

Use of Nanofiltration and Demineralization of Industrial Effluents : Evaluation of the Feasibility of Reuse for Irrigation of Green Spaces

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Abstracts: Assessment of the applicability of neutralization station wastewater in combination with nanofiltration for watering green spaces. To achieve this objective, various analyses were carried out, including pH, conductivity, suspended solids, chlorides, nitrates, sulfates, bicarbonates, silica, total nitrogen, BOD5, COD and heavy metals. The results of our analyses showed that most of the parameters analyzed complied with the standards in force for water intended for the irrigation of green spaces. A few values slightly outside the recommended ranges were observed, mainly due to the cationic resin regeneration process. With regard to heavy metals, the levels found were all below the regulatory threshold values, indicating a low risk of contamination by these elements. On the basis of these results, a number of recommendations were made to demonstrate the feasibility of using discharges from the neutralization pit for watering green spaces, subject to the implementation of appropriate treatment and monitoring measures.

Keywords: Nanofiltration, Demineralization, Industrial Effluents, Green Spaces.

1. INTRODUCTION

After reinforcing sewerage networks, collecting wastewater discharged into the sea and building wastewater treatment plants, the rate of wastewater reuse in Morocco will rise to 22% by 2020 and reach 100% by 2030 [1]. Treated wastewater is used in a variety of sectors, including agriculture (currently on a surface area of around 550 hectares, rising to 4,000 hectares by 2020), watering golf courses and green spaces, groundwater recharge and industrial recycling [2].

The growing consumption of water in industry is a major issue worldwide. Water use is vital to the operation of industry, but it can also have harmful effects on the environment [3].

The visible manifestation of the water used in a power plant is the river or sea on whose banks flame or nuclear power plants are built for their cooling, or the plume of steam escaping from cooling towers. Cooling is by far the most important use of water in power plants, as it cools the turbine outflow [4,5].

A power station involves various water circuits, which must undergo different upstream and downstream treatments. External cooling water must be filtered and chemically treated to prevent biological fouling, scaling, corrosion and pathogenic micro-organisms that develop in hot water; steam circuit water is chemically treated to prevent scaling, corrosion and pathogenic micro-organisms [6]. These chemical treatments end up in the river, and discharges of this type are governed by regulations.

The use of large quantities of water in its production process, which is discharged in the form of wastewater. This wastewater contains chemicals and pollutants that can be harmful to the environment. On the other hand, most cities are faced with problems of water supply for the irrigation of green spaces [7]. In this context, the question arises as to whether the wastewater from the thermal power plant can be used to irrigate green spaces safely and efficiently, without causing damage to the environment [8].

Membrane water treatment, also known as ultrafiltration or nanofiltration, is a water purification process that uses microporous membranes to filter out only particles smaller than the membrane's pore size. This is a mechanical technique, requiring no chemical reagents. Membrane water filtration is mainly used for drinking water treatment [9]. Ultrafiltration or nanofiltration (in this case, the membrane pores are even smaller, close to 0.001 micrometers) retains elements such as bacteria, organic molecules, algae, pollen and germs. It's a water disinfection process that can be integrated into a more extensive depollution program or used on its own [10].

Resin demineralization is a water purification technology that removes dissolved ions from water and replaces them with other ions of the same or similar electrical charge (hydrogen H⁺ or hydroxide OH⁻) to produce pure water. Cations targeted for elimination are calcium (Ca²⁺), magnesium (Mg²⁺), sodium (Na⁺), potassium (K⁺) and iron (Fe²⁺). The anions targeted for removal are bicarbonate chloride (HCO₃⁻), chloride (Cl⁻), sulfate (SO₄⁻), nitrate (NO₃⁻) and silica (SiO₂). The performance of a demineralization process depends on the condition of the incoming water, the design of the system (co-current or counter-current), the type of resin used and the type and concentration of the regenerant. In industrial processes, the demineralization method is generally applied when a very low dissolved salt content is required in the process water or boiler feed water [11].

In this research it is the combination of membrane technology and demineralization for the treatment of discharges for the purpose of "Physico-chemical characterization of industrial wastewater and evaluation of its potential for irrigation of green spaces at the thermal power plant" aims to address this issue by studying the physico-chemical properties of wastewater from the thermal power plant, as well as its potential for irrigation of green spaces. This study will determine whether wastewater can be used safely and efficiently for irrigation of green spaces, while minimizing adverse effects on the environment.

2. MATERIEL AND METHODS

2.1. Operation of the System

The water used to supply the boiler is demineralized before being returned to the boiler tank. Once stored in two tanks, each with a capacity of 5000 m³, the raw water passes through a treatment chain consisting of a filter, a cationic resin and an anionic resin. The plant has three treatment lines, and after each production run, the resin is washed and regenerated [12].

The neutralization tank is a wastewater treatment facility that treats osmosis water discharged to the production station for demineralized water, as well as discharges from the demineralization lines during regeneration with sulfuric acid and caustic soda. These lines are charged with cationic and anionic resins, the purpose of which is to remove dissolved salts from the water [13].

The water discharged from the osmosis and the demineralization lines, with a flow rate of 460m³/d, contains acidic or basic substances that can alter the chemical balance of the discharge water. The Neutralization Pit neutralizes these acids and bases to avoid them harming the environment. The operating principle of the neutralization pit is that chemicals (such as fleurs de chaux) are added to the wastewater to neutralize the acidity or basicity. Lime is added in precise quantities to ensure effective neutralization. The neutralization pit is also equipped with a mixing system that allows the discharge water to be mixed with the added chemical. After membrane filtration and neutralization, the water is sent to a settling tank where suspended particles can settle to the bottom [14]. The procedure is controlled by a pH meter, either on-site or portable. When the correct pH is reached, the operator stops the lime dosing unit, and then continues to feed lime milk until the dilution tank and plumbing have been thoroughly washed. At the same time, the neutral water discharge pump is started. Once the tank has been washed, the operator stops all the pumps and closes the automatic valve [15].

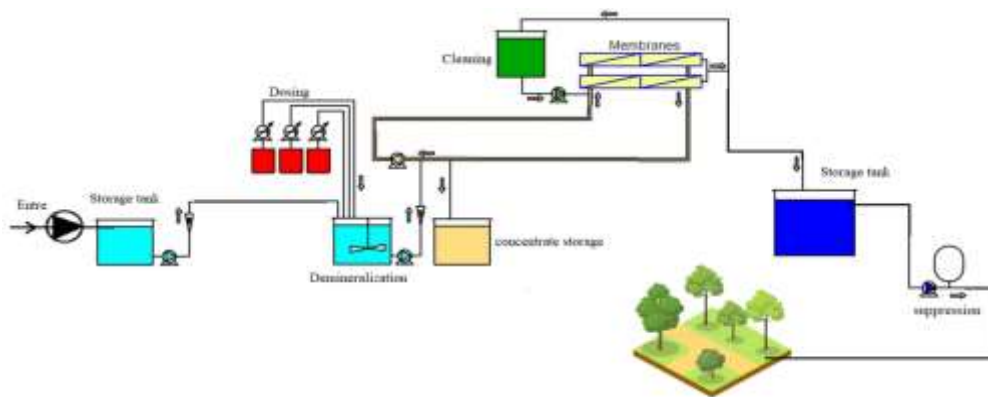


Figure 1. Operation of the system

2.2. Neutralization of Industrial Effluents

- Estimated quantity of lime milk required for neutralization

- Before proceeding with the neutralization operation, the chemistry section takes 1 liter of effluent from the tank and estimates the quantity of lime milk to be added for neutralization.

- Prepare 1 liter of lime milk at the same reservoir concentration.

- Slowly add the neutralizing agent to the sample, while stirring and checking the pH. Evolution is slow at first, and then accelerates sharply. The "turning point" is then close at hand, and milk of lime needs to be added in very small quantities to obtain a pH as close as possible to 7 (discharge is authorized between 6.5 and 9).

- Note the quantity (q) of lime milk required.

- This quantity corresponds to control 1 liter of effluent. To obtain total quantity Q, multiply it by the total volume of the tank to be emptied ($q \times V = Q$).

- Neutralization of the tank tank

- After adding the lime powder to the silo, fill the tank with water and start the agitator and dozer to bring the lime into solution.

- Once you have completed these operations, switch off the lime doser and leave the agitator running.

- Open the suction and discharge valves on the lime milk pump, and switch on the pump and air circuit.

- Add the Q liters of lime milk, stir and let stand for a few hours. Before discharging, check the pH one last time until the value is within the neutralization range (6.5 - 9).

- Once the acidic water has been neutralized, start the discharge pump to the wadi.

It is essential to eliminate any leaks of lime milk from the tank and lime powder through the inspection door of the lime dosing unit[16]. At the end of each centralization operation, the lime milk tank must be emptied and rinsed, as must the silo hopper, which must be emptied while the dosing unit is running with the shutter closed. After each neutralization, it is necessary to rinse with water either the pump or the lime whitewash discharge pipes to the tanks. Such rinsing is performed by operating the valves between the raw water manifold and the lime milk discharge pipes [17].

2.3. Release Sampling

Collecting a water sample is a crucial step that requires great care, as it influences the results of analyses and their interpretation. It is essential to ensure that the sample is representative, homogeneous and taken without altering the physico-chemical characteristics of the water [18].

For this sampling stage, it was decided to take one sample per day for a given period. Samples will be taken at the same time each day to minimize daily variations.

The preferred sampling method for discharges collected from the neutralization pit is to take a sample once a day. This approach provides an overview of the composition and characteristics of the discharge over a given period. By taking a sample every day, we capture potential variations in discharge over time, thus obtaining data that is more representative of reality [19].

The choice of sampling once a day is also pragmatic, as it provides sufficient information while limiting the costs and resources required for sampling. It is important to note that sampling frequency may vary according to specific environmental regulations, monitoring requirements and discharge characteristics. When sampling discharges from the neutralization pit, it is essential to follow rigorous protocols to ensure that samples are representative [20]. This includes using appropriate, sterile containers for sample collection, and following good sampling practices to minimize the risk of cross-contamination and ensure sample integrity.

3. RESULTS AND DISCUSSION

3.1. Assessment of Parameters

3.1.1. Monitoring of Hydrogen Potential and Nitrates

The lower pH values are the result of the cationic resins being washed during the regeneration operation, which may momentarily lower the pH of the water. It is important to note that these lower values are specific to the resin regeneration phase and are not representatives of the regular pH of the wastewater. They are caused by sulfuric activity during resin washing, and generally do not persist once this process has been completed. In conclusion, most of the pH values obtained are in the recommended range for irrigation water. The few values below the threshold value are due to the washing of cationic resins during the reclaim operation and should not have a significant impact as long as they remain limited to this specific phase [21].

The demineralization plant wastewater nitrate analysis results show that all the values obtained are below the threshold value for irrigation water, set at 30 mg/l. This indicates that the nitrate concentrations in the water samples analyzed are below the level considered problematic for green space irrigation. This indicates that the concentration of nitrates in the water samples analyzed is below the level considered problematic for the irrigation of green spaces [22]. Nitrates are nitrogen compounds naturally present in the soil and can also be present in groundwater and surface water as a result of fertilizer use, agricultural waste and human activities. High concentrations of the nitrate in irrigation water can have adverse consequences for plant health and lead to environmental problems such as groundwater contamination.

However, the results from this study indicate that discharge water samples from the demineralization station have nitrate concentrations below the recommended threshold value. This suggests that the demineralizing process used is effective in removing or significantly reducing the nitrates present in the treated water.

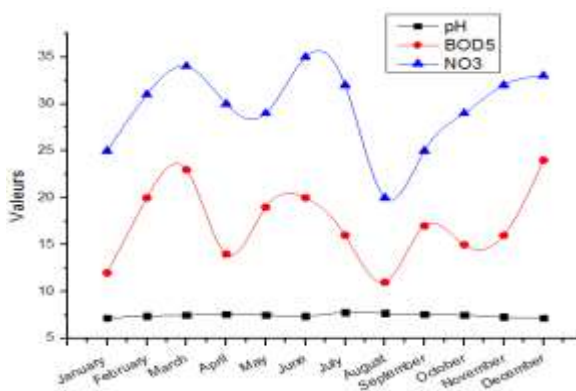


Figure 2: Variation Hydrogen Potential and Nitrates during the month

It is worth noting that the threshold value of 30 mg/l for nitrates in water intended for irrigation may vary according to local regulations or recommendations specific to each region. It is important to comply with the standards in force in the study area to ensure that treated water is used safely for irrigation [23].

Despite concentrations below the threshold value, it is recommended to continue monitoring nitrate levels in demineralization plant discharge water on a regular basis, particularly if ambient conditions or demineralization processes may change over time. Continuous monitoring will help ensure compliance with local standards and minimize potential risks to crops and the environment.

3.1.2. Monitoring of BOD5 and COD

The research results show that BOD5 and COD values for irrigation water are below the thresholds set for wastewater and groundwater. However, it should be emphasized that the Ministry of Water and the Environment has not yet defined specific limit values for these parameters in the context of irrigation.

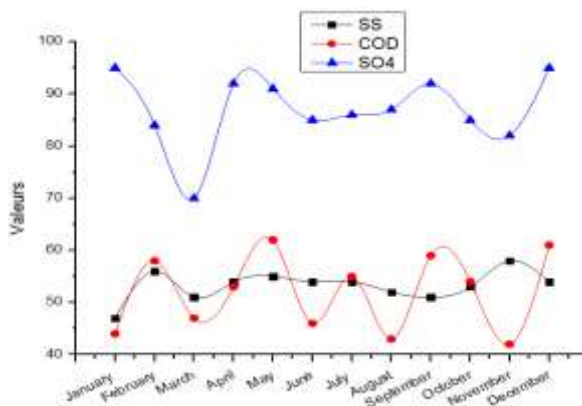


Figure 3: Variation in BOD5 and COD during the month.

While the resulting values are below the established thresholds for wastewater and groundwater, it is important to take into account the differences between the intended uses of water. Water intended for irrigation may have specific requirements in terms of impacts on soil, crops and human health.

It is therefore necessary to carry out a thorough assessment of the risks and potential effects of BOD5 and COD in the context of irrigation. This study therefore highlights the need to take into consideration a wider range of water quality parameters when assessing the suitability of irrigation water. The values obtained remain below the thresholds established for wastewater and groundwater, indicating a relatively good quality of water used for irrigation purposes [24]. However, it is important to note that irrigation water may have requirements that differ from

those of wastewater and groundwater due to its specific use in agriculture. Consequently, it is necessary to deepen the risk assessment by taking into account other relevant water quality parameters.

3.1.3. Monitoring of Sulfates and Suspended Solids

The analysis results for sulfates in the discharge water from the demineralization station show that all the values are below the threshold value for irrigation water, set at 250 mg/l. This means that the concentration of sulfates in the water samples analyzed is below the level considered to be of concern for green space irrigation. This means that the sulfate concentration in the water samples analyzed is below the level considered of concern for green space irrigation.

Sulphates are chemical compounds that occur naturally in water and can originate from a variety of different sources such as rocks, soils and groundwater. High concentrations of sulfates in irrigation water can have undesirable effects on soil quality and crops, notably by increasing soil salinity and reducing the availability of essential nutrients for plant growth. However, the results of the present study indicate that discharge water samples from the demineralization station show sulfate concentrations below the recommended threshold value. This suggests that the process of demineralization used is effective in eliminating or significantly reducing the sulfates present in the treated water [25].

It is important to note that the sulphate threshold value of 250 mg/l for irrigation water may vary according to local regulations or region-specific recommendations. It is important to comply with the standards in force in the study area to ensure safe use of treated water for irrigation. The results obtained in this study indicate suspended solids (SS) values in the discharge water of between 46 mg/l and 48 mg/l. These values are below the threshold value set by state recommendations, which is 100 mg/l. Suspended matter is a measure of the quantity of solid particles present in water. High levels of TSS in discharge water can lead to deterioration in water quality, affecting aquatic ecosystems and potentially human health.

However, the values obtained in this study indicate that the discharge waters studied have a TSS concentration below the established threshold value. This suggests that the treatment or filtration processes used in the demineralization plant's wastewater management system are reasonably effective. It is important to remember that state guidelines set a threshold value of 100 mg/l for suspended matter in discharge water. However, it should be borne in mind that this value may vary according to regulations specific to each region or country, as well as international water quality standards. A TSS concentration below the threshold value generally indicates better water quality, but this does not necessarily mean that the discharge water is free of any environmental impact. The other parameters to be analyzed must also be assessed to obtain a complete picture of the potential pollution of the wastewater.

3.1.4. Monitoring of Conductivity, Bicarbonates and Chlorides

The conductivity values all appear to be below the recommended limit for irrigation water. This indicates that the concentration of dissolved salts in the water is relatively low. Low electrical conductivity is generally desirable, as high levels of dissolved salts can be detrimental to plant growth. However, it should be noted that interpretation of conductivity alone provides only a very general indication of water quality for irrigation. In addition, regular monitoring of irrigation water quality is recommended to detect any significant changes. Variations in electrical conductivity can indicate changes in the chemical composition of the water, which can affect plant growth.

The results of the bicarbonate analysis in the discharge water collected in the demineralization station's neutralizing pit indicate that all the values obtained are below the threshold value set for water intended for irrigation, set at 518 mg/l. This means that the concentration of bicarbonates in the water samples analyzed is below the level considered problematic for irrigation of green areas.

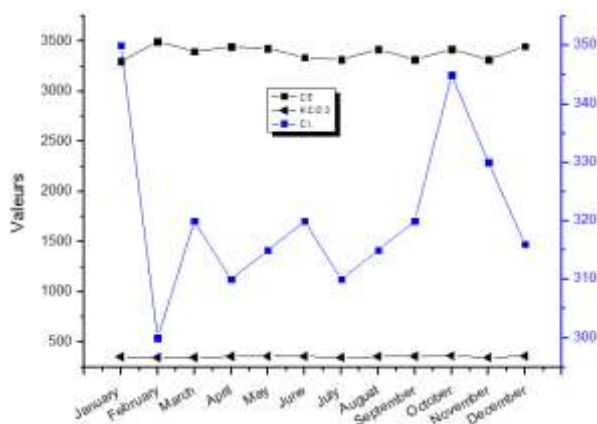


Figure 4: Conductivity, Bicarbonate and Chloride variations over one month

Bicarbonates are ions naturally present in water and play an important role in maintaining the chemical balance of water and soil. High concentrations of bicarbonates can have an alkalinizing effect on the soil, which can disrupt the chemical and physical properties of the soil, affecting crop growth and development.

However, the results of this study indicate that the water samples collected in the neutralization pit of the demineralization station had bicarbonate concentrations below the recommended threshold value. This suggests that the neutralization process used in the demineralization station is effective in reducing bicarbonate levels in discharged water.

It should be noted that the threshold value of 543 mg/l for bicarbonates in water intended for irrigation may vary according to local regulations or recommendations specific to each region. It is important to comply with the standards in force in the study area to ensure safe use of discharged water for watering green areas. Despite concentrations below the threshold value, it is recommended to continue regular monitoring of bicarbonate levels in the discharge water collected in the neutralization pit. Continuous monitoring will help ensure compliance with local standards and minimize potential risks to soil and crops.

The results obtained in this study show that all the chloride values measured are below the threshold value for irrigation water, set at 320 mg/l. This indicates that the chloride concentration in the water samples analyzed is below the level considered problematic for irrigation. Chlorides are naturally occurring salts in many types of water, and their concentration can vary according to geological factors, human activity and agricultural practices. High levels of chlorides in irrigation water can have adverse effects on soils and crops. It should be noted that the threshold value of 243 mg/l for chlorides in irrigation water is a commonly used standard but may vary according to local regulations or region-specific recommendations. It is important to comply with the standards and requirements in force in the study area to ensure the Safe Use Of Water For Irrigation.

3.2. Statistique Validation Analysais

Validation of industrial analytical methodologies is an essential step in any chemical research process. It involves assessing the performance and reliability of the methods used to measure the chemical compounds of interest. In the context of our project, we have chosen to focus on just three specific methods: iron and manganese analysis by photometry, nitrate analysis by spectrophotometry and sulfate analysis by granulometry.

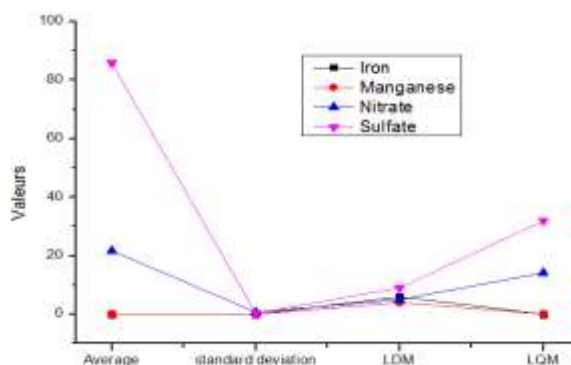


Figure 5: heavy metals variation indicator for May

Three specific analytical methods were explored and approved for this study: iron and manganese by photometry, nitrate by spectrophotometry and sulfate by granulometry. For each method, 10 different variants were arbitrarily selected in order to assess their performance and determine whether they met the method conformity criteria. By applying the relevant calculations for each parameter, results were obtained that enabled us to assess the accuracy, sensitivity and reliability of these methods. After a thorough analysis of the data, it was found that the results obtained with these 10 variants for each method complied with the criteria established for the validation of the methods.

This conclusion suggests that the methods for iron and manganese analysis by photometry, nitrate analysis by spectrophotometry and sulfate analysis by granulometry are all appropriate and reliable for the purpose of our study. These methods can be used with complete confidence to measure the concentrations of these compounds in our samples.

CONCLUSION

We found that most of the analyzed parameters were well within the recommended range for water used for irrigation of green spaces. Values were slightly outside the recommended ranges, primarily due to the process of regenerating the cation exchange resin. However, some solutions have been proposed to correct these deviations, such as pH adjustment and installation of additional filtration systems. As regards the heavy metals, we found that the concentrations were all below the regulatory threshold values. This is very encouraging and indicates that discharge from the neutralization pit does not present a significant risk in terms of heavy metal contamination. Regular monitoring of discharge water conditions, paying particular attention to key variables such as pH, heavy metals and other potentially worrying elements. Work closely with water purification experts, specialist engineers and regulatory bodies to ensure compliance with current regulations and adapt processes according to the recommendations and specific requirements.

In concluding, our study demonstrated that it would be feasible to use neutralization pit discharges for the watering of green spaces, with appropriate monitoring and treatment procedures. This would make it feasible to reduce the impacts on the environment resulting from these discharges, and to use this resource as reclaimed water for non-drinking purposes. It is also important to emphasize that these recommendations will require a multidisciplinary approach and close coordination between the relevant stakeholders. In addition, compliance both with local regulations and ongoing monitoring of treatment system performances are essential to ensure the safe and sustainable use of wastewater.

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DOI: <https://doi.org/10.15379/ijmst.v10i3.2017>

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