Application of salinity gradient power for brines disposal and energy utilisation

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ABSTRACT

Disposal of high saline brines is a common and important problem in many industrial plants. These waste streams may be generated in large volumes in many different industries. It is well known that these concentrated brines cannot be desalted by using the conventional desalination technologies due to two crucial factors which are; cost and reliability. Moreover, these factors have limited the scope of choice of other desalination processes for such applications. Hence this paper is aimed at providing an ideal disposal method that is economically and technically capable of producing energy by mixing and then disposing of high saline brines into a large body of water, with least harm to the environment. In this paper, various concepts in the utilisation of salinity gradient power are discussed to highlight what kind of methods are being proposed around the world for the energy exploitation, and also several novel ideas were addressed in this study to present the possibilities of implementing the osmotic power plants as a dual purpose plant (power plus disposal). In addition, the paper shows the results of the mathematical calculations for the amount of energy that can be generated by mixing high saline brines (with a TDS of 100,000 ppm up to 250,000 ppm) and different sources of water. These calculations have been performed for mixing of high saline brines with: river water (with an average TDS of 300 ppm), Normal Ocean seawater (35,000 ppm), Arabian Gulf seawater (46,000 ppm) and municipal wastewater (10,000 ppm). When mixing 1 m³ of concentrated brine (100,000 ppm) with 1 m³ of river water at 25°C, 1.6 kWh of energy can be generated, whilst for 1 m³ of concentrated brine (250,000 ppm) with 1 m³ of river water, 4.03 kWh is generated. This amount of energy becomes greater by increasing the volume ratio. For Normal Ocean seawater the results show that the maximum and minimum energies available (at a volume ratio of 1) are 2.15 and 0.38 kWh, respectively, for the mixing of seawater with concentrated brines of 250,000 and 100,000 ppm. While the maximum and minimum energy available decreased to 1.82 and 0.24 kWh, respectively if the concentrated brines of 250,000 and 100,000 ppm are mixed with the Arabian Gulf seawater. The amount of energy available when mixing the concentrated brines and municipal wastewater have also been determined, and the results show that the maximum and minimum amount of energy available (at a volume ratio of 1) are 3.24 and 1.01 kWh, respectively at brine concentrations of 250,000 and 100,000 ppm. Hence the advantages and also the theoretical results proved that the osmotic power plant might be competitive with other brine disposal processes, because the outcome would render several benefits including; utilisation of alternative energy, a significant amount of energy available can be generated, safe disposal, and the energy produced is completely renewable and sustainable, clean, and green since it does not produce CO_2 or other significant effluents that may interfere with the natural climate.

Keywords: High saline brine; Salinity gradient power; Reversed electrodialysis (RED); Pressure retarded osmosis (PRO); Brine disposal process

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