



## Efficient solar still for industrial and urban wastewater treatment for reuse in industry and agriculture

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### **Abstract:**

One of the renewable energy sources with numerous useful applications is solar energy. Solar-powered wastewater desalination is a top study area that has drawn interest from scientists and researchers worldwide. However, effectively cleaning and reusing industrial and other wastewaters can be difficult at times. Both the environment and human health are negatively impacted when contaminants are present in wastewater. In the current investigation, effluent from tanneries and cities was put into a solar still and allowed to evaporate in the presence of natural sunlight. Chemical oxygen demand (COD) and pH levels of different wastewaters were measured. Lastly, the test findings demonstrated that following the subsequent solar evaporation operation, the water quality had greatly improved. This is a method of treating.

## **1. Introduction**

Examining the situation from a global standpoint reveals that industrial development, particularly the intensification of industry aimed at fostering economic growth, has led to heightened natural resource consumption and increased environmental pollution. Additionally, the growth of the population and its concentration in major urban areas can result in ecological harm. Such factors can disrupt the ecological balance and may directly impact human health. In response to this danger, a new concept of development has been introduced to promote sustainability and protect the environment [1]. One viable solution for achieving this is the treatment and reuse of wastewater. Typically, similar treatment technologies are employed for municipal wastewater due to its consistent composition, which largely consists of unchanging compounds predominantly

discarded by households, cities, and communities. In contrast, the characteristics of industrial wastewater differ significantly across various industries. The substances present are varied and intricate, often exhibiting traits such as toxicity, non-biodegradability, and hazardousness. This necessitates an examination of various treatment methods tailored to each category of wastewater to effectively eliminate pollutants. For instance, the treatment involves heavy metals from the electronics sector, chemical solvents utilized in tanning, synthetic dyes employed in printing, and radioactive isotopes found in medical applications. The tanning industry is known to dispose of specific wastewater that is significantly tainted with a variety of chemicals, minerals, or organic substances. The primary chemical stabilizers utilized are chromium and sulfides. Additionally, during production, other substances such as salts, alkaline materials,

fungicides, masking agents, edible oils, and resins are incorporated. Various treatment processes are employed based on the type and composition of the industrial wastewater. These processes primarily consist of biological treatment, filtration, membrane techniques, ultraviolet (UV) radiation, and advanced oxidation processes [2-12]. It is advisable to incorporate renewable energy into all treatment strategies from the beginning to guarantee the wastewater treatment industry's sustainability. In fact, enhancing process efficiency requires the consideration of new parameters related to sustainability and environmental protection.

The objectives of the study are to study the performance of a solar distiller using tannery and urban wastewater and evaluate its operational performance.

## 2. Material and Methods

### 2.1 Water samples

The industrial wastewater effluent from the Tannery industry in Rouiba, Algeria, served as the wastewater sample for this investigation. An activated sewage sludge wastewater treatment plant in Blida, Algeria, provided the sample of urban wastewater. To maintain the samples' quality, waste water samples were gathered and sent to the lab within four hours after collection. Sufficient care was taken to guarantee the samples' integrity. The water samples underwent a variety of physicochemical and bacteriological analyses, which are detailed below.

### 2.2 Wastewater Physicochemical Analysis

According to conservation guidelines and standard analysis techniques, all parameters are examined in the lab as quickly as feasible, taking into consideration the tannery wastewater pollutants' quick biodegradability. A pH meter (Consort C5020) was used to measure the solution's pH. A turbidimeter (HANNA HI88703) was used to measure the turbidity. A conductivity meter method (HACH 7027) was used to measure the conductivity. The Algerian standard experimental methodology was used to analyze the biological oxygen demand (BOD5), and the standard experimental technique was used to analyze the chemical oxygen demand (COD). A membrane filtering method with a pore size of 0.45 μm was used to perform the microbiological water quality analysis.

### 2.3 Experimental set-up

The experiments and developed prototype (Figure 1) were performed at the EVER laboratory of the Solar Equipment Development Unit (UDES)/Algeria.



Figure 1. Solar still prototype Under Natural solar irradiation

## 3. Results and Discussions

The physicochemical analysis of the tannery effluent under study is displayed in Table 1. The results of this tannery wastewater are compared to the national industrial effluent liquid discharge standards in Algeria (Official Journal of the Algerian Democratic and Popular Republic, 2006).

Some parameter values, including DCO, which ranges from 89.12% to 998.33%, and turbidity, which ranges from 36 to 0.5 NTU with a rate of 98.61%, have exceptionally high decrease rates, according to the average of the results from Table 1. The Algerian limits are significantly exceeded by the DCO (5118 mg/L).

Table 1. Abatement of physicochemical pollution of tannery wastewaters

Parameters	Rawwaste water	Treated Waste water	Rate (%)
Temperature	25.7	25	-
Color	Blue	Transparent	-
pH	3.97	2.31	-
Conductivity (ms/cm)	37.2	0.96	97.41
Turbidity (NTU)	36	0.5	98.61
DCO (mg/l)	47079	5118	89.12
BOD5 (mg/L)	30 000	500	98.33
Salinity (g/l)	23.7	0.4	98.31
TDS (g/l)	21.5	0.5	97.67

Table 2. Abatement of physicochemical pollution of urban wastewaters

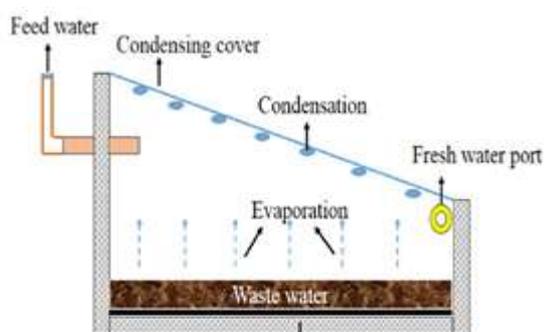
Parameters	Rawwaste water	Treated Waste water	Rate (%)
Temperature	28.7	28.7	-

Color	Brown	Transparent	-
pH	6.4	8.4	-
Conductivity (ms/cm)	1.4	0.29	79.28
Turbidity (NTU)	357	3.2	99.10
DCO (mg/l)	47850	800	98.32
BOD5 (mg/L)	943	67	92.89
Salinity (g/l)	0.7	0.1	85.71
TDS (g/l)	0.75	01.5	80
Total coliforms (ufc/100ml)	$3 \cdot 10^9$	$10^5$	99.99
Fecal coliforms (ufc/100ml)	$5 \cdot 10^8$	220	99.99

Urban wastewater treatment also recorded efficiency close to that of conventional treatment applying activated sludge applied in the Blida wastewater treatment plant. Turbidity was reduced by 99.10%; BOD was 92.89%; and inactivation of infectious organisms has reached 99.99%. As shows in Table 2.

### 3.1 Clarity of water after treatment

The water's clarity indicates a notable decrease in contamination, as seen in Figures 2 and 3, which were previously discussed in a related experiment [1, 11–13]. After the treatment process, the distillate was clearly clear and colorless.



**Figure 2.** Comparison of industrial wastewater after evaporation under natural sunlight and before evaporation.



**Figure 3.** Comparison of urban wastewater before and after evaporation under natural sunlight



**Figure 4.** Mechanism and working of solar still [14].

### 3.2 Working principle of solar still

The temperature of the blackened pool of water rises as a result of solar radiation entering through the glass cover of the solar still (Figure 4). The water then evaporates as a result of convection, which moves heat from the pool to the water's surface. Water condenses on the bottom of the glass surface because its surface is warmer than the glass's. The condensed water droplets are collected in a storage tank after flowing down the glass due to gravity [14].

## 4. Conclusions

The aim of this work was to determine the feasibility of using a solar still to recover fresh water from tanneries and municipal wastewater. The experiment demonstrated the feasibility of wastewater treatment to produce clean water, providing a possible solution for urban wastewater management in arid and semi-arid regions. Therefore, this study concluded that pure water can be generally obtained using solar stills.

### Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
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