MINI REVIEW

Quality Improvement of Reverse Osmosis Waste Water through Plant-Based Techniques: A Mini-Review

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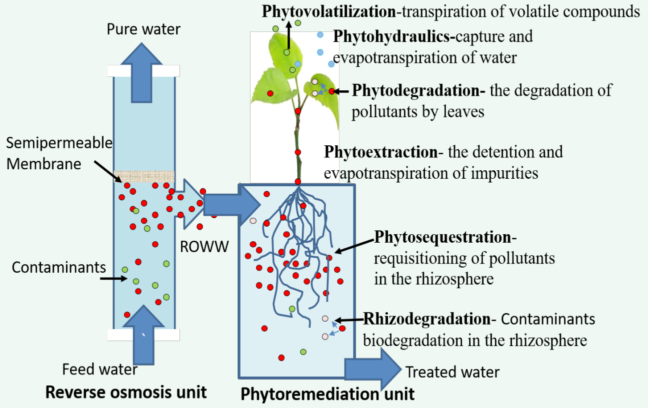
ABSTRACT

Water is a scarce resource in this millennium, especially clean water. Reverse osmosis (RO) technology is widely applied to achieve this goal. But, reverse osmosis waste water (ROWW) cannot be further utilized, due to the presence of a high concentration of salts, heavy metals, and pollutants of feed water. The solution to this problem may lie in employing plants for this very purpose that is phytoremediation. Phytoremediation converts this waste water into usable water with the help of plants. This is an eco-friendly technique that decontaminates the waste water in a very economical way. This mini-review thus, emphasizes on quality improvement of RO waste water through plant-based techniques with a special focus on recent studies carried out in this area.

Keywords: Phytodegradation, Phytoextraction, Phytoremediation, Phytovolatilization, Reverse osmosis (RO), Reverse osmosis waste water (ROWW), Rhizodegradation.

GRAPHICAL ABSTRACT



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INTRODUCTION

The RO process is a water purification technology which purifies drinking water; desalinate the sea/groundwater and treat effluents from various domestic and industries to yield potable water and waste water. On average, a RO unit that delivers twenty liters/day of purified water may discharge between 70 to 340 liters/day of RO waste water. Other than domestic RO units, there are many other places, like, industries, university campuses, hostels, and hospitals, etc., where a large quantity of potable water is utilized generating lakhs of liters as waste water, which is of no use (Bhakar *et al.*, 2016).

Keeping it in view, it is crucial to evaluate the constituents of the RO waste water to reduce the ill effects of the existing pollutants on the environment, as well as, human health. The membrane decides what would be the refusal rate of RO in terms of the percent removal of a particular contaminant. The rejection rates are very high (approx. 90%) for each of the constituents of the feed water for various insecticides, organics, total dissolved solids (TDS), biological oxygen demand (BOD),

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Table 1: Major components of reverse osmosis waste water

S. No.	*Parameters*	*Jeppesen et al., 2009*	*Lee et al., 2009*	*Hajbi et al., 2010*	*Zhang et al., 2011*	*Zhou et al., 2012*	*Wang et al., 2016*	*Fernandes et al., 2019*	*Athapattu et al., 2017*	*Virapan and Murugaiyan, 2017*	*Abinaya et al., 2018*	*Singh et al., 2018*	*Weng et al., 2018*	*Karunarathne and Ranwala, 2019*	*Pooi et al., 2019*
1.	Alkalinity (as $CaCO_3$) (mg/L)	-	-	-	395	-	-	-	336	-	654+2			20 ± 5	
2.	Calcium (as Ca) (mg/L)	4.0×10^3	63.5 ± 9.5	2.08×10^3	596	178.3 ± 1.6	-	-	-	1195 (± 20)	573.1+ 0.86	3011			
3.	Chlorides (as Cl) (mg/L)	19×10^3	333.2 ± 41.6	14.17×10^3	-	-	862.9 ± 14.0	$5.3 \pm 0.2 \times 10^3$	-	16500 (± 300)	617.3 + 1.06	900		3 ± 1× (0.046)	
4.	COD (mg/L)	-	-	-	-	120-150		$9.9 \pm 0.4 \times 10^3$		6700 (± 100)	55.03 + 3.72				
5.	EC @ 25°C µmhos/cm	-	-	-	-						6645 + 1.73				
6.	Iron (as Fe) (mg/L)	-	-		34	-	-	0.0108 ± 0.0006	0.02		3			0.4 ± 0.03× (0.032)	
7.	Magnesium (as mg) (mg/L)	1.35×10^3	11.5 ± 2.3	0.77×10^3	7.43		73.0 ± 0.4			1650 (± 20)	104.72 +1.52	1940		43 ± 1× (0.003)	
8.	pH @ 25°C		7.5 ± 0.2	7.2		7.2-7.6	7.69 ± 0.14	8.1 ± 0.1	8.5	8.8 (± 1)	8.4+ 0.011		7.84 ± 0.005		7.35 ± 0.33
9.	Reactive silica (as SiO_2) (mg/L)				426						<0.2				
10.	Sulphates (as SO_4^{-2}) (mg/L)	2.65×10^3	159.1 ± 24.1	5.92×10^3			831.7 ± 14.8			2750 (± 50)	722.3 + 2.08			33.5 ± 6.5	
11.	TDS @ 105°C (mg/L)		1276 ± 166	28000			3630 ± 184		563	47000 (± 900)	4323.33 + 4.9				
12.	Total hardness (as $CaCO_3$) (mg/L)				1088				306		1836.93 + 0.6			230 ± 30× (0.043)	
13.	Inorganic carbon (mg/L)						113.8 ± 1.5								
14.	Conductivity (ms/cm)		1990 ± 259	33	4.82	22.3		31 ± 4		62.6 (± 2)			$27.00 \pm 0.40 \times 10^3$		$2170 \pm 260 \times 10^3$
15.	TOC(mg/L)		24.5 ± 5		38.23	25-35							78.37 ± 2.59		
16.	Potassium (mg/L)		38.4 ± 4.5		121		34.7 ± 0.3			1085 (± 20)		125		6 ± 0.001× (0.001)	
17.	Nitrate (mg/L)		60.2 ± 14.4		74		.2 ± 0.3	<0.01	0.88					1.65 ± 0.55	
18.	Sodium (mg/L)	26.7×10^3	226.9 ± 13.5	5.12×10^3	579		642.7 ± 3.1					6635		155.5 ± 4.5× (0.012)	
19.	Fluoride (mg/L)								0.97			10			
20.	Phosphate (mg/L)		21.3 ± 21.8						0.68						
21.	Ammonia N (mg/L)						ND	$3.0 \pm 0.2 \times 10^3$	0.02						

22.	Chromium (mg/L)			ND			
23.	Lead (mg/L)			ND			
24.	Cadmium (mg/L)			ND			
25.	Arsenic (mg/L)			ND			
26.	Mercury (mg/L)			ND			
27.	Cyanide (mg/L)			ND			
28.	BOD (mg/L)	15-18	4.3 ± 0.2 × 10^3		2500 (± 50)		<2.0
29.	Turbidity (NTU)					2.00 ± 0.030	0.751 ± 0.339
30.	Total organic carbon (mg/L)						23.1 ± 4.0
31.	Total nitrogen (mg/L)						29.3 ± 11.6
32.	UV 254 (cm^{-1})					2.48 ± 0.15	0.413 ± 0.090
33.	SUVA						1.788 ± 0.447

chemical oxygen demand (COD), and metals. The constituents of the influent feed water and the membranes used in RO systems along with the applied pressure are the key factors that decide the concentration of the pollutants and contaminants in the RO reject. Hence, it is hypothesized that the low-cost phytoremediation through hydroponics/wetland would be an option for the treatment of RO rejected water (Athapattu *et al.*, 2017).

Though phytoremediation is a fairly new technique, has a great potential due to its environmentally friendly nature and low maintenance alternative to conventional active and invasive remedial methods (Singh & Singh, 2017). Compared to other techniques, it is a low-cost technology that makes it all the more desirable, especially in developing countries, such as, India. Apparently, this technique is novel, solar-driven, efficient, cost-effective, and eco-friendly; still, RO rejects treatment is not so widespread. It has been suggested that for the purpose of RO reject purification; processes, like phytofiltration, phytodegradation, phytostabilization, and phytoextraction could be utilized to eliminate the impurities, such as, BOD, COD, and TDS in anticipated domain and time (Ekta & Modi, 2018).

This review is focusing on pollutants of ROWW, phytoremediation technique to remediate ROWW, plant stress physiology, and plants utilization for ROWW purification.

Analytical Work on RO Waste Water Impurities

In order to get pure water, the reverse osmosis technique is of utmost importance. It is a method of obtaining basically pure, fresh water from contaminated or salt water by pressing the water with a semipermeable membrane through pressure, which allows the pure water molecules and extracts off salts and other soluble contaminants. The ratio of wastewater to purified water may be altered, yet not eliminated. Devices of reverse osmosis using a flow restrictor limits water flow out from the waste water system. This generates strain against the membrane of the RO and causes the membrane to separate the incoming water into filtered water and waste water. The expected recovery rate of most membranes is approximately 15% that can yield nearly 1-gallon of pure water to 6.7 gallons of waste water (Chaurasia *et al.*, 2019). In another study, RO waste water sampled from a typical industrial park was divided into hydrophobic base (HOB), hydrophobic neutral (HON), hydrophobic acid (HOA), and hydrophilic fraction (HI). HOA in the raw RO waste water displayed the highest toxicity, followed by HON and HI (Weng *et al.*, 2018). Components of RO waste water depend upon feed water; for this purpose, several studies have been carried out, some recent studies are summarised in Table 1. In an attempt to remove impurities of RO waste water, Xiang *et al.* (2017) studied that the RO mechanism generates a concentrate comprising of higher rates of rejected contaminants (approximately 15–20 percent of the influent volume). Many of the contaminants that appear in sewage effluent, including pharmaceuticals and personal care products, are very pervasive. Naidu *et al.* (2017) studied the high levels of calcium carbonate ($CaCO_3$) deposition on the reverse osmosis membrane occurred in treating RO waste water at elevated concentrations.

Table 2: Actively used plants for phytoremediation and their efficiency to remove water contaminant

S. No.	*Plant name*	*Waste water contaminant*	*Removal efficiency*	*Treatment duration (days)*	*Reference*
1.	Salvinia molesta	Phosphate COD nitrate	95% 39%	16	Ng & Chan, 2017
2.	Eichhornia crassipes	Chromium Cr (VI)	99.5%	15	Saha *et al.*, 2017
3.	*Spinacia oleracea, Raphanus sativus*, and *Brassica oleracea*	Lead (Pb)		81 80 120	Khalid *et al.*, 2017
4.	*Tagetes patula, Aster amellus, Portulaca grandiflora*, and *Gaillardia grandiflora*	Macro (N, P, K, and C), micro (B, Cu, Fe, and Mn) elements, and heavy metals (Cd, As, Pb, and Cr)		30	Chandanshive *et al.*, 2018
5.	*Eichhornia crassipes* and *Pistia stratiotes*	Ammonium PO_4^{3-} COD BOD	58.87% 50.04% 82.45% 84.91%	1	Victor *et al.*, 2016
6.	*Brachiara mutica* and *Phragmites australis*	Oil content COD BOD	97% 93% 97%	42	Rehman *et al.*, 2018
7.	*Canna indica*	RO concentrate (waste water)			Gunarathna *et al.*, 2016
9.	*Typha angustifolia* and *Eichhornia crassipes*	BOD Pb, Cd, and Zn	91%	21	Sricoth *et al.*, 2018
10.	*Typha latifolia* and *Thelypteris palustris*	Heavy metals	-	15 45	Hejna *et al.*, 2020
11.	*Lemna aequinoctialis*	COD Total N P	94.8% 39.3% 57.1%	-	Neto *et al.*, 2019
13.	*Pistia stratiotes* and *Eichhornia crassipes*	COD Phosphate Surfactant	77.5% 54.3% 99.9%	15	Siswoyo *et al.*, 2019
14.	*Eichhornia crassipes, Neomarica longifolia, Hydrilla verticillata*, and *Pistia stratiotes*	Gold mine Waste water	-	30	Fathia *et al.*, 2019
15.	*Typha angustifolia* L., *Canna indica* L., and *Hydrocotyle umbellata* L.	Chromium	99.78% 99.67% 86.36%	9	Taufikurahman *et al.*, 2019
16.	*Chara vulgaris*	TDS COD BOD EC	68% 78% 82% 86%	5	Mahajan *et al.*, 2019
17.	*Egeria densa, Ceratophyllumd emersum*, and *Myriophyllum aquaticum*	Paracetamol Diclofenac and MC-LR	- 93% 100%	14	Loise de Morais Calado *et al.*, 2019
18.	*Lemna minuta* and *Lemna minor*	Nitrate and phosphate	-	28	Ceschin *et al.*, 2020

Phytoremediation to Treat Multiple Contaminants

The literal meaning of phytoremediation pertains to the need for green plants and accompanying microbes to eliminate the harmful effects of probable contaminants in the atmosphere. The word "phytoremediation" is extracted from the Greek word "Phyto" **(**mean plant), as well as, from the Latin word "*Remedium*" **(**to correct or eliminate bad) (Sarwar *et al*., 2017). The idea of phytoremediation was first suggested by Chaney (1983). The idea appears aesthetically appealing, as well as, gains good public approval and can also be implemented in massive-scale field outlets, in which other physical remedial measures are not as efficient and budget effective. Plantation of the green plants on contaminated soil demonstrates supplementarily affordable in many ways: phytosequestration—the requisitioning of pollutants in the rhizosphere; rhizodegradation—the biodegradation of the pollutants in the rhizosphere; phytohydraulics—the capture and evapotranspiration of water; phytoextraction—the detention and evapotranspiration of impurities; phytodegradation—the degradation of pollutants and their transpiration by leaves; and phytovolatilization—the transpiration of volatile compounds taken up by the plant. Employing the combination of these technologies for the removal of waste water contaminants will help purify water, that may be utilized for several other purposes. Martino *et al*. **(**2019) described in a particular study, where prototype phytoremediation is directly compared to traditional groundwater or phytoremediation innovations. They used nitrate as an exemplar co-contaminant. The method includes the use of wastewater as a source of irrigation water for plant decontamination. Groundwater was then pumped to numerous drainage regions underneath the regulation of an independent irrigation system and every zone was containing of several trees.

Employed Plants for Waste Removal

The impact of irrigation involving diverse sources of recycled water on physiological and morphological alterations in *Myrtus communis* plants was examined in order to evaluate their ability to adapt to all these environmental conditions. *M. communis* were grown in a growth chamber, exposed to four different irrigation treatments up to nearly 4 months (120 days): control [tap water (0.8 dS m^{-1}), leaching 10% (v/v) of the applied water], and three treated water irrigation treatments, *viz.*, 1.5 dS m^{-1} leaching 25% (v/v) of the applied water (RW1), 4 dS m^{-1} leaching 40% (v/v) of the applied water (RW2) and 8 dS m^{-1} leaching 55% (v/v) of the applied water (RW3). After treatment, all plants were irrigated with tap water, as for the control plants, for a further 2 months (60 days). At the final stage of the first duration (4 months), myrtle plants demonstrate no negative changes in biomass, and the average total dry weight (DW) increased by 53 percent in RW2 treatment. However, at the end of the treatment and recovery period (180 days), accumulations of Cl^- ions and especially Na^+ ions, negatively affected the growth of all RW3 plants. Plants irrigated with all three recycled water samples had enhanced trouble in receiving water from the substrate, which is of the lower leaf water potential and water content. In their gas exchange parameters, the RW2 plants showed better response. Though the use treated water treatment diminished leaf K^+/Na^+ and Ca^{2+}/Na^+ ratios but did not cause chlorosis or necrosis. Based on the specific chemical properties of the water, all the three treated water samples had diverse effects on the myrtle plants. To control the ill effects of salinity in irrigation water, leaching seems to play a very important role. Maeng *et al*. (2018) achieve a better operational simplicity for the phytoremediation of ROWW using a microalgae *Scenedesmus quadricauda*. After the continuous supply of illumination and CO_2 to the algae present in ROWW, give rise to polymeric organic matter which is a mixture of polysaccharides and humic substances, biodegradable in nature triggering their quick elimination along with inorganic nutrients (PO_4^{3-} and NO_3^-). Indirectly, the algal-induced deterioration of humic-like chemicals that are usually quite resistant to microbial decomposition has been illustrated. In this study, the effects of algal treatment on the growth of *Escherichia coli* and the elimination of trace organic compounds (TORCs) from the RO waste water were also investigated. The treatment of RO waste water by aeration with 10% (v/v) CO_2 under constant illumination is extremely viable as a reasonable, as well as, affordable technological innovation for the removal of non-biodegradable organic matter, the reduction of enteric bacteria, and the attenuation of TORCs in wastewater. Several other studies have been carried out to utilize pants for the phytoremediation, recent studies are summaries in Table 2.

CONCLUSION

Based on these success studies mentioned above, it could be concluded that phytoremediation is yet another emerging eco-friendly technology with good efficiency for treating effluents and should be encouraged. It can be applied practically so that ROWW and water resources can be restored *in situ*. This green technology that uses plants for remediation and thus, would prove to be a safe technology for restoring the contaminated environment. Compared to the expensive conventional techniques, solar-driven phytoremediation is ecologically, a better and promising choice with a bright future. Efforts should be focused on exploring and utilizing this technology to get treated water meeting the standards and thus, conserve the environment aiming at sustainable development and reduce stress on natural resources.

REFERENCES

Abinaya, S., Saraswathi, R., Rajamohan, S. and Mohammed, S.A. 2018. Phytoremediation of total dissolved solids (TDS) by *Eichhornia crassipes, Pistia stratiotes* and *Chrysopogon zizanioides* from second stage RO-Brine solution. *Research Journal of Chemistry and Environment.* **22**:36-41.

Athapattu, B.C.L., Thalgaspitiya, T.W.L.R., Yasaratne, U.L.S. and Vithanage, M. 2017. Biochar-based constructed wetlands to treat reverse osmosis rejected concentrates in chronickidney disease endemic areas in Sri Lanka. *Environmental Geochemistry and Health* **39**(6): 1397-1407.

Bhakar, V., Kumar, D.H., Sai, N.K., Sangwan, K.S. and Raghuvanshi, S. 2016. Life cycle assessment of filtration systems of reverse osmosis units: a case study of a university campus. *Procedia CIRP* **40**:268-273.

Ceschin, S., Crescenzi, M. and Iannelli, M.A. 2020. Phytoremediation potential of the duckweeds *Lemna minuta* and *Lemna minor* to remove nutrients from treated waters. *Environmental Science and Pollution Research,* doi:10.1007/s11356-020-08045-3

Chandanshive, V.V., Kadam, S.K., Khandare, R.V., Kurade, M.B., Jeon, B.-H., Jadhav, J.P. and Govindwar, S.P. 2018. *In situ* phytoremediation of dyes from textile wastewater using garden ornamental plants, effect on soil quality and plant growth. *Chemosphere* **210**: 968-976.

Chaney, R.L. 1983. Plant uptake of inorganic waste constituents. In: Patt, J.F., Marsh, P.B., Kla, J.M. *(*Eds.), Land treatment of hazardous wastes. Park Ridge, NJ: Noyes Data Corporation, pp. 50-76.

Chaurasia, S., Suneetha, V. and Paul, A. 2019. A descriptive study to assess the knowledge regarding reverse osmosis waste water utilization among general public of Indore District. *International Journal of Advance Research, Ideas and Innovations in Technology* **5**(3): 1685-1687.

Ekta, P. and Modi, N.R. 2018. A review of phytoremediation. *Journal of Pharmacognosy and Phytochemistry* **7**(4):1485-1489.

Fathia, S.D., Hamim, H. and Triadiati, T. 2019. Morpho-physiological analysis of aquatic plants for phytoremediation of wastewater from gold mine wastewater treatment installation (IPAL). In *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, Vol. 299, No. 1, pp. 012060.

Fernandes, A., Chamem, O., Pacheco, M. J., Ciríaco, L., Zairi, M., & Lopes, A. (2019). Performance of electrochemical processes in the treatment of reverse osmosis concentrates of sanitary landfill leachate. mol*ecules* **24**(16):2905.

Gunarathna, M.H.J.P., Ranasinghe, A.I., Rathnayake, S.C., De Costa, T.K. and Lanka, P. 2016. Can *Canna indica* use as a phytoremediation agent in mitigating high pollution concentrations in reverse osmosis concentrate? *International Journal of Advances in Agricultural and Environmental Engineering* **3**(1):52-56.

Hajbi, F., Hammi, H. and Mnif, A. 2010. Reuse of RO desalination plant reject brine. *Journal of Phase Equilibria and Diffusion* **31**(4):341-347.

Hejna, M., Moscatelli, A., Stroppa, N., Onelli, E., Pilu, S., Baldi, A. and Rossi, L. 2020. Bioaccumulation of heavy metals from wastewater through a *Typha latifolia* and *Thelypteris palustris* phytoremediation system. *Chemosphere* **241**:125018.

Jeppesen, T., Shu, L., Keir, G. and Jegatheesan, V. 2009. Metal recovery from reverse osmosis concentrate. *Journal of Cleaner Production* **17**(7):703-707.

Karunarathne, G.R.P.S. and Ranwala, S.M.W. 2019. An eco-friendly approach to purify reject water from a reverse osmosis treatment plant. *Journal of Technology and Value* **1**(1):8-18.

Khalid, S., Shahid, M., Dumat, C., Niazi, N. K., Bibi, I., Gul Bakhat, H.F.S. and Javeed, H.M.R. 2017. Influence of groundwater and wastewater irrigation on lead accumulation in soil and vegetables: Implications for health risk assessment and phytoremediation. *International Journal of Phytoremediation* **19**(11):1037-1046.

Lee, S., Choi, J.S. and Lee, C.H. 2009. Behaviors of dissolved organic matter in membrane desalination. *Desalination* **238**(1-3):109-116.

Loise de Morais Calado, S., Esterhuizen-Londt, M., Cristina Silva de Assis, H. and Pflugmacher, S. 2019. Phytoremediation: green technology for the removal of mixed contaminants of a water supply reservoir. *International Journal of Phytoremediation* **21**(4):1-8.

Maeng, S.K., You, S.H., Nam, J.Y., Ryu, H., Timmes, T.C. and Kim, H.C. 2018. The growth of *Scenedesmus quadricauda* in RO concentrate and the impacts on refractory organic matter, *Escherichia coli*, and trace organic compounds. *Water Research* **134**:292-300.

Mahajan, P., Kaushal, J., Upmanyu, A. and Bhatti, J. 2019. Assessment of phytoremediation potential of *Chara vulgaris* to treat toxic pollutants of textile effluent. *Journal of Toxicology* **2019**(1):1-11.

Martino, L., Yan, E. and LaFreniere, L. 2019. A hybrid phytoremediation system for contaminants in groundwater. *Environmental Earth Sciences* **78**(24):664.

Naidu, G., Jeong, S., Choi, Y. and Vigneswaran, S. 2017. Membrane distillation for wastewater reverse osmosis concentrate treatment with water reuse potential. *Journal of Membrane Science* **524**:565-575.

Neto, A.B., Morais, M.B., Dutra, E.D. and Junior, T.C. 2019. Biological diversity of *Lemna aequinoctialis* Welw. isolates influences biomass production and wastewater phytoremediation. *Bioresource Technology Reports* **6**:251-259.

Ng, Y.S. and Chan, D.J.C. 2017. Wastewater phytoremediation by *Salvinia* mol*esta*. *Journal of Water Process Engineering* **15**:107-115.

Pooi, C.K., Loka, V. and Ng, H.Y. 2019. Treatment and hybrid modeling of domestic reverseosmosis concentrate using biological activated carbon. *Desalination* **468**:114047.

Rehman, K., Imran, A., Amin, I. and Afzal, M. 2018. Inoculation with bacteria in floating treatment wetlands positively modulates the phytoremediation of oil field wastewater. *Journal of Hazardous Materials* **349**:242-251.

Saha, P., Shinde, O. and Sarkar, S. 2017. Phytoremediation of industrial mines wastewater using water hyacinth. *International Journal of Phytoremediation* **19**(1):87-96.

Sarwar, N., Imran, M., Shaheen, M. R., Ishaque, W., Kamran, M. A., Matloob, A., and Hussain, S. 2017. Phytoremediation strategies for soils contaminated with heavy metals: modifications and future perspectives. *Chemosphere* **171**:710-721.

Singh, A., Sharma, S. and Shah, M.T. 2018. Successful cultivation of *Salicornia brachiata—Asea asparagus* utilizing RO reject water: A sustainable solution. *International Journal of Waste Resources* **8**:322.

Singh, T. and Singh, D.K. 2017. Phytoremediation of organochlorine pesticides: Concept, method, and recent developments. *International Journal of Phytoremediation* **19**(9):834-843.

Siswoyo, E., Utari, A.W. and Mungkari, L.G.N. 2019. Adsorption combined phytoremediation system for treatment of laundry wastewater. In *MATEC Web of Conferences*, EDP Sciences, Vol. 280, pp. 05002.

Sricoth, T., Meeinkuirt, W., Pichtel, J., Taeprayoon, P. and Saengwilai, P. 2018). Synergistic phytoremediation of wastewater by two aquatic plants (*Typha angustifolia* and *Eichhornia crassipes*) and potential as biomass fuel. *Environmental Science and Pollution Research* **25**(6):5344-5358.

Taufikurahman, T., Pradisa, M.A.S., Amalia, S.G. and Hutahaean, G.E.M. 2019. Phytoremediation of chromium (Cr) using *Typha angustifolia* L., *Canna indica* L. and *Hydrocotyle umbellata* L. in surface flow system of constructed wetland. In: *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, Vol. 308, No. 1, pp. 012020.

Victor, K.K., Séka, Y., Norbert, K.K., Sanogo, T.A. and Celestin, A.B. 2016. Phytoremediation of wastewater toxicity using water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*). *International Journal of Phytoremediation* **18**(10):949-955.

Virapan, S. and Murugaiyan, V. 2017. Treatment of reverse osmosis reject water from industries. *International Journal of Applied Environmental Sciences* **12**(3):489-503.

Wang, X.X., Wu, Y.H., Zhang, T.Y., Xu, X. Q., Dao, G.H. and Hu, H.Y. 2016. Simultaneous nitrogen, phosphorous, and hardness removal from reverse osmosis concentrate by microalgae cultivation. *Water Research* **94**:215-224.

Weng, J., Jia, H., Wu, B. and Pan, B. 2018. Is ozonation environmentally benign for reverse osmosis concentrate treatment? Four-level analysis on toxicity reduction based on organic matter fractionation. *Chemosphere* **191**:971-978.

Xiang, Q., Fukahori, S., Yamashita, N., Tanaka, H. and Fujiwara, T. 2017. Removal of crotamiton from reverse osmosis concentrate by a TiO_2/Zeolite composite sheet. *Applied Sciences* **7**(8):778.

Zhang, Y., Ghyselbrecht, K., Meesschaert, B., Pinoy, L. and Van der Bruggen, B. 2011. Electrodialysis on RO concentrate to improve water recovery in wastewater reclamation. *Journal of Membrane Science* **378**(12): 101-110.

Zhou, M., Tan, Q., Wang, Q., Jiao, Y., Oturan, N. and Oturan, M.A. 2012. Degradation of organics in reverse osmosis concentrate by electro-Fenton process. *Journal of Hazardous Materials* **215**:287-293.