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IMPACT OF EFFLUENTS IRRIGATION ON SOIL AND CROP PRODUCTIVITY OF GUMTHALA VILLAGE OF NAGPUR DISTRICT

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ABSTRACT

The study was conducted to estimate the characteristics of food industrial effluents, well and canal water for irrigation and to assess the possible impacts on soil and crop during the year of 2011-12. A total 10 irrigation water samples, out of which 5 effluent mixed (lake) water samples, one canal water sample and 4 well water samples were collected from food industrial area, Gumthala village , Nagpur district during pre-monsoon and post-monsoon season. pH of the untreated effluents from namkin, rasgulla and milk industry was in the range of 7.88 to 7.96, whereas the treated effluent of namkin, rasgulla and milk industry have the pH in the range of 7.42 to 7.68. The pH of canal and well water in the area was in the range of 7.01 to 7.10, this indicates that pH of the effluent was higher than the canal and well water except effluent of the rasgulla and milk industry. The pH values for effluent water, well water and canal water were found within the permissible limits compared with Central Pollution Control Board (CPCB) standards. The EC values of effluent water ranged from 0.62 to 0.81 dS m^{-1} and well water and canal water, the EC values were ranged from 0.42 to 0.52 dS m^{-1} during pre-monsoon season.

The cations (Na^+, K^+, Ca^{2+}, Mg^{2+})in effluent water were ranged from 6.10 to 11.85, 0.192 to 0.265, 0.54 to 0.68 and 1.48 to 1.66 me l^{-1} , respectively while, in well water and canal water cations were ranged from 0.37 to 4.00, 0.025 to 0.040, 0.09 to 0.42 and 0.53 to 1.15 me l^{-1}, respectively. Carbonates and bicarbonate content in effluent water were ranged from 0.44 to 0.55 and 3. 42 to 5.20 me l^{-1}, respectively and in well water and canal water sample ranged from 0.29 to 0.37 and 2. 24 to 3.31 me l^{-1}, respectively during pre-monsoon which were also lowered during post-monsoon season. Sodium adsorption ratio (SAR) in effluent ranged from from 0.29 to 0.37 and 2. 24 to 3.31 me l^{-1}, respectively during pre-monsoon which were also lowered during post-monsoon season. Sodium adsorption ratio (SAR) in effluent ranged from 11.85 to 18.51 during pre-monsoon season which was slightly decreased in post-monsoon season. Chloride content in well water and canal water were lower as compared to effluent.

According to the water class, mixture of treated and untreated effluents of namkin, milk and rasgulla industries, water quality class comes under C2S1 to C3S1 which is moderately high salinity to low sodium hazards. However, the well and canal water SAR ranged from 0.67 to 4.54. The Residual sodium carbonate (RSC) of the effluent except milk industry and lake effluent was higher in range of 2.63 to 3.54 indicating unsuitable for irrigation, because it may develop sodicity in soil by its continuous use. The RSC of milk industry, canal , lake and well water was observed in the range of 1.11 to 2.31 me l^{-1} , which comes under marginally suitable class for irrigation.

The micronutrients (Fe, Mn, Cu and Zn) in effluent was within the permissible limit of National Environmental Quality Standards (NEQS). Soils receiving effluent irrigation and crops grown were containing higher proportion of micronutrients as compared to soils and crops receiving well water and canal water irrigation. The soils receiving mixed industrial effluent irrigation were found rich in available N, P, K and organic carbon as compared to soils receiving well water and canal water irrigation.

From the study the results indicated that the mixture of untreated effluents of rasgulla, milk and namkin is ordinarily unsuitable for irrigation. While other effluents may be used for irrigation on coarse texture soil whereas the canal and well water can be used for irrigation for all types of soil. The micronutrients, N,P,K,pH,EC and organic carbon were found higher in surface soil irrigated with effluents mixed lake water than soil irrigated with well water. The above results confirmed that use of milk effluent water for agricultural purpose, provided not only water but also increased nutrient availability to plant, but efficient treatment of waste water is needed to reduce the salt content.

(Key words : Characteristics of effluents, fertility status, irrigation quality, micronutrient content and waste water)

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INTRODUCTION

Water is becoming an increasingly scarce resource for agriculture. Wherever good quality water is limited, water of marginal quality like sewage and other waste water are used to supplement irrigation needs, particularly in the peri-urban areas. About 3000 M L of wastewater is generated every day in India (Balkrishnan *et al*.,2008) and its economic utilization is emerging as an important dimension in soil and water resource planning. Although wastewater is an important source of plant nutrients (Sreeramulu, 1994) and helps in improving crop yields, its likely adverse impact on soil and human health warrants constant monitoring (Sen *et al.,* 1997).

Use of wastewater in agriculture is gaining importance now a day, because of its value as a potential irrigant and a nutrient donor. Use of wastewater for irrigation makes it possible to conserve the limited water resources for crop production and also prevent pollution of water bodies, as soil is a very good sink. Also application of wastewater to agricultural land may promote the growth of crops and conserve water and nutrients. But the indiscriminate use of the industrial effluents for irrigation to agricultural crops may cause soil and groundwater pollution problems in the long run when they are not properly handled before and after their application to land. The present investigation comprised of the study of effluent characteristics during pre-monsoon and post-monsoon period and the impact of effluent irrigation on soil and crop quality at Gumthala Village.

MATERIALS AND METHODS

The study area (Gumthala village, food industry area) is located at $21^0$13'58.71" N latitude and $79^0$38'03.82"E longitude in Nagpur District of Maharashtra. The total agricultural area in which the effluent was applied is about 100 acres (40.4685 ha). The sites selected for sampling were food industry, Gumthala and its surrounding area. A total 10 irrigation water samples, out of which 5 effluent mixed (lake) water samples, one canal water sample and 4 well water samples were collected during pre-monsoon and post-monsoon season. These water samples were analyzed for pH, EC, cations (Na^+,K^+,Ca^{2+},Mg^{2+}), anions (CO_3,HCO_3,Cl^-) and micronutrient content *viz.,* Fe, Mn, Zn and Cu were determined as per the procedure given by Anonymous (1975). The quality of irrigation water was assessed as per the guide lines of Richards (1954). Soil and plant samples were also collected from this area. A total of 12 soil samples (0-20 cm depth) and 12 plant samples of vegetable and cereal crops were collected from the same sites. Recently matured leaves just before the onset of reproductive stage were taken and processed for analysis using standard methods. Micronutrient content in plant samples were determined from di-acid extracts using AAS as per the method given by Page *et al*.(1982). Soil samples were analyzed for pH, EC and organic carbon as per the procedure given by Jackson (1973), the major nutrients *i.e.* available nitrogen was determined by alkaline permanganate method as described by Subbiah and Asija (1956) ,available P and K were determined as per the method given by Jackson (1973) and available micronutrients (Fe, Mn, Zn, Cu) were determined as per the procedure outlined by Lindsay and Norvell (1978) by using Atomic Absorption Spectrophotometer (AAS).

RESULTS AND DISCUSSION

Quality of irrigation water : The data on the characteristics of irrigation water collected from various sources during pre-monsoon and post-monsoon period of 2011-12 are presented in table1. The data revealed that, pH of the untreated and treated effluents from namkin, rasgulla and milk industry was in the range of 7.88 to7.96 whereas the treated effluent of namkin, rasgulla and milk industry had the pH in the range of 7.42 to 7.68. The pH of canal and well water in the area was in the range of 7.01 to 7.10, this indicates that pH of the effluent was higher than the canal and well water except effluent of the rasgulla and milk industry water. The pH values for effluent water, well water and canal water were found within the permissible limits compared with Central Pollution Control Board (CPCB) standards. The EC values of effluent water ranged from 0.62 to 0.81 dS m^{-1} and well water and canal water, the EC values were ranged from 0.42 to 0.52 dS m^{-1} during pre-monsoon season. Higher value of electrical conductivity was obtained during the rainy season due to increase in concentration of solids, while the value lowered in post monsoon season due to less discharge of solids from processing plant. The cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) in effluent water were ranged from 6.10 to 11.85, 0.192 to 0.265, 0.54 to 0.68 and 1.48 to 1.66 me l^{-1} , respectively while in well water and canal water cations were ranged from 0.37 to 4.00, 0.025 to 0.040, 0.09 to 0.42 and 0.53 to 1.15 me l^{-1}, respectively. Tikariha and Sahu (2014) reported that sodium value was varying from 21.0-83.0 ppm whereas, potassium value was ranging from 5.0 to 16.0 ppm in effluent receiving from milk processing unit in Bilaspur belt of Chhattisgarh. They further reported that higher value of sodium and potassium was obtained in the month of October due to higher influx of sodium and potassium in water used in milk industry for various works while lower values of sodium and potassium was obtained in summer months due to lower influx of sodium and potassium in water used in milk industry for various works.

The data depicted in table 2. revealed that, carbonates and bicarbonate content in effluent water were ranged from 0.44 to 0.55 and 3. 42 to 5.20 me l^{-1}, respectively and in well water and canal water sample ranged from 0.29 to 0.37 and 2. 21 to 3.31 me l^{-1}, respectively during pre-monsoon which were also lowered during post-monsoon season. Sodium adsorption ratio (SAR) in effluent ranged from 11.85 to 18.51 during pre-monsoon season which was slightly decreased in post-monsoon season. Chloride content in well water and canal water were lower as compared to effluent. According to the water class, mixture of treated and untreated effluents of namkin, milk and rasgulla industries, water quality class comes under C2S1 to C3S1 which is moderately high salinity to low sodium hazards. However, the well and canal water SAR ranged from 0.67 to 4.54. The RSC of the effluent except milk industry and lake effluent was higher in range of 2.63 to 3.54 indicating unsuitable for irrigation, because it may develop sodicity in soil by its continuous use. The RSC of milk industry, canal , lake and well water was observed in the range of 1.11 to 2.31 me l^{-1} , which comes under marginally suitable class for irrigation.

The data presented in table 3. indicated that, the micronutrient content (Fe, Mn, Zn and Cu) in effluents water during pre-monsoon ranged from 1.20 to 1.51, 0.13 to 0.25, 0.14 to 0.19 and 0.023 to 0.037 mg l^{-1},respectively. These results were within permissible limits of NEQS (National environmental quality standards).Similarly the micronutrients *viz.,* Fe, Mn, Zn and Cu in well and canal water during pre-monsoon were ranged from 0.42 to 0.78, 0.04 to 0.07, 0.03 to 0.09 and 0.010 to 0.018 mg l^{-1}.The concentration of micronutrients observed higher during pre-monsoon than post-monsoon season. It was two fold higher in effluents water than in the canal and well water. The cation content in effluent water was higher than the well water and canal water. Micronutrient content in well water and canal water were found within permissible limit for irrigation and may not pose any serious hazard (Balakrishnan *et al.,* 2008).However, Balpande and Mhaske (2017) also reported that sewage water of Nag river of four upstream locations in which, micronutrients were below the safe limit. Similarly Choudhari *et al.*(2013) reported that all micronutrients (Fe,Mn,Zn and Cu) content in well water which were collected from various sites in the vicinity of Butibori industrial area were found within permissible limit for irrigation and may not pose any serious hazard.

Fertility status of soil : The data presented in the table 4 showed that, the effluent mixed lake water irrigated soils in the study area are slightly alkaline in reaction with pH ranging from 7.74 to 7.97. The EC values of effluents mixed lake water irrigated soils ranged from 0.51 to 0.85 dS m^{-1} and found to be higher than the well and canal water irrigated soils. This can be attributed to addition of soluble salts in soil by way of effluent irrigation. It was observed that the organic carbon content of effluents mixed lake water irrigated soils were found in higher range of 4.80 to 7.35 g kg^{-1} than that of well and canal water irrigated soils *i.e* 3.45 to 4.20 g kg^{-1}. These findings are in conformity with the work of Kumar *et al.* (1998), who reported that organic carbon status of surface soil samples of effluent irrigated area increased as compared to that which received well water for irrigation. Available N, P and K in effluents mixed lake water irrigated soils ranged from 201.95 to 280.98, 22.84 to 27.78 and 315.80 to 370.19 kg ha^{-1} respectively. In well and canal water irrigated soils available N, P and K ranged from 166.83 to 193.17, 18.59 to 22.17 and 291.20 to 313.60 kg ha^{-1} respectively. Data indicates the usefulness of food industrial effluent as a source of providing the major nutrients. Maiti *et al.* (1998) reported that there was an increase in available N and K content of soil receiving effluent irrigation.

The data depicted in table 5 indicates that the DTPA extractable micronutrients (Fe, Mn, Zn and Cu) in effluent irrigated soil ranged between 5.45 to 7.97, 1.20 to 2.88, 2.33 to 2.67 and 0.80 to 1.20 mg kg^{-1}, respectively. Whereas the corresponding values for the soils irrigated with the canal and well water irrigated soils ranged from 2.15 to 4.41, 0.84 to 1.08,1.38 to 1.62 and 0.40 to 0.97 mg kg^{-1} respectively.

The data presented in table 6 indicates that, among the different crops the micronutrients (Fe , Mn, Zn and Cu) content in effluent mixed lake irrigated spinach and mustard crop were found to be higher than the rest of the crops. The micronutrients (Fe, Mn, Zn and Cu) content in effluent mixed lake water irrigated crops were ranged from 31.95 to 170.10, 16.18 to 111.80, 15.73 to 40.18 and 1.19 to 19.60 mg kg^{-1} respectively, whereas the micronutrients content (Fe, Mn, Zn and Cu) in well water and canal water irrigated crops were ranged from 8.00 to 45.87, 11.00 to 41.52, 15.18 to 26.01 and 3.50 to 5.68 mg kg^{-1} respectively. Saif *et al.* (2005) reported that, waste water mixed with industrial effluent used for irrigation in vegetable growing area, the plant sample had greater concentration of heavy metals than the recommended values. However, soils irrigated with well water was safer and heavy metals quantities were within the limits in soil and plant.

Table 1. Seasonal variation in physico-chemical characteristics of effluents and well water in food industry area of Gumthala village

Sample Site	Season	pH (1:2.5)	EC (dSm^{-1})	Na^+	K^+	Ca^{++}	Mg^{++}
				----------------$mmol_c\ l^{-1}$	-------------		
Untreated effluents of namkin, milk and rasgulla industries	Pre monsoon	7.96	0.81	6.1	0.265	0.68	1.66
	Post monsoon	7.88	0.76	5.6	0.244	0.62	1.61
Untreated effluents of Rasgulla industry	Pre monsoon	6.97	0.64	12.00	0.258	0.52	1.43
	Post monsoon	6.72	0.61	11.26	0.238	0.48	1.37
Treated effluents of namkin, milk and rasgulla industries	Pre monsoon	7.68	0.78	17.50	0.220	0.60	1.60
	Post monsoon	7.42	0.72	15.86	0.210	0.56	1.53
untreated effluents of Milk industry	Pre monsoon	6.90	0.62	11.85	0.192	0.54	1.48
	Post monsoon	6.67	0.58	11.36	0.184	0.49	1.41
Treated effluents discharge at lake	Premonsoon	7.24	0.65	9.85	0.110	0.47	1.27
	Postmonsoon	7.21	0.58	9.56	0.100	0.45	1.23
Canal Water in industrial area	Premonsoon	7.10	0.52	4.00	0.040	0.42	1.15
	Postmonsoon	7.08	0.47	3.72	0.030	0.37	0.83
Well water 0.5 km away from industrial area	Premonsoon	7.09	0.51	3.20	0.029	0.36	1.07
	Postmonsoon	7.07	0.49	3.15	0.018	0.34	0.96
Well water 1 km away from industrial area	Pre monsoon	7.05	0.47	1.10	0.032	0.13	0.67
	Post monsoon	7.03	0.43	0.98	0.017	0.12	0.63
Well water 2 km away from industrial area	Pre monsoon	7.04	0.44	1.01	0.028	0.07	0.81
	Post monsoon	7.01	0.41	0.79	0.023	0.06	0.32
Well water 3 km away from industrial area	Pre monsoon	7.02	0.42	0.37	0.025	0.09	0.53
	Post monsoon	7.01	0.40	0.31	0.021	0.08	0.47

Table 2. Seasonal variation in chemical characteristics of effluents and well water in food industry area of Gumthala village

Sample Site	Season	CO_3^{-2}	HCO_3	Cl^-	SAR	RSC	Water Class
		----------------mmol$_c$ l^{-1} -------------					
Untreated effluents of namkin, milk and rasgulla industries	Pre monsoon	0.55	5.20	2.38	18.51	3.54	C3S1
	Post monsoon	0.51	5.14	2.27	18.36	3.42	C3S1
Untreated effluents of Rasgulla industry	Pre monsoon	0.45	4.50	2.22	12.24	3.00	C2S1
	Post monsoon	0.38	4.20	2.20	11.72	2.63	C2S1
Treated effluents of namkin, milk and rasgulla industries	Pre monsoon	0.48	4.87	2.32	16.82	3.15	C3S1
	Post monsoon	0.42	4.64	2.24	15.54	2.97	C2S1
untreated effluents of Milk industry	Pre monsoon	0.44	3.42	2.21	11.85	1.84	C2S1
	Post monsoon	0.32	3.28	2.17	11.71	1.70	C2S1
Treated effluents discharge at lake	Premonsoon	0.40	3.35	1.28	10.59	2.01	C2S1
	Postmonsoon	0.31	3.24	1.22	10.50	1.87	C2S1
Canal Water in industrial area	Premonsoon	0.37	3.31	1.19	4.54	2.11	C2S1
	Postmonsoon	0.29	3.22	1.12	4.83	2.31	C2S1
Well water 0.5 km away from industrial area	Premonsoon	0.30	2.35	1.16	3.81	1.22	C2S1
	Postmonsoon	0.28	2.32	1.09	3.93	1.30	C2S1
Well water 1 km away from industrial area	Pre monsoon	0.31	2.28	1.13	1.74	1.84	C1S1
	Post monsoon	0.26	2.19	1.05	1.60	1.70	C1S1
Well water 2 km away from industrial area	Pre monsoon	0.33	2.30	1.09	1.53	1.75	C1S1
	Post monsoon	0.27	2.22	1.02	1.83	1.11	C1S1
Well water 3 km away from industrial area	Pre monsoon	0.29	2.24	1.15	0.67	1.91	C1S1
	Post monsoon	0.22	2.12	1.10	0.59	1.79	C1S1

Table 3. Seasonal variation in micronutrient content in effluent and well water as influenced by food industrial effluents

Sr. No.	Sample Site	Seasons	Fe	Mn	Zn	Cu
			(mg l^{-1})			
1	Mixture of untreated effluents of namkin, milk and rasgulla industries	Pre monsoon	1.51	0.25	0.19	0.037
		Post monsoon	1.01	0.20	0.13	0.033
2	Rasgulla industry effluents	Pre monsoon	1.22	0.12	0.15	0.022
		Post monsoon	1.18	0.10	0.13	0.018
3	Mixture of treated effluents of namkin, milk and rasgulla industries	Pre monsoon	1.35	0.18	0.17	0.031
		Post monsoon	1.29	0.15	0.13	0.026
4	Milk industry effluents	Pre monsoon	1.20	0.13	0.14	0.023
		Post monsoon	1.17	0.11	0.11	0.017
5	Treated effluents discharge at lake	Pre monsoon	0.97	0.09	0.12	0.015
		Post monsoon	0.92	0.08	0.10	0.012
6	Canal flowing near industrial area	Pre monsoon	0.78	0.07	0.09	0.018
		Post monsoon	0.73	0.06	0.07	0.015
7	Well water sample 0.5km away from industrial area	Pre monsoon	0.65	0.05	0.09	0.017
		Post monsoon	0.58	0.04	0.05	0.012
8	Well water sample 1 km away from industrial area	Pre monsoon	0.56	0.06	0.06	0.014
		Post monsoon	0.48	0.04	0.05	0.011
9	Well water sample 2 km away from industrial area	Pre monsoon	0.44	0.05	0.05	0.012
		Post monsoon	0.39	0.04	0.04	0.007
10	Well water sample 3-4 km away from industrial area	Pre monsoon	0.42	0.04	0.03	0.010
		Post monsoon	0.38	0.02	0.02	0.005
	NEQS		**2.0**	**1.5**	**5.0**	**1.0**

Table 4. Fertility status of soil as influenced by irrigation water

Sources of Irrigation Water	pH (1:2.5)	EC (dSm^{-1})	O C (g kg^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Soil irrigated with effluents mixed lake water						
Sample -1	7.87	0.82	6.00	245.86	27.33	358.40
Sample -2	7.97	0.58	5.10	228.30	26.43	324.80
Sample -3	7.82	0.85	7.35	280.98	22.84	370.19
Sample -4	7.92	0.56	5.04	219.52	27.78	336.12
Sample -5	7.74	0.69	7.05	263.42	26.21	315.80
Sample -6	7.91	0.53	4.95	210.73	25.76	348.18
Sample -7	7.89	0.51	4.80	201.95	24.64	369.60
Sample -8	7.76	0.75	5.85	237.08	23.07	347.24
Soil irrigated with canal water						
Sample -9	7.60	0.45	4.20	193.17	22.17	313.60
Soil irrigated with well water						
Sample -10	7.57	0.41	3.60	175.61	18.59	302.40
Sample -11	7.58	0.42	3.75	184.39	20.16	291.20
Sample -12	7.54	0.37	3.45	166.83	20.61	312.16

Soil samples	DTPA Extractable (mg kg $^{-1}$)			
	Fe	Mn	Zn	Cu
Soils irrigated with effluents mixed lake water				
Sample -1	7.29	2.88	2.46	1.04
Sample -2	7.61	2.84	2.62	0.80
Sample -3	5.71	1.86	2.33	0.94
Sample -4	6.20	1.40	2.51	1.07
Sample -5	7.38	1.37	2.49	1.20
Sample -6	7.97	1.20	2.67	1.00
Sample -7	6.74	1.66	2.34	0.86
Sample -8	5.45	1.52	2.57	0.88
Soils irrigated with canal water				
Sample -9	4.41	1.08	1.62	0.97
Soil irrigated with well water				
Sample -10	2.35	0.88	1.57	0.50
Sample -11	2.28	0..84	1.42	0.47
Sample -12	2.15	0.86	1.38	0.40

Table 6. Micronutrient content in crop leaves as influenced by irrigation water

Crop leaves	Fe	Mn	Zn	Cu
	(mg kg $^{-1}$)			
Irrigated with effluent mixed lake water				
Cabbage	40.00	35.00	20.00	6.00
Cauliflower	35.00	30.00	25.00	4.00
Brinjal	55.00	42.00	30.00	9.00
Tomato	50.00	40.00	20.00	5.00
Spinach	170.10	111.80	31.00	19.60
Mustard	80.26	30.52	40.18	8.47
Gram	33.95	16.18	15.73	1.19
Fenugreek	31.95	23.90	27.68	1.22
Irrigated with canal water				
Wheat	15.00	19.86	24.58	5.68
Irrigated with well water				
Maize	45.87	15.08	17.48	4.20
Spinach	40.29	41.52	26.01	4.45
Wheat	8.00	11.00	15.18	3.50
Safe limit	**500**	**5-20**	**1-400**	**20-100**

REFERENCES

Anonymous, 1975. Standard methods for the examination of water and waste water. American Public Health Association, Washington, USA.

Anonymous, 2000. National Environmental Quality Standards (NEQS) for municipal and liquid industrial effluents.

Balakrishnan, M., Arul S. Antony, S. Gunasekaran and R K. Natarajan, 2008. Impact of dyeing industrial effluents on the groundwater quality in Kancheepuram (India). Indian J.Sci. and Technol. **1** (7) : 1-8.

Balpande, S.S., Ashok Mhaske, 2017. Quality of sewage water and phytorid technology for its reuse in agriculture, Adv. in plants Agric. Res. **6(6):177-180.**

Choudhari,P.L.,M.M.Raut, D.S.Patil, P.P.Gurav and A.S.Gajare, 2013. Suitability of industrial effluents and well water for irrigation around Butibori industrial area of Nagpur. J.Soils and Crops **23**(2):359-364.

CPCB., 1975. Scheme for zoning and classification of Indian rivers, estuaries and coastal waters, ADSORBS/3 pp.78-79. Central Pollution Control Board, New Delhi.

Jackson, M. L.1973. Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi, India. pp. 38-82.

Kumar Ashok, B. R. Yadav, S. K. Singh and H. Pathak, 1998.Effect of mixed industrial effluent on properties of ground water and irrigated soils. J. Indian Soc. Soil Sci. **46** (3) **:** 427-429.

Lindsay, W. L. and W. A. Norvell, 1978. Development of DTPA soil test for Zinc, iron, maganese and copper. Soil Sci. Soc. America J. **42 :** 421-428.

Maiti, Shriniwashchari, M. Dhskshinamoorthy and G.Arunachalam, 1998. Effect of paper factory effluent on soil available micronutrients and yield of rice. Madras Agric. J. **85** (10-12) **:**564-566.

Page,A.L.,R.H.Millar and D.R.Kenny,1982.Methods of soil analysis, Part 1and 2 Am.Soc.Agron.Madison Wis.,USA.

Richards, L. A. 1954. Diagnosis and improvements of saline and alkali soils. Agricultural Handbook No.60, USDA, Washigton, D.C. pp.160.

Saif, M. Saleem, Midrar-ul-Haq and Kazi Suleman Memon, 2005. Heavy metals contamination through industrial effluent to irrigation water and soil in Korangi area of Karachi (Pakistan). Int. J. Agri. Biol. **7** (4) **:** 646-648.

Sen, T. K. , P. N. Dubey, S. T. Gaikwad and S.Murali, 1997. Soil health and sewage irrigation - A case study in Nagpur district.Agropedology. **7 :** 65-70.

Sreeramulu, U. S.1994. Utilization of sewage and sludge for increasing crop production. J. Indian Soc. Soil Sci. **42 :** 525– 532.

Subbiah, B.V. and G L. Asija, 1956. A rapid method for the estimation of available nitrogen in soils. Curr. Sci. **25 :** 259-260.

Takariha, Ashish and Omprakash Sahu, 2014. Study of characteristics and treatments of dairy industry waste water. J. Applied and Environ.Microbiology, **2** (1) : 16-22.

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