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POLLUTION CONTROL USING SOLAR EVAPORATION TANK

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Abstract:-

Control of water and land pollutions by industrial effluents using solar evaporation tank is presented here. Solar energy is available in plenty in tropical countries like India during most of the year. This enables the industries to use solar evaporation tank made of black body as a simple and economical effluent management method. An experimental industrial effluent evaporation tank is made by using natural black colored kadappa stone. Excellent results of evaporation utilizing solar radiation have been obtained. The results obtained during solar evaporation process are presented and discussed.

Keywords: - *Black Body, Solar Radiation, Evaporation Tank, Effluent, Total Dissolved Solids (TDS)*

1. INTRODUCTION

Industries have become more in number now-a-days. They are one of the main causes of environment pollution. Industrial effluents cause water and land pollutions, which have become a serious problem in the present world. In spite of the continuous efforts to prevent these pollutions, the high total TDS in the effluent is not yet successfully done. India, being the tropical country will receive plenty of solar radiation during most of the year. This enables the industries to use solar evaporation tank made of good solar energy absorbing material as a simple and cheap effluent treatment system.

Evaporation is effective for concentrating or removing salts, heavy metals and a variety of hazardous materials from solutions. It is also used to recover useful by-products from a solution or to concentrate liquid waste prior to additional treatment and final disposal. When water content is vaporized a solution is concentrated leaving behind saline liquor that contains all of the dissolved solids. The evaporation process may be carried out in solar evaporation tanks or through the use of commercially available evaporation equipment [1]. Presence of TDS in the treated effluent discharge by the industries spoils the surrounding agricultural land. So the optimum usage of the solar evaporation tank is the need of the hour. Hence there is a necessity for a study to find the variation in the rate of evaporation from the effluent stored in the tanks so as to suggest a method for an effective operation of the tank [2]. In solar evaporation a tank containing effluent is allowed to evaporate under the prevailing environmental conditions. This technique works best at low latitudes where sunlight duration and intensity are highest and areas with low relative humidity and rainfall. Historically this technique was common in coastal areas and continues to be a viable commercial process worldwide [3] and [4]. Solar evaporation could have been practiced at many inland salines where brine concentrations tend to be high, thus reducing total evaporation time [5].

Here, pharmaceutical effluent collected from IV fluid manufacturing unit located in Tamil Nadu region is used for the study. Pharmaceutical effluents are known to contain hazardous and toxic chemicals, high concentration of organic compounds and total solids [6]. The study covers the idea of utilization of solar radiation for pharmaceutical effluent treatment as an eco-friendly, cheap and simple method to protect and save our environment [7] and [8]. The result obtained during the process are presented and discussed.

2. Principle of Solar Evaporation Tank

When solar radiation strikes a black surface it is absorbed better rather than reflected. The surface becomes hot and re-radiates radiations to effluent at low temperature. The radiation emitted from the surface of a perfect radiator, so called black body, at a rate Q is given by

$$Q = A\sigma T^4$$

Where A is the area of the body, T is absolute temperature, σ is a constant known as Stefan's Boltzmann constant. Real bodies emit radiation at a lower rate than black bodies. The ratio of the radiation emission of a real body to that of a black body at the same temperature is called the emittance. Thus a real body emits radiations at a rate

$$Q = \varepsilon A\sigma T^4$$

where ε is the average emittance of the surface. A black surface which absorbs the entire energy incident upon it and reflects none is used extensively in radiation heat transfer work [9].

3. Experimental Details

3.1 Materials:

a. Black kadappa stone – natural material quite hard, long lasting, more resistant than most other sedimentary rocks and can withstand to any exposure
b. Industrial effluent (pharma effluent) collected from IV fluid manufacturing unit.

3.2 Method:

Solar evaporation tank is constructed with three segments, each with a depth of 17.5 cm and area of 1849 cm^2 in step-wise position upon cemented roof for greater absorption of solar energy. The three segments are connected with pipes. Twenty litres of effluent is poured in tank I. It is measured for TDS about 2170 ppm and depth about 11.5 cm. Effluent in tank I is treated with alum and poly electrolyte so as to facilitate the settlement of solids [10]. Then the supernatant liquid is allowed to flow into tank II and III. Now the depth of the effluent in each tank is 5.5 cm. TDS (measured using TDS meter), temperature and the depth of effluent in both the tanks are noted every one hour starting from 10 AM upto 4 PM. This is repeated every day till complete evaporation of effluent. It took 8 days for complete evaporation. The same is followed for 10 litres of effluent in tank I with depth 5.8 cm. The depth of effluent in tank II and III is 2.6 cm each. The process took four days for complete evaporation. The experimental setup is shown in figure 1 (a) and figure 1(b) shows digital electronic meter for measuring TDS.

Figure 1 Experimental setup.

Figure 1(b) Digital electronic meter for measuring TDS

4. Results and Discussions

Experimental observation is presented in table I and table II. Solar evaporation certainly causes the decrease in depth of effluent level in tank II and tank III to a greater extent according to temperature. The concentration of effluent in the tanks increases clearly indicating the evaporation.

Table I - Solar Evaporation of 20 L Effluent

Sl.no	Day no	Temp(deg Celsius)	Depth (cm)	TDS (ppm)
	Tank II & III			
1	Day 1 (Start)	40	5.5	2000
2	Day1 (End)	40	4.9	3100
3	Day 2 (Start)	42	4.8	3200
4	Day2 (End)	41	4.2	4300
5	Day 3 (Start)	44	4.1	4400
6	Day3 (End)	42	3.5	5500
7	Day 4 (Start)	36	3.4	5600
8	Day4 (End)	38	2.8	6800
9	Day 5 (Start)	42	2.7	6900
10	Day5 (End)	44	2.2	8000
11	Day 6 (Start)	45	2	8100
12	Day 6 (End)	37	1.4	9200
13	Day 7 (Start)	34	1.3	9400
14	Day 7 (End)	39	0.7	10400
15	Day 8(Start)	37	0.6	10600
16	Day 8 (End)	Completely evaporated		

Table II - Solar Evaporation of 10 L Effluent

Sl.no	Day no	Temp (deg Celsius)	Depth (Cm)	TDS (ppm)
	Tank II and III			
1	Day 1 (Start)	34	2.6	1600
2	Day1 (End)	33	2	2800
3	Day 2 (Start)	35	1.9	3100
4	Day2 (End)	32	1.3	4300
5	Day 3 (Start)	35	1.2	4500
6	Day3 (End)	33	0.6	5900
7	Day 4 (Start)	34	0.5	6000
8	Day4 (End)	Completely evaporated		

The five parameters such as temperature, velocity of wind, atmospheric pressure, extent of free surface of effluent and quantity of vapour already present in the environment affect the evaporation rate. Evaporation increases with temperature, velocity of wind and surface area of effluent. It decreases with quantity of vapour of that liquid in the air. It has also been found that low atmospheric pressure increases the evaporation rate and it is maximum in vaccum.

The variation of TDS of treated effluent with depth is as shown in figure 2. There is a gradual increase of TDS with decrease in depth of effluent in tank (due to evaporation).

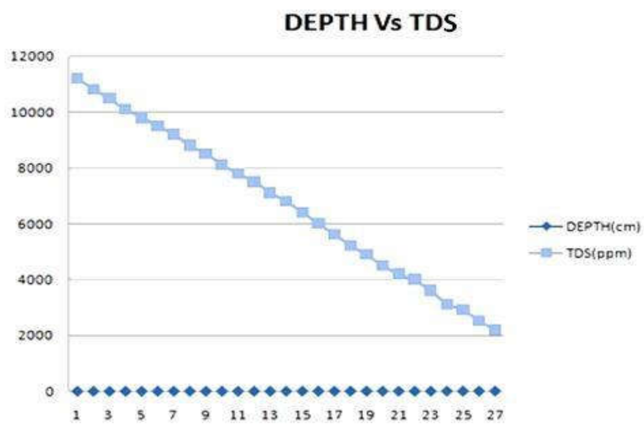

Figure 2. Depth Vs TDS of treated effluent in Tank II and III for 20 litres.
The variation of temperature during each day is shown against depth as in figure 3. There is decrease in depth of effluent because of evaporation. In figure 2 1, 2, 3….8 denote days.

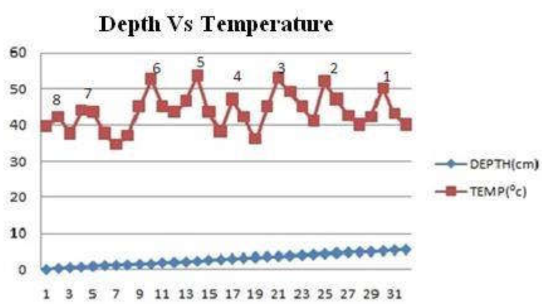

Figure 3. Depth Vs temperature on various days

Table III - Weight of salt obtained from tanks after evaporation

Sl No	Volume of the effluent (litres)	Weight of the salt from tank I (gm)	Weight of the salt from tank II (gm)
1	20	5	5.5
2	10	10	10.5

Results show that with evaporation of effluent, there is gradual decrease of effluent depth and increase of effluent TDS in both the tanks. The effectiveness of this method depends on the intensity of solar radiation and quantity of effluent in the tank. The tank functions effectively during summer with very high evaporation rate than cement tank. Thus solar evaporation proves to be an effective method for the recovery of dissolved salts within a period of 8 days for 20 litres and 4 days for 10 litres of pharmaceutical effluent.

5. Conclusion

Solar evaporation tank made of black kadppa stone is simple, easy, cheap and eco-friendly. Black body kadappa stone absorbs radiation and supplies more heat for evaporation. It has better performance than cement concrete tank. Salt and suspended matter from the effluent is recovered. Solar evaporation method is better for high TDS effluent and it also reduces the quantity of the effluent discharge. Usage of natural black kadappa stone alternate to cement concrete tanks increases the rate of evaporation of effluent by around 100% which can be easily adopted by industries to increase the evaporation rate with the above advantages to recover the solid matter from the effluent that causes ground water and soil pollutions.

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