IMPACT OF COVID-19 ON CONTAMINATION OF SOIL BY HEAVY METALS –A BLESSING TOWARDS SUSTAINABILITY

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Abstract:
Heavy metals present in soil cause a serious global environmental problem and pose a threat to plants, animals, and even to human health. In this study, the impact of heavy metals on soil health during Covid-19 phase has been studied to check out the effect of the shutdown of industries during lockdown on our natural habitat. Soil samples were analyzed for heavy metals using Atomic absorption spectrophotometer (AAS). The soil near industrial waste was contaminated with heavy metals following the order; Fe> Zn > Cr > Ni > Cu> Cd and that away from sludge was found to show the order Fe> Zn > Cr > Cu > Ni> Cd. Soil near sludge is rich in Fe at depth than in upper layer of soil. Soil away from sludge had been reported to have higher concentrations of Zn and Cu than the soil nearby sludge at each corresponding depth. That may be due to less use Zn and Cu compounds in industries, so disposed sludge contains low concentrations of Zn and Cu. Traces of Cd in all the samples were found below the permissible limit of WHO. Soil nearby sludge was found rich in Cr and Ni than the soil away from sludge, which may be due higher percentage of Cr and Ni in the disposed sludge and in upper layers. These results indicate the presence of heavy metals is within permissible limits as per WHO guidelines. Most of the earlier studies has reported that the soil near industries is fully contaminated with heavy metals and affected the health of soil and environment. But the data in the present study suggest that due to shutdown of industries during covid-19 has been proven to be a blessing for our natural habitat and health of soil has been improved.

Keywords: Sustainability, heavy metals, contamination, AAS.

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INTRODUCTION:

Soil health is a balance between its physical, biological and chemical properties and their relationship with overall environment. Keeping the view of crop production, healthy soil can be defined as the soil which produces good quality of crops (suitable for consumption of animal and human beings) and able to sustain further productions.[1] The land used for fruit growing, dairy growing , poultry farm, breeding and keeping of livestock, grazing and horticulture is referred as Agricultural land. (Agriculture act 1947). Soil plays a role of a crucial living ecosystem that assists living beings and act as a binding role among requirements of stakeholder and maintainable supply-chain management, soil science to policy. In ancient times, soil analysis focused on crop production mainly, but presently human health, water quality and change in atmospheric conditions also governed by soil health [2]. Nowadays many industries are near by the agricultural land, the pollutants emitted from these industries are affecting the soil health of this agricultural land in so many ways. That may be via air pollution, water pollution or soil pollution. All the pollutants ultimately reach the soil. So out of these three pollutions, soil pollution is a matter of great concern in the present situation. As this is an era of industrialization, so more and more industries are developing and a decline in the area of agricultural land can be seen nowadays. The environment gets contaminated with heavy metals mainly by industrial effluents. The addition of Arsenic As, Lead Pb, Cadmium Cd, Chromium Cr, Mercury Hg Heavy metals in the soil makes the soil highly polluted.[3] The solubility of heavy metal ions in soil is governed by various factors such as pH, conductivity, moisture content. Heavy metals may enter in the food chain as a result of their uptake by edible plants.[4] Most of the heavy metals are necessary such as Fe, Zn, Mn, Cu, Co and Ni at trace amount for growth and normal functions of plants and animals but excess of any of them may cause acute or chronic toxicity. Heavy metals are reported to oxidative stress to the metabolism of organisms and leads to production of reactive oxygen species at increased level.[5,6]Nucleic acids, proteins, and lipid get affected by these reactive oxygen species and ultimately destroy biological activities of organisms.[5] Long-term effect of heavy metal exposure to human and animals includes mental lapse, kidney failure, and central nervous system disorder.[7] Deposition of Mercury in soil is takes place by many sources like fungicidal spray, fertilizers and dye industries, which affects the oxidative mechanism in plants that results in retardation of plant growth. Pb accumulates in soil by leaded fuel, industrial effluents and old lead plumbing pipes is highly immobile and its quantity cannot be reduced from the soil. It can cause brain related problems in human beings. Arsenic is also highly toxic and carcinogenic.[3] Heavy metals accumulated in soil can also reaches to human being by food chains and exert very harmful effect on the human health. Cultivation of plants in the contaminated soil is the major factor to transmit the harmful chemicals and the metals to the animals and the human beings. The toxicity of Arsenic is depending upon its chemical form. Symptoms of contamination of as are also differing. It restricts the production of ATP by forming complex with coenzymes and cause difficulty in breathing. It also can induce a disorder in human being that results in weakening of immune system and muscles by nerve inflammation. Hg is also very toxic metal; even the traces of mercury can disturb the biochemistry of human beings. Its organic form can induce the neurological disorders, stomatitis, exfoliation of skin and damage to central nervous system. Whereas the inorganic form of mercury can cause gastrointestinal disorders and abortion. Lead has been entered in soil through various sources like gasoline, lead based paint, and mining etc. [8] Lead poisoning is a serious threat to human health. Inorganic form of lead can impart serious effects on the peripheral nervous system, gastrointestinal tract and CNS. Permanent or serious brain damage can take place due to the exposure of lead, Deficiency of Calcium and Zinc in the body may increase the absorption of lead. It can impart serious threat to the brain of children by causing poor development of brain and intelligence quotient.[9,10] In the present study attempts were made to find out the effect of industrial effluents on the trace metal concentration of soil adjacent to industrial area Bawal and to study the effect of Covid -19 on the soil health.

METHODS:

Soil samples were collected from the two sampling sites, that is source 1 (soil nearby sludge) and source 2 (soil away from the sludge) of the industrial area Bawal (Haryana), India. Samples were collected at the five corresponding depth that is 0 cm, 5 cm, 10 cm, 15 cm and 20 cm in self lock polythene bags with proper labeling. After collection, samples were brought to laboratory, dried and sieved through sieve of 2mm pore size and stored in glass vials for further analysis. All the samples were analyzed for the estimation of heavy metals like Fe, Ni, Zn, Cu, Cd and Cr using atomic absorption spectrophotometer.

RESULTS:

Source	**Depth(cm)**	**Fe (mg/kg)**	**Zn (mg/kg)**	**Cu (mg/kg)**	**Cd (mg/kg)**	**Cr (mg/kg)**	**Ni (mg/kg)**
Source1	0	421.6	14.3	7.3	0.24	14.2	5.1
	5	536.9	17.3	3.4	0.39	11.6	9.2
	10	903.4	23.4	9.2	0.41	12.1	8.6
	15	814.9	20.4	0.6	4.6	13.2	10.4
	20	936.4	18.6	5.2	0.29	12.9	11.2
Source2	0	737.3	24.1	8.4	0.36	9.6	6.2
	5	721.4	26.3	9.2	0.32	10.4	7.3
	10	803.8	36.4	10.4	0.44	11.6	7.1
	15	794.1	30.4	7.3	0.42	13.6	8.4
	20	814.4	29.2	7.9	0.3	8.6	7.3

Table 1 Heavy metals in the soil of different source (mg/kg)
(Source 1- nearby sludge, Source 2- 100 meter away from sludge)

	Fe	Zn	Cu	Cd	Cr		Ni
Fe	1						
Zn	0.820539	1					
Cu	0.174152	0.340777	1				
Cd	0.132631	0.595329	-0.27065	1			
Cr	-0.2876	-0.51807	0.22166	-0.26842	1		
Ni	0.767728	0.537518	-0.48914	0.497096	0.48918	1	

Table 2 Correlation matrix of heavy metals of samples (source 1)

	Fe	Zn	Cu	Cd	Cr	Ni
Fe	1					
Zn	0.736251	1				
Cu	-0.12376	0.472429	1			
Cd	0.318763	0.666114	0.412	1		
Cr	0.173976	0.454024	0.07004	0.810101	1	
Ni	0.430561	0.375539	0.41377	0.270139	0.69987	1

Table 3 Correlation matrix of heavy metals of samples (source 2)

PLOTS:

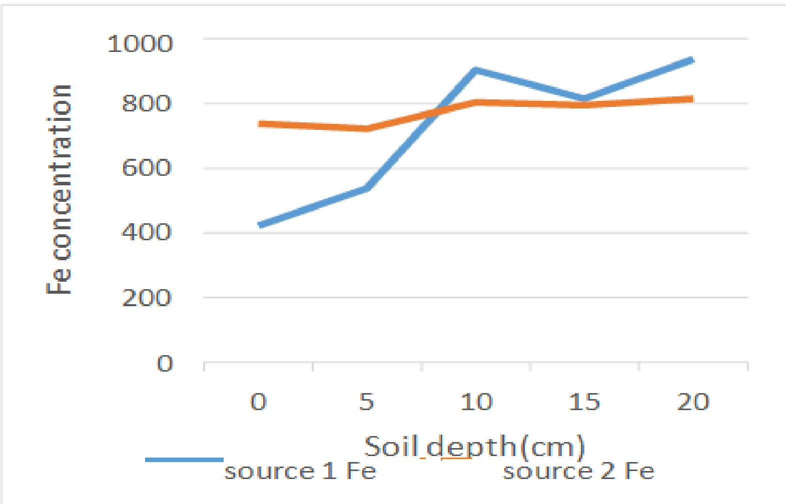

Fig: 1 Fe concentrations (mg/kg) of both thesources with depth

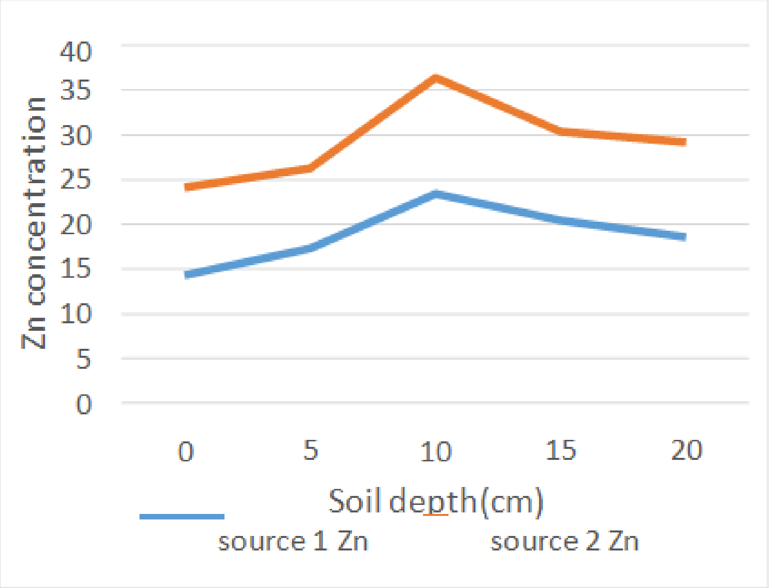

Fig: 2 Zn concentrations (mg/kg) of both thesources with depth

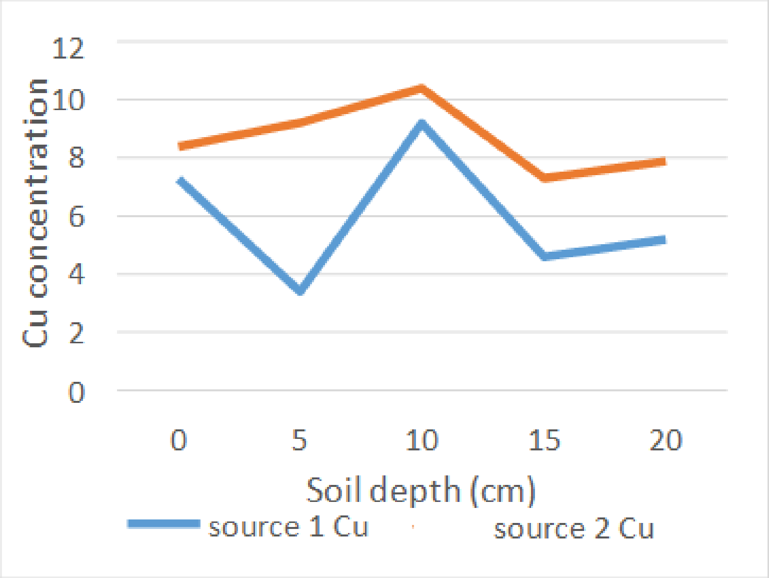

Fig: 3 Cu concentrations (mg/kg) of both thesources with depth

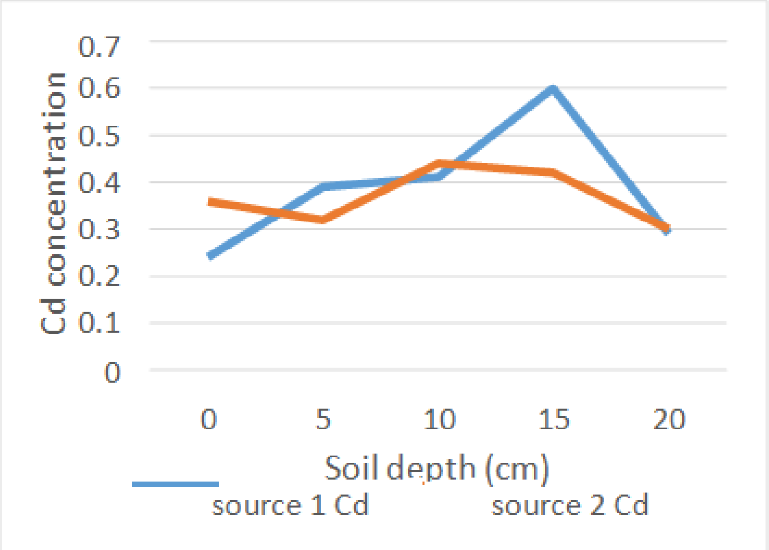

Fig: 4 Cd concentrations (mg/kg) of both thesources with depth

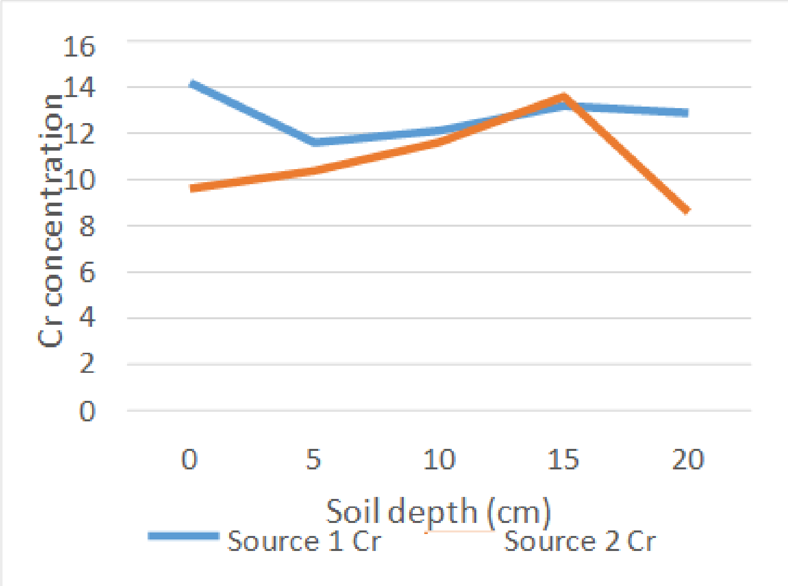

Fig: 5 Cr concentrations (mg/kg) of both thesources with depth

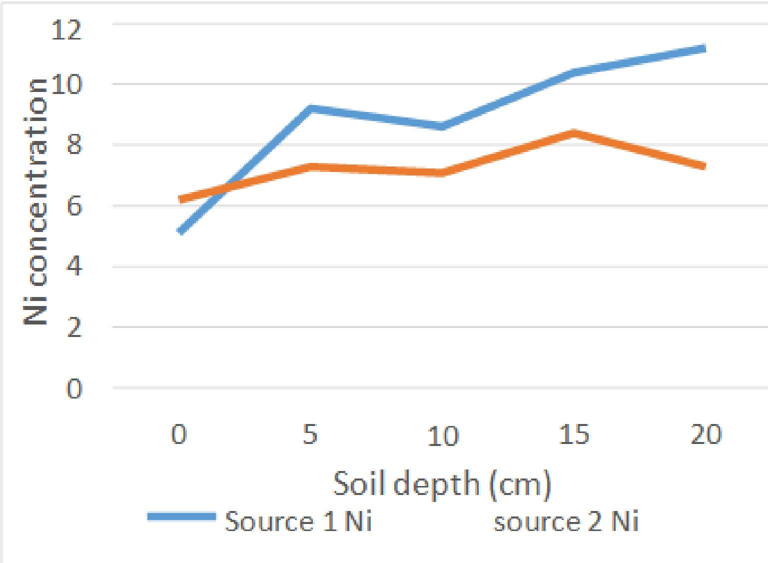

Fig: 6 Ni concentrations (mg/kg) of both thesources with depth

DISCUSSION:

Iron: Fe is the essential element for plants as well as animals and human beings. It is required in a definite amount to the plants and animals. Its deficiency can leads to various neurodegenerative disorders in human being and excessive intake can also become a cause of various diseases in living beings.[11] Soil samples of both the sources have reported the concentration of Fe between the range of 421.6 mg/kg to 936.4 mg/kg. Least concentration of iron was found in sample of 0 cm depth of nearby sludge and highest concentration was also reported in soil of source 1 at depth of 20 cm Table 1).

Concentration of iron in all the collected samples from both the sources was found to increase approximately with depth. Whereas samples collected from soil 100 meters away from sludge are found to show higher concentration at 0 and 5 cm depth than the samples nearby sludge at the same depth as shown in fig1. Soil of both the sources is found rich in iron. The Fe iron concentration in both the samples is found higher than the permissible limits according to WHO. Iron is found to show very good positive correlation (r) with Zn (0.820539 *source 1*, 0.736251 *source 2)* in both the sampling sites. It is found to show very good positive correlation (0.767728) with Ni in the soil nearby sludge and moderate positive correlation (0.430561) in soil away from the sludge. Weak negative correlation of iron has been observed with Cr (-0.2876) in soil of source 1(Table 2) and with Cu (-0.12376) in soil of source 2 (Table 3).

Zinc: Zn plays vital role in various physiological functioning of body like wound healing, brain development and DNA synthesis. [11, 12] . It is an important micronutrient but if present in excess amount in soil, can interfere with the absorption of other micronutrient and macronutrients.[13] Zn concentration was found to show similar trends in both the sampling sites with respect to depth. Soil away from sludge was found rich in Zn concentration at each analyzed corresponding depth as compared to soil nearby sludge. Its concentration was found highest at 10 cm depth and least at 0 cm depth in both the sampling sites. The soil of the first sampling site had shown a concentration in the range of 14.3 mg/kg to 23.4 mg/kg. Whereas soil of the second sampling site had reported concentrations within the range of 24.1 mg/kg to 36.4 mg/kg. Zinc concentrations in both the sampling sites were found below the permissible limit (50 mg/kg) of WHO 1996. Zn showed a very good positive correlation with Fe and moderate to good positive correlation with Ni, Cu (0.340777 *source 1* & 0.472429 *source 2)*, and Cd (0.595329 *source 1* & 0.666114 *source 2*) in both the sampling sites. However, it has been found to show a positive correlation (0.454024) with Cr in the soil away from sludge and a negative correlation (-0.51807) with the same in the soil nearby the sludge.

Copper: Cu is an essential micro element for many enzymes and plant growth. It is generally found to occur in soil, sediments and air. Its concentration has been reported to vary depending on the soil type and pollution source.[14,15,16] Copper concentrations in all the measured soil samples were found in the range of 3.4 to 10.4 mg/kg. Its concentration was found least (3.4 mg/kg) in the soil sample of source 1 and highest (10.4 mg/kg) in soil sample of source 2.In both the sample sites, Cu concentration was found to show irregular trend with depth. But its concentration was found highest at depth of 10 cm in both the sample sites. All the samples had reported the Cu concentrations below the permissible limit of WHO. WHO's permissible limit of copper in soil is 36 mg/kg.[26] Low copper concentration can leads to poor plant growth but high concentration of Cu can induce many unwanted changes in human body like hair and skin decolouration and cause diseases like dermatitis, respiratory diseases, and some other fatal disease in human being.[16] Cu had showed negative correlation with Cd and Ni in the soil of source 1 , whereas it had found to show positive correlation with soil of source 2.

Cadmium: Cd is very toxic and non-essential heavy metal. It can causes learning disabilities and hyperactivity in children, even at very low concentration.[17] Cd can affects our kidney and bones and can impart some serious issues in our body.[18,19] Reduced birth weight and an increase in rate of spontaneous abortion could be the after effects of exposure of Cadmium to becoming mother.[20,21] It has been induced to soil by industrial wastes, pesticides and herbicides, as many Cd compounds are used in chemical industries and it is also in manufacture of pesticides and herbicides.[22] Soil samples had reported Cd concentration in the range 0.24mg/kg to0.6 mg/kg near the sludge, whereas it was found in the range of 0.3 mg/kg to 0.44 mg/kg in soil samples away from the sludge. However all the soil samples had reported the Cd concentration below the permissible range of WHO (0.8 mg/kg). Soil sample at the depth 15 cm had reported highest concentration in samples nearby sludge; it was at 10 cm depth in samples away from sludge. Cd had showed moderate positive correlation with Zn ($r1$ = 0.595329, $r2$ =0.666114) in both the sampling sites. It had reported strong positive correlation with Cr ($r2$=0.810101) in soil samples of source 2 but found to show negative correlation ($r1$=-0.26842) with same in samples of source 1.

Chromium: Chromium is an essential trace element and plays a dynamic role in the metabolism of fat, glucose and cholesterol. Hyperglycemia, increased body fat, and reduced sperm count could be correlated to the deficiency of Cr in body. Whereas its presence at high concentration is toxic and carcinogenic.[23] The Cr contents in the soil samples were found in range 11.6 mg/kg to 14.2 mg/kg and 8.6 mg/kg to 13.6 mg/kg in first and second soil sampling sites respectively. Soil nearby sludge had reported the increased level of Cr with respect to the samples away from the sludge at same corresponding depth as shown in fig 5. However Cr concentration in all the soil samples was found below the permissible limit (100 mg/kg) of WHO. It had showed negative correlation with Fe, Cd and Zn in soil nearby sludge but found to show positive correlation with the same in samples away from the sludge. Top most layered sample had highest concentration and the sample at depth 5 cm had reported lowest concentration of Cr in first sampling site. In second sampling site, lowest concentration was found at 20 cm depth and highest at 15 cm.

Nickel: Nickel is an essential trace element for human, plant and animal health. It is easily absorbed from soil by plant. In human body, Ni is required in small quantities for the formation of red blood cells and the regulation of lipid contents in tissues. But it could be toxic at high concentrations and could be the reason for diseases like skin irritation, reduced body weight, loss of vision, and heart and liver failures. [24, 25] The experimental data revealed that Ni concentration in soil samples occurred in a range of 5.1 mg/kg to 11.2 mg/kg in soil nearby sludge and in a range 6.2-8.4 mg/kg in soil away from sludge.

The permissible limit by WHO 1996 is 10 mg/kg, the concentration values were all within the permissible limit. The correlation matrix revealed the strongest correlation (0.767728) of Ni with Zn in the first sampling site (Table 2) and with Cr (0.69987) in the second sampling site (Table 3).

CONCLUSION

All the studied heavy metals were found within the permissible limit of WHO. In the first sampling site, heavy metals were found to show the order Fe> Zn > Cr > Ni > Cu> Cd and in the second sampling site it was Fe> Zn > Cr > Cu > Ni> Cd as discussed in Table 1. Iron is themost abundant element on the earth and it is required for plant growth in small amounts. It plays a vital role in chlorophyll synthesis and in the proper functioning of certain enzymes. But if present in higher amounts, it could be toxic for plants. Except at the depth of 0 cm and5 cm, soil nearby the sludge was found rich in Fe concentration at a corresponding depth to soil away from sludge which may be due to a higher percentage of Fe in disposed sludge and may reach nearby soil by natural factors. As the samples were collected during lockdown due to Covid -19, so the upper layer of soil nearby the sludge contains less concentration of Fe due to closed industries and about minimum production on those days. Zn had reported the second-highest concentration in both sampling sites. It is an important micronutrient but if present in excess amounts in soil, can affect the absorption of other nutrients. It has been revealed in the present study that the Zinc and Cu both showed similar trends in both sampling sites. They were found in the highest concentration at a depth of 10 cm in both the sampling sites as shown in fig 2,3. Soil away from sludge had reported higher concentrations of Zn and Cu than thesoil nearby sludge at each corresponding depth. That may be due to less use of Zn and Cu compounds in industries, so disposed sludge contains low concentrations of Zn and Cu. Source 1 reported highest concentration of Cd, which may be the due presence of Cd traces in the disposed sludge. Cd in all the samples was found below the permissible limit of WHO. Soil nearby the sludge was found rich in Cr and Ni than the soil away from the sludge, which may be a due higher percentage of Cr and Ni in the disposed sludge. As the level of heavy metals found in the soil was not of too much concern but if it will exceeds the permissible limit, can be very harmful to living beings. In the present study, it can be concluded that the disposed sludge doesn't contain very high level of heavy metal which may be due to its treatment before disposal and as the collection of samples was done during Covid**,** so can be correlated to the effect of Lockdown during Covid -19.As most of the industry's production was almost negligible due to the lockdown.

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