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Heavy metals and physical parameters content of irrigated water to cereals crops grown around the NTPC in Singrauli region

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ABSTRACT
The assessment of the level of contamination is a noteworthy step towards counteracting ecological contamination. Anthropogenic activities are responsible for the contamination of the environment. Determination of heavy metals and physical parameters content were perfumed in samples of irrigated water used in cereals crops grown around the NTPC in Singrauli region. Investigation allowed for two sequential years 2020-2021 and 2021-2022. There are four cereals crops Paddy (Oryza sativa), Wheat (Triticum aestivum), Maize (Zea mays), and Jowar/Sorghum (Sorghum vulgare) were studied for two respective years 2020-21 and 2021-22. All the crops were according to their concern seasons and irrigated with waste irrigated water. Eight heavy metals (Cd, Cr, Pb, Fe, Cu, Zn, Mn, and Ni) were studied in the water samples.
Sampling station was NTPC of Sigrauli region. Irrigated water was shown variable accumulation of heavy metal content, multiple residues determination through AAS and physical parameters were determined through standard methods and suggestion of BIS, WHO. The correlation variation exists along with other supplemented parameters that indirectly affect the water physical parametric and heavy metals content measurements. The increase in growth characteristics with waste irrigated water is evident from data on water analysis, which showed high content of essential nutrients/heavy metals present in the irrigated waste water that established a direct indirect impact on physical parameters of water.
Key words: Cereal crops, heavy metal contents, industries, Singrauli region, acid digestion, AAS, physical parameters.

I. INTRODUCTION

The use of wastewater in metropolitan agriculture has become a general trend for over a century. Thus, heavy metals end up accumulating in plants and soils. Many perilous substances become part of soils and plants by means of dumping of hospital and industrial waste [1,2]. The affected and altered irrigated water directly affected the cereals crops and soil productivity. Effects of heavy metal pollution are reflected in ecosystems in different forms, like lowered productivity, decreased biodiversity, and simplification in structure [3-6]. Soil ecosystems are greatly disturbed by addition of noxious chemicals. Heavy metal percolation in soil causes contamination of underground water sources as well [7-9]. Region of Singrauli known for evolving industrial pollution, main discharge consist heavy metals. Disposal of et al sewage water and industrial wastes is a great problem. Often it is drained to the agricultural lands where it is used for growing crops including vegetables. Heavy metals are ubiquitous in the environment, as a result of both natural and anthropogenic activities, and humans are exposed to them through various pathways [10]. Wastewater irrigation is known to contribute significantly to the heavy metal contents of soil [11]. Heavy metals in wastewater come from industries and municipal sewage, and they are one of the main causes of water and soil pollution. Long-term use of wastewater on agricultural lands contributes significantly to the build-up of the elevated levels of these metals in soils and plants [12-14] which is of serious concern. The current study focuses on the industrial setting and the surrounding agricultural area. Heavy metals are released by industries after being disposed of. It is crucial to periodically evaluate the quality of food items in this region by metal analysis along with the physical profiling of water, due to the significance of these metals for humans and the associated threat they cause, as well as a growth in environmental contamination.

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II MATERIAL AND METHODS

1. Water samples collection and heavy metal analysis of irrigated water

Grab and integrated method givwas used to collect the samples from the sites. Autoclaved and labelled glass bottles and plastic bottles made of fluorinated polymers were used for collection of samples. The samples were immediately taken to the laboratory for analysis and stored at 4^{o}C for further analysis. The heavy metal analysis of the water and crop samples was carried out. Wet digestion method using Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) was followed for analysis. Physical parameters like BOD, COD, were determined through standard method of APHA, 1998, CPCB and WHO. Physicochemical properties of water like electrical conductivity (EC) and pH were determined using Solu-Bridge and pH meter, respectively [10]. For the estimation of carbonate and bicarbonate effluent, aliquot samples were titrated against H_2SO4.

III RESULTS AND DISCUSSION

Irrigated water analysis with physical parameters of collected samples during 2020-21 and 2021-22

During the investigation of water samples for physical parameters during the year 2020-21 in Station-1, the results showed maximum pH value in 1S-II (8.90), EC value (0.570 mS/cm) in 1S-II, OC% (0.06) in 1S-IV, OM% (4.96) in 1S-I, TDS (139.56) in 1S-IV, DO (8.5) in 1S-I, COD (46.58) in 1S- in 1S-V, and BOD (18.65) in 1S-V; However minimum pH value in 1S-V (7.23), EC value (0.550 mS/cm) in 1S-IV, OC% (0.04) in 1S-I, OM% (3.66) in 1S-V, TDS (132.54) in 1S-V, DO (5.36) in 1S-V, COD (38.01) in 1S-I, and BOD (16.34) in 1S-I (Table 1 and 2). The investigation of heavy metals in water samples collected for the same station in the same year found that maximum Cd (0.05±0.3), Cr (0.051±0.3), Pb (0.079±0.2), Fe (1.43±0.3), Cu (0.024±0.4), Zn (0.078±0.2), Mn (1.56±0.3), and Ni (0.36±0.5) analyzed in (1S-III and 1S-V), (1S-I), (1S-I), (1S-I, 1S-V), (1S-I), (1S-IV), (1S-II), and (1S-III) respectively. While for the same station in the year 2021-22, the highest pH value in 1S-II (9.10), EC value (0.568 mS/cm) in 1S-II, OC% (0.07) in 1S-IV, OM% (4.99) in 1S-I, TDS (149.56) in 1S-IV, DO (9.46) in 1S-III, COD (48.58) in 1S-V, and BOD (26.34) in 1S-I. The analysis of Heavy metals in the next year (2021-22) found that maximum Cd (0.06±0.3), Cr (0.059±0.3), Pb (00.089±0.3), Fe (1.55±0.2), Cu (0.049±0.3), Zn (0.084±0.4), Mn (1.64±0.3), and Ni (0.38±0.2) analyzed in (1S-III and 1S-V), (1S-I), (1S-I), (1S-I), (1S-III), (1S-IV), (1S-I), and (1S-III) respectively (Table 1-4, fig. 1,2).

The associated physical nature of soil offers the best ability to bond with other elements, which expedites the problem of metal toxicity at varying levels. The high OM% of the Singrauli water and soil sample supports the likelihood of similar composition. When compared to its geographic position and the presence of mining resources, another study indicated that various metrics pertaining to soil and water data were present in more significant numbers due to other sampling field site variances [11]. The heavy metals of the soil and water samples varied due to geographical alteration and discharge of effluents from industries to surrounding existing agronomic fields selected in our investigation during 2020-2022. Crop quality, quantity, and soil composition are greatly affected by the quality of water used for irrigation. Water contains salts, minerals, and various pollutants but their level differs depending on the source from which the water is obtained. The high concentration of these salts, minerals, and some toxic pollutants like heavy metals present in the irrigation water changes the soil composition and the pollutants are also absorbed by the plants cultivated in such soils [13-15].

The presence of essential compounds in waste irrigated water makes it beneficial for crop production but the presence of toxic pollutants in it drastically affects the physiochemical structure of the soil. Toxic pollutants, especially heavy metals, get easily transferred and bio-accumulated in edible crops such as crops grown in such soil which poses serious health risks among the consumers of such cereals crops [16]. The average BOD level of irrigated water was found to be greater used for irrigation. A similar trend of BOD in wastewater and groundwater was also observed [17]. Similar higher values of COD in irrigated water of different industrial s et ups used for irrigation have also been previously observed by [18]. Comparatively higher amounts of EC in waste irrigated water as observed in the present study also correlate with the similar results obtained in their studies [19]. A higher amount of TDS in waste irrigated water as compared to normal groundwater has also been reported by previous researchers [20]. During the year 2020-21 analysis of water samples was determined in station 1 (NTPC), the correlation was calculated among 8 parameters and the matrix was determined. The results showed that all the

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parameters were uniquely related to itself however maximum positive (0.767368) and negative correlation (-0.65689) was determined between Pb-Cr and Ni-Mn respectively. However minimum positive (0.117041) and negative correlation (-0.09325) was determined between Ni-Cu and Fe-Pb accordingly. Similarly, in years 2021-22 for the same station maximum positive correlation (0.968465) was obtained in Pb-Cr and a negative correlation between Ni-Mn (-0.63714) respectively. Similarly, minimum positive and negative correlations obtained (0.015401) and (-0.01072) respectively recorded between Cu-Cd and Ni-Fe (Table 5 and 6). The correlation variation exists along with other supplemented parameters that indirectly affect the water parametric measurements (fig 3 and 4). The increase in growth characteristics with waste irrigated water is evident from data on water analysis, which showed high content of essential nutrients present in the irrigated waste water.

The composition of wastewater does not remain constant; it changes with time due to several factors The values of water contamination, EC, and pH observed [21] were low during rainy season. EC for water recorded by the WHO was 400 -600 µS/cm, and the present value was higher than the WHO standards [22]. The FAO [23] examined lower values of Cd in waste irrigated water as compared to the present value. The mean Ni value for irrigated water samples varied. In a report a lower value of Ni than the present study. The mean value of Mn for water samples ranged from 1.42 to 1.54 mg/L in the present study. The concentration of Mn observed by Indian Standards [24,25] and the FAO [26] is 0.2 mg/L. The Cu means value varied from 0.021 to 0.045 mg/L in water samples. The permissible value of Cu is 0.2 mg/L according to the Indian Standards [25] and the FAO [26]. In water samples, Cr values ranged from 0.041 to 0.059 mg/L. the value of Cr depend according to the valent based binding which examined chemically [27-29].

Table 1 Concentration of heavy metals in water collected from cereals crops growing station-1 in 2020-21.

Station 1	Heavy Metals (Mean) (mg/l) (n=4)							
	Cd	Cr	Pb	Fe	Cu	Zn	Mn	Ni
1S-I	0.03±0.2	0.051±0.3	0.079±0.2	1.43±0.3	0.024±0.4	0.059±0.5	1.54±0.2	0.22±0.4
1S-II	0.04±0.2	0.044±0.5	0.077±0.4	1.40±0.3	0.020±0.2	0.056±0.4	1.56±0.3	0.26±0.3
1S-III	0.05±0.3	0.042±0.4	0.076±0.4	1.41±0.5	0.023±0.4	0.074±0.2	1.42±0.2	0.36±0.5
1S-IV	0.02±0.2	0.043±0.2	0.073±0.5	1.40±0.2	0.022±0.3	0.078±0.2	1.48±0.3	0.28±0.3
1S-V	0.05±0.3	0.041±0.3	0.070±0.5	1.43±0.3	0.021±0.2	0.044±0.3	1.45±0.5	0.24±0.4
Desirable Limit	0.001	0.05	0.05	0.3	0.05	5	0.2	-
Permissible Limit	0.01	-	0.1	1.0	0.2	15	0.2	-

Table 2 Concentration of heavy metals in water collected from cereals crops growing station-1 in 21-22

Station 1	Heavy Metals (Mean) (mg/l) (n=4)							
	Cd	Cr	Pb	Fe	Cu	Zn	Mn	Ni
1S-I	0.04±0.3	0.059±0.3	0.089±0.3	1.55±0.2	0.045±0.3	0.065±0.5	1.64±0.3	0.23±0.2
1S-II	0.05±0.3	0.057±0.3	0.086±0.5	1.54±0.5	0.043±0.2	0.065±0.3	1.59±0.5	0.27±0.3
1S-III	0.06±0.3	0.053±0.5	0.085±0.5	1.52±0.5	0.049±0.3	0.074±0.4	1.48±0.3	0.38±0.2
1S-IV	0.03±0.2	0.052±0.4	0.083±0.4	1.54±0.4	0.046±0.3	0.084±0.4	1.51±0.5	0.29±0.4
1S-V	0.06±0.3	0.049±0.3	0.081±0.5	1.47±0.4	0.043±0.2	0.057±0.5	1.49±0.3	0.25±0.5
Desirable Limit	0.001	0.05	0.05	0.3	0.05	5	0.2	-
Permissible Limit	0.01	-	0.1	1.0	1.5	15	0.2	-

Table 3 Physical parameter of water sample collected from cereals crops growing station-1 in 2020-21.

Station 1	Heavy Metals (Mean) (mg/l) (n=4)							
	pH	EC (mS/cm)	Organic Carbon%	Organic Matter %	TDS	DO	COD	BOD
1S-I	8.85	0.570	0.04	4.96	135.50	8.5	38.01	16.34
1S-II	8.90	0.562	0.05	4.82	138.74	8.07	46.43	17.26
1S-III	8.80	0.560	0.05	4.81	137.56	8.36	44.82	17.03
1S-IV	8.61	0.550	0.06	4.70	139.56	7.34	45.08	17.56
1S-V	7.23	0.553	0.05	3.66	132.54	5.36	46.58	18.65
Desirable Limit	6.5	0.250	0.01	0.08	-	-	-	-
Permissible Limit	8.5	1.500	25	0.09	-	-	-	-

Table 4 Physical parameter of water sample collected from cereals crops growing station-1 in 2021-22.

Station 1	Heavy Metals (Mean) (mg/l) (n=4)							
	pH	EC (mS/cm)	Organic Carbon%	Organic Matter %	TDS	DO	COD	BOD
1S-I	8.87	0.574	0.05	4.99	145.50	8.45	40.01	26.34
1S-II	9.10	0.568	0.05	4.88	139.74	8.57	45.33	24.26
1S-III	8.66	0.565	0.06	4.94	147.56	9.46	44.92	21.03
1S-IV	8.90	0.558	0.07	4.59	149.56	6.34	45.88	15.56
1S-V	7.69	0.558	0.06	4.22	138.54	6.36	48.58	20.65
Desirable Limit	6.5	0.250	0.01	0.08	-	-	-	-
Permissible Limit	8.5	1.500	25	0.09	-	-	-	-

Table 5 Correlation among various heavy metals present in water samples collected from station-1 during 2020-21

	Cd	Cr	Pb	Fe	Cu	Zn	Mn	Ni
Cd	1							
Cr	-0.47423	1						
Pb	-0.21693	0.767368	1					
Fe	0.303433	0.357787	-0.09325	1				
Cu	-0.24254	0.598565	0.447214	0.417029	1			
Zn	-0.4813	-0.03277	0.234621	-0.62306	0.410578	1		
Mn	-0.45374	0.661223	0.585662	-0.11146	-0.18708	-0.25909	1	
Ni	0.326446	-0.52776	-5.716	-0.5003	0.117041	0.66342	-0.65689	1

Table 6 Correlation among various heavy metals present in water collected from station-1 during 2021-22.

	Cd	Cr	Pb	Fe	Cu	Zn	Mn	Ni
Cd	1							
Cr	-0.33555	1						
Pb	-0.2655	0.968465	1					
Fe	-0.69303	0.81792	0.78073	1				
Cu	0.015401	-0.0502	0.139027	0.23776	1			
Zn	-0.61313	-0.04239	-0.01597	0.528378	0.651845	1		
Mn	-0.40664	0.913515	0.840933	0.654116	-0.39133	-0.26035	1	

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Ni	0.342997	-0.26876	-0.15028	-0.01072	0.839309	0.520855	-0.63714	1

Fig. 1 Concentration of heavy metals in water samples collected from cereals crops growing station-1 in 2020-21.

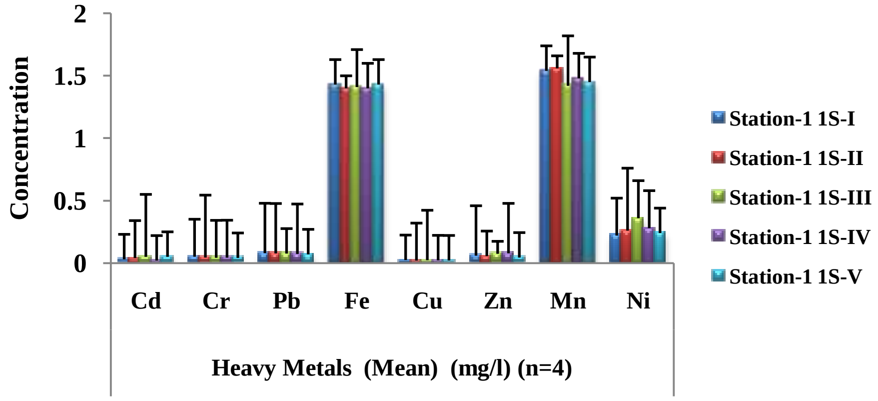

Fig. 2 Concentration of heavy metals in water samples collected from cereals crops growing station-1 in 2021-22

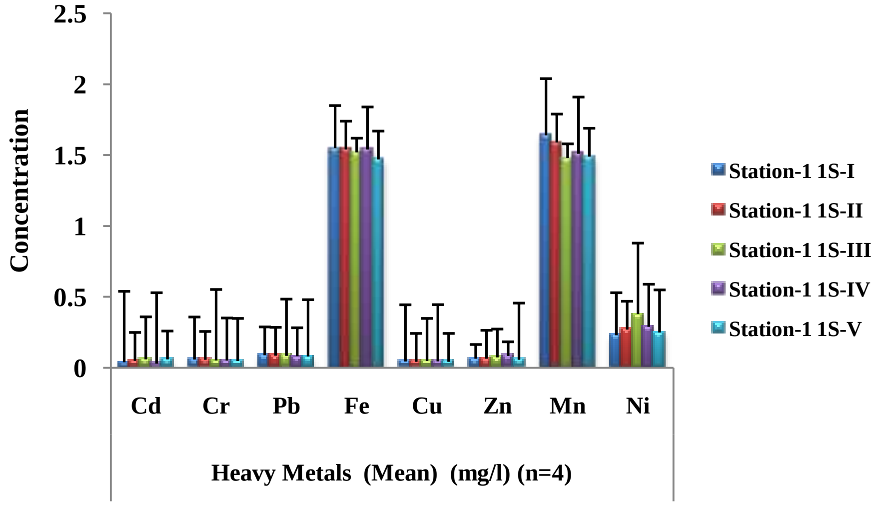

Fig. 3 Correlation among various heavy metals present in water samples collected from station-1 during 2020-21

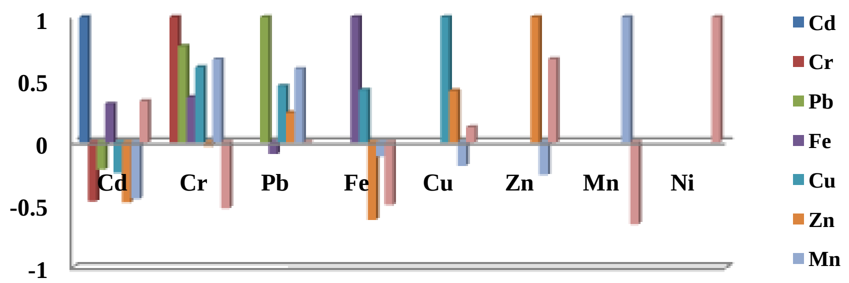

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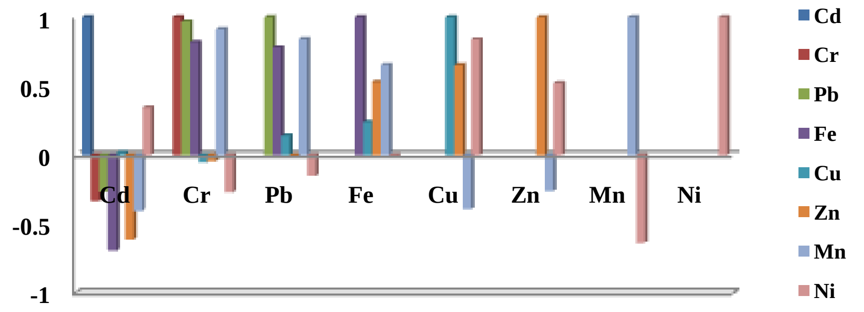
Table 4 Correlation among various heavy metals present in water samples collected from station-1 during 2021-22



IV. CONCLUSION

The associated physical nature of soil and water offers the best ability to bond with other elements, which expedites the problem of metal toxicity at varying levels in present investigation. The heavy metals of the soil and water samples varied due to geographical alteration and discharge of effluents from industries to surrounding existing agronomic fields selected in our investigation during 2020-2022. Crop quality, quantity, and soil composition are greatly affected by the quality of water used for irrigation. Application of untreated waste irrigated water caused toxicity in humans due to metal accumulation. Overall finds highlighted that The pollution load index values indicated that the wastewater-irrigated soils were moderately enriched with Cr, Cu, Ni, Pb, Zn and Cd.

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