

# A Zero Liquid Discharge in Pharmaceutical Industry

Kinjal Patel<sup>1</sup>, Rushabh Aghera<sup>2</sup>, Dharmen Mistry<sup>3</sup>, Ekta Jasrotia<sup>4</sup>

<sup>1234</sup>Department of Environment science and technology Shroff SR Rotary Institute of Chemical Technology, Vataria

\*\*\*

**Abstract** - Zero Liquid Discharge (ZLD) is an ideal situation of complete closed loop cycle, where discharge of any liquid effluent is eliminated; it is a remarkable effort of every industry who implements it to meet with the environmental regulation in a challenging way. For achieving ZLD system for the industry, certain steps are needed to be taken. These steps include: Analysis of major characteristics of all influent streams entering into ETP, Identification of potentially recyclable streams and highly polluted stream, Segregation of streams on the basis of their characteristics and applicability of 4R (Reduce, Reuse, Recycle and Recover) principle in particular plant. Optimization of Effluent Treatment Plant (ETP), RO Plant and Multi Effect Evaporator (MEE) plant. The industry, for which we are working on ZLD, is basically a chemical industry discharging around 370 m<sup>3</sup>/day. By achieving ZLD, this huge discharge can be eliminated and daily water consumption of industry can be reduced significantly. The effluent coming to ETP is having some significant effluent characteristics like widely varying pH, high COD and Ammonical nitrogen. After primary, secondary and tertiary treatment, the effluent meeting discharge norms is sent to FETP of NCTL for further treatment and disposal. In this project an attempt would be made to optimize the dose of chemicals added etc. would also be done during the course of the project. Applicability and feasibility study of different techniques like: ultra-filtration, reverse osmosis, different type of evaporator etc. would also be done in later stage of project. Based on all studies and results of experiments, methodology would be suggested to achieve ZLD in given industry.

**Key Words:** Multi effect evaporator (MEE), Zero Liquid Discharge (ZLD), Reverse osmosis (RO), Effluent, Environmental

## 1. INTRODUCTION

Everyone needs water. Supplies of water are vital for agriculture, industry, recreation and human consumption. One problem that the water industry faces is disposal of concentrate from advanced water treatment processes. This research paper discusses Zero Liquid Discharge (ZLD) systems, one possible solution to concentrate disposal. ZLD disposal is the only option currently available in many inland regions where surface water, sewer, and deep well injection disposal are prohibited. A ZLD-system can produce a clean stream from industrial wastewater. Suitable for reuse in the plant and a concentrate stream that can be disposed, or further reduced to a solid. Furthermore, the prevalent technologies used for ZLD-systems and different types of components in a ZLD-system are being described in this

review paper. A zero liquid discharge (ZLD) can be defined as combination of techniques or facilities and system which will help the water loop of the industry to become close one for absolute recycling of permeate and converting solute (dissolved organic and in-organic compound/salts) into residue in the solid form by adopting methods like concentration and thermal evaporation. ZLD will be recognized and certified will be based on two broad parameter that is, water consumption versus waste water reused or recycled (permeate) and corresponding solids recovered (percent total dissolved/suspended solid in influent).

In Panoli there are many companies which have already implemented this system for their respective companies. And there are other company also which are planning to implement this, one of this was R.P industry (Unit-1), situated at Panoli. Fortunately we got the opportunity to undergo from a one month of industrial training program at the company. So, we accept this as our final year project "To Achieve ZERO LIQUID DISCHARGE" system for R.P Industry Unit-1".

## I. ANALYSIS OF WASTE GENERATING UNIT OPERATIONS

The most important part of ZLD is to reduce waste from source generation. For achieving this one has to go through in plant production process with influent characterization. On basis of characteristics and quantum of influent one can decide zero liquid discharge stages.

- 1) The first part is in plant treatment or diversified usage of waste water.
- 2) Second Part is segregation of unavoidable waste water depends on its strength.
- 3) Third part is further sub classified in various stages
  - i) General Traditional ETP plant with efficient tertiary system
  - ii) Part of waste water went through typical ZLD guzzlers and part typical ETP
  - iii) The whole waste water need to pass through typical ZLD guzzlers

## II. STUDY OF EXISTING WATER BALANCE DIAGRAM

Water balance estimation is an important tool to assess the current status and trends in water resource availability in an area over a specific period of time. By using water balance

diagram we conclude that which amount of water use at plant and from that which amount of waste water is generated. With the help of water balance diagram is very useful to determine water quantity used at each and every unit or process, so we can identify the streams using excess water than required, which will be resulted in the reduction of waste water generated. All together reducing load on the ETP.

### III. STUDY OF EXISTING ETP PLANT

Table.:1 Influent characteristic:

Sr. No	Parameter	Strength in Equalization Tank-1	Strength in Equalization Tank-2
1	pH	5 to 8	5 to 8
2	COD (mg/l)	>3000	< 3000
3	NH <sub>3</sub> -N (mg/l)	200	400
4	TDS (mg/l)	4000	6000-7000

Influent coming from the different plant is taken to the two equalization tank. They have provided two equalization tanks. In equalization tank 1 they accept influent having COD less than 2000 to 3000 mg/l. And in equalization tank 2 they add influent having COD more than this. Then fed this water in proper predefined ratio by adjusting valves into neutralization tank. In neutralization tank they add lime and poly electrolyte for increasing pH up to 9. This action of mixing coagulant is done manually.

Effluent from the neutralization tank sent to primary settling tank. Here flocks generated are settled down in given retention time. Overflow from this tank then fed to the secondary settling tank. Sludge of this primary and secondary settling tank is send to the filter press where moisture content of the sludge is decreases. And solid sludge is sent to the BEIL for land filling.

### IV. SEGREGATE THE EFFLUENT STREAM

In this sector most of the industries are operating based on partial ZLD system and partially treating effluent in the conventional way. In most of the cases domestic effluent is treated separately or mixed with either low or high TDS effluent. The mixed salt recovery and no takers of salt generated is one of the problems of the industry since there is no reuse of same by the industry. In pharmaceuticals the reuse of by products are not encouraged much since it is

following very high quality standards for each raw materials. The effluent is generally segregated based on the strength of the pollutants in the early stages itself.

- Low TDS Effluent treatment system
- High TDS Effluent treatment system

### V. SAMPLING AND ANALYTICAL WORK

We will collected almost all major influent streams for the analysis of the characteristics like Chemical Oxygen Demand (COD), Ammoniacal Nitrogen,, Total dissolve Solids (TDS), and pH. We have personally performed the entire practical at our college laboratory. These practical include determination of COD, Ammoniacal nitrogen, pH, TDS, DO etc.

### VI. EXISTING ETP PERFORMANCE ANALYSIS

As a part of our work we will need to analyze the performance of existing ETP. It will help us to identify the experiments to carry out for, implementing its performance efficiency. For this first of all we decided certain points at the ETP. After collecting sample from the predetermined points and analyze on the basis of different parameters, on the basis of these performance of efficiency of each and every unit will determined.

Table : 2 Analysis of parameter:

Sample	pH	Chemical Oxygen Demand (mg/L)	TDS (mg/L)	Ammoniacal Nitrogen(mg/L)
Scrubber Water	8.88	6200	13000	45
Lab/Canteen	5.02	88	980	45
RO Reject	6.12	32	4620	76
Industrial Effluent (Boiler, Cooling Tower)	7	20	2000	Nil

### VII. TREATABILITY STUDY OF EFFLUENT :

For treatability study we provide the air to the effluent of industry and take the sample from the effluent after 24,48,72 hr. And check the efficiency. According to the result Parameter are decrease by providing the air therefore we conclude that the efficiency of the ETP plant will increase.

Table : 3 Treatability study:

Parameter	Initial parameter	After 24 hr	After 48 hr	After 72 hr	Percentage reduction
pH		6.5	4.8	3.1	53.62%
		6.3	4.6	3.3	
COD	850	780	649	530	39.41%
		860	730	500	
TDS	26500	17,000	12,800	8,050	69.7%
		16,500	11,000	8,000	
Ammonical nitrogen	14.23	14.00	13.89	13.56	5.05%
		14.17	13.67	13.47	

**VIII. LIME SLURRY VERSES LIME POWDER**

Based on the lime consumption experiment we obtain the results that if we are using 1 gm of lime powder in 100ml of sample it will take 1 hour to achieve 8.8 pH only and 1 hour to 45 minutes to achieve desired pH of 11. So we are having 3 variables here one is lime, second is pH and third is quantity of lime .At the industry point of view all three are important. Now, let’s take an example if we want to make constant factor quantity of lime, while using lime slurry so, it will decrease time required to achieve desire PH. If we want to achieve same pH achieved by lime solid in 1 hour so it will decrease time required as well as lime consumption. So in this manner when will conduct experiment to see performance for lime slurry and lime powder we get below result which clearly shows that using lime slurry instead of lime powder is a better option. It will enhance performance of neutralizing unit as well as whole it will affect overall process efficiency too.

Table 4: Result Table Of Lime Slurry Experiment

Using Lime powder	Using lime slurry
100 ml sample → 1 g lime Vigorous stirring → 1 hour → pH 8.8	100 ml sample → 1 g lime in 100 ml water sample Vigorous stirring → 30 minutes → pH 10.9 (And stable afterwards also)
	100 ml sample → 1g lime in 100 ml water sample Vigorous stirring → 20

minute → pH 9.3
100 ml sample → 1g lime in 100 ml water sample Vigorous stirring → 15 minute → pH 8.4zone.

**IX. CHECKING APPLICABILITY OF THE RO**

As we discussed earlier that for achieving ZLD there are number of ways available in the market, from which one of the most common option is RO (Reverse osmosis). There can be specially designed membrane and RO for the desirable characteristics and need of the industry. Generally RO is installed at the end of the ETP, so that permeate water can be taken directly in the use.

This technology uses a semi permeable membrane to remove larger particles from water, with an applied pressure higher than osmotic pressure. Membrane used in RO has a tight pore structure (less than 0.001 micron) that effectively removes up to 99% of the dissolved salts (ions), particles, colloids, organics, bacteria and pathogens from the feed water. In a normal case 40-50% water rejected during the RO process, but this ration can be reduced up to 20-25% by means of recycling the rejected water again and again until and unless it achieves its goal of 70-75% efficiency.

So, after considering our characteristics of the water, we decided to check possibility of fitting RO in our water loop. For that we took reference visits to the different units which are already having RO systems at their plant, then we obtained worst case parameters for the RO feed water and also carried out experiment on RO pilot plan. Details of these activities are included in the further sections.

**X. ANALYSIS OF RO FEED WATER CHARACTERISTICS:**

Table 8: Analysis Characteristics Of Ro Feed Water Characteristics

**APPLICATION OF TREATED WASTE WATER**

The potential application for the reuse of recycled water:

- In cooling towers, especially large scale industry
- Can be used in the gardening purpose for watering plants and lawns
- In toilet flush
- In water scrubber as scrubbing media
- For preparing lime slurry for ETP
- Different industrial washing operations
- Boiler feed water (particularly for generating steam for MEE)

Sr. No	Design Parameter	Unit	Value
1	Temperature	°C	30-40
2	pH	-	6.5 - 7.5
3	Chemical Oxygen Demand (COD)	Mg / l	90
4	Total Dissolved Solids (TDS)	Mg / l	6000
5	Total suspended Solids (TSS)	Mg / l	100
6	Biological Oxygen demand (BOD)	Mg / l	30
7	Ammonical Nitrogen	Mg / l	50
8	Turbidity	NTU	20

**ADVANTAGES/ BENEFITS:**

- Water Conservation
- ZLD systems employ the most advanced wastewater treatment technologies to purify and recycle virtually all of the wastewater produced.
- Reduces the wastewater discharge i.e. reduces water pollution
- Preferred option for industry where disposal of effluent is major bottleneck
- Prevents exploitation of hydraulic capacity of disposal system
- Separation of salts / residual solvents improve efficiency of ETP and CETP
- Separated solids valuable by-product which helps in reducing the payback period
- Mixed solvent separated in stripper can be reused or used as Co-processing
- Ease in getting environmental permissions
- More focus on production/ business rather than tracking after regulatory authorities
- Reduction in water demand from the Industry frees up water for Agriculture and Domestic demands.

Possibility of use of sewage for recovery of water, for Industrial and municipal use, using ZLD technologies.

**RESULT AND CONCLUSION**

After performing various experiments and installation of RO pilot plant, we have concluded as per followed diagram. The water from process plant, having high TDS will fed to multi

effect evaporator , from where shell condensate will fed to RO plant. After passing from RO, the permeate will used in boiler whereas the reject water will flows to existing ETP plant and the water from different process plants will also fed to ETP plant.. After treatment in ETP plant, the water is sent for further treatment and sea disposal at NCT (FETP) as per existing scheme. But as per proposed scheme, water will sent for sand filtration. After filtration, it is sent to cartridge filter and fed to RO plant. From where, the permeate will be used in industry and RO-reject will be fed to MEE.

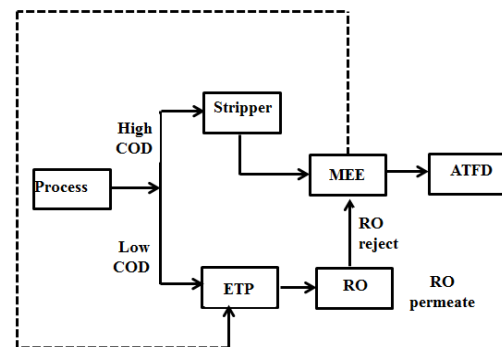


Fig : proposed ETP plant

**ACKNOWLEDGEMENT**

The authors would like to thank Mr. Urvij Dave of department of Environmental Science and Technology, SRICT for support and guidance in this paper. We would also like to appreciate all the faculty of department of science and technology, SRICT.

**REFERENCES**

- [1] Dr.Komal. Mehta “Design of Reverse Osmosis System for Reuse of Waste Water from Common effluent treatment Plant” (E-Issn: 2395 -0056)
- [2] P. Kousi, E. Remoundaki, A. Hatzikioseyan, M. Tsezos “Sulphate –Reducing Bioreactors: Current Practices and Perspectives” (Iwabalkanyoung Water Professionals-2015)
- [3] J. Suschka and L. Przywara “Chemical and Biological Sulfates Removal” (University Of Bielsko- Biala 43-309 Bielsko- Biala, Ulwillowa 2, Poland)
- [4] Michael mickey; “Survey of High –Recovery and Zero Liquid Discharge Technologies for Water Utility” (Water reuse Foundation)
- [5] Amit Udgirkar, Sr. Manager; “Zero Liquid Discharge for the Industrial Sector”; Environmental Engineering, (Praj Industries Ltd)

- [6] Viatcheslavf reger, Wolfson; "Zero Liquid Discharge (Zld) Concept, Evolution And Technology Options"; Israel Institute Of Technology, Haifa, Israel ("Zero Liquid Discharge" Workshop, Gandhinagar (January 27 - 28, 2014)
- [7] I. Sajid Hussain, Chief Operating Officer, "An Overview of Case Studies On Zero Liquid Discharge" Tamilnadu Water Investment Company Limited
- [8] Guidelines on Techno – Economic Feasibility Of Implementation Of Zero Liquid Discharge (Zld) For Water Polluting Industries - Cpcb
- [9] Mehta Komal P. And Patel A.S (Journal Of Environmental Research And Development) "Reverse Osmosis Design With Hydranautics Design Software For Industrial Waste Water Reuse"
- [10] Overview of Industrial Pollution Management Policies In India And Context Of Zld – Hardik Shah, Member Secretary, Gpcb
- [11] R.Sadik,R. Lahkale, N. Hssaine, M. Diouri And E. Sabbar "Sulfate Removal From Wastewater By Mixed Oxide";Euilibrium, Kinetic And Thermodynamic Studies; (Issn : 2028-2508)
- [12] Huldswanepoel "Sulphate Removal From Industrial Effluents Through Barium Sulphate Precipitation"(Dissertation Submitted In Fulfilment Of The Reuirments For The Degree Master Of Engineering In Chemical Engineering At The Potchefstroom Campus Of The North-West University )
- [13] Achieving Compliance With Zero Liquid Discharge Norm; Sn. K. Srivastava, Adviser, Tata Strategic Management Group 3rd; annual Conference On "Balance Of Plant"-New Delhi22nd& 23rdmay 2013"
- [14] J.P.Maree, I. Netshidaulu, G. Strobos, R. Nengovhela And A.J. Geldenhuys "Integrated Process For Biological Sulphate Removal And Sulphur Recovery"; (Division Of Water, Environment And Forestry Technology, Csiir, Po Box 395, Pretoria, 0001, South Africa)
- [15] Joe Bostjancic "Getting To Zero Discharge: How To Recycle That Last Bit Of Really Bad Waste Water" Rodiludlum, Resource Conservation Company (Rcc) (Ge's Water & Process Technologies)
- [16] "Removal Of Pesticides From Water By NF And Ro membranes- By Chemical Process" Engineering Research Institute , Center For Research And Technology- Hellas, P.O. Box 60361, 6th Km Charilaou- Thermi Road, Thermi, Thessaloniki, Gr 57001, Greece)