Advanced Hydration Plan

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Abstract

The canoe marathon is a long distance race in which hydration is crucial. In these marathons, current methods of hydration such as water bags are inefficient and time consuming as they need to be replaced during portages. As such, this project aimed to create an alternative hydration plan which would allow users to drink directly from the reservoir, hence saving time. The final product used a filter combining Lifestraw fibres and activated carbon, as well as incorporating a check valve to prevent backflow and allow for easier sucking. The tube could also be unscrewed to allow the filter to be easily replaced for hygiene purposes. By testing the reservoir water before and after going through the filter, it was determined that the filter was able to remove coliforms from it, which were the main contaminants in water. This indicated that the water was safe to drink when using the product. It was also determined that the best place to put the product would be at the stern of the boat, behind the rudder, as it would reduce water resistance. As such, the final product allowed the user to drink on the go, saving time at the portage and improving the overall racing experience, thus making it a more efficient alternative to the current hydration plans.

1. Introduction

The canoe marathon is a long distance race with events that include distances up to 30km, and it can take up to 2.5 hours to complete. During the race, there are also multiple portages, in which the participants would have to carry their boats for a short distance on land. Due to the long and intensive nature of the race, hydration is crucial for the athletes to help maintain their performance throughout the whole race. Through hydration, athletes can constantly regulate their body temperature, reducing any heat stress and maintaining muscle function. (Jade, 2018) Furthermore, the race takes place under the hot sun, thus the athletes lose water very fast, increasing the chances of dehydration, which can have severe consequences such as heatstroke. (Wald, 2012) As such, there is a need to constantly replenish bodily fluids for optimal performance.

Despite the importance of hydration, the current hydration plans used by athletes are quite inefficient. The most common method is to use a water bag, which can only store up to 800ml of liquid. As such, they need to be replaced periodically due to their limited capacity. This is done during portages, where the athletes would have to go into a feeding lane, and their support crew would help them change their water bags. By doing so they would have to travel a longer distance, and their competitors could overtake them by taking the shorter express lane if they do not need to replace their water bags. This wastes valuable time and energy, and with multiple portages throughout the race, it becomes an even bigger problem. As such, the current hydration plans are quite inefficient as they need to be replaced during the race, which is time-consuming.

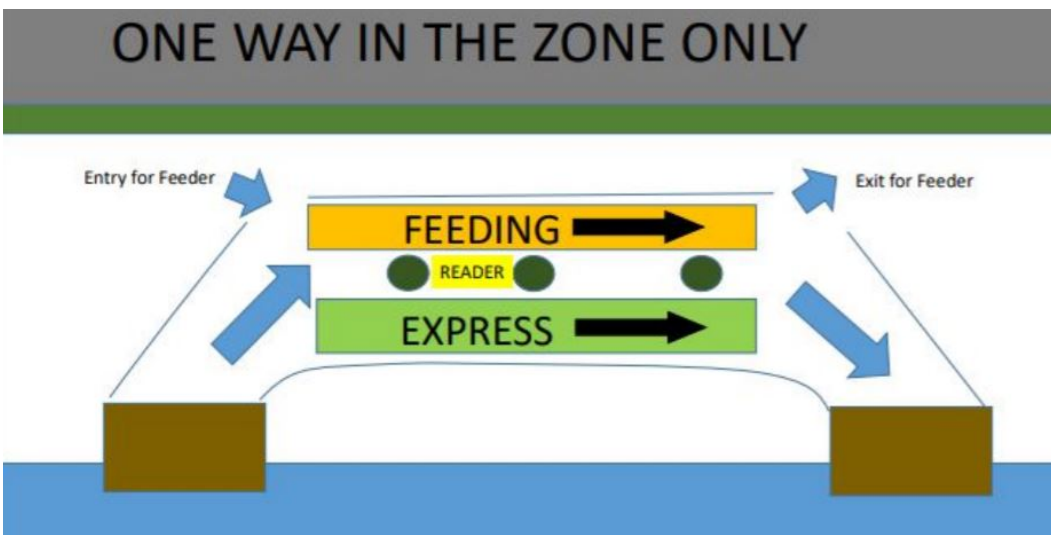


Figure 1: Difference between feeding and express lanes

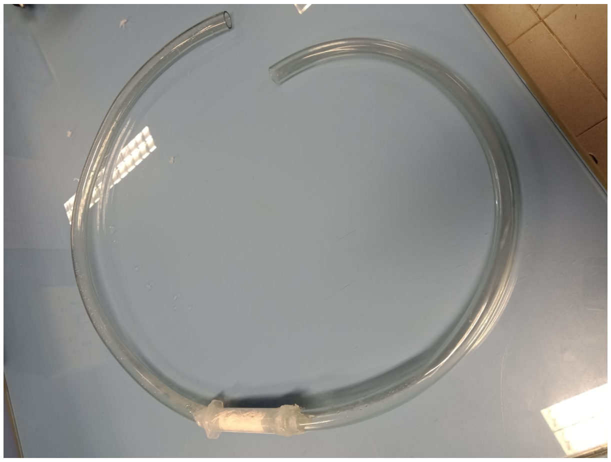
Due to the drawbacks of current solutions, this project aimed to create an alternative hydration plan that would allow users to drink water directly from the reservoir, thus eliminating the problem of having to change water bags at the portage. This would help the athlete to save valuable time and energy at the portage, while still providing sufficient hydration for the athlete throughout the race, allowing him to perform at his best.

2. Solution Design

The product would be a straw-like structure with a filter, which would be attached to the boat, thus allowing the athlete to drink water directly from the reservoir. This would allow them to drink with ease while paddling. Since the athlete would not have to carry the product personally, as it is attached to the boat, it also reduces the strain on the athlete. As such, the proposed solution could help save time and energy, allowing for a better race.

2.1: First Prototype

The first prototype comprised two plastic tubes of diameter 1.70cm, which were attached to both sides of the body of a syringe by using hot glue. The syringe contained the filter, which was the hollow fibres used for filtration in the commercial product, the LifeStraw. The LifeStraw used physical filtration, in which water was forced through hollow fibres with pores measuring less than 0.2 microns across. These fibres trapped dirt, bacteria and parasites, allowing clean water to flow through. (Barksdale & Kreshner, 2009) This method of filtration was selected as it was the most cost effective, costing only $11.57 as compared to other alternatives. The LifeStraw fibres were also lightweight, and could be easily modified to fit tubes of different sizes, thus making them ideal for this project. However, due to the tubes being too wide, it took a long time to suck up water, thus making it ineffective.



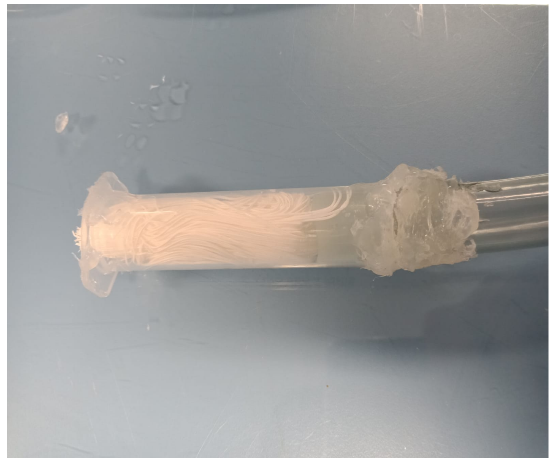


Figure 2: The first prototype

Figure 3: Close up view of the filter

2.2: Second Prototype

Two changes were made to increase the efficiency of sucking from the tube. Firstly, the large tubes were replaced with smaller tubes of diameter 0.70cm. The LifeStaw fibres were also placed directly into the smaller tube. This made it easier to suck, but since it took a while for the water to pass through the filter, it still took some time to suck water through the full length of the straw. As such, a check valve system was also implemented at the bottom of the straw. This system allowed water to flow in one direction only, which was into the straw, while preventing water from flowing out. This allowed the tube to remain full once it was filled up, saving time as water did not need to be sucked through the entire tube. During the race, when the athlete drinks, he would suck in water from the bottom of the tube, replenishing the water in the tube. With the one-way valve, the water would not flow out from the tube even when he stops drinking. Although this might have required the athlete to fill up the tube before the race, the benefit of being able to drink water more efficiently outweighs the slight inconvenience. The valve was constructed using the rubber stoppers from a 10ml and 20ml syringe, and it was successful in increasing the sucking efficiency. However, one main problem with this prototype was that the filter could not be replaced, thus making it infeasible for long term usage.

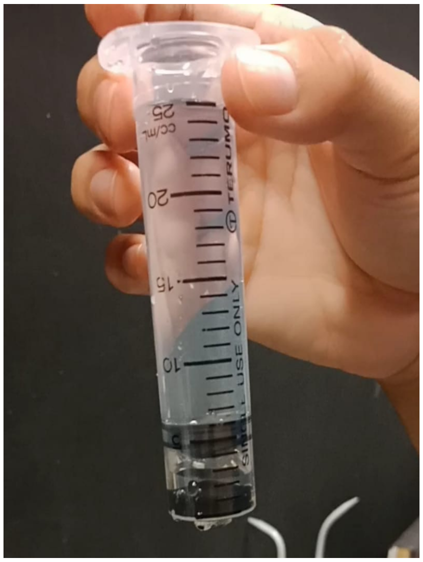


Figure 4: The check valve

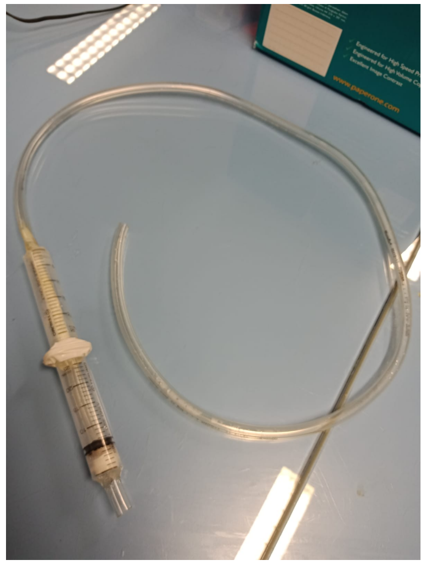
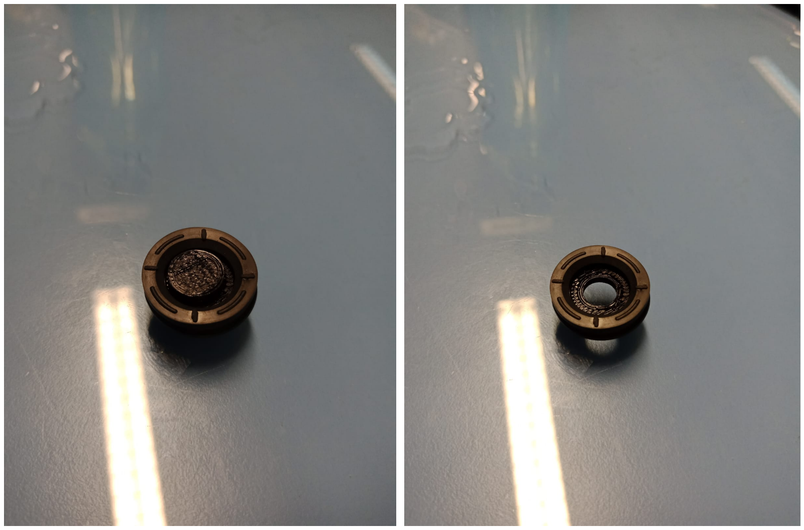


Figure 5: 2nd prototype

2.3: Final Product

The final product had 3 main changes from the second prototype. Firstly, 3D printing was used to construct a more effective check valve, which would be better at preventing leakage. A cylinder of diameter 15.50mm and height 2.20m was printed with a 7.20mm wide hole in the middle, and it was slotted into a rubber stopper to allow it to fit into the 20ml syringe. A cylindrical stopper of diameter 11.50mm and height 2.3mm was also 3D printed.



Figures 6 & 7: Improved check valve with and without the stopper

Secondly, activated carbon (AC) was added to the filtration system. Activated carbon is a highly porous, high surface-area adsorptive material that is commonly used in water purification. (Koehlert, 2017) It can trap chemical impurities, contaminants and odours through adsorption, in which the impurities are chemically bound to the carbon. (Helmenstine, 2019) As such, by adding it to the filter, it would be able to further purify the water, as well as removing the potential smell that would be caused by long term use. To incorporate AC into the system, 3D printing was used to manufacture two cylindrical partitions of diameter 20.00mm and height 5.00mm, with multiple holes measuring 1.5mm across. These were slotted into the syringe, and the space in between was filled with activated carbon pellets. Due to the small size of the holes, only water could flow through the AC to be purified, while the AC pellets would not fall out, thus creating an effective activated carbon filter.

Figure 8: 3D printed partitions

Figure 9: Activated carbon filter

Thirdly, a modified structure of a bottle cap was incorporated and spiral grooves were added to allow the tube to be unscrewed. This change was made to the prototype so that users can replace the filter and AC pellets after long term usage. This was more hygienic as the filters would get dirty from trapping impurities, thus they would need to be replaced after a while to allow for continued usage. After unscrewing the tube, a pair of tweezers must be used to remove the LifeStraw fibres to replace the filter. Similarly, to replace the AC pellets, a pair of tweezers had to be used to remove one of the partitions, before the pellets could be poured out and replaced. The structure was made by 3D printing two separate parts, namely the finish and the closure. The finish was the part with outer grooves, usually located at the opening of a bottle. On the other hand, the closure was the part with inner grooves, which would usually be the cap of a bottle. The finish was made with an inner diameter of 20.60mm and a height of 20.10mm, in order to allow the partitions to be removed for efficient replacement of the AC pellets. The closure was made with an inner diameter of 22.30mm and a height of 24.4mm, in order to be screwed on nicely to the finish.

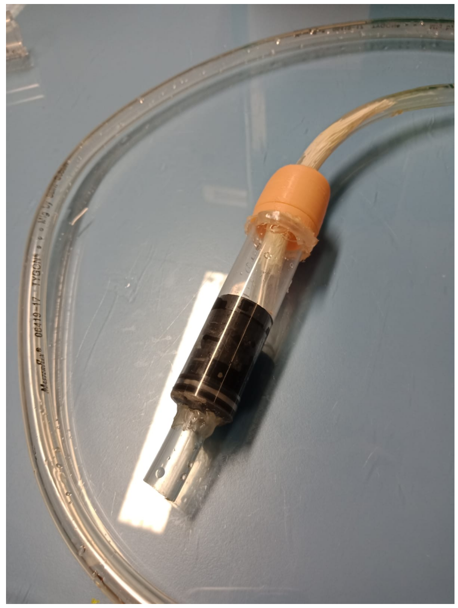


Figure 10: Finish & closure   Figure 11: Final Product

In conclusion, the final product made use of both LifeStraw fibres and activated carbon in its filtration system, thus involving both physical and chemical filtration. It also had a check valve to increase the efficiency of drinking, and the tube could be easily unscrewed to allow the fibres and AC pellets to be changed easily, thus it could be used for a long period of time. As such, the final product would be a viable alternative to current hydration plans, as it was more efficient, simple to use, and it could help save valuable time and energy during the race itself.

3. Results and Discussion

To ensure that the product was functional, testing was carried out to determine the effectiveness of the filter, and research was done to find the optimal position on the boat to place the product.

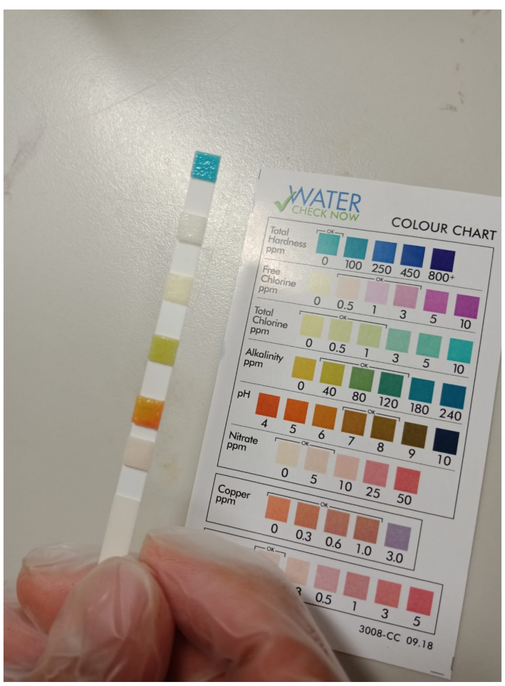
3.1: Testing of Water

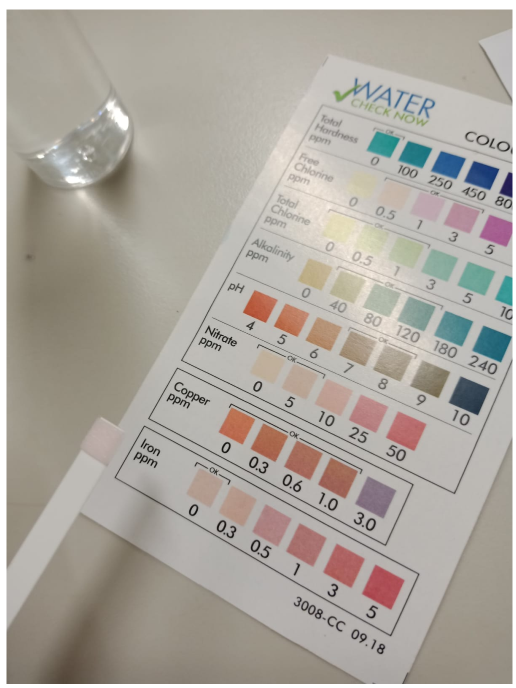
Samples of water from MacRitchie Reservoir were collected and tested by using the Water Check Now™ Advanced Water Test Kit from Wateroam, which could be used to identify safe drinking water according to World Health Organisation (WHO) standards. These samples were tested before and after being passed through the filtration system, in order to determine the effectiveness of the filter. The water samples were tested for the presence of coliforms, which are a type of bacteria that is usually present in larger numbers and is relatively easy to identify. As a result, testing for coliform bacteria could be a reasonable indication of whether other pathogenic bacteria were present. As such, total coliform counts give a general indication of the sanitary condition of a water supply. (New York State Department of Health, 2017)

Figures 12 & 13: Positive and negative results for unfiltered and filtered water respectively

For the coliform bacteria test, 10ml of filtered and unfiltered water respectively was poured into two tubes with the testing tablet and left to incubate at room temperature for 48 hours. After that, a yellow solution would indicate the presence of coliforms while a red solution would indicate that coliforms were not present. As such, it could be seen that the unfiltered reservoir water on the left tested positive for coliforms, while the filtered water tested negative, indicating that there was likely no bacterial contamination and the water is safe for consumption. Therefore, it could be concluded that the filtration system was effective and the product could allow the user to drink straight from the reservoir safely.

Chemical testing was also carried out on the unfiltered water to determine the total hardness, chlorine content, alkalinity, pH level, and the presence of nitrate, copper and iron ions. This was done using test provided in the water testing kit. The results showed that most of the categories were already in the safe range, with only the pH level being slightly acidic. As such, the original water was already free of chemical contaminants, making bacteria such as coliforms the main problem. Since the filter was able to filter out such coliforms, it was determined that the filtered water was largely free of both chemical and bacterial contamination, making it safe to drink.





Figures 14 & 15: Results of chemical testing

3.2: Optimal position for attachment of product on boat

Technically speaking, the ideal position of the product would be at the end of the boat, at the stern, where the water resistance it created would be the least, as the product would have minimal effect on the shape of the boat. However, such a system would not be feasible. The close proximity of the product to the rudder could affect the steering of the boat, and the length of the straw would make the process of sucking the water too tedious. As such, the best position to place the structure would be approximately 1m behind the seat in the kayak, right after the point where the kayak starts to thin out, as shown in figure 16, to obtain the optimal balance between the water resistance caused and effort used to suck the water efficiently. In addition, the product should be attached such that only the tip is submerged underwater to reduce water resistance.

Figure 16: Optimal position to place product on boat

4. Conclusion

This project had successfully constructed an alternative method of hydration, which enabled users to drink water directly from the reservoir safely. The product was simple to use and its parts are easily replaceable, allowing it to be used for a long time. The parts used in the product were also relatively cheap, and the overall product is lightweight and would not cause strain on the user. As such, the product is a feasible alternative to current hydration plans, allowing users to save time and energy during their race by taking away the hassle of replacing their water bags.

Possible future work would be to improve the check valve system, as it currently still allows some water to drip out slowly. The filtration system could also be further improved on, possibly incorporating other methods of filtration to increase the effectiveness of filtering heavy metal ions. Further testing could also be done by actually attaching the product to a boat and testing it while paddling. This would help to better determine if the product is feasible under real life racing conditions.

5. References

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