Design and Development of Aquabin

Vaishnavi Dusane[1], Madhura Gayate[1], Prayag Gite[1] and Sarthak Gangurde[1]

[1]Student, Department of Mechanical Engineering, K.K.Wagh Institute of Engineering Education and Research, Maharashtra, India

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Abstract - *Water has been scuffling with plastic waste and other pollutants for years. Water is the blood and bone of our environment and humans and it is in our best interest to keep it pure and palatable. The need to sustain the purity of water is desiderated past couple of decades as millions of tons of debris already in water like plastic; micro-, meso-, or macro debris, based on size. The toxins that are components of plastic include diethylhexyl phthalate, which is a toxic carcinogen, as well as lead, cadmium, and mercury for biotic life and ultimately the human race, through the food chain, ingest these highly toxic carcinogens and chemicals. Also water contains some biotic waste, micro organic waste known as pathogen, grease, and oil etc.*

Effective solution for this chaos is the development and mobilization of technologies that either 1) Prevent plastics from entering waterways or if entered not letting it settle down the waterbed or 2) Collecting biotic/plastic pollution round the clock. As few projects or reports are initiated but are debilitated to work long hours or are reckoning heavy expense.

So it is the best interest of the organizations/innovators to come up with solution to all these shortcomings.

Aquabin Project is an innovative ecological floating bed clean tech start up on a simple and ambitious mission: to help resolve the global problem of water bodies' plastic pollution and its conservation. Aquabin technologies have the potential to intercept mismanaged waste such as macro and micro-plastic debris, and micro fibers before they have the chance to reach the ocean hence Aquabin is tagged as "Floating Debris Trapper". Also the main objective of this project is to make nonconventional system which will give continuous & sufficient power in all working conditions and most importantly at negligible expenditure. The decision to supply non-conventional source was to create the imperative necessity to seek out and develop renewable energy resources as they are inexhaustible, pollution free and less priced because of native use and straightforward taken care of. We concede that using Science, Education, Technology and collective Community initiation is a step towards a whole solution.

Key Words: Debris, Diethylhexyl Phthalate, Carcinogen, Pathogen, Aquabin, Floating Debris Trapper, Nonconventional, Inexhaustible, Pollution Free, Initiation.

1. INTRODUCTION

From last decade world's oceans have become the hotspots for plastic waste. Nearly 8 million tons of plastic gets dumped in our oceans every year. Out of which floating plastic debris accounts 269000 tons and more than 14 million tons of plastic believed to be at the bottom of the sea. Addition to this, 25 trillion macro and 51 trillion micro plastics litter our oceans creating 4 billion microfibers per square kilometer which clutter the sea. So the question arises that from where does this plastic come from? [6] River plays a critical role in transporting plastic waste to the oceans. 80% of world's ocean plastics enters the ocean via rivers in which 90% of plastics came only from 10 rivers. So freshwater bodies like rivers, lakes, ponds being the being the crucial route of pollution we need to extend our concern to freshwater pollutants [5]. Major categories of water pollutants in river are pathogens, inorganic compounds, organic compounds and macroscopic pollutants. One of the best solutions to control litter in the water bodies is to trap the debris on the surface of water itself before settling down. This idea relates to skimmers and floating debris trapper devices. There are many water cleaning devices running by government today but water is cleaned once in a while during this period maximum amount of floating garbage gets settled down .That is where Aquabin comes into the play. The Aqua Bin is a "trash skimmer" designed to acts as a floating garbage bin skimming the surface of the water by pumping water into the device which can collect fresh trash for 24 hours a day. Aquabin floats on top of the water in a stationary position and slowly draws in surface water into its filtration system. This is key because there is a lot of trash that sits on top of the water. It can collect any floating garbage as well as it has filter bag which is capable of trapping oil, micro plastic. The main components of Aquabin are PVC bucket, water pump, solar panel, nylon net, storage battery, supporting frame [6]. The input power to the pump is given by solar energy. Solar panel is used to charge the battery as solar power is nonconventional source of energy it is completely clean with zero pollution and no greenhouse gas effects. Also no harmful emission gets released when electricity being produced by solar panels. So not only does the Aquabin collect the trash from water but also it motivates the use of renewable energy without consuming the energy from finite sources [9].

1.1 Problem statement:

Water pollution is major type pollution these days. There are currently millions of tons of debris already in water like plastic; grease, oil, & wood. Even though water cleaning process is done once in a while but there is need of cleaning it for every minute before the garbage settles down. To overcome that problem, there is need to make Aquabin Floating Debris Trapper using Solar energy use.

1.2 Objectives:

Objectives behind development of Aquabin Floating Debris Trapper system are given below:

1. The main objective of this project is to assess the feasibility and economic viability of utilizing solar based standalone power supply system to meet the load requirements for Aquabin.
2. To make nonconventional system this will give continuous & sufficient power in all working conditions.
3. To make "zero" working cost for working such that Aquabin should run on low operating and maintenance cost.
4. To reduce the concentration of contaminants in the water.

1.3 Methodology:

1. Proposed Methodology 1–Basic information and literature survey. By studying the literature of previously available system helps in maximizing the output by minimizing the effort, cost, time & money in future develop new machine.
2. Proposed Methodology 2 – Design and calculations of the forces acting on Machine components. This presents the design constraints that influence on the use, efficiency & benefits their impacts on machine.
3. Proposed Methodology 3 – Selection of Materials for Components of Machine. Suitable material is selected to achieve the requirements of given application.
4. Proposed Methodology 4 – 3-D modelling & Fabrication of Machine parts. This project work will start to manufacture after purchasing of required specification material & making sample simulations which will be easy for visualization.
5. Proposed methodology 5 – Project Assembly and Testing. Finally, after complete manufacturing procedure, will test the working model which will verify if aquabin satisfy probable objectives or not.

2. Literature Review:

i. Emma Schmaltz, Emily C. Melvina, Zoie Diana, Ella F. Gunady, Daniel Rittschof, Jason A. Somarelli John Virdin, and Meagan M. Dunphy-Daly done the work on, Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution, published at Environmental International journal, Elsevier. According to their work the one solution for pollution control is the development and mobilization of technologies that either 1) prevent plastics from entering waterways or 2) collect marine and riverine plastic pollution. They studied 52 technologies which fall into the two categories of prevention or collection of plastic pollution. Of these, 59% focus specifically on collecting macro plastic waste already in waterways. While these efforts to collect plastic pollution are appreciable, their current capacity and widespread implementation are limited in comparison to their potential [1].

ii. Andrew Turton and Pete Ceglinski created “The Sea bin V5- For clearer oceans” project which is revolutionary in ocean cleaning technology to create cleaner oceans with healthier marine life. The idea was to build a sustainable floating garbage bin that could collect water borne plastics and trash 24 hours a day. The Seabin moves up and down with the range of tide collecting all floating rubbish. Water is sucked in from the surface and passes through a catch bag inside the Seabin, with a submersible water pump capable of displacing 25.000 Lph (litre s per hour), plugged directly into either a 110V or 220V outlet. The device is aimed at collecting pollution of all sizes, down to floating debris as small as 2mm in diameter. It's even capable of collecting oil from the water, a priceless innovation in the event of an oil spill. The cost is about 3,300 euros each approximately 291910.13 Indian rupee [6].

iii. Andrew Parr in Hydraulics and Pneumatics (Third Edition), 2011 stated that piston pump is superficially similar to a motor car engine, and a simple single cylinder arrangement. Such a simple pump, but, delivering a single pulse of fluid per revolution, generates not accepted in large pressure pulses into the system. Practical piston pumps therefore employ multiple cylinders and pistons to smooth out fluid delivery, and much ingenuity goes into designing multicylinder pumps which are surprisingly compact. The pump consists of several hollow pistons inside a stationary cylinder block. Each piston has spring-loaded inlet and outlet valves. As the inner cam rotates, fluid is transferred relatively smoothly from inlet port to the outlet port [16].

iv. Keith Mobley, in Fluid Power Dynamics, 2000 studied the Swash Plate Design Pumps. In axial piston pumps, the cylinder block and drive shaft are on the same centreline and the pistons reciprocate parallel the cylinder blow in this pump is turned by the drive shaft. Pistons fitted to bores in the cylinder are connected through piston shoes and a retracting ring, so that the shoes bear against an angled swash plate to the drive shaft. The simplest type of axial piston pump is the swash plate inline design. In these pumps the size and number of pistons as well as their stroke length also determine the displacement. The stroke length is controlled by the swash plate angle [13].

v. S.C. Bhatia, in Advanced Renewable Energy Systems, 2014 Solar panels, generally comprising of arrays of photovoltaic cells, use the solar energy directly from the sun to generate electricity for our daily use. Being environment friendly in nature, solar panels collect the solar energy which is available in abundance on our planet and convert it using the advanced technology developed by human beings. This invention of humans has led to a great achievement in world's history of conserving non-renewable resources and saving the planet as well as the natural resources from depletion [9].

3. Construction & Working:

Component of Aquabin floating debris trapper system is given below,

Table 1: List of components of Aquabin floating debris trapper system.

Sr. No	Components	Quantity
1	Supporting frame	1
2	DC pump	2
3	PVC Buckets	3
4	Solar panel	1
5	Solar charger unit	1
6	Storage Battery	1
7	Fasteners	10
8	Nylon Net	1

a) Supporting Frame:

This frame basically helped in supporting the installation of Aquabin on river bank. It supported of all components of Aquabin, like pump, bin, and nylon net etc. Also the height of the Aquabin bucket is adjusted.

Fig (1) Supporting Frame

b) DC Piston Pump:

A piston pump is a type of positive displacement pump where the high-pressure seal reciprocates with the piston. Piston pumps can be used to move liquids or compress gases. They can operate over a wide range of pressures. High pressure operation can be achieved without a strong effect on flow rate.

Specifications: housing material: tough abs winding material: copper power source: battery / power supply 12 volt dc adapter 3 amp voltage: dc12v power: 36w working current: 3a max output / suction / suction power: 4.5l/min max pressure/ bursting pressure of water: 100 psi / 6.9 bar.

Fig (2) DC piston pump

c) PVC Buckets:

PVC Buckets are durable in nature and are made with accuracy at vendors end. These products have high strength and are delivered in standard configurations. PVC Buckets are performance oriented and have fire retardant capacity. In this project we had used concentric buckets: Outer Bucket of dimensions 40*55 and inner bucket of dimensions 37*47 with nylon net to trap or collect garbage from water bodies.

Fig (3) PVC buckets

d) Solar Panel:

Photovoltaic directly convert solar energy into electricity. They work on the principle of the photovoltaic effect. When certain materials are exposed to light, they absorb photons and release free electrons. This phenomenon is called as the photoelectric effect. Solar panels actually comprise many, smaller units called photovoltaic cells. A collection of PV modules is called a PV Panel, and a system of Panels is an Array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.

Specifications: Max Power 15W, Voltage 18 V, Open Circuit 21V, Current 0.83A, Normal Operating Temp 45.5^{0}C

Fig (4) Solar panel

e) Lead–Acid Battery:

The batteries are used as a storage device for solar energy which can be further converted into electrical energy. The only exceptions are isolated sunshine load such as irrigation pumps or drinking water supplies for storage, for small units with output less than one kilowatt. To be economically attractive the storage of solar electricity requires a battery.

Specifications: Input Voltage 12V, Output Voltage 14.4V, Power 86.4W, Current 8A.

Fig (5) Lead acid battery

f) Fasteners:

A fastener is a hardware device that mechanically joins or affixes two or more objects together. In general, fasteners are used to create non-permanent joints; that is, joints that can be removed or dismantled without damaging the joining components. Steel fasteners are usually made of stainless steel, carbon steel, or alloy steel.

Fig (6) Fastener

A washer is a thin plate (typically disk-shaped) with a hole (typically in the middle) that is normally used to distribute the load of a threaded fastener such as a screw or nut. Other uses are as a spacer, spring (wave washer), wear pad, preload indicating device, locking device, and to reduce vibration (rubber washer).

Fig (7) Washer

As nuts and bolts are not perfectly rigid, but stretch slightly under load, the distribution of stress on the threads is not uniform. In fact, on a theoretically infinitely long bolt, the first thread takes a third of the load, the first three threads take three-quarters of the load, and the first six threads take essentially the whole load.

Fig (8) Nuts and bolts

g) Nylon Net:

Nylon is a generic designation for a family of synthetic polymers composed of polyamides (repeating units linked by amide links). Nylon is a thermoplastic silky material that can be melt-processed into fibers, films, or shapes. Nylon polymers have found significant commercial applications in fabric and fibers, electrical appliances, cars and food carriage.

We had used nylon net of dimensions 40*47 mm.

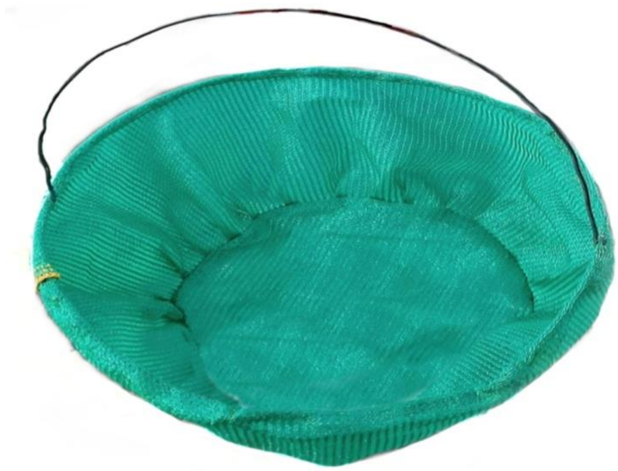

Fig (9) Nylon net

3.1 Working:

Aquabin "Floating Debris Trapper" is basically a floating trash bin to help rid the oceans of plastic and pollution. Aquabin device works independently removing wastes from the water 24/7. By focusing on this one specific kind of water-location, the Aquabin actually provides a solution to help clean waste in our waters before it reaches the open pond. The Aquabin sits near the top of the water, where all of the pollution floats, and sucks in everything around it by using two piston pumps connected in series. The inner mesh of the bin can then be periodically emptied into a trash can and disposed of responsibly. It is very easy to use and runs continuously throughout the day. It is also to operate "soars operated trash-bin." The Aquabin can collect many garbage items such as old bottles or plastic bags. The water flows through the system as the pump plays the major role. The pump pulls the water through the Aquabin filter, bringing any trash with it.

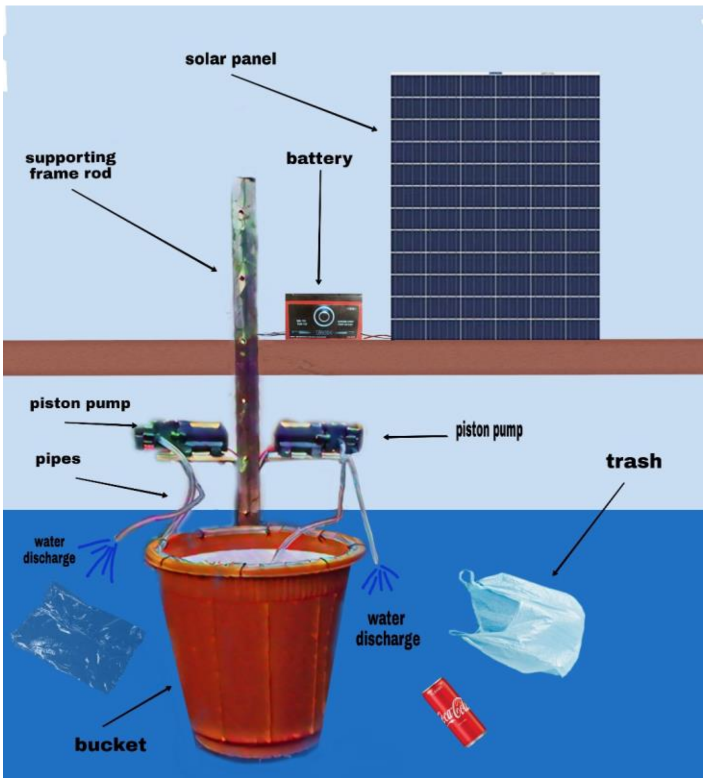

Fig (10) Working of aquabin block diagram

a) Design and Calculations:

Buoyancy: It is net vertical force acting on the submerged body in a fluid, due to the hydrostatic pressure distribution. It is not a fundamental or physical force. It is an artifact of net pressure distribution in the vertical direction [11].

Buoyancy Force = rAV

r= Density of Water

A = Area on which force is applied

V = Volume of Displaced Fluid

L = Cylinder of Length

h1= Distance of top surface of Aquabin from level of Water = 10mm = 0.01m

D =Dia. of Aquabin = 40cm = 0.4m

A. Vertical force acting on the top circular surface is:

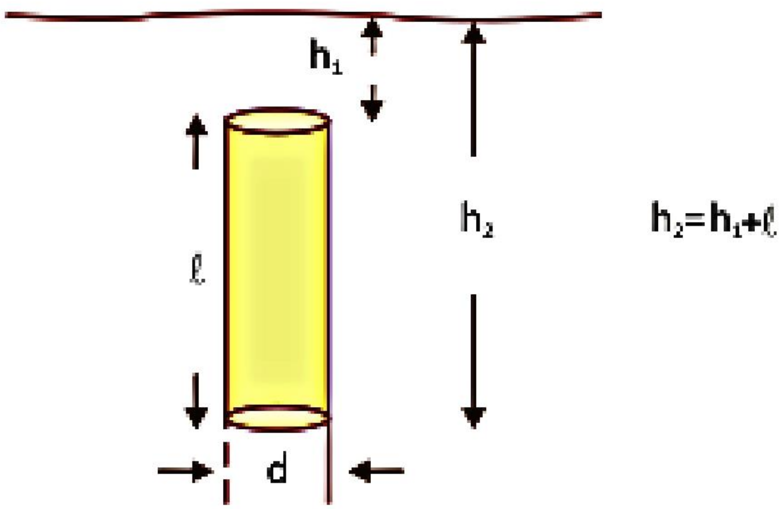

Fig (11) Buoyant force acting on top surface of aquabin.

= [Patm + (rgh1)] A

= [1 + (1000x9.81x0.01)]/4(0.4)^2

Ft = 12.4532 N

b

Vertical force on the bottom surface:

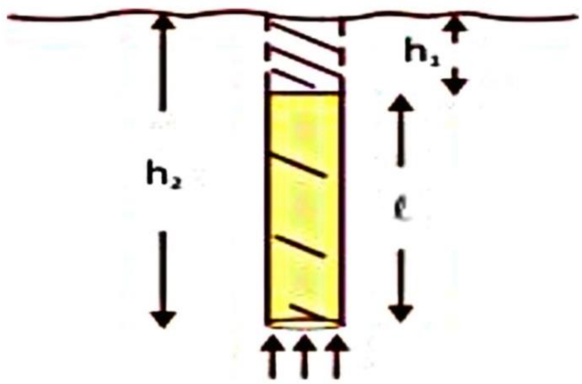

Fig (12) buoyant force acting on bottom surface of aquabin.

This acts vertically upward. Note that this is the weight of the fluid trapped in the column of height over the bottom surface of the cylinder.

h2= Distance of top surface of Aquabin from level of Water (h1 + l)

h2= (10+550) =560mm= 0.56m

B. Vertical force acting on the bottom circular surface

= [Patm + (rgh2)] A = [1 + (1000x9.81x0.56)] π/4 (0.4)^2

Fb= 690.471 N

C. Net force (vertical) on the cylinder:

F = rg(h2-h1) Or rgl = 1000 x 9.81 x (0.560-0.01)

F = 5395.5 N

This is the same as rAV, where V is the volume of the cylinder. Thus, buoyancy is the weight of the displaced fluid by the cylinder, acting upward.

D. Charging of solar battery

Volt of solar battery: 12 V

100W solar panel

To estimate maximum current output;

Solar panel voltage/battery voltage

100/12= 8.33A

(20% losses) PWM effect=75%

8.33*(1-20%)*75%= 5A

By rule of thumb battery charge effect lead acid=85%

12*1/0.85

= 14.11Ah

To charge battery entirely,

Battery capacity/ current

14.11 Ah/5

2.82hr to charge battery entirely.

Time required to charge battery to current level

Charge time/ battery depth of discharge

2.82hr*50% DOD

=3.53hr

Add 1 hr to account the absorption of charging stage for most of the controllers:

3.53+1

=4.53hrs

4.1 Designs on CATIA V5 R21 Software:

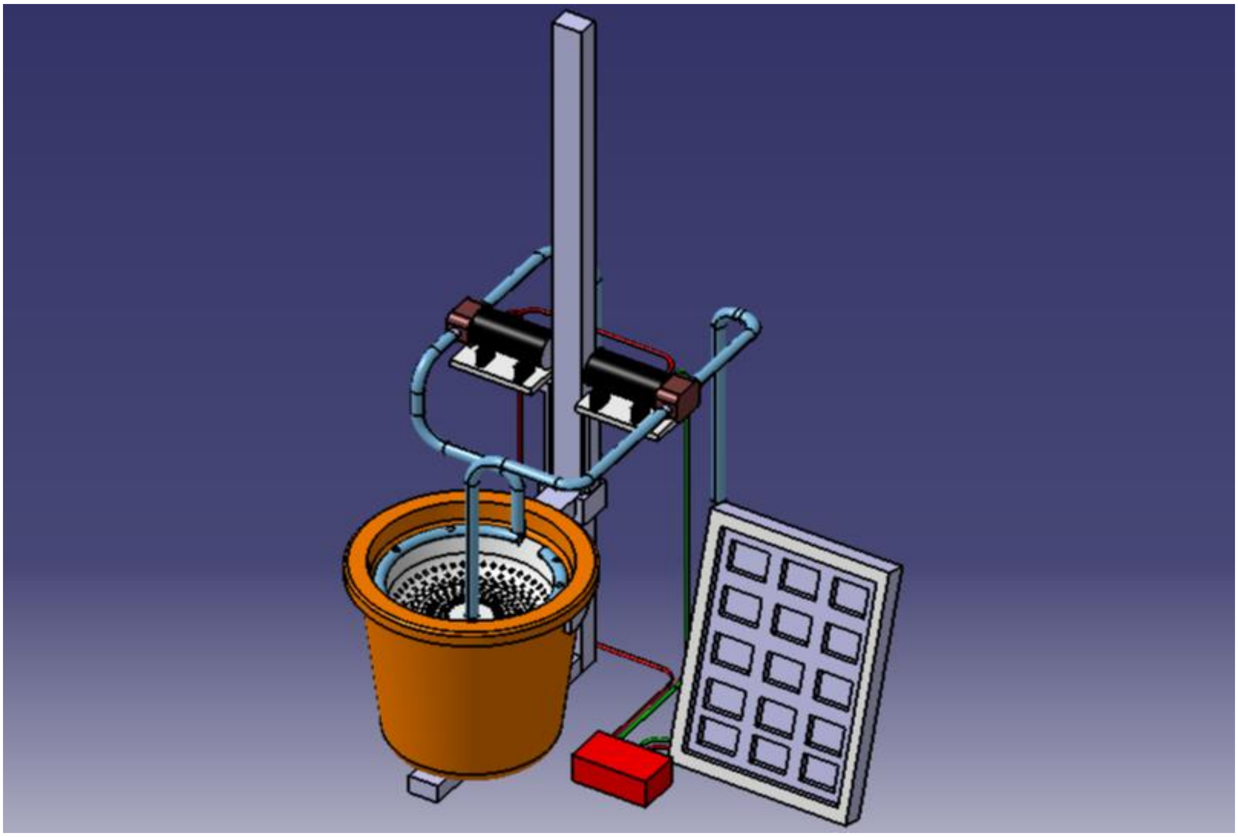

Fig (13) 3-D Modelling of Aquabin.

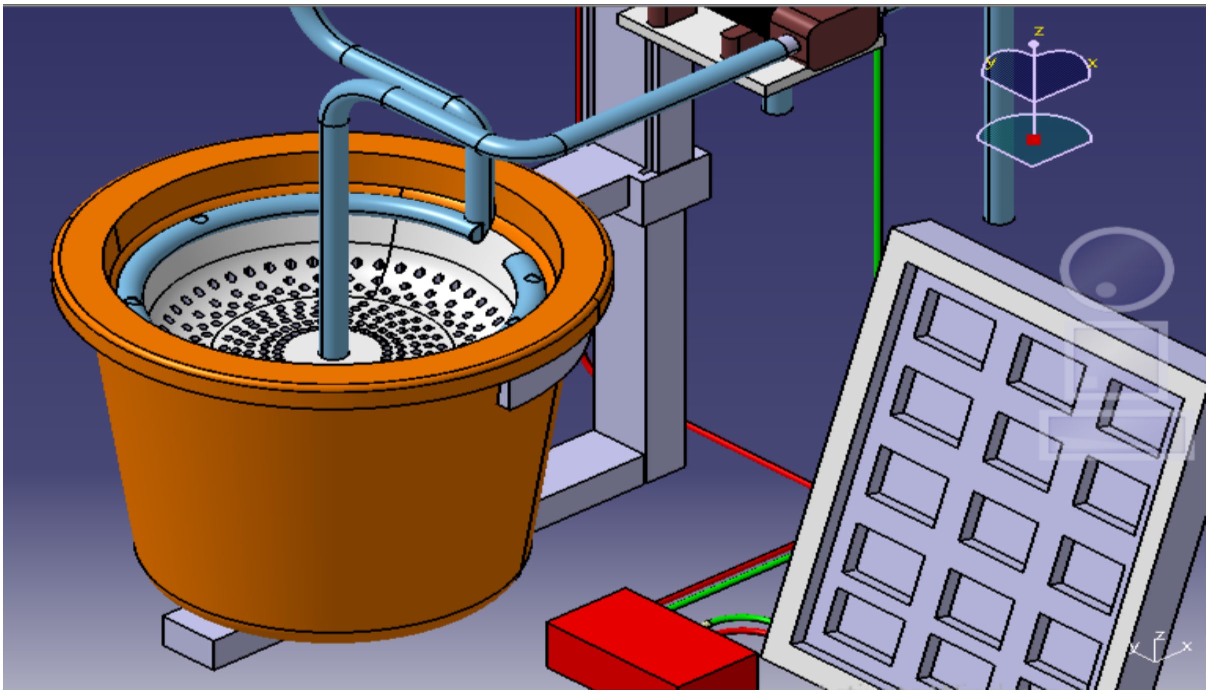

Fig (14) 3-D Modelling of Aquabin.

i. 12DC pumps are connected to battery which is then connected to solar panel.
ii. There are two concentric buckets of varying diameters are used.
iii. The smaller bucket has hole in its centre. Water entering the bucket gets collected between the two buckets.
iv. The suction pipe inserted in the bucket hole. This stored water between the buckets gets pumped out by discharge pipe.
v. Holes are made in the pipe surrounded around bucket. This hole helps to attract more debris by suction.

4. Process Sheets:

1. PART NAME: Vertical Supporting Column.

Part weight – 5 kg

Part material – M.S. Part quantity – 1

Part size – 1200mm x 40mm x 25mm.

Table 2: Process sheet of vertical Supporting Column.

Sr. No.	Operation	Machine	Tool	Time
1	Cutting the material as per our required size. 1200mm x 40mm x 25mm.	Cutting machine	Cutting machine	20 min
2	Drilling the holes as per our required size. Ø5 mm. for bucket height adjustment.	Drill machine	Drilling tool	25 in

2. PART NAME: Vertical Supporting Column Clamp Adjuster Pipe.

Part weight – 1 kg

Part material – M.S. Part quantity – 1

Part size – 200mm x 50mm x 25mm.

Table 3: Process sheet of vertical Supporting Column Clamp Adjuster Pipe.

Sr. No.	Operation	Machine	Tool	Time
1	Cutting the material as per our required size. 200mm x 50mm x 25mm.	Cutting machine	Cutting machine	15 min
2	Drilling the holes as per our required size. Ø5 mm. for Vertical Supporting Column Clamp Adjuster.	Drill machine	Drilling tool	20 min
3	Welding the clamp as per our required size.	Welding machine	Welding machine	15 in

3. PART NAME: Floating Bucket Height Adjustment Pipe

Part weight – 1 kg

Part material – M.S.

Part quantity – 1

Part size – 200mm x 50mm x 25mm

Table 4: Process sheet of Floating Bucket Height Adjustment Pipe

Sr. No.	Operation	Machine	Tool	Time
1	Cutting the material as per our required size. 200mm x 50mm x 25mm.	Cutting machine	Cutting machine	15 min
2	Drilling the holes as per our required size. Ø5 mm. for bucket height adjustment.	Drill machine	Drilling tool	20 min
3	Welding the bucket bracket as per our required size.	Welding machine	Welding machine	20 min

4. PART NAME: Bin Supporting Clamp.

Part weight – 1 kg

Part material – M.S.

Part quantity – 0.25 Part size – 200mm x 25mm x 5m

Table 5: Process sheet of Bin Supporting Clamp.

Sr. No.	Operation	Machine	Tool	Time
1	Cutting the material as per our required size. 200mm x 25mm x 5mm.	Cutting machine	Cutting machine	10 min
2	Drilling the holes as per our required size. Ø5 mm. for bucket fitting.	Drill machine	Drilling tool	15 min

5. Cost Estimation:

Total cost of material: 585/- Rs.

Total cost of machining: 725/- Rs.

Total cost of standard part: 2350/- Rs.

Cost of Project =

Cost of material + Cost of machinating + Cast of STD part

= 585 + 725 + 2350

= 3660 Rs/-

6. Aquabin

Fig (15) Aquabin

7. Testing:

Fig (16) Testing of Aquabin.

i. Aquabin was tested at Gandhi Talav Nashik, Maharashtra.
ii. The testing was done for five hours.
iii. Aquabin was installed on the bank first. Then power was supplied to pump by solar battery. Solar battery was charged timely by solar panel.
iv. The result of the test was quite appreciable within 5 hours aquabin was able to trap 750gms debris.

Fig(16) Debris collected in Aquabin

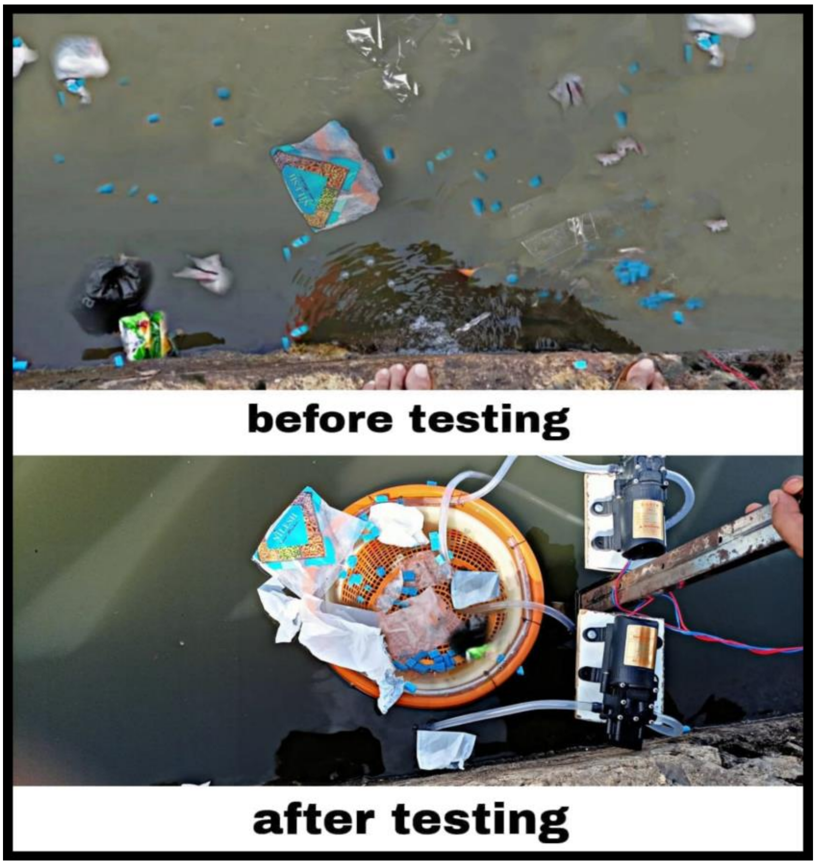

Fig (17) Testing results

i. As shown in Fig (17) we can see the difference between post testing and pre testing which is quite significant.
ii. Thus we can conclude that of Aquabin was successfully achieved.

8. Result

i. After testing we segregated the trash which was trapped inside the aquabin.
ii. Most of the debris were of plastic, polystyrene (thermocol) and floral waste.
iii. Aquabin's nylon net was able to trap the grease, oil, foam successfully.
iv. Thus aquabin was able to satisfy all the probable objectives of the project.
v. As mentioned earlier, actual cost of Seabin is 291910.13 Rs but we are able to make it for just 3660 Rs that too for all working conditions. That means we were able to cut almost 99% of cost form the project.

9. CONCLUSIONS

i. By successful implementation of Aquabin affective floating debris trapper system can be achieved

ii. There is no size limit for the debris for aquabin as it is able to catch all microplastics and microfibers as well.

iii. As Aquabin runs from solar energy it promotes the use of non-conventional energy which diversify energy supply from conventional sources causing the pollution.

iv. Aquabin requires less capital cost.

v. Aquabin cuts the need of continuous assessment of a human for water cleaning projects.

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