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ZERO LIQUID DISCHARGE – THE NEW AGE EFFLUENT TREATMENT TECHNOLOGY

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Abstract—*Industrialization over the past few decades has brought rapid development to many regions in the world today. Rapid development of the industrial sector has constantly degraded the quality of water resources available in nature, especially freshwater resources. Freshwater sources account for just about 3% of the total water resources on Earth and there has been large scale scarcity of fresh water around the globe, posing a major threat to economic growth, water security, and ecosystem health. Industrial processes of the most polluting industries like Tanneries, Paper-pulp, Pharma, Dyeing, Chemicals, etc. generate wastewater with high TDS, salinity, and pH, thus reducing the value and availability of water for the environment or other processes since they require water as a raw material or an intermediate processing material. To tackle this challenge, many governments are now aiming to push high-polluting industries towards Zero Liquid Discharge by creating regulations that require ZLD compliance. Zero Liquid Discharge (ZLD) is a modern engineering approach to conventional water treatment practices where the contaminants are reduced to solid waste and all water is recovered. Environmental experts consider ZLD to be beneficial to industrial and municipal organizations as well as the environment because no effluent, or discharge, is left over. ZLD systems are capable of purifying and recycling virtually all of the wastewater produced and also converting wastewater from an industrial process to solids, sometimes recovering valuable resources.*

1. INTRODUCTION

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. The public and industrial sectors consume substantial amounts of freshwater while producing vast quantities of wastewater. If inadequately treated, wastewater discharge into the aquatic environment causes severe pollution that adversely impacts aquatic ecosystems and public health. The most viable solution to this issue is recycling the wastewater generated as much as possible. Recovery and recycling of wastewater has become a growing trend due to rising water demand. It not only minimizes the volume and environmental risk of discharged wastewater, but also alleviates the pressure on ecosystems resulting from freshwater withdrawal.

Zero Liquid Discharge (ZLD) is the only option currently available in many inland regions where surface water, sewer, and deep well injection disposal are either prohibited or have caused damage to water and land resources, and effected biotic health. The strategy eliminates any liquid waste leaving the plant or facility boundary, with the majority of water being recovered for reuse. In this paper we will learn how a ZLD-system can produce a clean stream from industrial wastewater and make it suitable for reuse in the plant or can be further reduced to a solid. We will also understand the major advantages ZLD systems have over conventional ETP technologies.

2. ETPS IN INDIA

India has witnessed rapid industrialization over the past 30 years and several large scale industrial projects have generated effluents that contain either oils or grease or toxic materials (e.g., cyanide). Effluents from food and beverage factories contain degradable organic pollutants. Since industrial wastewater contains a diversity of impurities and therefore specific treatment technology called Effluent Treatment Plant (ETP) is required.

India over the past few decades, has been taking aggressive actions to curb severe water pollution, even in the holy river Ganga. In the beginning, the government came out with common effluent treatment plants (CETPs) to collect the polluted discharges from various industries at one point objectively to treat remove pollutants to an extent and then discharge the treated effluent into the rivers, lakes, ponds etc. Again this noble objective failed for two primary reasons:

- Industries have passed the responsibility on to CETPs started sending out (discharging) severely contaminated water coupled with escalating flows.
- Administrative malfunction of CETPs management.

The objective of a well-functioning ETP is to reuse and to release safe water to environment from the harmful effect caused by the effluent. The plant works at various levels and involves various physical, chemical, biological and membrane processes to treat wastewater from these industries. However, the most polluting industrial sectors in India like chemicals, drugs, pharmaceutical, tannery, refineries, dairy, ready mix plants & textile, etc. that have been relying on ETP to purify industrial wastewater in India are failing to meet the water discharge standards, thus leading to pollution of fresh water sources. This scenario is being further aggravated due to rising water scarcity in the country.

3. ZERO LIQUID DISCHARGE (ZLD)

After the failure of conventional ETPs systems in complying to the effluent disposal standards, the apex body (related ministry/government department, pollution control boards, and equivalent body) foreseeing the future came down with a legal directive for each and every industry to install a ZLD scheme. The recent three-year target set by the Indian government, known as the "Clean Ganga" project, imposes stricter regulations on wastewater discharge to 9 State Pollution Control Boards of states along the Ganga basin and move high-polluting industries toward ZLD. The government had issued a draft policy in 2015 that requires all textile plants generating more than 25 m3 of wastewater effluent per day to install ZLD facilities.

4. WASTEWATER RECLAMATION USING ZLD

ZLD employs the idea of water reclamation and reuse with definable treatment reliability for beneficial uses, such as agricultural irrigation and industrial boiling and cooling. In the recent light of public environmental awareness and pollution control regulations, water reclamation and reuse has assumed a more important and diversified role. The attractiveness of reuse results from several circumstances, one or more of which may be appropriate in any situation. Some of the rationale behind water reclamation and reuse are hereby highlighted below:

- Water reuse accomplishes zero liquid discharge (ZLD) mandates. Reclamation and reuse of wastewater for beneficial purposes eliminates potential pollution load to receiving water.
- Water reclamation optimizes conservation ethics. Legislative directives have asked for more wise use of resources. Extensive wastewater treatment requirements imposed for the maintenance of receiving water quality often results in the production of a product that is literally too good to throw away. This water may serve many purposes in a community.
- Water is a limited resource and where there is insufficient potable water of high quality, growth of a community may also be limited. Reclaimed water may be utilized for many of the purposes ordinarily served by the high-quality potable source, thereby permitting the high quality water to serve increasing populations.

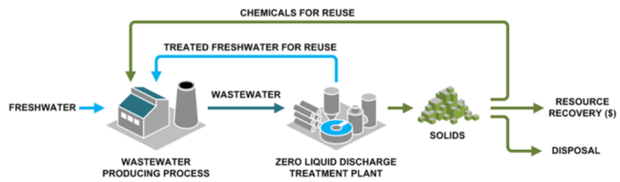
5. PRINCIPLE OF ZLD

Early ZLD systems were based on stand-alone thermal processes, where wastewater was typically evaporated in a brine concentrator followed by a brine crystallizer or an evaporation pond. The condensed distillate water in ZLD systems is collected for reuse, while the produced solids are either sent to a landfill or recovered as valuable salt byproducts. Such systems, which have been in successful operation for 40 years and are still being built, require considerable energy and capital. Reverse osmosis (RO), a membrane-based technology widely applied in desalination, has been incorporated into ZLD systems to improve energy and cost efficiencies.

ZLD technology includes pre-treatment and evaporation of the industrial effluent until the dissolved solids precipitate as salts and residue. These salts are removed and dewatered. The water vapor from evaporation is condensed and returned to the process. It is the most "In demand" water treatment technology that can treat wastewater as the contaminants are concentrated.

6. WORKING

In general, most of the ZLD systems in operation these days are based on stand-alone thermal processes, where wastewater was typically evaporated in a brine concentrator followed by a brine crystallizer or an evaporation pond. The condensed distillate water in ZLD systems is collected for reuse, while the produced solids are either sent to a landfill or recovered as valuable salt byproducts.



Normally the evaporation-crystallizing section receives the reject from a Reverse Osmosis (RO) section that concentrates dissolved solids. To prevent fouling during the reverse osmosis process, ultrafiltration is often used to eliminate suspended solids.

- **Pretreatment and conditioning**

Pretreatment is used to remove simple things from the wastewater stream that can be filtered or precipitated out, conditioning the water and reducing the suspended solids and materials that would otherwise scale and/or foul following treatment steps.

Typically this treatment block consists of some type of clarifier and/or a reactor to precipitate out metals, hardness, and silica. Sometimes this step requires the addition of caustic soda or lime to help with coagulation, a process where various chemicals are added to a reaction tank to remove the bulk suspended solids and other various contaminants.

This process starts off with an assortment of mixing reactors, typically one or two reactors that add specific chemicals to take out all the finer particles in the water by combining them into heavier particles that settle out. After this, the Ultrafiltration (UF) process is used to bring outa liquid that is then filter-pressed into a solid, resulting in a solution much lower in suspended solids. UF is an essential step to protect the RO process.

- **Phase-one concentration**

Concentrating in the earlier stages of ZLD scheme is usually done with reverse osmosis (RO), brine concentrators, or electro-dialysis. The pretreated water must be sent through the semipermeable membranes of the RO system. Brine concentrators may beused to remove dissolved solid waste with a much higher salt content than RO.

Electro-dialysis can also be used in this part of the ZLD treatment system. It's a membrane process that uses positively or negatively charged ions to allow charged particles to flow through a semipermeable membrane and can be used in stages to concentrate the brine. It is often used in conjunction with RO to yield extremely high recovery rates.

- **Evaporation and crystallization**

After the concentration step is complete, the next step is generating a solid, which is done through thermal processes like evaporation followed by crystallization.In this stage you evaporate all the water off, collect it, and reuse it. The concentrated effluent (25-30% concentration) then goes from an evaporator to a crystallizer (Centrifuge) to desalt the water and generate solid for disposal.

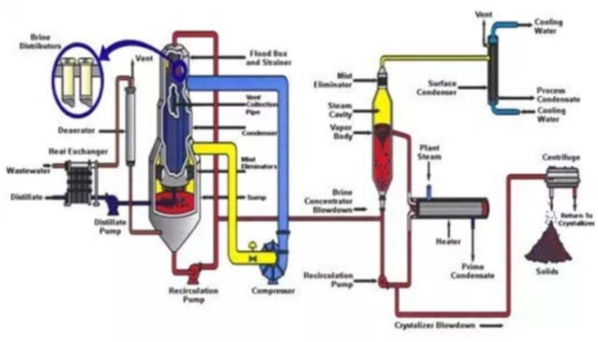
- **Recycled water distribution/solid waste treatment**

If the treated water is being reused in an industrial process, it's typically pumped into a holding tank where it can be used based on the demands of the facility. The ZLD treatment system should have purified the water enough to be reused safely in your process.

The solid waste, at this point, will enter a dewatering process that takes all the water out of the sludge with filter or belt presses, yielding a solid cake. The sludge is put onto the press and runs between two belts that squeeze the water out, and the sludge is then put into a big hopper that goes to either a landfill or a place that reuses it. The water from this process is also typically reused.

7. COMPONENTS

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.



The basic structure of a properly functioning ZLD system comprises of the following components:

- **Clarifier and/or Reactor** to precipitate out metals, hardness, and silica
- **Chemical feed** to help facilitate the precipitation, flocculation, or coagulation of any metals and suspended solids
- **Filter press** to concentrate secondary solid waste after the pre-treatment or alongside an evaporator
- **Ultrafiltration (UF)** to remove all the leftover trace amounts of suspended solids and prevent fouling, scaling, and/or corrosion down the line of treatment
- **Reverse Osmosis (RO)** to remove the bulk of dissolved solids from the water stream in the primary phases of concentration
- **Brine concentrators** to further concentrate the reject RO stream or reject from electro--dialysis to further reduce waste volume
- **Evaporator** for vaporizing access water in the final phases of waste concentration before crystallizer.
- **Crystallizer** to boil off any remaining liquid, leaving you with a dry, solid cake for disposal.

8. COST AND EFFICIENCY

ZLD systems are associated with high capital investments and even higher operating expenses. More than 90% of this operating cost is incurred during evaporation, which is a very energy intensive process. This is because, after various stages of filtration, chemical treatment, and separation of water from chemicals following Reverse Osmosis (RO), the RO Reject is first evaporated and then condensed to recover the water. In some cases however, this cost can be offset by the resource recovery i.e. salt and other chemicals which can be again reused in the process. For example, in textile industries, there is enough scope to recover salts and brine solution which can be reused in the manufacturing process and reduce the impact of treatment cost on the overall cost of production.

This mandate will drive water efficiency measures in the Indian industry. Lesser waste water means lesser treatment cost and thus improving water use efficiency will have significant benefits especially for industries like Sugar and pulp and paper industry, which have a considerably large water footprint.

9. MERITS OF ZLD

Environmental experts consider ZLD to be beneficial to industrial and municipal organizations as well as the environment because no effluent, or discharge, is left over. ZLD systems are capable of purifying and recycling virtually all of the wastewater produced and also converting wastewater from an industrial process to solids, sometimes recovering valuable resources. Targeting ZLD for an industrial process or facility holds a number of benefits like:

- Lowered waste volumes decrease the cost associated with waste management.
- Recycle water on site, lowering water acquisition costs and risk. Recycling on-site can also result in fewer treatment needs.
- Use of the most advanced wastewater treatment technologies to purify and recycle virtually all of the wastewater produced
- Some processes may recover valuable resources, for example, ammonium sulfate fertilizer or sodium chloride salt for ice melting.
- Reduces the wastewater discharge i.e. reduces water pollution
- Preferred option for industry where disposal of effluent is major bottleneck
- Separation of salts/residual solvents improve efficiency of ETP and CETP
- Reduction in water demand from the Industry frees up water for Agriculture and Domestic demands.
- Ease in getting environmental permissions
- Improved environmental performance and regulatory risk profile for future permitting.

10. CONCLUSION

The textile and tannery sectors in India generate the maximum amount of wastewater and have been facing a severe crunch from the government to install ZLD solutions along with conventional ETP systems as a mandate. As the severe consequences of water pollution are increasingly recognized and attract more public attention, stricter environmental regulations on wastewater discharge are expected, which will push more high-polluting industries toward ZLD. ZLD will effectively help reduce water demand from the industry and free up water for Agriculture and Domestic demands. Intensified freshwater scarcity, caused by both climate change and freshwater overexploitation, will likely facilitate ZLD implementation.

REFERENCES

[1] Viatcheslav Freger, 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)

[2] Kinjal Patel, Rushabh Aghera, Dharmen Mistry and Ekta Jasrotia; "A Zero Liquid Discharge in Pharmaceutical Industry"

[3] S. Virapana, R. Saravananeb and V Murugaiyanb; "Zero Liquid Discharge (ZLD) in Industrial Wastewaters in India-Need for Sustainable Technologies and a Validated Case Study"

[4] Tiezheng Tong and Menachem Elimelech; "The Global Rise of Zero Liquid Discharge for Wastewater Management: Drivers, Technologies, and Future Directions"

[5] Mutiu K. Amosa, Mohammed Saedi Jami, Suleyman Muyibi and Maan Alkhatib; "Zero liquid discharge and water conservation through water reclamation & reuse of bio-treated palm oil mill effluent"