of which are harmful in large amounts, and some of few heavy metals even at very small doses, mercury, cadmium, lead, and arsenic are hazardous substances,[27] these are affecting the air, water, soil, and living creatures.[28,29&30]

Methodology & Method.

Study Area

The research area is in East Godavari district, there are eight villages in Rajahmundry region was chosen to collect the soil samples, which is exceptionally fertile and lush green fields. It is one of Andhra Pradesh's 12 coastal districts and a part of the Godavari delta, it has a tremendous potential for surface water resources are more commonly seen in canal-irrigated portions of the delta region composed with red clayey, deltaic alluvial and deltaic alluvium soils, all of which are grey brown to black in color and have fine to medium textures. (Figure 1) The major crops are Coconut, Banana and Paddy, as well as more vegetable crops are also practices in the study area.

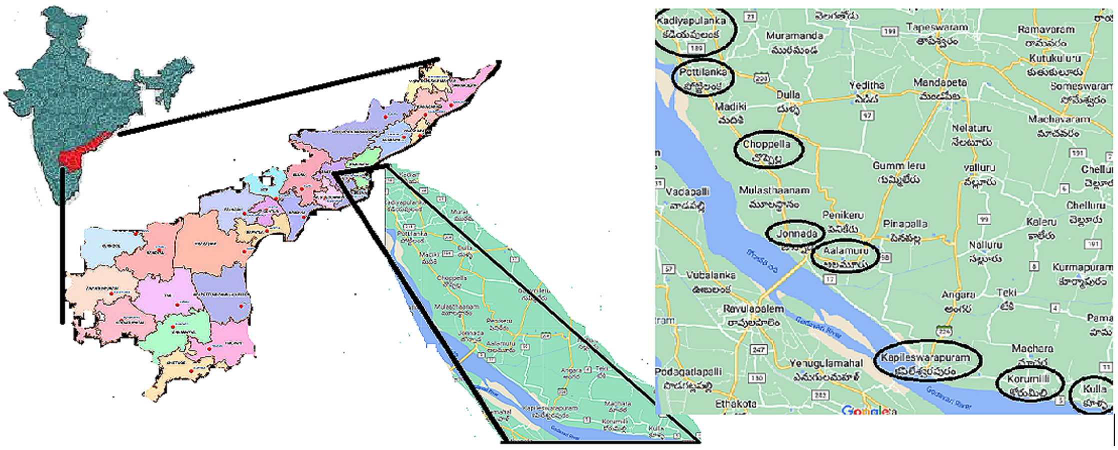

Fig. 1: Study area and sampling stations map

Sampling Method

To assess the impact on soil quality by anthropogenic activities, sample were collected from agricultural land, eight soil samples are collected in 16 agricultural farms in the month of December 2020 to July 2021. They are located in Godavari river basin, that includes Kadiyapulanka- S1 (field 1 & 2), Pottilanka-S2 (field 3 & 4), Choppella-S3 (field 5 & 6), Jonnada –S4 (field 7 & 8), Aalamuru -S5 (field 9 & 10), Kapileswarapuram -S6 (field 11 & 12), Korumilli -S7 (field 13 & 14), and Kulla-S8 (field 15 & 16) (Table 1, Figure 1 & 2). Four composite soil samples were collected from 8 sampling station, 15 kg of soil from each of the four forming areas, making a "V" type cut with shovel at a depth about 15 cm to collect thick slices of soil and exposed dirt from top to bottom then placed in a bucket. There are approximately 15 samples were collected from each sampling unit. The sample has been mixed well and removed foreign materials like pebbles, gravel and roots. The quartering technique was applied by dividing the mixed samples into 4 parts, the 2 contrary quarters are detached and remaining two quarters remixed and process has repetitive upto the desired sample size is obtain, the sample was collected in polythene bag and labeled the place of collection, date and time.

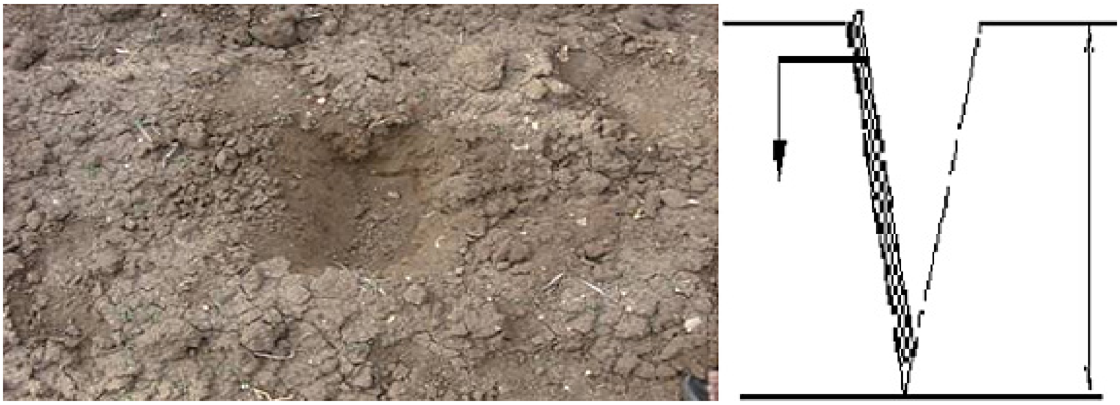

Fig. 2: Soil sample collection point "V" Shaped cutting in the soil in the study area

Table 1: Sampling stations in the study area

Name of the sampling station	Station No	Longitude	Latitude
Kadiyapulanka	S1	81.8131°	16.8925°
Pottilanka	S2	81.8082°	16.9021°
Choppella	S3	81.8483°	16.7383°
Jonnada	S4	81.8627°	16.6969°
Aalamuru	S5	81.8996°	16.7793°
Kapileswarapuram	S6	80.8641°	16.3232°
Korumilli	S7	81.9108°	16.7541°
Kulla	S8	82.0068°	16.7541°

Methods

The calcium chloride solution (0.15%) used as extractant to analyse soil samples.[31] The heavy metals concentrations are determined by using an AAS (Lab-India AAS 8000. Make (model): Varian (AA240FS)), diethylene triamine penta acetic acid extractant used for assessed Fe, Zn and Cu in soil samples.[32] The instrument AAS was utilized for estimation of Fe, Zn and Cu, the glass ware are cleaned with 10 % HNO_3 solution & distil water,[33&34]

the standard and blank samples are made with analytical grade chemicals and reagents. The device was calibrated with a heavy metal blank of different concentrations and a reference standard. A blank and standard sample was run to ensure quality, the analysis were performed in three times.

Estimation of Contamination & Ecological Risk.
An estimation of metal pollution in soil samples by calculating Contamination Factor, Coefficient Variation, PERI.[35&36]

Contamination Factor (CF)
The CF was calculated using follow Equation ... (1), it is a ratio of particular metal content -C_i, C_b-is a background value of such metal.[37&38]

$$CF= C_i/C_b \quad ...(1)$$

Table 2: CF Classification.

Concentration levels	Un-contaminated	slight	moderate	considerable	strong	Very-strong
CF (Individual - metal)	Less than are equal to 0 (≤ 0)	0 less than are equal to 1 (0≤1)	1 less than are equal to 3 (1≤3)	3 less than are equal to 5 (3≤5)	5 less than are equal to 6 (5≤6)	greater than 6 (≥6)

Coefficient Variation (CV)
The level of human interference is clarified using the coefficient of variation. It is inversely correlated with human intervention, which is the more extensive category of human activity.[39] It has been categorized into 3 categories, CV< 0.15 are low variation, 0.15 < CV < 0.36 are medium variation & CV > 0.36 are high variation are estimated as per Eq. (2).[36&40]

$$CV= \text{Standard Deviation/Mean} \quad ...(2)$$

Soil Contamination Assessment.
Contamination of heavy metals status in collected soil sample was assessed with PERI. This is a process to recognize the impact of pollutants (heavy metals) in Agricultural soils using the formula showed that in Eqs. (3) & (4). PERI is the risk index in ecologically and elucidate as the sum of the PERI (Ei) of various metals, categorization of PERI was showed in Table 3.[41]

$$PERI = \Sigma E_i \quad ...(3)$$
$$Ei= T_i(C_i/ C0) \quad ...(4)$$

The following metals have different toxic response factors: Ni, Cu,Pb-5, Cd-30 Cr-2, Fe-1, & Zn- 1. Ci is a level of the trace metal in soils, and C_0 is background concentration of trace metals in collected samples of agricultural soils. Ei is PERI of a specific trace metal present in soil sample, RI is Risk Index.

Table. 3: PERI Classification.

Risk-R	low-level	moderate level	considerable level	high-level	very High
Ei	<40	40≤80	80≤160	160≤320	≥320
RI	≤150	150<RI≤300	300<RI≤600	-	>600

Results and Discussion
Trace metals (heavy metals) are harmful to the environment & put nature in peril. This essay focuses on harmful impact of heavy metals on agricultural soils, including toxic effects of Cd, Pb, Cu, zinc (Zn), Cr, cobalt (Co), As, Ni, and Fe.[22]

Pb can be found in rocks that are rich in phosphate and superphosphate a powerful affinity for organic material, the concentration of Pb in samples were observed as S4-88.29 ppm > S1-85.45 ppm > S8-83.27 ppm> S6-77.88 ppm > S3-72.16 ppm >

S2-60.14ppm > S5, S7-57.92 ppm and the mean, standard deviation levels are 12.755 ± 72.878. The high content acceptable for lead in soil samples is 70 mg/kg^{-1} as per WHO standards. The higher levels are pointing towards the anthropogenic activities and natural sources. It may be elated a large distance from the source to sink point by volatilizing at high temperatures.[42&38] It will change the soil pH,[43&44] affected the soil absorption capacity & reduce fertility of the soil.[45,46,47 &48]

The Iron concentration at different sampling stations is below the standard level as per WHO. The minimum and maximum levels are observed in S1-10882.7mg/kg^{-1}, S4 - 22038.6 mg/kg^{-1} in study area, higher levels are observed in S4>S5>S8>S7 samples, the mean and standard deviation levels are 4571.72±16889.1, similar studies results are by.[18,38&49] Higher levels were observed in all sampling stations, because the major sources is rock systems, high organic matter and continuous usage of inorganic fertilizers for good crop productivity in agricultural region,[50&51] the addition of fertilizers and compost is also increases Iron in soil samples.[49&52]

Zinc is an essential element to organisms, Zn levels were observed as higher to lower levels in the study area are S3>S1>S2 > S8 >S6>S4>S6>S7, the maximum levels are reported in S3-324.23 ppm, S1-257.34 ppm, S2-254.87 ppm, S7- 204.77 ppm indicated in Table 4 & Fig 5 . The mean and standard deviation is 224.583 ± 52.103 (Table 2 & fig 3). The Zn will increase by highly leached acidic soils. There are four samples have higher values remaining are in the below standard limit in the soil samples. Zn concentration in soils is raised by drain water, municipal waste water; industrial effluents utilized for irrigation, over usesage of Zn sulphate fertilizers might be cause for high level of Zn in agricultural soils leads to change the physic chemical parameters in soils.[53] largely contributed by anthropogenic activities like agricultural practices[54] human activities,[53] excess Zn may alter the bicarbonate and organic matter contents, prevent organisms from producing certain enzymes, and change the pH of the soil.[55&56] Similar studies were observed that higher concentrations in soils.[57&58]

Typically, nickel is viewed as a geogenic element,[59] mostly connected to the crystalline network of basic minerals.[60] Nickel concentration in soil samples are as follow S1> S2> S5 > S7> S8 >S4 > S6> S3 sowed in figure 4, there are four samples have higher levels due to over usage of fertilizers and human activities,[53] the mean and standard deviation is 12.492 ± 75.673 indicated in Table 2 and fig 3.

The major contribution of Cu is agricultural practices,[53] and derived from anthropogenic activities,[54] higher cupper levels are observed in S6 > S2 > S4 > S5 remaining all samples are below the standard limit as per the WHO standards indicated in fig 3 & 5, the mean and standard deviation values are 9.313 ± 27.511 (table 2 & fig 4). Cu might be attributed to the use of Cu containing and irrigation by sewage, [61&62] high concentration of Cu may be affected the soil micro organisms, change urease activity and oxidation potential,[63,64&65], damage the earthworms[66&67] Northern Tanzania's cultivated soils were found to have accumulated significant amounts of copper Northern Tanzania's cultivated soils were found to have accumulated significant amounts of copper.[68]

The Cd concentration is very high in soils due to irrigation drains along with sewage.[17,69&70] The cadmium concentration levels in the present study soils samples have slightly concentration, the mean and standard deviation levels are 0.610 ± 1.15, the samples S1 & S8 have the minimum and maximum levels of the cadmium, due to over usage of chemical fertilizers its concentration had been increased. Cadmium is found in phosphate fertilizers.[71&72] It (Cd^{+2}) Effects in soils and kill microorganisms, increase the Earthworm mortality,[73] absorb organic matter, as well as change the soil physicochemical characteristics[74,75,76&77] It enters the food chain by being absorbed by cereal-based crops such as rice and other crops such as vegetables.

The cobalt levels are slightly higher than the standard limit, the mean & standard deviation of cobalt was observed as 4.11173 ± 15.5663, and the maximum concentration observed in S5 > S2 > S1 sampling stations. Few samples are below the standard levels of WHO in soil samples.[38&78]

Chromium levels in the present soil samples has been observed slightly higher levels in S3-127.82 ppm > S1 -118.85 ppm > S8- 112.72 ppm > S4- 108.91 ppm, reaming four samples have lower levels of the chromium, the minimum level of Cr was found in S6-73.94 ppm, the mean and standard deviation levels are 103.741 ± 17.0258. The high concentration of Cr was by using the waste water for irrigation in agricultural regions and dumping of waste from chemical industries in the drain.[38] similar studies stated that high concentration of Cr affected the soil microorganisms.[79&80] Arsenic levels in the present study area observed as S4-15.21 ppm> S3-14.78 ppm> S8-13.27ppm are higher levels and the S6< S1< S7< S2 and S5 are have the minimum levels of the Arsenic, and the mean, standard deviation levels are 3.10689 ± 11.0325. Arsenic pollution is not a major concern.[81] The major source of Arsenic was the industrial activities and their products such fungicides, insecticides, pesticides, herbicides.[82& 83] Over usage of these may cause the soil pollution,

Anthropogenic and geogenic sources are distinguished as the two main sources of the metal relationship,[84,85&86] The overall higher levels were observed in S1- Kadiyapulanka, S4- Jonnada, and S8- Kula, the Mean levels in soil are obaserved in the order like Zn>Cr>Ni>Cu>Pb>Fe>Co>As> Cd. An average & standard deviation in study area are Iron, Zinc, Chromium, Nickel, lead, Copper, Cobalt, Arsanic and Cadmium. were 16889.1 ± 4571.72mg kg^{-1}, 224.583 ± 52.103mg/kg^{-1}, 103.741 ± 17.0258 mg/kg^{-1}, 75.6738 ± 12.4923mg/kg^{-1}, 72.8788 ±12.7551mg/kg^{-1}, 27.5113 ± 9.31357 mg/kg^{-1}, 15.5663 ± 4.11173mg/kg^{-1}, 11.0325 ± 3.10689mg/ kg^{-1} and 1.15125 ± 0.61096mg kg^{-1}, respectively., It has assumed that long term exposure to high level of arsenic (As) damages the organs of organisms per trace metal levels in soil samples.[11] The Copper (Cu) & lead (Pb) was impaired the immunity as well as fertility.[87] This may be due to the Pb added to gasoline in the past, as well as the low sensitivity of analytical methods used for measurement An increased efficiency of metal pollutants in crops are very different like rice, banana, Vegetables, and in commercial crops,[88,89 &90] but the contaminations are very easy in paddy than other crops.[91] Which suggest regular rice consumption is a significant risk to the health based on the concentration in soil samples.[92]

Lead in soils is found in various forms, such as the ionic form in soil solution, exchangeable in organic and inorganic matrixes, structural components of mineral lattices, and insoluble precipitates,[45&93] Mining and related activities discharge large amounts of wastewater and solid waste to the environment, which often contain Pb.[94] Thus, Pb enters into soils through atmospheric diffusion, surface runoff flushing, and weathering.[95]

Contamination Factor (CF)

Soil Pollution indices make it simple to gauge the degree of soil pollution,[18] the present study samples are observed as contamination by heavy metals, as per the classification (Table 2) Ni, Pb, Cr, Zn, As, Co and Cu metals were moderate contamination but the Cd is considerable contamination in S5, S7 and S8 soils samples (table 4) which indicated that agricultural soil are contaminating by the heavy metals. Hence, the fertilizers utilization should be decrease in agricultural sector.

Coefficient Variation (CV)

The categorization of coefficient Variation like (< 0.15) is low variation, (0.15 <0.36) is medium & (>0.36) was high variation found in order like Cd > Cu > As > Fe > Co > Zn > Pb>Ni> Cr with values 0.530691 > 0.338537 > 0.281612 > 0.27069 > 0.264144 > 0.231999 > 0.175019 > 0.165082 > 0.164118. Based on the categorization Cd is in the high variation remaining all metals are in medium variation in soil samples, indicates that the input of metals by anthropogenic activities in study area, and it shows heterogeneous occurrence.[40]

Potential Ecological Risk Index

The PERI was calculated for Pb, Zn, Co, Ni, Cd, Cr, Cu & As, results are indicated in table 6 and 7, as per the categorization of risk index (Table- 3), the values of PER index found to be highest for Cd in S2, S3, S5, S7 and S8 samples, The high level of Cd in fertilizers become a source for its enrichment in soil samples.[82] Which indicates the carcinogenic problems will rise in the organisms,[96] as well as low risk to moderate risk has been observed in all sampling stations in study area, toxic concentrations are gradually increasing & accumulate into to crops leads to ecological risk in study region.

The findings showed that the percentage of Cu, Pb and Cd are considerably enriched in soil. According to study of Mohammed[97] fertilizers and pesticide residuals are increases the toxicity in agricultural soils,[98] the distribution of heavy metals (Cr, Ni, Pb, Cd, & Zn), were found by colombian researchers in soil sample.[99] The similar study have been observed in soils samples wide-ranged as follows Zn>Cr>Ni>Pb>Hg> Cd,[99,100,101,102,103&104] Heavy Metal content in study area soils are very high, due to over use of fertilizers, both natural & human activities contribute heavy metals into soil.[105,106, 107&108]

Pearson's correlation was widely used to know similarity to find interrelationship of parameters, the correlation analysis was showed in table 6. Cr - Co, Zn, Fe, Cd, Pb and As has positive correlation, Arsanic having positive correlation with Cr, Fe, Cd, Zn, Pb & Co. Cu has positive relation with Ni, Cd has positive correlation between Ni and Fe. A significant positive correlation was observed in agricultural soils is usage over usage of fertilizers, the Pb, and As are accumulated by using fertilizers.[109] The correlation coefficient of Cr-Zn (0.559), Zn-Co (0.5609) As-Fe (0.5514) were greater than 0.5. The positively correlation was observed in between heavy metals ($p < 0.01$). A relatively negative correlations were noticed between (Pb - Ni), (Pb - Cu), (Pb - Co), (Cd - Zn), (Zn – Cu), (Ni - Zn), (Cr - Ni), (Cu - Cd), (Fe - Co), (Fe - Ni), (Fe - Cu) and so on in table 6. It indicates the less significant correlations between heavy metal, due to affect of different pollutant source.[80,110&111]

Table 4: Minimum, Maximum, Mean & SD

	Pb	Zn	Ni	Cu	Co	Fe	Cd	Cr	As
Min	57.92	159.83	55.81	13.82	10.28	10882.7	0.23	73.94	6.73
Max	88.29	324.23	91.37	38.63	19.81	22038.6	1.82	127.82	15.21
Mean	72.8788	224.583	75.6738	27.5113	15.5663	16889.1	1.15125	103.741	11.0325
SD	12.7551	52.103	12.4923	9.31357	4.11173	4571.72	0.61096	17.0258	3.10689

Table 5: Correlation of the heavy metals

	Pb	*Zn*	*Ni*	*Cu*	*Co*	*Fe*	*Cd*	*Cr*	*As*
Pb	1								
Zn	0.1996	1							
Ni	-0.36	-0.2909	1						
Cu	-0.041	-0.3245	0.4181	1					
Co	-0.356	0.5609	0.369	-0.1759	1				
Fe	-0.133	-0.5975	-0.2017	-0.2579	-0.254	1			
Cd	-0.393	-0.6996	0.1456	-0.1076	-0.202	0.778	1		
Cr	0.3422	0.5592	-0.2253	-0.7095	0.4282	0.1086	-0.2699	1	
As	0.2247	0.2717	-0.5994	-0.5742	0.0194	0.5514	0.23602	0.6295	1

** Correlation is significant at the 0.01 level.

Table 6: Contamination Factor values.

CF value	Pb	Zn	Ni	Cu	Co	Cd	Cr	As
S1	***M	***M	***M	***M	***M	**S	***M	**S
S2	***M	***M	***M	***M	***M	***M	***M	***M
S3	***M	***M	**S	**S	***M	**S	***M	***M
S4	***M	***M	***M	***M	**S	***M	***M	***M
S5	***M	***M	***M	***M	***M	****C	***M	***M

S6	***M	***M	***M	***M	**S	***M	**S	**S
S7	**S	**S	***M	***M	**S	****C	***M	***M
S8	***	***M	***M	**S	***M	****C	***M	***M

** Slight contamination, ***Moderate contamination, ****Considerable contamination

Table 7: Coefficient Variation (CV).

	Pb	Zn	Ni	Cu	Co	Fe	Cd	Cr	As
CV	0.175019	0.231999	0.165082	0.338537	0.264144	0.27069	0.530691	0.164118	0.281612

Table 8: Classification of Potential Ecological Risk

Ei&Ri Values	S1	S2	S3	S4	S5	S6	S7	S8
Pb	low	low	low	low	low	low	low	low
Zn	low	low	low	low	low	low	low	low
Ni	low	low	low	low	low	low	low	low
Cu	low	low	low	low	low	low	low	low
Co	low	low	low	low	low	low	low	low
Cd	low	Considerable	low	Considerable	Considerable	Moderate	Considerable	Considerable
Cr	low	low	low	low	low	low	low	low
As	low	low	low	low	low	low	low	low
Ri = ∑Ei	low	low	low	low	Moderate	low	Moderate	Moderate

* L –Low level, **M-Moderate level, ***C- Considerable level

Table 9: Potential ecological risk index values.

Ei	S1	S2	S3	S4	S5	S6	S7	S8
Pb	7.283	5.126	6.150	7.525	4.936	6.638	4.936	7.097
Zn	1.425	1.411	1.795	1.099	1.0149	1.133	0.885	1.183
Ni	7.027	6.839	4.292	5.104	6.363	5.190	6.332	5.411
Cu	8.818	10.350	4.031	9.600	9.165	11.268	6.595	4.372
Co	15.578	16.289	15.745	8.968	16.573	8.600	9.972	12.457
Cd	15	87.391	28.043	86.739	105.652	46.956	112.173	118.695
Cr	2.629	2.012	2.8276	2.409	2.209	1.635	2.142	2.493
As	8.478	11.074	15.922	16.385	11.074	7.250	10.600	14.295
Ri	66.240	140.494	78.809	137.833	156.991	88.675	153.639	166.008

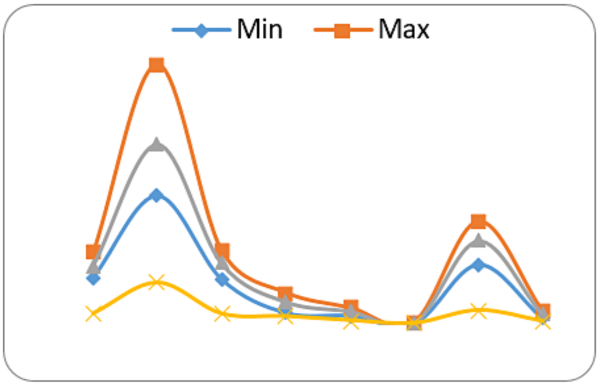

Fig 3: Min & Max values of Heavy metals

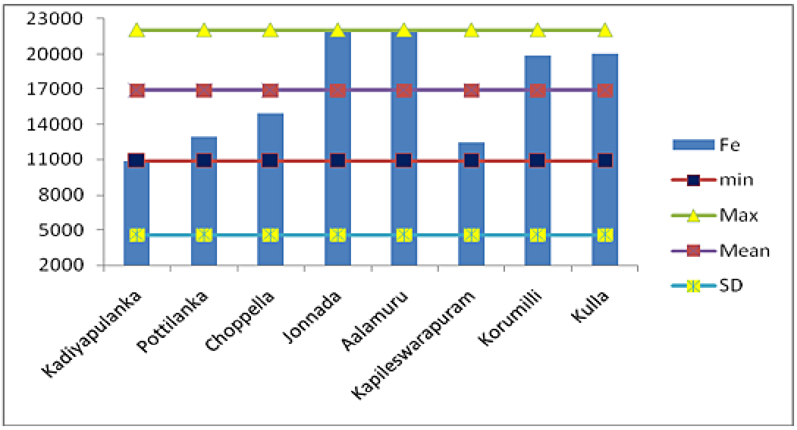

Fig 4: Min, Max, Mean & SD of Fe in soil sample

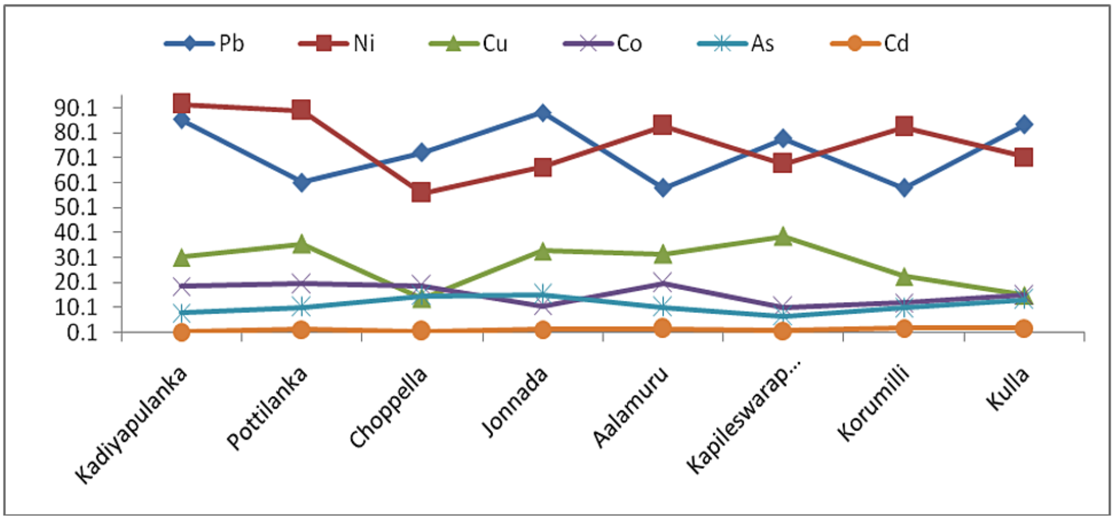

Fig 5: Concentration of trace metals in soil sample

Conclusion

Soil samples are collected for analyse the heavy metals concentrations and calculated the soil ecological risk index, results are showing enrichment of (heavy) trace metals like Fe>Zn> Cr>Ni>Pb>Cu>Co>As>Cd, most of the samples have high concentrations. The Pearson's correlation matrix showed that significant strong correlation in between the heavy metals and influenced by each other metal. The contamination factor indicated soil samples were found to be contaminated, that is moderate contamination of heavy metal except Cd., it is in considerable contamination in S5, S7 and S8 soil samples. The coefficient variation was observed as high variation in metals concentration like Cd > Cu > As > Fe > Co > Zn > Pb > Ni > Cr, based on the categorization, here also Cd is in high variation remaining all metals are in medium variation and showing heterogeneous occurrence of metals. Potential ecological risk index was observed very high for Cd in S2, S5, S7 and S8 samples based on the PERI categorization. Based on the result analysis heavy metals concentrations are gradually increasing and may be accumulated into crops leads to ecological risk in study area due to over usage of chemical fertilizers, which indicated that agricultural soil are contaminating by the heavy metals. Hence, the fertilizers utilization should be decrease in agricultural sector.

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Conflict of interest

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References

1. Avellaneda-Torres LM, Núñez APP, Pérez LDJ, Buitrago BA. (2022), Heavy metals and pesticides in soils under different land use patterns in neotropical high Andean Páramos. *Rev Bras Cienc Solo.* Vol-46:0210135.
2. Jiao, W., Chen, W., Chang, A.C., Page, A.L., (2012). Environmental risks of trace elements associated with long-term phosphate fertilizers applications: a review. *Environmental Pollution.* Vol- 168, 44–53.
3. Janae Csavina, J., Field, J., Taylor, M. P., Gao, S., Landázuri, A., Betterton, E. A., (2012). A review on the importance of metals and metalloids in atmospheric dust and aerosol from mining operations. *Sci. Total Environ.* Vol-433 (C), 58–73.
4. Bechan Sharma, B., and Singh, S., and Siddiqi, N. J. (2014). Biomedical implications of heavy metals induced imbalances in redox systems. Biomed. Res. Int. 640754
5. Vivek Kumar Gupta, Singh, S., Agrawal,A., Siddiqi, N.J., and Sharma, B. (2015). Phyto-chemicals mediated remediation of neurotoxicity induced by heavy metals. Biochem. Res. Int.534769
6. Dinakaran J., Abbas N. S., Arora S., Bhardwaj S., Kaula B. C. (2021), Assessment of heavy metals in ground water of different locations of National Capital Region, Delhi, *India. Curr World Environ*.Vol-16:143–150.
7. Bharti P. K., Kumar P., Singh V. (2013), Impact of industrial effluents on ground water and soil quality in the vicinity of industrial area of Panipat city, India. *J Appl Nat Sci.* Vol-5(1):132-136.
8. Singh N, Gupta VK, Kumar A and Sharma B (2017), Synergistic Effects of Heavy Metals and Pesticides in Living Systems. *Front. Chem.* Vol-5:70
9. Zhang H., Huang B., Dong L., Hu W., Akhtar M. S., Qu M. (2019), Accumulation, sources and health risks of trace metals in elevated geochemical background soils used for greenhouse vegetable production in south western China. *Ecotoxicol Environ Saf.* Vol-137:233-239.
10. Tariq SR, Shafiq M, Chotana GA (2016), Distribution of heavy metals in the soils associated with the commonly used pesticides in cotton fields. Scientifica.

11. Mingbo Ma, Suozhuai Dong, Wanhui Jin, Chongqi Zhang , Wenlong Zhou (2019), Fate of the organo phosphorus pesticide profenofos in cotton fiber. *Jr Environ Sci Health* B,.Vol- 54: 70-75.
12. Zayed, J. (2001). Use of MMT in Canadian gasoline: health and environment issue. *American Journal of Industry Medicine.* Vol-39, 426–433.
13. Granero, S., & Domingo, J. L. (2002). Levels of metals of Alcala de Henares, Spain: human health risks. *Environmental International.*Vol-28, 159–164.
14. Zhang, H. B., Luo, Y. M., & Zhao, Q. G. (2010). Hong Kong soil research on fractions of heavy metals and their potential Environmental risks in soil based on BCR sequential extraction. ActaPedologica Sinica.Vol-47: 865–871.
15. Li Wei- xin., Zhang, X.,Wu, B., Sun, S., Chen, Y., Pan,W., Zhao, D., & Cheng, S. (2008). A comparative analysis of environmental quality assessment methods for heavy metal contaminated soils. Pedosphere. Vol-18:344–352.
16. Mar SS, Okazaki M (2012) Investigation of Cd contents in several phosphate rocks used for the production of fertilizer. Micro chemical Journal. Vol-104: 17-21.
17. Roberts TL (2014), Cadmium and phosphorous fertilizers: The issues and the science. Procedia Engineering. Vol- 83: 52-59.
18. Sijin Lu, Yeyao Wang, YanguoTeng, Xuan Yu (2015), Heavy metal pollution and ecological risk assessment of the paddy soils near a zinc-lead mining area in Hunan, *Environ Monit Assess.* Vol-187:627
19. Wong S. C, X. D. Li, G. Zhang, S. H. Qi, and Y. S. Min. (2002) Heavy metals in agricultural soils of the Pearl River Delta, South China, *Environmental Pollution.* Vol-119, (1):33–44.
20. Hang, X.S., Wang, H.Y., Zhou, J.M., Ma, C.L., Du, C.W., Chen, X.Q., (2009). Risk assessment of potentially toxic element pollution in soils and rice (Oryza sativa) in a typical area of the Yangtze River Delta. *Environ. Pollution.* Vol-157:2542-2549.
21. Xiao, R., Guo, D., Ali, A., Mi, S.S., Liu, T., Ren, C.Y., Li, R.H., Zhang, Z.Q., (2019). Accumulation, ecological-health risks assessment, and source apportionment of heavy metals in paddy soils: A case study in Hanzhong, Shaanxi, China. *Environmental Pollution.*Vol-248:349-357.
22. Alengebawy A, Abdelkhalek ST, Qureshi SR, Wang MQ. (2021), Heavy Metals and Pesticides Toxicity in Agricultural Soil and Plants: Ecological Risks and Human Health Implications. Toxics. Vol- 9(3): 42.
23. Martley E, Gulson BL, Pfeifer HR. (2004), Metal concentrations in soils around the copper smelter and surrounding industrial complex of Port Kembla, NSW, Australia. *Sci Total Environ.* Vol-325:113-27.
24. Brian J Alloway. (2013). Sources of heavy metals and metalloids in soils. In: Alloway BJ, editor. Heavy metals in soils: Trace metals and metalloids in soils and their bioavailability. 3rd ed. Dordrecht: Springer; p. 11-50. (Environmental Pollution 22).
25. Gagan Preeti singh sidhu. (2016). Heavy metal toxicity in soils: Sources, remediation technologies and challenges. Adv Plants *Agric Res.* Vol-5:00166.
26. Sana Ashraf, Ali Q, Zahir ZA, Ashraf S, Asghar HN. (2019), Phytoremediation: Environmentally sustainable way for reclamation of heavy metal polluted soils. Ecotox Environ Safe.Vol-174:714-27.
27. Uluozlu. O. D, K. Kinalioglu, M. Tuzen, and M. Soylak, (2007), Trace metal levels in lichen samples from roadsides in east Black sea region, Turkey, Biomedical and *Environmental Sciences,* vol-20(3):203–207.
28. S. Topcuoğlu, Ç. Kirbaşoğlu, and N. Güngör, (2002), Heavy metals in organisms and sediments from Turkish coast of the Black sea, 1997-1998, *Environment International,* vol. 27,(7), pp. 521–526.
29. Tepe .Y., M. Türkmen, and A. Türkmen, (2008), Assessment of heavy metals in two commercial fish species of four Turkish seas, *Environmental Monitoring and Assessment.* Vol-146(1–3):277–284.
30. Akcali. I, and F. Kucuksezgin, (2011). A bio monitoring study: heavy metals in macro algae from eastern Aegean coastal areas, Marine Pollution Bulletin.Vol-62(3): 637–645.
31. Williams, C. H. &Steinbergs, A. (1959), Soil sulphur fractions as chemical indices of

available sulphur in some Australian soils. Aust. *Journal of Agric. Res.* Vol-10: 340–352.
32. Lindsay, W. L. &Norvell, W. A.1978, Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc.* Am. J. Vol-42:421–448.
33. Panel Wasim Yawar, Kashif Naeem, Perveen Akhter, Ishrat Rehana, Muhammad Saeed (2010), Assessment of three digestion procedures for Zn contents in Pakistani soil by flame atomic absorption spectrometry, *Journal of Saudi Chemical Society,* Vol-14(1): 125-129.
34. Christophe Waterlot, Aurélie Pelfrêne and Francis Douay (2012), Effects of Iron Concentration Level in Extracting Solutions from Contaminated Soils on the Determination of Zinc by Flame Atomic Absorption Spectrometry with Two Background Correctors, *J Anal Methods Chem.* 2012: 512709.
35. Gabarrón M., Faz A., Martínez-Martínez S., Zornoza R., Acosta J. A. (2017) Assessment of metals behaviour in industrial soil using sequential extraction, multivariable analysis and a geo statistical approach. *J Geochem* Expl.Vol-172:174-183.
36. Chen L., Wang G., Wu S., Xia Z., Cui Z., Wang C., Zhou S. (2019), Heavy metals in agricultural soils of the Lihe River watershed, East China: spatial distribution, ecological risk, and pollution source. *Int Journal of Environ Res Public Health.* Vol-16(12):2094.
37. Wang, H.H.; Li, L.Q.;Wu, X.M.; Pan, G.X. (2006), Distribution of Cu and Pb in particle size fractions of urban soils from different city zones of Nanjing, China. *J. Environ. Sci.* Vol-18:482–487.
38. Jyothi Rani, Tripti Agarwal and Sudesh Chaudhary (2021) Heavy Metals in Agricultural Soils of National Capital Region, Delhi: Levels and Ecological Risk, *Curr. World Environ.* Vol-16(3):804-817
39. Harikumar, P.S, Nasir, U.P, Rahman, M.P.M., 2009, Distribution of heavy metals in the Core Sediments of Tropical Wetland System. Int. *J. Environ. Sci.* Technol.Vol- 6:225–232.
40. Jie Zhou, Feng, K., Pei, Z., Meng, F., & Sun, J. (2016). Multivariate analysis combined with GIS to source identification of heavy metals in soils around an abandoned industrial area, *Eastern China.* Ecotoxicology.Vol-25(2):380–388.
41. Hakanson, L. 1980. An ecological risk index for aquatic pollution control: A sedimentological approach. Water Res.Vol-14:975–1001.
42. Vanita C., Piar C., Avinash N., Kaur K. J., Pakade Y. B. (2014), Evaluation of heavy metals contamination and its genotoxicity in agricultural soil of Amritsar, Punjab, India. Int *J Res Chem Environment.*Vol-4(4):20-28.
43. Chao, L, Zhou, Q.X, Chen, S, Cui, S, Wang, M.E. (2007), Single and joint stress of acetochlor and Pb on three agricultural crops in northeast China. *J. Environ. Sci.* Vol- 19:719–724.
44. Divisekara, T, Navaratne, A.N, Abeysekara, A.S.K. (2018), Impact of a commercial glyphosate formulation on adsorption of Cd(II) and Pb(II) ions on paddy soil. Chemosphere. Vol- 198:334–341.
45. Kabata-Pendias, A. (2010), Trace Elements in Plants. In Trace Elements in Soils and Plants Fourth Edition; Kabata-Pendias, A., Ed.; CRC Press (Taylor and Francis Group): Boca Raton, FL, USA. pp. 93–122.
46. Masindi, V.; Muedi, K.L. (2018), Environmental Contamination by Heavy Metals. In Heavy Metals; Saleh, H.E.-D.M., Aglan, R.F., Eds.; Intech Open: london, UK, pp. 115–132.
47. Zhou, J.; Zhang, Z.; Zhang, Y.; Wei, Y.; Jiang, Z. (2018), Effects of lead stress on the growth, physiology, and cellular structure of privet seedlings. PLoS ONE, Vol-13:0191139.
48. Lan, M.M.; Liu, C.; Liu, S.J.; Qiu, R.L.; Tang, Y.T. (2020), Phyto stabilization of Cd and Pb in highly polluted farmland soils using ramie and amendments. *Int. J. Environ. Res. Public Health.* Vol-17:1661
49. Narsimha Adimalla, Hui Qian and Haike Wang (2019), Assessment of heavy metal (HM) contamination in agricultural soil lands in northern Telangana, India: an approach of spatial distribution and multivariate statistical analysis Environ Monit Assess.Vol- 191:246
50. Molla S. R., Huq S. M. I. (2004). Availability of some heavy metals in soil due to compost application and its correlation with the growth of AmaranthusGangeticus L. *J Asiat Soc Banglaesh, Sci.* Vol-30:47–56.

51. Kaushik A., Kansal A., Santosh, Meena, Kumari S., Kaushik C. P. (2009), Heavy metal contamination of river Yamuna, Haryana, India: Assessment by Metal Enrichment Factor of the Sediments. *J Hazard Mater.* Vol-164(1):265-270.
52. Punetha D., Tewari G., Pande C., Kharkwal G. C., Tewari K. (2015), Investigation on heavy metal content in common grown vegetables from polluted sites of Moradabad district, *India. J Indian Chem Soc.* Vol-92(1):97-103.
53. MaofeiNi, RongMao, ZhongminJia, RuozhuDong, SiyueLi, (2018), Heavy metals in soils of Hechuan County in the upper Yangtze (SW China): Comparative pollution assessment using multiple indices with high-spatial-resolution sampling, *Eco toxicology and Environmental Safety.* Vol-148:644-651
54. S. Samanta, V. Kumar, S. K. Nag, K. Saha, A.M. Sajina, S. Bhowmick, S.K. Paul, and B.K. Das, (2022), Assessment of heavy metal contaminations in water and sediment of River Godavari, India," *Aquatic Ecosystem Health & Management.* Vol-24(4): 23-33,
55. Ciarkowska, K, Gargiulo, L, Mele, G. (2016), Natural restoration of soils on mine heaps with similar technogenic parent material: A case study of long-term soil evolution in Silesian-Krakow Upland Poland. Geoderma. Vol- 261:141–150
56. Plum, L.M, Rink, L, Haase, H. (2010), the Essential Toxin: Impact of Zinc on Human Health. *Int. J. Environ. Res.* Public Health. Vol-7:1342–1365.
57. Chaudhary S., Banerjee D. K., Kumar N., Yadav S. (2016), Assessment of bio available metals in the sediments of Yamuna flood plain using two different single extraction procedures. *Sustain Environ Res.* Vol-26(1):28-32.
58. Tian K., Huang B., Xing Z., Hu W. (2017), geochemical baseline establishment and ecological risk evaluation of heavy metals in greenhouse soils from Dongtai, *China. Ecol Indic.*Vol-72:510-520
59. Khademi, H., Gabarrón, Marí., Abbaspour, A., Martínez-Martínez, S., Faz, A.,Acosta, J.A., (2018), Environmental impact assessment of industrial activities on heavy metals distribution in street dust and soil, Chemosphere doi: https://doi.org/10.1016/j.chemosphere.2018.11.045.
60. V. Acosta Martínez, S.E. Dowd, Y. Sun, D. Wester, V. Allen (2010), Pyro sequencing analysis for characterization of soil bacterial populations as affected by an integrated livestock-cotton production system, Applied *Soil Ecology,* Vol- 45,(1):13-25.
61. Antil R. S. (2012), Impact of sewage and industrial effluents on soil-plant health. In: Show, K. Y. and Xinxin, G. Industrial Waste. Croatia: Intech Open. 53-72. DOI: 978-953-51-0253-3.
62. Bhushan C., Bhardwaj A., Misra S. S. (2013). State of Pesticide Regulations in India. Centre for Science and Environment, New Delhi. p.1-72.
63. Frenk, S, Ben-Moshe, T, Dror, I, Berkowitz, B, Minz, D. (2013), Effect of metal oxide nanoparticles on microbial community structure and function in two different soil types. PLoS ONE. Vol-8:84441
64. Caetano, A.L, Marques, C.R, Gonçalves, F, da Silva, E.F, Pereira, R. (2016), Copper toxicity in a natural reference soil: Eco toxicological data for the derivation of preliminary soil screening values. Ecotoxicology. Vol-25:163–177.
65. Panagos, P, Ballabio, C, Lugato, E, Jones, A, Borrelli, P, Scarpa, S, Orgiazzi, A, Montanarella, L. (2018), Potential Sources of Anthropogenic Copper Inputs to European Agricultural Soils. Sustainability. Vol- 10:2380
66. Liu, J, Xie, J, Chu, Y, Sun, C, Chen, C, Wang, Q. (2008), Combined effect of cypermethrin and copper on catalase activity in soil. *J. Soils Sediments.* Vol- 8:327–332.
67. Liang, J, Zhou, Q. (2003), Single and Binary-Combined Toxicity of Methamidophos, Acetochlor and Copper Acting on Earthworms EsiseniaFoelide. Bull. *Environ. Contam. Toxicol.* Vol-71:1158–1166.
68. Mzimba SB (2001), Assessment of environmental pollution by residues of copper fungicides used on coffee in Arusha region, Tanzania.
69. Murti C. R. K. (1987). The Cycling of Arsenic, Cadmium, Lead and Mercury in India. In: Thomas C. Hutchinson KMM, ed. Lead, Mercury, Cadmium and Arsenic in the

Environment. Wiley–Blackwell.p.315-333.

70. Singh S., Kumar M. (2006), Heavy metal load of soil, water and vegetables in peri-urban Delhi. Environ Monit Assess.Vol-120:79-91.
71. Hutton M (1983), Sources of cadmium in the environment. Eco-toxicol Environ Saf.Vol-7: 9-24.
72. Alloway BJ, Alloway, B.J, (1995). Cadmium Heavy metals in soils. 2 nd Edition. Blackie Academic (Chapman and Hall). London. 122 - 151.
73. Wang, Y, Chen, C, Qian, Y, Zhao, X, Wang, Q. (2015), Ternary toxicological interactions of insecticides, herbicides, and a heavy metal on the earthworm Eiseniafetida. J. Hazard. Mater. Vol-284:233–240.
74. Jibril, S.A.; Hassan, S.A.; Ishak, C.F.; MegatWahab, P.E. (2017), Cadmium Toxicity Affects Phyto chemicals and Nutrient Elements Composition of Lettuce (Lactuca sativa L.). Adv. Agric., 2017, 1–7.
75. Oumenskou, H.; El Baghdadi, M.; Barakat, A.; Aquit, M.; Ennaji, W.; Karroum, L.A.; Aadraoui, M. (2018), Assessment of the heavy metal contamination using GIS-based approach and pollution indices in agricultural soils from Beni Amir irrigated perimeter, Tadla plain, Morocco. Arab. J. Geosci., Vol-11:692
76. Loi, N.N.; Sanzharova, N.I.; Shchagina, N.I.; Mironova, M.P. (2018), the Effect of Cadmium Toxicity on the Development of Lettuce Plants on Contaminated Sod-Podzolic Soil. Russ. Agric. Sci. Vol- 44:49–52.
77. Vardhan, K.H.; Kumar, P.S.; Panda, R.C. (2019), A review on heavy metal pollution, toxicity and remedial measures: Current trends and future perspectives. *J. Mol.* Liq. Vol- 290: 111197
78. Verma P., Agrawal M., Sagar R. (2015), Assessment of potential health risks due to heavy metals through vegetable consumption in a tropical area irrigated by treated wastewater. *Environ Syst Decis.* Vol-35(3):375-388.
79. Bhagure G. R., Mirgane S. R. (2011), Heavy metal concentrations in groundwaters and soils of Thane Region of Maharashtra, India. *Environ Monit Assess*.Vol-173:643-652.
80. Chen, H., Lu, X., & Li, L. Y. (2014). Spatial distribution and risk assessment of metals in dust based on samples from nursery and primary schools of Xi'an, *China. Atmospheric Environment.*Vol-88:172–182.
81. Radomirovic M, C´ irovic´ Ž, Maksin D, Bakic´ T, Lukic´ J, Stankovic´ S and Onjia A (2020) Ecological Risk Assessment of Heavy Metals in the Soil at a Former Painting Industry Facility. Front. *Environ. Sci.* Vol-8:560415.
82. Semu E, Tindwa H, Singh BR (2019), Heavy Metals and Organo pesticides: Eco toxicology, Health Effects and Mitigation Options with Emphasis on Sub-Saharan Africa. *Journal of Toxicology and Current Research.* Vol- 3: 010.
83. Ratnaike RN (2003) Acute and Chronic Arsenic toxicity. Postgrad Med Journal. Vol-79: 391-396
84. Iwegbue CM. (2012), Metal contents in some brands of biscuits consumed in Southern Nigeria. *Am J Food Technol.* Vol-7(3):160-7.
85. Adegbola R.A, Adekanmbi A.I, Abiona DL, Atere A.A. (2015), Evaluation of some heavy metal contaminants in biscuits, fruit drinks, concentrates, candy, milk products and carbonated drinks sold in Ibadan, Nigeria. Int *Jr BiolChem Sci*. Vol- 9(3):1691- 6.
86. Godwill EA, Jane IC, Scholastica IU, Marcellus U, Eugene AL, Gloria OA. (2015), Determination of some soft drink constituents and contamination by some heavy metals in Nigeria. Toxicol Rep. Vol-2:384-90.
87. Yong Du., Chen, L., Ding, P., Liu, L.L., He, Q.C., Chen, B.Z., Duan, Y.Y., (2019). Different exposure profile of heavy metal and health risk between residents near a Pb-Zn mine and a Mn mine in Huayuan County, South China. Chemosphere. Vol- 216:352-364.
88. Xiangyu Kong, Liu, T., Yu, Z.H., Chen, Z., Lei, D., Wang, Z.W., Zhang, H., Li, Q.H., Zhang, S.S., (2018). Heavy metal bioaccumulation in rice from a high geological background area in Guizhou Province, China. *Int. J. Environ. Res, Public Health.* Vol-15: 2281
89. Zhaoxue Zhang, Z.X., Zhang, N., Li, H.P., Lu, Y., Yang, Z.G., (2020). Potential health risk assessment for inhabitants posed by heavy metals in rice in Zijiang River basin, Hunan Province, China. *Environmental Science Pollution and Research*.Vol-1:12.
90. Zhou, Y.J., Jia, Z.Y., Wang, J.X., Chen, L., Zou, M.M., Li, Y., Zhou, S.L., (2019). Heavy metal distribution, Relationship and prediction

in a wheat-rice rotation system. *Geoderma.* Vol-354:113886.

91. Williams, P.N., Lei, M., Sun, G.X., Huang, Q., Lu, Y., Deacon, C., Menarg, A.A., Zhu, Y.G., (2009). Occurrence and partitioning of cadmium, arsenic and lead in mine impacted paddy rice: Hunan, China. *Environ. Sci. Technol*.Vol-43:637-642.
92. Nahid Vatanpour, Javad Feizy, Hossein Hedayati Talouki, ZarrinEs'haghi, Laura Scesi, Amir Mohammad Malvandi, (2020), The high levels of heavy metal accumulation in cultivated rice from the Tajan river basin: Health and ecological risk assessment, *Journal of Chemosphere.* Vol -245:125639
93. B.J. Alloway (2013), Heavy Metals in Soils - Trace Metals and Metalloids in Soils and Their Bioavailability. *Environmental Pollution book series* (EPOL,volume 22).
94. Hanjie Wen , Yuxu Zhang, Christophe Cloquet, Chuanwei Zhu, Haifeng Fan, Chongguang Luo, (2015), Tracing sources of pollution in soils from the Jinding Pb-Zn mining district in China using cadmium and lead isotopes, Appl. Geochem., Vol-52:147-154.
95. Vojtěch Ettler, Ondřej Šebek, Tomáš Grygar, Mariana Klementová, Petr Bezdička, and Halka Slavíková (2008), Controls on metal leaching from secondary Pb smelter air-pollution-control residues, *Environ. Sci. Technol.* Vol-42 (21):7878-7884
96. Mohsen Ahmadpour, Mohammad Hosein Sinkakarimi, Mohammad Hossein Gorjian Arabi, Mohammadreza Abdollahpour, Amirhossein Mansour, Aref Asgharpour, ImanIslami, Mousa Ahmadpour, Seyed Hamid Hosseini, Mojtaba Shokrollahzadeh Taleshi, Jeffrey Leven good, Paul Hapeman (2022), Minerals and trace elements in a long term paddy soil rice system in the north of Iran: Human health and ecological risk assessment, *Journal of Food Composition and Analysis.* Vol-110:104573.
97. Mohammed H Kailani, Al-Antary TM, Alawi MA. (2021), Monitoring of pesticides residues in soil samples from the southern districts of Jordan in 2016/2017. Toxin Rev. Vol-40:198-214.
98. Vera Silva, Mol H, Zomer P, Tienstra M, Ritsema C, Geissen V. (2019), Pesticide residues in European agricultural soils – A hidden reality unfolded. *Sci Total Environ.* Vol-653:1532-45.
99. Martínez-Mera EA, Torregroza-Espinosa AC, Crissien-Borrero TJ, Marrugo-Negrete JL, González Márquez LC. (2019), Evaluation of contaminants in agricultural soils in an Irrigation District in Colombia. *Heliyon.* Vol-5:e02217.
100. Sharma R. K., Agrawal M., Marshall F. (2007), Heavy metal contamination of soil and vegetables in suburban areas of Varanasi, India. *Ecotoxicol Environ Saf.* Vol-66(2):258-266.
101. Taghipour, H., Amjad, Z., Jafarabadi, M. A., Gholampour, A., and Norouz, P. (2014). Determining heavy metals in spent compact fluorescent lamps (CFLs) and their waste management challenges: some strategies for improving current conditions. Waste Manag. Vol-34:1251–1256.
102. Du, Y., Chen, L., Ding, P., Liu, L.L., He, Q.C., Chen, B.Z., Duan, Y.Y., (2019). Different exposure profile of heavy metal and health risk between residents near a Pb-Zn mine and a Mn mine in Huayuan County, South China.Chemosphere.Vol-216:352-364.
103. Zhao, K.L., Fu, W.J., Qiu, Q.Z., Ye, Z.Q., Li, Y.F., Tunney, H., Dou, C.Y., Zhou, K.N., Qian, X.B., (2019), Spatial patterns of potentially hazardous metals in paddy soils in a typical electrical waste dismantling area and their pollution characteristics. Geoderma. Vol-337:453-462.
104. Liping He, Wei Hu, Xiaofeng Wang, Yu Liu, Yan Jiang, YanbinMeng, Qipeng Xiao, XinxinGuo, Yanfeng Zhou, Yongyi Bi and Yuanan Lu, 2020, Analysis of Heavy Metal Contamination of Agricultural Soils and Related Eect on Population Health-A Case Study for East River Basin in China *Int. J. Environ. Res.* Public.Vol-23(5):56-77
105. Albanese, S., Cicchella, D., (2012). Legacy problems in urban geochemistry. Elements. Vol- 8 (6):423–428.
106. Desaules, A., (2012). Critical evaluation of soil contamination assessment methods for trace metals. Sciences. *Total Environ.* Vol- 426:120–131
107. Li, X., Feng, L., (2012), Multivariate and geo statistical analyzes of metals in urban soil of

Weinan industrial areas, Northwest of China. Atmos. *Environ.* Vol- 47:58–65.

108. YanguoTeng, G., Wu, J., Lu, S.J., Wang, Y.Y., Jiao, X.D., Song, L.T., (2014). Soil and soil environmental quality monitoring in China: a review. *Environ. Int.* Vol- 69:177–199.
109. Al-Wabel, M. I., Sallam, A. E.-A. S., Usman, A. R. A., Ahmad, M., El-Naggar, A. H., El-Saeid, M. H., Al-Faraj, A., ElEnazi, K., & Al-Romian, F. A. (2017). Trace metal levels, sources, and ecological risk assessment in a densely agricultural area from Saudi Arabia. Environmental Monitoring and Assessment. Vol-189 (6):252.
110. Zhou, L., Yang, B., Xue, N., Li, F., Seip, H. M., Cong, X., Yan, Y., Liu, B., Han, B., & Li, H. (2014). Ecological risks and potential sources of heavy metals in agricultural soils from Huanghuai Plain, China. *Environemental Science and Pollution Research.*Vol-21(2):1360–1369.
111. Yang, Z., Jing, F., Chen, X., Liu, W., Guo, B., Lin, G., Huang, R., & Liu, W. (2018). Spatial distribution and sources of seven available heavy metals in the paddy soil of red region in Hunan Province of China. *Environmental Monitoring and Assessment.*Vol-190(10):611

Abbreviations

AAS- Atomic Absorption Spectroscopy
PERI – Potential Ecological Risk Index
CF – Contamination factor
CV – Coefficient variation
TSDR -Toxic Substances and Disease Registry