Integrated Brine Mining Platform: Turning Desalination Waste into Strategic Resources

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Every day, reverse osmosis (RO) desalination plants provide essential drinking water, but at the cost of discharging more than 20 million m³ of RO brine per day in the UAE alone. Across the MENA region, RO brine discharge is more than three times higher (above 70 million m³ per day). Such massive discharges raise local salinity and temperature which disrupt marine ecosystems and accelerate environmental degradation. In addition, releasing these large volumes of brine without recovery results in the irreversible loss of valuable minerals such as calcium, magnesium, lithium, rubidium and sodium chloride. These strategic and industrial resources can be recovered for use across construction, chemical, energy and advanced materials industries.

To address these challenges, we are developing an Integrated Brine Mining Platform (IBMP), a circular economy solution that transforms desalination brine into valuable resources instead of waste. The IBMP combines several advanced technologies in a fully integrated system: nanofiltration (NF) to separate multivalent from monovalent ions and osmotically assisted reverse osmosis (OARO) to maximize water recovery while further concentrating the brine. For these membrane processes, we are developing ceramic membrane technology based on 2D materials to enhance performance and selectivity. Concentrated RO brine from the OARO process is directed to membrane distillation crystallization (MDC) to recover water and produce high-purity sodium chloride. At the same time, concentrated brine is fed into bipolar membrane electrodialysis (BPED), which sustainably generates acid and base. The produced caustic soda is utilized for carbon capture, converting CO_2 into sodium carbonate and reducing the overall carbon footprint. Additionally, we are developing advanced processes for specific ion separation to enable the recovery of highly valuable industrial and strategic minerals.

Furthermore, we will present the business case demonstrating the strong economic viability of the IBMP, using a relatively small desalination plant (ca. 40,000 m3 per day) as a reference site. The IBMP shows the potential to recover calcium, magnesium, sodium chloride, lithium, and rubidium with an estimated daily value of over half million USD. This translates to several hundred million USD in annual revenues from mineral recovery alone. Alongside mineral recovery, the desalination plant gains additional capacity by improving overall water recovery. Income from mineral recovery, freshwater recovery and carbon credit utilization shows that the projected yearly benefits significantly outweigh operational costs such as energy, manpower, and maintenance. At full scale, the IBMP demonstrates a payback period of less than one year and generates a net present value exceeding 2 billion USD over ten years. This integrated approach transforms desalination waste into valuable industrial and strategic resources, shifting from a linear (produce–use–dispose) to a circular economy (produce–use–reuse/recover).