Comparative Evaluation of Source Waters and Reverse Osmosis Treated Waters in Relation to User Preferences for Consumption at the University of Jaffna, Sri Lanka

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Introduction

Water connects every aspect of life. The demand for safe drinking water that has no negative environmental or societal impacts is increasingly rising worldwide. Guidelines for safe water, as outlined in the 'Rigveda', the oldest sacred text of Hinduism (BC 1200-1000), emphasise the importance of cold, clean, transparent water with appropriate mineral content and neutral acidic and alkaline (pH) conditions (Rummi Devi Saini, 2017). Access to safe drinking water faces significant challenges in many regions, stemming from climate change, population growth, increased water consumption and wastage, depletion of water resources, deterioration of water quality, and economic factors related to water pricing. Additionally, high mineral content in waters in many regions has led to serious health issues associated with their consumption (Khodadadi, 2016; Verma et al., 2020; Verma and Lal, 2022). Waters with high levels of total dissolved solids or hardness, along with those contaminated by natural or human-made factors, pose significant health risks to consumers in many regions around the world, including Sri Lanka (Villholth & Rajasooriyar, 2010). In this scenario, water softening aims to enhance consumer convenience while potentially providing socio-economic and environmental benefits, particularly in areas where water hardness or pollution lead to serious health issues. Such practices are increasingly seen as convenient even in areas of untreated hard waters that exemplify very little or no threats in terms of drinking water quality. Consequently, Reverse Osmosis (RO) is gaining attention in various parts of the world, including Sri Lanka and the Jaffna Peninsula. This membrane-based technology purifies water by separating dissolved solids from the feed stream, ensuring drinking water quality that is safe from inorganic ions and microbial contamination. However, the removal of ions larger than water molecules by reverse osmosis, which are essential for human wellbeing, is also believed to pose health risks (WHO, 1996). However, in Sri Lanka, aside from a few general studies involving a limited number of RO stations, there has been insufficient research on the performance, operational issues, and product water quality of RO treatment plants (Imbulana et al., 2020; Jayasumana et al., 2016; Wei et al., 2021).

Historically, water softening has been implemented primarily to comply with regulatory guidelines concerning copper and lead, which can leach from pipe materials. Currently, however, water softening is mainly adopted for consumer convenience, shifting its perception from a "need to have" to a "nice to have" technology, with no fixed guidelines on constituent concentrations as treatment objectives (Tang, 2021). In Jaffna, the consumption of reverse osmosis has become increasingly popular in a post-war context, following the in-migration of various ethnic groups within the Peninsula. Traditionally, Jaffna has relied entirely on untreated natural groundwater sources for all its drinking and domestic needs (Villholth and Rajasooriyar, 2010), a practice that dates back (around 1500 years) historically (Ragupathy, 1987). However, water softening has gained traction, likely due to heightened awareness of contamination from agrochemical inputs such as nitrates and pollution from low-density wastes associated with filling stations, pollution due to lack of sewage systems (Anoja et al., 2017; Mahagamage et al., 2019; Sunda, 2018; Sivakumar, 2024) as well as concerns regarding consumer satisfaction related to taste, odour, and other physical properties of water. Consumer convenience has significantly influenced the Jaffna community, including local academic institutions like the University of Jaffna. Consequently, the increasing demand for water softening in Jaffna raises two major concerns: the quality of water produced by RO membranes and the emerging issues of energy consumption and unjustifiable pricing associated with RO waters.

In this context, it is crucial to consider the local conditions of available water resources when evaluating or establishing water softening scenarios, supplies, and consumption (Tang, 2021). The quality of drinking water should be viewed not merely as a technical issue, but as a factor that significantly impacts human health, socio-economics, resource utilisation and management. Water quality guidelines and indicators often serve as valuable decision support systems (DSSs), integrating various information and models to assess decision alternatives. Enhancing decision support can be achieved by broadening the traditional frameworks within the evaluation of water quality indicators, facilitating more effective decision-making, because, a narrow focus may obscure the overall effects of water and its' softening in relation to drinking water quality.

Aims and Objectives

The study aimed to investigate the water quality of the source waters (Dug well waters) extracted for drinking supplies, as well as the RO treated waters (permeate waters) at the University of Jaffna. It focused on the objectives of the RO treatment and the quality of the resulting drinking water. Additionally, the study sought to understand people's perspectives on the consumption of RO water. This exploration sought to support legislative guidelines for drinking water quality by identifying potential adverse effects of drinking water at the University of Jaffna and maximizing benefits of untreated and treated waters to promote environmental and socio-economic sustainability. Additionally, the study aimed to inform effective decision-making on essential technologies or methods for purification of waters based on the hydrogeochemistry of the calcareous karstic and non-karstic formations of the Jaffna Peninsula.

Data and Methods

Two Reverse Osmosis plants providing drinking water at the premises of the University of Jaffna were continuously monitored over two consecutive years to assess the physical (Total Dissolved Solids (TDS), turbidity), chemical (pH, electrical conductivity (EC), Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Fe^{2+}, HCO_3^{-}, CO_3^{2-}, Cl^{-}, SO_4^{2-}, NO_3^{-}, PO_4^{3-}, F^{-}, residual chlorine, arsenic (As), cadmium (Cd), chromium (Cr), and lead (Pb), and microbial (total coliforms and E. coli) quality of the source waters (two dug wells on the University premises from which the water is extracted), RO treated waters (permeate waters), and discharge waters. This monitoring covered both the wet (October to January) and dry (February to September) seasons of the region, commencing in February 2023 and continued for one year. Monitoring followed a quarterly plan, with daily measurements of EC, TDS, pH, and turbidity in the first quarter. In the second quarter, these parameters were measured every other day, followed by twice a week in the third quarter and once a week in the fourth quarter. Major and minor cations and anions and heavy metals were measured as a one-off monitoring exercise during the latter parts of the wet and dry periods.

Additionally, an opinion survey on RO water consumption within the University community was conducted among students and staff (n=200) via a Google form in 2025. The survey aimed to explore the quantities of water collected for drinking and cooking, awareness of the benefits and drawbacks of RO water consumption, and individuals' priorities regarding drinking water supplies and consumption.

Results and Discussion

Water extracted from the two source groundwater dug wells within the University premises indicated good quality in terms of WHO and Sri Lankan guidelines, except for the microbial content. The dug well waters showed no harmful effects concerning physical and chemical parameters. EC, TDS and turbidity were on safe levels whereas pH of waters were neutral. A few essential chemical parameters/electrolytes, such as sodium (Na^{+}), potassium (K^{+}), iron (Fe^{2+}), and fluoride (F^{-}), displayed very low ion concentrations in relation to WHO and Sri Lankan guidelines. Ions such as chloride (Cl^{-}) and sulphate (SO_4^{2-}) also recorded low concentrations, falling below the water quality guidelines. In contrast, calcium (Ca^{2+}) and magnesium (Mg^{2+}) concentrations were consistent with water quality standards. Nitrates (NO_3^{-}) and phosphates (PO_4^{3-})

exhibited more than a half-fold decrease in concentrations compared to the permissible levels outlined in the water quality guidelines. Heavy metals, including arsenic, cadmium, chromium, and lead, which can have serious effects on human health, were found at trace levels. However, the raw waters (feed waters) supplied to the RO plant exhibited increased concentrations of most of the ions. This is because the raw waters are a mix of water extracted from two dug wells, which are then combined in a common water tank before being supplied to the RO plant. Nonetheless, these concentrations did not exceed the limits set by the water quality guidelines.

Faecal coliforms were identified as a major threat in the groundwater wells, with numbers that were uncountable. However, all the major and minor cations and anions as well as heavy metals in the RO treated waters were well below the guidelines established by the WHO and Sri Lankan standards. There were no faecal coliform contamination was found in the RO waters. Waters discharged from the RO treatment showed slightly elevated concentrations of Ca^{2+} and Cl^{-} of the guidelines.

An inventory conducted within the staff and students of the Faculty of Arts, University of Jaffna revealed that 79% of respondents obtain RO water for drinking, cooking, or both, primarily due to health concerns. The estimated total quantity of water consumed for drinking is 500 litres per day, while 1,000 litres per day is used for cooking (n=200). More than 50% of respondents were unaware of RO treatments, including the resulting chemical compositions of the water, the energy consumption involved in the RO process, and the potential long-term health impacts of consuming less mineralized waters; hence more 90% of the respondents preferred RO treated waters for drinking and other domestic needs mainly due to issues related to the taste of water.

The findings of the present study indicate that the quality of groundwater wells in the study area meets acceptable standards for physical and chemical parameters, with no significant harm evident to water quality. The low levels of sodium, chloride, and sulphate, along with low levels of calcium and magnesium concentrations in the groundwaters, suggest that the taste is likely to be acceptable. Faecal coliform levels were the only threat found, but it can be effectively treated by soft treatments such as boiling the water, chlorination, etc. On the other hand, mineral contents of permeate waters were very low as Reverse Osmosis (RO) systems not only remove undesirable salts and contaminants but also eliminate essential ions such as calcium, magnesium, sodium, potassium, and fluoride, which can pose health risks.

The study suggests that the naturally available groundwater resources on the University premises are generally safe for consumption, at least according to WHO and Sri Lankan water quality standards. However, despite this evidence, the university community exhibits a strong preference for RO treated water. This preference appears to stem more from perceptions and socio-cultural factors than from actual needs related to water quality. In many regions, there is a growing trend to associate RO water with higher purity, safety, and modernity, even when the source water poses no risks to human health. Such perceptions are often reinforced by the commercial promotion of RO technology and peer influence within communities.

The study highlights a clear gap between scientific evidence and community perception. A key concern revealed by this study is the lack of awareness among communities regarding the quality of source waters as well as the RO permeate waters. Bridging this gap requires integrated approaches that combine water quality monitoring, medical endemic studies, public health awareness, and community engagement to ensure that safe, healthy, and sustainable water consumption practices are maintained.

Conclusions

The study shows that the source waters of the University of Jaffna are safe at its point location, except the faecal coliform count, and the said waters meet the required physical and chemical standards for consumption. The risk of faecal coliform contamination can be mitigated through soft treatments, which help to reduce the costs associated with water treatment. In contrast, all the major and minor cations and anions as well as heavy metals in the RO treated waters were well below the guidelines established by the WHO and Sri Lankan standards. However, the University community's preference for RO-treated water indicates a disconnect between scientific findings and public perception. This reliance on RO water, without understanding its lower mineral content, energy consumption and production costs may result in unintended long-term health issues as well as economic impacts towards feasibility on supplies. It is crucial to raise public awareness about the safety of natural water sources and the effects of consuming demineralized water. Encouraging informed decision-making will help ensure that the community's water use remains both safe and sustainable.

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