Available online at https://www.gyanvihar.org/researchjournals/ctm_journals.php
SGVU International Journal of Convergence of Technology and Management
E-ISSN: 2455-7528
Vol.8 Issue 1 Page No 20-25

Continuous process of industrial waste water treatment by using solar energy

Krishna Kumar Sinha[1], Pankaj Kumar[2], Mukesh Kumar Gupta[3], M. K. Banerjee[4]
Department of Energy and Electrical Engineering, Suresh Gyan Vihar University Jaipur-302017, India
*Corresponding Author: mkgupta72@gmail.com

Abstract: -Today, the world is facing challenge towards availability of safe drinking water. The available drinking water entrapped in Ice-caps, river, pond and ground water are less than 2.5% of the total water available on the earth. Due to the rapid industrialization, the water demand for the industrial process is substantial. Therefore, there is a need to treat the wastewater generated from the industries to reuse and recycle the water for the industrial process, horticulture and even domestic purpose. The need of safe drinking water near sea-coast or island, where saline water is only available, can be met through desalination process. In order to treat industrial and domestic wastewater, sea water or polluted river/ground water, desalination is required which is normally done through Reverse Osmosis process or other desalination methods which require high energy to operate. The paper narrates the result of a study on the use of solar energy for waste water treatment at higher energy economy.

1. Introduction

The energy demand is normally met through the conventional energy sources like Coal & Petroleum whose reserve is getting exhausted and their by-product of its combustion has resulted in a wide range of problem from air pollution, climate change, health challenges etc. Therefore, the focus lies to go to utilize Solar Energy [1,2]. The acceptance of Solar Energy because of their many advantages which far outweighs their disadvantages and these are in main areas of: (i) Cost, (ii) Availability, (iii) Environmental Effect, (iv) Sustainability, (v) Easy utilization (low technical knowhow involved) and (vi) Long Life span of solar devices [3,4].

Of all the renewable sources of energy available, solar thermal energy is the most abundant one and is available in both direct as well as indirect forms. The Sun emits energy at a rate of 3.8×10^{23} kW, of which, approximately 1.8×10^{14} kW is intercepted by the earth, which is located about 150 million km from the sun. About 60% of this amount or 1.08×10^{14} reaches the surface of the earth [5].

The treatment of high TDS water is basically based on the evaporation technology. The evaporation can be done through steam or heating effect. The common technologies are: (i) Reverse Osmosis followed by Multi-Effect Evaporator, (ii) Multi-Stage Flash Process (MSF) and (iii) Multi effect distillation (MED). In small scale of evaporation, Solar still is very suitable; however, the area requirement would be large. Solar Concentrate/ Solar Collector would reduce the area requirement [6-10].

The distillation process is very much required where there is scarcity of fresh water; grid electricity is not spread and easy access to seawater or brackish water. However, 1000 m^3 of fresh water per day required 10,000 tons of oil per year. Therefore, the only feasible technology is based on solar energy. It may either through solar pond, electro dialysis, and solar still at smaller scale or RO, MSF, MED at the larger scale [11-14].

The technology, based on Solar Energy may be broadly classified into two [14-15]:

(i) Concentrating Solar Power (CSP):

- Parabolic trough
- Linear Fresnel reflector system
- Central Tower receiver

(ii) Photovoltaic (PV) technology

- Flat Plate PV Module
- Concentrating Photovoltaic (CPV)

The efficiency of the above technologies could be improved through selection of better material, geometry design of Solar Collector, Sun Tracking System [4].

Thus, the solar energy could be used either through thermal or electrical. If we convert solar energy into electrical

Correspondence to: Mukesh kr Gupta, Department of Energy & Electrical Engineering, Suresh Gyan Vihar University, Jaipur
E-mail addresses: mkgupta72@gmail.com

energy, then all motors and electrical operated devices in the evaporation system as well as RO system can be run through electrical energy generated through solar energy in a cost effective way at any location irrespective of grid connectivity [3,7,9].

It is important to note here that the permissible limit of TDS in the drinking water is 500 mg/l. Therefore, the high TDS of sea water (more than 40,000 mg/l); RO rejects (more than 20, 000 mg/l) need to bring down to 500 mg/l for drinking purpose. Similarly, for the agriculture purpose, TDS should bring down to 2100 mg/l. However, for industrial application, the TDS requirement could be less than 50 mg/l for boiler purpose. Thus, the degree of treatment required varies with the different application and accordingly the Technology could be selected [9-11]. Typical value of TDS in the ater polluting industries is given in the table 1.

Table 1. Typical value of TDS in the water polluting industries

Industrial Sector	Process	TDS range (mg/l)
Tannery	Composite	14,000~20,500
	Soaking	19,500~29,500
	Liming	25,000~33,000
	Deliming & Batting	13,500~22,000
	Pickling	43,000~60,000
	Chrome Tanning	38,000~60,000
	Neutralization	6,000 ~10,000
	Dyeing and fatliquoring	6,200~10,000
Pulp & Paper	Combined	1500
Sugar	Mill House waste	1210
	Filter cloth washing	3890
	Floor & Boiler washing	2486
	Combined Wastewater	2368
Distillery	Spent wash	22,143
	Final effluent	4902
Leather (Finished leather processing)	Stripping	8620
	Washing	3500
	Rechroming	14,780
	Basification	9580
	Fat liquoring	6580
	Composite Wastewater	4440
Textile (Cotton Mill)	Bleaching	3184~5532
	Mercerising	1450~2600
	Dyeing	1900~6180
	Printing	830~2360
	Combined	2180~7710
Textile (Synthetic)	Combined	1060~1080
Textile (Woolen)	Combined	1236~6410
Textile (Boiler)	Boiler Blowdown	18,000
Dye & Dye Intermediate	Combined	5455~5658

2. Desalination & Evaporation of High Total Dissolved Solid (TDS) Wastewater

The domestic and industrial wastewater treatment undergoes several stages of wastewater treatment processes like- Pre-treatment, Primary Treatment, Secondary Treatment, Tertiary Treatment and Advance treatment. The requirement of advance treatment has come up in India due to enforcement of Zero Liquid Discharge (ZLD) concept by Pollution Control Board (PCB) and National Green Tribunal (NGT) as shown in figure 1.

In order to meet the compliance and recycle/reuse of industrial and domestic wastewater, the industries and Urban Local Bodies (ULBs) have started to install Reverse Osmosis (RO) plant to reduce the high TDS wastewater to permission

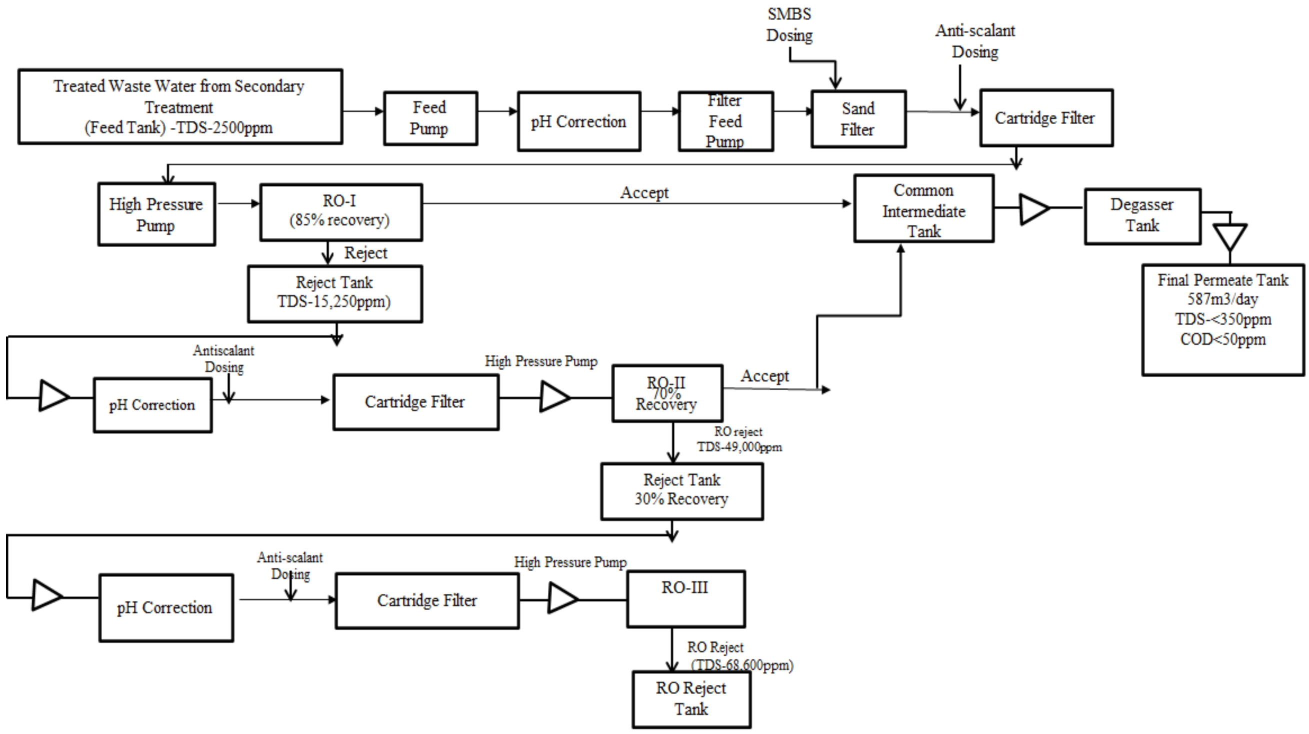
Correspondence to: Mukesh kr Gupta, Department of Energy & Electrical Engineering, Suresh Gyan Vihar University, Jaipur
E-mail addresses: mkgupta72@gmail.com

level of drinking, industrial application, and recycle/reuse. The disposal of rejects from RO plant through evaporation method using conventional energy sources is a serious problem due to high capital & operating cost and serious environmental issues [7,8]. Therefore, there is a need to reduce recurring or operating cost and using environmental clean technology for sustainable solution. Solar Energy is one of the most suitable options for evaporation to reduce the operating cost without damaging the environment.

A solar based Zero Liquid Discharge system comprises of following stages of wastewater treatment:

a) The industrial wastewater undergone normally (i) pre-treatment. (ii) Primary Treatment, (iii) Secondary Treatment and (iv) Tertiary treatment that generally comprises of equalization tank, Oil & Grease trap, coagulation & flocculation tank (Chemical treatment), primary settling tank/tube settler. Aeration tank, secondary settling tank, Multi-grade Filter (MGF), Activated Carbon Filter (ACF) and disinfection either by chlorine treatment or through Ultra Violate (UV) treatment. This system primarily reduces the Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and other micro pollutants so it can be passed through RO membranes without damaging them.
b) Multiple stages RO process – It is reducing the quantity of RO rejects so that evaporation becomes more feasible.
c) Membrane Distillation (MD) is one of the distillation processes with which can handle TDS up to 200, 000 ppm
d) The RO reject with maximum concentration could be evaporated through Solar Energy.

Thus, the integration of the renewable energy in to water desalination systems has become increasingly attractive due to growing demand for the water and energy and the reduction of carbon footprint.



Correspondence to: Mukesh kr Gupta, Department of Energy & Electrical Engineering, Suresh Gyan Vihar University, Jaipur
E-mail addresses: mkgupta72@gmail.com

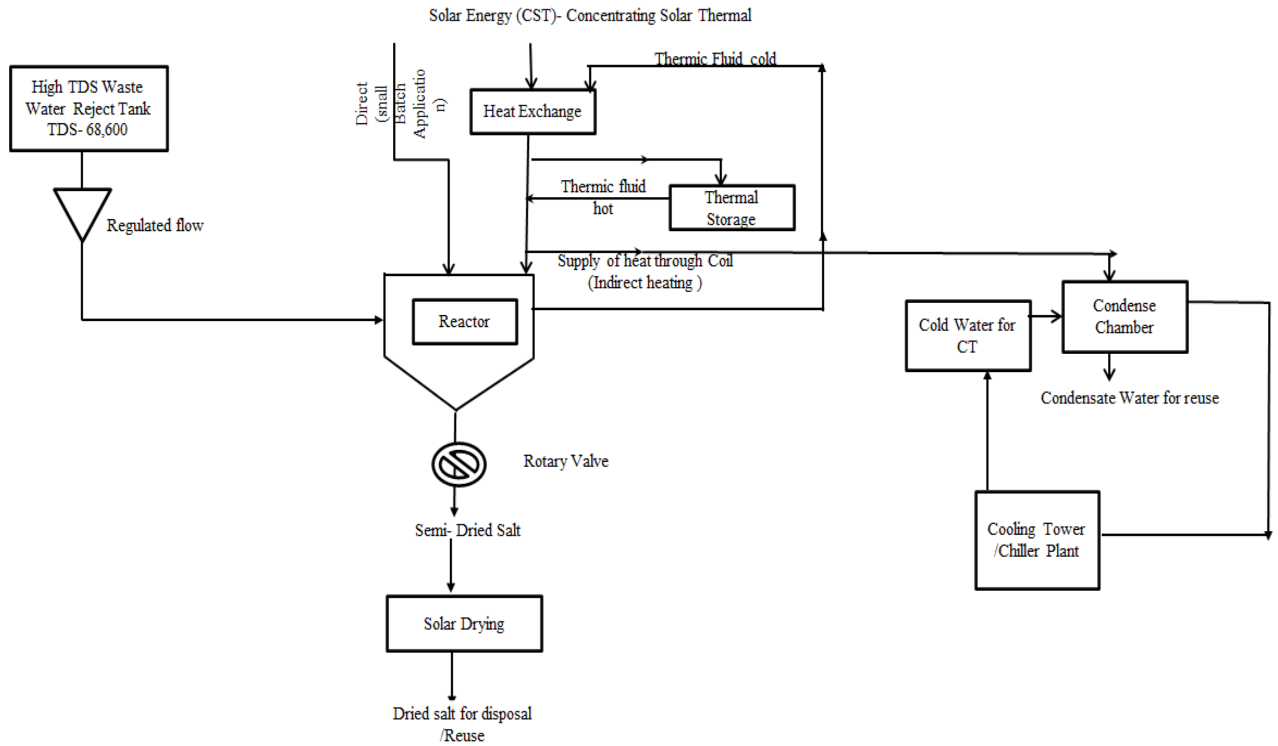


Figure 1: Industrial waste water treatment using continuous process with solar energy

3. Energy Requirements for the Desalination Process

It is important to know the amount of the conventional energy required by the desalination processes to understand why we need to move toward the renewable and sustainable energy resources. Energy requirements of the main desalination techniques is given in table 2. The contribution of the conventional desalination systems to the global warming phenomenon can be assessed by estimating the amount of the fossil fuel needed to be burned to produce a certain amount of fresh water. In the average, producing 1000 cubic meters of fresh water by desalination technology consumes about 5 tons of crude oil which produces about 10 tons of carbon dioxide or about 5000 cubic meters of greenhouse gases. The total global desalination capacity has witnessed a severe increase within the last few years, from 66.48 million cubic meters per day in 2011 to 86.6 million cubic meters per day in 2015. Therefore, serious forward steps toward integrating the desalination systems with the renewable and sustainable energy technologies will be required to mitigate the negative effects of the desalination systems [7-12].

Table-2. Energy requirements of the main desalination techniques.

	MSF	MED-TVC	MED	MVC	RO	ED
Typical unit size (m^3 d^{-1})	50,000 - 70,000	10,000 - 35,000	5,000 - 15,000	100 - 2500	24,000	- 145,000
Electrical Energy Consumption (kWh m^{-3})	4 – 6	1.5 – 2.5	1.5 – 2.5	7 - 12	3 – 7	2.6 – 5.5
Thermal Energy Consumption (kJ kg^{-1})	190 – 390	145– 390	230– 390	None	None	None
Electrical Equivalent for Thermal Energy (kWh m^{-3})	9.5 – 19.5	9.5 – 25.5	5 – 8.5	None	None	None
Total Equivalent Energy Consumption (kWh m^{-3})	13.5 - 25.5	11 – 28	6.5 - 11	7 - 12	3 – 7	2.6 – 5.5

Correspondence to: Mukesh kr Gupta, Department of Energy & Electrical Engineering, Suresh Gyan Vihar University, Jaipur
E-mail addresses: mkgupta72@gmail.com

4. Result

The quality of water has improved several times by using continuous process using solar energy as depicted in table 3.

Table 3. Test Report

Physio- chemical characteristic	Feed Water (Before Distillation)			Solar Distillation (after solar distillation)
	Basin Water	Kitchen Water	Muddy Water	
PH	8.2	8.8	5.2	6.8 – 7.2
Total Solid(mg/l)	923	1332	1421	00
TDS	700	880	316	00
TS	210	452	617	00
Sulphate	168	254	216	00
Phosphates	151	176	162	00
Chloride	194	233	212	00

5. Conclusions

The results of the present study make authors infer that the quality of water is significantly improved by way of removing high TDS of see ater, industrial waste water as well as contaminated ground water. Simillarly it is concluded that by using continuous process for tratment of waste water of industrial water, the other water quality parameters are significantly imroved; the pH value of muddy water is increased from 5.2 to its desirable value within 6.8 to 7.2.

References

[1] D.N.Kale, A.A.Desai, A.H.Khan2, C.D. Pawar3, V.N. Chougule (2017) Topic "Development of waste water Treatment Using Solar Energy", Published in "e-ISSN: 2278-1684,p-ISSN: 2320-334X".

[2] Pascale Compain (2012) Topic "Solar Energy for Water desalination", Published in "Procedia Engineering 46 (2012) 220 – 227".

[3] Ahmed Alkaisi, Ruth Mossad, Ahmad Sharifian-Barforousha (2017) Topic "A review of the water desalination systems integrated with renewable energy", Published in "Energy Procedia 110 (2017) 268 – 274".

[4] P. G. Youssef, R.K. AL-Dadah, S. M. Mahmoud (2014) Topic "Comparative Analysis of Desalination Technologies", Published in "Energy Procedia 61 (2014) 2604 – 2607".

[5] Andrea Ghermandi*, Rami Messalem (2009) Topic "Solar-driven desalination with reverse osmosis: the state of the art", Published in "1944-3994 / 1944-3986 © 2009 Desalination Publications"

[6] Virapana , R. Saravananeb , and V Murugaiyanb (2017) Topic "Treatment of Reverse Osmosis Reject Water from Industries", Published in "ISSN 0973-6077 Volume 12, Number 3 (2017), pp. 489-503".

[7] James C. Lozier, P.E., CH2M HILL, Tempe, Arizona (2014) Topic "Evaluating Traditional and Innovative Concentrate Treatment and Disposal Methods for Water Recycling at Big Bear Valley, California", Published in "International journal of low carbon technology, 2014, 1-19".

[8] Mahmoud Shatat* and Saffa B. Riffat (NA) Topic "Water desalination technologies utilizing conventional and renewable energy sources", Published in "NA".

[9] Soteris A. Kalogirou (2011) Topic "Concentrating solar power plants for electricity and desalinated water production", Published in "World Renewal Energy Congress 2011- Sweden".

[10] Arash Shahmansouri a, Joon Min b, Liyan Jin b, Christopher Bellona a (2015) Topic "Feasibility of extracting valuable minerals from desalination concentrate: a comprehensive literature review", Published in "ELSEVIER".

[11] Ghassan A. Al-hassan1, Salem A. Algarni2 (2013) Topic "Exploring of Water Distillation by Single Solar Still Basins", Published in "Scientific Research; American Journal of Climate Change, 2013, 2, 57-61".

[12] Ammar Alkhatib (2014) Topic "Reverse-Osmosis Desalination of Water Powered by Photo- Voltaic Modules", Published in "Computational Water, Energy, and Environmental Engineering, 2014, 3, 22-29".

Correspondence to: Mukesh kr Gupta, Department of Energy & Electrical Engineering, Suresh Gyan Vihar University, Jaipur
E-mail addresses: mkgupta72@gmail.com

[13] Fawzi Banat1, Hazim Qiblawey2, Qais Al-Nasser3 (2012) Topic “Design and Operation of Small-Scale Photovoltaic-Driven Reverse Osmosis (PV-RO) Desalination Plant for Water Supply in Rural Areas”, Published in “Computational Water, Energy, and Environmental Engineering, 2012, 1, 31-36”.
[14] Fawzi Banat1, Hazim Qiblawey2, Qais Al-Nasser3 (2012) Topic “Design and Operation of Small-Scale Photovoltaic-Driven Reverse Osmosis (PV-RO) Desalination Plant for Water Supply in Rural Areas”, Published in “Computational Water, Energy, and Environmental Engineering, 2012, 1, 31-36”.
[15] P. Asiedu-Boateng1,2, B. J. B. Nyarko2, S. Yamoah1, F. Ameyaw1, K. Tuffour-Acheampong1 (2013) Topic “Comparison of the Cost of Co-Production of Power and Desalinated Water from Different Power Cycles”, Published in “Scientific Research; Energy and Power Engineering, 2013, 5, 26-35”

Correspondence to: Mukesh kr Gupta, Department of Energy & Electrical Engineering, Suresh Gyan Vihar University, Jaipur
E-mail addresses: mkgupta72@gmail.com