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Studies on Chemical Pollution of Soil by Effluent Released from Cane Sugar Factory

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Abstract

The Present work is taken up to investigate the possible influence of cane sugar factory effluent on the physico-chemical properties and heavy metal contamination of Agricultural land. The effluent sample is collected and analyzed. The Soil samples are collected at sugar factory effluent irrigated area at the depth of 0-15, 15-30, and 30-45cm and the five samples are collected at the depth of 0-15cm at different distances from effluent channel to study the lateral seepage of effluent. These samples are analyzed by standard methods and the heavy metal concentration is estimated by using ICP – AES.

Introduction

Industrial effluents disposal on agricultural land is becoming a wide spread practice[7] (Rajannan and oblilisamy 1979 and Junwarkar and Subramanyam 1987). The main disadvantage of the system in the potential contamination of Ground water resources and agricultural crops with toxic metals and mutagenic or carcinogenic trace organics. Municipal waste waters and Industrial effluents usually contain high amount of heavy, metals such as Fe, Cu, Mn, Zn, Ni, Pb, As and Cd (Larsen et.al. 1975 and Arora *et.al.* 1985). Their continuous use on agriculture land may results in metal accumulation in surface soil. A large volume of organic wastes produced during the period of sugar production and they are discharged on land are the sources particularly without any pretreatment served as a major cause of environmental population (Rao and Datta 1979). Normally effluents discharges from sugar factories contains a large number of chemical pollutants[5]. Toxicity to crops is caused by excess salinity and toxic ions such as Cu, Zn, Na, Ni and Co (Cabriole Bitton 1974). These pollutants amount to a partial or complete alteration in physical, chemical and physiological spheres of the biota (Varma & Shukla 1969). In the present work an attempt has been made to study the chemical pollution of soil by sugar factory effluent discharged from Nizam Duccan Sugar Factory, Bodhan, Nizamabad Dist. of Andhra Pradesh.

Experimental

"The Nizam Sugar Factory (NSF)" was one of the major sugar factories of India. It was established in the year 1938 at Bodhan Dist. Nizamabad of Andhra Pradesh (India) and was run under the government sector. Now its present name is "*The Nizam Duccan Sugar Factory*", is under taken by a private sector during the year 2002 with the crushing capacity of 3500 tones of Sugar Cane and it generates 5 tones of waste water and used for irrigation purpose. The common agricultural crop is Sugar Cane and Paddy.

Effluent Sample is collected in acid washed air tight polythene containers of one litre capacity (APHA, 1995). The soil samples are collected at different depths (0-15, 15-30, 30-45cm) at different locations of agricultural land irrigated with sugar factory effluent by using the core sampler and the control samples also collected at the same depths at the farmers field where un-irrigated with this effluent. In addition five soil samples (LS1, LS2,LS3, LS4 & LS5) are collected at 0-15cm depth at 0, 7.5, 15.0, 22.5 and 30.0 metre distances away from the effluent channel in the breath wise direction to study the lateral seepage of the effluent.

Effluent Analysis :

The various physico-chemical analysis for effluent samples are done very carefully according to the standard methods[10] and the pH and EC of the samples are measured immediately after transportation to the laboratory. For the metal analysis of effluent samples, 500 ml of sample is transferred to one litre beaker, after adding 5ml of concentrated HNO_3 and $HClO_4$(70%) mixture (5+1) on a hot plate, a light coloured residue indicates the completion of digestion. The residue was diluted with double distilled water, filtered (APHA 1995) and analysed for metal contents by using Inductively Couple Plasma – Atomic Emission Spectrophotometer (Mazzucotelli et al., 1991 and Lokhande *et al*., 1996) available at A.P. State Pollution Control Board, Hyderabad (India).

Soil Analysis :

The collected soil sample are air dried in clean room to avoid contamination and ground by wooden pestle and mortar to pass through 2mm sieve. Soil pH is measured in a 1:2 soil to water ratio. The suspension was allowed to stand overnight prior to pH determination. Electrical Conductivity (EC) is measured in saturated extract of soils using an EC meter. Particle size of the soil samples are analysed by hydrometer method[6], soil organic carbon is determined by Wet Oxidation method of Walkley and Black (1934). Cation Exchange Capacity (CEC) and the Exchangable cations (Ca, Mg, Na, and K) are found after the extraction with 1N NH_4OAc at pH 7.0 (leckson, 1975). The extract is analysed for Exchangeable Ca, Mg, Na, and K by Flame photometer. Available N,P, and K are also measured by the standard methods discovered by Subbaiah and Asia[8,9]. Olsen *et. al*., (1954) and Hanway *et al*., (1952) respectively.

To determine the total concentration of heavy metals, acid digestion (HNO_3 $HClO_4$) of soil samples are made as described by Alam *et al*., (1991). After the digestion, the elements are estimated by using Inductively Coupled Plasma – Atomic Emission Spectrometer (ICP – APS).

Results and Discussion

The physico-chemical properties and the heavy metal concentrations of sugar factory effluent is furnished in Table 1. The effluent of the sugar factory which is blackish in colour has lower quantities of suspended and dissolved solids. The pH of the effluent is acidic in nature and the EC values of effluent is 13050 μmcm^{-1}, which is higher than the recommended maximum limit (Kalyanaraman *et al*., 1998). When EC value exceeds 3000 μmcm^{-1}, the germination of all the crops would be affected and it may result in much reduced yield (Lohande *et. al*., 1996). Similar trend was observed by Ramesh[11]. The total solids. BOD, COD, Sulphate, Fluoride and Chloride have been exceeded the permissible limits[2]. Nitrates are common water inorganic pollutants. They are converted into nitrites in the intestines of human beings. These nitrites

Table 1. Physico – Chemical Characteristics and Heavy Metals concentration of Cane Sugar Factory Effluent

Parameters	Contents
Physical Parameters	
1. Colour	Blakish
2. Odour	Disagreeable
3. Total Solids	7177 mgL^{-1}
4. Suspended Solids	66 mgL^{-1}
5. Dissolved Solids	3 mgL^{-1}
Chemical Parameters	
1.pH	4.34
2. Electrical Conductivity (EC)	13050 μmcm^{-1}
3. Bio Chemical Oxygen Demand (BOD)	20339 mgL^{-1}
4. Chemical Oxygen Demand (COD)	37600 mgL^{-1}
5. Total Hardness	2142 mgL^{-1}
6. Nitrate	48 mgL^{-1}
7. Chloride	1600 mgL^{-1}
8. Fluoride	NIL
9. Sulphate	28 mgL^{-1}
10. Phosphate	0.6 mgL^{-1}l
11. Sodium	64.2 mgL^{-1}
Heavy Metals	
1. Cd	0.035 mgL^{-1}
2. Cu	0.024 mgL^{-1}
3. Fe	12 mgL^{-1}
4. Pb	0.047 mgL^{-1}
5. Mn	0.176 mgL^{-1}
6. Zn	0.085 mgL^{-1}
7. Mg	22.3 mgL^{-1}

Tabel 2. The effect of Cane Sugar Factory Effluent on Physical Characteristics of Soil

Sample No.	Depth (cm)	Sand (%)	Slit (%)	Clay (%)	Textural Class	Bulk density (Mg m^{-3})	Pore space (%)
S1	0-15	3.5	36.2	56.2	Clay	1.26	48
	15-30	3.2	35.6	56.3	Clay	1.32	47
	30-45	3.0	35.5	56.7	Clay	1.37	47
S2	0-15	5.4	36.5	57.5	Clay	1.26	48
	15-30	3.4	37.2	57.8	Clay	1.36	48
	30-45	3.0	38.5	58.0	Clay	1.36	45
S3	0-15	6.9	38.1	58.1	Clay	1.36	48
	15-30	5.4	38.7	58.3	Clay	1.35	46
	30-45	3.6	38.0	58.2	Clay	1.37	46
S4	0-15	15.5	36.5	55.7	Clay	1.30	47
	15-30	6.9	36.6	57.5	Clay	1.32	45
	30-45	5.5	37.6	57.2	Clay	1.35	45
S5	0-15	7.3	37.1	56.6	Clay	1.35	48
	15-30	3.5	36.5	58.7	Clay	1.36	45
	30-45	5.3	37.8	59.2	Clay	1.38	43
Control	0-15	15.5	28.6	54.5	Clay	1.22	60
	15-30	14.7	29.5	55.0	Clay	1.23	56
	30-45	10.5	33.3	55.5	Clay	1.26	56
LS1	0-15	4.6	36.0	59.0	Clay	1.25	45
LS2	0-15	5.6	36.2	57.5	Clay	1.21	47
LS3	0-15	3.6	38.1	59.0	Clay	1.24	47
LS4	0-15	5.2	37.2	57.1	Clay	1.22	51
LS5	0-15	5.1	37.5	57.7	Clay	1.23	55

combine with haemoglobin in RBC and forms methaemoglobin with reduced oxygen carrying capcity. In this study the concentration of nitrate is observed as 34mg/l. The total concentration of heavy metals Cd, Cu, Fe, Mn, and Zn are greater than the recommended maximum concentration for irrigation water[1].

Effect of Cane Sugar Factory Effluent on Soil :

Analyses of the both control and effluent irrigated soil samples for mechanical components indicated that they belonged to the clay texture shows in Table 2. The absorption pattern of heavy metals pesticides etc is more in clay soil (Jeevan Rao, 1999). Further the clay content is increasing with depth which is due to the illuviation of clay along with effluents moving down the soil (Prasanth et. al., 1999). The bulk density of the effluent irrigated soil

Table 3. Effect of Effluent on Chemical Characteristics of Soil

Sample No.	Depth (cm)	pH	EC (mmhos /cm)	Available Nutrients (kg hq^{-1})			Organic Carbon (g.kg^{-1}) kg	Exchangeable cations (mol/kg^{-1})			
				N	P	K		Ca	Mg	Na	K
S1	0-15	5.3	0.65	8.52	21	>250	0.3	13.9	3.68	4.10	0.79
	15-30	5.6	0.71					11.5	2.64	3.50	0.68
	30-45	6.0	0.78					9.6	2.55	3.53	0.57
S2	0-15	4.9	0.61	7.82	9	195	0.75	13.13	2.31	3.43	0.62
	15-30	5.4	0.66					10.2	1.66	2.85	0.13
	30-45	5.7	0.70					9.6	1.32	2.65	0.24
S3	0-15	5.2	0.65	7.64	12	250	0.3	13.5	2.95	3.40	0.85
	15-30	5.5	0.70					12.6	2.06	3.15	0.63
	30-45	5.9	0.79					11.1	2.10	2.57	0.56
S4	0-15	4.8	0.70	7.61	15	110	0.25	14.1	2.33	3.69	0.65
	15-30	5.1	0.78					13.8	2.36	3.30	0.47
	30-45	5.5	0.85					11.2	2.39	2.86	0.13
S5	0-15	4.6	0.72	7.55	10	250	0.23	14.5	3.11	3.64	0.98
	15-30	5.1	0.79					12.6	3.10	3.12	0.27
	30-45	5.9	0.86					9.2	2.35	2.92	0.15
Control	0-15	6.9	0.36	5.32	14	130	0.3	4.6	2.75	3.20	0.16
	15-30	7.1	0.40					4.2	2.35	2.80	0.09
	30-45	7.2	0.56					3.1	2.23	2.35	0.05
LS1	0-15	4.8	0.72	7.80	21.1	240	0.35	14.6	3.31	3.15	0.72
LS2	0-15	4.9	0.75	7.60	9.0	185	0.77	13.5	2.46	2.63	0.63
LS3	0-15	5.1	0.69	7.51	11.0	250	0.32	14.3	2.15	2.54	0.54
LS4	0-15	5.4	0.65	8.41	16.1	120	0.27	13.8	2.54	2.89	0.39
LS5	0-15	5.0	0.60	7.91	13.9	140	0.39	13.9	2.51	2.83	0.26

is increased as compared to control soil. Kamalam (1978) reported that the bulk density significantly increased with the concentration of industrial effluent. The total porosity decreases in the contaminated area as compared with the control soil which could be attributed to the clogging of the pores by Grammy substances present in the effluent. This corroborates with the finding of Rajannan and Obiliswamy[7]. Similarly in the soil samples LS1 to LS5, bulk density decreased with distance while the pore space increased. Both the content of bulk density and porespace are nearly closed to values of control soil at the distance of 30cm (LS5). This Indicated that the effluent seepages into the soil up to 30m from the effluent channel.

Impact on Chemical Characteristic of Soil:

The data on chemical characteristics of soil are presented in Table 3. Soil pH plays a vital role on the availability of nutrients, metal elements, existence of micro organisms and maintenance of physical properties. In the present study : Soil pH in top, middle, and

Table 4. Heavy Metals Concentration in the Soil Samples

Sample No.	Depth (cm)	Zn	Cu	Cd	Ni	Cr	Mn	Fe (%)	Mg (%)
S1	0-15	99.50	62.00	9.10	88.50	63.00	1200.00	16.10	3.50
	15-30	91.40	53.85	8.65	76.81	61.70	1160.70	15.20	3.25
	30-45	82.70	48.88	7.95	66.90	55.50	1065.00	13.50	2.80
S2	0-15	92.50	58.90	8.65	81.00	73.00	1010.00	11.50	2.80
	15-30	86.65	48.75	7.75	71.05	68.75	985.25	9.80	2.25
	30-45	83.20	43.80	6.50	62.25	56.50	895.00	7.80	1.95
S3	0-15	110.00	66.50	8.25	92.15	134.00	825.00	15.20	3.75
	15-30	102.20	55.70	7.75	86.60	105.50	805.50	16.50	3.00
	30-45	92.75	48.30	6.50	78.50	97.45	765.00	13.50	2.75
S4	0-15	82.50	53.50	7.50	82.25	124.00	1006.00	12.00	2.50
	15-30	81.25	52.30	5.25	78.15	115.00	865.70	11.50	2.25
	30-45	76.80	47.40	5.00	69.90	110.00	835.50	9.90	2.00
S5	0-15	92.00	59.00	7.75	89.00	128.75	1250.00	16.00	3.50
	15-30	94.50	60.00	7.50	87.50	132.50	107.00	11.35	2.50
	30-45	94.95	55.00	7.00	82.50	110.00	989.00	9.90	2.30
Control	0-15	83.50	26.50	4.85	39.00	28.50	425.00	7.75	1.50
	15-30	56.50	22.00	3.75	35.75	24.50	350.00	5.61	1.20
	30-45	54.00	21.15	3.50	33.95	16.80	330.50	5.50	0.95
LS1	0-15	101.00	62.00	8.25	92.00	123.00	1210.00	15.25	3.25
LS2	0-15	92.70	55.00	8.00	91.50	109.00	1160.00	10.50	3.00
LS3	0-15	85.75	50.75	7.50	84.50	95.80	1010.50	9.90	2.65
LS4	0-15	82.90	46.60	5.50	78.25	91.10	975.20	9.25	2.10
LS5	0-15	81.20	34.95	5.20	60.00	78.50	788.50	8.50	1.75

bottom soils varies from 4.3 to 4.9, 5.2 to 5.7, and 5.8 to 6.1 respectively and it shows in strongly acidic whereas in control soil is in neutral (Jeevan Rao 1999). Under these conditions most of the micronutrient element are expected in large quantities soil-water (Vasu *et al*., 1998). The increasing in mean EC values was niticed in soil of the area compared to control and this is due to disposal of effluent on land as reported by Prashanthi *et al*. (1999). The soil EC is also increased with depth. Similar view was expressed by Ranbir Singh *et al*.[12]. The higher values of EC at the depth of 30-45 cm in the contaminated soils are due to higher soluble salt concentration (Prasanthi et al. 1999). The organic carbon content of the effluent irrigated soils is greater than control, this may be due to addition of organics through the effluents. Similarly Bansal *et al*. (1992) reported that the organic carbon was more in the top soil and decreased as depth increased while studying the soil irrigated with industrial waste water at Jamalpur in Punjab. The available nitrogen, phosphorus and potassium content are also higher in contaminated soil as compared to control soil. These higher values shows the contamination of soil by soil as compared to control soil. These higher values shows the contamination of soil by effluents. Similar trend was reported by Olaniya et al. (1995).

Concentration of Heavy Metals:

The heavy metal concentration in the soil of the study area in comparison with control soil is furnished in the table – 4 the total Zn, Cu contents increased as compare to control and it ranged from 76 to 110ppm and 43.8 to 65.5ppm the potential for phyto toxicity by Zn, Cu exists not only in the total content of an element also in the chemical forms of the elements. It is observed from the analysed data total heavy metal concentration in sugar factory effluent irrigated soil increased as compare to control as reported in literature (Davies 1980, Satya nagarayana 1992, Jeevan Rao & Samaram 1994 & Chowdary & Chavad 1999), among the chemical parameters EC., COD, BOD of effluent seems to have greater influence on the accumulation of heavy metals in effluent irrigated soil.

The content of various chemical properties and the total concentration of metals in the soil samples (LS1 to LS5) collected at different distances from the effluent channel are also given in Table 3&4. The soil sample LS5 shows the values which are nearly closed to the control soil. It clearly indicates that the effluent discharged from the sugar mill, laterally seepages up to 30 m on from the effluent channel.

The results shows that the effluent contains higher concentration of salts. High osmotic pressure caused due to these higher values of salts concentrations, might be the cause for a rapid decrees in percentage of germination[8] on seedling. The heavy metals decrees root respiration water and nutrient up take and in root mearistematic reason. Further heavy metals reduce enzymatic activity and the microbial and micro faunal populations in soil (Jeevan Rao 1999). Thus present study reveals that the study area is contaminated by the application of sugar factory effluent discharged from Nizam Duccan Sugar Factory, Bodhan (A.P). The higher concentration of metals may enter into human and animal through food chain and it becomes harmful.

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