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Research Article

ZERO LIQUID DISCHARGE (ZLD) SYSTEM: AN APPROACH TOWARDS SUSTAINABLE DEVELOPMENT

Dasaiah Srinivasulu[1]., Yakkala Kalyan[1]., Battala Gangadhar[1]., Pindi Pavan Kumar[2]., and Gurijala Ramakrishna Naidu*[1]

[1]Department of Environmental Sciences, Sri Venkateswara University, Tirupati-517 502 Andhra Pradesh, India

[2]Department of Microbiology, Palamuru University, Mahabubnagar-509 001, Telangana State, India

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ABSTRACT

The goal of a well-designed Zero Liquid Discharge (ZLD) system is to minimize the volume of liquid waste that requires treatment, while also producing a clean stream suitable for use elsewhere in the plant processes. A common ZLD approach is to concentrate (evaporate) the wastewater and then dispose of it as a liquid brine, or further crystallize the brine to a solid. The evaporated water is recovered and recycled while the brine is continually concentrated to a higher solids concentration. The effluents are desired to be treated to meet the regulatory limits. Basically the levels of COD and total suspended solids are to be reduced to acceptable values given by the Pollution Control Board and pH to neutral. Treated water can be reused for activities such as gardening, boiler feed, etc. and the removed waste is classified as organic and inorganic waste and treated accordingly. Other by-products during treatment, such as hydro carbons, lead etc. are used or sold according to the need of the industry. Other than the necessity of meeting the pollution control board norms, treating the wastewater helps in reusing tons of water within the industry and not wasting a single drop and hence it is called Zero Liquid Discharge. The role of engineer in Zero Liquid Discharge plant is to optimize operating cost, to increase steam economy and to increase solvent recovery.

INTRODUCTION

The term "Zero Liquid Discharge (ZLD)" has cropped up more and more frequently in conjunction with water and waste water treatment processes over the last few years. This should be understood to mean processes without liquid waste or waste water[1]. Initiatives and measures to bring this idea closer to fruition or to implementation have been ongoing in various industries for many years. Some ZLD plants are already in use. The motivation to develop and construct such plants is complex and not standardized. The following objectives can be realized by a ZLD plant: - cost savings resulting from the recycling of water and ingredients and energy, - cost savings from the disposal of the contamination loads removed from the waste water (e.g. reduction in the waste water charges), - load relief on existing waste water plants, - preservation of the water supply and/or the water quality, - realization of environmental benefits. Measures for reducing the waste water flows have been introduced and implemented in many companies over the last thirty years or even longer [2-4]. These developments were encouraged in Germany, especially through the Waste Water Charges Act introduced on the 13th September 1976. A waste water charge has been levied since 1981, which has been gradually increased over several years. This has clearly reduced the water consumption and the amount of waste water in many industries. In the majority of cases this was linked to cost savings in the form of reduced fresh water and waste water charges [5]. It is also possible that this was linked to water treatment and the procurement of internal water circuits. The amount of waste water could then be clearly reduced, but the amount of contamination loads from the waste water that has to be disposed of clearly increased. The water recycling spectrum in many companies ranged from 80% to 90%. However, the complete elimination of waste water flows does not exist, except for a few exceptions [6-8].The reduced waste water flow is disposed of in centralized waste water treatment plants or it undergoes further treatment in separate plants, so that the contamination level is reduced even further. Not all of the

Corresponding author:* **Gurijala Ramakrishna Naidu
Department of Environmental Sciences, Sri Venkateswara University, Tirupati-517 502, Andhra Pradesh, India

water-borne impurities can be removed or eliminated, which means that they have to be drained with the reduced waste water flow [9]. The remaining flow normally includes salts, non-volatile compounds and colloidal substances, which are measured as "Total Dissolved Solids (TDS)". A large proportion is made up of salts, which form as the result of the neutralization of acids or basic waste water, etc.. pH value shifts can also be made during waste water treatment, so that impurities can be reduced and separated mechanically. Waste water containing compounds that include metals that have been detached by the metal and surface technologies can be treated using a pH value shift. The metallic compounds become hydroxide, hydrated oxides or metal salts, which can be separated through sedimentation or filtration and disposed of as sludge. The residual aqueous liquid will be neutralized. They can either be removed or undergo further treatment, depending on the contaminants [10].

MATERIALS AND METHODS

***Source of wastewater*:** The source of wastewater used in the pilot plant studies generated from various source of API manufacturing unit, which includes process outlets, process equipment washings, process area floor washings, utilities wastewater (i.e., cooling tower blow downs, boiler blow downs and utilities washings), effluent treatment plant washings, etc.

***Segregation of wastewater*:** Total effluents were broadly segregated to High Concentration Streams (HCS) and Low Concentration Streams (LCS), which was based on COD (Chemical Oxygen Demand) and TDS (Total Dissolved Solids). If a wastewater stream characteristics, i.e., COD >15000 mg/l and TDS >8000 mg/l, segregated to HCS. If both the above said parameters were within the below levels (i.e., COD 15000 COD or >8000 TDS), those are also segregated as HCS.

***Characterization of wastewater*:** Wastewater characterized by approved methods (i.e., pH by pH Electrode, COD by HACH COD track, BOD by HACH BOD track, TSS by Gravimetry, Millipore, and TDS by Gravimetry, watt man).

Experimental

***Operating Procedure of Stripper Column*:** Start the cooling water pump, treated effluent transfer pump, feed pump and keep the feed rate to the stripping column constant. After reaching 70% level in the kettle, stop the feed pump. Open the steam value (steam pressure should be 1.0-1.5 kg/cm²) to the reboiler and drain the condensate water by opening the bypass valve. After removal of the condensate water close the condensate bypass valve. Collect the top condensate in the collection receiver. Start the feed pump and keep the required feed rate by adjusting the flow meter. Start the stripper bottom pump and transfer the bottom with required flow rate. Collect the condensate in the collection receiver up to 50% of the level. Start the reflux and collection pump. Keep 75% flow rate as reflux and 25% as collection. Maintain the kettle and top vapour temperature around 105±20C and 85±50C respectively.

***Operating Procedure of Multiple Effect Evaporator*:** Start cooling water pump, treated effluent feed pump and fill the effluent in the phase separator (PS-I) up to the 50% of the view glass. Start recirculation pump-I, effluent treatment pump-I and transfer the effluent from PS-I to PS-III and fill the 50% of the view glass. Start the recirculation pump-III, ETP-III and transfer the effluent from PS-III to PS-I and maintain the 50% of the view glass. Recirculate the effluent by maintaining the levels in the phase separators. Start the vacuum pump and maintain vacuum up to 600-650 mmHg. Open the steam valve and keep the steam pressure 1.5-2.0 kg/cm² and temperature < 850C. Collect the vapour condensate in the vapour condensate collection receiver and feed the effluent simultaneously. Send the MEE concentration, mass and vapour condensate samples to ETP lab for analysis. When the MEE concentration mass is around 2 lakh ppm start collecting the concentrated mass to storage tank. Start the pump to transfer the condensate H2O to LTDS neutralization tank. Stop the recirculation pumps.

***Operating Procedure of Agitated Thin Film Dryer (ATFD)*:** Start the cooling water pump. Keep the interlock switch in "ON" position. Open the steam to the top and bottom jacket of the dryer and drain the condensate water by opening the by-pass valve, after removal of the condensate water close the condensate by-pass valve. Start the air blower then the agitator. Start the feed rate 300-500 l/hr to the dryer when the vapour temperature reaches 950C. Collect the vapour condensate in the low TDS collection tank using pump. Check the pH, TDS of vapour condensate and water content in the solid waste collected at the bottom and record the same. Collect the solid material and transfer to the hazardous waste storage shed.

***Operating Procedure of Reverse Osmosis Plant*:** Treated effluent is collected in the storage tank for further treatment. Send the sample to the lab for checking of pH, TDS, COD and TSS to meet the operating properties of the RO plant feed. Adjust the pH of the effluent to 6.5 prior to feed in the system. Clean all the filter cloths and cartridges before starting the system. When pressure increases gradually the effluent separates as permeates and reject. Permeates and reject are collected in respective tanks. Send to lab to meet the output specifications. Otherwise send the permeate water to RO feed plant for further treatment and record the analysis.

RESULTS

i. The stripper and multiple effect evaporators (MEE) are used for treating high total dissolved solids.
ii. The condensate from MEE and condensate from the utilities are collected on day to day basis and analysed where various methods are applicable for the reduction of the organic content present in the effluent waste by filtration, aerobic degradation electrochemical treatment and biological methods.
iii. These methods can reduce the COD up to 80-90% in the effluents.
iv. These methods contribute to better environmental conditions which can be easily maintained and very economical. The effluent water reduced in COD, BOD, TSS and TDS content can be recycled to different utilities.
v. In this plant the treated water is used only for boiler.

Theoretical Results

Feed flow rate: 300 kl/day Input: TDS - 100000 ppm - 30000 l/day - 1250 kg/hr COD – 130000 ppm - 39000 l/day - 1282 kg/hr Output: TDS - 0 (as 100% collected at ATFD bottom) COD - 70 kg/hr remains in stripper bottom.

DISCUSSION

The present investigation is directed towards the study of wastewater treatment in the angle of continuous improvement and confirming to the norm prevailing as per the national standards. This cost effective treatment leading to further reduction of COD, BOD, TDS, and SS and make use of the treated water for hygienic appellation such as agriculture, washing, and gardening. From the experimental study the process requires up-gradation of secondary stripping column for 100% recovery of solvents. Reduces volatile organic compounds (VOC) which causes obnoxious smell in the entire plant area. This can be done by keeping the effluent in an enclosed space and the vapours are burnt to reduce VOC. In ZLD treatment plant cooling tower water is contaminating due to usage of barometric condenser for the purpose of vacuum creation by condensing MEE 3rd stage vapours. This problem is overcome by using external vacuum pump connected to shell and tube condenser to create vacuum and parallelly condensing 3rd stage vapours.

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