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Performance Evaluation Of Automobile Industry Effluent Treatment Plant To Achieve Zero Discharge

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ABSTRACT

The study is to evaluate the performance efficiency of an Effluent treatment Plant (ETP) of 120 cum/day for an Automobile Industry at Chennai. The waste water is analyzed for the major water quality parameters such as pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS) and Ammonical Nitrogen (NH_3-N). The Raw waste water was treated with ETP consisting of Equivalisation tank, Flash mixer, Bio aeration tan, Lamella plate separator, Multigrade filer, Activated carbon filter, and is followed by RO system and the RO reject is sent to solar evaporation pond of Spray nozzle system and aerodynamic blower system. It was found that effluent parameters were within the limits the treated water was used for various purposes like process and utilities.

KEYWORDS: Zero Discharge, Effluent, Waste water, Reverse Osmosis, BOD, COD, TDS.

1.0 INTRODUCTION:

In the era of industrial growth and economic development, the concept of waste minimization stems from the need to "produce better while polluting less" in order to avoid environmental damages that may affect quality of life in short and medium terms, and threaten the survival of living beings on the planet, in longer terms. The basic goal of waste minimization is to eliminate formation of byproducts which are discarded as wastes and harm the environment. Metal finishing operations are carried out by most of the Automobile industries engaged in forming and finishing metal products. The wastes from metal finishing industries include cleaning acids, sludge containing toxic heavy metals, solvents and oils, and spent chromate and cyanide solutions, which are classified as hazardous substances

Hazardous wastes in an industry can be generated directly as a by-product, and also as a result of treatment of wastes. In case of metal finishing industries, hazardous wastes are generated in both of these ways. Hence, metal finishing industries are regarded as major generators of hazardous wastes in many industrialized nations. Waste minimization in metal finishing industries helps to reduce hazardous waste generation, and hence the cost of treatment and disposal.

This article briefly reviews major metal finishing operations and characteristics of waste streams from these operations. While identifying opportunities for waste minimization, proven techniques and their practical implementation in many industries around the world are presented. For this case study, one of the leading coil spring & stabilized bar manufacturing company was discussed to improve the waste minimization by reverse osmosis by installing additional stage for RO and Improved version of solar evaporation pond (spray nozzle systems and aerodynamic systems).

2.0 SOURCE & QUANTUM OF WATER USAGE & WASTEWATER GENERATION

The waste effluent processed The Source & Quantum of Water to be consumed & Wastewater generation details are furnished in *Table 1&2*.

Table 1: Water Consumption for metal finishing industries

<table>
<tr><th rowspan="2">S.No</th><th rowspan="2">Description</th><th colspan="2">Water Consumption</th></tr>
<tr><th>Source</th><th>Quantity(m^3/day)</th></tr>
<tr><td>1</td><td>Industrial Purposes</td><td rowspan="2">in sourcing</td><td>120 KLD</td></tr>
<tr><td>2</td><td>Cooling tower make up</td><td>5 KLD</td></tr>
<tr><td></td><td colspan="2">Total</td><td>125 KLD</td></tr>
</table>

Table 2: Waste water Generation for metal finishing

S. No	Description of the Source	Description of the effluent	Quantity (m^3/day)
1.	Effluent generated from the surface treatment, Phosphating, Painting, & scrubber drain	Painting, phosphating and wet scrubber Effluent	120 KLD

Table 3: Mode of Treatment & Method of Disposal.

S. No	Description	Mode of Treatment	Method of Disposal
1.	Industrial Effluent from (surface treatment, Phosphating, Painting, Cooling tower blow down & Scrubber effluent)	Effluent treatment consisting of Equivalisation tank, Flash mixer, Bio aeration tank, Lamella plate separator, Multigrade filer, Activated carbon filter, and followed by RO Plant- stage I & Proposed RO plant – stage II & III	The Permeate water will be recycled in the process for phosphate rinsing The RO Reject of Stage III will be dried in Improved version of SEP as per local PCB discharge standards

Table 4: Analysis of Untreated Effluent

Sl. No	Parameter	Units	Results			
			1st week	2nd Week	3rd Week	4th week
1	Physical Appearance	-	Coloured	Coloured	Coloured	Coloured
2	Color	Hazen	9.5	9.3	9.4	9.6
3	pH @ 25°C	-	8.2	8.4	8.1	8.2
4	TDS	mg/lt	3300	3291	3315	3310
5	Conductivity	Microhmos/cm	5076	5017.5	5138.7	5175
6	Turbidity	NTU	100	105	97	101
7	Total Hardness as $CaCO_3$	mg/L	286	274	280	289
8	Calcium as $CaCO_3$	mg/L	210	207	215	212
9	Magnesium as $CaCO_3$	mg/L	55	55	55	57
10	Calcium as Ca	mg/L	98	98	98	97
11	Magnesium as Mg	mg/L	28	24	25	22
12	P-Alkalinity as $CaCO_3$	mg/L	120	117	124	121
13	M-Alkalinity as $CaCO_3$	mg/L	85	83	87	84
Sl.No	**Parameter**	**Units**	**Results**			
			1st week	**2nd Week**	**3rd Week**	**4th week**
14	Total-Alkalinity as $CaCO_3$	mg/L	205	200	221	205
15	Chloride as Cl^-	mg/L	925	904	915	920
16	Iron as Fe	mg/L	0.9	0.2	0.3	0.2
17	Silica as SiO_2	mg/L	32	30	31	30
18	Sulphate as SO_4	mg/L	78	84	76	81
19	Biological Oxygen Demand @ 27°C for 3 days	mg/L	180	192	176	168
20	Chemical Oxygen Demand	mg/L	720	692	686	672

2.1 Inlet Parameter
The treatment process is shown in Fig.1

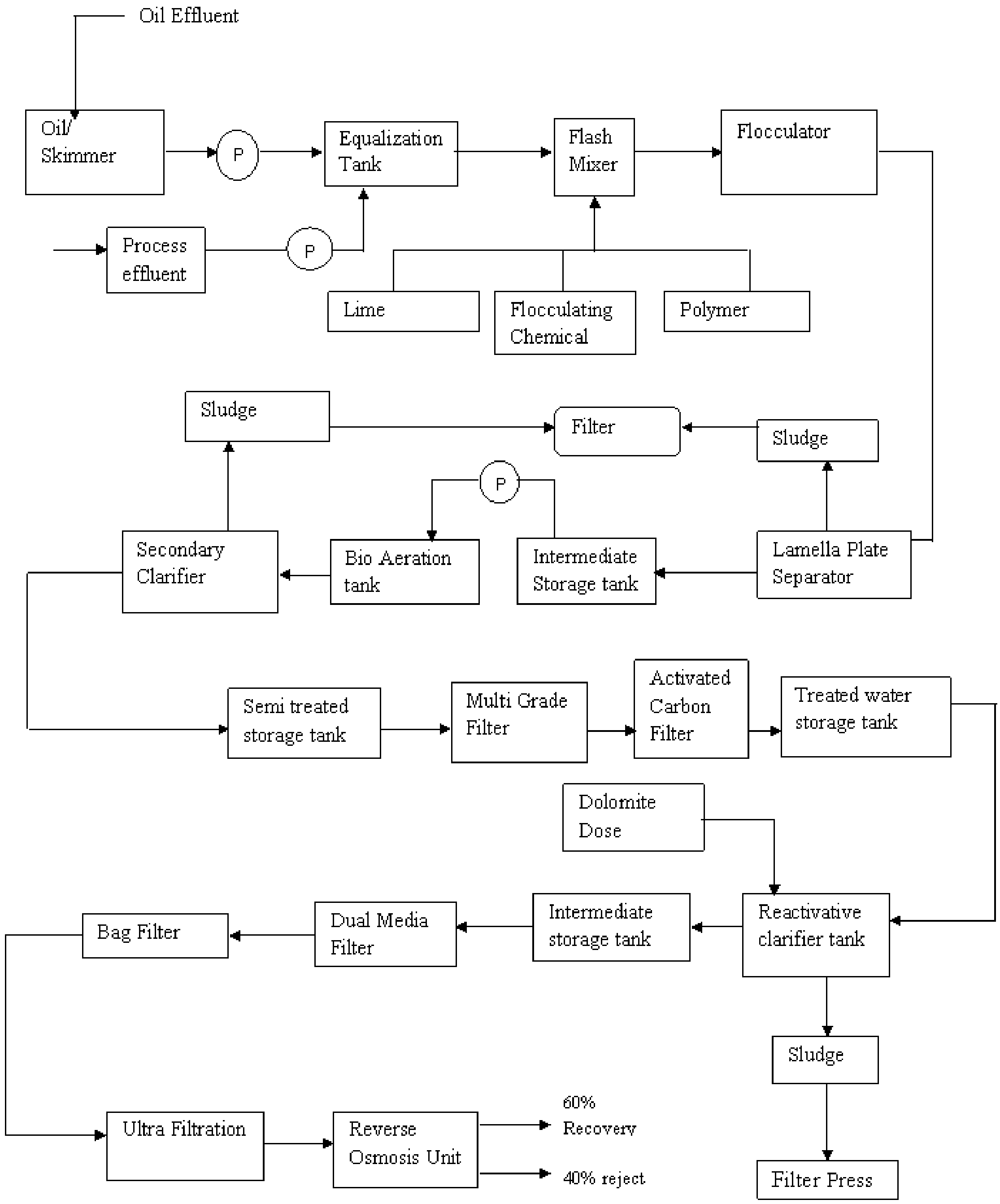


Fig. 1 General Flow Chart for the effluent treatment plant

3.0 EFFLUENT TREATMENT METHODOLOGY
The flow chart of effluent treatment method is described above.

3.1 Bar screen & Oil skimmer system

The effluent will be collected in the oil effluent collection tank. The oil removal chamber is fitted with belt/tube type oil skimmer mechanism for removal of floating oil in the effluent. Further the effluent is pumped to Equalization tank for further treatment.

3.2 Industrial Effluent Collection Tank

The phosphating effluent, scrubbing effluent, Paint booth effluent, cooling tower blow down is collected in the Industrial effluent collection tank and further sends to Equalization tank to obtain the uniform characteristics.

3.3 Equalization Tank

Equalization dampens fluctuations. Flow equalization can improve performance of subsequent steps significantly. Often the rest of the plant can be designed with smaller equipment (less capital investment) because of this improvement in performance. Equalization allows reactions in the equalization tank. More important for industrial wastes that can have wide swings in pH is the reaction of acids with bases because otherwise each would have to be neutralized with costs for equipment and reagents.

3.4 Flash Mixer &Flocculator

The equalized effluent from the collection tank is pumped to the Flash Mixer. Required dosage of lime, ferrous sulphate/Ferric chloride & polymer are dosed in tothe Flash Mixer. Addition of lime aids in better coagulation. Mixing is accomplished with the low speed agitator. The reacted effluent is sent to the flocculation tank for flocculation of the effluent and finally sent to settling tank for solid liquid segregation

3.5 Lamella Plate Separator

The purpose of Lamella plate separator is to remove readily settle able solids. Nearly 95 % of inorganic are removed as chemical sludge at a higher pH of 8.5-9.The main advantage of lamella clarifiers over other clarifying systems is the large effective settling area caused by the use of inclined plates, which improves the operating conditions of the clarifiers in a number of ways. The unit is more compact usually requiring only 65-80 % of the area of clarifiers operating without inclined plates. A further advantage of the lamella clarifier is its' distinct absence of mechanical, moving parts. The system therefore requires no energy input except for the influent pump and has a much lower propensity for mechanical failure than other clarifiers. This advantage extends to safety considerations when operating the plant. The absence of mechanical parts results in a safer working environment, with less possibility for injury.The Chemical sludge will be sent to Sludge drying beds for dewatering. The dried sludge is then packed and removed as local pollution control board Regulations/Standards.

3.6 Intermediate Storage Tank

The treated overflow is then collected in Intermediate Storage tank for further treatment in Pressure Sand Filter, Activated Carbon Filter and Multi Grade Filter to reduce the suspended solids and colloidal impurities prior to the Reverse Osmosis treatment.

3.7 Biological Aeration Tank

The main purpose of an aeration tank is to facilitate the biological treatment of wastewater by pumping or inducing air into it. An aeration tank should be leak-proof, and sufficiently large to enable aeration to take place without overflowing. In general, there should be at least $0.285m^3$ of aeration tank volume per porker if a full wet muck out system is used. Less tank volume will be required for a hybrid system, depending on the effectiveness of the dry muck out operation. There are many types of aeration systems using different types of aerators, with different design and operating requirements for the aeration tank. Aeration system suppliers should be able to recommend the most appropriate system for each individual farm and provide technical advice on the operation and maintenance aspects. A typical aeration tank comprises an aerator, a wastewater inlet, a treated water outlet and a sludge outlet. In general, wastewater should be continuously aerated so as to maintain a dissolved oxygen level of 1-2mg/L for 18 to 20 hours. This should be followed by at least an hour of settling in order to achieve the required quality for discharge. The settled sludge should be drained off to a drying unit after each aeration cycle. It must be stressed that excessive aeration could also result in very poor treated water quality. Farmers are therefore strongly advised to adhere strictly to the suppliers' operating recommendations and seek their assistance whenever necessary.

3.8 Secondary Clarifier

Secondary clarifiers help to separate the solids from the liquid phase of the mixed liquor, and remove settled solids from the floor. The three secondary clarifiers at the Glens Falls plant are of the circular, center-column, siphon feed type. Each of these clarifiers are 90 feet in diameter with a water depth of 12 feet. The clarifiers have a detention time of 4.5 hours and an overflow rate of 479 gallons per day per square foot.

3.9 Multi Grade filtration

The overflow from the secondary settling tank is collected in filter feed tank from where it is pumped to Pressure sand filter for filtration and removal of suspended solids and turbidity in the effluent. The Pressure Sand Filter comprises of one vertical mild steel pressure vessel with dished ends, painted internally with anti-corrosive bitumastic paint and externally with three coats of epoxy paint. The filter is filled with various types of graded filter sand and under bed material.

3.10 Reactivative Clarifier Tank

The filtered water is pumped from treated water storage tank to reactivative clarifier tank here the treatment takes place by the mixing of Dolomite Dose.

3.11 Intermediate Storage Tank

The treated overflow is then collected in Intermediate Storage tank for further treatment in Pressure Sand Filter, Activated Carbon Filter and Multi Grade Filter to reduce the suspended solids and colloidal impurities prior to the Reverse Osmosis treatment.

3.12 Dual Media Filter

Water is pumped from intermediate tank to the filter. A sand-anthracite filter or Dual media filter/multi-media filter is primarily used for the removal of turbidity and suspended solids as low as 10-20 microns. Dual media filters provide very efficient particle removal under the conditions of high filtration rate. Inside a sand-anthracite filter is a layered bed of filter media. The bed is graded from bottom to top as follows: Having the filter media graded this way enables the sand anthracite Filter to run for longer times before a backwash is necessary. A Dual media filter consists of 2 main parts: A composite pressure vessel with Multiport Valve. Internally, the dual media filter is fitted with an inlet distributor and a bottom Colleting system. Externally, the system is fitted with frontal pipe work and isolation valves. Sand is used to remove the suspended particles and anthracite is used to remove the odor and color etc. to make the water fit for different applications. Gravels and pebbles are provided to support to both the media. Periodically, the sand-anthracite filter will backwash, which changes the water flow through the sand-anthracite filter.

3.13 Bag Filter

The bag filter is made of a metallic housing designed for continuous operation and automatic cleaning. The dirty gas enters through the collector in the center or bottom part of the body, being sent to the tray, where the heavier particulate is separated, and the lighter material is carried along with the gas to the filter intermediate part, being forced to pass through the filtering bags where all the particulate is collected. The clean gas is then sent to the higher plenum (filtered air chamber) and then to the atmosphere or exhausted to the discharge chimney. The bag cleaning process is automatically performed through compressed air pulses that are controlled by a programmer. The compressed air is stored in a reservoir located beside the higher filter chamber. Above each row of bags there is a tube with holes that are aligned with the central air passage gap, located on top of the bags, through which compressed air is injected to momentarily invert the gas flow, causing the particulate material accumulated outside the bags to be removed. Such tube is connected to the reservoir through a diaphragm valve activated by a solenoid/temporized sequencer that activates cleaning of a row of bags. In the filter, there will be a differential manometer with local reading capabilities in a 150..0..150mmCA range to provide monitoring of the dirty gas chamber (gas input) and the clean gas chamber (gas output plenum). As the bags get dirty, the difference in pressure increases up to previously established values for each filter. Such values provide a reference on the efficiency of the equipment cleaning system and establish the cleaning interval from one bag row to another and the duration of compressed air pulse. Filtering bags can be removed through access doors located on the top or side of the filter. The whole filtering assembly will be will be firmly in place through the metallic structure and there may optionally be a climbing ladder on the top of the filter, with a body safeguard rail and a handrail around it.

3.14 Micron Filtration

After preliminary filtration in Dual media filter and Bag filter to remove the suspended solids in the treated & filtered effluent is then passed to micron filter of 5 microns for the removal of finer suspended solids thereby reducing the load on to the RO membrane.

3.15Acid / Anti Scalent dosing

Antiscalent and acid dosing is dosed prior to the micron filter with respect to the level of the hardness and to maintain the PH before entering to the RO plant.

4.0 REVERSE OSMOSIS UNIT

The filtered water is passed to the RO unit to achieve 88 % recovery in stage 1& 2 to reduce dissolved solid content in the treated effluent.The RO membranes are embedded within the pressure vessel. One side of the membrane is enclosed within the brine seal to avoid the mixing of filtered water and inlet water. Each membrane is connected to the other by means of interconnect or, and has a common permeate end. The filtered water is collected from the permeate end is sent to process and the RO reject is sent to solar evaporation pond.

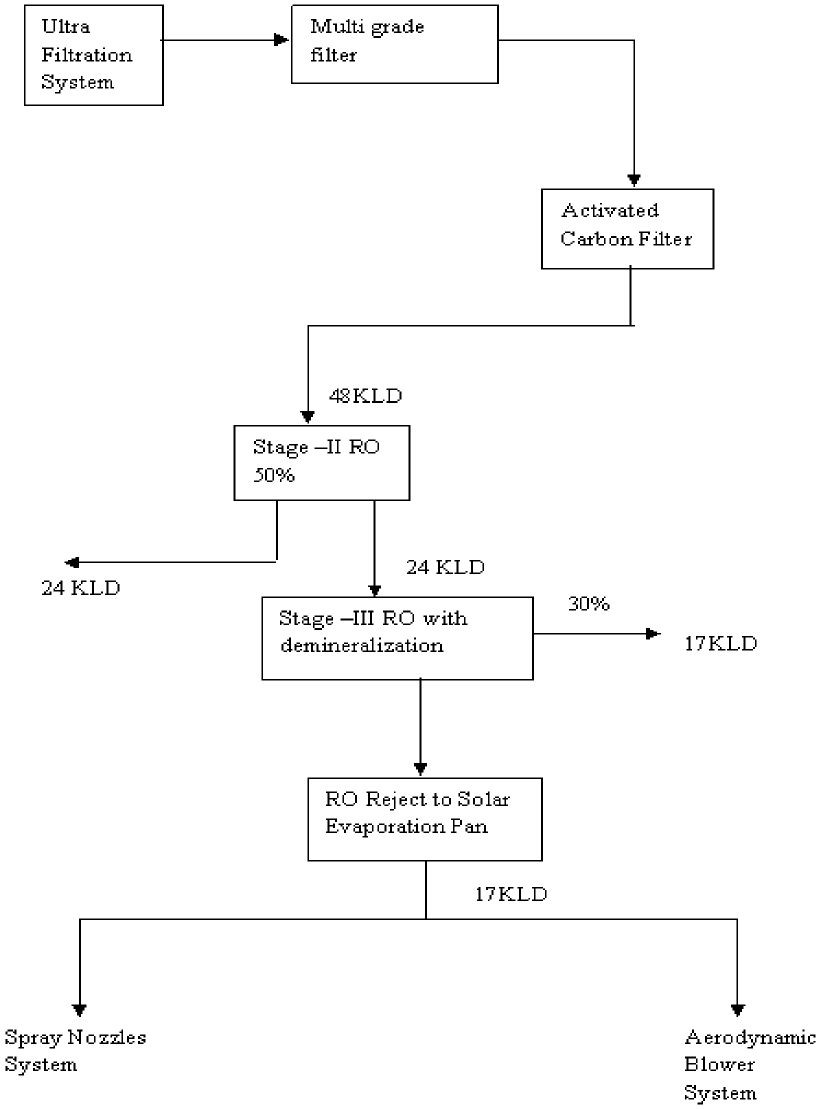
Stage	Total Flow	Recover Rate	Recovery rate
Stage I	120 m3/day	72m3/day	60%
Stage II	48 m3/day	24m3/day	50%
Stage III	24 m3/day	7.0m3/day	30%

Over all recovery: 103 m3 /day
Over all Rejects: 17 m3 /day

Sl. No	Parameter	Units	Results of Stage – 3 RO rejects			
			1st week	2nd Week	3rd Week	4th week
1	Physical Appearance	-	colorless	colorless	colorless	colorless
2	Color	Hazen				
3	pH @ 25°C	-	7.1	7.2	7.0	7.1
4	TDS	mg/lit	21810	21820	21820	21820
5	Conductivity	Microhmos/cm	33246	33245	32256	32276
6	Turbidity	Ntu	1	1	1	1
7	Total Hardness as $CaCO_3$	mg/lit	1230	1225	1237	1232
8	Calcium as $CaCO_3$	mg/lit	747	735	752	750
9	Magnesium as $CaCO_3$	mg/lit	137	132	139	138

10	Calcium as Ca	mg/lit	420	414	428	422
11	Magnesium as Mg	mg/lit	223	219	227	224
12	P-Alkalinity as $CaCO_3$	mg/lit	439	432	442	440
13	M-Alkalinity as $CaCO_3$	mg/lit	406	401	410	408
14	Total-Alkalinity as $CaCO_3$	mg/lit	4	433	452	448
15	Chloride as Cl^-	mg/lit	5710	6692	5730	6721
16	Iron as Fe	mg/lit	NIL	NIL	NIL	NIL
17	Silica as SiO_2	mg/lit	135	131	137	135
18	Sulphate as SO_4	mg/lit	8.1	7.9	8.2	8.1

5.0 SUGGESTED REJECT MANAGEMENT SYSTEM



5.1 Ultra Filtration

Ultra filtration (UF) is a variety of membrane filtration in which forces like pressure or concentration gradients lead to a separation through a semipermeable membrane. Suspended solids and solutes of high molecular weight are retained in the so-called retentate, while water and low molecular weight solutes pass through the membrane in the permeate. This separation process is used in industry and research for purifying and concentrating macromolecular (10^3 - 10^6 Da) solutions, especially proteinsolutions. Ultra filtration is not fundamentally different from microfiltration. Both of these separate based on size exclusion or particle capture. It is fundamentally different from membrane gas separation, which separate based on different amounts of absorption and different rates of diffusion. Ultra filtration membranes are defined by themolecular weight cut-off (MWCO) of the membrane used. Ultra filtration is applied in cross-flow or dead-end mode.

5.2 Solar Evaporation Pan

Solar Evaporation of liquid Effluents is a primitive concept practiced as a low cost treatment for effluents with high dissolved solids content and /or highly non-biodegradable organic matter. The success of this low cost technology stems from the advantages of the tropical climatology of our country. Evaporation and thermal methods waste heat recovery and heat exchange systems,etc., were developed and Practiced. The inherent problems of scaling, clogging of pipe lines and spray nozzles, reduction in heat recovery due to scaling, have limited the application of these options for evaporating effluents with high TDS.

In Solar evaporation ponds, the rate of evaporation depends on the incoming solar radiation, relative humidity, wind speed(surface turbulence), surface area of the pond, liquid depth and salinity of water. The rate of evaporation increases with increasing temperature and wind speed, and decreases with increasing humidity. Evaporation occurs most frequently during wind times, and during the passing of the winds of the hot dry weather front.When the air temperature drops below pond surface temperature (at night during over cast days, and after the passage of a cooler weather front), and there is no wind the pond will lose heat mostly by radiation into the atmosphere, and surface water gets cooled, limiting the rate of evaporation.

Several methods were practiced to increase the turbulence in the water; few prominent methods are **Spray ponds** and **Aerodynamic Blower system.**

5.3 Spray Ponds

Conventionally, high pressure spray ponds are used for cooling warm waters from the condensers. The evaporative cooling occurs due to the exchange of heat between the warm water and the ambient air. In ponds designed for increasing the evaporation rates from effluent water surfaces, the efficiency of the system depends on the relative humidity of the air, area of the pond and the size of the sprayed water droplets. Higher the water temperature and higher the spray area, higher will be the evaporation rate.

The area of the pond is critical on account of arranging the spray nozzles in such a manner that there will be adequate air circulation between the spray zones and the water curtains do not overlap with each other. Literature reports 750 Litres/m^2/hour as the best volumetric loading rate per unit area of the pond.

The spray nozzles play a crucial role in achieving the desired evaporation efficiency.The nozzles are usually quantified using the following formulae:

$$Q=0.36CS\sqrt{2gH}$$

where
Q = Capacity of Nozzle in m^3/h
C = Coefficient of contraction, usually 0.5
S = Cross-section area of the Nozzle orifice, in m^2
g = Acceleration due to gravity, 9.81 m/s^2
H = Pressure head of water, 0.5m

Despite sizing the nozzles and providing the best material to resist corrosion, these spray nozzles often get clogged due to the scale formation, thus increasing the power consumption per unit of water evaporated. Frequent shut down of the system due to maintenance and replacement of nozzles due to enlargement of nozzle diameter during cleaning, leaves the system to permanent shut down, within a short duration of installation.

On the environmental perspective, the water droplets saturated in the ambient air along with traces of salts will deposit on the plant building, machinery or on the downstream resources and community, inducing the costs of maintenance and health care.

5.4 Aerodynamic Blower system

Aerodynamically designed blowers are run by simple axial fans with very high discharge of air, converged into sheets of air dispersed parallel to the water surface. The air flow increases the degree of turbulence in the water surface, thus increases the evaporation rates. The major advantage of the system is the detainment of toxic materials and salts within the pond surface and evaporating the water content only.

Other advantages include:

1. Low capital cost
2. Low maintenance cost
3. Lowest operating cost
4. Highest evaporation rate achievable per unit area of the pond surface, at the prevailing meteorological condition
5. No adverse impact on environment
6. Economics of Enhanced Evaporation

The cost of enhanced evaporation of water in solar evaporation ponds is arrived as 1.20 Paise per Litre of water evaporated (or Rs.12/m^3). This is the most economical method when compared with all available mechanical evaporation techniques. In a conventional triple effect mechanical evaporator, the evaporation cost will be Rs.85/m^3 (after adjusting the cost savings in terms of condensate water recovery). Huge investments, high power costs and skilled operation and maintenance,

Mechanical evaporators are highly unreliable and uneconomical.
On the other hand, enhanced evaporation in solar ponds is not only economical, but also simple, easy to operate/ maintain and doesn't require any skilled labour. All existing solar evaporation ponds can be easily augmented to increase the porated, without increasing.

About 3 m^3/day of RO reject containing high amount of dissolved solids to a maximum of 6000 mg/l will be evaporated in Solar Evaporation Pan. Existing area of solar evaporation pond constructed for RO Reject management is = 225 m^2 and Additional area is proposed as improved version in elevated solar pan is 400$m^{2.}$The dried sludge will be Stored in bags for disposal as per Pollution control Board norms.

7. FINDINGS

It is generally possible to precipitate the divalent calcium and magnesium as their carbonate and hydroxide before admitting the effluent to RO so that the load on RO becomes lesser in the divalent ions which are not permeated there and thus pass on to the rejects. But this requires the anionic part to be in bicarbonate. Here it is all present almost as the chlorides and hence, the above technique will not be applicable. Thus it is a case where the R O has to take the brunt of the ionic load. Clearly, whereas minimal Sodium comes in the rejects, the bulk of calcium and magnesium comes through in the reject. Thus in dealing with the rejects, it is all chlorides. The use of spray ponds and air blowers are obvious low cost choices. However, if the industry can switch over to sulphuric acid instead of hydrochloric acid, the anions will be sulphates and it will be a lot easier to cool the RO rejects and recover the salts as crystallized sulphates and which will save a lot of space besides being a controllable operation.