

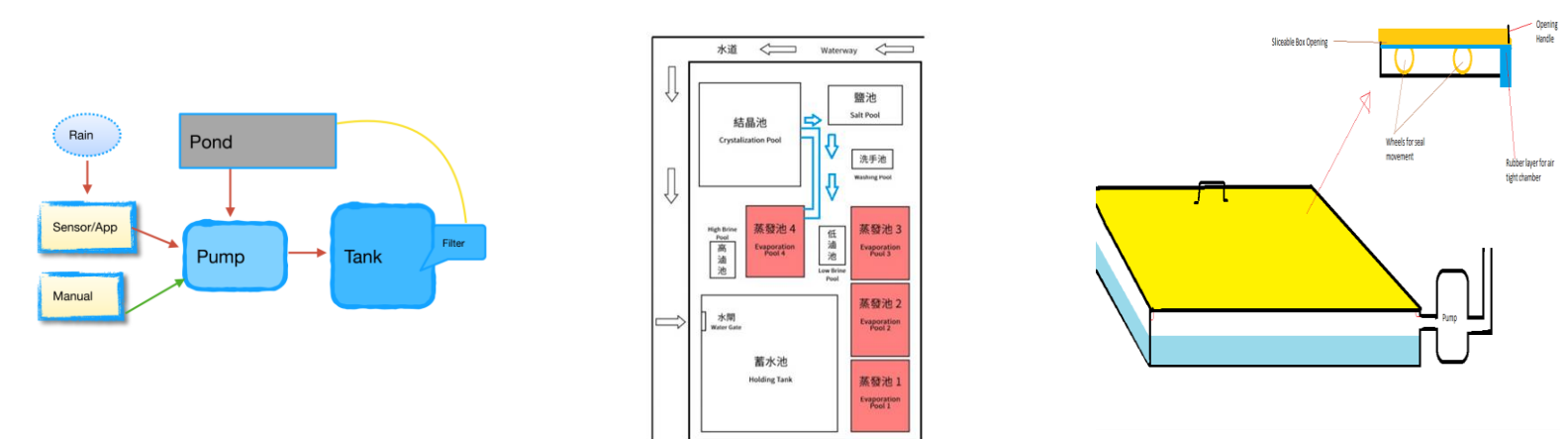
# SALT PRODUCTION ACCELERATION AND PURIFICATION SYSTEM

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## Introduction

This project aims to help our community partners to solve the problems they encountered in their salt production process on Yim Tin Tsai Island salt field. Through the field trip to the salt field and close communication with our community partners, we understand that the primary concern of our community partners is the low salt production rate and low purity of the salt produced using traditional method. Through our research and experimentation, we finalized a design of a salt production acceleration and purification system aiming to solve the problems.

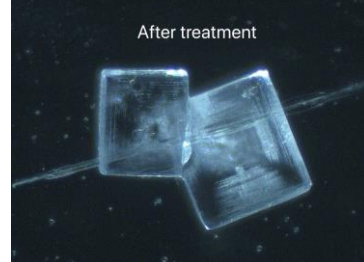
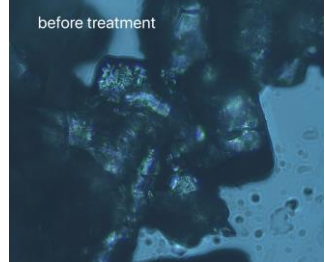
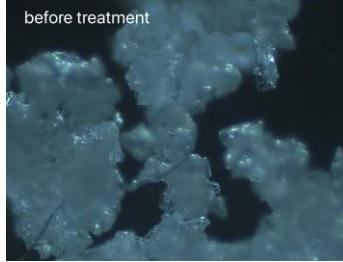
In order to meet our community partner's needs, we organized several meeting between our group members and consulted our mentors for advice. Our initial design solution was proposed in Nov, 2018, using water pumps and the separation of different ponds, (see figures below).



However, after a closer examination of the cost, manpower and feasibility of the system, we realized that it is not energy effective to move the salt water into different tanks. Thus, we refined the design into a more environmentally friendly and more feasible system, where the purification and the evaporation of salt water can be completed in one container. Based on this refined model, we build a prototype of our system (see figure below). This system contains two parts: (1) the purification system, (2) the vaporization accelerating system.



To test whether our prototype works or not, we conducted experiments using seawater collected from West Pier. To find out whether the purity of salt produced from this prototype increased or not, we also conducted a detailed analysis of the trace elements (impurities) inside the salt and compared the result of the salt produced using traditional method and our system. The results indicated a significant decrease in the trace elements of Cu ( $p=0.007$ ) and Pb ( $p=0.005$ ), which indicates our system is effective in improving the purity of salt. As for other impurities, we also took pictures of the before- and after-treatment salt crystals (see pictures below)



As can be seen from the pictures, the salt crystals after the treatment is clearer and sharp, which indicates a higher purity.

Based on the experiment results of our prototype, it is expected that this system could help improve the production rate and the purity of the salt produced on Yin Tim Tsai Island.

## Limitation and Difficulties

There were several limitations and difficulties that was met throughout the experiment. One of which was the time constraint since we were limited to the amount of days per month we could met to conduct the experiment. Due to this, we were unable to collect enough samples to replicate the data for different batches of samples for a more conclusive result on the purity of salt. Also, we were required to boil the seawater instead of slow evaporation to ensure that we were able to obtain the sample within a day and this would increase the amount of impurities on the crystals.

In this experiment, measuring density in real time was difficult since it was measured using a Baume hydrometer so we had to cool the seawater to take measurement after every interval to ensure that the density is within the limit. However, in application, this should not be a limitations as slow evaporation was used without boiling of seawater using heat so the measurement of density could be taken instantaneously.

## Individual Reflections

It was a fun and engaging experience to collaborate with my team members to solve some real-world problems. We went through the whole engineering design process: starting with identifying the problems, proposing possible solutions, refining our solutions and building a prototype and testing. The testing results indicated that our prototype contributed to the purity of the salt and the production rate. However, due to the limit of time and budget, we were not able to construct a field system on Yin Tim Island. Further tests and evaluation are needed to be considered when transferring our prototype into the sale field site. (Sunny)

Being able to work on the applied science and engineering field has both been really fun and challenging. As a team, we were able to successfully collaborate and brainstorm for ideas and plans for a solution to the problem encountered in the Yim Tin Tsai salt field which led to us doing experiments to test our theories. This is also my first real experience on using STEM education to contribute back to the society and I felt satisfied and fulfilled especially when I have a great teammates to be able to work together with. (Ching)

## Design Rationales

### • The Black Box

This is a device aiming to accelerate the speed of evaporation, the principle lays in the use of low pressure, since the boiling point of fluid changes when pressure varies. It is predicted at a pressure low enough, the sea water shall boil at room temperature where normally such evaporation is not possible, the salt will thus be left behind.

It is known as the Black Box as it is painted with black paint, according to the black body theory, black body can absorb wavelength of all type, thus maximising the energy it absorbs and be utilised for the evaporation process. During evaporation, the liquid body will lose massive amount of heat and will the heat obtain from sun, the liquid will remain at a boiling point or above. (Experiment 1 demonstrated)

Box design is inspired from one of the concern by the salt field owner, which was rain water seeping in the partially processed sea water rendering those sea water to be spoiled and needs to be reprocessed. There is also a water vapor filtering unit connecting the vacuum pump and box water as water vapor will ruin the pump if it gets into the pump.

As a backup, we have also equipped a heating unit which activated upon detected a low temperature in sea water during a cloudy day or cold day (Temperature lower than boiling point). This way, salt can be generated continuously without interruption from the change of weather, countering the problems in traditional salt making. The whole system can also be monitored and record by sensors offline as well as online for further investigation for a more effective system.

### • Salt Lab

Due to the nature of the Yim Tin Tsai salt farming method, we approached the treatment of the salt crystals by traditional means and not introduce new chemicals into the system. In the end, we proposed that the salt crystals should be collected at low density saltwater of about 25 Baume degree to increase the purity of the salt.

We have done several experiments using West Pier's seawater to test the purity of salt. The seawater was first filtered to remove any solid impurities and due to time constraint, the seawater was subjected to evaporation through boiling instead of slow evaporation which would produce salt that has even better purity. From there, we obtained 2 types of salt including salt crystals which was collected at after the liquid has evaporated to dryness and salt which was collected at about 25 Baume degree.

Another method was also proposed where the seawater was initially added pure table salt which would decrease the percentage of impurities in the seawater and so higher purity of salt crystals can be obtained. The amount of additional salt can be adjusted depending on how much volume of seawater do we want when the density is 25 Baume degree which can be calculated from the salinity of seawater. However, the experiment was inconclusive due to time constraint and the result was not able to be determined.

## Conclusion and Recommendations

This project is divided into two parts: Designing a Black Box device to accelerate the production of salt, and improving salt purity by controlling salt water density.

The Black Box is originally proposed to vaporize salt water in order to accelerate the salt production process. The black surface in the system can absorb more energy from electromagnetic waves, while the vacuum condition inside the box can lower the boiling point of salt water such that water can be vaporized at lower temperature. Sensors may also be installed inside the system to monitor the temperature, pressure inside the box. The major problem encountered is the difficulty in extracting air away from the box, since it is less cost-effective to apply large power to keep the device vacuum.

Salt purification is done by controlling the Baume degree of the salt water such that less impurity is accumulated during the crystallisation of salt. Without addition of chemicals, we have collected and filtered samples of salt water, followed by boiling the salt water to a desired salt density in the experiments. Although the experiment has produced clearer salt crystals, it is difficult to determine the exact amount of water needed to be evaporated due to time constraints.

For recommendations, it is suggested that the field work of the project is performed in summer. Since the temperature in summer is higher and more electromagnetic waves are proved, the black box can absorb more energy to accelerate the production of salt crystals.