

## Impact of Dairy Effluents on Physico-Chemical Characteristics of Soil

MRIDULA BHATNAGAR\* and SURUCHI GUPTA

*Department of Chemistry, Government Dungar College, Bikaner-334 001, India*

The nature and quality of soil impaired by dairy effluents was assessed to ascertain the feasibility of use of the effluents for establishment and growth of trees and forage crops suited to the desert region. The impact of the effluents on soils was studied by examining the physico-chemical characteristics of soil (treated and virgin soil) in comparison to due standards used for irrigation of soils.

**Key words:** Impact, dairy effluents, soil.

### INTRODUCTION

Water resource is becoming scarce for agriculture and for meeting the due demands of the rapidly growing population and industries. Now-a-days, a new trend has come up to utilize the effluents from dairies for irrigation purposes. The pollutants usually associated with dairy effluents are milk products, detergents, organic matter, inorganic dissolved solids, fertilizing materials, suspended solids and micro-organisms. The whey washings from the cheese plant, casein and lactose as milk residues from evaporators give the effluents a very high BOD and COD, indicating high organic matter<sup>3-6</sup>.

Dairy effluent is acidic in nature and contains plant nutrients such as N, P, K, which may enhance the growth of plants in alkaline soils in general and calcareous soils in particular. Apart from consideration of the role of N and P, we must also consider the role of macro- and micro-nutrient elements in the soil, which promote the growth of crops. Disposal of effluents may also cause depletion of natural soil nutrients and finally mineral and soil accumulation from irrigation point of view.<sup>6</sup>

The dairy chosen for observation is situated at the outskirts, 5 km to the north of the main city of Bikaner. The dairy plant covers an approximate area of 10 acres with sturdy construction in 3 acres. The remaining 7 acres is a farm with crops and tree plantation. The daily water consumption of the dairy is 2–3 lakh litre. The effluent discharged from the dairy ultimately finds its way into the soil. The present study is aimed to monitor the alteration in physico-chemical properties of the soil impaired due to effluent and sludge disposal.

### EXPERIMENTAL

#### Location of Soil Sample Fields

The whole farmland was divided into four fields, the mid-point being the storage tank—the storage point of the effluent.

**Field-I:** The area within the boundaries having the treatment plant and the storage tank was marked as Field-I.

**Field-II:** Following Field-I, north to disposal point, was marked as Field-II. It is the point where fodder is raised.

**Field-III:** South to disposal point, separated from field-II by a furrow was marked as Field-III. It is having a stand for fodder crops.

**Field-IV:** This field is located near the dairy entrance gate, where tap water irrigation is practised. This soil is supposed to be virgin soil (having no pollutants).

Three samples were collected from each block

Physico-chemical analysis of soil samples was done by standard procedures.<sup>8-11</sup>.

## RESULTS AND DISCUSSION

Results of all the parameters studied are tabulated in Tables 1-3.

**Mechanical Composition and Bulk Density:** Soils of the area are found to be highly stratified and varied in mechanical composition, even at a short distances. Based on Brigg's classification<sup>9</sup>, majority (83%) of soils samples are coarse textured. The distance from effluent disposal point may be the reason for variation in mechanical composition. The impact of effluent disposal in nearby land can be markedly visualized as conversion of sandy soil to loamy sand, sandy loam and finally to loam.

Mean bulk density of the treated soil is 1.36 g/cc, whereas for virgin soil it is 2.66 g/cc. Bulk density is related to porosity; bulk density decreases as porosity increases<sup>11</sup>.

**Water Holding Capacity:** There is marked increase in the bulk densities of treated samples as compared to the virgin soil. Maximum water holding capacity depends upon organic matter and texture of the soil. The application of sludge and foam has greatly enhanced the water holding capacity of the sandy soil.

**CaCO<sub>3</sub> Percentage:** CaCO<sub>3</sub> percentage of the treated soil indicates calcareous nature of the soil (Table-4).

The percentage of CaCO<sub>3</sub> values indicates that 33% samples are normal and suitable for growing citrus fruits, 44% samples are medium and suitable for growing other fruits and 56% have excess which has detrimental influence on plant growth.

**pH:** The soil of Bikaner is alkaline in nature. The soils under investigation reveal slightly alkaline to slightly acidic nature with most of the soils falling in the neutral range. The acidic nature can be attributed to effluent and sludge disposal and also to the activity of micro-organisms on the large quantities of organic matter due to the conversion of lactose into lactic acid<sup>12</sup>.

**Extent and Nature of Soluble Salts:** Results of chemical analysis of saturation extract reveal large amount of soluble salts. Incorporation of high amounts of cations (Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>) and anions (CO<sub>3</sub><sup>2-</sup>, HCO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>) in soil has been found which, in turn, causes increase in electrical conductivity (EC) of the soil. These findings are in agreement with findings of earlier workers<sup>13</sup>, who reported an increase in conductivities and Na, K, Ca and Mg contents in the treated soils.

TABLE-1  
PHYSICO-CHEMICAL CHARACTERISTICS OF SOIL

S. Field No. No.	Mechanical composition			Texture	Bulk density (g/cc)	Max. water holding capacity (%)	CaCO <sub>3</sub> (%)	pH
	Sand	Clay	Silt					
1.	90.10	01.63	08.80	Sand	0.90	22.50	09.11	07.10
2. I	60.10	02.90	22.20	Loam	1.00	95.20	25.10	07.90
3.	87.10	06.30	05.30	Loamy sand	1.05	90.70	16.10	08.05
4.	09.50	80.82	03.16	Loamy sand	0.54	90.70	09.50	06.40
5. II	00.90	65.70	25.12	Loamy sand	0.57	60.50	02.90	07.40
6.	00.80	60.70	21.20	Loamy sand	0.67	80.20	02.80	06.99
7.	97.10	03.00	07.20	Sand	2.10	90.70	10.00	06.09
8. III	92.10	02.05	01.15	Sand	2.50	95.20	10.20	07.04
9.	95.60	07.05	03.65	Sand	2.90	93.30	09.20	06.85
Mean	59.25	25.57	10.86		1.36	79.89	10.54	07.09
S.D.	43.10	43.09	09.30		0.89	24.15	06.76	00.64
10.	80.60	07.10	13.20	Loamy sand	2.60	25.10	07.10	07.40
11. IV*	85.70	07.20	12.30	Loamy sand	2.60	29.20	07.20	07.70
12.	86.70	07.10	12.05	Loamy sand	2.78	30.20	07.00	07.70
Mean	84.03	07.13	12.67		2.66	28.12	07.10	07.60
S.D.	03.30	00.55	00.50		5.10	02.70	00.10	01.17

TABLE-1 (Continued)

S. Field No. No.	EC in mmhos/L	Cations (meq/L)				Anions (meq/L)				SAR	ESP (%)
		Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	CO <sub>3</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>		
1.	04.10	18.48	01.06	08.90	08.90	03.10	13.80	24.05	20.00	06.20	07.30
2. I	03.95	07.90	00.50	04.50	04.50	04.10	12.80	05.90	09.00	03.72	04.05
3.	05.05	16.10	00.96	17.50	12.50	07.90	18.40	15.00	12.90	04.09	04.55
4.	01.50	08.70	00.60	03.00	07.25	02.40	04.10	04.40	07.50	03.86	04.24
5. II	02.15	10.90	00.84	01.50	05.50	02.80	03.60	03.60	01.86	05.42	06.30
6.	01.98	18.10	00.76	03.65	03.65	04.40	06.68	06.50	09.90	02.75	02.71
7.	03.50	19.77	06.65	14.55	16.65	02.05	18.80	19.00	13.86	04.99	05.74
8. III	02.10	08.48	01.00	01.70	03.70	01.50	05.60	13.00	03.20	04.98	05.73
9.	03.98	15.10	00.90	02.95	03.80	04.20	11.60	04.20	03.00	08.25	09.83
Mean	03.10	13.76	01.49	06.47	07.38	03.60	10.60	10.63	09.26	04.92	09.60
S.D.	01.20	04.40	01.90	05.90	05.20	01.90	05.90	07.40	06.00	01.60	02.10
10.	01.50	05.20	00.40	02.00	01.60	01.50	01.60	05.10	01.70	03.85	02.85
11. IV*	01.40	05.40	00.44	02.70	01.95	01.35	01.40	05.20	01.90	03.25	02.72
12.	01.40	05.20	00.43	02.87	01.85	01.30	01.30	04.95	01.75	03.66	02.73
Mean	01.43	05.27	00.42	02.52	01.80	01.38	01.43	05.08	01.78	03.59	02.77
S.D.	00.05	00.11	00.02	00.27	00.18	00.07	00.10	00.62	00.10	00.20	00.37

IV\*Data representing physico-chemical characteristics of virgin soil.

TABLE-2  
SHOWING THE VARIOUS RATIOS FROM SATURATION EXTRACT ANALYSIS

S. No.	Field No.	$\text{Na}^+/\text{Ca}^{2+} + \text{Mg}^{2+}$	$\text{Ca}^{2+} + \text{Mg}^{2+}$	$\text{Cl}^-/\text{SO}_4^{2-}$
1.		1.038	1.000	1.200
2.	I	0.877	1.000	0.665
3.		6.848	1.400	1.162
4.		3.493	0.413	6.571
5.	II	2.420	0.327	1.935
6.		0.633	1.000	0.655
7.		3.570	0.873	1.370
8.	III	2.237	0.459	4.062
9.		0.540	0.776	1.400
10.		1.444	1.250	3.000
11.	IV*	1.161	1.380	2.730
12.		1.100	1.550	2.820

IV\* Data representing physico-chemical characteristics of virgin soil.

TABLE-3  
SHOWING THE FERTILITY STATUS OF SOIL

S. No.	Field No.	Organic carbon (%)	Available nutrients (kg/hect)	
			$\text{P}_2\text{O}_5$	$\text{K}_2\text{O}$ (potash)
1.		1.40	240	1020
2.	I	0.62	144	1180
3.		1.14	176	1090
4.		0.55	104	0440
5.	II	1.70	090	0390
6.		0.50	090	0340
7.		1.07	120	0250
8.	III	0.44	302	0290
9.		1.90	320	0282
10.		0.58	110	0540
11.	IV*	0.57	109	0520
12.		0.58	115	0572

IV\* Data representing physico-chemical characteristics of virgin soil.

These findings indicate predominance of sodium and chloride ions in soils. A close relationship is reported between the contents of sodium and chloride with the salinity of the soil<sup>14,15</sup>. It is further corroborated by the ratio between sodium and calcium plus magnesium (Table-2). Thus, the major constituent of soluble salts appears to be sodium chloride.

The mean value of SAR (Sodium Absorption Ratio) is 5.15. The value of SAR for all the samples is < 10.0, *i.e.*, below the tentative limit indicating alkali hazard.

ESP (Exchangeable Sodium Percentage) calculated from corresponding SAR value is 5.63%, indicating low alkali character of these soils. Under such conditions (high sodium content) only tolerant crops can be grown.

**Fertility Status of the Soil:** Results in Table-3 indicate that treated soils have high percentage of organic carbon. The soils are also high in available phosphorus and available potash. Thus, the soils are high in all the three fertilizer elements. The high organic matter and high available phosphorus is due to the application of the dairy effluent rich in organic matter.

TABLE-4  
PERCENTAGE OF CaCO<sub>3</sub> STATUS

Particulars	Soil lime status (%)		
	Normal	Medium	High
Percentage CaCO <sub>3</sub> range	< 5	< 10	> 10
Percentage of samples falling in each category	33	44	56

The above findings clearly indicate that sludge and effluent ponded at dairy farms are potentially polluted and aesthetically unacceptable for irrigation purposes before being primarily treated. Use of untreated water deteriorates the soil causing salinity hazards.

#### ACKNOWLEDGEMENT

The authors are thankful to Dr. P.C. Tater, Head of the Department of Chemistry, Govt. Dungar College, Bikaner for providing facilities for this work and Prof S.C. Thakural for his valuable suggestions in this venture.

#### REFERENCES

1. R.W. Carwan, V.N. Jones and A.P. Hansen, *J. Dairy Science*, **62**, 1243 (1979).
2. D.D. Gautam and S. Bishnoi, *Oikasaay*, **7** (1990).
3. G.J. Mohanrao and Subrahmaniyam, *Indian J. of Env. Health*, **14**, 207 (1972).
4. I.C. Gupta and B.L. Jain, *Curr. Agric.*, **16**, 59 (1992).
5. R.N. Gallaher and T.A. Lang, Dairy Production Conference, University of Florida, p. 12 (1994).
6. P.W. Jones, *British Vet. Jour.*, **136**, 529 (1980).
7. R.K. Aggarwal and P. Kumar, *Ann. of Arid Zone*, **29**, 295 (1990).
8. G. Vellidis, S. Henry, C. Perry and R.K. Hubbard, *Amer. Soc. of Agr. Eng.*, **91-2598**, 9 (1991).
9. L. J. Briggs, Bulletin 24, Bureau of Soil, U.S. Dept. of Agric. (1904).
10. C.A. Bower and L.V. Wilcox, *Soil Sci. Soc. Amer. Proc.*, **29**, 93 (1965).
11. G.B. Bodman, *Amer. Soc. Agron. Jour.*, **34**, 883 (1942).
12. F.C. Gerresten, *Plant and Soil*, **1**, 51 (1948).
13. A.L. Sutton, D.W. Nelson and N.J. Moelter, *Jour. of Envir. Quality*, **8**, 5165 (1979).
14. R.R. Aggarwal and J.S.R. Yadav, *J. Indian Soc. Soil Sci.*, **4**, 141 (1956).
15. J.S. Kanwar, J.T. Sehgal and D.R. Bhumla, *J. Indian Soc. Soil Sci.*, **11**, 39 (1963).