INTRODUCTION OF CANDIDATE

1. I, Lieutenant Commander (E) Koku Hennadige Kanchana Madhushanka Abeysooriya, BTech Mech Eng, CEng (UK), CEng (Ind), AMIE (SL), AMIE (Ind), MIMarEST (UK) am presently employed in the Engineering Branch of the Sri Lanka Navy. I joined the Sri Lanka Navy on 19th December 2005 as an officer cadet and graduated from the **Naval College of Engineering INS Shivaji, which is a fully-fledged engineering college of the Indian Navy**, affiliated with Sri Jawaharlal Nehru University, New Delhi, India. I graduated in the field of Mechanical Engineering in the year 2009 and obtained a Bachelor of Technology degree in Mechanical Engineering from Sri Jawaharlal Nehru University, New Delhi, India.

2. After graduating from India, I have been dealing with the profession of Engineering for approximately 12 years. I had undergone various types of training as well and held several responsible experiences in my career spanning merely 17 years since 2005. I have gained knowledge in various aspects of engineering and human resource management during my tenure. My performance has been judged by superiors as well as juniors and entrusted with several key appointments in Sri Lanka Navy. In this backdrop, I have been motivated to forward this paper under the sub-theme of *Zero Liquid Discharge System* to merge another experience with my naval career.

TECHNOLOGICAL INNOVATION IN SEAWATER DESALINATION, WASTEWATER MANAGEMENT AND ZERO LIQUID DISCHARGE

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Abstract

The term "Zero Liquid Discharge" (ZLD) refers to a technical method of treating water in which all water is recovered and contaminants are turned into solid waste. Even though many water treatment methods aim to recover as much freshwater as possible while producing as little waste as possible, ZLD is the most difficult goal to achieve because as wastewater becomes more concentrated, recovery becomes more expensive and difficult. Concentrations of salinity, scaling substances, and organics all rise, which raises the expense of handling these increases. ZLD is accomplished by integrating wastewater treatment technology that can handle wastewater when the toxins are concentrated. ZLD system adoption is regarded as an important industrial wastewater management tactic that can reduce water contamination and improve water supply all over the world. For more widespread adoption of ZLD, issues concerning high energy consumption and increased capital expenditures need to be addressed. Energy needs are still higher than those of typical wastewater treatment and disposal methods, as are other related costs. In the end, regulatory authorities are implementing increasingly strict environmental laws on industrial wastewater discharge that would compel enterprises toward ZLD applications due to the serious concerns produced by water contamination. Additionally, freshwater scarcity brought on by climate change and excessive water resource use will make it easier to implement ZLD systems.

Keywords: ZLD, Water Treatment Technology, Waste Water

INTRODUCTION

1. A key danger to economic growth, water security, and ecosystem health is freshwater scarcity, one of the most pressing global concerns in the present day context. Climate change, pressure from economic growth and industrialisation, and other factors make it more difficult to provide enough clean drinking water. Both the public and industrial sectors use a sizable amount of freshwater while generating a sizable amount of wastewater. Wastewater discharge into the aquatic environment without proper treatment results in severe contamination that harms aquatic ecosystems and public health. Due to the increased demand for water over the past ten years, the recovery and recycling of wastewater have become a major trend.

2. Reusing wastewater reduces freshwater withdrawal's negative effects on ecosystems while also reducing the volume and environmental risk of discharged wastewater. Wastewater can be used again and is no longer viewed as a "pure waste" that might harm the environment, but as a resource that can be used in conjunction with other resources to help achieve water sustainability.

3. An ambitious wastewater management method known as Zero Liquid Discharge (ZLD) aims to eliminate any liquid waste from leaving the plant or facility border while recovering most of the water for further use. The dual problems of water scarcity and aquatic environment degradation have received more attention in recent years, reviving interest in ZLD on a global scale. ZLD is becoming a useful or even required solution for wastewater management as a result of rising freshwater value.

4. The earliest ZLD systems relied on independent thermal processes, where wastewater was typically evaporated in a brine concentrator followed by a brine crystallizer or an evaporation pond. ZLD systems have adopted reverse osmosis (RO), a membrane-based desalination technology, to increase energy and financial efficiencies. Although RO is far more energy efficient than thermal evaporation, it can only be used with feedwaters with a specific salinity range. The profitability of ZLD is dependent on striking a balance between the advantages of ZLD, energy consumption, and capital/operation expenses. Despite ZLD's significant potential to reduce water pollution and increase water supply.

5. Determining the possible applicability of ZLD for water treatment is essential since the environmental effects of brine disposal from saltwater desalination plants and wastewater treatment plants are a matter of growing concern. Technologies based on membranes are a potentially appealing approach that can be employed to accomplish this. Recent research has also shown that a practical method for generating ZLD for industrial usage involves merging several membrane processes.

ADVANTAGES OF ZLD

6. For an industrial process or facility, aiming for zero liquid discharge has a variety of advantages:

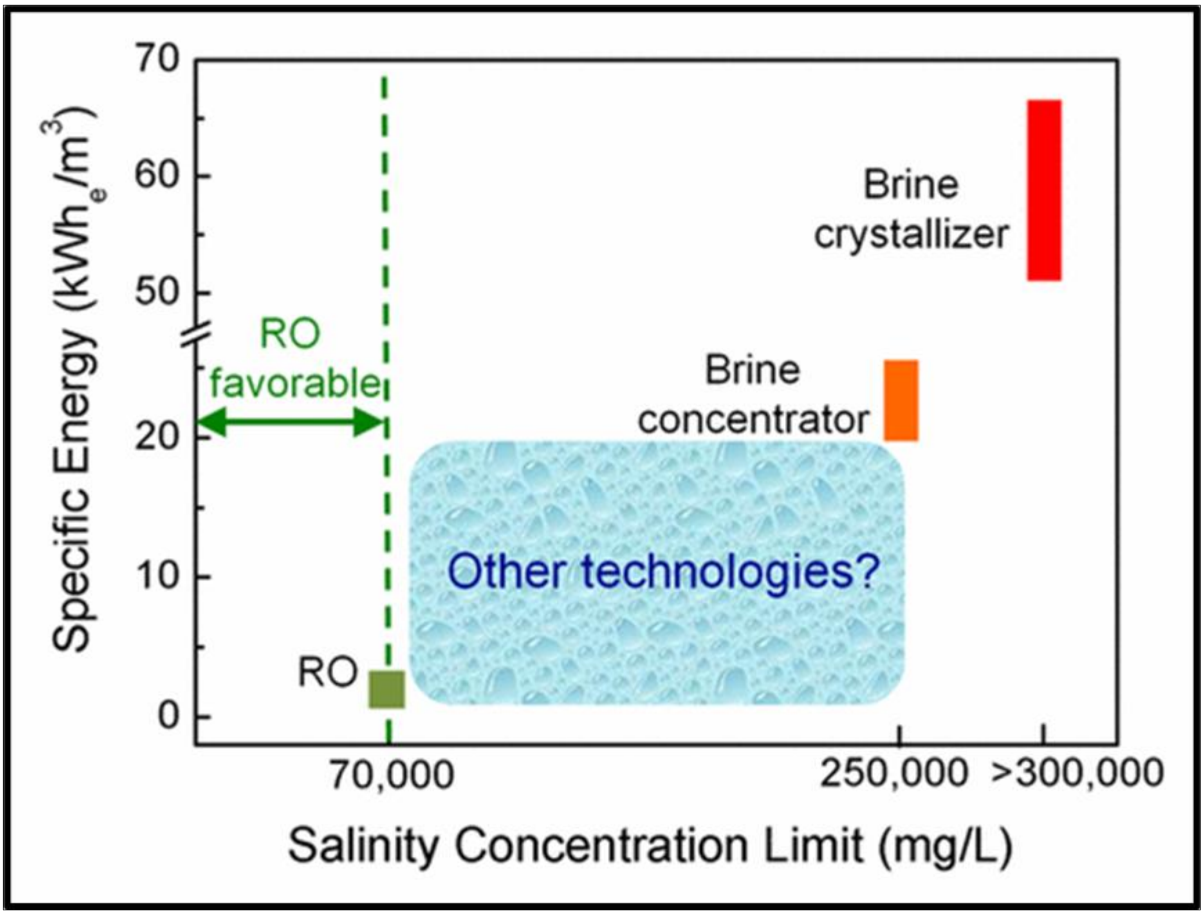
a. Reduced trash quantities lower the expense of waste management.

b. Reduce the cost and risk of water acquisition by recycling water on the spot. In comparison to treating to achieve strict environmental discharge regulations, on-site recycling can also result in fewer treatment requirements.

c. Reduce the number of trucks needed for off-site wastewater disposal, as well as the accompanying greenhouse gas emissions and danger of neighbourhood traffic accidents.

d. Increased regulatory risk profile and environmental performance for upcoming permits.

e. Some procedures can save valuable resources, like Sodium Chloride salt for ice melting or Ammonium Sulphate fertilizer.



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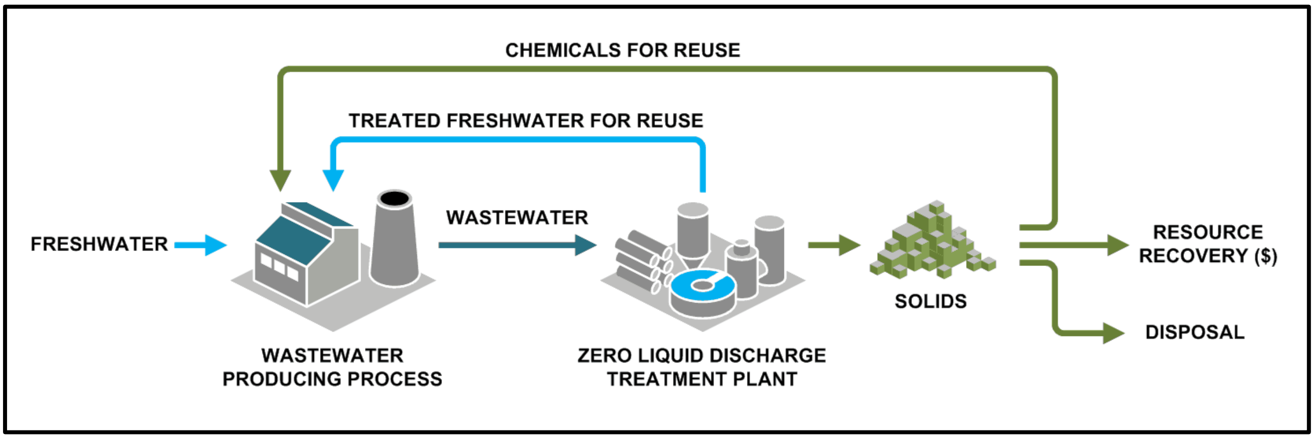
SIGNIFICANT OF ZLD

7. Freshwater availability is under threat from industrial operations on two fronts in a world where it is becoming an increasingly important resource unless the water is cleaned. Water is needed for many industrial operations, but as a result, less water is available for the environment or other processes, or contaminated water is released into the environment, causing harm. The capacity to recover resources from wastewater is a significant additional justification for zero liquid discharge. Because ZLD can sell the solids created or reuse them as part of their industrial process, some organizations target ZLD for their trash. Lithium, for instance, has been discovered in brines from US oil fields at levels that are practically identical to those of South America.

8. Another illustration is the recovery of Gypsum from mine water and wastewater from Flue Gas Desalination (FGD), which may then be sold and used to make drywall.



9. Whatever the organization's reasons for aiming for ZLD indicate sound business practices, corporate accountability, and environmental stewardship. Operating an internal ZLD plant can save disposal costs, increase water reuse, and reduce greenhouse gas emissions from off-site trucks, reducing the impact on regional ecosystems and the climate.

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ZLD SYSTEMS FOR RESOURCE RECOVERY: CURRENT STATE OF THE WORLD

10. **USA**. The majority of ZLD systems in operation worldwide right now are in the USA. Power stations close to the Colorado River first implemented ZLD systems in the 1970s as a result of the rising salt of river water. The USA Environmental Protection Agency has updated its regulations for the discharge of wastewater from thermal power facilities. Therefore, ZLD is a preferable alternative for power plants to achieve the stipulated limits of hazardous metals and other dangerous pollutants. Installation of ZLD at power stations is encouraged by compliance with recently approved criteria for wastewater outflow. Brine management is one of the largest issues for inland desalination plants, although conventional methods could have negative effects on surface and groundwater. ZLD systems that can handle brine consequently have a lot of potential for inland desalination in areas with a lack of water.

11. **CHINA**. China has seen an increase in water use and water contamination as a result of its rapid economic expansion and urbanization. As a result, China unveiled a new action plan to combat water pollution by 2020 by improving the quality of water resources and ecosystems. The construction of coal-to-chemicals plants, which use a lot of fresh water, has boomed recently in China. ZLD is now required for coal-to-chemicals facilities to protect water resources and ecosystems.

12. **INDIA**. India's accelerated industrialisation and urbanization are severely stressing the country's water resources and causing more pollution. The Indian government recently established a three-year goal for the "Clean Ganga" project, which sets strict rules on wastewater discharge and forces high-polluting enterprises to transition toward ZLD. In Tirupur, India, a ZLD system was put into place in 2008 to collect precious salts and water from textile effluent for reuse in the dyeing process. In the Indian government's water conservation efforts in 2015, ZLD installation was mandated by policies at all textile factories that produced more than 25 m3 of wastewater per day. ZLD has been expanded in India to several industrial sectors, including the steel, power, pharmaceutical, chemical, textile, food, and beverage industries.

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ENVIRONMENTAL AND OPERATIONAL EFFECT OF ZLD

13. Despite ZLD systems' benefits in reducing water pollution and enhancing water sustainability, several environmental issues are connected to their use. In the first place, the created solid wastes combined with salts are inappropriate for reuse and, if kept in evaporation ponds, they emit aromas, have an adverse effect on wildlife, and pose a risk of leakage. Additionally, these wastes may result in chemical leaching if they are disposed of in landfills. Since they frequently necessitate hazardous waste disposal facilities, these waste solids consequently pose substantial storage and disposal issues.

14. Second, the high operational costs associated with current ZLD technologies are a major worry because more advanced pre-treatment systems are needed to obtain better water recovery. In addition, complex system design results in high chemical costs, significant sludge generation, and salt in the wastewater discharged downstream. As a result, complete hardness removal using pre-treatment systems is now essentially a norm in ZLD technology. Thus, efforts are made to develop a hybrid membrane and a room-temperature crystallization process for high-efficiency preconcentrating technology to recover water and make Calcium Sulphate solids concurrently.

15. Thirdly, pre-treatments that release CO_2 into the environment, including acidification and degasification, result in air pollution. Additionally, heavy greenhouse gas emissions are brought on by high energy usage. Additionally, CO_2 is released during decarbonisation to prevent scaling and from ED applications used to concentrate RO brine from energy-intensive sources.

16. Implementing technologies like RO can reduce greenhouse gas emissions in terms of energy efficiency. Incorporating novel membrane technologies into ZLD systems also enables the utilization of low-cost or renewable energy, which can lower greenhouse gas emissions.

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CONCLUSION

17. ZLD system adoption is regarded as an important industrial wastewater management tactic that can reduce water contamination and improve water supply all over the world. For more widespread adoption of ZLD, issues concerning high energy consumption and increased capital expenditures need to be addressed. Energy needs are still higher than those of typical wastewater treatment and disposal methods, as are other related costs. In the end, regulatory authorities are implementing increasingly strict environmental laws on industrial wastewater discharge that would compel enterprises toward ZLD applications due to the serious concerns produced by water contamination. Additionally, the overuse of water resources and freshwater scarcity brought on by climate change will make it easier to deploy ZLD systems.

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