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Compairative Study of Heavy Metals Concentration in Water Collected from Different Sewage Irrigated Fields around Bikaner city

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Abstract

In this study, the effect of sewage water irrigation was assessed at 5 agricultural sites around Bikaner city, Rajasthan, India. Variation in heavy metals concentration in sewage water samples were studied during the pre monsoon and post monsoon period in year 2016. Twenty eight water samples were collected from Chandmal baag, Sujandesar, Kadari colony (Shriramsar), Kocharo ka bhaththa (Gangashahar-Bhinasar) and Gharsisar in the month of may-june and october-november. Heavy metals concentrations (like Fe, Zn, Mn, Cu, Cd, Cr, Ni, As and Pb) were determined using atomic absorption spectrophotometer (AAS). The results were compaired with the World Health Organization (WHO) values. The experimental results indicated the presence of heavy metals in sewage water samples and hence refered metal contamination. This concentration of metals is high enough to be accumulated in soils. The t-test was conducted and a drastic decrease in all heavy metals concentration in post monsoon season was recorded. Results also shows that the content of heavy metals in pre monsoon season is higher than the permissible limit of WHO and the content of heavy metals in post monsoon season is less than the permissible limit of WHO. These results suggested that this sewage water has significant health implications for both consumers and farmers and hence, proper health education is essential for women and men who are in contact with sewage during farming and should be treated before use.

Keywords: Sewage water, Irrigation, Health education, Contamination, WHO

INTRODUCTION

All around the world, water scarcity is an increasing problem and it is interlinked with water contamination and pollution. As per WHO estimates, the average water use for

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a person is about 280 litres per day. After usage, the water is returned to environment as "wastewater". This domestic wastewater from its origin to treatment system on its way blended with some of the industrial wastes, pharmacy wastes and also agricultural runoff and termed as "sewage water". Finally, the sewage water is heavily polluted with heavy metals, pharmaceutical compounds, nutrients and all the local wastes specific to the particular locality. Sewage water is complex in nature which requires specialized treatment systems depending on the composition. Sewage composition shows discrepancy from one location to another and it is heavily influenced by biotic and abiotic factors. 18 Biotic factors include humans and their socio-economical behaviour whereas the abiotic factor encompasses all the wastes from food wastes to industrial wastes that are added on its way to treatment.[1-4] The arid and semiarid regions of Rajasthan face severe problem of freshwater scarcity due to very low rainfall. This problem is further aggravated due to indiscriminate use and uncontrolled deterioration of the quality of the surface and groundwater. In addition to this growing population exerts pressure on the agriculture for production of sufficient food material. This forces the farmers to use sewage water for agriculture in the lack of fresh water. Several researches in various countries have found that sewage water use in agriculture can have beneficial effects on the soil health due to its high nutrient content including organic matter, nitrogen and other elements.[5] The sewage water and industrial waste are often drained to agricultural lands where they are used for growing crops, including vegetables. Increasing use of sewage containing domestic and industrial wastes on soils of sewage farms is a common practice in several places. The effect of sewage water utilization is detrimental when the sewage water contains industrial effluents which contribute to several toxicants including heavy metals in the soil and food material. Heavy metals are one of the important types of contaminants that can be found on the surface and in the tissues of fresh vegetables.[6] The prolonged human consumption of unsafe concentrations of heavy metals in foodstuffs may lead to the disruption of numerous biological and biochemical processes in the human body. Nevertheless higher concentrations of heavy metals on land receiving the sewage are of public concern because of possible phytotoxicity or increased movement of metals into the food chain.[7] The heavy metals may also accumulate in the soil at toxic levels as a result of long-term application of untreated segwae waters. Heavy metals like Cd, Cr, Ni, As and Pb are known to cause several diseases in human beings including certain cancers. The excess amount of Fe, Cu, Mn and Zn is also harmful for plants and human beings. Due to their chronic toxic effect and long half life, they have potential hazardous effect on soil characteristics and human health.[8] To minimize the threat of land and ground water contamination, accurate estimation of heavy metals is important. Keeping the above mentioned points, the present study was designed to check the heavy metals concentration of sewage water taken from five different sewage irrigated sites in two different seasons before and after monsoon. Seasonal variation of heavy metals contamination in sewage water samples was determined and the results were compared with the World Health Organization (WHO) values. Experimental data obtained was further statistically analyzed using t- test. The results are reported in mean with the standard deviation.

MATERIALS AND METHOD

Experimental site-Twenty eight water samples were collected from 5 major agricultural sites around Bikaner city, Rajasthan, India. Out of these 28 samples 8 samples are of Chandmal baag (1 to 8), 4 are of Sujandesar (9 to 12), 5 are of Kadari colony (Shriramsar) (13 to 17), 7 are of Kocharo ka bhaththa (Gangashahar-Bhinasar) (18 to 24) and 4 are of Gharsisar (25 to 28).

Sample collection and analysis-All samples were collected for two seasons pre and post monsoon in the month of may-june and october-november in year 2016. Sewage water samples were collected in plastic bottles. 10 ml of samples were taken in 100 ml conical flask followed by adding 15 ml of aqua-regia (HCl : HNO3 @ 3:1). Then the acid digested content was filtered through Whatman No.40 filter paper and the heavy metal was analyzed using an Atomic Absorption Spectrophotometer (AAS) with air-acetylene flame.[9-11]

Statistics- Data collected were subjected to analysis of variance. t-Test was used to determine the significance of the seasonal difference. The significant differences between two seasons were compared.

RESULT AND DISCUSSION

The results for water analysis for pre monsoon and post monsoon period (table 2) shows contamination of heavy metals in the water due to sewage water irrigation. Significant difference at ($p<0.05$) level is observed of pre monsoon sewage water samples for the heavy metals (Fe, Zn, Cu, Mn, Cd, Cr, Ni, As and Pb) as compared to the post monsoon season. The t-test was conducted and a drastic decrease in all heavy metals concentration in post monsoon season was recorded. Higher concentration of metals was observed at sewage water irrigated sites during pre monsoon period as compared to post monsoon period. The content of heavy metals is higher than the permissible limit of WHO (table 1) during pre monsoon season except Ni.[12-15] Ni concentration is low in chandmal baag site. Post monsoon concentration of metals Mn, Cd, Cr, Ni and Pb is lower than the permissible limit of WHO. The possible reason for this could be application of large quantities of sewage water during dry season as compared to the rainy season where minimal or no sewage water is applied to the fields, reducing the concentration of metals. The concentration of Zn, Cu and As is higher than the permissible limit of WHO during both seasons. The concentration of all metals was found to be higher at Kadari colony (Shriramsar) as compared to that found at other 4 sites during pre monsoon season. It may be due to a dye factory is situated in this area. It drains all its effluents in nearby sewage naala.

Several studies support the results obtained in the present study, where long term irrigation with the sewage water containing heavy metals leads to the accumulation of these metals in soil. 143 times more accumulation of Cd in sewage effluent irrigated soils around Calcutta over non-sewage irrigated soils, followed by Pb (18.5 times), Cr (5.6 times), and Ni (2.3 times).

Table 2: Concentrations (mg/lit) of various Heavy metals in sewage water during different seasons

	Pre monsoon									Post monsoon								
S. No	**Fe**	**Zn**	**Cu**	**Mn**	**Cd**	**Cr**	**Ni**	**As**	**Pb**	**Fe**	**Zn**	**Cu**	**Mn**	**Cd**	**Cr**	**Ni**	**As**	**Pb**
Chandmal Baag																		
1	1.8	2.74	0.6	0.4	0.90	0.49	0.20	0.06	1.0	0.76	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
2	1.5	2.72	0.5	0.4	0.70	0.97	0.19	0.06	0.91	0.51	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
3	1.3	2.71	0.5	0.3	0.65	0.97	0.15	0.05	0.89	0.50	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
4	0.9	2.71	0.5	0.2	0.40	0.98	0.14	0.05	0.60	0.15	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
5	0.8	2.66	0.5	0.1	0.03	0.05	0.13	0.05	0.50	0.12	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
6	1.6	2.72	0.5	0.4	0.50	0.60	0.18	0.05	0.91	0.59	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
7	1.5	2.99	0.6	0.3	0.40	0.54	0.18	0.05	0.75	0.50	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
8	1.4	2.97	0.5	0.3	0.37	0.51	0.15	0.05	0.71	0.40	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
Mean	1.35	2.78	0.53	0.3	0.49	0.639	0.165	0.53	0.78	0.44	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
SD	0.34	0.13	0.05	0.11	0.26	0.32	0.03	0.005	0.17	0.22	4.75	0.00	7.42	0.00	0.00	0.00	0.00	0.00
t-Test	6.36	12.85	27.80	6.61	5.31	5.50	16.00	13.75	12.61									
Sujandesar																		
9	1.1	2.91	0.6	0.4	2.50	0.98	0.28	0.07	1.20	0.21	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
10	1.0	2.94	0.5	0.3	2.41	0.97	0.25	0.07	0.90	0.18	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
11	0.9	2.91	0.5	0.3	2.39	0.87	0.21	0.07	0.84	0.15	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
12	0.8	2.90	0.5	0.3	2.30	0.75	0.20	0.07	0.61	0.12	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
Mean	0.95	2.915	0.53	0.33	2.4	0.893	0.235	0.07	0.888	0.165	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
SD	0.13	0.02	0.05	0.05	0.08	0.11	0.04	0.00	0.24	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t-Test	11.65	82.56	18.20	11.00	58.45	16.46	11.63	-	7.22									
Kadari colony (Shriramsar)																		
13	1.8	3.72	0.6	0.6	3.10	2.40	0.37	0.07	1.51	0.75	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
14	1.7	3.50	0.6	0.5	3.00	2.40	0.35	0.07	1.17	0.69	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
15	1.7	3.40	0.6	0.5	2.90	2.20	0.34	0.07	1.12	0.69	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
16	1.6	3.39	0.5	0.5	2.80	2.20	0.35	0.07	1.00	0.61	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
17	2.0	3.94	0.6	0.6	3.30	2.50	0.40	0.08	1.77	0.90	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
Mean	1.76	3.59	0.58	0.54	3.02	2.34	0.362	0.09	1.314	0.728	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
SD	0.15	0.24	0.04	0.05	0.19	0.13	0.02	0.01	0.32	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t-Test	12.38	13.15	25.50	20.00	35.08	38.83	32.03	21.00	9.18									
Kocharo ka bhaththa (Gangashahar-Bhinasar)																		
18	1.5	2.97	0.6	0.4	0.80	1.80	0.29	0.06	1.60	0.51	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
19	1.5	2.94	0.5	0.4	0.77	1.70	0.27	0.06	1.54	0.50	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
20	1.4	2.91	0.5	0.4	0.74	1.70	0.24	0.07	1.40	0.45	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
21	1.4	2.94	0.5	0.4	0.70	1.60	0.28	0.07	1.10	0.46	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
22	1.4	2.93	0.5	0.4	0.79	1.79	0.27	0.07	1.52	0.47	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
23	1.3	2.91	0.5	0.4	0.76	1.69	0.21	0.07	1.45	0.40	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
24	1.3	2.91	0.5	0.4	0.50	1.45	0.20	0.07	1.30	0.39	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
Mean	1.4	2.93	0.51	0.4	0.723	1.676	0.251	0.067	1.416	0.454	2.2	0.07	0.05	0.002	0.01	0.02	0.03	0.01
SD	0.08	0.02	0.04	6.00	0.10	0.12	0.04	0.004	0.17	0.05	4.8	0.00	7.49	0.00	0.00	0.00	0.00	0.00
t-Test	26.73	86.37	31.10	0.10	18.39	36.69	17.34	20.14	21.79									

Pre monsoon										Post monsoon								
Gharsisar																		
25	**1.8**	**2.81**	**0.6**	**0.5**	**1.90**	**2.10**	**0.31**	**0.07**	**1.61**	**1.52**	**2.2**	**0.07**	**0.05**	**0.002**	**0.01**	**0.02**	**0.03**	**0.01**
26	**1.7**	**2.79**	**0.5**	**0.5**	**1.81**	**2.00**	**0.30**	**0.07**	**1.58**	**0.70**	**2.2**	**0.07**	**0.05**	**0.002**	**0.01**	**0.02**	**0.03**	**0.01**
27	**1.6**	**2.77**	**0.5**	**0.5**	**1.71**	**1.81**	**0.24**	**0.07**	**1.49**	**0.60**	**2.2**	**0.07**	**0.05**	**0.002**	**0.01**	**0.02**	**0.03**	**0.01**
28	**1.5**	**2.71**	**0.5**	**0.4**	**1.70**	**1.79**	**0.22**	**0.07**	**1.30**	**0.55**	**2.2**	**0.07**	**0.05**	**0.002**	**0.01**	**0.02**	**0.03**	**0.01**
Mean	**5.025**	**2.77**	**0.525**	**0.475**	**1.78**	**1.925**	**0.268**	**0.07**	**1.495**	**0.843**	**2.2**	**0.07**	**0.05**	**0.002**	**0.01**	**0.02**	**0.03**	**0.01**
SD	**0.13**	**0.04**	**0.05**	**0.05**	**0.09**	**0.15**	**0.04**	**0.00**	**0.14**	**0.46**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
t-Test	**3.41**	**26.39**	**18.20**	**17.00**	**37.76**	**25.50**	**11.19**	**-**	**21.27**									

Table 1: Maximum Allowable Limits of Heavy Metal in Irrigation water (mg/lit)[12-15]

S. No.	**Heavy Metal**	**Maximum permissible level in irrigation water (mg/lit)**
1	Fe	0.50
2	Zn	0.20
3	Cu	0.017
4	Mn	0.20
5	Cd	0.01
6	Cr	0.10
7	Ni	0.20
8	As	0.01
9	Pb	0.05

CONCLUSION

The results obtained from the study show high concentration of heavy metals in sewage water samples. Several studies have shown that these metals are a cause of several fatal diseases including the disruption of vital systems of the body. Heavy metals like Fe, Zn, Cu, Mn, Cd, Cr, Ni, As and Pb are toxic for plants and humans. Pb can cause serious injury to the brain, nervous system, red blood cells, and kidneys.[16] Cd adversely affects the kidney and liver, Cr affects the cardiovascular, hepatic, renal and neurological systems whereas Ni causes decrease in sperm count, motility and loss of fertility in males.[17] Long-term exposure to As is mainly related to increased risks of skin cancer, but also some other cancers, as well as other skin lesions such as hyperkeratosis and pigmentation changes. Inorganic arsenic is acutely toxic and intake of large quantities leads to gastrointestinal symptoms, severe disturbances of the cardiovascular and central nervous systems and eventually death.[18] Cu is indeed essential, but in high doses it can cause anaemia, liver and kidney damage, stomach and intestinal irritation.[19] Fe overload can lead to hemochromatosis, which can lead to liver, heart and pancreatic damage, as well as diabetes. Early symptoms include fatigue, weight loss and joint pain. Excessive iron is never recommended for digestion; it can lead to stomach problems, nausea, vomiting, and other issues.

Ingestion of Zn can result in a variety of chronic effects in the gastrointestinal, hematological and respiratory systems along with alterations in the cardiovascular and neurological systems of humans. Prolonged zinc exposure via these routes has been shown to result in copper deficiency characterized by hypocupremia, anemia, leucopenia and neutropenia; some subjects additionally report headache, abdominal cramps and nausea.[20] Chronic exposure to Mn at very high levels results in permanent neurological damage. Chronic exposure to much lower levels of manganese has been linked to deficits in the ability to perform rapid hand movements and some loss of coordination and balance, along with an increase in reporting mild symptoms such as forgetfulness, anxiety or insomnia.[21,22] Thus the use of untreated sewage water in agriculture fields is a major concern for human health. These results suggested that this sewage water has significant health implications for both consumers and farmers and hence, proper health education is essential for women and men who are in contact with sewage water during farming. It is thus recommended to treat the sewage water prior to use in soil. This investigation showed that sewage water lead to significant pollution of soils, water and plants in and around agriculture fields. These metals, even in trace amounts, interfere with or inactivate enzymes of living cells, therefore their discharge into the environment must be minimized and carefully controlled.[23]

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