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# A Sustainable Concept for Recovering Industrial Wastewater Using Adjustable Green Resources †

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**Abstract:** In arid environments, specifically in Africa, inadequate water sources have resulted in poor-quality water use in business and agricultural industries. This can also negatively impact the ecosystem, along with the industry's water management. In solar power generation facilities, evaporating basins are usually used to release and store industrial contaminated wastewater. An examination of the environmental implications and concerns of this experience suggests such a form of wastewater discharge to reduce industrial effluents' direct release into the environment. Unfortunately, this strategy could have far-reaching global environmental consequences and issues. In this research, we examined the evolution of the effluent's physicochemical characteristics over a long period using a methodological approach for a power station located in Morocco; the findings of this practical study show a significant increase in the physicochemical characteristics of the wastewater released in the evaporating basins, which might be interpreted by an increase in water pollution. The primary objective of this study is to examine wastewater recycling and the generation of treated water in a solar still, utilizing renewable energy to minimize the environmental and ecological problems associated with wastewater discharged into evaporating basins.

**Keywords:** evaporating basins; wastewater; ecosystem; environment; physicochemical characteristics

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## 1. Introduction

The exploitation of resources is becoming increasingly destructive, and durable resource limitations, particularly in relation to freshwater, continue to pose a significant challenge in the twenty-first century.

Evaporating basins (Figure 1) are ponds made of earth that are lined with a geomembrane and contain a volume of water that evaporates due, mainly, to exposure to full sunlight. The substances that are included in the mixtures begin to crystallize in the saline because of the evaporation of the surface water from the basins, and they are then routinely recovered and disposed of as solid waste [1].

However, there appear to be some disadvantages to employing evaporating basins, such as the need for large amounts of land once the evaporating rate has reduced or if the dumping quantities are very high, and the necessity for such huge tracts when these situations arise [2].

Regardless of their numerous benefits, evaporating basins may cause a variety of environmental problems. It is possible, for illustration, that any industrial effluents from the evaporating basins could have devastating effects on the local ecosystem. Being open waterways, evaporating basins attract a variety of animals, which can lead to an increase in the mortality of some species if the collected effluent exceeds the permissible limits [3].

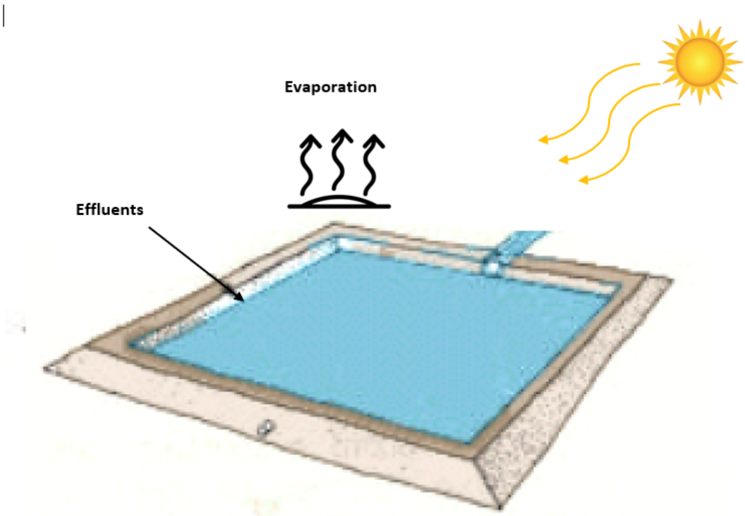


**Figure 1.** Evaporating Basin.

Wastewater treatment is crucial now because of the need to preserve the planet's precious resources. Many methods have been created to control effluents and reduce water pollution to reach this objective [4].

By analyzing the wastewater from a power plant in Morocco, we expect to demonstrate how serious an issue this has become for all factories, notably for water treatment factories that discharge their effluent into evaporation basins. This study examined the physicochemical factors that contribute to pollution in wastewater.

## 2. Material and Methods

### 2.1. Study Area

From November 2021 to October 2022, we obtained effluent samples from the evaporation basin of a Moroccan power plant; the idea was to make sure that we had a representative sample for a whole year.

### 2.2. Effluent Physicochemical Analysis

The Sigma SD900 Portable Sampler was used to collect the dataset from the power plant between November 2021 and October 2022.

The physicochemical analyses of the wastewater were performed according to accepted and relevant techniques at an independent chemical analysis laboratory in Morocco.

The relevant physicochemical analyses were performed using the methods described below:

Total suspended solids (TSS), electrical conductivity (EC), and pH were measured in accordance with norms ISO 10523:2012, ISO 7888:2001, and EN 872:2013.

The organic pollutants' biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were assessed using the norm 03.7.054 v 2013.

Soluble sulphate (SO4) levels were measured in accordance with NM ISO/TR 896.

### 2.3. Regression Analysis

The least-squares regression method is used in statistics to make predictions about how control variable could change over time. When employing least-squares analysis, it is essential to focus on the optimum path in conjunction to all other keypoints. It is common practice for users to examine the relationship between the regression model and a set of probable variables by carrying out regression analysis (Equation 1) [5].

$$Y = ax + b \tag{1}$$

where Y = dependent, x = independent, a = intercept, and b = constant.

To better understand the relationships between the various effluent properties, a statistical study has been conducted. The statistical method of regression analysis is used to ascertain the strength and direction of the connection between the variables being investigated [6].

## 3. Results and Discussion

### 3.1. Physicochemical Results

The results from a year's length of physicochemical analysis on the power plant's wastewater are summarized in Table 1.

**Table 1.** Results of physicochemical evaluation.

| Parameter | Unit | Limit | 11/21 | 12/21 | 01/22 | 02/22 | 03/22 | 04/22 | 05/22 | 06/22 | 07/22 | 08/22 | 09/22 | 10/22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | pH unit | 5.5–9.5 | 8.1 | 7.9 | 7.6 | 7.9 | 8.0 | 7.5 | 7.6 | 8.1 | 8.1 | 7.1 | 7.7 | 8.0 |
| EC | ms/cm | 2.7 | 9 | 18 | 19 | 23 | 38 | 18 | 45 | 26 | 33 | 28 | 44 | 36 |
| $SO_4$ | mg/L | 600 | 1800 | 1840 | 2320 | 1985 | 1300 | 3500 | 2900 | 4256 | 1987 | 2692 | 2569 | 4200 |
| TSS | mg/L | 100 | 102 | 79 | 105 | 129 | 153 | 304 | 215 | 116 | 98 | 197 | 203 | 171 |
| COD | mg $O_2$/L | 500 | 356 | 620 | 560 | 519 | 614 | 652 | 498 | 516 | 563 | 578 | 452 | 512 |
| $BOD_5$ | mg $O_2$/L | 100 | 95 | 120 | 95 | 115 | 118 | 103 | 142 | 109 | 98 | 102 | 115 | 124 |

Table 1 shows that the main effluent parameters (COD, $BOD_5$, EC, $SO_4$ and TSS) exceeded the maximum level imposed by Moroccan regulations for effluent released into the environment [7].

In May of 2022, the highest EC value measured was 45 ms/cm, which is much higher than the threshold value of 2.7 ms/cm. In June of 2022, a maximum $SO_4$ value of 4256 mg/L was measured, which is over the permissible limit of 600 mg/l. In April 2022, the highest TSS measurement was 304 mg/L, which is above the allowable 100 mg/L. In April 2022, the highest COD value was 652 mg $O_2$/L, which is over the permissible 500 mg $O_2$/L. In May of 2022, the highest $BOD_5$ measurement recorded was 142 mg $O_2$/L, which is more than the permissible 100 mg $O_2$/L.

### 3.2. Regression Results

Descriptive and inferential statistics were employed in the regression study of effluent characteristics.

Table 2 displays the final square of the regression method developed utilizing statistically significant correlations between effluent properties.

**Table 2.** Regression's least square of the effluent variables.

| Y: Dependent | X: Independent | Correlation ® | $R^2$ | a | B (Constant) | Regression Equation (Y = ax + b) |
|---|---|---|---|---|---|---|
| TSS | pH | −0.603 | 0.364 | −127.88 | 1153.5 | TSS = −127.88 pH + 1153.5 |
| TSS | $SO_4$ | 0.415 | 0.172 | 0.028 | 81.68 | TSS = 0.028 $SO_4$ + 81.68 |
| TSS | EC | 0.314 | 0.098 | 1.81 | 105.13 | TSS = 1.81 EC + 105.13 |
| $BOD_5$ | EC | 0.649 | 0.422 | 0.79 | 88.91 | $BOD_5$ = 0.79 EC + 88.91 |
| COD | pH | −0.319 | 0.1023 | −84.03 | 1192.2 | COD = −84.03 pH + 1192.2 |

Figure 2 shows linear connections between the following physicochemical properties of the effluent:

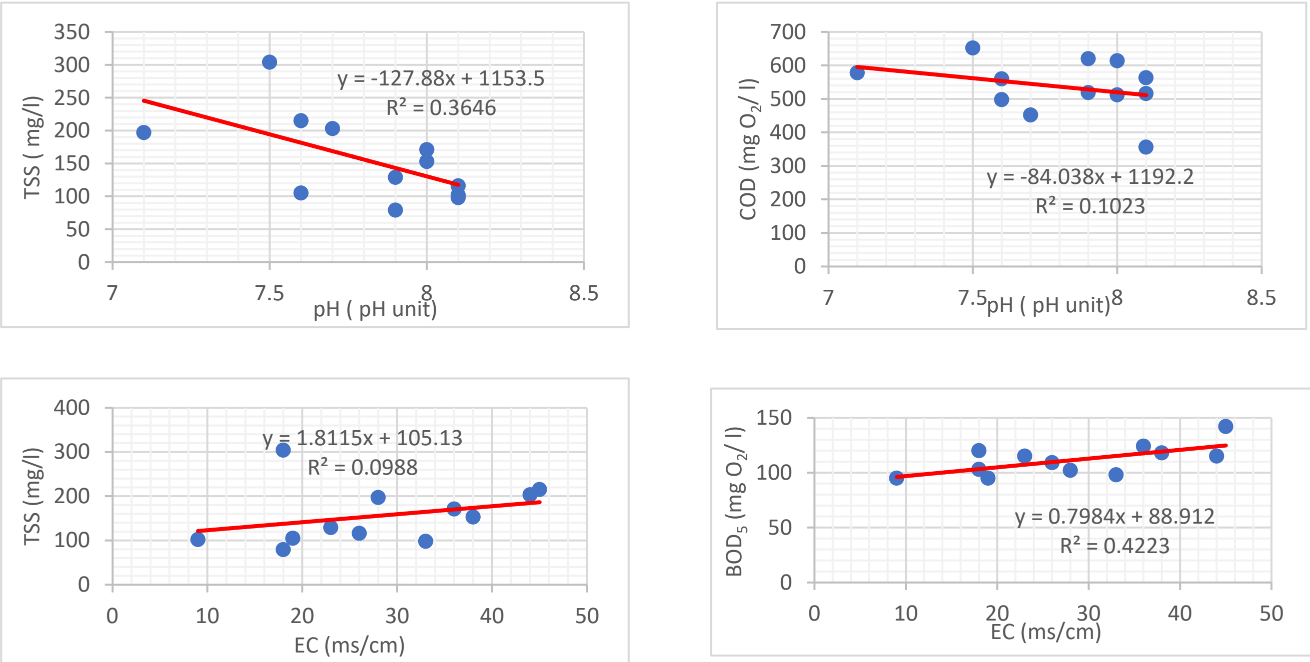


**Figure 2.** Regression linear plots for effluent variables.

The scatter plots showed positive linear relationships between total suspended solids (TSS) and $SO_4$, total suspended solids (TSS) and EC, and $BOD_5$ and EC. Nonetheless, both TSS and COD showed negative linear relationships with pH.

By employing linear regression, we were able to determine the strength of those associations via the obtained R and $R^2$ values.

The graph demonstrates a positive correlation between $SO_4$ and EC with TSS, and that increasing TSS likewise increases $SO_4$ and EC. However, it demonstrates a negative correlation between TSS and COD with pH, and that increasing pH likewise decreases TSS and COD.

The storage of wastewater in the open air has a deleterious impact on the physicochemical and bacteriological properties of industrial effluents, as evidenced by an increase across various effluent properties that exceeds the maximum limits specified by international regulations. Since this phenomenon has the potential to cause ecological and environmental damage, it is imperative that every industry carry out a thorough environmental risk assessment to determine the most appropriate response [8].

According to the results of the physicochemical analysis of the wastewater kept in evaporation ponds, the primary external factors that have altered the physicochemical characteristics of the wastewater over time include biological waste from species that are attracted to the surface of the water, dust, and the concentration of salt in the waste water as a result of evaporation.

Industrial power plants have employed evaporation ponds to retain their effluent based on several criteria for power plant facilities. This approach is intended to prevent the direct discharge of wastewater into the environment. For power plants that still use water vapor as the primary input to power steam turbines, this solution is used to compare the results from this research with those of other current research which suggests evaporation ponds as the ultimate wastewater retention and discharge method.

Wider research might explore the viability of properly recycling effluent instead of storing it in evaporation ponds. It could also look into the possibility of heating the wastewater using the solar collectors already in place for the power plant's process, and then injecting the heated wastewater into a solar sill to create clean water which could be utilized by those solar power plants again, maximizing the surface water utilization to support the required sustainable development.

Considering that evaporation pond techniques are only used in arid, warm climates that are comparable to this study, we may generalize the disadvantages of all worldwide companies that may release their effluents into evaporation basins.

This research and analysis bring us to the conclusion that discharging effluent into evaporating basins is not a viable solution due to the severe negative consequences it has on the environment and its resources.

Consequently, we propose that industries, especially power plants, use environmentally friendly strategies for recycling this effluent. As a result, this might help businesses to justify charging higher rates for water consumption.

Among the most eco-friendly solutions for companies that utilize evaporation ponds is installing huge renewable solar stills; the benefit is conserving the environment as well as reusing wastewater. By doing so, the industry will be able to properly recycle its effluent while spending less on water.

Alternatively, the solar still can be warmed using solar panels that rely solely on sunshine, as shown in the following scheme (Figure 3) for connecting the solar still with evaporating basins. A clear sky all the time reflects a climate that is conducive to this technique.

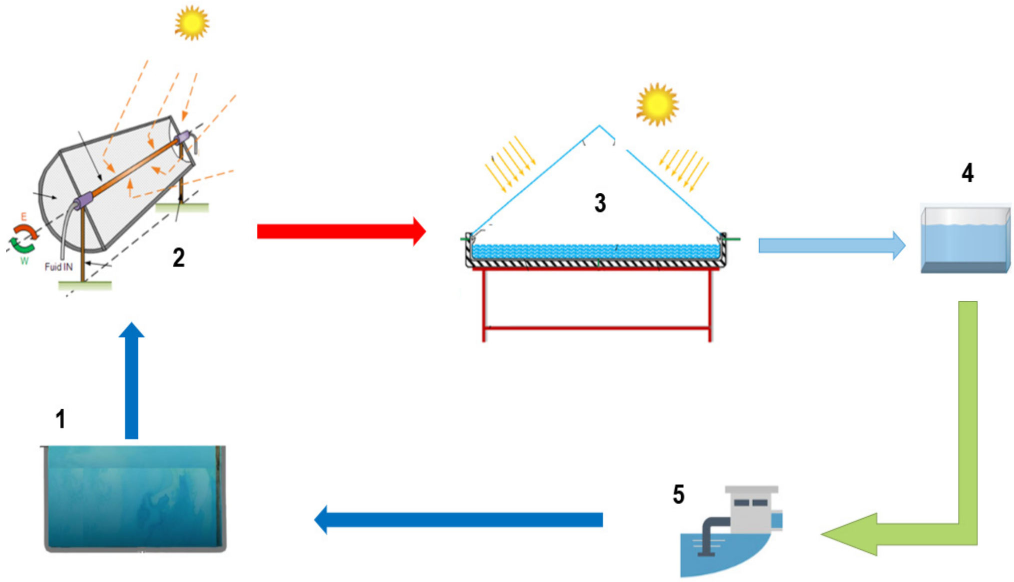


**Figure 3.** Recycling effluent proposed solution. (1) Effluent; (2) solar collector; (3) solar still; (4) clean water; (5) water processing.

## 4. Conclusions

This research, which examined the physicochemical features of the effluents released by power plants, revealed that effluent quality worsened when exposed to stagnation or when stored in evaporation basins. Consequently, several physicochemical characteristics, such as electrical conductivity, total suspended particles, sulfates, and chemical and biological oxygen demand, rise substantially as a result of wastewater storage. As a result, there will be a rise in water contamination.

This study used data collected annually from a power plant's wastewater quality assessments to determine the most significant associations between most linked variables.

According to the findings, there is a correlation between the various physical and chemical characteristics of industrial effluent. In comparison, the values obtained for chemical and biological oxygen needs, electrical conductivity, total suspended solids, and sulfates are all greater than the permissible limits for wastewater quality attributes in the research region.

The proposed eco-friendly option for businesses that utilize evaporation ponds is to install huge sustainable solar stills instead. This has the dual benefit of conserving the environment and reusing wastewater. Because of this, businesses will be able to save money on water bills while reusing wastewater.

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