Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Invention)

(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: JAPE190

Project Title: SWIFT Singapore Water International Filtration Team

Project Type: Invention

***To our best knowledge, there are** *similar works in the market*; (if there are,) related product links are as below:**

[1] **https://pubmed.ncbi.nlm.nih.gov/30927225/**

Gravity filtration is a simple water filtration technique on earth to produce clean, filtered water. However, gravity filtration cannot be applied in space due to the lack of gravitational force. Hence, we planned to design a simple water filtration device using centripetal force. Dirty water can be pushed through a filter to produce filtered water by applying centripetal force.

Centripetal force, the force that acts on an object moving in a circular path and pulls it inward toward the center of the circle, can be used to filter space water. In this process, a container of water spins at high speed, creating a centripetal force that pulls the water toward the walls of the container. Water will then be separated and collected at the bottom of the tank. As the water moves toward the walls of the tank, solid particles and impurities in the water are pushed to be trapped within the layers of our model, allowing clean water to come out.

Centripetal filtration is a highly effective method of filtering water as it requires an initial force and would continue to move in space, with no air resistance. This makes it an ideal solution for filtering water in space during their daily 30 minutes exercise routine to stay fit. To conserve energy, astronauts can ride on the exercise bike in space as the isolation mounts are mounted on four corners that move up and down and provide motion covering the entire axis which will help rotate the water filter. This will allow astronauts to filter water in space, ensuring a safe and reliable source of portal water. Upon disinfection, it could potentially before drinking water in space.

The enhancement our project made / the difference with related products are:

The enhancement our project made is that we created a centripetal filtration that can function efficiently in space applications and under microgravity situations with an energy conservation proposal, utilizing the astronaut's daily exercise routine to filter water and save water resources that can be utilized on other parts of the spaceship like toiletry.

I. Background

'One million dollars per day is the cost to supply water to the astronauts on the International Space Station (ISS). Four astronauts on the ISS require 12 gallons of water each day, and at $83,000 per gallon to lift into space'(Pancopia NASA, n.d.). The centripetal water filter we have created is created as a new alternative to filtering out clean water. Astronauts can harness the wasted kinetic energy into generating a centripetal force needed to turn the water filter, allowing a fast and efficient way for clean water to be created from any source of contaminated water (eg. urine)

The main literature report we would like to highlight is an article published by the Environmental Science and Pollution research (Repentigny, Zagury and Courcelles, 2019), discussing the use of MgO reactive media in permeable reactive barrier filters to treat water contaminated with metals cobalt and nickel, by raising the pH and promoting hydroxide precipitation. It compares the performance of axial and centripetal column tests in both chemical and hydraulic capabilities, with the centripetal column expected to delay contaminant breakthrough as it has lower flow speeds. However, the centripetal column filter experienced a breakthrough of contaminants before the axis filter due to a hydraulic shortcut leading to clogging,

A water filter based on centripetal force utilizes the principle of applying a force towards the center of rotation. When water is rotated at high speeds, the heavier particles are pushed towards the wall of the filter while clean water moves downwards and gets filtered and separated out. The use of centripetal force in water filtration could be an essential back-up plan for water recycling systems in space, which mainly depend on fuel cells.

II. Objectives

1. Provide a backup plan for the current water recycling system which uses fuel cells or reverse osmosis in case the system fails to work

2. Reducing waste: By enabling astronauts to recycle water for different tasks like washing and cleaning, filtered water can help minimize waste on spacecraft.

III. Methodology

Because of the microgravity, centripetal force is used to filter water in space. Without gravity, solid particles or other impurities would not fall to the bottom of a container in microgravity. Therefore, conventional filtration techniques like gravity filtration or sedimentation are ineffective in space.

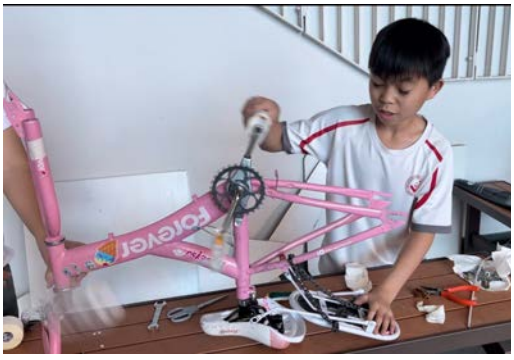
When water is spun at high speeds, the centripetal force produced by the motion pulls the liquid toward the container walls while the solid particles or impurities, which have a higher density, are pushed to the bottom of the container.

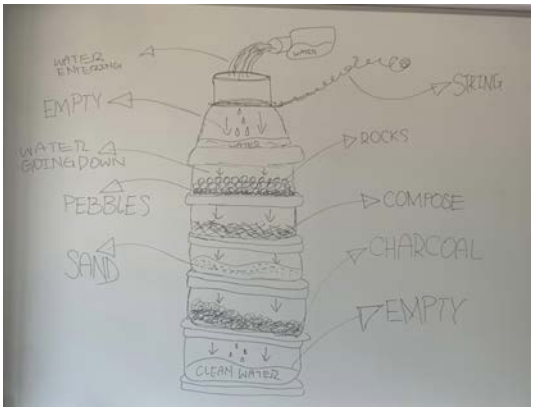
To make the filter, we used circular reusable containers as the structure of our model, as it is lightweight and easily stackable. Inside our water filter, we used

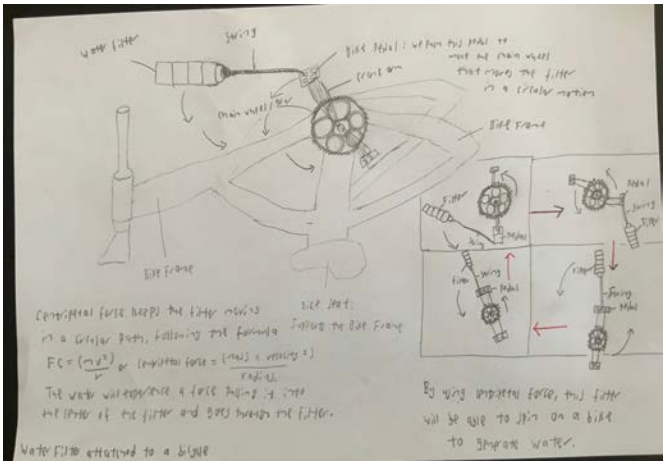
- Pebbles on the first layer to remove impurities in water and trap larger particles inside contaminated water and also increase the pH of water
- Sand on the second layer to remove suspended matter and floatable particles, trapping small dirt particles from the water in the fine pores of the sand
- Activated Charcoal/ carbon on the third layer that removes some chemicals and toxins inside the contaminated water and increases the pH of contaminated water, making it safe for household use.
- An option of compost (either using pomegranate or coconut husks, more environmentally friendly) that helps retain pollutants like oil, grease, fuels, and heavy metals, especially nickel. If needed, it will be placed between the layer of pebbles and sand.

IV. Design of Invention

The water filter consists of 6 layers, each stuck with gauze to prevent materials from mixing together. The exterior of the container is made out of plastic, and each of the layers is a different container that can be separated to replace the materials. The topmost layer is where all the contaminated water goes into, while the last layer is where the clean water comes out of. We have a string attached to the container such that it can be used to generate centripetal force when we tie it up to a bike or physically spin it so that it is more efficient. We also have holes under every layer to let the water pass on to the next layer. Using this filter, we are mostly filtering acidic waste e.g. urine.







Before making this prototype, we have made 2 previous prototypes which had containers that were permanently sealed, meaning that materials kept inside the filter cannot be replaced. In this prototype, we added an option to change fresh materials by using screw top capsules thus more practical.

V. Application / Market Need

Water is a critical resource for space missions, but many traditional filtration systems may not work effectively in microgravity conditions, meaning that an alternate solution needs to be made as microgravity can cause water to flow in unpredictable ways, making filtration difficult.

Centripetal force can be used to separate contaminants from water in a microgravity environment meaning that a centripetal force-based water filter would provide a reliable source of clean water for space missions. The development of such a filter would enhance the sustainability of long-term space missions as little to no energy is needed to continue operating it once the centripetal water filter starts spinning because of microgravity

VI. If your team will compete for the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. *(Word limit: 300 words)*

The water filter applies to the goal of clean water and sanitation. By creating this filter, we make it a possible alternative for people to filter water cheaply without using hard-to-obtain resources, making any dirty water in less-developed countries receive proper water for their sanitation and daily activities.
A centripetal water filter can improve sanitation and water supply in low-income countries in several ways:

With enough antibacterial technology in the future, the centripetal water filter will remove contaminants, especially organic compounds, which can reduce the risk of diseases due to the lack of a proper water source . This is particularly important in low-income countries where access to clean water is limited, and waterborne diseases are a significant public health concern.

Easy to use: Centripetal water filters are easy to use and maintain. They do not require electricity or complex machinery, making them suitable for use in areas with limited infrastructure and resources.

Cost-effective: Centripetal water filters are relatively inexpensive to produce and maintain, making them an affordable option for low-income countries. They can also be constructed using locally available materials, which can further reduce costs.

Increases access to clean water: Centripetal water filters can increase access to clean water in low-income countries by providing a simple and effective way to purify water. This can improve the health and wellbeing of communities by reducing the incidence of waterborne diseases.

Sustainable: Centripetal water filters are a sustainable solution to improving water quality in low-income countries. They can be used repeatedly and do not generate waste, making them environmentally friendly.

Overall, a centripetal water filter can improve sanitation and water supply in low-income countries by providing a simple,

affordable, and sustainable way to purify water. This can help to improve the health and wellbeing of communities and reduce the burden of waterborne diseases.

VII. If your team will compete for the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award. *(Word limit: 300 words)*

This water filter will also target people living in low income countries as it is easily affordable and reusable, using cheap common resources like rocks and charcoal which can be easily found. Currently, water contamination in low income countries is an alarming issue as it is full of impurities and not safe for human consumption, meaning that water-borne diseases like cholera and typhoid fever are especially common, causing many deaths and illness without proper affordable treatment. Using this filter, any dirty water found in rivers or water sources can be filtered, such that it becomes more safe for consumption very quickly and cheaply. Currently, our centripetal water filter does not filter out any bacteria or viruses, but only lowers the total amount of dissolved solids inside the water. As technology develops, with the help of UV light and a larger scale model, this might

Additionally, by installing bikes and attaching these filters to it, a larger amount of clean water will be produced once they exercise, meaning that dirty water can swiftly be transformed into a larger amount of clean portable water that can easily be replaced once in a while to consistently allow it to work. It also does not require electricity or chemicals as everything is generated by bikes or humans, meaning that it is an effective and energy efficient idea applied for low income people allowing them to receive fresh water and prevent them from ever suffering from water related diseases.

VIII. Conclusion

From the results after testing our water filtration system, the TDS and pH of water that comes out is within the range of good household freshwater, which can then be boiled for safe consumption. As the water levels are within the range, we believe that the centripetal water filter works efficiently as a substitute for reverse osmosis if it is needed in the International Space Station. Although it may not be as efficient as the Brine Processor which recovers up to 98% of water onboard the ISS , it will continue to operate under microgravity conditions,without the use of fuel cells. It is an achievable and possible alternative to what they currently have, and might even replace the current system when UV light is incorporated on it.

With the help of this water filter, resources resupply for the astronauts do not have to occur as often, as there are more ways to effectively filter out household water.

With more advanced technology (e.g. UV sterilization and ball bearing spinning axis and a larger prototype, the preliminary results on water pH and TDS make the objectives achievable.

Our project is developed based on previous project and the enhancement is below:

From our previous project, we have encountered a few challenges when we used our original filter, which we have since changed, including redesigning the entire filter model with unscrewable compartments that allow us to effectively clean the filter materials and potentially add or remove different types of materials. Last year, our filter model took 2 days to create, and was only to be used 3 times before the filter materials became dirty, or potential leaks in the filter. Additionally, last years filter was manually spinned. On top of the fact that the filter was heavy, it was very tiring to spin for 10 minutes. This year, we not only made the filter much lighter since it was made of mostly plastic, we also included the use of bike pedals to spin the bottle easier and faster without getting tired easily. The materials we used to filter the water were the same from our previous project, since we had good results in terms of filtrate purity.