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CHARACTERISATION OF DAIRY INDUSTRY EFFLUENT AMENDED SOILS IN WARANGAL, ANDHRA PRADESH

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The dairy industry effluent amended soils were characterized for their physical, chemical and biological parameters and enzyme production during 1995-96. pH showed an increasing trend in polluted soils over control soil. The mean bulk density of the soils was 1.4 g/cm^3. The water holding capacity was high in polluted soils. The chemicals in the soils varied considerably with changes in locations and load of pollutants in effluents. Five microbial enzyme viz., cellulase, catalase protease, a -amylase, and urease were shown their considerable fluctuation in polluted and control soils.

Key Words: Dairy industry, effluents, physico-chemical and biological characterisation, heavy metals, enzymes.

Dairy industry is one of the leading industries in India, producing lot amounts of milk and its related compounds, generating high amounts of effluents (Ajmal *et al.*, 1984). The application of these effluents on the surface of the soil results in the degradation of soil quality and proliferation of disease causing micro-organisms (Page, 1974; Megharaj *et al.*, 1986; Kapoor *et al.*, 1989; Rijke, 1989; Hattingh, 1990; Omer *et al.*, 1994; Brady, 1995). Warangal Dairy was started in the year 1969 with handling capacity of 25,000 litres per day. It has six milk routes and 27 milk collection centres with 2361 milk producers. The processes of dairy industry includes fat tests, acidity tests etc. with various chemicals such as sulphuric acid, nitric acid amyl alcohol, costic soda, excess amount of milk sugar lactose, casein etc. In the present study the soils amended with dairy industry effluents were characterised and assessed during 1995-96.

Two soil samples were taken every month from the 0-15 cm depth in polluted and control (garden

Table 1. Physical characteristics of soils amended with dairy industry effluents in Warangal during 1995-1996

	1995						1996							
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	M.V.	S.E.
pH														
A:	7.0	7.5	7.5	8.0	7.0	7.0	7.5	7.0	7.0	7.5	7.0	8.0	7.33	±0.12
B:	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.00	±0.00
Bulk Density (g/cm^3)														
A:	1.31	1.29	1.42	1.26	1.17	1.16	1.36	1.32	1.21	1.26	1.19	1.36	1.28	±0.54
B:	1.19	1.23	1.26	1.39	1.26	1.36	1.42	1.41	1.23	1.32	1.38	1.28	1.31	±0.52
Pore space (%)														
A:	50.6	51.3	46.8	52.5	55.9	50.2	48.7	50.2	54.3	55.1	55.1	48.7	51.6	±1.13
B:	55.1	53.6	52.5	47.6	52.5	46.7	46.4	46.7	53.6	50.2	47.9	51.7	50.4	±0.95
Water holding capacity														
A:	22.9	20.1	22.9	21.8	20.4	20.8	20.6	22.6	25.4	24.3	25.6	25.9	22.8	±0.64
B:	24.2	23.4	22.8	20.3	20.3	21.9	19.7	20.2	21.8	20.6	24.8	24.9	22.4	±1.73
Conductivity (μ mho/cm)														
A:	0.98	0.80	0.84	0.32	0.26	0.59	0.48	0.68	1.79	0.98	4.28	0.94	2.85	±1.29
B:	0.62	0.46	0.17	0.37	0.19	0.20	0.68	0.72	1.02	0.98	0.44	1.28	0.49	±0.33
Permanent wilting co-efficient														
A:	7.89	6.93	7.89	7.52	7.04	7.12	7.13	7.19	8.76	8.38	8.80	9.62	7.86	±0.47
B:	8.35	8.07	7.85	7.00	7.55	6.79	6.93	7.52	7.79	8.39	8.89	8.93	7.84	±0.28

A - Polluted; B - Unpolluted; M.V. - Mean Value; S.E. - Standard Error

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Table 2. Chemical characteristics (mg/g) of soils amended with dairy industry effluents in Warangal during 1995-1996

	1995						1996						Mean Value	Standard error
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June		
Alkalinity														
A:	0.10	0.38	0.10	0.08	0.06	0.32	0.36	0.36	0.28	0.24	0.16	0.24	0.22	±0.03
B:	0.06	0.10	0.08	0.04	0.06	0.14	0.08	0.20	0.16	0.06	0.01	0.20	0.09	±0.01
Chlorides														
A:	2.69	2.05	2.55	2.13	1.13	1.52	3.55	4.82	6.06	1.91	2.05	3.97	2.87	±0.42
B:	1.77	2.05	1.42	1.27	1.56	1.42	1.98	1.98	2.13	1.27	0.92	2.13	1.66	±0.11
Calcium														
A:	6.33	3.12	7.53	1.76	3.68	3.20	19.4	9.77	5.13	10.4	4.08	3.68	2.87	±0.42
B:	4.84	2.48	5.29	1.44	1.76	1.92	6.41	9.45	7.85	4.94	7.05	9.29	1.66	±0.17
Magnesium														
A:	5.35	0.68	2.04	0.19	0.97	2.33	0.12	0.68	2.04	2.82	2.19	1.55	1.75	±0.41
B:	3.89	1.26	3.99	4.71	0.48	0.55	1.36	5.83	0.49	1.12	1.36	0.48	2.21	±0.53
Calcium carbonate														
A:	46.0	42.5	23.5	25.5	29.0	33.5	30.5	45.0	35.5	36.5	40.5	36.0	3.53	±0.21
B:	37.5	28.0	27.5	22.5	36.0	42.5	30.0	36.0	31.0	29.0	40.5	20.0	3.17	±0.20
Aluminium														
A:	0.05	0.04	0.10	0.06	0.07	0.14	0.18	0.12	0.19	0.12	0.07	0.22	0.08	±0.01
B:	0.04	0.05	0.04	0.04	0.13	0.10	0.62	0.11	0.14	0.18	0.12	0.08	0.07	±0.01
Silica														
A:	0.78	0.80	0.58	0.66	0.56	0.45	0.30	0.52	0.68	0.54	0.72	0.52	0.59	±0.04
B:	0.45	0.25	0.45	0.35	0.21	0.37	0.71	0.43	0.54	0.74	0.72	0.56	0.48	±0.05
Sodium														
A:	8.4	9.4	18.8	2.4	1.2	1.2	4.5	3.3	9.6	23.2	27.6	4.5	1.65	±0.07
B:	0.9	2.3	1.2	0.6	0.9	0.6	4.3	0.9	2.3	1.5	2.0	0.6	1.50	±0.03
Postassium														
A:	1.24	0.48	0.37	0.68	0.56	0.32	0.60	0.69	0.42	1.34	1.67	0.57	0.74	±0.12
B:	0.39	0.48	0.44	0.42	0.43	0.44	0.48	0.52	1.08	0.69	0.74	0.54	0.54	±0.05
Iron														
A:	0.05	0.60	0.22	0.09	0.70	0.22	0.28	0.08	0.16	0.62	0.29	0.32	0.29	±0.07
B:	0.92	0.70	0.90	0.08	0.18	0.09	0.08	0.15	0.09	0.23	0.16	0.48	0.27	±0.07
Sulphates														
A:	0.1	13.0	9.0	4.2	6.0	9.0	1.6	6.5	16.0	0.8	8.5	18.0	9.27	±1.36
B:	7.5	9.5	6.5	4.3	5.5	1.7	3.5	3.3	6.1	5.5	6.8	5.6	5.48	±0.60
Phosphates														
A:	8.0	35.0	182.0	58.0	60.0	72.0	156.0	156.0	220.0	86.0	240.0	156.0	119.0	±21.8
B:	9.0	22.0	78.0	25.0	48.0	58.0	140.0	128.0	86.0	46.0	80.0	72.0	66.0	±11.4
Nitrates														
A:	0.42	0.46	0.72	0.46	0.29	0.46	0.54	0.48	0.78	0.58	0.60	0.52	0.05	±0.01
B:	0.34	0.28	0.41	0.45	0.56	0.52	0.74	0.72	0.96	0.48	0.62	0.46	0.05	±0.01
Nitrites														
A:	0.17	0.34	0.16	0.26	0.39	0.26	0.33	0.21	0.26	0.14	0.15	0.61	0.27	±0.03
B:	0.15	0.22	0.14	0.19	0.25	0.21	0.38	0.09	0.12	0.22	0.17	0.22	0.19	±0.02
Ammonia														
A:	0.25	0.23	0.26	0.35	0.58	0.39	0.46	0.35	0.46	0.15	0.33	0.35	0.38	±0.03
B:	0.23	0.38	0.32	0.72	0.25	0.45	0.29	0.56	0.34	0.17	0.36	0.92	0.41	±0.06
Organic matter (%)														
A:	72.4	58.9	48.6	66.2	65.2	65.2	37.2	64.2	65.2	52.9	34.1	27.5	54.79	±4.26
B:	52.8	47.6	54.8	53.8	24.8	27.9	53.8	58.9	71.4	41.7	36.6	25.9	45.84	±4.22

A-Polluted: B-Unpolluted

soil 4 kms away from industry) sites and immediately brought to the laboratory. Soils were screened through an ASTM No. 10 sieve and analysed. Physical and chemical characteristics, were analysed in the soils as methods suggested by APHA (1985) and Trivedy *et al.* (1987). The heavy metals-mercury, cadmium, cobalt, chromium and lead were analysed using atomic absorption spectrophotometer. The biological organ-

Table 3. Enzymes in soils amended with dairy industry effluents in Warangal during 1995-1996

	1995						1996						Mean	Stan-ard
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Value	error
Cellulase (REA-Relative Enzyme Activity)														
A:	304.8	284.4	400.0	189.9	286.5	189.8	160.0	153.7	160.0	282.5	278.3	304.9	249.9	±22.18
B:	248.8	284.1	307.7	294.1	232.6	229.9	142.9	140.9	141.8	250.0	278.6	306.8	238.1	±18.38
Catalase (units)														
A:	1.9	2.6	1.5	1.6	2.1	4.2	1.8	0.9	0.6	1.6	1.8	1.9	1.8	±0.26
B:	1.8	2.2	1.8	2.2	2.1	5.9	0.9	0.8	1.8	1.7	1.4	0.8	1.95	±0.39
a -amylase (units)														
A:	1.12	0.90	0.08	0.10	0.12	0.10	1.55	2.30	1.10	0.34	0.29	0.17	0.67	±0.21
B:	0.80	0.18	0.18	0.48	0.16	0.08	1.64	2.29	3.42	0.18	0.16	0.09	0.81	±0.31
Protease (mg/g)														
A:	0.36	0.35	1.22	0.66	1.50	0.96	1.84	2.46	1.41	0.92	0.62	0.71	1.08	±1.18
B:	0.26	0.12	0.34	0.36	1.00	1.11	1.92	2.66	3.59	0.56	0.41	0.28	1.05	±0.25
Urease (mg/g)														
A:	0.42	0.21	0.74	0.57	0.83	1.25	0.64	1.68	1.08	0.94	0.88	0.92	0.85	±0.11
B:	0.36	0.17	0.43	0.13	0.96	1.50	0.48	0.80	1.20	0.52	0.68	0.74	0.58	±0.09

A-Polluted B-Unpolluted

isms-fungi, bacteria and actinomycetes were quantified in the soils as methods suggested by Aneja *et al.* (1993). The soil enzymes such as, cellulase, catalase, protease, a -amylase and urease were analysed methods suggested by Ross *et al.* (1996). The parameters analysed were presented in Tables 1-3.

pH is an important factor in the characterisation of soil systems and its range was in between 7-8. The pH in control soil was always 7. The bulk density of the soil at dairy industry showed maximum value in the month of September with the mean value of 1.41 g/cm^3. The maximum porosity was recorded in the polluted soils in the month of September and in control soils in January. The water holding capacity of the soils at dairy industry ranged between 20.1 to 25.9 and in control soils it was 19.7-24.9. The mean value of conductivity was 2.85 μ mho/cm in polluted soils while control soils showed the range of conductivity between 0.17 to 1.28 μ mho/cm with mean value of 0.49 μ mho/cm.

It was observed that the maximum alkalinity was recorded in August with the range of variation in between 0.06 to 0.38 mg/g and the control site recorded maximum alkalinity (0.2 mg/g) in June (Table 2). The highest quantities of chlorides were recorded in the month of March in both polluted and unpolluted soils. The calcium was also high in winter months with a range between 1.76 to 19.47 mg/g in polluted and 5.35 to 9.45 mg/g in control soils. Magnesium was high (5.35 mg/g) in the month of July in polluted soils while it was in February in control soils (5.83 mg/g). The high amounts of silicates were recorded in both polluted and unpolluted soils. The sodium was high 27.6 (mg/g) in the month of May and low in November and December (1.20 mg/g) in contaminated soils. The potassium content was high in winter season with the range between 0.32 to 1.67 mg/g in polluted and 0.39 to 1.08 mg/g in control soils. The iron content was also high in winter season. Sulphates showed their range of variation in between 0.15 mg/g (July) to '18.0 mg/g (June) in polluted soils and 1.7 mg/g (December) to 9.5 mg/g (August) in control soils. The nitrates were in the variation of 0.29 to 0.78 mg/g in polluted and 0.28-0.96 mg/g in control soils. The nitrite content was high in the month of June (0.61 mg/g) in polluted and in January (0.38 mg/g) in control soils. The maximum ammonium content was recorded in control soils. The organic matter content fluctuated in between 27.5 to 72.4 per cent. The heavy metals such as mercury, cadmium, cobalt, chromium, lead, were analysed during July 1995 to June 1996 and found to be very meagre in their concentrations in polluted and unpolluted soils.

The variation of fungi was in between 0.9 to 2.7x10^{5}g in the soils effected by dairy effluents. The minimum and maximum number of fungal colonies were 0.5 and 2.3x10^5/g in control soils. The range of

variation of bacterial density was in between 6.2 to $23.9x10^6$/g in dairy amended soil, whereas it was only 3.4-$12.3x10^6$g in control soil. The range of actinomycetes in the soils amended with dairy effluents were 0.7 to $7.4x10^5$/g and 0.6 and $1.7x10^5$/g in control soils.

The soil enzymes which determines the physiological status of the soils were estimated and presented in Table-3. The soils recorded higher ranges of cellulase activity in polluted soils over control soils. The relative enzyme activity of cellulase enzyme was in between 140.9-307.7 in control soils and 153.7 to 400.0 in polluted soils. The catalase activity was ranged between 0.6-4.2 units in control and contaminated soils. The range of proteases were in between 0.35 to 2.46 mg/g, and urease was 0.21 and 1.68 mg/g in the polluted soils and 0.13 to 1.50 in control soils.

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