Eliminating microplastics from bodies of water by using an innovative system

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Abstract

It is reasonably certain that microplastics are the most dangerous pollutants of plastic for aquatic organisms and humans. Thus far, there is not yet a large-scale system in place to eliminate microplastics from major bodies of water. In this report we describe different developmental phases of one such design and suggest possible applications. It is named ‘The Banana’, and takes its name from its distinctive shape. The front of the Banana is equipped with a wall which redirects larger litter, stopping it from entering the Banana itself and preventing it from clogging. The remaining litter, carried by the flow of water, will follow the net of the Banana and flow through the storage containers. Valves in the storage containers prevent the water from flowing back. Attached to the storage container is a storage bag which collects the microplastics. These bags can easily be exchanged for new bags while emptying the Banana. This system has been tested and operated as desired, eliminating microplastics. The system can be used in all kinds of circumstances for example in front of a weir or in the plastic litter trap from Recycled Island Foundation.

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Personal motivation

When we had to start with the 'meesterproef'[1] we knew we wanted to create something that could contribute to a better planet and world. That's easier said than done. The initial question was what is a big problem regarding our planet and is also a possible threat for us humans? We were gripped by the plastic crisis. This is a problem that damages our planet, is everywhere, isn't easy to solve and it is a threat for humans. Besides that, it is a problem we are faced with every day: polluted roadsides on our way to school and riverbanks of the Waal[2] covered with plastics. The ideal problem for us to tackle! But there are already solutions to eliminate plastic from the environment or preventing it. However, the existing solutions for catching plastics don't catch smaller plastics, microplastics. After some research, we found out that these plastics were even more harmful than the larger plastics. After that, we were determined to create a solution to filter the microplastics out of our rivers.

[1] The 'meesterproef' is a project from the subject O&O (research and design) which lasts one school year.
[2] The Waal is the main branch of the Rhine river, which the city of Tiel is located next to

Introduction

Mostly images of marine animals suffocating in plastic and birds with stomachs full of plastics comes to mind when thinking about the plastic crisis. But when we take a closer look, we discover that there is a possibly bigger, more invisible problem caused by smaller plastic litter called microplastics. Microplastics are small plastic particles with a size between 5 mm and 50 µm (0,05 mm) (Wageningen, 2018). Microplastics can be divided into primary and secondary microplastics. Primary microplastics are deliberately made this small and are used for example in cosmetics, personal care or for the production of plastic items (as shown in figure 1) (GESAMP, 2016) (McDermid & McMullen, 2004) (Lei, et al., 2017) (Review of Microplastics in Cosmetics, 2014). Secondary microplastics originate from bigger plastic items, due to for example wear and tear and degradation (KNOLL, 2016).

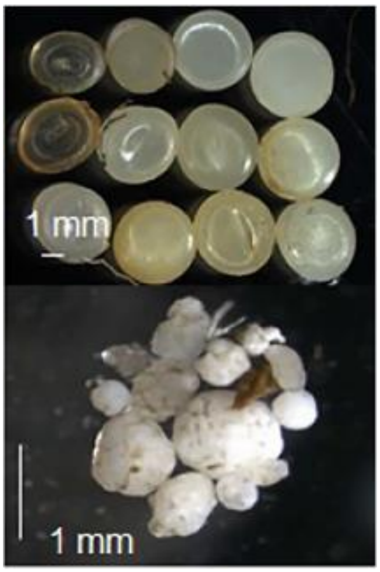

Figure 1- Typical particles found in the runoff from the production plant. The upper image shows translucent pellets and the lower image shows fluff and fragment found in the lower size-fractions. (Karlsson, et al., 2018).

Microplastics have been found in a wide variety of aquatic species (Gall & Thompson, 2015). There is also evidence of trophic transfers of plastics and transfers of sorbed contaminant from plastic due to ingestion of other organisms have been suggested (Bakir, Rowland, & Thompson, 2014). Microplastics absorb dangerous chemicals from water or already contain them (Mato, et al., 2001). The absorption of these pollutions when microplastics are ingested could be harmful to aquatic organisms, the amount of ecologically adverse effects are however unknown (Bakir, Rowland, & Thompson, 2014).
Not only are microplastics harmful due to the added and adsorbed chemical but also due to the shape. The shape of microplastics can perforate the intestines of organisms. Microplastics can pass through the created holes and cause even more damage to other cells and could possibly stay in the organism for a long time (Browne, Dissanyake, Galloway, Lowe, & Thompson, 2008). There has even been documented that microplastics can be taken up into cells of the blue mussel where they cause significant effects on the tissue (Von Moos, Burkhardt-Holm, & Köhler, 2012).

The potential damage of microplastics doesn't only limit itself to aquatic organisms. The average European that consumes shellfish on a regular basis ingests 6400 pieces of microplastics a year (Ghent University, 2018). There has been research on accumulation of microplastics in different kinds of tissue of mice. Mice are chosen for this research because a mouse has many genetic similarities with humans. The results of the investigation indicated that microplastics accumulated in liver, kidney and gut. The results suggest an induced disturbance of energy and lipid metabolism. The also mice needed more energy because of oxidative stress[3]. The results also indicated potential toxicity from exposure to microplastics. (Deng, Zhang, Lemos, & Ren, 2017)
There's little published research about the effects of microplastics on the human body. We suggest that there should be more research on this subject because it's concerns the health of humans there shouldn't be taken any unnecessary risks. Research with the smallest indications that indicate health risks should be taken seriously until the contrary is proven.

The question is then; how can we solve the microplastic problem? There are three main solutions: stopping the use of plastic altogether, eliminating bigger plastic litter from water or preventing them from entering the water (because these will break down in microplastics) and eliminating microplastics for water itself. For the first two solutions are already campaigns and litter traps made. Only for the latter, the

[3] Oxidative stress is a metabolic condition were more reactive oxygen molecules are released than usual. Creating free radicals which attack molecules and genes causing the molecules to change their structure.

elimination of microplastics directly from water aren't solutions yet. That's why we have challenged ourselves to create this solution.

For our meesterproef we had to find a client. Our client was Recycled Island Foundation (RIF) who catches plastics from the Rhine in Rotterdam right before they can enter the ocean. After the meesterproef we continued with this project. With this report we want to put our system in a bigger perspective than only the application in the plastic litter trap of Recycled Island Foundation.

Design requirements

The design requirements were drafted from the findings of our preliminary investigation. The design requirements are the foundation for each design. All requirements will be included which vary from limitations for the design, conditions, and wishes. Furthermore, the design requirements also acts as a checklist to see if the design fits the requirements. We had made a full checklist from that we will mention the main requirements. The most obvious demand is of course that the design should be able to catch microplastics. Besides improving the water quality, the design may not cause more damage to the environment than that it heals. This includes that the product may not cause irreparable damage to multi-celled organisms when applied; that the product consists of sustainable materials that have a long lifespan and are reusable and most important the product may not be a source of microplastics itself. There are also some functional demands. The system must be energy neutral, must be durable (for instance it should survive the impact of trunks) and the microplastics can be easily removed from the system where one person can do all the operations in a quarter of an hour. Besides the design requirements, there were also wishes. It is preferred that the system is passive which means that it doesn't use electricity. Such a system will need less maintenance. We want a system that needs as less maintenance as possible, preferable twice a year or less. The focus of this project is to eliminate microplastics but one of the wishes is that the design eliminates plastics smaller than one centimetre because these plastics aren't caught by the existing plastic catchers like the one from Recycled Island Foundation, see figure 2.

Figure 2 - One of the plastic litter traps from Recycled Island Foundation (Recycled Island Foundation, 2018)

First prototypes

We have come up with multiple ideas to eliminate microplastics from water. We have chosen two of them based on the design requirements to be further developed: 'the Bubble Maker' and 'the Banana'.

The Bubble Maker

The Bubble Maker is derived from a technique called froth flotation which is used in scientific research to separate microplastics from other materials (Alter, 2005) (Fraunholcz, 2004). The technique is based on the fact that microplastics are hydrophobic which means that microplastics prefer to adhere to other hydrophobic substances, for instance to air instead of water (Crawford & Quinn, 2017). At the front of the Bubble Maker, there's a wall that will separate the bigger waste from smaller litter (see Figure 3). This will prevent clogging and damage to the more fragile electronics. The water without the bigger waster will pass through layers of air bubbles. The microplastics will adhere to the bubbles due to the hydrophobic nature of air and will, therefore, rise to the surface. The bubbles will create a foam layer together with other substances in the water (e.g. algae) in which the microplastics are located. The foam with microplastics will accumulate above the storage container where it will be smashed due to the waves which are able to pass over the top plate. As a result, there will only be microplastics in this container. Figure 3 shows that the air hose is located under a roof, therefore no water can enter this air supply. The power supply has not yet been taken into account in this prototype.

The Banana

The shape of this idea, as shown in figure 4, gave this idea its name. The idea of Banana arose during brainstorming about applications of the method 'density separation' and ‘algae nets’ (Crawford & Quinn, 2017). Algae nets are mostly used to catch microplastic in the upper water layers when towed behind a boat, but can also be used in deeper water layers (Silva, 2018) (Hydrobios, 2018). Density separation uses the fact that microplastics have a certain density, which is around 1 gram per cm3 and that water itself has a density of 1 gram per cm3 (Crawford & Quinn, 2017) (Hidalgo-Ruz , Gutow , Thompson, & Thiel , 2012).However, the microplastics do not have a density of exactly 1 gram per cm3, so the microplastics tend to be in higher or lower water layers, depending on their density. To capture the microplastics, we have come up with the idea of attaching a net in the shape of a Banana to a wooden frame. By attaching a frame to the bag, the net can't close and therefore can’t block the flow of microplastics. Water will follow the shape of the net and go through the storage cylinders. This system has a shape of a banana so that it has storage cylinders at the top and bottom. Thence the microplastics with lower densities will mainly be collected in the higher storage container and vice versa. In the storage cylinder is a bag attached with small enough pores which micro plastics can’t pass but big enough so that water can pass true it. Therefore, the microplastics will accumulate in the bag.

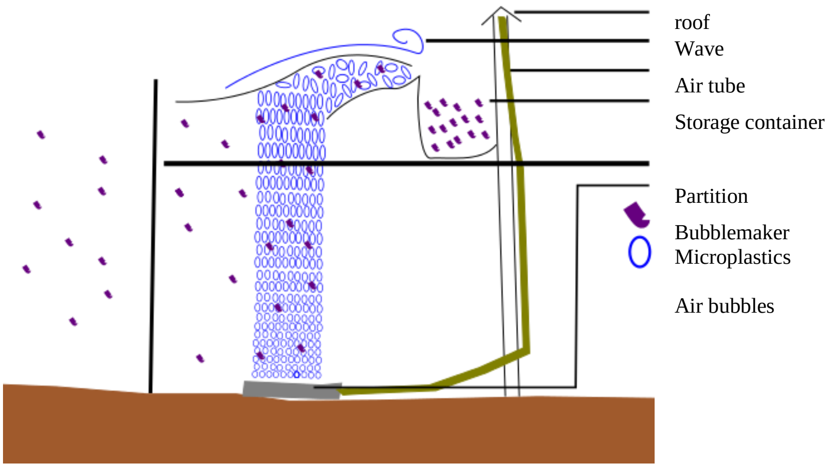

Figure 3- The Bubble Maker

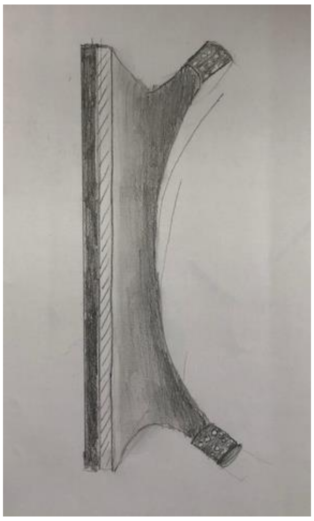
Figure 4- The Banana sketch

Test

In this test the Bubble Maker and the Banana were tested. In this test we have investigated which prototype could eliminate the most micro plastics from the test setup.

Research question

Which of the two ideas is the best in eliminating microplastics from the test setup?

Method

Materials: The ‘Bubble Maker’ prototype; The ‘Banana’ prototype; Scale with three decimals, Fountain pump; Tap water; Timer; Container

The 'Banana' and 'Bubble Maker' were placed separately from each other in a container filled with water for a period of 30 minutes. Pre-weighed microplastics (PVC) in all sizes were added to the water tank. To create a flow in the tank, a fountain pump was placed in the container. The suction side of the pump was located behind the prototype and the end of the hose in front of the prototype. In this way, there was a flow in the container which moved mainly in one direction. During the test, occasional stirring took place in the tank so that the precipitated microplastics would float in the water layers again. After 30 minutes the prototype was removed from the water, dried and the percentage of removed microplastics were calculated.

Results

	Added microplastics	Total microplastics captured	Mass percentage of microplastics captured
The Banana	1.257 grams	0.136 grams	10.8%
The Bubble Maker	1.266 grams	0.003 grams	0.24%

Conclusion

The Banana captures more microplastics, 4500% more than the Bubble Maker when looking at the mass percentage of the microplastics eliminated from the water.

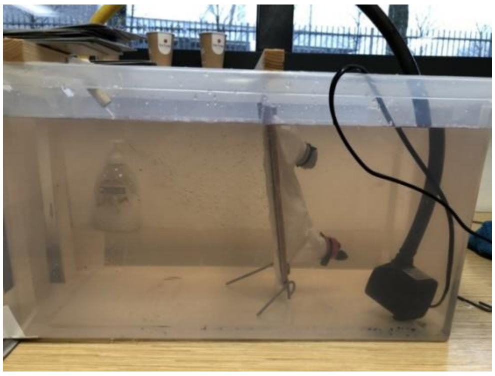

Figure 5- The Banana first prototype

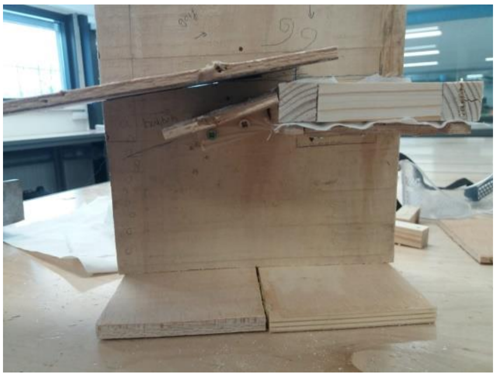

Figure 6- The Bubble Maker first prototype

Improvement proposal 1

Given the program requirements, ‘The Banana’ has been chosen, mainly because of the following points, which will be further explained:

- Test results
- Energy consumption
- Robustness
- Maintenance
- Time to empty the system
- Pollution during the production process

The test results of the Banana were considerably better. While the Banana captures almost 11% of the total microplastics, the Bubble Maker captures only 0.24% of the microplastics. In addition, we had the feeling that the Banana is easier to improve in order to achieve a better result than the Bubble Maker.

Another advantage of the Banana compared to the Bubble Maker is that the Banana does not consume any energy and therefore is a passive system. This was one of the wishes included in the design requirements. When the system is passive, it requires less maintenance and less pricier components, which makes it cheaper to realize.

The idea of the Banana is much easier to empty; the Banana's storage containers are easier to loosen due to the screw mechanism. It is also easier to reach the Banana storage container, because the Banana is not behind or under anything. This was not the case with the Bubble Maker, because the cloth, where the microplastics ended up, had to be removed from the top. The Bubble Maker needs to be removed from the water to remove only the microplastics. That's why the Banana is much easier to use as well as to empty the storage containers. Emptying the bubbler's tray could be made easier, but that would be a difficult process and it would be unsure if the test results would then be better.

It is expected that the Bubble Maker will pollute the environment more during the production process than the Banana, because the Bubble Maker needs solar panel, electronics and a pump to function. The production of all these products contributes to environmental pollution (Greenpeace, 2019).

For these reasons it was decided to continue with the idea of the Banana. Besides the things that were already good about the idea, there are of course always points of improvement. In the case of the Banana, these are the storage containers and the wall. In the text below we're going to improve the storage containers with an added heart valve and ad a sieve wall in front of the system.

Storage container

During tests, we discovered that it was not easy to remove the microplastics from the system. At each end of the Banana there was a cap of a soft drink bottle. Between this cap and the corresponding screw there was a small pouch attached. The bags had to be loosened with great care before they could be emptied to ensure that no microplastics were released. When the bag had been emptied, the bag had to be put back between the screwing mechanism. This was quite a difficult job to do because the bag was difficult to keep in the right place while screwing. In order to improve user comfort, an application has been devised, which makes it easier to replace the bag. This application works as follows: at the Banana side is threaded side in which a bag is integrated instead of a separate bag. A cylinder goes over the bag and tightened itself to the screw by turning (just like a bottle). The cylinder is tightened at the end of the Banana. The bag is attached by a string to the threaded side (end of the Banana). If the cylinder is unscrewed to remove the microplastics, another string can be tied around the bag so that the bag is closed.

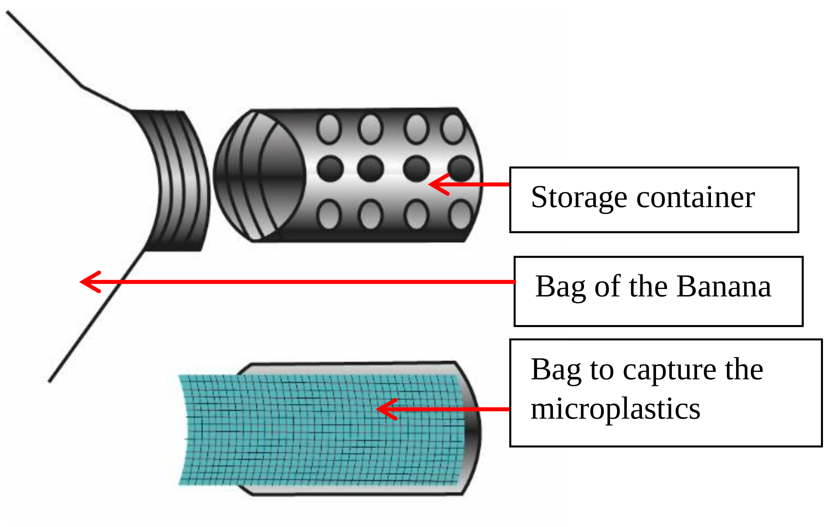

Figure 7- Outer view of cylinder and cross-section with bag

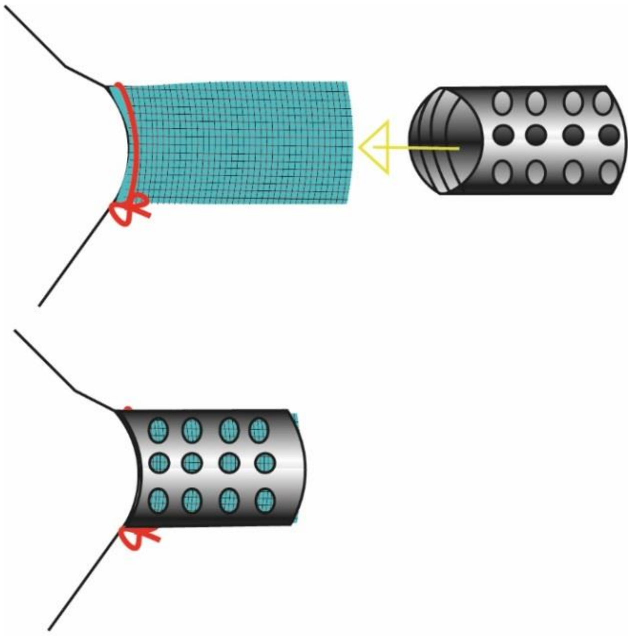

Figure 8- Outer view of application cylinder and bag

After that the bag has been tied tightly, the thread on the screw side is loosened. Then a new bag is attached to it in the same way, the cylinder goes over it again and the system can be put back in the water. So that the system can capture microplastics again.

Heart valves

Captured microplastics are stored in cylinders, but it is also important that the captured microplastics remain there. After some brainstorming, an idea came up that is derived from heart valves. The function of the heart valves is to let the water flow in one direction only, so that the microplastics stay in the cylinders when the directions of the flow changes.

The choice was made to build an aorta valve. The valve is attached with strings to the wall of the end of the Banana. This prevents the valves from folding the wrong way when the flow direction changes, thus holding the microplastics in place.

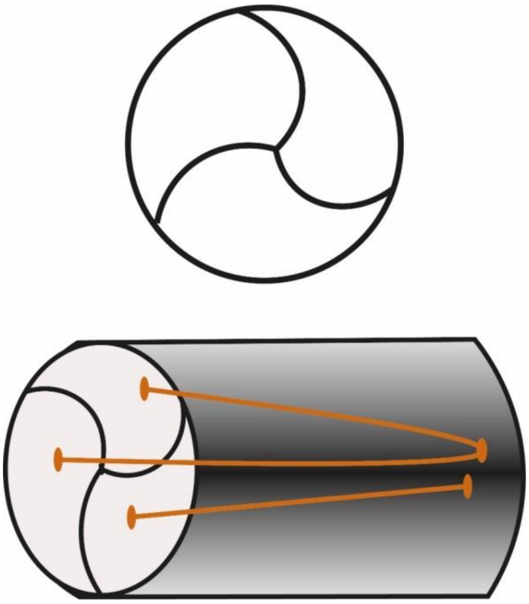

Figure 9- artificial heart valve

Sieve wall

Before the water enters the system, the large components in the water must be separated from the smaller components otherwise these will clog. For this purpose, a wall has been designed with openings of one by one centimetre. The 'sieve wall' must not be blocked by leaves, plastic bags or other large pieces. For this purpose, a wall has been made that undulates from the top to the bottom and from the left to the right. This creates 'tops' and 'valleys' where the water can flow from the sides so that leaves or other large components won't clog the wall. With a short test we tested the wall in a container with water and leaves. We observed that the leaves couldn't stick to the wall and lock up the wall completely, the water could always go behind the leaves. The leaves would stick to a normal flat piece of chicken wire and clog it up.

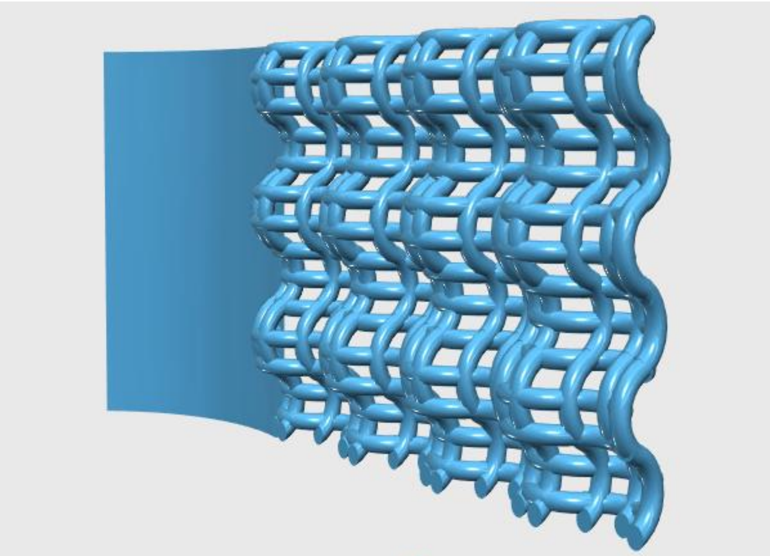

Figure 10- Angled front view of the sieve wall

Elaborations of Improvement proposal 1

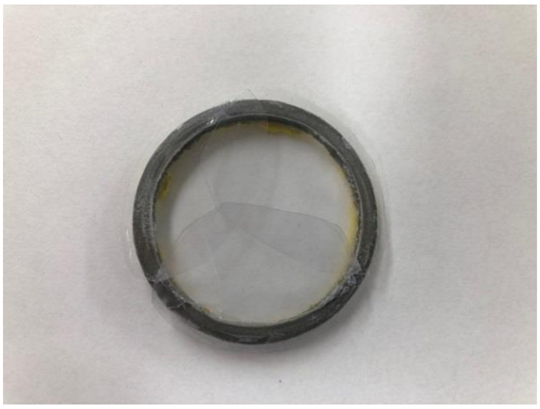

Figure 11- Aorta valve made of plastic semi-circular

We have tested a variety of heart valves. The first heart valve that was made was based on the aorta. There are three semi-circular flaps placed on top of each other so that the microplastics can only enter them in one way (see figure 11). The material of the moon-shaped flaps had to be both firm and flexible at the same time. In the first test we used paper as a material, this worked perfectly. This was tested by blowing against the valve from both sides. However, this is not a water-resistant material. A material that does meet this requirement is plastic. After carefully assembling the heart valve made of plastic, it was time to test it. This was done using a bucket of water. To see if the water could pass through only one direction, food dye was used which was added to the water. The water couldn't pass through in any direction. The material was apparently too strong, so that the valve didn't open during the current. So, we decided to create a different mechanism.

Figure 12- bottom and side view of the heart valve made of crafting foam

In the other mechanism, there is one circular valve attached between two beams that are placed transversely onto a ring (see figure 12). The material used for this test is crafting foam. This material was chosen because it is slightly weaker than plastic. Crafting foam offers less resistance but is still strong enough to stop the water. After making the heart valve, it turned out that by attaching the material to the beam, the material assumed certain curvature. So, that the heart valve couldn't close completely.

In the end, the choice was made for a two-valve heart valve, because this mechanism does not suffer from warping and is easy to make. However, a different material had to be used than the crafting foam because this wouldn't work with the hinges. Besides that, in our final design we want to use a more sustainable material. In the end we made the choice to use aluminium. This is because it is both a strong material as well as easy to work with. During the testing of this heart valve, a problem was discovered: the valves could be opened too far so that the valves could no longer return to their closed position due to the water pressure (see figures 13 and 14). To ensure that the valves could not 'overstretch', two small blocks that have a slanting side have been placed on the beam. As a result, the valves could not be opened too far because they would bump against the blocks. This application makes it possible for the valve to close when the water was flowing from the other side.

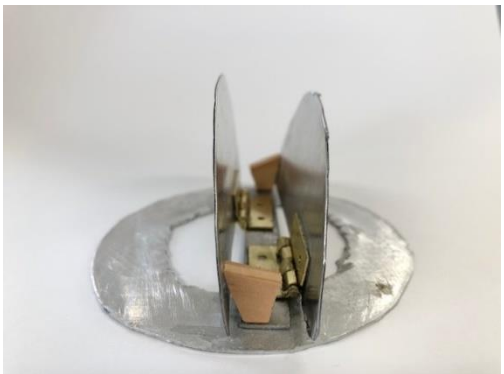

Figure 13- Side view metal heart valve (opened)

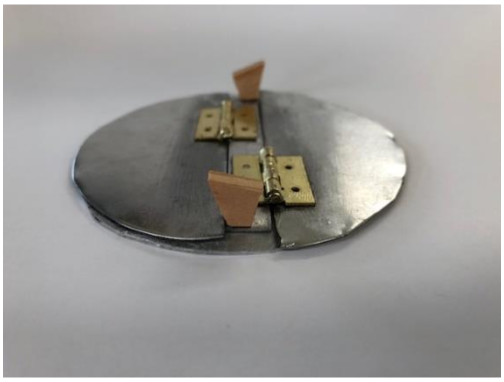

Figure 14- Side view metal heart valve (closed)

Improvement proposal 2

After our brainstorm sessions and improvement proposals 1, the idea was finally made in such a way that it captures the plastic and retains it when there is a change of current direction. The idea is explained using the images below. These images will be used to create a prototype.

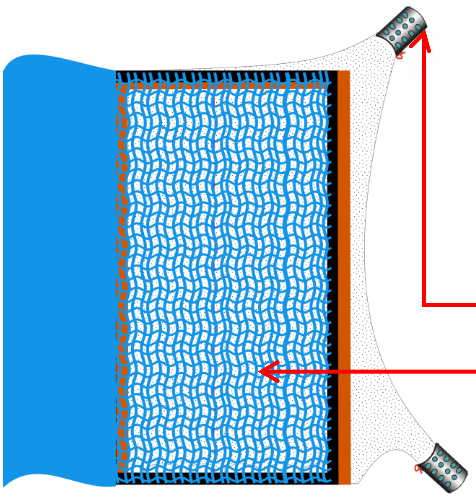

Figure 15- Front view banana (sketch)

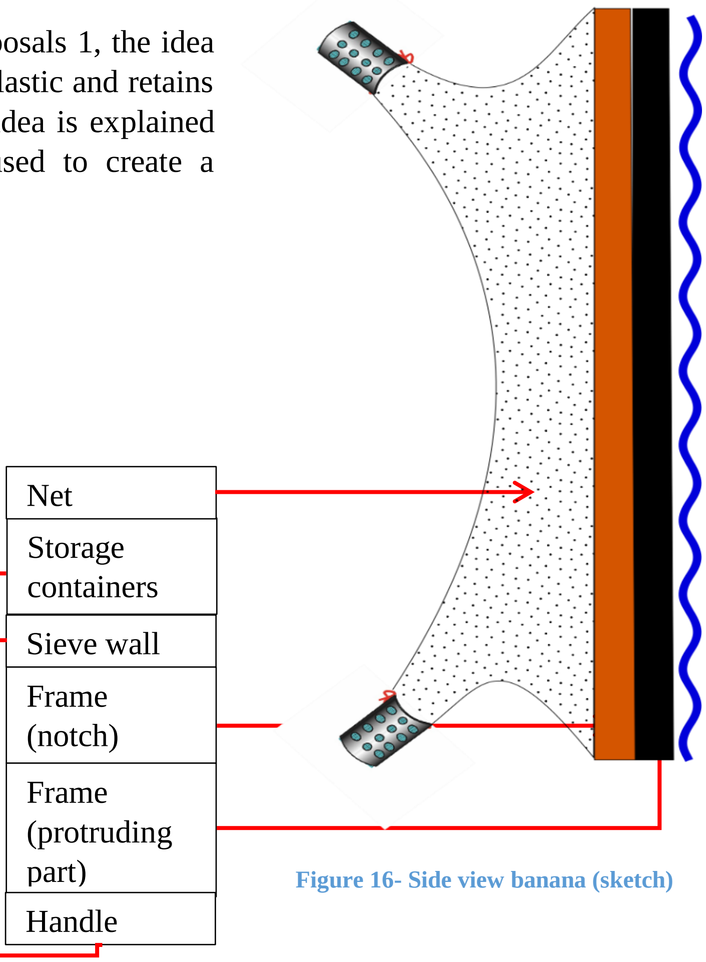

Figure 16- Side view banana (sketch)

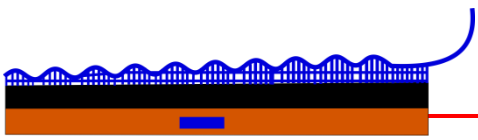

Figure 173- Top view banana (sketch)

The water that is filtered from the coarser litter goes to the net. This net is made of fabric (cotton tent cloth) that allows very little water to pass through, so that the water with components is led to the storage cylinders. The water has to pass through the heart valves before it ends up in the storage cylinder. These heart valves are explained below. In the storage cylinders there is a fabric bag in which the microplastics end up. The holes in the fabric bag are 50 µm in diameter. The rest of the cylinders work in the same way as explained in 'improvement proposal, storage container' page 9.

The heart valves are integrated in the edge of the rotating mechanism (i.e. at the point where the net touches the storage cylinder). The heart valve consists of a solid circle (made of metal) with two half circles cut out (see figure 18). Between these two semi-circles there is a beam attached to which two semi-circular valves are attached by hinges. The beam is at the same level as the semi- circles so that the valves fully connect to the solid circle with the openings. The valves are larger than the openings so that

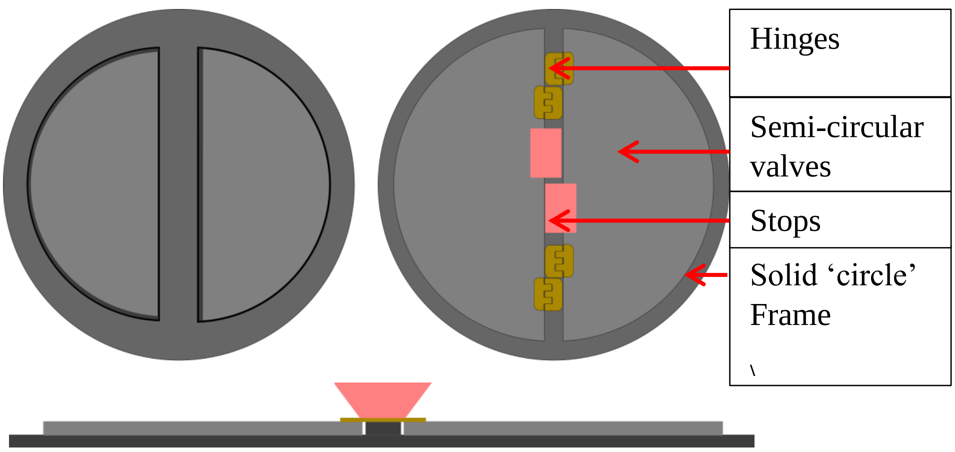

Figure 18- On the left rear view, on the right front view and at the bottom side view of the final heart valve

they seal the circle. In the middle of the beam two diagonally cut blocks placed ('stops'), these stop the valves when they tend to overstretch.

The frame consists of two parts (see figure 19). The net is attached between the notch of one beam and the protruding part of the other beam. These two beams are bolted so that the net is firmly attached between the two beams. The bolts make it easy to disassemble the frame, which can be useful when the net needs to be replaced.

Some modifications have been made to the prototype to make it more user-friendly. A handle has been attached to the frame of the Banana to make it easier to get the system out of the water. There are also holes made at the bottom of the net, so that fish that are still in the net can get out through these holes (see figure 20). In addition, the holes ensure that the system is less heavy when it is lifted from the water.

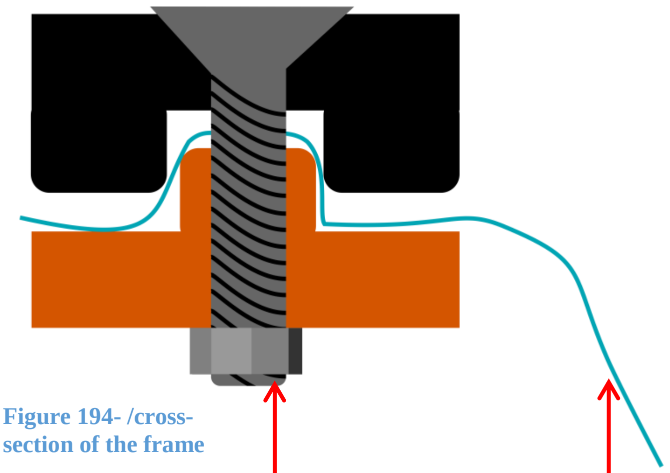

Figure 194- /cross-section of the frame

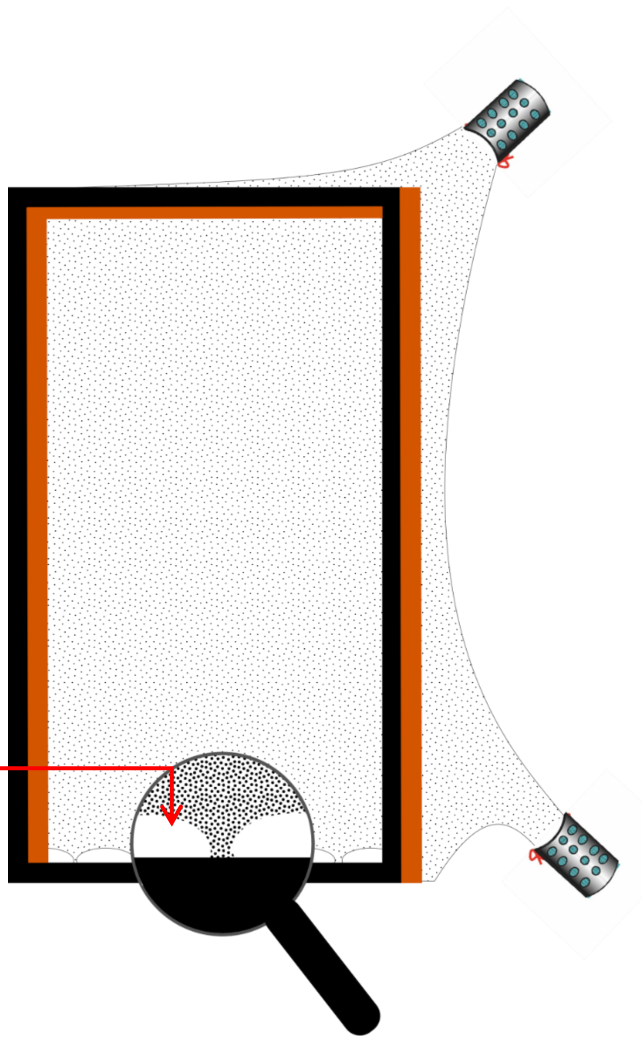

Figure 20- front view zoomed in on the holes

Test of the prototype derived from improvement proposal 2

The prototype (see figure 21) has been tested in the harbour of Tiel. The current changes often because of the changing water level every time a ship passes. This makes it the ideal spot to test the new prototype, especially the heart valves.

This test was qualitive and not quantitative because the flow rate isn't known and differs a lot. Besides that, we don't have the equipment to determine how much microplastics are present per litre water in the harbour. The test is intended to see if the prototype catches microplastics and to discover possible points of improvements.

The materials used are: prototype derived from improvement proposal 2, two ropes, microscope, binocular, tweezers, microscope slides and coverslips.

The prototype was connected to the raft with a beam and with two additional ropes. The Ropes were connected to the prototype to stop it from tilting (see figure 21). We discovered when we first applied it to the raft that the prototype would tilt in the direction of the current. Thus, making it lie slantwise with the opening to the surface or away from the surface, depending on the direction of the current. To make the prototype extra stable we connected some weights to the bottom. In figure 23, it is seen that with the changing current the bag stretches or collapses.

After six days we emptied the Banana and searched with a microscope and a binocular for microplastics.

On the third day of the test, we did an interim check. We noted that in the bags were some amphipods and other small animals (see figure 24). The 'big bag' had turned brown, probably due to clay that has sedimented to the bag (see figure 22). We discovered that loosening the storage cylinders was easy but putting them back together was very difficult.

On the sixed day the Banana was disconnected from the beam due to the overnight storm but was still attached to the ropes.

Figure 21- connection of the prototype to the raft

Figure 22- 'Browning' of the main net

Figure 23- The left image shows the bag stretched out and the right image collapsed

Figure 24 an amphipod which was trapped in the top bag

There were several amphipods in the bags and some shrimps. We found a lot of micro plastic fibres and some Styrofoam pieces. See the images below.

Figure 25- Micro fibre. Microscope 40 x

Figure 26- Probably a Styrofoam microplastic approximately 0,5 mm. Binocular 10x

Figure 27- Bunch of fibres probably a piece of rope approximately 1 mm. Binocular 10x

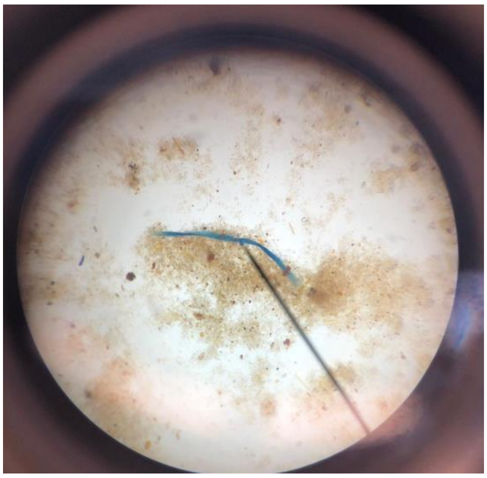

Figure 28- Micro fibre. Microscope 40 x

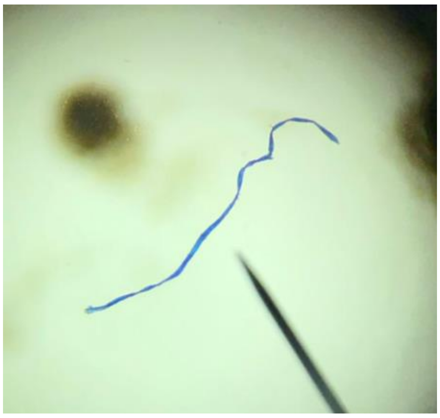

Figure 29- Micro fibre. Microscope 40 x

Figure 30- styrofoam ball approximately 5 mm. Photographed with iPhone 8 camera.

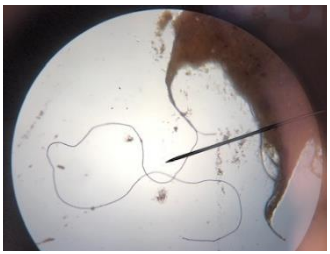

Figure 31- A micro fibre. Microscope 10 x

Conclusion

The Banana prototype is able to catch micro plastics. It wasn't the case that the whole bag was full of micro plastics, but as being said is the amount of plastic in the harbour unknown. For that reason, we could not expect to catch that many. There was one problem we run into and that was the mechanism of the storage cylinders. This should be improved and will be in the final design.

Final design

It was difficult to attach the storage cylinders to the bag of the Banana. The problem was the storage bags. They were too thick to easily screw the cylinder on the cap. We solved this problem by creating a separate tube to attach the bag to with a clamp for easy attaching and disconnecting (see figure 33). On the outside of the tube is a larger tube which is threaded (see figure 32). The bag itself is provided with a tube (sewn tot the bag) with a rope inside, so that the bag can easily be closed. The new system also makes it easier to integrate the heart valves in the storage containers (see Figure 34).

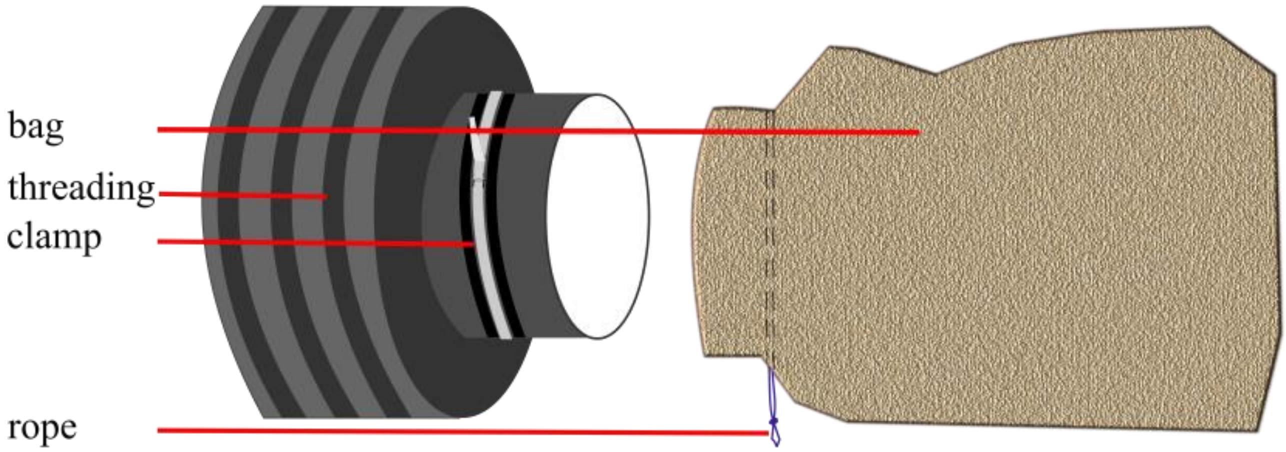

Figure 32- New storage cylinder mechanism

Figure 33- Side view clamp for storage bag

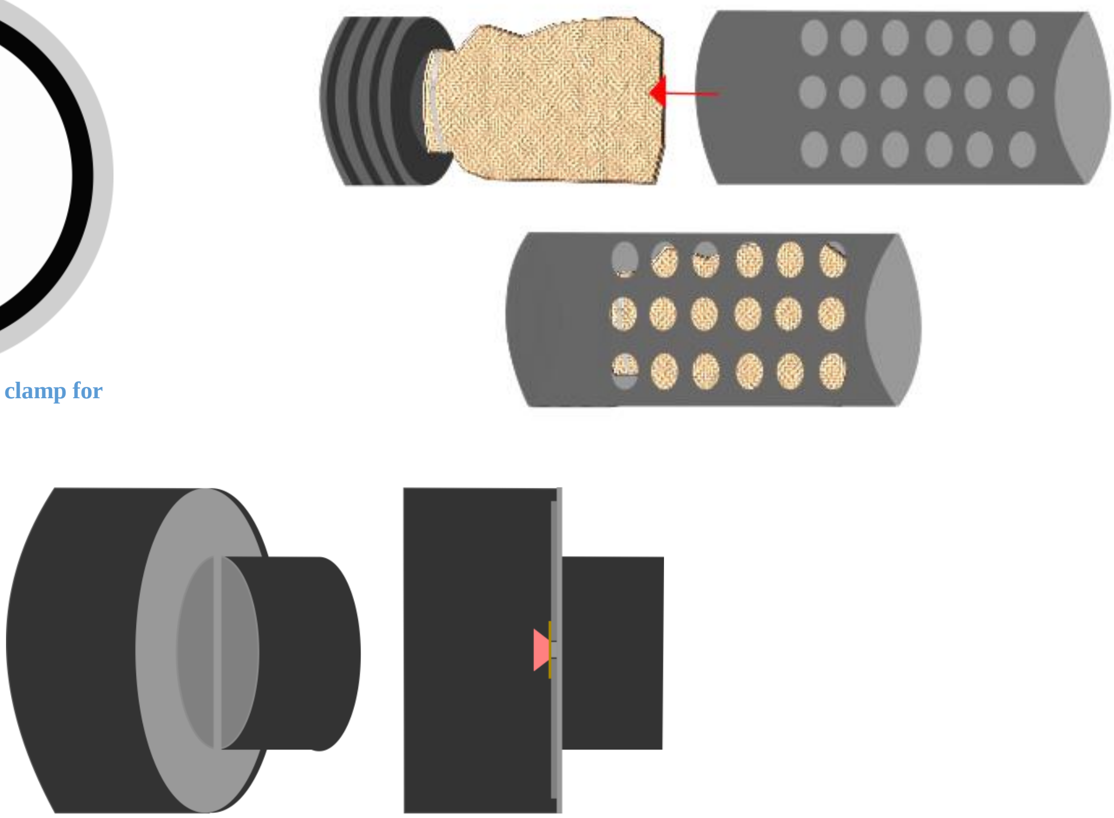

Figure 34- Heart valve integrated in the new storage system

The rest of the design remains the same as elaborated in improvement proposal 2.

For the test, we searched for microplastics by hand but when eliminating microplastics from the water on a larger scale we need a more time efficient method. We will describe three methods with which the bags can be much easier emptied and the microplastics filtered from the other materials.

Density separation

Originally this method is mostly used for sediment samples. It uses the different densities of microplastics and sediments. Materials with a lighter density than the used liquid will float to the surface where they can easily be collected and the heavier density than the liquid will sink to the bottom see figure 35 (Crawford & Quinn, 2017). After the floating materials are collected they will be sorted by hand on microplastics (Hidalgo-Ruz V. , Gutow , Thompson, & Thiel , 2012).

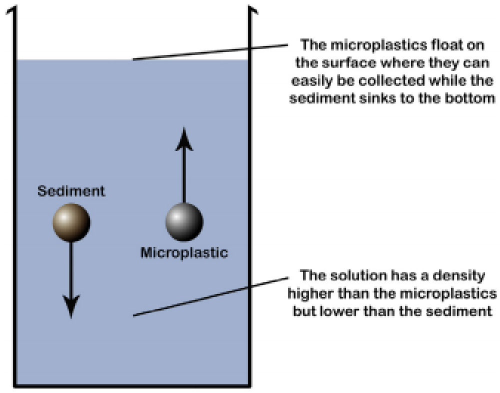

Figure 35- Density separation of microplastics and sediment (Crawford & Quinn, 2017)

Electrostatic separation

Electrostatic separation is a technique that separates microplastics due to their electrostatic behaviour from sediment. An absolutely prerequisite is the use of dried and loosely arranged samples: otherwise, the separator cannot completely divide the materials. The samples will be scattered by the vibrating conveyer and brought on to the drum. The drum moves the materials through a high-voltage corona field, where each particle is electrostatically charged based on its substance-specific properties. The drum is grounded, causing the better conductive materials to discharge quicker than nonconductive materials and therefore will fall of the drum earlier. Therefore, combined with the rotational movement of the drum, will the particles will fall into different collectors as shown in figure 36. The samples with microplastics are mostly not pure and will contain other materials. (Felsing, et al., 2018)

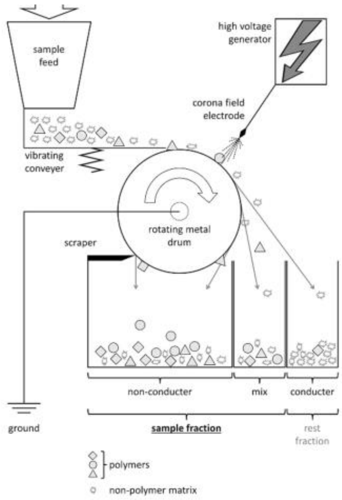

Figure 36- Scheme of the Korona-Walzen-Scheider (KWS) electrostatic metal separator (hamos GmbH). (Felsing, et al., 2018)

Froth flotation

Froth flotation is based on the fact that microplastics are mostly hydrophobic which means that microplastics prefer to adhere to other hydrophobic substances, for instance to air instead of water. The hydrophilic particles will remain in the water see figure 37. This technique has been successfully used but can be negatively influenced by additives in the plastics. Besides that, chemicals can also be added to make specific plastics hydrophilic and therefore make them stay in the water. (Crawford & Quinn, 2017)

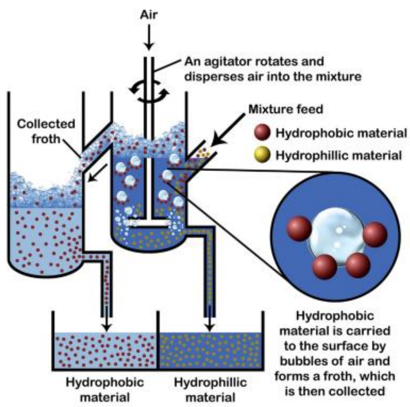

Figure 37- Schematic drawing of the operation of froth flotation

We recommend this method combined with eventual use of one of the above mentioned methods.

Applications

The final design is versatile, this is because the system is not dimensionally bound. So, if you want the system to be wider, deeper or longer, that's no problem. The system will still work at its best. The net can also be customized to any situation. If the system is in very rough water, you can choose for a more water-permeable net or for larger storage containers. An additional advantage of the microplastics system is that it also takes care of removing toxins from the water. This is because toxins have the tendency to attach themselves to microplastics (Mato,et al., 2001).

So, when the microplastics are captured, the water is actually cleaned in two different ways.

The system can be used in several situations. Three of these will be explained in more detail.

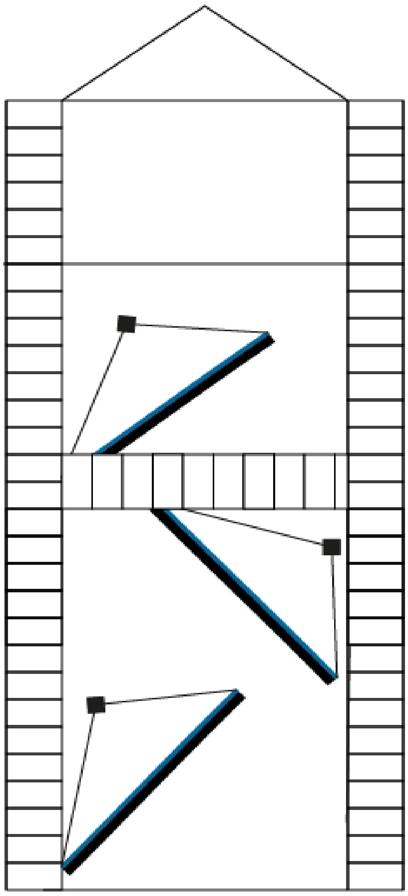

Figure 39- Schematic illustration of the plastic trap with integrated banana.

Recycled Island Foundation

The system can be used in the RIF plastic trap as discussed in 'Design Requirements'. The microplastic trap can be placed between the u-profiles that are attached to the frame of the existing catcher. By using the handle, the system can be easily removed if necessary. By placing a microplastic trap in the RIF plastic trap, both the macro and microplastics are captured.

Figure 38- Top view of the banana with the U-profile. The blue bar represents the handle.

Weir/effluent

There is a lot of current at a weir, because the water crosses a difference in height. This is therefore an ideal place for the microplastic catcher. Because a lot of water goes through the plastic trap. Also at the outlet of a water treatment plant there is a lot of current and therefore a good place to catch microplastic. The system can be attached to these places in two different ways. First of all, an u profile can be attached to the weir/outlet where the plastic trap is inserted. But the system can also be attached by means of two poles.

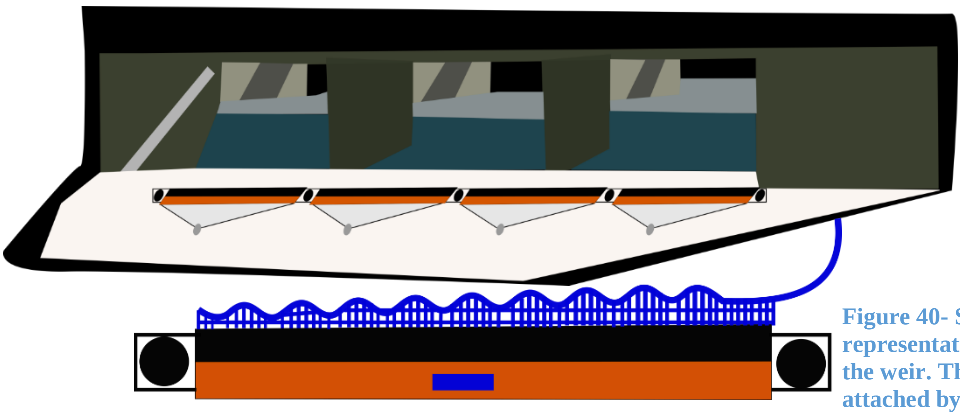

Figure 40- Schematic representation of the banana at the weir. The banana is attached by two poles (bottom picture).

Foreshore

The last application is that the system is placed in an area where there is a lot of tide. Because this location is close to the coast, where there are many microplastics here. So if the plastic trap is placed here, a lot of microplastics will probably be captured. Because there is a lot of change of flow, it is important that the system is able to move with it. That is why it was decided to attach a pole or chain in the middle of the frame so that the system can rotate around its own axis. Due to the placement of two panels on the side, the plastic catcher is always in the right direction to capture microplastics. Because the device can change direction, the normal wall does not work, it can be used without the 'sloping' part or a new wall can be used at all.

Expressions of gratitude

We want to express our gratitude to a couple of people who helped us. Firstly we want to thank Hilke Hol, Brendan Oonk and Anneke van der Meer, our mentors for helping us through the different stages of the project. We were always welcome and they had always time to answer questions or would even point out some potential problems. Our school, RSG Lingecollege in Tiel also deserves gratitude for giving us a budget and providing us with the tools to make our prototype. Thanks to Bertus and Helga Maasbach, we could test our prototype at their houseboat and they even reinforced the construction that held down the prototype to the raft, many thanks for that! We also want to thank Marlieke Sietsema for pre reading our report and organising the trip to Sweden. Our last thanks go to platform WOW and Wetsus for giving us the opportunity to participate in the Stockholm Junior Waterprize.

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