International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 2237-2239

Received: 07-05-2019
Accepted: 09-06-2019

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Effect of industrial dairy effluent on soil properties in Guntur district of Andhra Pradesh, India

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Abstract
Physico-chemical and chemical properties of soils collected at 250 to >1000 m from the dairy industry were studied before sowing and after harvest of the crop. Soil samples were acidic and non-saline in nature. Available nitrogen, potassium, sulphur, magnesium and micronutrients were high in the soils irrigated with dairy effluent. Overall, the results indicate that dairy effluent application increased the nutrient content in the soils when irrigated and also can reduce adverse effects on environment.

Keywords: Dairy effluent, soil properties, pH, electrical conductivity, nitrogen and potassium

Introduction
Over the last few decades large scale usage of chemicals in various human activities has grown very fast, particularly in countries like India for rapid industrialization in order to sustain over growing large problem of population (Mustafa *et al* 2010) [7]. Industrialization plays a very important role for developing nations. But the disposal of wastewaters has become a global concern as the industries are associated with the generation of high volumes of effluents, limited space for land needed for the treatment including high cost of treatment technologies.
Dairy industry is one of the major food industries in India, and India ranks second among the major milk producing nation. The number of the diary plants of medium and large size has increased. Dairy effluent has high organic loads as milk is its basic constituent with high levels of chemical oxygen demand, biological oxygen demand, oil & grease and nitrogen and phosphorous content. Large amount of water is used to clean dairy processing plants; hence, the resulting waste water can contain detergent, sanitizers, base, salts and organic matter, depending upon source. The nature and composition of effluents from a dairy depend upon the quantity of milk processed and the type of products made. Characterization of waste water, treatability studies and planning of proper units and processes for effluent treatment is very much necessary (Barnett *et al*. 2010) [1].
In the world, India occupies 2nd position in milk production producing 173 million litres. In India, Andhra Pradesh produces 12.76 million litres holding 3rd rank. The milk production capacity will be around 254.5 million litres as per the vision 2021-22 document (The Hindu Business line, 2018). Presently, around 6.2 billion litres of untreated dairy effluent is produced every day that leads to pollution of land and natural water resources.

Material and Methods
Soil samples were collected from Sangam dairy located at Vadlamudi, Guntur district. Total number of 100 soil samples was collected with 50 samples before sowing of the crop and 50 after harvest of the crop from 50 locations which were analysed for various physico-chemical and chemical properties. Samples were transferred to air tight poly bags and were labelled with information like sample number, place and depth of sampling etc. pH, EC, available phosphorus, potassium, secondary nutrients, micronutrients and heavy metals were determined following methods of Tandon (2017) [10]. Organic carbon content were determined following method given by Walkley and Black (1934) [12]

Results and Discussion
The results of all the parameters studied have been given in table 1. The mean pH values before sowing of the crop at study area (250 m to check) ranged from 6.8 to 7.7 and 6.7 to 7.7

after harvest of the crop respectively. Acidic pH was recorded near the dairy effluent discharge site and increasing trend followed with increase in distance. Devi and Narasimha (2007) [3] collected effluent from Nandhyal dairy industry, Kurnool and reported that acidic pH of the dairy effluent was due to presence of lactic acid. Electrical conductivity of the soils were non-saline in the study area before sowing was 0.31 to 0.19 dSm^{-1} and after harvest of the crop was 0.3 to 0.19 dSm^{-1}. Mean electrical conductivity of soils decrease with increase in distance. Liu and Haynes (2013) [6] reported that increase in soil electrical conductivity irrigated with dairy factory effluent was due to increase in Exchangeable sodium percentage, Exchangeable sodium and soluble salts in the soil. Organic carbon content in the soil irrigated with dairy effluent before sowing of crop was 0.42 to 0.4 and after harvest of the crop was 0.42 to 0.4%. Results showed that there was no significant difference in Organic Carbon content in soils when irrigated with treated Dairy effluent. This corroborates with the findings of Liu and Haynes (2011) [5].

The results of nitrogen content in the soils before sowing of the crop was 367 to 300 and after harvest of the crop was 340 to 218 kg ha^{-1} respectively. Similarly, phosphorous and potassium content of the soils in study area (250 m to check area) before sowing of the crop ranged from 19.7 to 32.4 and 462 to 220 kg ha^{-1} whereas after harvest of the crop from 19.7 to 30.8 and 441 to 229 kg ha^{-1} respectively. Available nitrogen and potassium content in soils increased with the effluent application whereas phosphorus content in soils after dairy effluent application was not affected. Sparkling *et al.* (2001) [9] reported that N, K and S contents in the land has enhanced significantly under long term application of Dairy Factory Effluent to the soils due to presence of these macronutrients in them. Parmara *et al.* (2017) [8] reported that application of tube well water alone was found to contain highest amount of phosphorous in the soils than with the dairy effluent which tally with the results of present investigation.

Mean calcium content in the soil samples when irrigated with the dairy effluent before sowing was 6.3 to 7.4 and after harvest of crop was 6.1 to 7.2 meq per 100g soil whereas magnesium content ranged from 2.3 to 3.0 before sowing and 2.3 to 3 meq per 100g soil after harvest of the crop. Available sulphur content in the soils ranged from 5.3 to 3.9 and 5.4 to 3.9 mg kg^{-1} before sowing and after harvest of the crop respectively. The results of the present investigation fall within the range of findings of Jiang *et al.* (2018) [4]

Table 1: Effect of dairy effluent irrigation on soil properties

Parameters	**Soil samples collected before sowing of crop**					**Soil samples collected after harvesting of crop**				
	Distance from Dairy industry (m)					**Distance from Dairy industry (m)**				
	250	**500**	**750**	**1000**	**check**	**250**	**500**	**750**	**1000**	**check**
pH	6.8	7.3	7.6	7.7	7.7	6.7	7.2	7.5	7.7	7.7
EC dSm-1	0.31	0.28	0.23	0.28	0.19	0.30	0.29	0.25	0.24	0.19
Organic Carbon%	0.42	0.41	0.43	0.42	0.40	0.42	0.43	0.44	0.43	0.40
Nitrogen (kg ha-1)	367	324	301	275	300	340	280	262	262	218
Phosphrous (kg ha-1)	19.7	22.6	25.7	28.6	32.4	19.7	22.9	23.8	26.1	30.8
Potassium (kg ha-1)	462	353	396	290	220	441	346	345	293	229
Calcium (meq per 100g soil)	6.3	6.5	6.7	7.1	7.4	6.1	6.4	6.6	7.0	7.2
Magnesium (meq per 100g soil)	2.3	2.6	2.4	2.9	3.0	2.3	2.7	2.3	2.7	3.0
Sulphur (mg kg-1)	5.3	5.0	4.4	4.0	3.9	5.4	4.4	4.2	4.0	3.9
Copper (ppm)	0.035	0.029	0.029	0.026	0.020	0.030	0.029	0.028	0.026	0.020
Iron (ppm)	2.82	2.70	2.45	2.49	1.63	2.72	2.70	2.53	2.71	1.88
Zinc (ppm)	2.75	2.73	2.44	2.11	2.54	2.61	2.66	2.69	2.37	2.58
Manganese (ppm)	0.94	0.92	0.96	0.78	0.73	0.87	0.96	0.89	0.79	0.75
Lead (ppm)	0.004	0.013	0.021	0.022	0.038	0.004	0.012	0.021	0.040	0.028
Cadmium (ppm)	0.003	0.003	0.006	0.005	0.006	0.003	0.003	0.004	0.004	0.006
Chromium (ppm)	0.002	0.010	0.013	0.013	0.016	0.002	0.011	0.012	0.011	0.017
Nickel (ppm)	0.004	0.004	0.003	0.003	0.005	0.003	0.005	0.003	0.003	0.006

Mean values of the DTPA extractable copper content in the soils irrigated with dairy effluent before sowing of crop was 0.035 to 0.02 and 0.03 to 0.02 ppm after harvest of the crop. Iron content in the soils was 2.82 to 1.63 and 2.72 to 1.88 before sowing and after harvest of the crop. Zinc content before sowing at study area (250 m to check) ranged from 2.75 to 2.54 and after harvest of crop was 2.61 to 2.58 ppm respectively. Similarly, manganese content ranged from 0.94 to 0.73 before sowing of the crop whereas 0.87 to 0.75 ppm after harvest of the crop. Heavy metal *viz.*, lead, cadmium, chromium and nickel content in the soils irrigated with the dairy effluent ranged from 0.004 to 0.038; 0.003 to 0.006; 0.002 to 0.016 and 0.004 to 0.005 ppm before sowing of the crop whereas 0.004 to 0.028; 0.003 to 0.006; 0.002 to 0.017 and 0.003 to 0.006 ppm after harvest of the crop respectively. Challam (2013) [2] reported that heavy metal effect on soil properties was probably less because dairy effluent unlikely to contain contaminants such as heavy metals.

Conclusion

pH of the soils irrigated with dairy effluent increased with increase in distance *i.e.*, 250 m to check area (>1000 m). Electrical conductivity of the soils decreases with increase in distance. An increase in available nitrogen, potassium, sulphur and magnesium content in soils was observed whereas calcium was decreased near the dairy effluent application (250 m) compared with check area (>1000 m) and no much difference was observed in organic carbon content and phosphorous. Mean values of micronutrient in the soils increased with dairy effluent application whereas no much difference in heavy metal content. According to the present study dairy effluent application increased the nutrient content in the soil when irrigated. Therefore, dairy effluent application increases the fertility content and can mitigate the pollution problems.

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