Addressing global water scarcity with a novel hydrogel based desalination technique using saponified starch grafted polyacrylamide's hydrophilic properties to harvest fresh water with a low energy and chemical footprint

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WATER scarcity is a global crisis affecting over a billion people; it creates environmental and social stress. Desalination is a promising approach to address this crisis. With approximately 97% of the water on Earth represented by oceans, the prospect of extracting arable or potable water from seawater has the potential to impact millions of lives, particularly along the world's coasts. Current approaches are still expensive, both in monetary and energy terms; and remain out of reach for many countries. They rely on thermal, membrane, or hybrid approaches to desalinate water and impose high energy and environmental costs. Yet, seawater is on average only 3% - 4% by weight salt and other dissolved solids, while the maximum solubility of salt in water is approximately 30%. Consequently, nearly 90% of seawater is water that is not bonded with salt and potentially available for harvesting. The primary question that motivates this investigation is - whether it is possible to harvest this remaining 90% of seawater using superabsorbent hydrophilic polymers, with no external energy, under room temperature and pressure and produce drinkable water within WHO's guidance for safe drinking water. This study harvested fresh water from seawater using saponified starch-grafted-polyacrylamide's hydrophilic properties. This required a) the creation of a hydrogel to separate freshwater from seawater, b) the separation of the hydrogel from the brine, c) the dewatering of the gel resulting in aqueous sulfuric acid and d) the recovery of fresh water from the aqueous solution. The results of the investigation were promising. The study demonstrated that:

1. It is possible to use such hydrophilic polymers to desalinate water without thermal or electrical energy. Water that was not bonded with salt, bonded with the starch grafted polyacrylamide to form a hydrogel, effectively isolating it from the salt water.
2. The extracted water's conductivity was comparable to fresh water indicating that the salts have been separated. The average conductivity of the resulting water was 306.32 µS/cm, comparable to the conductivity of 200 µS/cm for the reference distilled water used.
3. That this approach has promise in mitigating desalination pre-treatment and post-treatment problems. Mass and conductivity analysis confirmed that the extracted water had a total dissolved solids concentration of 513 mg/L, (WHO guidance is <600 mg/L) compared to 35,000 mg/L for seawater. The concentration of sodium in the extracted water was 25.8 mg/L (compared to 10,500 mg/L for seawater) and that of chloride was 36 mg/L (compared to 19,000 mg/L for seawater). The corresponding EPA secondary concentration levels (aesthetic standards) for sodium is 20 mg/L and for chloride is 250 mg/L.

The process required no external energy – a significant improvement over current energy dependent techniques; fresh drinkable water yield was over 70% and produced a commercially useful fertilizer, $CaSO_4$, as a byproduct. Another significant promise of this approach is that it appears amenable to small scale use. Sustainable and accessible means for desalination have potential to improve millions of lives; the implementation of the proposed hydrogel based desalination technique may be able to address this need with very low infrastructure investments and a high yield.