Technologies that meet water quality parameters and guarantee robust treatment: River Water Treatment Plant potability

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Highlights:

- **River Water Treatment Plant (RWTP): contributes to ensuring that natural processes, such as self-purification, can be resumed.**
- **Membrane technology for water potability: reverse osmosis and others integration processes improve the quality of water.**
- **Water quality is directly related to the treatment applied.**

Keywords: River water treatment plant; reverse osmosis; process integration

INTRODUCTION

Tailing dam ruptures have increasingly been reported worldwide, rising from 37 incidents in the first decade of the 21st century to 67 in the following decade. The United States has reported the highest number of such events, followed by Chile and Canada. Fortunately, these countries have seen a decrease in tailing dam failures, in contrast to rising incidents across Asia and Africa (Islam and Murakami, 2021). One of the major concerns following a dam rupture is the deterioration of water quality, which depends on the composition and characteristics of the tailings. This poses a significant threat to water usage, particularly in areas dependent on surface water (Guimarães et al., 2022a).

Changes in the quality surface water resulting from the presence of iron mining tailings, mainly by iron and manganese, impact water transport in riverside settlements that make direct use of rivers, in addition to causing shortages in large urban centers. Strategies for river restoration aim to improve water quality, with the most effective interventions targeting the specific activities responsible for degradation. A review of case studies from Asia, Europe, and North America by Viswanathan and Schirmer (2015) highlights that successful river restoration projects focus on reducing pollutants in the water and implementing appropriate restoration techniques. River water treatment plants play a crucial role in these restoration efforts. Unlike drinking water facilities, these plants are designed to meet surface water quality standards, ensuring that water can be used for various purposes such as recreation, irrigation, and human consumption. These facilities typically employ physicochemical processes, including coagulation-flocculation, sedimentation, and filtration. The process integration concept in this scenario becomes attractive, given its performance and robustness and the potential to accelerate the river water restauration or even allow to produce water for potable application. For example, combining a river conventional water treatment plant with the reverse osmosis technology makes it a viable alternative to potable applications.

Membrane separation processes offer several advantages, including compact space requirements, rapid deployment, and availability as mobile units, making them particularly suitable for emergency water shortages. They act as a tight filtration media, capable of retaining suspended (in the case of micro- and ultrafiltration membranes) and dissolved (in the case of nanofiltration and reverse osmosis membranes) matter from surface water, guaranteeing the water quality requirements. That differs from conventional treatments, which generally have high efficiency for suspended matter, but present low performance in the removal of dissolved fractions (Guimarães et al. 2022b). It should also be mentioned that when deployed in water treatment, reverse osmosis membranes require less energy compared to their conventional application in desalination processes (Rana et al., 2023).

This study aimed to evaluate the effectiveness of a tertiary treatment process using reverse osmosis (RO) to enhance the performance of a full-scale water treatment plant designed to restore water quality following a dam failure incident. In addition to supporting river restoration efforts, the quality of the reverse osmosis permeate was compared against drinking water standards to assess its potential for emergency human consumption in scenarios of water scarcity after such rupture events.

METHODOLOGY

The reverse osmosis technology was selected to integrate the river water treatment plant with the aim of evaluating its performance as a water polishing step (tertiary treatment) in addition to its application to meet potability standards, according to GM/MS nº 888, of May 4, 2021 of the Ministry of Health. The RO system was tested at a water treatment facility in Minas Gerais, Brazil, with a treatment capacity of 2000 m³/h. The treatment process involved coagulation and flocculation using aluminum polychloride as the coagulant (200 mg/L) and FLOPAM™ AN 945 VHM (9 mg/L) as the flocculant, followed by decantation and pressurized filtration. The osmosis pilot plant was equipped with a reverse osmosis membrane (BW30-2540, supplied by DuPont Water Solutions), with an area of 2.6 m^2, an average permeate flow of 3.8 m³/d.

The characterization of the study waters was carried out after being collected at different points in the process (Water River Treatment Plant entry and exit) and analyzed according to physical, chemical, and biological parameters according to Standard Methods for the Examination of Water and Wastewater (APHA, 2017), and were correlated to water quality national standards (CONAMA 357/2005). The reverse osmosis permeate was also compared with drinking water standards to assess its potential for emergency human supply in water scarcity scenarios.

RESULTS AND CONCLUSIONS

Aluminum, iron, and turbidity were removed with high efficiency (>98.2%) by the water treatment plant. The limitation of the conventional processes in the removal of dissolved species could be seen by the reduction in total dissolved solids, with a value of < 52%. The high retention capacity from reverse osmosis membranes allows the drinking water production. The results

showed the constituents removal, such as iron, manganese, and aluminum, in addition to contributing to the reduction of turbidity remaining from the previous process (Table 1).

Table 1- Summary of Reverse Osmosis Efficiency Data

	Feed RWTP	Feed RO[(a)]	Permeate RO	%R RO[b)]	VMP GM/MS n° 888 [(c)]
Aluminum (mg. L^{-1})	14.7	0.52	0.001	100.0	0.200
Iron (mg. L^{-1})	12.100	0.160	0.001	100.0	0.300
Manganese (mg. L^{-1})	0.701	0.113	0.001	99.9	0.100
Turbidity (NTU)	398.000	1.610	0.480	99.9	5.000

a) RWTP filter output; b) % reverse osmosis removal; c) maximum value allowed GM/MS nº 888, of May 4, 2021 of the Ministry of Health.

The permeate produced through the membrane separation process met all national potable water standards, presenting a viable option for water supply in scenarios of water scarcity following dam failures, where alternative water supplies are needed. Furthermore, the coagulation process employed in the River Water Treatment Plant, though efficient, poses a potential risk of toxicity in cases of overdosing, especially when dealing with highly variable water quality. The RO membrane tests demonstrated that this technology effectively mitigates such risks by removing excess compounds, thereby preventing ecotoxicity downstream from effluent discharges into the river. In the context of river restoration, it's important to note that discharging the desalted RO permeate into the river is unlikely to disrupt osmotic equilibrium at the discharge point, given the significant difference between the river's flow rate (58.1 m^3/s) and the RO flow rate (0.56 m^3/s).

Thus, the positive outcomes discussed in this study serve to demonstrate the potential of water treatment plants to restore the water quality under adverse circumstances, including but not limited to events of mine tailing contamination. Membrane separation processes, which have seen continual advancements and optimization in recent years, offer enhanced performance when integrated with other technologies. This makes them highly suitable for producing potable water, particularly during critical events. The high retention capacity of RO membranes is crucial for ensuring the delivery of safe drinking water to the population. Moreover, it is necessary to mention the importance of carrying out multidisciplinary work, which involves public policy programs, due to the social impacts of society's acceptance of the consumption of drinking water from reused water. It is necessary and urgent to understand that water quality is directly related to the treatment applied, and not to the source of origin. Above all, it is a cultural issue that needs to be respected, but given the severe events already recorded, the trend for this type of application will be highlighted in the water and social sphere.

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