Desalination of seawater for Agriculture irrigation

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The growing scarcity of fresh water has driven to use of non-conventional and re-used water resources for agriculture by applying some efficient technologies. The need for water covers not only the water needed for human consumption, but also mainly the consumption in agriculture and industry. Considering the incidence of the constant available freshwater to the rapid growing population the water consumption level is increasing. When it comes to distribution and local conditions which expected to be more adversity to the countries which are already suffering from water shortages, this challenge becomes even more critical. Meanwhile, desalination has been increasingly adopted for agriculture irrigation over the last decades. Desalination is playing vital role in satisfying growing water demands in water scare regions and sometimes as a necessity to overcome water shortages in many areas around the world. Although, some of the thermal and membrane separation processes are well established as efficient technologies. For example, reverse osmosis (RO), moreover integrated RO with nanofiltration (NF), microfiltration (MF) processes. Anyway, the burning of fossil fuels to fulfil the energy demand is again becoming expansive. Additionally, greenhouse gases emission is considered as harmful to the environment. Thus, our efforts should be directly focused on cost reduction and energy efficient technologies.

To overcome this challenges desalination of seawater with membrane distillation could be a possible solution. Membrane Distillation (MD) is a thermally driven separation process in which only vapour molecules pass through a microporous hydrophobic membrane. The driving force for this separation process is a temperature gradient between the feed sides and permeate or distillate side, which results in a partial pressure difference of water vapour along the membrane pore. Membrane distillation can be adapted effectively for desalination technique. It can also be implemented for industrial water treatment applications, food industry applications etc due to its lower energy consumption and simplicity. Membrane distillation requires low operating temperature and pressure conditions which leads as an efficient and gentle separation process among the membrane separation techniques that are currently available.

To investigate the possible solutions ttz Bremerhaven solely designed and constructed membrane distillation test stand in a pilot scale level with four common configurations as follows, direct contact membrane distillation (DCMD), air gap membrane distillation (AGMD), sweeping gas membrane distillation (SGMD), vacuum membrane distillation (VMD). Individual module size is 0.25m^2. Test trails are carried out with salt water of 35 ppt (Saline water). For this membrane distillation operation, a hydrophobic PTFE membrane was used. Feed temperature ranges between 40-45^oC, whereas permeate temperature ranges from 10-20^oC. All the experiments conducted with a constant flow rate of 5 l/min. During the experimentation all the necessary parameter values like temperature, pressure, conductivity etc has taken manually as well as monitored and recorded online. Performance metrics involved estimation of energy consumption and recovery rates.

Based on the test trails for the application of desalination, it is observed that direct contact membrane distillation has reflected very good performance with highest permeate flux with 3.54 l/hm^2. Followed by AGMD 1.4 l/hm^2, VMD 0.45 l/hm^2, and SGMD with 0.32 l/hm^2. Additionally, to ensure the quality of end product, to make sure that it can be suitable for the irrigation process, some of the analytics were performed. For instance, an untreated water sample with the hardness (^{o}dh) of 1.1 g/l was treated with PTFE flat sheet module. In return, permeate with almost negligible amounts of salts was obtained. Evidently, membrane distillation capable in terms of quality output by reduction of salts. Coming to energy consumption in terms of 1 litre permeate recovery per m^2 area, DCMD consumed 0.052 KWH which is by far the best result for desalination application among the installed membrane distillation configurations. On the other hand, to achieve the similar goal, AGMD 0.13 KWH, VMD 0.4 KWH, and SGMD 0.44 KWH energy consumed. As an another alternative, to make membrane distillation process more efficient, it could be possible using industrial low-grade waste heat (>100^oC) as a primary heat source.

To conclude, desalinated saline water by using membrane distillation can be used in terms of agriculture irrigation. So far DCMD configuration considered to be easiest and quickest among the common configurations of MD. It has not only the highest permeate flux, but also the lowest energy consumption. Based on the current water scarcity that world is facing, it is necessary to implement most efficient separation process with respect to cost and energy savings. In that case membrane distillation is likely to be a best option. Beside agriculture applications, ongoing research on membrane distillation techniques for various industry applications is active worldwide.