BIOLOGICAL NITRATE REMOVAL FROM REVERSE OSMOSIS (RO) BRINE USING MOVING BED BIOFILM REACTOR (MBBR)

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INTRODUCTION

Reverse Osmosis (RO) processes are widely used for desalination of sea water as well as for brackish ground water. In Israel, about 40% of the water supply for domestic, public & industrial consumption is based on Desalination processes (1). The volume of brine produced in brackish water desalination is approximately 10 to 20% of the feed water. Therefore, the salts concentrations in the brine are 5 to 10 times higher than their concentration in the source water. The brine disposal problem is relatively new due to the rapid implementation of reverse osmosis technology for upgrading water supplies.

One of the alternatives for brine is disposal to the sea or other water bodies. However, this will require reduction in Nitrate levels in the disposed brackish water brine, as required by the Israeli Environment Agency.

Many Physico-Chemical technologies are known for nitrate removal, among them are: Ion Exchange, Reverse Osmosis and Electrodialysis. The main disadvantage of those Physico-Chemical methods is the production of concentrated brine that needs to be removed and/or treated further. Therefore, Biological denitrification is the best solution for nitrate removal from brines due to the conversion of nitrate to nitrogen gas (N_2) – a harmless and environmentally friendly product (2).

During 2011-2012, Aqwise together with together with Mekorot - the Israeli national water company, operated a pilot to study the Biological Nitrate removal from RO brine using moving bed biofilm reactor (MBBR). Unlike denitrification process to remove Nitrate from drinking water, the process for RO brine needs to pit against other parameters such as salinity and high alkalinity values.

This paper will present results obtained from a 1.5 years pilot.

METHODS

Water is pumped from the RO system to 2 consecutive pre anoxic MBBR stages, where dissolved oxygen (DO) was consumed, following by an Anoxic stage at a total Hydraulic Retention Time (HRT) of about 2 hours. Carbon source as well as P and N sources, were dosed to the pre-anoxic stage as required.

The main goal of the pilot was to define design parameters for a full scale system. Other sub-goals were also defined:

Optimization of the Anoxic reactor - including: optimal C:N:P ratio, salinity influence on the biological process and removal efficiency for two different C source.

Analysis for different parameters such as Nitrate, Nitrite, DO, hydraulic parameters, and more was performed at different point of the system, on a daily base.

RESULTS AND DISCUSSION

Since it is very important to keep very low Dissolve oxygen levels for anoxic process, it was very important to define the DO reduction efficiency in the pre-anoxic stages.

Figure 1 demonstrates the average DO concentration observed at the different biological stages of the process.
Since the brine come up with an average DO levels of 7.8 mg/l, which inhibit the denitrification process, the overall DO reduction achieved in the two pre-Anoxic stages is essential. As can be seen from Figure 1, the DO reduction in the Pre-anoxic stages (designated in the figure as De-Ox) is very efficient and resulted in very low DO levels in the Anoxic stage, where the denitrification process is performed. It should also be noted that some of the nitrate removal occurs also in parallel to the DO reduction.

Figure 1 Average DO concentrations at different pilot's stage

Figure 2 Inlet and outlet NO_3 results Using Methanol as C source

Figure 3 Product water NO_2 results (Methanol as C source)

Figure 2 present the inlet and outlet Nitrate concentrations gathered during the pilot period, with Methanol as Carbon source. The red and green lines presents, respectively, the average and maximal Nitrate concentration required by the Israeli regulations, of the Israeli Environmental Protection Agency, for sea disposal. Results show good nitrate removal during the pilot. In few occasions, when the Nitrate levels exceeded the desire values, it was related to insufficient dosing of Carbon source due to technical pumping problems.

Even more toxic element is the Nitrite, formed as a by-product when the denitrification process is incomplete. Figure 3 presents the Nitrite concentration obtained during dosage of Methanol as Carbon source. As can be seen from the figure, after system stabilization, the nitrite levels were below the required level, presented by the red line.
From the amount of Nitrate removed in the system, the denitrification rates can be calculated, from which design parameters can be derived for full scale plant. As mentioned above, Nitrate removal starts already at the pre-anoxic reactors and from Figure 4 it can be seen that about 40% of the removed nitrate is removed at the first Pre anoxic stage. The second pre-anoxic stage remove an average of about 17% of the Nitrate. The amount of Nitrate removed at the anoxic stage can't be calculated exactly, since the results are always below the detection limit of the test analysis. Therefore, the sum of the Nitrate amount removed from the three stages, as presented in figure 4, is less than 100%.
In order to achieve an absolute Nitrate concentration at the outlet of the anoxic stage, the daily amount of the removed Nitrate should be increased. This can be achieved by increasing the amount of Nitrate enters the system, which can be controlled by increasing the brine flow to the system. Figure 5 presents the influence of the current flow elevation on the normalized Denitrification rate. As for now, the results at the outlet are below the detection limit of the test kit. Nevertheless, it can be seen that the rate is increased.

Figure 4 Average daily amount of removed Nitrate at different biological system stage

Figure 5 Change of the total Denitrification rate with the increase in the flow rate to the system.

Results will be presented comparing denitrification rate observed for two different Carbon sources applied during the pilot period. In addition, the influence of various process parameters, on the denitirification rates, such as DO levels, salinity and alkalinity will be demonstrated.

REFERENCES

1. Israel water authority: www.water.gov.il
2. Beliavsky M., Meerovich I.,Tarre S. and Green M., 2010, Biological denitrification of Brines from membrane treatment processes using an upflow sludge blanket (USB) reactor, Water Science & Technology 61.4 , PP 911-917.