ECOLOGY

PURIFICATION OF PHARMACEUTICAL WASTE WATER RESULTING FROM HERBAL PLANTS BY ZERO LIQUID DISCHARGE TECHNIQUES (ZLD)

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Abstract. Introduction. Zero liquid discharge (ZLD)is advanced water treatment process technology that remove waste water product economically and produce clean water for reuse e.g. irrigation. this water treatment process is money saving, environmentally friendly and highly trustable. zero liquid technology (ZLD) is the most effective solution for obtaining strict environmental discharge standards and produce water treatment recovery with lowest possible cost. ZLD help in recovering materials from the waste water streams e.g. potassium sulfate, soda, sodium sulfate and lithium.

ZLD treatment system should be: Convenient to large scale of waste contaminations. This treatment recover 95% of liquid waste for reuse. Can produce dry solid disposal. Can be separate by product from waste. Help to adjusting chemical volumes.

Purpose. Used treated waste water as Cooling towers industry. Boiler water for generating steam for MEE. Used in water scrubbers as scrub media. Prepare of lime slurry for ETP. Various operations of industrial washings.

Keywords: *Zld, UF, Ro, MEE, MVR, pharmaceutical waste waters treatment.*

Methods. ZlD treatment process steps:

Pretreatment it is should be remove simple contaminants from waste water stream by filtration or precipitation out.

The treatment consists of clarifier or a reactor to precipitate out metals, hardness and silica. This step require caustic soda or lime for coagulation. This step require add chemicals and one or two reactors to settle down the small particles from water.

Using coagulates contains aluminum with slight PH adjustment when coagulation is complete the water enters a flocculation chamber followed by sedimentation part of ZLD process.

Where the water rises to the top and allowing solids to settle down into sludge blanket.

Ultra filteration can also used which pump water directly from waste water through UF (chlorination) and eliminate the clarifier/filteration.

Concentration in ZLD is usually performed by (RO)reverse osmosis, brine concentrator or electrodialysis or combined together.

They are used to remove dissolved solids waste and to obtain pretreated water.

RO has a tight pore structure (membrane used less than 0.001micron) that effectively removes up to 99% of the dissolved salts (ions) particles, colloids, organics, bacteria and pathogens from the water [7].

Evaporation / crystallization:

After concentration steps is completed then followed by next step of generating solids by thermal process or evaporatation, which lead to evaporate all water off and reuse it. This is Can be done by adding acid which neutralize the solution and. also can perform dear ration at this step to release dissolved oxygen, carbon dioxide and other gases. the leftd waste go then from evaporator to a crystallizer which continues to boil off all the water where all waste presented in the water crystallized and turned to solids.

Results:

ZLD system depend on thermal and evaporative process e.g multi stage flash (MSF), multi effect distillation (MED), mechanical vapor compression (MCV) and crystallizers. Evaporations and crystallizations system capacity range from around 10 gpm to 1500 gpm per units. Falling film evaporators called brine concentrators are technology for heat transfer which produce high pure distillation and water recovery greater that 90%recovered water in a brine water concentrator is suitable as cooling tower or scrubbing media and can be recycled to other plant process including demineralization of water. this waste water evaporators can be acted by mechanical vapor decompression (MVR) or with other stream depending on the costs of electric power and steam.crystallizes are used to handle crystallization of the dissolved salts which can be recovered as by products. waste water crystallizes are used to concentrate the effluent from brine concentrators when equipped with dry solid comprise zero liquid discharge system. this brine crystallizes are acted by live steam or MVR technology to recycle the vapor and this can help in reducing energy use and costs.

The wastewater is analyzed for the major water quality parameters, such as pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Dissolved Solids (TDS). The effluent samples were collected on a daily basis for a period of one month. The raw wastewater pH was highly alkaline it was then bringing down to neutral which was helpful for biological treatment. The BOD, COD of the treated effluent reduced significantly, where as very small reduction was observed in dissolved solids.

Transformation of COD into organics and TDS (total dissolved solid) into dry salts for disposal by zero liquid discharge treatment system [5].

In zero liquid discharge system the overall loads reduction was 99.2 percent in TDS, 99.9 percent in COD and 100 percent in both the TSS and BOD. By the various experimental analysis relieving that the designed ZLD unit can be used effectively to treat and recycle API manufacturing unit effluents, which helps to meet statutory requirements and reduce concerns on ground water depletion.

By the experimental studied MEE (Multiple Effective Evaporator), ATFD (Agitated Thin Film Drier) and LCS effluent treatment unit made of a SBR (Sequential Batch Reactor) and MBR (Membrane Bio-Reactor) with other unit which is called as water recycling unit consisting RO (Reverse Osmosis) plant the pilot plant of ZLD shown a huge reduction in TDS (Total Dissolved Solids), TSS (Total Suspended Solids), BOD (Biological Oxygen Demand) and TSS (Total Suspended Solid) to 99.2, 100, 100 and 99.9 percent respectively [9]. ZLD Reduce your carbon which eliminates liquid waste by converting it into disposable dry solids by application of powdered activated carbon and by reverse osmosis almost 50%total organic carbon (TOC)removal removal takes place during coagulation lime softening process include using of powdered activated carbon.

Table 1. Table of ZLD process.

ZLD Technology	Use	Advantages	Disadvantages	Application
Membrane Bio Reactor (MBR)	Used as biological secondary treatment for reduction of organic load.	Secondary clarifier not required.	Capital cost is more than other aerobic biological technologies (ASP, SBR, MBBR).	Textile Industry
		Treated water quality is better than conventional ASP, MBBR and SBR.	Membrane replacement after five years.	CETPs
		Post treatment of sand filtration not required.		Oil Refineries Fertilizer Industry
Solvent recovery – Air Stripper	Used for recovering solvents/ammonia recovery by providing air.	Conventional proven method for removal of solvents.	Applicable only when large quantity of solvent with low solubility in water is present in wastewater.	Recovery of useful solvents, ammonia in pharmaceutical industry
		Economical when solvents with low solubility in water are present in wastewater.	Difficult to capture solvent when in low concentration.	Pesticide Industry Chemical Industry
Solvent Recovery – Steam Stripper	Used for recovering solvents by using steam.	Solvent recovery is more compared to air stripping.	Not suitable for water miscible, high boiling solvents.	Recovery of useful solvents, ammonia in pharmaceutical industry
	Solvents can be reused or are saleable.	Useful even less quantity of solvent present in wastewater	Scaling occurs in column which is to be cleaned periodically.	Pesticide Industry Chemical Industry

Continuation of table 1

ZLD Technology	Use	Advantages	Disadvantages	Application
Ultra Filtration (UF)	Used for removal of colloidal matter and bacteria and viruses.	Removes suspended, colloidal particles, bacteria, viruses.	Does not filter dissolved solids, gases and organics. Frequent backwash, membrane cleaning.	Pre-treatment to RO in all ZLD plants.
	Used as pre-treatment to RO.	Best pre-treatment for RO.	Replacement of membranes after 5 years required.	
Reverse Osmosis (RO)	Used for removal of salinity (TDS) and residual organics by passing wastewater through semi-permeable membrane by applying high pressure.	Most effective treatment for removal of salinity (TDS) with more than 99% salt rejection.	Very high capital cost.	Used in all industrial sectors for TDS removal and recycling the water.
		Clean technology and no handling of chemicals like acid/alkali like ion exchange technology.	High energy consumption due to high pressure pumps.	
			Membrane replacement required after application of 3 years.	
		Permeate water is free of ions and can be used in industrial processes.	Cleaning of membrane frequently due to membrane fouling	
			Reject Water	
Multiple Effect Evaporator (MEE)	Used to evaporate wastewater to separate water and salt by using heat of steam in sequence of vessels.	Proven method for recovery of water from saline water and separation of salt.	Very high operating cost due to steam requirement.	Pharmaceutical Industry, Textile Industry, Pesticide Industry, Dyes and Dye Intermediates, Steel Industry, Fertilizer Industry
Mechanical Vacuum Compressor (MVR)	Water vapour generated in the evaporator is compressed to higher pressure which acts as heat source for evaporation.	Eliminates thermal energy requirement.	Suitable only for liquid with narrow boiling point rise (BPR).	Textile Industry
		Useful when steam not available.	Suitable when ready steam is not available in the industry.	
		Low operating cost.		
Crystallizer	Used to dry high TDS water or products using heat.	Used for recovery of salts like Sodium Sulphate, Sodium Chloride, Sodium Thiosulphate, Zinc Sulphate etc.	Scaling and corrosion of unit is a problem.	All industrial sectors.
		Simple Evaporation method of single effect evaporation.	Requires frequent cleaning.	
Agitated Thin Film Dryer (ATFD)	Used to dry high TDS water or products using fast revolving rotor in a heating jacket.	Good heat conductivity so can be applied for highly viscous fluids.	Scaling and corrosion of unit is a problem.	Application in salt recovery in Dye and Dye Intermediates
		Gentle evaporation and high evaporation rate.		Textile Industry
		Continuous cleaning of heating surface.		Pharmaceutical Industry for final drying before disposal.
		One passes Evaporation.		
Incinerator	Used for burning the concentrated effluent by thermal energy	Useful method for very high strength (High COD) effluent which is difficult to biodegrade. No further treatment is required.	Requires very high energy.	Pharmaceutical Industry
			Operational cost is high.	Dye and Dye Intermediates
			Capital cost is high.	Pesticide Industry
			Viable for only small quantities of effluent.	

Table 2. Table of Sector wise of ZLD treatment options for industries.

S. No.	Sector	Treatment options	Remarks
1	Distillery	1. Bio-methanation followed by RO/MEE followed by incineration (slop fired). 2. Bio-methanation followed by RO/MEE followed by drying (spray/rotary). 3. Concentration through MEE followed by coprocessing in cement/thermal power plant. 4. Bio-methanation and RO followed by MEE followed by bio-composting.	ZLD Achievable
2	Tannery	Primary treatment + secondary treatment+ pre-treatment for RO + Reverse Osmosis + MEE (recovery of permeate, crystallised salt, reuse of the recovered condensate)	ZLD Achievable
3	Pulp & Paper	Primary treatment + Degasification + RO, 2 stage + NF and UF + Evaporator, Concentrator/Crystallizer	Black Liquor totally to be ZLD in any plant.
4	Sugar	Restricting effluent generation to 100 Litres/ton cane crushed. Water consumption to be restricted to 100 Litres/ton initially and further to 50 Litres/ton cane crushed. Condensate polishing unit mandatory Recycle of excess condensate to process or ancillary units. Water management/audit to reduce spray pond/ cooling tower blow downs and excess condensate. Irrigation protocol for disposal into land applications	Water conservation & irrigation protocol as alternate to ZLD
5	Pharmaceuticals	**High COD, Low TDS Effluent treatment system** Primary treatment+ Secondary treatment + tertiary chemical treatment to reduce TDS (Pressure sand filter, Activated Carbon filter and filter press for dewatering of sludge). RO system (permeate is utilized as cooling tower makeup water) + Multi effect evaporator/incinerators. **High COD, High TDS Effluent treatment system** Primary treatment + stripper to remove VOC + 3 stages Multi Effect Evaporator (forced circulation) Agitator Thin Film Drier (ATFD)+(MEE condensate is being taken along with Low TDS effluent for further treatment)+ MEE/incineration.	ZLD Achievable
6	Textiles	1. Ozonation + bio-oxidation + sand filtration + activated carbon adsorption + micro filtration + reverse osmosis(3 stage) + multiple effect evaporator 2. Chemical precipitation + bio-oxidation + chemical precipitation + sand filtration + Activated carbon adsorption + micron filtration + reverse osmosis (3 stages) + multiple effect evaporator 3. Chemical precipitation + bio-oxidation + sand filtration + dual media filtration + micron filtration + reverse osmosis (3 stages) + multiple effect evaporators	ZLD Achievable
7	Refineries	API, primary treatment, secondary treatment and tertiary treatment. The tertiary treatment is mainly Reverse Osmosis and permeate is utilized and rejects are discharged into cooling tower	Water conservation, Reuse & partial ZLD
8	Fertilizer	Chemical treatment+ Reverse Osmosis (Rejects as filler material and permeate in the process)	Water conservation, Reuse & partial ZLD
9	Dye & Dye Intermediates	Chemical Treatment+ MEE	ZLD Achievable

Conclusions. ZLD had a high successful process for waste water industry treatment which minimize the high toxicity, PH, organic pollutants and resources of recovery. the consumption of water that generated from ZLD systems able to recycle in plant premises which reduce use of water and decrease waste pollutions and maximize water resources. ZLD carried out by systematic waste water control strategy consists of coagulation, UF, RO, aeration system, etc.

Although the high capability of ZLD systems in industrials scales but it has a limited use due to increased energy consumptions and their costs.

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