EXTENDED ABSTRACT

INFLUENCE OF REVERSE OSMOSIS REJECT WATER ON SOIL QUALITY IN DISPOSAL SITES OF VAVUNIYA, SRILANKA

Yathurshiga Vigneswaran,[1] T.A.N.T. Perera,[*,2] S. Saravanan,[3] and G.Y. Jayasinghe[1]

[1]University of Ruhuna, Sri Lanka
[2]University of Colombo, Sri Lanka
[3]National Water Supply and Drainage Board of Vavuniya, Sri Lanka
[*] nilusha@et.cmb.ac.lk

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Abstract

Reverse Osmosis (RO) technology is a major solution for facilitating the safe portable water. The aim of this study was to investigate the influence of RO reject water on soil chemical parameters (pH, electrical conductivity (EC), fluoride, and hardness) at selected RO plant locations in the Vavuniya District of Sri Lanka. Feed water, reject water, and soil samples at different depths (D1 16.5 cm, D2 33 cm, and D3 50 cm) were collected during a period of four months. The results clearly demonstrated the deterioration of soil chemical properties over time owing to ion accumulation. The observed values of pH, EC, fluoride, and hardness of the feed water ranged from 6.67 to 7.53, 798.6-1437 S/cm, 0.37-1.43 mg/L, and 374.10-586.2 mg/L, respectively, whereas the reject water varied from 6.92 to 7.86, 1402.6 -5877 S/cm, 1.32 -2.64 mg/L, and 735 - 2808 mg/L. As a result, releasing RO reject water directly into the soil without primary treatment may have an unfavourable impact on land quality and soil health. Hence, stringent policies and regulations should be implemented to reduce the negative consequences on disposal sites.

Keywords: Membrane technologies, reverse osmosis, feed, reject, soil

1. Introduction

1.1 Background of the study

RO is a membrane process that is commonly used in water desalination, drinking water processing, and tertiary waste treatment (Pérez-González et al., 2012). RO plants are one of the most widely used techniques for providing clean drinking water to the general public (Athapattu et al., 2017). To guslsarantee the public's health and safety, treated water must be made available. This technology use semi-permeable membranes to separate a solution into two streams: permeate, which contains the filtered water that passes through the membrane, and reject, which contains salts and other chemicals. Depending on the consistency of the feed water, the waste stream is classified as reject water, concentrates, retentive, or brine. The constituent concentrations in the reject are found to be double or greater than those in the feed water (Pérez-González et al., 2012). Water quality is a major issue in many regions of the Northern Province, especially for drinking and domestic usage. The primary issue with water quality in most groundwater sources in Vavuniya is consumers' limited acceptability, largely owing to excessive hardness and alkalinity concentrations (Ranasinghe, 2014).

Seasonal fluctuations in nitrite and fluoride are extremely important to address in some areas, since concentrations of these parameters exceed healthy levels of Sri Lankan standard (SLS) and World Health Organization (WHO) standard in drinking water due to pollution and low water recharge during dry spells (Ranasinghe, 2014). The technical, economic, and environmental issues associated with RO reject water in the Vavunia region have not been adequately addressed. As a result, the purpose of this research is to determine the composition of feed water, reject water, and soil at the selected disposal sites based on their chemical properties, as well as to evaluate the status of RO plants (capacity - 10m3/day) in the Vavuniya district, dry zone Sri Lanka.

1.2 Objectives of the study

- Analyze the chemical parameters of feed water and RO reject water (pH, EC, fluoride, and hardness) of selected RO plants.
- Measure the variations of soil chemical parameters at different depths.
- Compare the quality changes in RO reject water and feed water.

2. Materials and Methods

2.1 Study Area

The research sites were Rajendrankulam, Sooduventhapilavu, and Periyaulukkulam in the Vavuniya district (Figure 1).

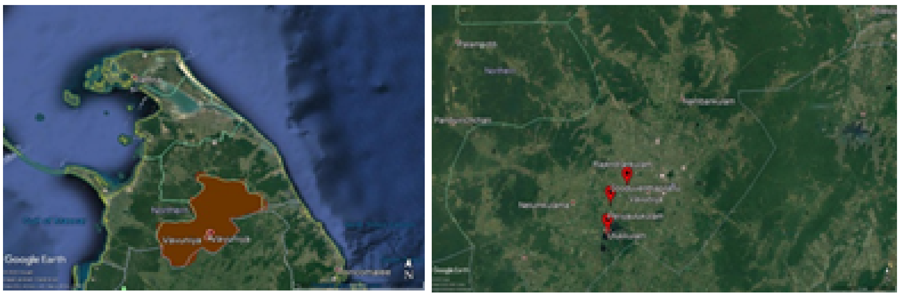

Figure 1. Locations of selected plants; (a) Vavuniya district and (b) selected RO plant sites.

2.2 Sampling and Sample Analysis

Samples of feed water and RO reject water were collected from three different RO plant locations. Furthermore, soil samples were collected in triplicates from the reject water disposal site from each location at various vertical depths (16.5 cm, 33 cm, and 50 cm). A standard multi-parameter pH and EC meter was used to test the pH and EC (HQ14d, HACH). The fluoride concentration was determined using a spectrophotometer (UV-1800 Shimadzu). The calcium hardness of the samples was determined using EDTA titration (Chakraborty 2021; Yadav et al. 2021). SAS (9.0) was used to analyze the data.

3. Results and Discussion

3.1 Physico-chemical analysis of feed water and reject water samples

(a) pH

According to the findings of this study, the pH of RO reject water was within the SLS and WHO standards of 6.5 to 8.5 (WHO, 2011, and SLS, 2012), respectively (Table 1). The pH of feed water and reject water did not differ significantly. However, as compared to the pH values of the feed waters, the pH value of the reject water in all three RO plants was slightly higher (Figure 2).

Table 1.pH value range in RO water in the selected study sites

Location	pH values for feed water	pH values for reject water
Rajenthirankulam	7.13 -7.53	7.63 - 7.80
Sooduventhapilavu	6.67 -7.49	6.92 - 7.86
Periyaulukulam	7.15 -7.53	7.22 - 7.78

(b) EC

In all purification plants, the EC of RO reject water was significantly higher (p0.05) than the EC of corresponding feed waters (Table 2). Furthermore, the Sri Lankan standard (SLS) and World Health Organization (WHO) standards for the optimum drinking water EC were 1500 S/cm (WHO 2011, and SLS 614:2013), and the reject water exceeding those limits.

Table 2.EC value range in RO water in the selected study sites

Location	EC values for feed water (μS/cm)	EC values for reject water (μS/cm)
Rajenthirankulam	1338–1437	4830 – 5877
Sooduventhapilavu	798.6 – 890	1402.6 – 1563
Periyaulukulam	1221 – 1426	2270 – 2726

(c) Hardness

Water hardness is caused by the presence of alkaline elements such as calcium and magnesium. Higher degrees of hardness may result in heart disease and renal issues (Akther Tharani, 2017). The hardness of reject water was considerably higher (p0.05) than that of feed water (Table 3, Figure 2).

Table 3. Hardness value range in RO water in the selected study sites

Location	Hardness values for feed water (mg/L)	Hardness values for reject water (mg/L)
Rajenthirankulam	544.5 - 586.2	2340.5–2808
Sooduventhapilavu	374.1 - 438.2	735.3–821.3
Periyaulukulam	445.5 - 528.9	922.5–1053

(d) Fluoride

Fluoride is basically taken into the human body through drinking water (Loganathan et al., 2013). The WHO recommends less than 1.5 mg/L fluoride in drinking water (WHO, 2011), whereas SLS is less than 1.0 mg/L (SLS, 2012). (Table 4). The fluoride content in reject water was considerably greater (p0.05) than in feed water (Figure 3).

Table 4. Fluoride value range in RO water in the selected study sites

Location	Fluoride values for feed water (mg/L)	Fluoride values for reject water (mg/L)
Rajenthirankulam	0.37 - 0.76	1.87 - 2.64
Sooduventhapilavu	0.87 - 1.43	1.7 - 2.16
Periyaulukulam	0.94 - 1.28	1.32 - 1.93

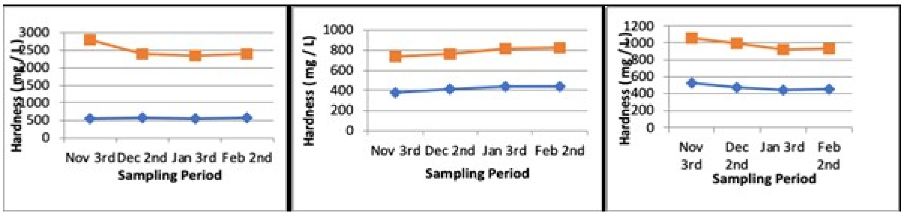

Figure 2. Hardness of RO water samples in different locations; (a) Rajenthirankulam (b) Sooduventhapilavu and (c) Periyaulukkulam

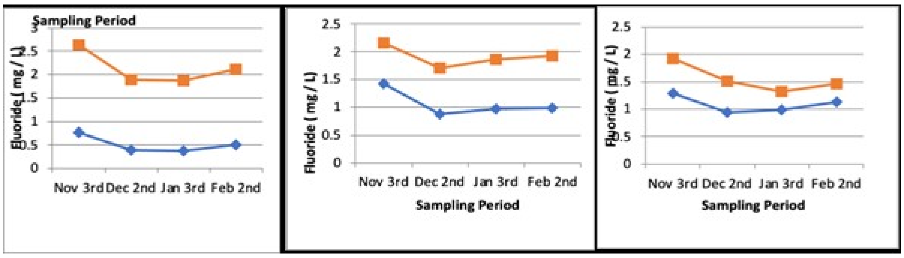

Figure 3. Fluoride of RO water samples in different locations; (a) Rajenthirankulam (b) Sooduventhapilavu and (c) Periyaulukkulam

Figure 4

3.2 3.2 Physicochemical analysis of soil samples

(a) pH

The optimal pH range for agricultural crops growing in the study area (Paddy, Gingerly, and Black Gram) was 6.5 to 7.5. (Kassim, 2013). As a result, the pH of the soil surface at Rajenthirankulam, Sooduventhapilavu, and Periyaulukkulam was unsuitable for agriculture due to its high pH, and soil pH values increased with the depth (Table 5).

Table 5. Fluoride value range in soil in the selected study sites

Location	D1 (16.5 cm)	D2 (33 cm)	D3 (50 cm)
Rajenthirankulam	7.63 – 8.07	8.03 to 8.21	8.33 to 8.45
Sooduventhapilavu	7.44 to 8.24	7.55 to 8.36	8.39 to 8.67
Periyaulukulam	7.53 to 8.20	8.24 to 8.43	8.25 to 8.48

(b) EC

The EC of the soil indicates its salinity as well as the quantity of water and nutrients available for plant uptake (Trolier-McKinstry Newnham, 2018). The soil study also revealed that EC values in the disposal locations ranged from 131.07 to 66.93S/cm and were significantly (p0.05) different. Furthermore, the soil sample depth was effective in that the EC was significantly greater in the first soil depth (D1:0 to 16.5 cm) and decreased in the other two depths (D1 > D2 > D3). This is most likely due to the buildup of soluble salts generated by the continuous disposal of RO concentrate into the soil. (c) Hardness

The hardness levels of soil samples varied significantly between locations (Table 6). This hardness increased as a result of the effective removal of Ca^{2+} and Mg^{2+} from RO plants (Xiao-XiongWang et al., 2016).

Table 6. Hardness value range in soil in the selected study sites

Location	D1 (16.5 cm)	D2 (33 cm)	D3 (50 cm)
Rajenthirankulam	360 to 640 mg/kg	405 to 570 mg/kg	315 to 585 mg/kg
Sooduventhapilavu	315 to 550 mg/kg	180 to 480 mg/kg	225 to 280 mg/kg
Periyaulukulam	360 to 660 mg/kg	301 to 500 mg/kg	301 to 460 mg/kg

(d) Fluoride
Sooduventhapilavu had the greatest value (19.95 mg/kg), while Periyaulukkulam had the lowest value (0.32 mg/kg). The study locations exhibited relatively low soil fluoride concentrations ranging from 20 to 1000 mg/kg (Loganathan et al., 2013).

4. Conclusion

The study confirmed the adverse impacts of release in untreated reject water from RO plants released into the soil system. The results explicitly proved the degradation of soil quality over time due to the accumulation of ions. The pH, EC, fluoride, and hardness of feed water varied in the range of 6.67 to 7.53, 798.6 µS/cm to 1437 µS/cm, 0.37 mg/L to 1.43 mg/L and 374.10 mg/L to 586.2 mg/L, respectively, whereas the reject RO water varied from 6.92 to 7.86, 1402.6 µS/cm to 5877 µS/cm, 1.32 mg/L to 2.64 mg/L and 735 mg/L to 2808 mg/L, respectively, showing a significant elevation in reject RO water compared to feed water. Groundwater EC, hardness, and fluoride concentrations were greater in all three RO plant locations as compared to standard values (EC 1000 S/cm, Fluoride 0.7 mg/L, and hardness 300 mg/L). However, using RO concentrate for irrigation or direct discharge into the soil may increase soil salinity, alkalinity, and sodicity. As a result, direct discharge of RO concentrate into the soil without primary treatment, it may have a negative impact on soil quality and health. However, more investigations on the horizontal distribution of chemical characteristics in soil is required. Appropriate eco-friendly treatment is required to discharge the water within safety limits.

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