Assessment of Water Treatment Processes and Quality Parameters at the Al Hoceima Desalination Plant

Iman. AOUERYAGEL[1] , Faiza. CHAOUKET[1], Nihade. BENSITEL[2], Ihssane.RAISSOUNI[1], Dounia. BOUCHTA [1]
[1]Materials Engineering and Sustainable Energy, Faculty of Science Tetouan, MOROCCO.
[2] Laboratory LSIA, ENSAH, Abdelmalik Essaadi University, Tetouan, MOROCCO.

Abstract. Water is a vital resource essential for sustaining life and supporting human development. In the face of increasing population growth, urbanization, and environmental challenges, ensuring access to clean and safe drinking water remains a global priority. This study focuses on assessing the efficacy of water treatment processes at the Al Hoceima Desalination Plant in Morocco, examining various parameters to evaluate water quality improvement. Physicochemical parameters such as pH, conductivity, turbidity, total hardness, alkalinity, chloride, sulfate, calcium, magnesium, and dissolved oxygen, as well as bacteriological indicators including Escherichia coli, intestinal enterococci, coliforms, specific growth rates at 22°C and 37°C, and clostridia spores, were analyzed. The study aims to provide insights into the effectiveness of advanced treatment technologies in producing potable water and ensuring a sustainable water supply. Results indicate significant improvements in water quality following treatment processes, highlighting the importance of reverse osmosis in meeting water quality standards and addressing water scarcity challenges. **Keywords:**Desalination; Water ; Physicochemical;Bacteriological ;Quality.

1 INTRODUCTION

Water is a fundamental component of life on Earth[1], serving as a vital resource essential for the survival and thriving of all living organisms[2]. Its pivotal role extends beyond biological functions, significantly influencing the continual advancement and development of human civilization. Throughout history, the availability and quality of water have profoundly shaped human societies, from ancient civilizations to modern communities[3].

Access to clean and safe drinking water is not only a basic human right but also a crucial aspect of public health and environmental sustainability[4]. In recent years, increasing population demands, industrialization, and environmental contamination have exerted substantial pressure on traditional water sources[5], prompting the need for innovative water treatment technologies[6]. Desalination processes offer a promising solution to produce potable water[7] by removing salts and impurities from seawater or brackish water[8], primarily through reverse osmosis membrane technology[9]. While other advanced treatment technologies like Multi-Stage Flash Distillation (MSF), Multiple-Effect Distillation (MED), Vapor-Compression Evaporation (VCE), and Electrodialysis (ED) exist, RO stands out for their energy efficiency, scalability, and environmental compatibility[10]. RO requires less energy compared to thermal desalination methods, making it cost-effective in the long run and reducing the plant's carbon footprint[11]. Additionally, its modular nature allows for easy scalability to meet fluctuating water demands, a crucial aspect of a facility. Furthermore, the environmental impact of RO is relatively low, as it produces less brine discharge compared to thermal methods, thus minimizing harm to marine ecosystems.[6]

In Morocco, the challenge of surface water scarcity poses significant concerns, leading to the exploration of alternative water sources in various regions, including the city of Al Hoceima. The establishment of the Al Hoceima desalination plant exemplifies the effectiveness of advanced treatment processes in enhancing water quality and ensuring a sustainable water supply[12].

This article aims to conduct a comprehensive analysis of the water treatment processes implemented at the Al Hoceima desalination plant and their impact on improving water quality. Through examination of key parameters such as physicochemical properties, bacteriological indicators, and treatment efficiency, we endeavor to underscore the critical role of advanced treatment technologies in ensuring access to safe and dependable drinking water.

2 MATERIALS AND METHODS :

2.1 Location

The AL HOCEIMA seawater desalination plant is situated approximately 8 km southeast of AL HOCEIMA city, adjacent to SFIHA Beach within the AJDIR municipality. Occupying a 3.2-hectare area, it was established on land expropriated by the National Office of Electricity and Drinking Water - water branch. The plant has a production capacity of 200 l/s for drinking water, equivalent to 17,280 m3/day. [13] The location is presented in figure1. The desalination plant is depicted in Figure 2, highlighting five primary procedural stages.

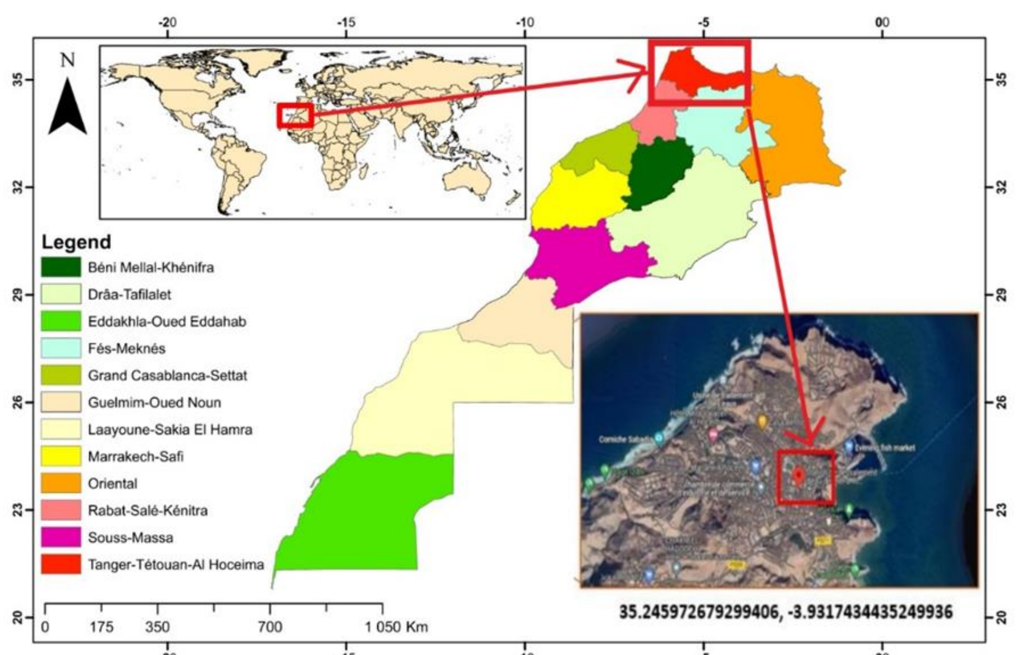

Fig. 1. Geographic location of the desalination plant.

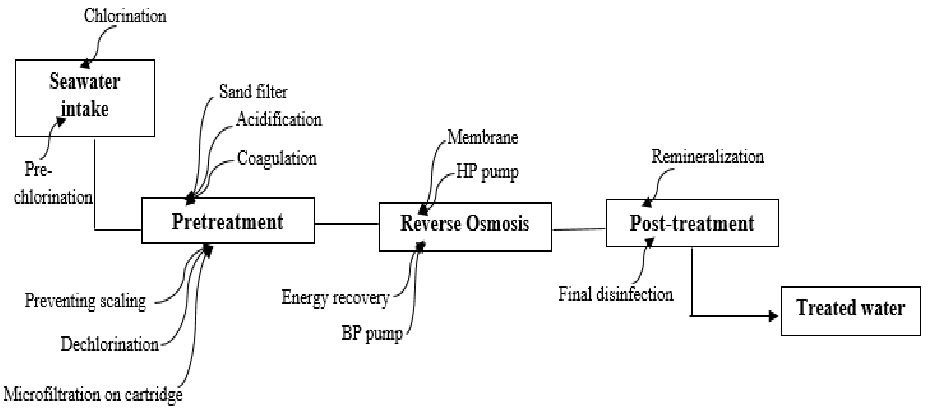

Fig.2. The stages of the desalinated water production process at the AL HOCEIMA seawater desalination plant are as follows.

2.2. Sampling of waters

Water samples are collected at four points within the station: raw water intake, after microfiltration, after reverse osmosis, and at the treated water outlet. These samples are collected over a period of five months, from January to May, for physicochemical analyses, while bacteriological parameters are sampled every two months.

2.3. Physicochemical and bacteriological analyses

The methods used for physicochemical analyses closely follow those adopted by the National Office of Drinking Water (ONEP) as per the testing methods guide. Water samples are collected in 2liter bottles to measure 11 parameters, namely pH, conductivity (C.E.), turbidity (NTU), total hardness (TH), total alkalinity (TAC), alkalinity (TA), chlorides (Cl^-), dissolved oxygen (O_2), sulfates ($SO_4{}^{2-}$), calcium (Ca^{2+}), magnesium (Mg^{2+}). For bacteriological analysis, water samples are collected in sterile 0.5-liter bottles, and the enumeration of fecal contamination indicator bacteria, including Escherichia coli, Intestinal Enterococci, Coliforms, Growth Rate at 22°C, Growth Rate at 37°C, and Clostridia spores, is performed using techniques described by Rodier.[14]

3 Results and discussion

3.1 Physicochemical water quality

Figures 3.4 and 5 present the results of physicochemical parameters, including pH, conductivity, and turbidity, for raw, microfiltered, osmosed, and treated waters. The other parameters are also detailed in Table 1 for both raw and treated waters.

The conductivity dataset (Fig. 3) sheds light on the effectiveness of different water treatment processes and their impact on water quality. Conductivity, influenced by dissolved ions and contaminants, serves as a measure of water's ability to conduct electrical current[15]

Raw water consistently shows the highest conductivity, indicating its mineral content and contamination potential. Microfiltration lowers conductivity by removing particulate matter and ions, though some conductivity remains due to dissolved ions. Osmosed water, produced via reverse osmosis, exhibits significantly reduced conductivity, highlighting its effectiveness in removing contaminants. Treated water, treated chemically or through advanced filtration, also shows reduced conductivity, indicating the successful removal of remaining contaminants.This reduction is crucial for ensuring water quality, especially considering the maximum permissible conductivity value of 2700 μS/cm, a threshold commonly associated with potable water quality standards. Thus, the findings suggest that processes, including reverse osmosis and chemical treatment, have been effective in producing water that meets quality standards, with contamination levels well below the recommended thresholds for human consumption.

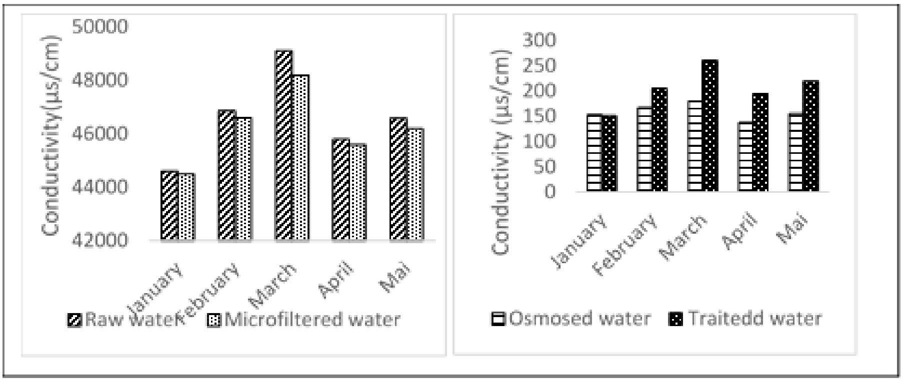

Fig.3. The conductivity variation of raw, microfiltered, osmosed, and treated waters from the Al Hoceima desalination plant.

The figure 4 presents turbidity levels across different types of water for January through May. Turbidity is a measure of the cloudiness or haziness of water caused by suspended particles such as sediment, organic matter, and microorganisms.[16]

Turbidity values for raw water exhibit fluctuations over the months, ranging from 0.11 NTU in January to 0.3 NTU in April. These variations could be attributed to changes in environmental conditions, precipitation, or upstream activities affecting water quality.

Microfiltration effectively reduces turbidity levels compared to raw water, with values ranging from 0.08 NTU in January to 0.2 NTU in May. The consistent trend of lower turbidity levels suggests the efficient removal of suspended particles through the filtration process.

Turbidity levels in osmosed water are consistently low across all months, ranging from 0.06 NTU in January to 0.13 NTU in May. This indicates a high level of clarity and minimal suspended particle content, attributable to the comprehensive removal of contaminants during the osmosis process.

Treated water, subjected to additional steps, exhibits varying turbidity levels, ranging from 0.11 NTU in January to 0.48 NTU in May. While some fluctuations are observed, turbidity values generally remain within acceptable limits, with occasional spikes possibly attributed to changes in treatment conditions or influent water quality.

Overall, the data underscores the effectiveness of water treatment processes in ensuring clear and safe water for consumption and various applications, with osmosed water particularly excelling in purity and clarity.

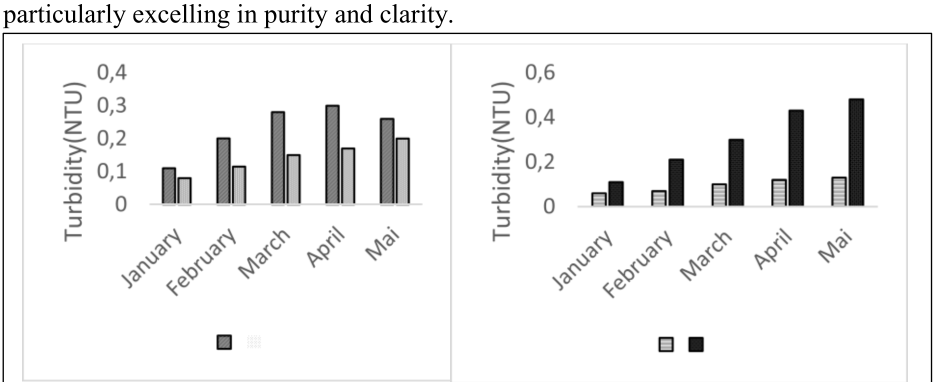

Fig.4. The turbidity variation of raw, microfiltered, osmosed, and treated waters from the Al Hoceima desalination plant.

Figure 5 provides pH data and offers insights into the acidity or alkalinity levels of various water sources throughout the observed months. Plays a crucial role in determining the corrosiveness of water, with lower pH values indicating a higher level of corrosiveness.[17]

Raw water consistently maintains a slightly alkaline pH range, fluctuating between 7.1 and 7.4. This alkalinity could be attributed to the presence of dissolved minerals and bicarbonates originating from natural sources.

In contrast, microfiltered water exhibits pH levels slightly higher than raw water, ranging from 7.23 to 7.48. The filtration process may have contributed to the removal of certain acidic components, resulting in a slightly elevated pH compared to raw water.

Osmosed water consistently shows lower pH levels across all months, ranging from 5.43 to 5.7. The significant reduction in pH suggests the removal of alkaline minerals during the osmosis process, leading to a mildly acidic pH. This alteration in pH is a common outcome of water purification methods that target mineral removal.

Treated water presents a wider pH range, varying from 6.8 to 8.2 over the observed period. The fluctuations in pH levels could stem from additional treatment steps or adjustments made to meet regulatory standards. Factors such as the introduction of alkaline agents or changes in water composition during treatment processes may influence pH variations.

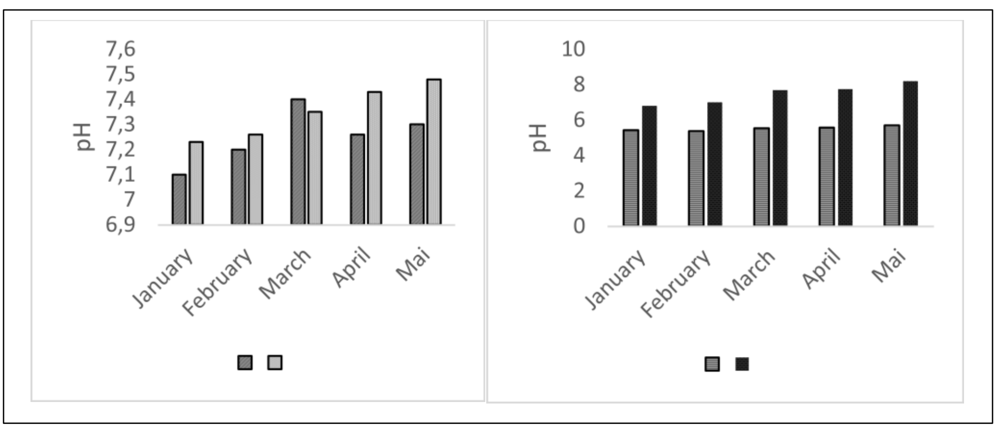

Fig.5. The pH variation of raw, microfiltered, osmosed, and treated waters from the Al Hoceima desalination plant.

Table 1 summarizes the average water quality parameters for both raw and treated water over five months. Initially, raw water exhibits characteristics indicative of mineral content and alkalinity. However, after treatment, there is a notable decrease in these parameters, suggesting an effective removal of minerals and dissolved contaminants. This improvement is further highlighted by the reduction in sulfate and chloride levels, indicating an overall enhancement in water quality. Additionally, treated water shows a significant increase in dissolved oxygen content, which is beneficial for aquatic ecosystems and human consumption. Overall, the data underscores the positive impact of treatment processes in producing clean and safe water that meets regulatory standards.

Table 1 : Physicochemical parameters of raw and treated waters

Parameters	Raw water	Treated water	MAV
TAC (méq/l)	2.9	0.7	8°F
TA (méq/l)	0	-	8°F

TH (méq/l)	128	1.08	-
Ca^{2+} (mg/l)	444	12.8	-
Mg^{2+} (mg/l)	1111.2	0.32	-
SO_4^{2-}(mg/l)	2574.3	5.9	400mg/l
Cl^- (mg/l)	18105	50.6	750mg/l
Dissolved Oxygen	3.8	9.1	$5 \leq O_2 \leq 8$

3.2 Bacteriological water quality

Evaluating bacteriological quality is paramount in water quality assessment. Table 2 presents bacteriological quality for both raw and treated waters. Raw water shows low concentrations of Escherichia coli, Intestinal Enterococci, and Coliforms (all < 3), with no detectable Clostridia spores. After treatment, treated water exhibits no detectable levels of these indicators, indicating effective removal by reverse osmosis. Specific growth rates (GR) at 22°C and 37°C are reported as 1 and 2 respectively for treated water, suggesting some microbial activity but at acceptable levels. Overall, treatment has improved bacteriological quality by reducing contamination.

Table 2 : Bacteriological parameters of raw and treated waters

Parameters	Raw water	Treated water	MAV
Escherichia coli	<3	0	0/100ml
Intestinal Enterococci	<3	0	0/100ml
Coliforms	<3	0	0/100ml
GR à 22°C	-	1	100/1ml
GR 37°C	-	2	20/1ml
Clostridia spores	-	0	0/100ml

4 Conclusion :

In conclusion, this study comprehensively assesses water treatment processes and quality parameters at the Al Hoceima Desalination Plant in Morocco. The efficacy of advanced treatment technologies in improving water quality was evaluated through the analysis of various physicochemical and bacteriological parameters, and bacterial indicators. The results demonstrate significant improvements in water quality following treatment processes, underscoring the importance of desalination as a viable solution for addressing water scarcity challenges and ensuring access to safe drinking water. The findings highlight the critical role of advanced treatment methods in meeting water quality standards and supporting environmental sustainability. Continuing research and investment in innovative water treatment technologies will be essential for meeting the growing demand for clean and safe water worldwide.

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