A Studies on Wind Aided Intensified Evaporation for Rapid Removal of Salts and Pollutants

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Abstract— Reverse Osmosis (RO) process is a water purification technology which purifies drinking water, desalinate the seawater and treatment of effluents from various domestic and industries to yield potable water in the form of permeate and waste in the form of RO reject or Retentate or Concentrate. The main objective of the present research work is the optimization of RO rejects process management efficiency and issues related to the conventional ZLD approach. In order to minimize the large land requirement, while we using conventional type method such as evaporation pond, which are expensive and needs maintenance because of the materials of construction and their complexity, with particularly high operating costs primarily due to energy consumption and for the management of reject water ZLD technologies intends to develop an alternative solution for brine water management by modern method using wind as an energy source for managing the reject water. Wind aided intensified evaporation is a method in which water is pumped on to fabrics to provide additional surface area for evaporation. The brine is slowly distributed across the sheets. Brine flows down the vertical sheets, concentrating as it falls, due to the evaporation of water by the wind passing across the surface of sheets. The concentrated brine is collected at the base of the system and returned to the holding area. In this article the surface of sheets acts as an absorbing medium that simply absorbs the feed solute and suppose to evaporate the solute with the action of wind velocity. The experimentation is done by practising NaCl solution with different range of concentration in the laboratory scale unit which is almost equivalent to brine concentrations.

Key words: Wind Aided Intensified Evaporation, Rapid Removal, Salts and Pollutants

I. INTRODUCTION

A. Disposal of brine water

Many major improvements have been done in the management and handling of brine water is expensive and faces major environmental challenges. Evaporation ponds have been used over the centuries to remove water from saline solution. Despite of this economical and environmental problem, the options for brine management have been limited. Modern Water's brine concentration technologies can either eliminate or substantially reduce the brine disposal or ZLD treatment process.

B. Zero liquid discharge technologies:

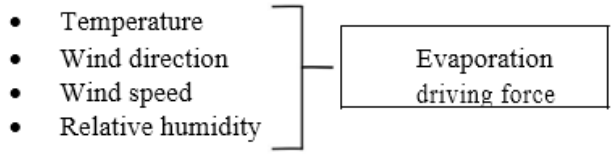
Processes capable of reducing the concentrate, either directly from the conventional RO or the volume-reducing processes to zero liquid discharge (ZLD), (i.e. sufficiently dry salt or other solid to be land filled) were evaluated as a means for final concentrate disposal. Specifically, the analysis focused on mechanical evaporation, solar evaporation (evaporation ponds), and constructed wetlands.

The available zero liquid discharge technologies include:

- Thermal processes
- Enhanced membrane and thermal processes
- Evaporation ponds
- Wind-aided intensified evaporation

C. Evaporation:

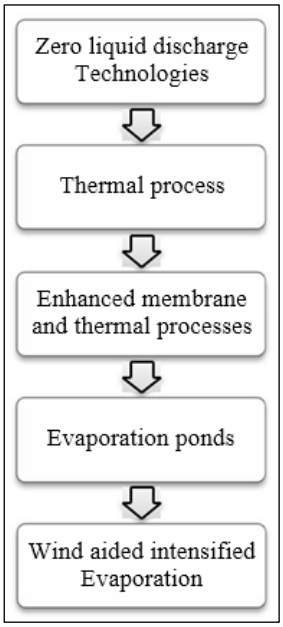
Evaporation performance is a function of the following meteorological parameters;



D. Evaporation ponds (conventional method)

Evaporation ponds are one of the primary technology options while discharging wastewater effluent with minimum concentration in order to gain some sort of benefit by collecting and marketing the salt, which settles as residue at the end of the evaporation process. This technology has a large land requirement, which makes it costly. The one of the main disadvantage, while using these kinds of technologies induced you to attain proper maintenance and energy requirement. These also include the expense of using an impervious liner to avoid seepage of saline water intrusion.

E. Wind-aided intensified evaporation (modern method)



The Wind aided intensified evaporation unit (W.A.I.V)-An alternative solution for brine management. is designed so that

the array of sheets are located closely to get a good enhancement of evaporation capacity (i.e. increased surface area for evaporation) per footprint area without unnecessary blocking of the wind. These technologies used to minimize the large land requirement, when we using conventional type evaporation pond for management of reject water intends to develop an alternative solution for brine water management by modern method using wind as an energy source for managing the different levels of concentrator.

II. MATERIALS AND METHODS

A. General

In the study of analysis, in order to reduce the reject water brine from various treatment plant by means of evaporation process along with the act of intense of wind for rapid evaporation and to mitigate the external energy source. Salinity of water influences the rate of evaporation. As the salinity increases, evaporation decreases. In order to mitigate the significance, the brine is slowly distributed across the sheets. Brine flows down the vertical sheets, concentrating as it falls, due to the evaporation of water by the wind passing across the surface of sheets. The evaporation rate can also be increased by following types of arrangement of array of sheets and type of materials that would be selected for sheet fabric and further it accompanied by the force of agitation this would be practised by one end fixation and the other end might be a free flow movement.

B. Sampling

The brine water concentration can be achieved by practising the artificial mixing proportion. Hence the sample chosen in this physical experimentation should be a synthetic sample; the proportion range should be described by varying the addition of dosage rate of sodium chloride proportion for per litre of water. The variation of proportion may be in the descending 20, 15, 10, 5, and 2 all in (grams per litre) in our case. The main intentions for the proportion of feed water concentration are based on sea water major parameters (i.e. chloride and TDS) in our case study. This inducts effects on conversion the saline induced water into potable type of water.

C. Methodology analysis & fixation from existing methods and literature studies

III. ANALYSIS OF WATER DROPLET PATTERN

A. Need for the study

Flow rate is one of the main objectives when considering evaporation technique as a fixed standard methodology in our experimentation study. The necessity for the analysis of water droplet is to pretend whether thus the enhancement of evaporation of water droplet based on either by its droplet size and also by its driving force (i.e. intensity of flow rate).The evaporation rate of water droplet mainly based on the intensity of velocity of wind, while in a controlled laboratory condition in our experimental case. The experimentation practising by alternating the flow rate accompanied along with the intensity of wind and literature analysis tends to predict the droplet evaporation rate thus correlate the selection of surface medium.

B. Theoretical study on droplet evaporation in order to predict the selection of different surface contact medium

While performing the evaporation by using wind as an energy source, we pretend to observe the evaporative pattern of liquid droplet for intensive rapid evaporation. These analyses of droplet by means of various literature studies, we observed and able to predict the droplet size, that intends to paved the way for fixation of droplet size which illustrate the intense rapid evaporation rate. The evaporative pattern varies for different standard solutions. In our case we are practising the experiment with standard NaCl concentration in different proportion such as 20, 15,10,5 & 2 all in (g/l).The parameters fixation such as total dissolved solids (TDS), chloride etc is based upon literature reviews. Generally the evaporative patterns appear as rings, whose boundaries were either curved or straight (source-spatially resolved evaporative pattern from water, dept of bio-technology).

The evaporation rate always increases linearly based on droplet radius. The evaporation rates as a function of the maximum radius of the deposited droplets on different substrates (glass, silicon wafer) .The above principle only valid for a fresh water droplet but in our case the sample should be the salt solutions that pretends to impact variation in evaporation rate based on different substrate medium (i.e. the droplet radius depends on the types of standard solution (i.e. fresh or saline solution) and substrate medium. The substrate medium analysis is carried out in order to check the evaporation rate by simply flowing the standard solution on the contact surface medium which absorbs the solution and able to evaporate quickly with the act of intensity of wind along with rapid agitation of medium. In order to increase the efficiency of evaporation rate the medium which we selected in these research level case studies should be able to agitate while in the case of wet stage also. (E.g. Different observance in evaporation rate from normal aqueous medium and lime scale or salt strains formation in our kettle or bathroom) illustrates that uneven energy evaporates unevenly based on substrate medium and evolution of droplet.

IV. ANALYSIS OF FABRIC MATERIAL FOR SURFACE CONTACT MEDIUM

The necessity for the analysis of fabric material must be need for the study for perspective experimental procedure work.

In our case fabric are generally classified into two types (based on absorption factor) they are listed as below:

- Non woven fabric
- Woven fabric

A. Non woven fabric

Non-woven fabric is a fabric-like material made from long fibres, bonded together by chemical, mechanical, heat or solvent treatment.

B. Woven fabric

The processing of weaving fibres which combine together to form a cohesive material. In woven fabrics, threads or yarns are placed perpendicular to one another, and then attached together through a pattern called “warp” and “weft.” This creates woven fabric.

C. Material selection

The selected material fabrics are from the above described woven fabric material accompanied by netting arrangement due to the absorption characteristics. The material selected for initial assessment be jute fabric that comes under netting woven fabric. In order to know about the absorption factor for described type of fabric, the experimentation work was carried out by using dye as an initial objective. The result may be concluded via through the retention period of time for the liquid droplet in that above types of fabric material.

V. TRACER STUDY (FABRIC SELECTION CRITERIA)

Tracer study can be experimented for above two types of fabrics which show whether there is any difference in retention period of time for liquid droplet that travels over the selected material of respective cross section area. Using a dye in order to measure the detention period of liquid droplet in the surface medium clearly examines the travelling time period. Retention time for non-woven fabric material (i.e. geo polymer material)-7seconds. Retention time for woven fabric material (i.e. jute material)-18 seconds.

Fig. 1: Tracer study by using dye

VI. PARAMETER FIXATION BY BRINE CHEMICAL ANALYSIS BY INVESTIGATION PRINCIPLE OBTAINS FROM CASE STUDIES

- TDS
- TEMPERATURE
- CHLORIDE CONCENTARTION
- BOD
- COD

Check for saturated limit of NaCl concentration in a litre of water

Fig. 2: Check for saturated limit

The maximum limit for saturation of salt in a litre of water was calculated by dissolving amount of NaCl in a one litre of water for maximum extent. The end level is determined by observance of settlement inference at the bottom of the beaker as precipitate form. This study signifies the allowable limit of NaCl maximum concentration for the converging evaporation technology by using intensity of wind as a major energy source. The maximum level for saturation of salt in a litre of water was calculated to be around 398 g/l (approx).

VII. EXPERIMENTATION PROCEDURE (USING NON WOVEN FABRIC AS SHEET MATERIAL)

The experimental setup should be kept in a controlled environmental condition (i.e. intensity of wind, temperature and intensity of light) the act of wind for evaporation process is fulfilled by the intrusion of artificial wind by the use of blower as energy source. While intends to do an experimentation work, we have to enrol the details as explained data therefore the intensity of wind via through the blower setup can be concluded by the anemometer The intensity of wind =1.136 msh (miles per hour). In this case, the evaporation operation is carried out in the non woven fabric material by the act of different rate of flow in order to check at which flow rate thus the evaporation attains maximum concentration removal efficiency.

Fig. 3: W.A.I.V technique for non woven fabric

A. Modern Water brine concentrator indicative performance at variable flow rate

Feed water concentration (g/l)	Product water concentration at high flow rate (g/l)	Product water concentration at low flow rate (g/l)
20	0.792	0.594
15	0.45	0.413
10	0.693	0.528
5	0.33	0.281
2	0.231	0.165

Table 1:

B. Graphical representation of concentration reduction rate

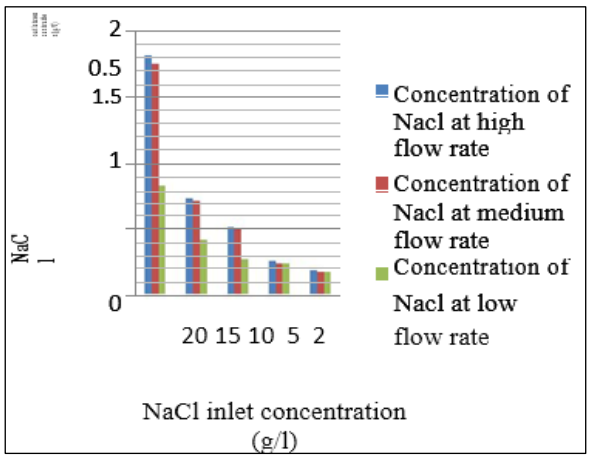


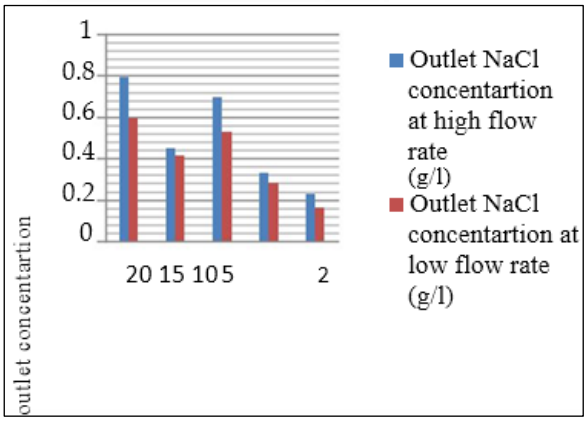
Fig. 4: Graphical representation for variant flow rate

VIII. Replacing Medium by Woven Fabric (I.E. Jute Fabric) and Continuation of Assessment of Methodology Based on Variant Flow Rate

Outlet concentration (g/l)			
Inlet feed water Nacl concentration (g/l)	Conc. of Nacl at high flow rate (g/l)	Conc. of Nacl at medium flow rate (g/l)	Conc. of Nacl at low flow rate (g/l)
20	1.815	1.75	0.825
15	0.726	0.71	0.413
10	0.511	0.495	0.264
5	0.25	0.231	0.231
2	0.18	0.165	0.165

Table 2:

A. Graphical representation of concentration reduction rate in the jute fabric sheet



Inlet NaCL concentration (g/l)

Fig. 5: Graphical representation for variant flow in jute fabric sheet

IX. Different Types of Patterns Practised in Order to Yield Optimum Efficiency

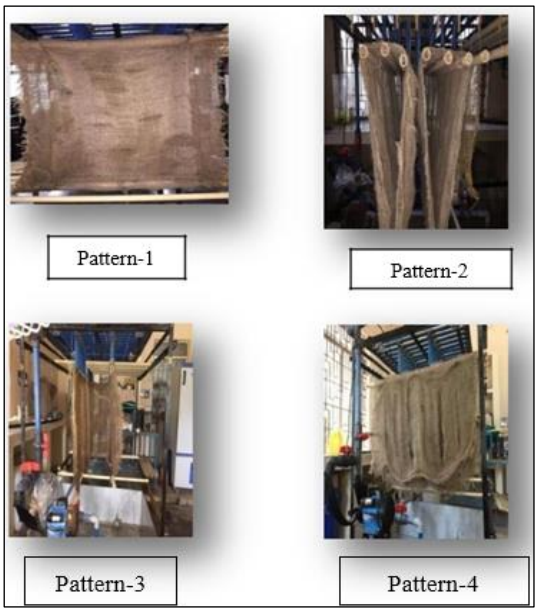


Fig. 6: Different types of patterns arrangements

X. Determination of Efficiency Based on Comparative Study

TDS (g/l)	pattern-1 (g/l)	pattern-2 (g/l)	pattern-3 (g/l)	pattern-4 (g/l
22.293	9.46	1.59	0.842	6.7
18.11	9.29	0.8075	0.825	6.9
13.63	8.416	0.565	0.53	6.5
6.74	2.62	0.468	0.246	4.9

Table 3:

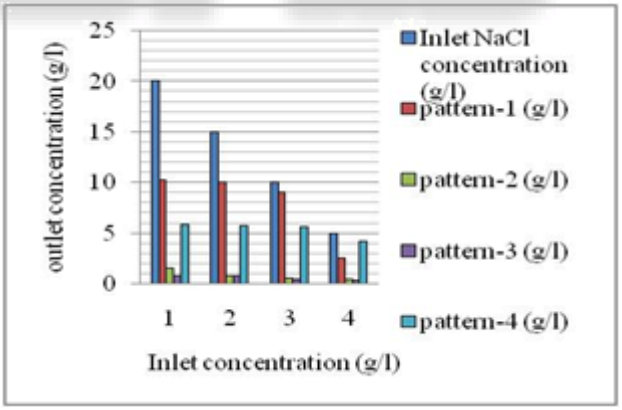


Fig. 7: NaCl concentration variance chart

XI. TDS Concentration for Above Patterns

Inlet feed water concentration (g/l)	pattern-1 (g/l)	pattern-2 (g/l)	pattern-3 (g/l)	pattern-4 (g/l)
20	10.25	1.52	0.78	5.83
15	10.04	0.74	0.76	5.775
10	9.03	0.51	0.48	5.665
5	2.57	0.41	0.36	4.23

Table 4:

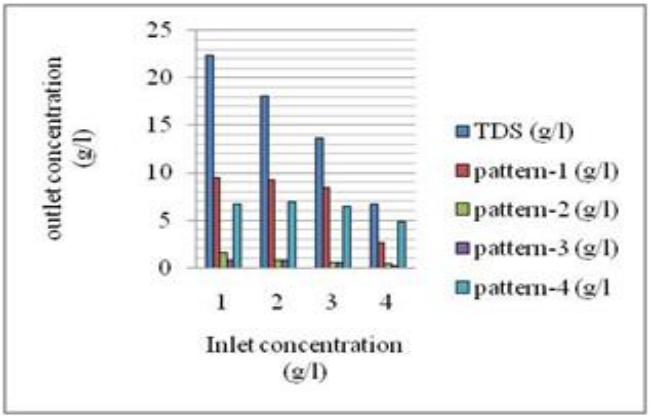


Fig. 8: TDS concentration reduction chart

XII. Results and Discussions

From the brine chemical analysis, the main parameters are fixed and respective modern management technique (i.e. wind aided intensified evaporation technique) enhance the maximum removal percentage. The reduction efficiency are based upon the material absorbance characteristics (i.e. types of fabrics used).The minimization phenomenon are seduced by inducing different types of pattern formation in the types of fabrics selected from the brine chemical analysis, the complex dynamic parameter organic (i.e. BOD &COD) and inorganic parameter (i.e. total dissolved solids and chloride) which intend to cause certain effects while disposing into the land from the list of brine chemical analysed parameters which pretends to be considered as important parameter. Therefore the reduction of considerable parameter to a greater extent by means of material selection and practising different types of patterns in the subjected material acting as a settlers for liquid droplet.

A. Summary and conclusions remarks

In these research work ,the concentration of the sample are fixed by artificial means likewise concentration of sample (i.e. sodium chloride) are tested in a descending manner in order to find whether these methodology practise inhibit the concentration to an extinct limit. The droplet patterns are analysed for both normal fresh water liquid and saline water liquid that would produced the information that uneven driving pressure evaporates the solution unevenly. So that paved the way thus evaporation ratio are based upon the action of wind pressure and mainly accompanied by the surface contact medium that only predict the evaporation concentration. From this sort of circumstance the conclusion preview that droplet evaporation works under the principle on surface medium. The experimentation is carried on both woven fabric (i.e. jute) and non-woven (i.e. geo polymer material) synchronise the reduction percentage factor. The reduction efficiency may be intend to raise to great extent via through the different way of approach by practising various types of pattern design in the fabric sheets and the sheets are arranged in certain array of row in order to interact direct contact of wind. In this case different types of pattern design and arrangements are followed in the prescribed manner and corresponding brine chemical parameter that influence major effect in discharging process are estimated before and after the inclusion of methodology as an objective. From that we conclude based upon the experimentation pattern-3 obtains better efficiency than other types of patterns by reduction rate factor.

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