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REUSE OF WASTEWATER OF TREATMENT PLANT OF DAIRY PLANT: IRRIGATION

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Abstract: Dairy industry is one of the major industries causing water pollution. In India, dairy industry generates about 6-10 L wastewater/L of milk processed depending upon the process employed and product manufactured. Poorly treated wastewater with high levels of pollutants caused by poor design, operation or treatment systems creates major environmental problems when discharged to surface water or land. The paper presents the evaluation of one of the existing wastewater treatment plant of dairy plant. The objective is to find whether the wastewater is complying with the standards of land discharge as per EPA (1993) guidelines. BOD and SS of secondary effluent from WWTP were 34 and 52 mg/L which within limits of EPA standards The TDS, Chloride, Potential salinity of secondary effluent were 966.7 mg/L, 209. mg/L and 10.7 meq/L respectively, which are in acceptable range for irrigation. Classification of irrigation waster based on SAR values, the secondary effluent from WWTP could be classified as low sodium hazard value. The SAR was found to be 0.06 meq/L. RSC value [-2.1meq/L] of secondary effluent from milk based food industry was found to be safe. In the present case BOD load applied to land is 4 Kg/hac/day which is below loading rate acceptable.

Keywords: Reuse, Wastewater, Irrigation, Potential Salinity

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INTRODUCTION

India is the second largest milk producing country with a production of about 78 million tons during 1999-2000.There has been a remarkable growth in milk production and milk processing centres (dairies) in India during the past decades. Dairy industry is an important economic sector, but the pollution potential of this activity may be considered high, mainly when recovery of proteins, lipids and lactose is not performed (K lata et.al.2002). A dairy has a water requirement for washing and cleaning operations, in the range of 0.2 to 10 L of water per litre of milk processed [M Vourch et.al.2008]. Consequently, the quantity of effluents discharged is also high with a high proportion of biodegradable organics in it. Therefore, this industry poses a major threat to the environment, unless such effluents are subjected to proper treatment [Ramasamy and Abbasi 2000]. The dairy industry, like most other agro-industries, generates strong effluents characterized by high Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) reflecting their high organic content. Dairy effluent is invariably high in nutrients (i.e. nitrogen, phosphorus and potassium) and organic material (e.g. oils and fat, dissolved lactic acid, etc.) and consequently has a high BOD. Furthermore, dairy-processing effluent also has high concentrations of total dissolved solids (TDS). The use of acid and alkaline cleaners and sanitizers in the dairy industry additionally influences effluent characteristics and typically results in a highly variable pH [M Vourch et.al.2008]. Considering the above stated implications an attempt has been made in the present project to evaluate one of the WWTP for dairy waste. The objective of the project is to monitor the performance of WWTP of dairy plant.

MATERIALS AND METHODS

The WWTP of Milk plant at Patiala having capacity to treat 700- 1300 m^3/day of wastewater was selected for the study. A general systematic flow diagram of WWTP is shown in Fig. 1. The system was designed to handle BOD_5 at 20°C of 800 mg/L and Suspended Solids (SS) 250 mg/L.

Grab samples were collected once in a month from WWTP. Samples were collected in plastic bottles. Procedure in Standard Method was followed for samples collection, preservation and transportation. Samples for BOD, COD, Nitrogen, Phosphorus, Chlorides and Solids etc were analyzed in accordance with the procedure laid down in Standard *Methods for the Examination of Water and Wastewater (APHA 1996).*

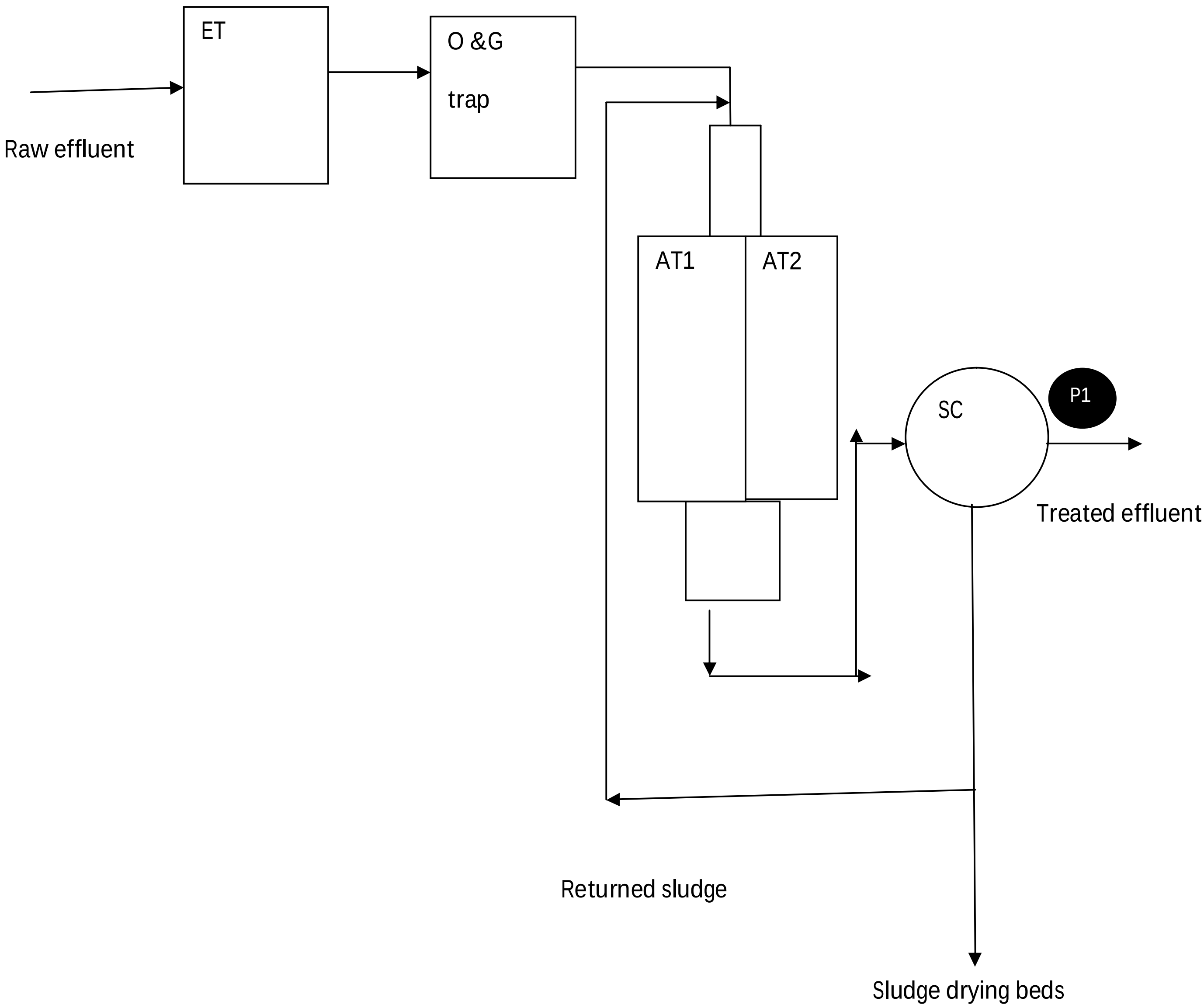

Fig 1. : Process Flow Diagram for Wastewater Treatment Plant

Result and Discussion Wastewater from milk based food industry was treated by Activated Sludge Process (ASP). Treated secondary effluent from WWTP and irrigation water quality guidelines are summarized in table 1. BOD and SS of secondary effluent from WWTP were 34 and 52 mg/L which within limits of EPA standards. The Treated effluent is used for eco-plantation. The plants which are grown are Eucalyptus, Poplar, Teak and Jatropha. The high transpiration capacity of plants grown in soil matrix enables the system to serve as biopump. These plants transpire water equivalent of 7 to 13 times the potential evapo-transpiration from the soil matrix alone. Nutrients present in the water are used by the plants and partially retained in the soil matrix without affecting the soil ecosystem. Irrigation agriculture is dependent upon adequate good quality irrigation water.

Table 1: Secondary effluent from WWTP and irrigation water quality guidelines

Properties	Secondary effluent	EPA Guidelines
pH	8	5.5-9
Oil & grease	9	10
TDS	966.7 mg/L	2100 mg/L
SS	52 mg/L	200 mg/L
Fecal Coli forms	-	2.2-23/100ml
BOD_5 at 20°C	34.5 mg/L	100 mg/L
Ammonical Nitrogen	3 mg/L	-

Source: Ayers and Westcot (1985)

The suitability of a given body of water is judged from the following characteristics

- Total Dissolved Solids (TDS)
- Relative proportion of sodium to other cations
- Residual carbonates
- Sulphate Salinity
- Organic loading
- Nutrient
- Microbiological aspects

1. Total Dissolved Solids (TDS) – The salt concentration can also be obtained indirectly by measuring the Electrical conductivity (EC) of agriculture water and using the empirical relationship

TDS (mg/L) = 0.64 * EC (µ mho/cm) (i)

The main effect of high EC and TDS water on crop productivity is the inability of the plant to compete with ions in the soil solution for water. The higher the EC and TDS, the less water is available to plants, even through a Field may appear wet.

TDS concentration in the treated effluent was found to be 966.7 mg/L. It's value is below the Indian Standard Guidelines.

2. The Sodium hazard- The soil structure is considerably affected in the long run by the sodium content in the irrigation water. Sodium enters into cation exchange relationships with clay particles in the soil, tends to break down the clays. Dispersed soils have poor infiltration and permeability.

Sodium Adsorption Relationship (SAR) as shown in the following equation defines the relationship between sodium, Ca++ and Mg++. Typical recommended values are given in table 2.

$$SAR = \frac{Na+}{[(Ca++ + Mg++)/2]0.5} \qquad (ii)$$

In above equation the chemical symbols stands for the concentrations of respective elements in agriculture water, all expressed in meq/L.

Table 2: Typical recommended values are given for irrigation

SAR values (meq/L)	Sodium Hazard to soil
0-10	Low
10-18	Medium
18-26	High
Above 26	Very high

Source: Ayers and Westcot (1985)

Classification of irrigation waster based on SAR values, the secondary effluent from WWTP could be classified as low sodium hazard value. The SAR was found to be 0.06 meq/L. The % Na was found to be 30% as per Indian guidelines for irrigation.

3. Residual Sodium Carbonate (RSC) – Large amount of bicarbonates tends to precipitate out the Calcium, as Calcium Carbonate from water and soil.

Magnesium enters the exchange complex of the soil, replacing the precipitated Calcium. As Calcium and Magnesium are lost from the soil water, the relative proportion of sodium is increased, with an attendant increase in sodium hazard. This is general evaluation in terms of RSC defined as in table 3.

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+}) \quad \text{(iii)}$$

Table 3.0: Typical recommended values for irrigation water

Water Quality	RSC (meq/L)
Safe	Less than 1.25
Marginal	1.35-2.5
Unsuitable	Over 2.5

Source: Ayers and Westcot (1985)

RSC value [-2.1meq/L] of secondary effluent from milk based food industry was found to be safe.

4. Chlorides – Chlorides are said to have no effect on a soil's physical properties. Certain plants, however, are sensitive to chloride ions. In Israel, for citrus fruits, chloride up to 15 meq/L on sandy- loamy soils and up to 7.5 meq /L on clayey soils is considered to be of low risk. In India some irrigation water standards allow up to 600meq/L (i.e.16.92 meq/L) but the soil conditions are not satisfied.

In our case, chloride = 209.9 mg/L [standards allow up to 600 mg/L]

5. Sulphates – The term 'Potential Salinity' of water has been suggested in terms of

$[Cl^- + 0.5\, SO_4^{2-}]$ in meq/L and following values have been proposed to ensure sustainability.

Table 4.0: Potential Salinity of water

Potential salinity (meq/L)	Desirable soil permeability
5-20	Good
3-15	Medium
3-7	Low

Source: Ayers and Westcot (1985)

The Potential Salinity was observed to be 10.7 meq/L. Permeability of soil was found to be good.

6. pH- Soil- pH affects the availability of nutrients to plant. Effluent pH was in the range of 6.5-9 is acceptable for irrigation.

In our case pH=8, acceptable.

7. Organic Content- Organic matter in effluent can be measured as BOD, COD or TOC. Organic matter when applied on an appropriate rate, can contribute to soil fertility.

Ordinarily, concentrations are low enough to preclude short-term detrimental affects on the soil or vegetation. Continued overloading with organic matter can physically clog soil pores, favors anaerobic soil microbes and slimy bacterial scum coating the soil, blocking pores and closing up cracks. These changes could limit the effective life of the application site. Table 5.0 summarizes a few typical organic loading acceptable on land.

Table 5.0: Typical organic loading acceptable on land

Waste	Organic Loading Kg BOD_5/hac/day	References
Dextrose	1026	[6]
Raw domestic & Industrial Waste (India)	25-150	[7]
Secondary effluents	2-5	[7]
Milk wastes	12-125	[8]

Source: Ayers and Westcot (1985)

In the present case BOD load applied to land is 4 Kg/hac/day which is below loading rate acceptable.

9. Microbiological aspects: Effluent irrigation may also lead to microbial contamination of soil and plants in the vicinity of the irrigation site. The potential risk of health hazard due to bacteria and viruses to farm workers and consumers depend on the degree of treatment received by the wastewater and persistence of pathogens in the soil and on crops. Further survival of bacteria and virus in the soil are governed by several environmental fractions viz. soil, pH, cations, soluble organics, moisture, organic matter and temperature. Thawale et al. (2006) studied the survival of pathogens in the soil irrigated with different types of wastewater. Survival of different pathogens in soil and crops are reported in table 6.0. The result indicated the degree of health hazard was more in the use of untreated and primary treated wastewater. However, survival of organisms was insignificant in case of secondary treated wastewater.

Table 6.0: Survival of pathogens in soils

Pathogen	Survival in days
Coli forms	38
Streptococci	38 to 63
Faecal streptococci	26 to 77
Salmonellae	15 to > 280
Salmonela typhi	1 to 120
Tubercle bacilli	>180
Leptospira	15 to 43
Entamoeba histolytica cysts	6 to 8
Enteroviruses	8 to 175
Ascaris ova	up to 7 years
Hookworm larvae	42
Brucella abortus	30-125
Q-fever organism	148

CONCLUSIONS: The wastewater is complying with the standards of land discharge as per EPA (1993) guidelines. BOD and SS of secondary effluent from WWTP were 34 and 52 mg/L which within limits of EPA standards The TDS, Chloride, Potential salinity of secondary effluent were 966.7 mg/L, 209.9 mg/L and 10.7 meq/L respectively, which are in acceptable range for irrigation. Classification of irrigation waster based on SAR values, the secondary effluent from WWTP could be classified as low sodium hazard value. The SAR was found to be 0.06 meq/L. RSC value of -2.1meq/L of secondary effluent from milk based food industry was found to be safe. In the present case BOD load applied to land is 4 Kg/hac/day which is below loading rate acceptable.

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