



**CALIFORNIA STATE SCIENCE FAIR  
2008 PROJECT SUMMARY**

<b>Name(s)</b> Narayan S. Subramanian	<b>Project Number</b> <b>S0517</b>
<b>Project Title</b> <b>A Preliminary Investigation of the Effectiveness of Freeze Desalination</b>	
<p style="text-align: center;"><b>Abstract</b></p> <p><b>Objectives/Goals</b> The purpose of this project was to determine the viability of freeze desalination (FD) as a preliminary treatment process to reverse osmosis (RO) by measuring its efficiency through theoretical analysis and assessing its effectiveness through experimentation to find the removal of salts. FD involves a process in which seawater is placed in a freezer unit circulated with a refrigerant at very low temperatures until it is partially frozen creating an ice-brine slurry. The freezing process causes impurities to be largely excluded from the ice crystals which are relatively salt free. The ice is then separated from the brine and melted resulting in a solution with lesser saline concentration. It was hypothesized that FD would be a viable feeder process to known processes such as RO because of its potential to increase overall efficiency and decrease costs by decreasing pressure and membrane requirements through its removal of salts.</p> <p><b>Methods/Materials</b> The theoretical analysis was conducted by utilizing Van't Hoff's equation: <math>\pi=cRT</math> and determining the independent energy requirements to conduct FD and RO. The experimental analysis was conducted by designing an FD apparatus consisting of a constant temperature bath and a stainless steel vessel with an external jacket to circulate a refrigerant. 500mL of synthetically produced seawater solutions were then frozen at times of 35, 40, and 45 minutes.</p> <p><b>Results</b> The results of the theoretical analysis comparing the energy requirements for RO and FD, showed that RO would take ~11.6 kJ and FD would take ~370 kJ to produce one liter of filtered water proving that RO is far more efficient than FD. The experimental data showed that the volume of ice proportionally increased with higher freezing times. The entrainment ratio, the ratio of brine that adheres and freezes in the ice during the process, however, increased as freezing time progressed and the percentage of removal of salts consistently decreased showing that freezing for a lower time would allow for less entrainment along with a higher removal of salts lowering energy costs for reverse osmosis, but would entail lesser yield.</p> <p><b>Conclusions/Discussion</b> It was concluded that with current conditions, FD is not a viable feeder process to RO, but the experimental results still prove the effectiveness of the process in removing salts suggesting its future viability with further innovation.</p>	
<b>Summary Statement</b> A study aimed to determine the efficiency and effectiveness of an unconventional desalination process which utilizes freezing.	
<b>Help Received</b> Facilities and guidance were provided by the Indian Institute of Technology in Madras, India and Dr. Shankar Narasimhan	