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STUDIES ON ENHANCING THE EFFICIENCY OF ZLD PLANT FOR TANNERY EFFLUENT BY IMPLEMENTING LOW-COST AMBIENT AIR EVAPORATOR SYSTEM

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ABSTRACT
The waste generated from tanning process poses a threat to the environment and has a major challenge of waste management. In India, all tannery industries are bound to achieve Zero Liquid Discharge (ZLD) with the objectives of recovery of water and prevention of environment. This study deals with the mechanical evaporation to increase the efficiency of concentrating the tannery effluent. The evaporator works on the principle of using ambient air instead of hot air for the process of evaporation. The project was undertaken to understand the process flow and design of the evaporator setup and to optimize the process parameters to increase the outlet concentration of the effluent to 85000mg/L for the single run, so that the area required for sludge drying was reduced.The outlet concentration was varying from 42000mg/l to 43306mg/l with a mass of dry air as 38570kg/h. The preheating of air improves the concentration of outlet to 55690 mg/l.
Keywords: Tannery effluent, ZLD, Ambient air evaporator, Waste management.

INTRODUCTION

The tanning industry is one of the industries that considered as high polluting industry.[1] Tanning generates a large volume of waste water.[2] On the average of 28-30 m^3/h of effluent is generated for 1000 kg of raw material.[3,4] Tannery industry generates wastewater with the variable pH and high concentration of BOD, COD, suspended solids and heavy metals.[5] It was found that 20% of chemicals absorbed by the leather, and the rest is washed away with the process water.[6,7] The sludge settled during the physicochemical treatment as well as the wasted sludge from the oxidation ditches was taken to the sludge well and pumped to sludge drying beds.[8] The dewatered sludge was disposed of (Hafez *et al.,* 2002). According to norms prescribed by TNPCB 222 m^2 of solar pan, area is required to evaporate 1 m^3 of saline effluent per day.[9] The main aim of this work is to increase the concentration of sludge leaving the evaporator and reduce the consumption of energy and area for the solar pond. The major issues faced in the multi-effect evaporator by the tannery effluent treatment plants were consuming high energy for desalination, corrosion, and scaling of the evaporators resulting in frequent interruptions and downtime that affects processing capacity.[10,11] Compared to normal evaporators the ambient air evaporators require less area, low capital investment, low energy consumption, can handle high TDS content and no additional crystallizer is required to achieve ZLD. In this work, studies were carried out for the evaporation rate at various effluent flow rates and changes brought forth like passing a preheated air that can ease the evaporation rate so that the area required by solar evaporation was reduced and no need for the alternate effluent treatment process.

EXPERIMENTAL

Process of Evaporation

The effluent (RO reject) was collected in a sump and it is pumped to the evaporator through an atomizer operating at a speed of about 11000 rpm. The effluent is fractured mechanically into a very fine mist, of 4 to 5 micron in a chamber. A large volume of ambient air is passed through an evaporator in which the saline effluent is dispersed to a fine mist by the atomizer. The air and mist are mixed within the chamber and the effluent gets evaporated. The evaporation is primarily based on ambient air temperature and humidity. The moist air leaves from the top of the chamber after demister made of polypropylene baffles, traps the salt carried by air and only the moist air is sent outside the tower. The concentrated effluent falls at the bottom and it is recirculated until it reaches desirable concentration. The temperature inside the chamber becomes less than ambient temperature because of evaporation. The slightly higher temperature of the ambient air aids the evaporation. The cycle is repeated until the salt concentration reaches about 1, 00,000 mg/l. Then the effluent is drawn from the bottom of the settling tank and sent to solar tunnel driers for solidification (Fig.-1).

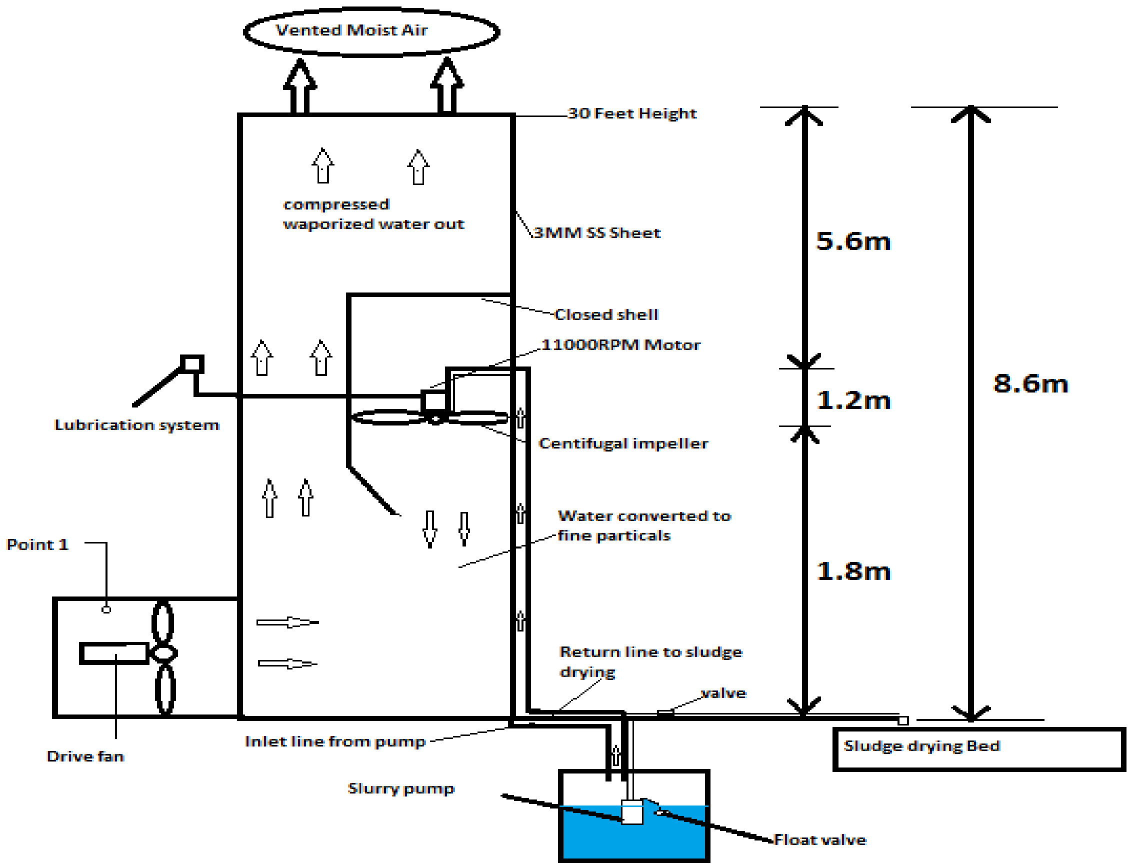

Fig.-1: Schematic representation of Ambient Air evaporation system

Preheating the Air

In order to raise the temperature of the incoming air, a preheater is used. Tubular pre-heater was used for preheating the air from the exhaust gas.[12,13] Ambient air is forced by a fan through ducting, with one end collecting air for the preheater and at other end gives the heated air by passing through the preheater tubes towards the atomizer. Steam from the tannery boiler unit was also used for preheating the air. This hot air comes into contact with an atomizer. A partition is placed inside the evaporation unit. This increases the directional flow of the incoming air towards the atomizer. Since the air coming in will be directed towards the atomizer, it will provide higher contact area, thus providing a good chance of an increase in outlet concentrations.

Open Pond Evaporation

The high TDS stream from the tannery and the outlet concentration stream from the ambient air evaporator is sent to open ponds of evaporation [14]. The concentration of the solutions increases with depth.[15] High concentration effluent at the bottom does not mix with the low concentration effluent above it, so when the bottom layer of water is heated, convection occurs separately in the bottom and top layers. This reduces heat loss to the great extent and allows for the high concentration effluent to get up to 90°C while maintaining 30°C low concentration. This hot, salty water can then be pumped away for use in electricity generation.

RESULTS AND DISCUSSIONS

The evaporator is able to evaporate about 15,000 liters per day from the initial reject volume of 20,000 liters. The TDS is increased from about 60,000 to 175,000mg/l. Average evaporation achieved was 75 %. The concentration of wastewater increases from 7% to 13% in one hour for the various flow rate (Table-2).

Table-1: Specification of the Evaporator

Parameters	Values
Duct Area	2.7 x 1.8 m^2
Height of Tower	8.6 m
Height between the bottom of Atomizer and Forced Draft Fan	1.8 m
Height between Top of tower to top of Atomizer	5.6 m
Capacity	20 m^3/day

For 1000 LPH of wastewater flow the runs were carried out to determine the efficiency of the evaporator by increase the temperature of the air. The result shows that the percentage of concentration increases up to 35% in one hour and an average amount of water evaporated was 56 kg/hr (Table-3).

Table-2: Variation in the Concentration of Wastewater at Evaporator Outlet at various Flow Rates

Parameters	600LPH	800LPH	1000LPH
DBT(°C) at inlet	26	26	26
WBT(°C) at inlet	24.5	24	23
DBT(°C) at outlet	24	24	23
WBT(°C) at outlet	23.5	23.5	22.5
Conductivity at the Inlet(µS/Cm)	54.7	55.7	56.9
Conductivity at the outlet(µS/Cm)	58.7	60.5	64.5
Concentration of the solids at the Inlet(mg/l)	38290	38990	39830
Concentration of the solids at the Outlet(mg/l)	41090	42350	45150
Total amount of sludge Inlet (kg/h)	660	776	1018
Solids present in the sludge at Inlet (kg/h)	38.29	31.2	39.41
Amount of Water present at the Inlet (kg/h)	621.71	744.7	978.59
Total amount of sludge at the Outlet (kg/h)	640	760	983
Solids present in the sludge at the Outlet (kg/h)	41.09	42.35	45.15
Amount of Water present at the Outlet (kg/h)	598.91	717.65	937.85
Water evaporated (kg/h)	22.98	27.05	40.74

Table-3: Variation in Concentration for 1000 LPH with preheating air

Parameters	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7
DBT(°C) at inlet	34.2	36	37.5	37.2	38.3	38.7	37
WBT(°C) at inlet	24.5	23.9	26.8	24	24.9	23.3	23.1
DBT(°C) at outlet	28.9	30	30.1	27.8	29.3	28.7	28.3
WBT(°C) at outlet	23.9	23.7	24.2	23.7	23.9	23.5	22.6
Conductivity of solids at the Inlet(µS/Cm)	56.9	59	57.6	58	59.61	57.66	57.16
Conductivity of the solids at the outlet(µS/Cm)	77.08	77.38	74.62	76.13	77.86	75.37	79.56
Concentration of the solids at the Inlet(mg/l)	39830	41300	40360	40600	41730	40360	40010

Concentration of the solids at the Outlet(mg/l)	53960	54170	52240	53290	54500	52760	55690
Total amount of sludge at the Inlet (kg/h)	1002	1035	1134.4	1044.9	1042.9	1044	1018.7
Solids present in the sludge at Inlet (kg/h)	39.83	41.3	40.36	40.60	41.73	40.36	40.01
Amount of Water at the Inlet (kg/h)	960.63	993.77	1092.0	1002.1	1001.17	1003.6	978.65
Amount of sludge at the Outlet (kg/h)	950	971.2	1101.3	1017.2	1007.01	1011.7	953.22
Solids present at the Outlet (kg/h)	53.96	54.17	52.24	53.29	54.50	52.76	55.69
Amount of Water present at the Outlet (kg/h)	896.04	917.03	1049.0	963.93	952.51	950.99	897.53
Water evaporated (kg/h)	63.96	54.17	52.3	53.27	54.5	60.71	55.69

CONCLUSION

Based on this study was carried out to increase the efficiency of the setup and also the concentration variation was compared with modification in preheating the air. The increased air capacity drafters were provided that allowed more mass of dry air to flow inside the setup to increase the solid concentrations. When the pre-heater setup is employed, considerable effects were observed but a restriction in the air flow was witnessed. The higher efficiency or increase of concentration about 53950 mg/l was achieved. Preheating is required essential during the rainy season, but utilizing the waste heat from the exhaust gas will increase the efficiency of the evaporator. On comparing with conventional multi-effect evaporator system the operating cost and the capital cost was very much reduced.

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