HYDROCYCLONIC MICROPLASTIC SEPARATOR

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OVERVIEW

This hydrocyclonic microplastic separator is an innovative solution to microplastic pollution, both in its purpose and function. Microplastic pollution is a relatively new and inadequately addressed problem. This invention targets microplastics which are typically not removed from the ocean, even by current plastic pollution removal strategies which are can't remove particles as small as microplastics. Additionally, the innovative use of a hydrodynamic cyclone allows the separator to be environmentally sustainable and easy to maintain. These qualities not only allow the separator to benefit the environment, through removing harmful microplastics, but also makes it accessible to a wider population (as it's low-cost and easy to maintain), allowing more people to benefit the environment by implementing it without detrimenting themselves.

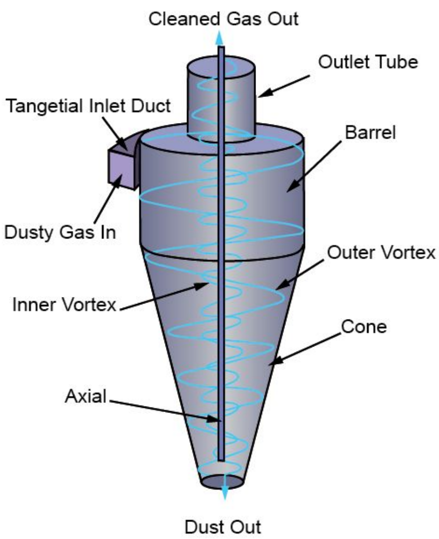
BACKGROUND INFORMATION: WATER FILTRATION

SEDIMENT FILTERS

There are two main categories: depth filters and surface filters. While they are both effective in filtering out small particles, they require regular maintenance, making them unappealing for use where they are located far from humans (e.g. in oceans), and create a lot of waste in the maintenance process.

CYCLONIC FILTRATION

Cyclone separators are typically used in gas filtration though similar principles apply to hydrodynamic cyclones (hydrocyclones) which remove particles from liquids. They usually have two main sections: the conical collection chamber and a cylindrical main chamber. Separation is reliant on inertial and gravitational forces which create a centrifugal forces. The substance must enter with high rotational velocity, usually through a tangential or scroll inlet, to create a centrifugal force field which results in an axially descending spiral.

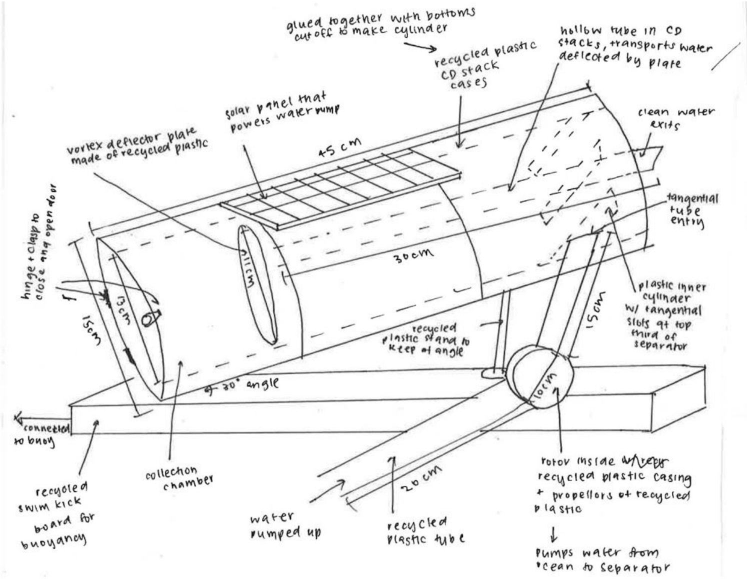


As the substance rotates in this spiral, particles in it are thrown against the outer wall. While substances are forced to change direction as they rotate, the inertia of heavier particles force them to continue in their original direction (that of their tangential entry). In this way, particles become separated.

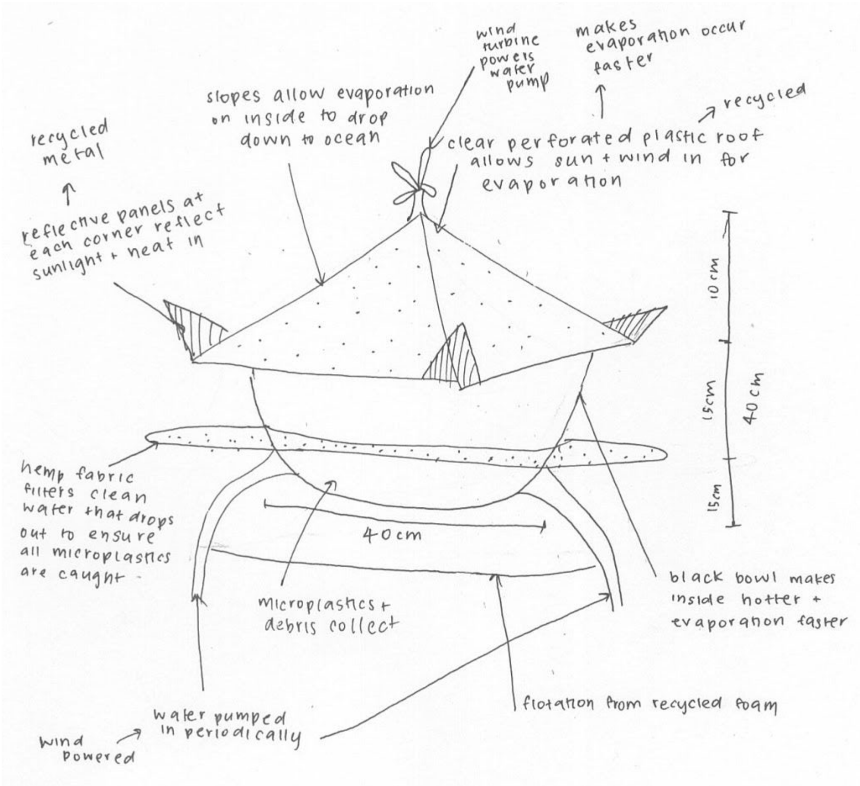
Gravity pulls particles down into a collection chamber while the filtered substance forms an upwards-rotating vortex, due to a centre of negative pressure created as pressure decreases radially inside the separator. The outlet tube ("vortex finder") which is partially inside the separator guides this vortex out. The "vortex finder" also helps to protect the opposite vortex from the high inlet velocity and stabilise its swirling motion. The absence of moving parts and simple construction makes these separators low-cost and easy to maintain.

PROJECT DEVELOPMENT

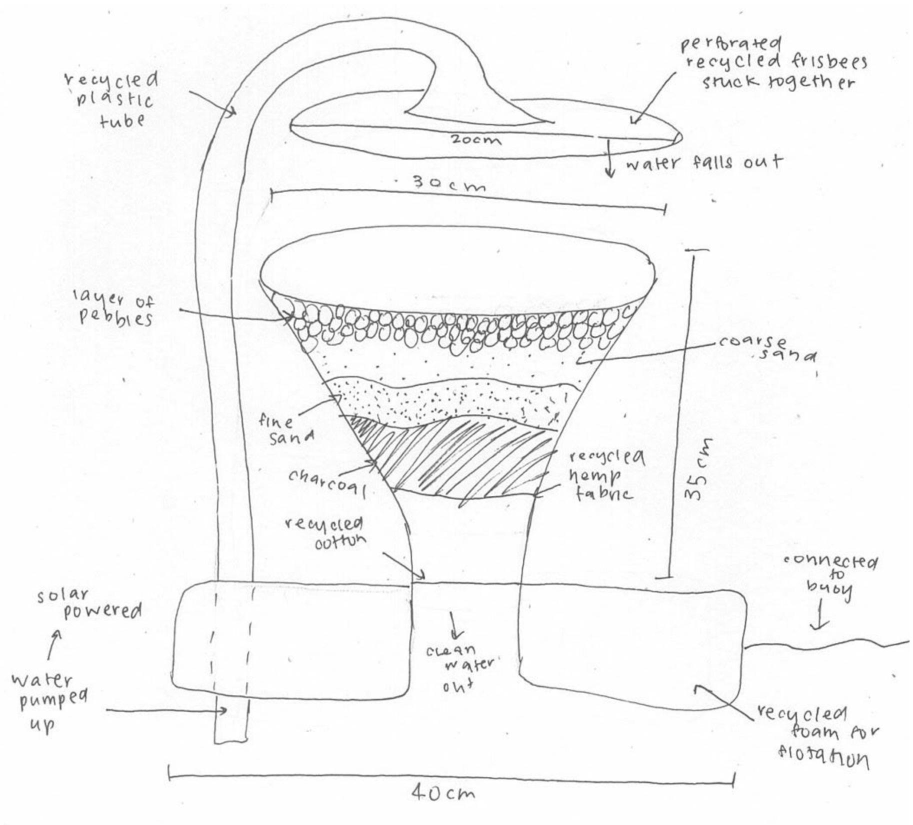
CONCEPT 1



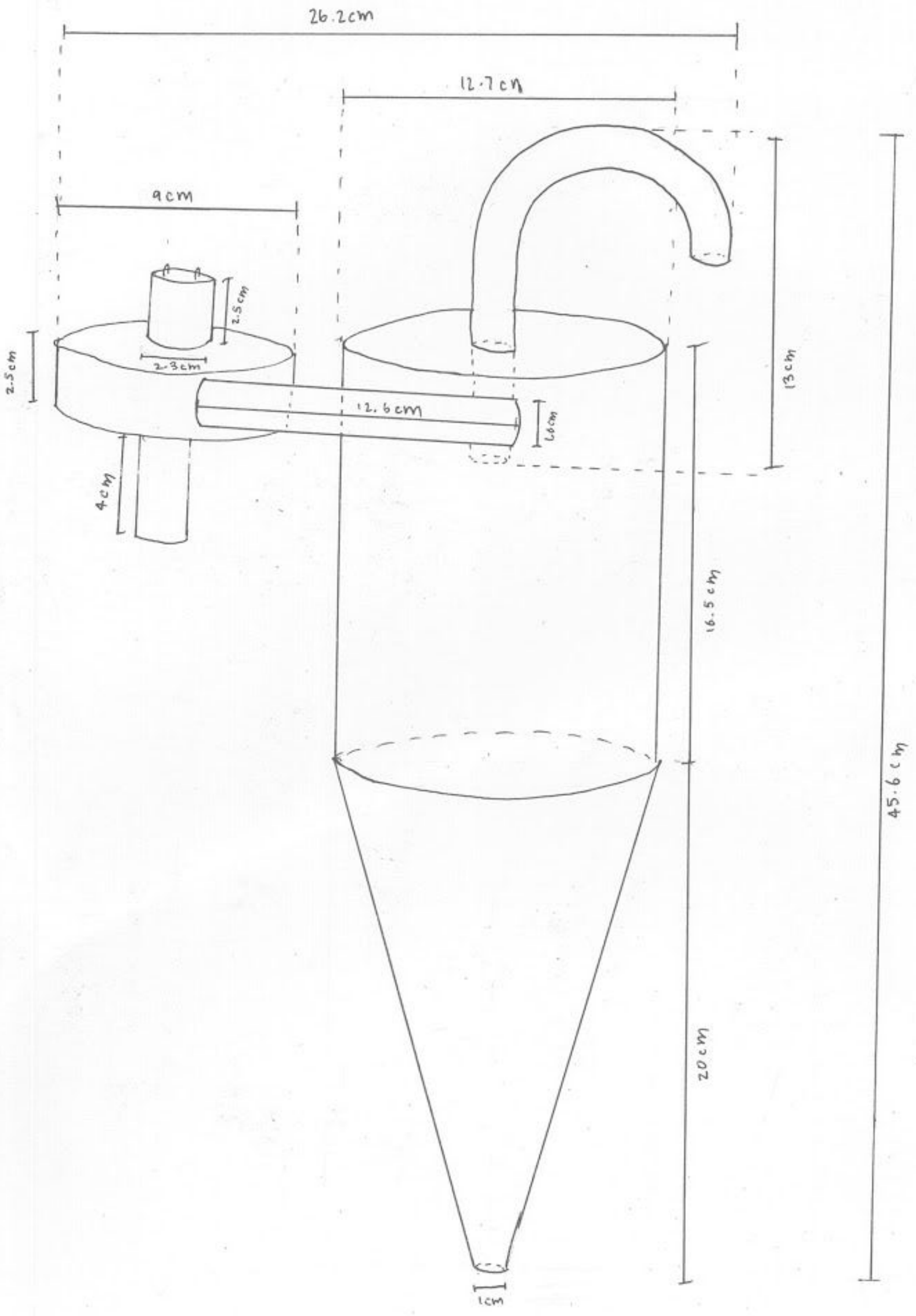
CONCEPT 2



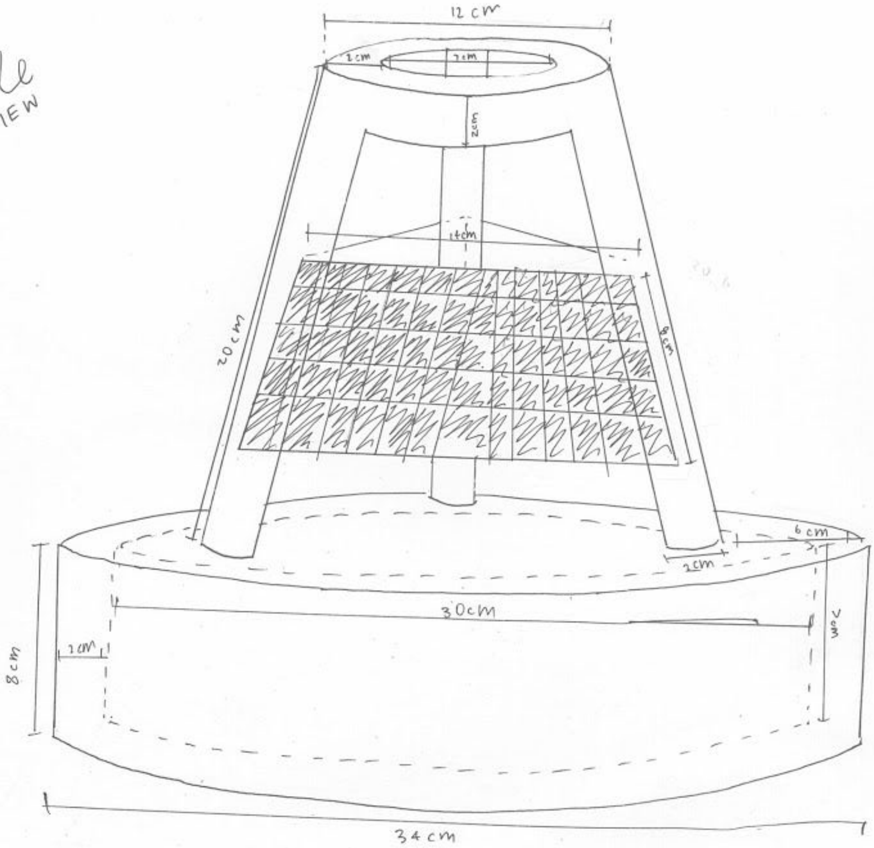
CONCEPT 3



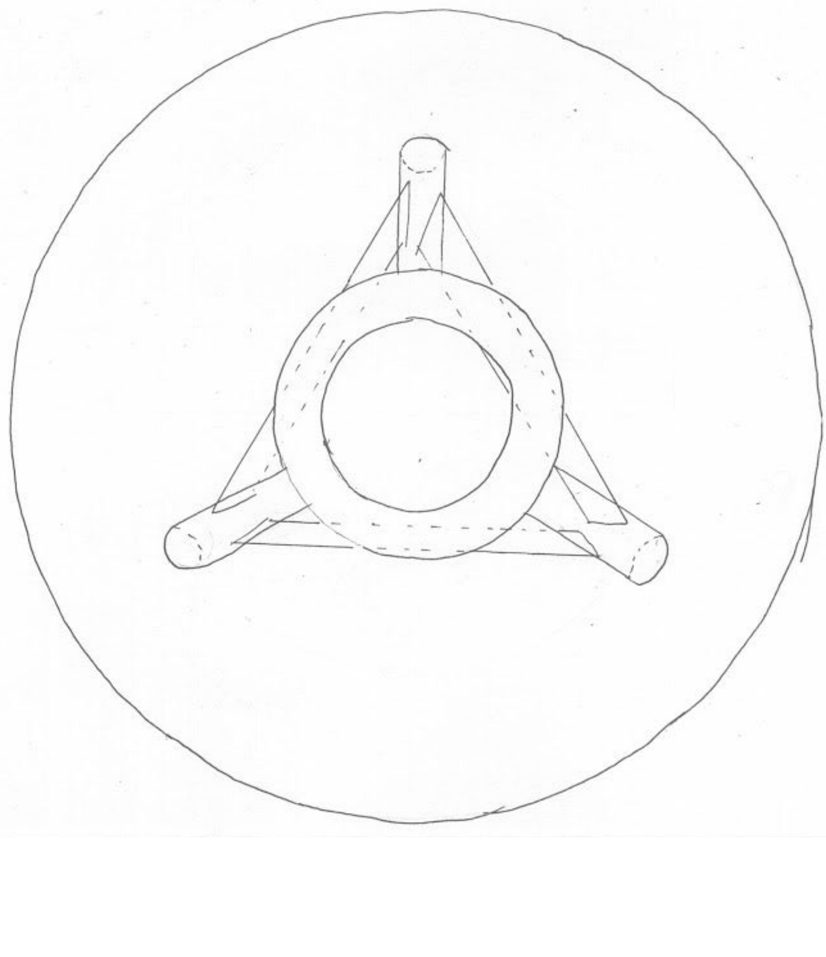
Concept 1 was chosen as its use hydrocyclonic technology, but was changed to stand vertically and to have a conical collection chamber similar to existing cyclones and so making it more likely to work. A buoy was added, to give the separator buoyancy and to protect electrical parts.

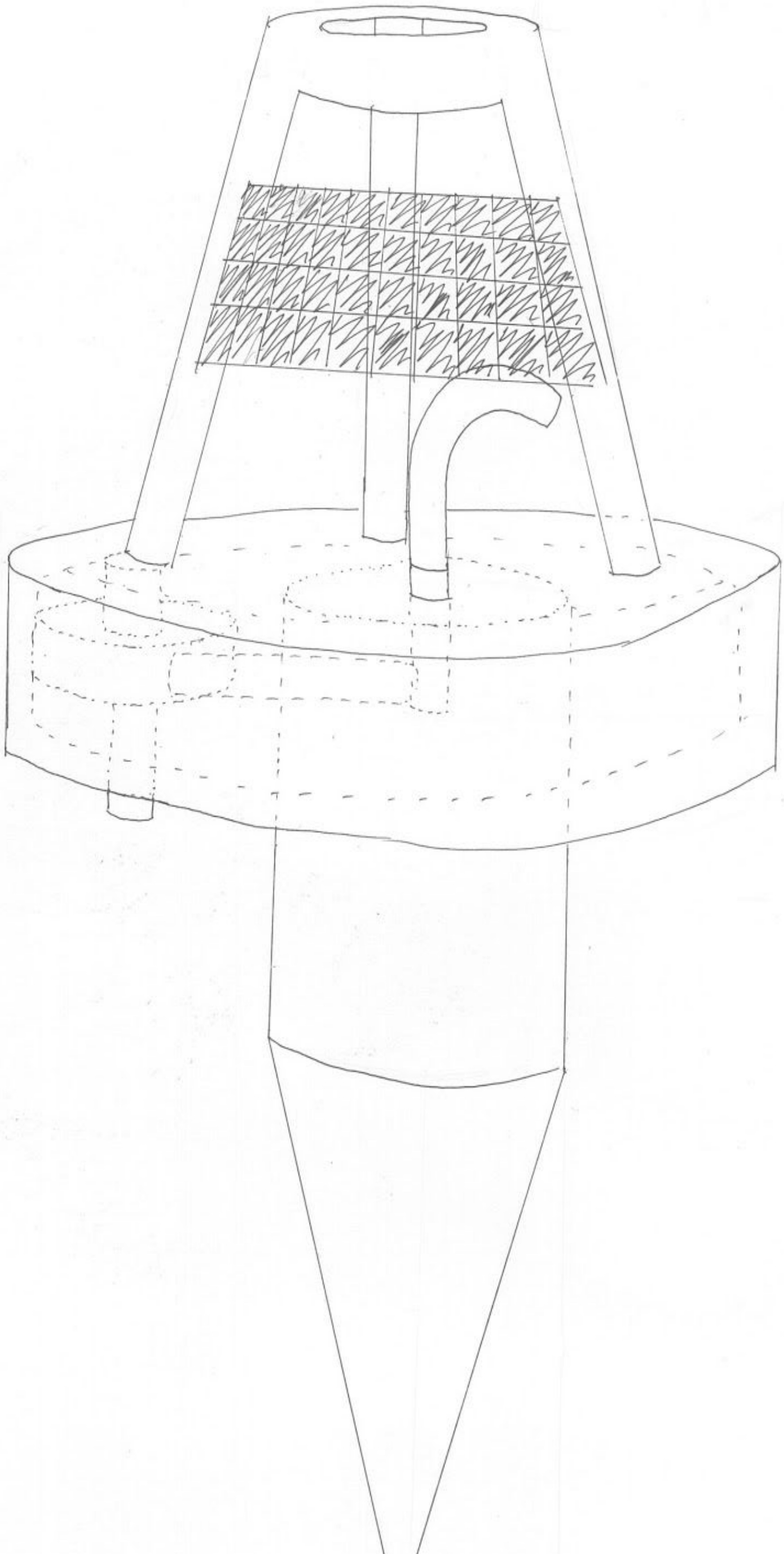

26.2cm
12.7cm
9cm
2.5cm
2.3cm
2.5cm
12.6cm
6cm
13cm
4cm
16.5cm
45.6cm
20cm
1cm

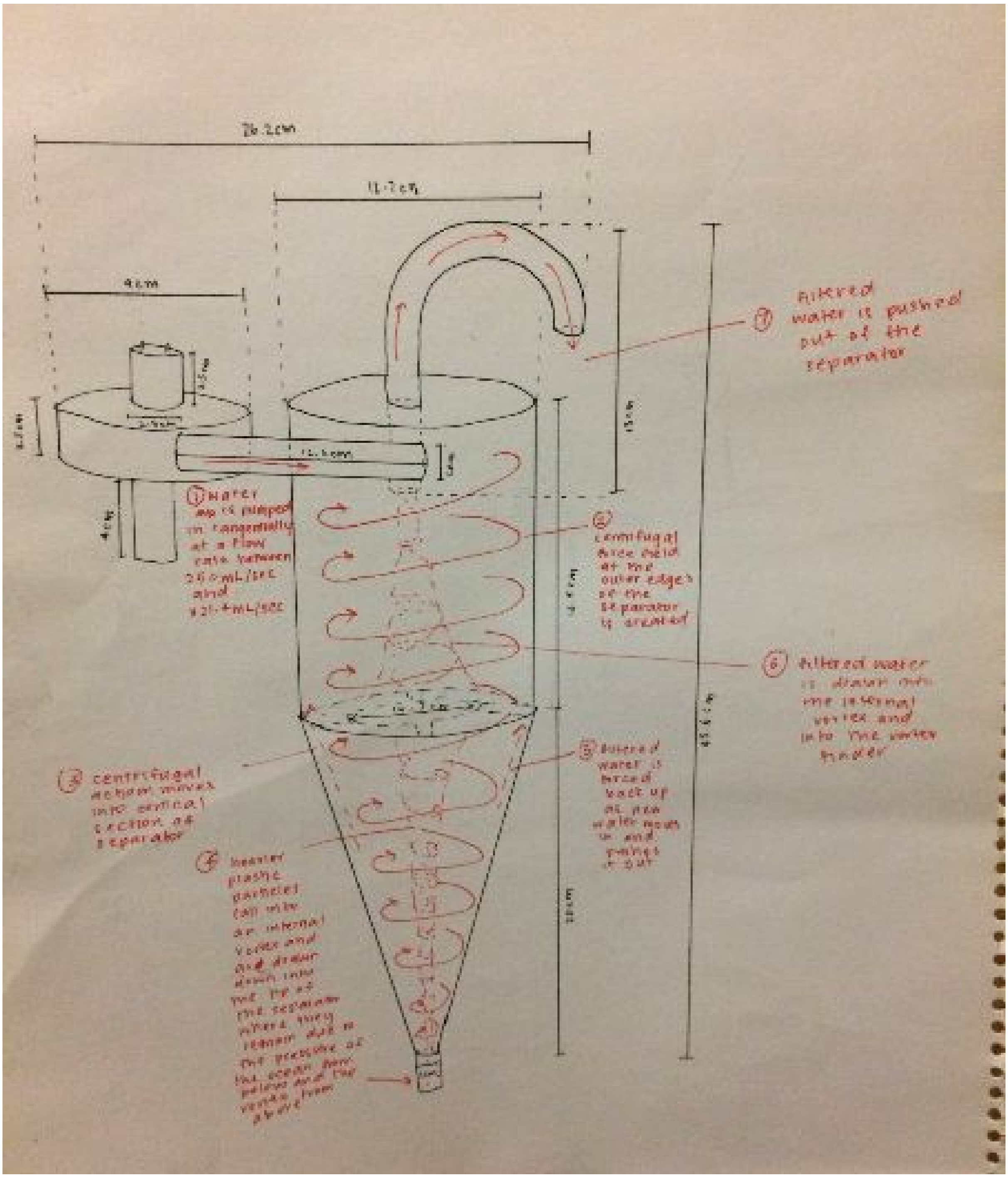
side VIEW



top VIEW







For efficiency, the separator will be located in a coastal marine environment (20m to 100m from shore) where, according to oceanographer Dr Erik van Sebille and Peter Sherman from the *Imperial College*, cleanup efficiency increases by 15% as compared to collectors in gyres. Collecting at this point also ensures that microplastics are captured where they enter, before they greatly harm marine life. This location also makes it easier to access. For environmental sustainability, the pump (which draws water from the ocean's subsurface region where most microplastics and few organisms exists) is solar-powered and the separator is constructed with recycled plastics.

CONSTRUCTION

RISK ASSESSMENT

RISK	INJURY	PRECAUTION
Touching the hot glue gun or glue	Mild to severe burns	Wear gloves. Work under supervision. Unplug and leave glue gun for 20 minutes before touching.
Sharp blade of the stanley knife	Mild to severe cuts	Wear appropriate clothing and gloves. Work on a stable, flat surface while under supervision.
	Irritation from inhaling dust from cut plastic or getting it in eyes	Wear a mask and safety goggles. Work in a well-ventilated area.
Sharp edges of the plastic after being cut	Sharp edges could cause cuts or infections	Wear safety gloves. Sand extremely sharp edges.

Construction is shown in the images below. Recycled plastic was collected or purchased from Reverse Garbage. This construction is simple and sustainable but was sometimes time-consuming and difficult as my tools (specifically knives) were not designed to manipulate plastic with my limitations of skills, time and safety. Furthermore, I had little experience so construction was at times messy. However, during construction, through evaluating my progress to identify possible improvements, I was able to refine my skills and complete a neat, working model.

HYDROCYCLONE SEPARATOR BODY CONSTRUCTION

26. Take one of the large CD stack cases and, using a stanley knife, cut out the base to leave an open ended cylinder as shown to the right. Retain the cut out base for later. 27. Put hot glue along one edge of this cylinder and stick it to the rim of the other large case so that their edges line up. This will be the collection cylinder 28. Take a round, plastic container which gradually becomes smaller towards the base but is the same diameter as the open end of the collection cylinder at one end. This is the lower cylinder 29. Cut the base out of this cylinder then put glue around the rim and stick it to the open end of the collection cylinder	
30. Taking the base which was retained from the previous section, measure and mark out a hole in the centre which is large enough for one of the plastic tubes to stick through. 31. Cut around the marked line using a stanley knife 32. Put hot glue around the edge of this hole then stick the straight end of the tube through until there is a 6cm length of tube sticking out, as shown to the right. 33. Glue this to the open end of the collection cylinder, ensuring that there are no holes.	
34. Put a straight tube over the top of the collection cylinder, at a tangent to its circular base 35. Outline onto the tube, using a marker, where the curved edge of the cylinder lies underneath 36. Use a stanley knife to cut through this line so that the tube ends up having a curved lip 37. Line this up against the collection cylinder, 2 cm from its open end. Use a marker to mark around the tubes lip where it makes contact with the cylinder 38. Use a stanley knife to cut around this line 39. Put glue around the cut edge and stick the lip of the tube against it, as shown to the right, ensuring that there are no holes	

40. Cut the bottom off the plastic martini glass to leave a funnel like shape, as shown to the right.	
41. Take the remaining un-cut CD stack case and cut out the base 42. Measure a circle, which shares the same centre point as the base, that has a radius 1cm less than that of the base (5.35cm) 43. Cut four 5cm by 1cm rectangles out of the cylindrical plastic tub. 44. Measure 2.5cm of each rectangle and mark the point with a marker. Bend each rectangle at this point at a 90 degree angle. 45. Hold each of the plastic rectangles so that one of the bent faces is facing upwards. Put glue on this face and stick it to the plastic circle, so that there is a rectangle every 90 degrees (as shown to the right) 46. Put glue on the part of the rectangle which is facing out from the circle and stick this face to the inside of the cone which was cut out in step 40	
47. Put glue around the open end of the lower cylinder and stick the rim of the cone to this, once again ensuring that there are no holes 48. The model should look like the image to the right. Test that there are no leaks in the model by holding it horizontally, pouring water through the tubes so that water extends to all the joints, then rotate it slowly. Make a mark wherever water drips out and seal the identified hole with hot glue.	

EVALUATION

While the model isn't identical to the working drawing, construction and testing clearly demonstrated that hydrocyclonic technology is a viable and effective solution to microplastic pollution. However, the formation of an opposite vortex beneath the vortex deflector plate which concentrated plastics into the collection chamber's tip was unexpected and likely because my research was mostly on cyclonic filtration of gases (as hydrocyclones are rarely used). As a result, the separator doesn't cater for long-term collection as the tip is quite small. Despite this, the proposed design is an improvement from existing solutions. It is made of cheap, recycled plastic so is financially and environmentally sustainable. It is small and implementable in various settings. This, combined with the absence of moving parts and its coastal location, also makes it easy to maintain and therefore more appealing to a larger market, unlike current solutions. Furthermore, it specifically targets microplastics which makes it more efficient.

IMPROVEMENTS

The model should, in future, be constructed exactly to the working drawings. After this, it can be tested in coastal environments where its efficiency/functionality can be appropriately evaluated. The separator could be 3D printed as this would allow it to be neater, sturdier and potentially cheaper. The current model has joints connected by hot glue which may be susceptible to leaks/breakages. Therefore, a model with no joints or joint reinforcements could be more durable. Since the separator wasn't tested in the ocean, it may not be entirely suited to conditions like rips, currents and debris. Future testing may reveal that the separator requires additions, like a GPS tracker to monitor where current pushes it, to ensure it can withstand ocean conditions. The tip of the separator, where plastics collect, is quite small so limits long term collection. Hence, a larger tip or periodic flushes to clear out plastics may be required.