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# Performance analysis of plain pan with pipeline arrangement solar evaporation system (PPPA) for treating textile dye effluent

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**Abstract:** The reject from the R.O.Plant in the treatment of textile effluents is a major environmental concern due its high dissolved solids. Solar evaporation is the only cost effective technique for treatment and disposal of high TDS. In the Plain solar evaporation system (PP), the rate of evaporationis 4.5 lit/$m^2$ day which requires large land area. In this study, the plain pan with vertically installed pipeline line arrangement (PPPA) was fabricated for the evaporation of textile waste to increase the rate of evaporation. Comparison study on performance of plain pan with vertically installed pipeline line arrangement (PPPA) system was made with PP. The daily rate of evaporation and TDS along with the meteorological parameters such as temperature, relative humidity and wind speed were measured for a period of 31 days. It was observed that, the rate of evaporation in PPPA was about 4 timesmore than the PP System.
**Keywords :** Solar energy; Solar Evaporation; Plain Pan; Pipeline arrangement;Textile dye effluent; R.O. Reject disposal.

## 1. Introduction

There are about 10,000 garment manufacturers and 2100 bleaching and dyeing industries in India. Majority are concentrated at Tirupur and Karur in Tamil Nadu, Ludiyanain Punjab and Surat in Gujarat[1,2]. Textile dyeing is a combined process of bleaching and coloring, which generates voluminous quantities of wastewaters and in turn causes environmental degradation.

Wastewater from the textile finishing industry commonly contains moderate concentrations (10 - 200 mg/l) of dyestuffs, contributing significantly to the pollution of aquatic ecosystems. Various physico-chemical and biological techniques have been employed for the treatment of dye containing effluents. They include coagulation/ flocculation, biological degradation using aeration system, activated carbon adsorption, oxidation, ozonation, membrane separation, Multiple effect evaporation etc., The mechanical Evaporation are reported as expensive and not environment friendly [3,4]. The technical and economic feasibility of each of these techniques is determined by several factors such as dye type, wastewater composition, operation costs and generated waste

products. Also, the use of one individual technique is not sufficient to achieve complete disposal and therefore textile effluent strategies consisting of a combination of different techniques may be necessary.

In recent years, the use of reverse osmosis (RO) technique in wastewater treatment is a highly efficient process, in terms of high recovery, low operating cost and easy operation and maintenance. RO membranes have a retention rate of 90% or more for most types of ionic compounds and they produce a high quality of permeate. However in RO permeates, the removal of all mineral salts, hydrolyzed reactive dyes and chemical auxiliaries, but the problem involved is that the higher the concentration of salts, the more important the osmotic pressure becomes and consequently, the greater the energy required. Nano filtration membranes retain organic compounds of low molecular weight, divalent ions or large monovalent ions, such as hydrolyzed reactive dyes and dyeing auxiliaries. Multiple effect evaporators were used in large scale industries wherein the initial investment and operational costs are high. Small scale industries generating small quantity of effluent can't go for such costlier technologies and depend on low cost technology of solar evaporation. In Solar wind evaporation, the initial investment, maintenance cost and operational cost are less[6].

Hence, economical evaporation technologies for the disposal of waste water become need of the industries. Solar evaporation is one of the efficient methods. The construction of solar evaporation system can easily be built, operation cost is very less and no skilled person required. The rate of evaporation in conventional solar evaporation pan is very less and hence requires large surface area[7-9]. The availability of land and its cost makes plain solar evaporation system as an uneconomical. The efficient use of the given surface area by utilizing the vertical space over the solar evaporation pan also will increase the rate of evaporation. This concept led to development of Plain pan with pipeline arrangement (PPPA) evaporation system. Here the rate of evaporation was observed to be 4 to 5 times more when compared to the plain pan solar evaporation system.

## Materials and methodology

### Plain pan with pipeline arrangement (PPPA) evaporation system

Two types of evaporation system Viz. plain pan (PP) and plain pan with pipeline arrangement (PPPA) evaporation system was fabricated in lab scale. The fabrication detail is given below.

### Fabrication details of PP and PPPA

**Fig. 1 (a) Photographic image of PP**

**Fig. 1 (b) Photographic image of PPPA**

Two trays made of G.I. Sheet of Size 1m×1m×0.3m. One tray was considered for PP-1 system. In the second tray, 9 number of PVC pipes of 1.30 m height and 0.1m dia were fixed vertically with a spacing of minimum 10 cm so that the flow of wind occurs in between the pipes. The pipes were woven with Gunny bags. The dye waste water was dropped over the pipes and kept wet all the times. Here the surface area of all the 9 number of pipes has been increased to 4.8 sq.m and this area were utilized for solar evaporation instead of 1 sq.m plain area and the system was allowed for solar evaporation. The daily evaporation rate is recorded. Fig 1(a) and 1(b) represents the photographic image of PP and PPPA respectively.

## Experimental method

The experiment was conducted for the period of 27 days in PP and PPPA. The raw textile dyeing waste water was collected from the textile industry. The effluent parameters such as pH, TDS, Suspended Solids, Chlorides, Sulphate, BOD and COD were analyzed. The metrological parameters such as Temperature, Wind Speed and Relative Humidity were recorded. The influence of rate of evaporation on the metrological parameters was determined by plotting rate of evaporation against Temperature, Wind Speed and Relative Humidity.

## Result and discussion

The rate of evaporation of water from the textile effluent using enhanced natural evaporation system such as PP and PPPA were studied. This section deals with the discussion on rate of evaporation of water from enhanced natural evaporation system

### Study 1-Plain pan(PP) with pipeline arrangement (PPPA) evaporation system

The characteristics of the textile dyeing effluent was analyzed and given in Table 1.

**Table 1 Characteristics of raw textile dyeing effluent**

| S.No | Parameters | Value |
|---|---|---|
| 1 | pH | 8-9 |
| 2 | TDS | 5000-8000 |
| 3 | Suspended Solids | 350-450 |
| 4 | Chlorides | 2000-2500 |
| 5 | Sulphates | 500-750 |
| 6 | BOD | 100-200 |
| 7 | COD | 250-450 |

The initial volume of 85 litres of effluent was taken and fed into the PP and PPPA. The duration of evaporation per day was kept for 7 hrs. The amount of waste water in the pan was measured. The rate of evaporation was calculated for the duration of 7hrs. The meteorological data for Temperature, relative humidity, wind speed and the observed rate of evaporation for PP and PPPA system was given in the Table 2. From the table 2, it was observed that the rate of evaporation is higher for PPPA when Compared to PP. This may be due to the increase in the surface area by pipeline arrangement in PPPA. The average rate of evaporation for water from textile effluent in PP and PPPA was observed as 0.3 and 1.53 respectively. Also the rate of evaporation of PPPA was found to be 5 times more than PP.

**Table 2. The meteorological data and observed rate of evaporation for PP and PPPA System**

| S.No | Temperature °C | Relative Humidity (%) | Wind Speed (Km/hr) | Duration of evaporation (hrs) | Qty of waste Stored in Tank (litre) | Amount after evaporation (litre) | | Amount Waste evaporated (litre) | | Rate of evaporation ($l/m^2.hr$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | PP | PPPA | PP | PPPA | PP | PPPA |
| 1. | 28 | 96 | 5 | 7 | 85 | 82.9 | 75.55 | 2.1 | 9.45 | 0.3 | 1.35 |
| 2. | 28 | 93 | 4.9 | 7 | 85 | 83 | 76 | 2 | 9 | 0.3 | 1.29 |
| 3. | 27 | 93 | 4.9 | 7 | 85 | 82.86 | 75.33 | 2.14 | 9.67 | 0.3 | 1.38 |
| 4. | 30 | 92 | 4.5 | 7 | 85 | 82.8 | 75.1 | 2.2 | 9.9 | 0.3 | 1.41 |
| 5. | 31 | 82 | 4 | 7 | 85 | 82.85 | 75.32 | 2.15 | 9.68 | 0.3 | 1.38 |
| 6. | 32 | 93 | 4.2 | 7 | 85 | 82.7 | 74.65 | 2.3 | 10.35 | 0.3 | 1.48 |
| 7. | 32 | 93 | 4.3 | 7 | 85 | 82.45 | 73.53 | 2.55 | 11.47 | 0.4 | 1.64 |
| 8. | 31 | 91 | 4.1 | 7 | 85 | 82.6 | 74.2 | 2.4 | 10.8 | 0.3 | 1.54 |
| 9. | 31 | 78 | 4 | 7 | 85 | 82.55 | 73.98 | 2.45 | 11.02 | 0.4 | 1.57 |
| 10. | 32 | 80 | 4.3 | 7 | 85 | 82.5 | 73.75 | 2.5 | 11.25 | 0.4 | 1.61 |
| 11. | 32 | 90 | 4.5 | 7 | 85 | 82.5 | 73.75 | 2.5 | 11.25 | 0.4 | 1.61 |
| 12. | 31 | 91 | 4.4 | 7 | 85 | 82.53 | 73.89 | 2.47 | 11.11 | 0.4 | 1.59 |
| 13. | 31 | 90 | 4.6 | 7 | 85 | 82.52 | 73.84 | 2.48 | 11.16 | 0.4 | 1.59 |
| 14. | 30 | 91 | 4.7 | 7 | 85 | 82.6 | 74.2 | 2.4 | 10.8 | 0.3 | 1.54 |
| 15. | 32 | 90 | 4 | 7 | 85 | 82.5 | 73.75 | 2.5 | 11.25 | 0.4 | 1.61 |
| 16. | 32 | 91 | 4.3 | 7 | 85 | 82.52 | 73.84 | 2.48 | 11.16 | 0.4 | 1.59 |
| 17. | 31 | 90 | 4.2 | 7 | 85 | 82.51 | 73.8 | 2.49 | 11.2 | 0.4 | 1.60 |
| 18. | 32 | 91 | 4.1 | 7 | 85 | 82.7 | 74.65 | 2.3 | 10.35 | 0.3 | 1.48 |
| 19. | 32 | 90 | 4.3 | 7 | 85 | 82.5 | 73.75 | 2.5 | 11.25 | 0.4 | 1.61 |
| 20. | 32 | 88 | 4.3 | 7 | 85 | 82.55 | 73.97 | 2.45 | 11.03 | 0.4 | 1.58 |
| 21. | 30 | 90 | 4 | 7 | 85 | 82.56 | 74.5 | 2.44 | 10.5 | 0.3 | 1.50 |
| 22. | 31 | 92 | 4.5 | 7 | 85 | 82.61 | 74.11 | 2.39 | 10.89 | 0.3 | 1.56 |
| 23. | 31 | 92 | 4.6 | 7 | 85 | 82.6 | 74.02 | 2.4 | 10.98 | 0.3 | 1.57 |
| 24. | 32 | 93 | 4.8 | 7 | 85 | 82.5 | 74.11 | 2.5 | 10.89 | 0.4 | 1.56 |
| 25. | 32 | 91 | 4.5 | 7 | 85 | 82.53 | 74.2 | 2.47 | 10.8 | 0.4 | 1.54 |
| 26. | 30 | 90 | 4.3 | 7 | 85 | 82.62 | 73.77 | 2.38 | 11.23 | 0.3 | 1.60 |
| 27. | 31 | 91 | 4.4 | 7 | 85 | 82.59 | 73.88 | 2.41 | 11.12 | 0.3 | 1.59 |

**Influence of Metreological Parameters for PP and PPPA System**

The influence of meteorological parameters such as Temperature, Relative Humidity and Wind speed on rate of evaporation for both PP and PPPA system was studied.

**Effect of Temperature on rate of evaporation.**

The experiment was conducted for the period of 27 days. The temperature of the study period varies from the range of 27°C-32°C. The average rate of evaporation of each temperature was calculated and the plot was drawn between rate of evaporation against Temperature for both PP and PPPA system. Fig. 2 shows the effect of Temperature for PP and PPPA. From the Fig 2, it was observed that the rate of evaporation increased with increase in temperature. The increasing trend was observed for both PP and PPPA system. Also it was observed that the rate of evaporation is higher for PPPA when compared to PP at all temperatures. The average rate of evaporation for temperatures was observed as 0.32 and 1.46 lit/$m^2$hr for PP and PPPA respectively. Hence the rate of evaporation of PPPA was found to be 4.5 times more than PP for the effect of Temperature.

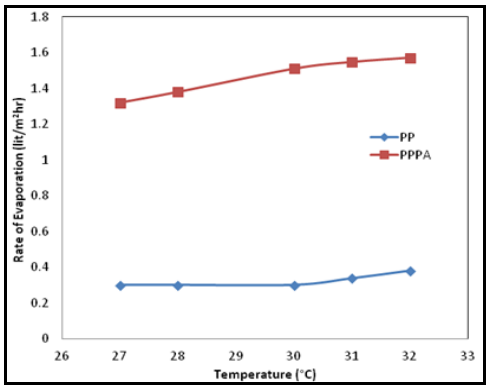


**Fig. 2 Effect of Temperature on Rate of Evaporation for PP and PPPA**

**Effect of Relative humidity on rate of evaporation**

The Relative Humidity of the study period varies from the range of 78%-96%. The average rate of evaporation of each Relative humidity was calculated and the plot was drawn between rate of evaporation against Relative humidity for both PP and PPPA system. Fig. 3 shows the effect of Relative humidity for PP and PPPA. From the Fig 3, it was observed that the rate of evaporation decreased with increase in Relative humidity. The decreasing trend was observed for both PP and PPPA system. Also it was observed that the rate of evaporation is higher for PPPA when compared to PP at all Relative humidity. The average rate of evaporation for Relative humidity was observed as 0.34 and 1.51 lit/$m^2$hr for PP and PPPA respectively. Hence the rate of evaporation of PPPA was found to be 4.38 times more than PP for the effect of Relative humidity

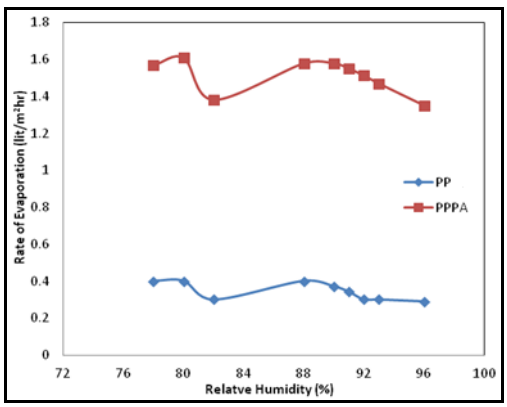


**Fig. 3 Effect of Relative Humidity on Rate of Evaporation for PP and PPPA**

**Effect of Wind Speed on rate of evaporation.**

The experiment was conducted for the period of 20 days. The wind speed of the study period varies from the range of 4-5 kmph. The average rate of evaporation of each wind speed was calculated and the plot was drawn between rate of evaporation against wind speed for both PP and PPPA system. Fig. 4 shows the

effect of wind speed for PP and PPPA. From the Fig 4, it was observed that the rate of evaporation increased with increase in wind speed. However the decreasing trend was observed at wind speed of 4.5kmph for both PP and PPPA. This may be due to the effect of various other parameters. The same trend was observed for both PP and PPPA system. Also it was observed that the rate of evaporation is higher for PPPA when compared to PP at all wind speed. The average rate of evaporation for wind speed was observed as 0.34 and 1.54 lit/$m^2$hr for PP and PPPA respectively. Hence the rate of evaporation of PPPA was found to be 4.5 times more than PP for the effect of wind speed.

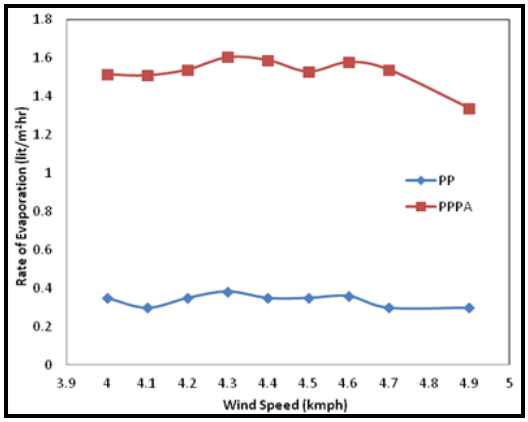


**Fig. 4 Effect of Wind Speed on Rate of Evaporation for PP and PPPA**

## Conclusion

The plain pan with arrangement solar evaporation system was fabricated in lab scale for the textile effluent. The metreologicalparameters were measured. Comparison on rate of evaporation between PP and PPPA was made and observed that the rate of evaporation is higher for PPPA when Compared to PP. This may be due to the increase in the surface area by pipeline arrangement in PPPA. The Rate of evaporation was increased with increase in Temperature and Wind speed and decreased with increase in relative humidity. The rate of evaporation of PPPA was found to be 5 times more than PP.

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