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A Project Report on

"DESIGN AND FABRICATION OF SOLID WASTE COLLECTOR AND WATER DE-FROTHING DEVICE"

Carried out by

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Submitted in partial fulfillment for the award of
BACHELOR OF ENGINEERING
IN
MECHANICAL ENGINEERING

Under the Guidance Of
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DEPARTMENT OF MECHANICAL ENGINEERING
K S INSTITUTE OF TECHNOLOGY
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CERTIFICATE

This is to certify that the project work entitled **"DESIGN AND FABRICATION OF SOLID WASTE COLLECTOR AND WATER DE-FROTHING DEVICE"**is a bonafide work carried out by

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In partial fulfillment for the award of **Bachelor of Engineering** in **Mechanical Engineering** from**Visvesvaraya Technological University**, Belagavi during the academic year 2019-2020. It is certified that all the corrections/suggestions indicated for the internal assessment have been incorporated in the report deposited in the department. The project has been approved as it satisfies the academic requirements.

Signature of Guide	Signature of HOD	Signature of Principal& CEO
(Prof. Umashankar M)	**(Prof.Umashankar M)**	**(Dr. K VA BALAJI)**
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DECLARATION

We, Ashwin Maiya M, Harshith S, M Venkatesh Kashyap and Manoj R , students of 8th semester B.E, Mechanical Engineering, K.S. Institute of Technology, Bengaluru hereby declare that the project report entitled "**DESIGN AND FABRICATION OF SOLID WASTE COLLECTOR AND WATER DE-FROTHING DEVICE**" embodies the record of the project work carried out by us, for the fulfillment of the course requirement for the award of Degree in Bachelor of Engineering in Mechanical Engineering, Visvesvaraya Technology University, Belagavi during the academic year 2019-2020. Further, the matter embodied in dissertation has not been submitted previously by anybody for the award of any Degree or Diploma to any other University.

Signature of the candidates

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Place: Bengaluru
Date:

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Thank You,

Ashwin Maiya M

Harshith S

M Venkatesh Kashyap

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ABSTRACT

Water covers 71% of the Earth's face. About 98% of the water is present in seas and oceans which is not viable for human usage. Around 1% of the water of the available fresh water is in the form of glaciers, less than 1% of the fresh water is readily available for usage. Since, water is considered as a fundamental entity for all living beings, it is imperative that we, human beings try and save the available fresh water. Water Pollution is a major problem faced by the human civilization from the past decades and the main sources of water for human usage are lakes, ponds, rivers, underground water, etc., which are used for domestic and drinking purposes. It is the duty of us, human beings, to keep it clean so that it can be transferred to our future generations the way it was passed onto us by our ancestors, if not in a better way. Water bodies contain a large number of pollutants apart from the floating solid wastes. The sewage that carries the waste from domestic houses, contains large amounts of fats, fatty acids, metal ions, suspended in the water which exceed the permissible value. These contribute in producing froth on the surface of the water bodies. This results in less area of water being exposed to the atmosphere; hence, less oxygen dissolution will take place in the water, leading to a lack of oxygen supply for the aquatic life.

The project aims to contribute to a pollution-free environment by collecting waste from water bodies without human interference, which makes it easier and less risky. This device can be deployed in any small to medium volume water bodies that have domestic waste such as soaps, detergents, fats, fatty acids, organic and inorganicsubstances that act pollutants. The collected waste can be recycled or processed according to their usage. Marine life gets depleted due to lack of oxygen dissolution, which can be reduced using this device, as it helps in removing the organic wastes that contribute to the formation of foam on the water surface. This device also incorporates a mineral-filters that help in removing excessiveamounts of minerals from the water bodies, which act as pollutants. This device also aims at reducing the odor of the water by exposing it to the atmosphere for a prolonged period for better aeration.

Keywords: Pollutants, organic and inorganicpollutants, floating solid waste, solid waste collector, oil skimmer, foam fractionator, mineral-filters, Ultra Violet Chamber, TDS (Total dissolved Salts), pH, water hardness.

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CHAPTER 1
INTRODUCTION

Pollution is the introduction of contaminants or harmful substances into natural environment or the disruptive levels of noise, light, chemicals, etc., into the natural environment.

1.1 Water Pollution

Water is one of the fundamental elements required for the survival of living beings.Water pollution occurs when harmful substancesoften chemicals or microorganismscontaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment. Around 80% of the world's wastewater is dumpedlargely untreatedback into the environment, polluting rivers, lakes, and oceans.Water is uniquely vulnerable to pollution. Known as a "universal solvent," water is able to dissolve more substances than any other liquid on earth. It's the reason we have Kool-Aid and brilliant blue waterfalls. It's also why water is so easily polluted. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution.This widespread problem of water pollution is jeopardizing our health. Unsafe water kills more people each year than war and allother forms of violence combined. Meanwhile, our drinkable water sources are finite: Less than 1 percent of the earth's freshwater is actually accessible to us.

Fig 1.1: Polluted lake

1.2 Most Common Types of Water Contamination

➢ Agriculture

Not only is the agricultural sector the biggest consumer of global freshwater resources, with farming and livestock production using about 70% of the earth's surface water supplies, but it's also a serious water polluter. Around the world, agriculture is the leading cause of water degradation leading to contamination in rivers and streams,in lakes. Every time it rains, fertilizers, pesticides, and animal waste from farms and livestock operations wash nutrients and pathogens, such bacteria and virusesinto our waterways. Nutrient pollution, caused by excess nitrogen and phosphorus in water, is the number-one threat to water quality worldwide and can cause algal blooms, a toxic soup of blue-green algae that can be harmful to people and wildlife.

➢ Sewage and Wastewater

Used water is wastewater. It comes from our sinks, showers, and toilets (think sewage) and from commercial, industrial, and agricultural activities (think metals, solvents, and toxic sludge).

Fig 1.2: Sewage water entering the water body

The term also includes storm water runoff, which occurs when rainfall carries road salts, oil, grease, chemicals, and debris from impermeable surfaces into our waterways. According to EPA estimates, our nation's sewage treatment systems also release more than 850 billion gallons of untreated wastewater each year.

➢ Oil Pollution

Big spills may dominate headlines, but consumers account for the vast majority of oil pollution in seas, including oil and gasoline that drips from millions of cars and trucks every day. Moreover, nearly half of the estimated 1 million tons of oil that makes its way into marine environments each year comes not from tanker spills but from land-based sources such as factories, farms, and cities. At sea, tanker spills account for about 10 percent of the oil in waters around the world, while regular operations of the shipping industry, through both legal and illegal discharges contribute about one-third. Oil is also naturally released from under the ocean floor through fractures known as seeps.

➢ Radioactive Substances

Radioactive waste is any pollution that emits radiation beyond what is naturally released by the environment. It's generated by uranium mining, nuclear power plants, and the production and testing of military weapons, as well as by universities and hospitals that use radioactive materials for research and medicine.

Fig 1.3: Radioactive wastes from a nuclear plant being released into a water body

Radioactive waste can persist in the environment for thousands of years, making disposal a major challenge. Consider the decommissioned Hanford nuclear weapons production site in Washington, where the clean-up of 56 million gallons of radioactive waste is expected to cost more than $100 billion and last through 2060. Accidentally released or improperly disposed of contaminants threaten groundwater, surface water, and marine resources.

1.3 Effects of Water Pollution

➢ On Human Health

"Water pollution kills". Every year, unsafe water sickens about 1 billion people. And low-income communities are disproportionately at risk because their homes are often closest to the most polluting industries. Waterborne pathogens, in the form of disease-causing bacteria and viruses from human and animal waste, are a major cause of illness from contaminated drinking water. Diseases spread by unsafe water include cholera, giardia, and typhoid. A wide range of chemical pollutants from heavy metals such as arsenic and mercury to pesticides and nitrate fertilizers are getting into our water supplies. Once they're ingested, these toxins can cause a host of health issues, from cancer to hormone disruption to altered brain function. Children and pregnant women are particularly at risk.

➢ On the Environment

When water pollution causes an algal bloom in a lake or marine environment, the proliferation of newly introduced nutrients stimulates plant and algae growth, which in turn reduces oxygen levels in the water. This dearth of oxygen, known as eutrophication, suffocates plants and animals and can create "dead zones," where waters are essentially devoid of life. In certain cases, these harmful algal blooms can also produce neurotoxins that affect wildlife, from whales to sea turtles. Chemicals and heavy metals from industrial and municipal wastewater contaminate waterways as well. These contaminants are toxic to aquatic lifemost often reducing an organism's life span and ability to reproduceand make their way up the food chain as predator eats prey. That's how tuna and other big fish accumulate high quantities of toxins, such as mercury. Marine ecosystems are also threatened by marine debris, which can strangle, suffocate, and starve animals. Much of this solid debris, such as plastic bags and soda cans, gets swept into sewers and storm drains and eventually out to sea, turning our oceans into trash soup and sometimes consolidating to form floating garbage patches. Discarded fishing gear and other types of debris are responsible for harming more than 200 different species of marine life.

CHAPTER 2
LITERATURE REVIEW
& OVERVIEW

2.1 LITERATURE REVIEW

This literature review is a study of papers and journals that are related to water pollution and the methods adopted in treating polluted water bodies.

TV Ramachandra et al.[1] have investigated the spatial patterns of heavy metal accumulation in sediments and macrophytes in Bellandur Lake, Bengaluru, India. The study shows the accumulation of metals in sediments were in the order ofZn > Cu > Cr > Pb > Ni > Cd. All these metals exceeded the critical limits of metals in sediment. In the macrophytes, Eichhornia crassipes samples had higher metal concentrations in the middle and inlet reaches.

Mahindra Salvi et al. [2] The “Lake cleaning machine” can be used to clean water in places where floating waste is present. This machine shall reduce water pollution and subsequently reduce the aquatic animal’s death. This machine consists of Paddle driven waterwheel which collect waste (garbage & plastic wastages) but it requires a skilled human and the system is not safe.

SParthipan et al. [3] The work has done looking at the current situation of our national rivers which are dumped with litters of sewage and loaded with pollutants, toxic materials, debris etc. The river cleaning process is done through the moving links on the conveyor setup which is powered with the help of manual force. Meanwhile boat movement is also controlled by the pedaling force through turbine activation.

Dr. Akash Langde Anjuman et al.[4] have designed an equipment to collect the solid floating wastes from the water bodies. The machine once deployed into the water body uses a conveyor belt mechanism, which is stored into a collecting tank. A gate is fixed at the front which opens and closes for the intake of floating wastes. This system is only able to collect the garbage and other solid wastes from the lake without direct human intervention.

Prof. Basanagouda Shivalli et al. [5] have designed equipment to the collect solid wastes from the water bodies using a mesh rather than the conventional conveyor belt. But the usage of mesh leads to clogging by aquatic plants like weeds and other floating wastes. This system is only collecting floating aquatic plants and weeds from the water bodies.

Prof. Ankur Joshi et al.[6] have designed and fabricated "River Waste Collector", a machine which involves the removing the waste debris from water surface and safely dispose from the water body. This machine is able to collect the waste which is only floating on water level. Although this system able to collect the garbage from the river with human interaction.

Dr. N. Nithyavathy et al. [7] the motive of the project is to automate the sewage cleaning process in drainage, to reduce the spreading of diseases to human. The set-up runs even in sewage area with water (limited to a particular amount) so that the wastages which floats on the water surface also gets collected. The garbage which affects the drainage is also picked up and removed. This system has limited human intervention in the process of cleaning.

NDUBUISI C. Daniels et al.[8] has designed a Drainage system cleaner, a machine which helps to protect the environment from different kinds of environmental hazards through the promotion waste management by the removal of garbage from the drainage system. The Drainage system functioned well when there is maximum load.

Marino Morikawa et al. [9] used in Nano organic compost in de-nitrification of the lake. This process was found to be time consuming; the manufacturing of Nano particles is costly and not economically feasible to use for large water bodies as the compost is requirement gets high. Also, the Nano particles in wastewater yield toxic effects on aquatic beings over the period of time.

Hemanth Naveen K S et al. [10] in his paper discussed about removing both solid and dissolved pollutants involve using activated sludge, synthetic coagulation of wastewater. It was found that the sewage treatment plants are not feasible to setup near small water bodies also the water to be treated should be allowed to settle for a longer duration

2.2 OVERVIEW

Lakes contain contaminants like, floating-solid wastes, fats, fatty acids, carbohydrates, metal ions that exceed the permissible safe value, organic contaminants like phytoplankton, bacteria, etc. which are the main sources causing foam in any water bodies.

The methods adopted for the purification include removal of only floating solid wastes, aquatic plants and weeds and does not focus on reducing the foam levels water bodies. Also, the present approach involves a complex design as it uses conveyor belt, pedaling mechanism etc. which in turn increases the kerb weight, hence reducing the payload.

Most of these approaches eliminate human intervention but few of them require a skilled human to operate and the system is not safe. Recent studies show that the usage of Nano particles in wastewater yields toxic effects on aquatic beings over the period of time. Hence this method is also not suitable.

The method used for removing both solid and dissolved pollutants involves using activated sludge, synthetic coagulation of waste water. It was found that the sewage treatment plants are not feasible to setup near small water bodies also the water to be treated should be allowed to settle for a longer duration.

CHAPTER 3
PROBLEM DEFINITION
& OBJECTIVES

3.1PROBLEM DEFINITION

- Water pollution is a serious environmental issue. Water is polluted by physical, chemical and biological waste, that is deteriorated via anthropogenic and natural activities in water bodies. These wastes are a result of human activities, mainly due to industrialization which is very hazardous to the environment. There are few methods that are able to remove the pollutants from water and entitle it for reusage. However, these methods cannot remove the effluents completely and are not feasible enough to be installed for smaller water bodies.

- As research done over Bellandur lake, Bengaluru it is found that the lake containsheavy metals that are mainly released from industrial processes; industrial discharges, mining operations and acid mine drainage. Another major source of heavy materials are fertilizers, pesticides, untreated or partially treated industrial waste water, leachates from mining sites, industrial waste, wastes from smelting ores, sewage sledge, etc., due to indiscriminate disposal of untreated sewage and industrial effluents into urban water bodies, heavy metals are getting accumulated in the sediment, plants and other organisms. Accumulation of heavy metal ions and macrophytes in high concentrations cause ill effects to the surrounding environment.

- Present projects related to wastewater treatment are restricted for collecting only solid waste. This method does not remove any chemical waste dissolved in water. Hence, it'sthe most effective and feasible method to be incorporated for wastewater treatment.

- One of the most commonly used process is wastewater treatment in sewage treatment plants. The problems faced in sewage treatment plants include the setting up of the plant near the water body. In metropolitan cities like Bengaluru, setting up of a sewage treatment plants near every lake is highly impossible due to the constraints like land disputes and high cost. The alternative for sewage treatment involves transporting the water from the water body to the treatment plant. This is not feasible, as the cost for transportation to and from the water body before and after purification is very high. Also, in sewage treatment plants, the time taken for the purification is very high.

3.2OBJECTIVES

The aim of the project is to remove the pollutants from the water bodies so that the water can be transported to suburban areas and villages around the cities for domestic or irrigation usage. The following points give the results expected from each process in the purification processes.

- To integrate solid waste separator and chemical purifier in the same device.
- Separation of floating solid waste from the water.
- Separation of floating oil and grease.
- Removal of dissolved pollutants.
- Removal of metal ions and chemical pesticides.
- Reducing the alkalinity and maintaining the pH value of the water.
- Killing or inhibiting the activities of micro-organisms.
- Reducing the growth of algae.
- To reduce the odour by aeration.

CHAPTER 4
METHODOLGY&
PROCESS FLOW

4.1PROCESS FLOW

The proposed device incorporates physical methods to remove the pollutants from water bodies. This device can be deployed into any water body, small, medium or large and can be transported easily. The purification of water takes place in series of stages involving various processes, which removes a specific impurity or contaminant in every stage.

- In the initial stage, the polluted water enters the solid waste collector, which also acts as the input for the device. Here, the floating solid waste is separated from liquid water.

- In the later stage, oils and fatty acids are skimmed by employing acrylic oil skimmer [11].

- Further the organic pollutants such as, animal and plant waste dissolved detergents, soaps, are filtered by foam fractionation using a fractionator[12].

- Chlorine, iodine, fluorine and other organic chemicals are filtered using mineral filters consisting of heavy absorbent membranes.

- De-odorizing and microbial activities are inhibited by passing the water through an Ultraviolet Clarifying Chamber.

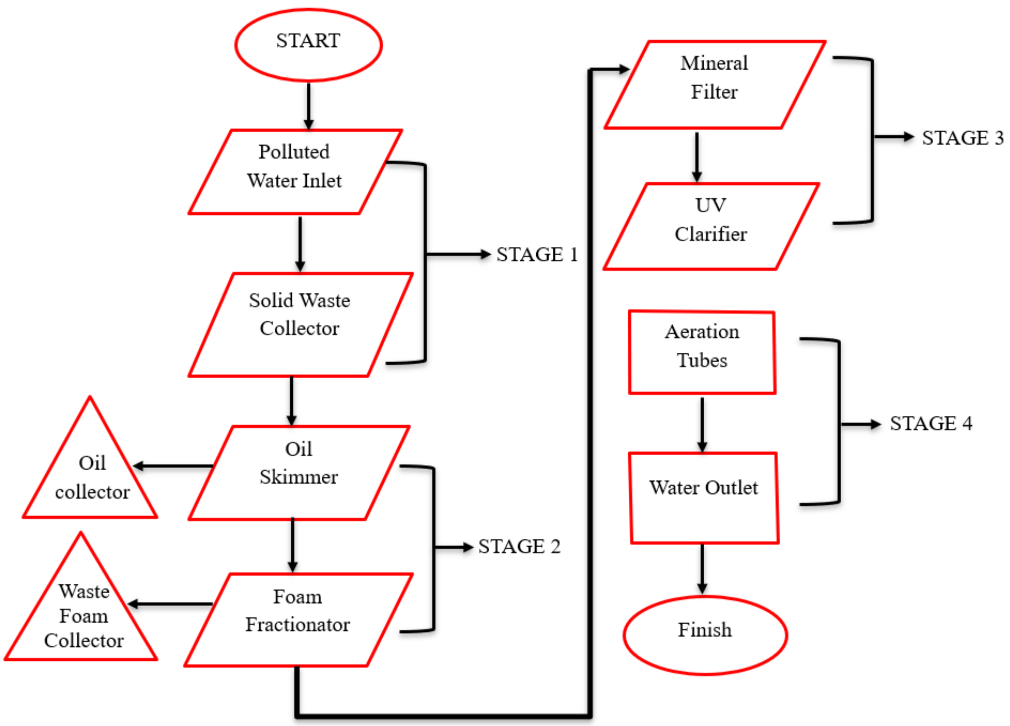

Fig 4.1 Process flow diagram

4.2 METHODOLOGY

4.2.1 Stage 1

In the first stage of the water purification, the polluted water from the water body flows into the device from inlet section and to the solid waste.

- **Solid Waste Collector**

A Solid Waste Collector is a device which effectively collects floating solid wastes from the water bodies with less or without any human intervention. Here the polluted water enters through inlet and the Solid Waste Collector separates the floating and suspended particles (of considerable particle size). Water flowing to the next stages are free from solid wastes and only liquid water flows to the further components.

Fig 4.2: Solid waste collector fitted at the mouth of the sewage pipe

4.2.2 Stage 2

After the solid waste collector, the water flows into the second stage of components, which houses an oil skimmer used to remove floating oils, and foam fractionator to remove dissolved organic pollutants.

- **Oil Skimmer**

An oil skimmer is a device that is designed to remove oil floating on a liquid surface. Depending on the specific design they are used for a variety of applications such as oil spill response, as a part of oily water treatment systems, removing oil from machine tool coolant and aqueous parts washers, and collecting fats oils and greases in wastewater treatment in food manufacturing industries.

Types of oil skimmers

- Weir skimmers function by allowing the oil floating on the surface of the water to flow over a weir. There are two main types of weir skimmer, those that require the weir height to be manually adjusted and those where the weir height is automatic or self-adjusting.
- Belt oil skimmers are one of the most reliable and economical equipment for removing liquid surface floating oil with low electric consumption without the need for any consumable. They can effectively remove all kinds of floating oil (including machine oil, kerosene, diesel oil, lubricating oil, plant oil and other liquids with specific gravity less than water.
- Oleophilic skimmers function by using an element such as a drum, disc, rope or mop to which the oil adheres. The oil is wiped from the oleophilic surface and collected in a tank. As the oil is adhering to a collection surface the amount of water collected when oil is not present will be limited.

Fig 4.3: Drum type Oil skimmer

- **Foam Fractionator**

Foam Fractionator is a device used to remove the dissolved pollutants by creating foam in the water. The hydrophobic contents in the water get adsorbed onto the water bubbles and raise to the surface of the water.

Foam Fractionator removes certain organic compounds, including protein sand amino acids found in food particles, by using the polarity of the protein itself. Due to their intrinsic charge, water-borne proteins are either repelled or attracted by the air/water interface and these molecules can be described as hydrophobicorhydrophilic, such as salt, sugar, ammonia, most amino acids, and most inorganic compounds. Basically, there's two main areas that are of focus when people talk about their skimmers: water flow and air injection method. With water flow, there's two general methods:

- Co-current
- Counter-current

Fig 4.4: Commercial Foam fractionator

4.2.3 Stage 3

Water coming out of the foam fractionator is free from the organic pollutants and the water flows to the third stage in which it flows through a series mineral filters and Ultra-Violet Clarifier.

- **Mineral Filters**

A water filter removes impurities by lowering contamination of water using a fine physical barrier, a chemical process, or a biological process. Filters cleanse water to different extents for purposes such as providing agricultural irrigation, accessible drinking water, public and private aquarium, and the safe use of ponds and swimming pools. Point-of-use filters for home use include granular-activated carbon filters (GAC) used for carbon filtering, depth filter, metallic alloy filters, microporous ceramic filters, carbon microfiltration and ultrafiltration membranes. Some filters use more than one filtration method. Carbon filtering works by absorption, in which pollutants in the fluid to be treated are trapped inside the pore structure of a carbon substrate. The substrate is made of many carbon granules, each of which is itself highly porous. As a result, the substrate has a large surface area within which contaminants can be trapped. Activated carbon is typically used in filters, as it has been treated to have a much higher surface area than non-treated carbon. One gram of activated carbon has a surface area in excess of 3,000 m^2 (32,000 sq ft).

Fig 4.5: Commercial mineral filters

- **Ultra-Violet Clarifier**

UVC (Ultra-Violet Clarifier) is a water and air disinfecting unit. This consists of a UV lamp housed inside a chamber which facilitates the deactivation of bacteria, viruses and other micro-organisms in the water.

The high intensity UV light inhibits the activity of bacteria, virus and other micro-organisms and their growth is reduced resulting in odour control and clearer water.

Fig 4.6: Commercial UV clarifier

4.2.4 Stage 4

After the microorganisms are de-activated in the UV chamber, the water flows to next stage, which concentrates on the reduction of odour from the water.

The fourth stage has a shower that is used to spray the water to a distance. This allows the water to come in contact with the atmosphere for a prolonged period, deodorizing the water. A Kinetic Degradation Fluxion (KDF) filter is incorporated in the shower. It is a high-purity copper-zinc formulation that uses a basic chemical process known as redox (oxidation/reduction) to further remove any traces of chlorine, lead, mercury, iron, and hydrogen sulfide from water.

Fig 4.7: Commercial KDF filter with shower

CHAPTER 5
EXPERIMENTAL PROCESS

EXPERIMENTAL PROCESS

The previous chapter explains the basic principles of the components used in the device. This chapter emphasises the process of the project, right from the beginning of the design phase to the fabrication of each component and testing of the assembled device.

5.1 DESIGN PHASE

5.1.1 Frame

The designing of the frame had to be changed during the course of the project as there were no previous references. The frame was designed for supporting member the components mounted on it, while a part of the frame was submerged under water and the rest was to float above the surface.

Many iterations of the frame design were considered as shown below;

1. Iteration I

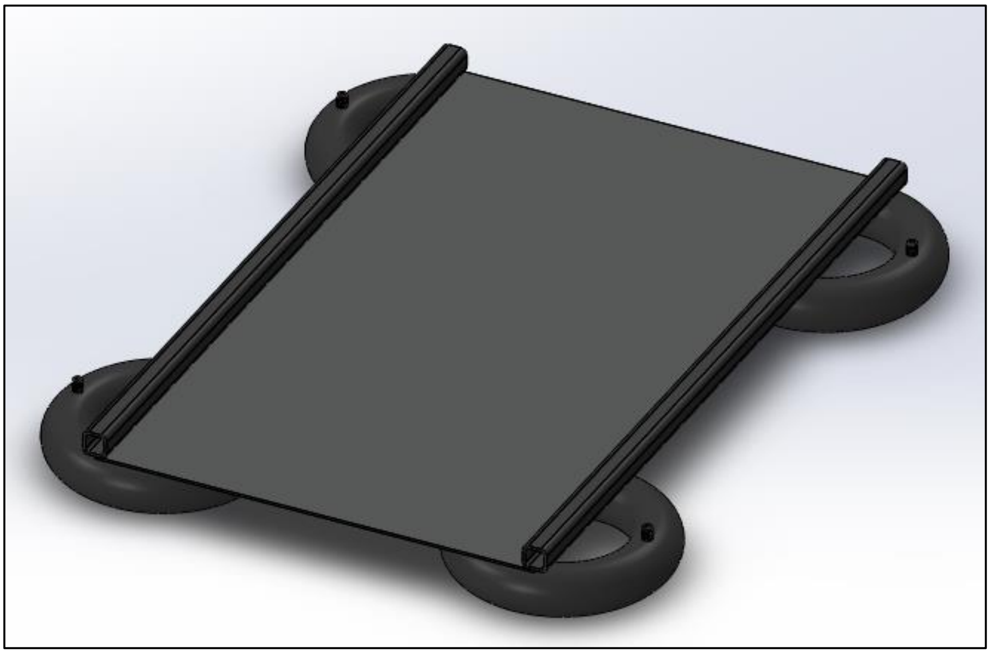

Fig 5.1: Frame design- Iteration I

The first iteration was a simple flat-bed frame, just enough to float above the surface of the water and hold the components on top of it.

The problems faced with this frame was that the inlet for the polluted water with the floating solid wastes could not be submerged in the water and the other components could not be fixed rigidly onto the flat platform, as some of the components required more than just the base support. To avoid the rocking of the components due to waves in the water body, fixed on a flat-bed frame, the design of the frame was changed.

2. Iteration II

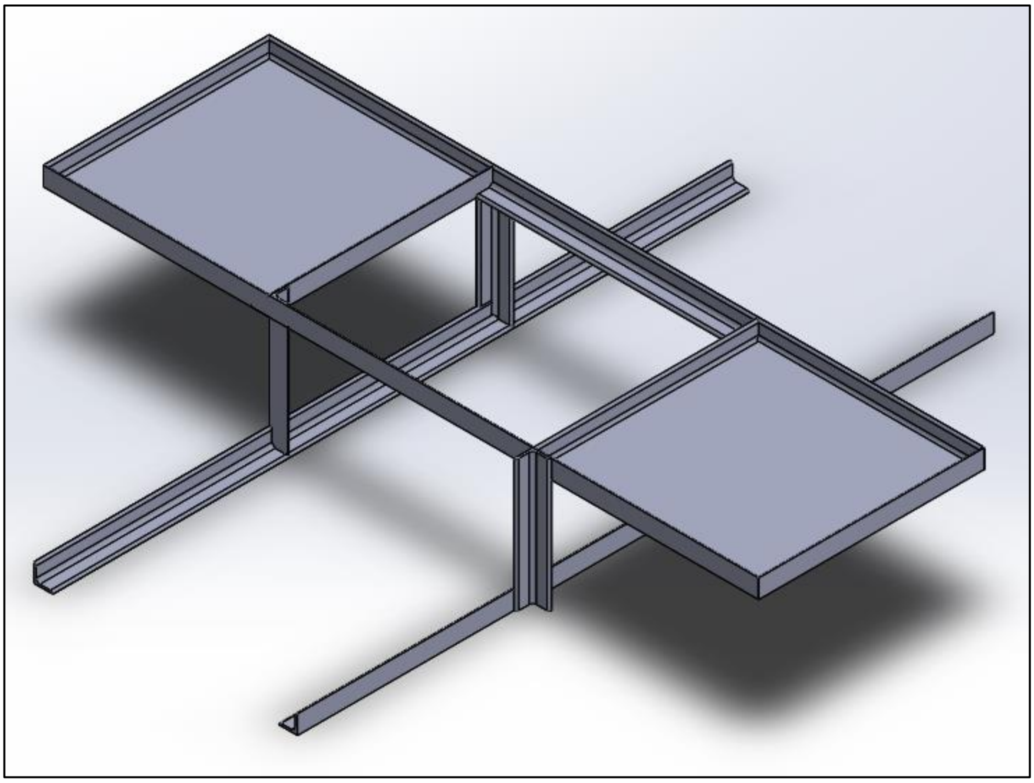

Fig 5.2: Frame design- Iteration II

The second iteration solved the problem of submerging the solid waste collector as this frame was designed in such a way that the lower part of the frame would be submerged with the solid waste collector fixed to one of its ends and the other components would be mounted on the upper compartment which would be floating above the water surface.

The problem faced with this frame was that the weight of the components mounted on one side of the upper compartment of the frame was not compensating with the other side. This would result in the frame toppling over in the water body. These problems were solved in the final iteration of the frame.

3. Iteration III

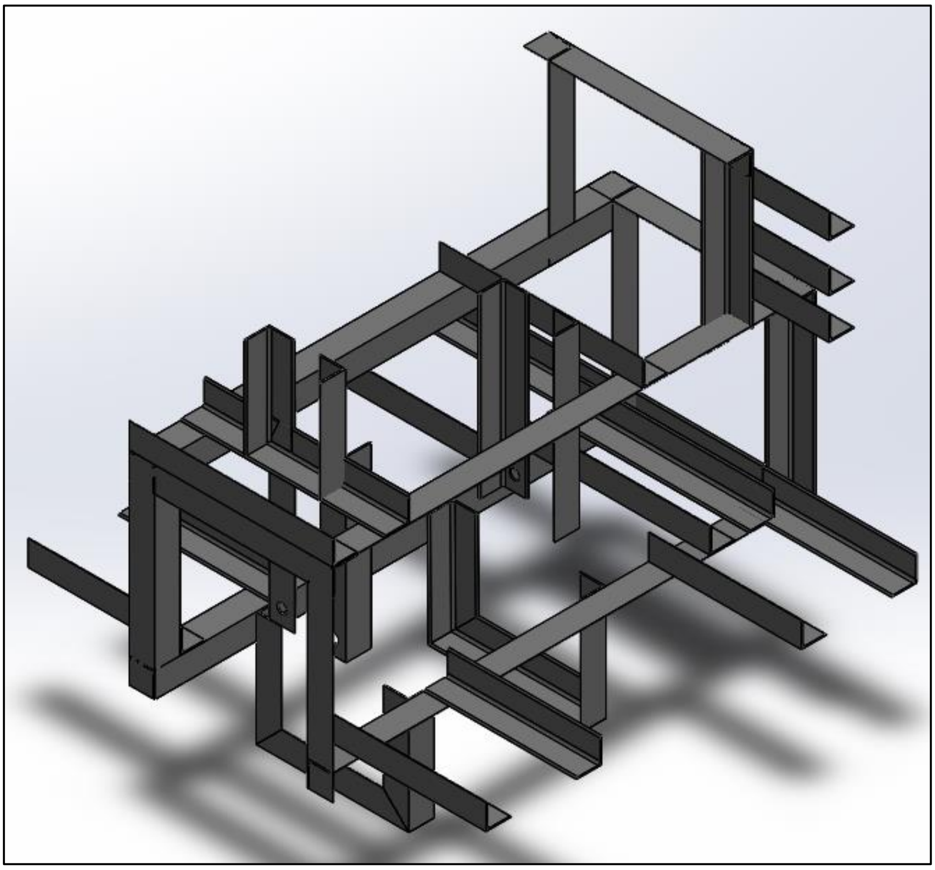

Fig 5.3: Frame design- Iteration III

This frame design satisfied all the required purposes and solved the problems faced with the previous designs.

This frame is simple in design and the components that require more than the base support can be mounted with ease, the weight distribution on the frame is also equal throughout the frame as the components are mounted on the lateral centre axis of the frame. The solid waste collector, oil skimmer and the surge tanks are mounted on the bottom compartment and the rest of the components are mounted on the upper compartment of the frame.

Due to the submerging of the lower compartment of the frame, the water flows freely into the device and does not require any external pump.

5.1.2 Solid waste collector

The solid waste collector has to fulfil the purpose of separating the floating solid wastes from the polluted water and store it, so that it can be removed once the device is ashore.

There were many references from the previous projects, but those projects had the sole purpose of removing the floating solid wastes from the water bodies, hence those designs were considerably huge and cannot be incorporated into this device, as the device has to house other components required to perform different filtration processes. To device such a solid waste collector, there were some iterations during the designing phase which had its own pros and cons.

1. Iteration I

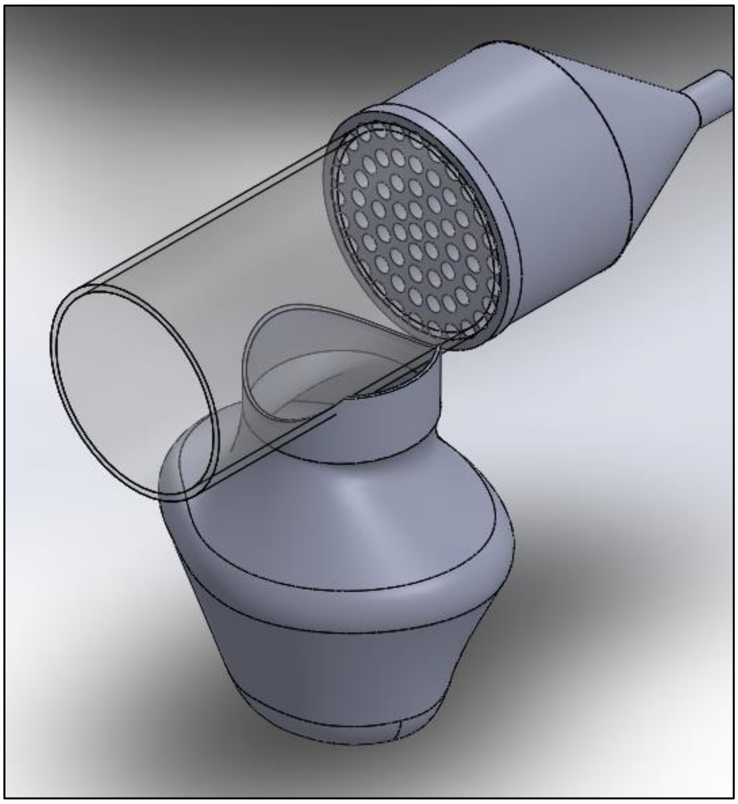

Fig 5.4: Solid waste collector design- Iteration I

This was the first iteration of the solid waste collector, which was designed to fit the initial design of the frame. This solid waste collector was designed in such a way that the solid waste collected would be transferred to another storage unit connected to the inlet pipe of the collector. A mesh was to be fixed at a point at which the solid waste and the liquid water were supposed to be separated.

This collector had difficulties with being submerged and also there required an external pump to drive the water into the inlet pipe.

2. Iteration II

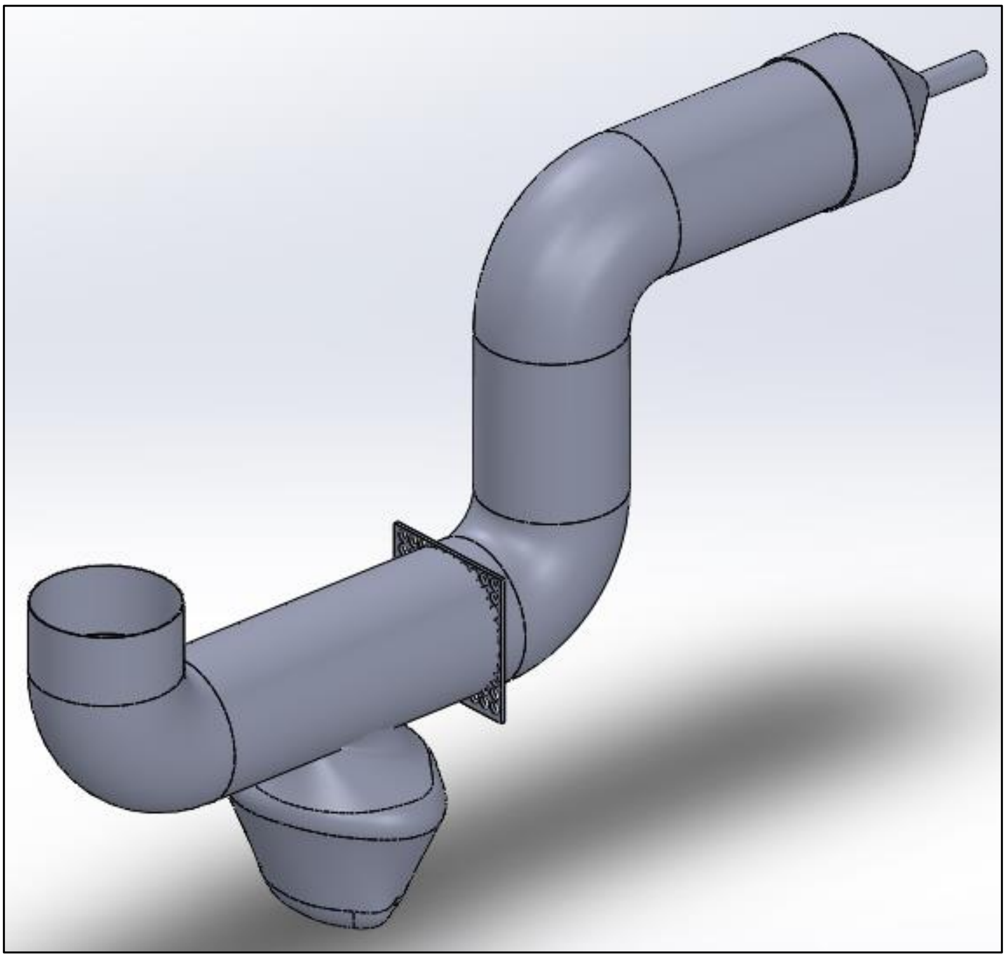

Fig 5.5: Solid waste collector design- Iteration II

This iteration of the solid waste collector solved the problem of submerging, with the U-bend of the inlet pipe.

This design failed to solve the problem eliminating an external pump required to drive the water through the inlet pipe. Another problem faced in this design of the collector was that the storage unit was placed in such that there was possibility of water being diverted from its direction.

3. Iteration III

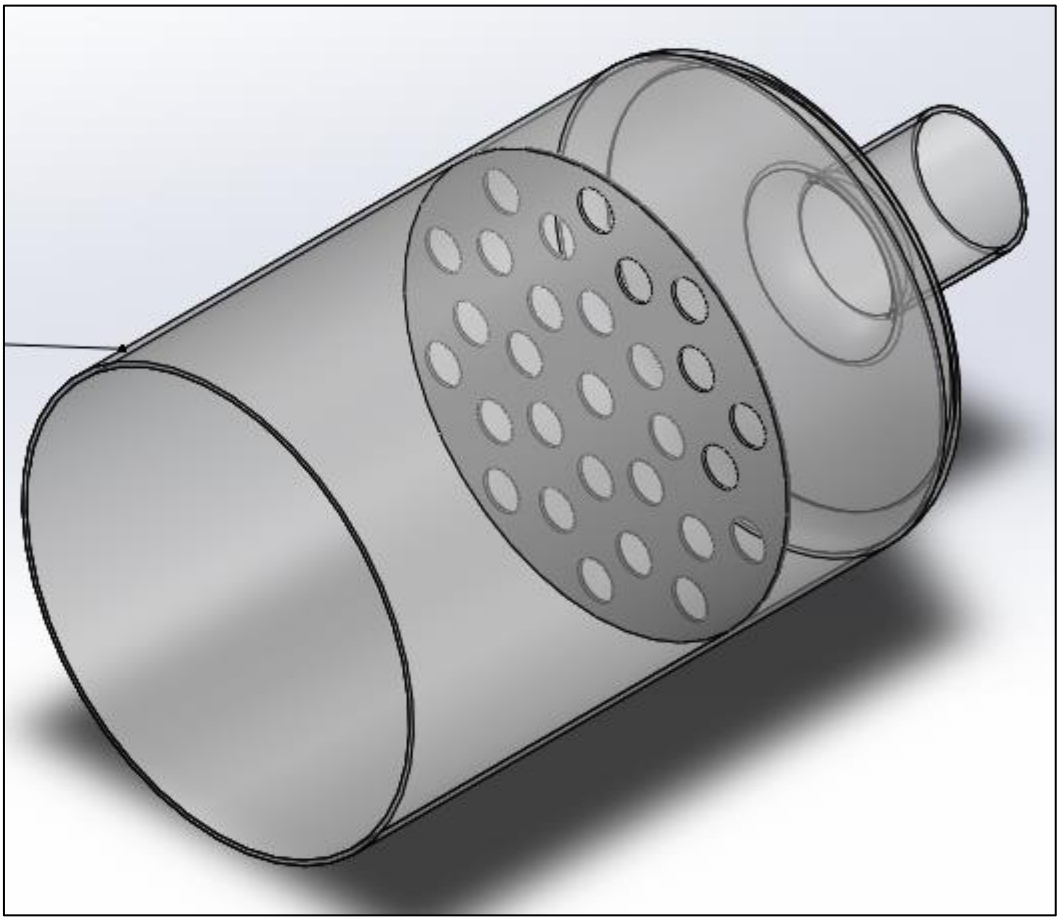

Fig 5.6: Solid waste collector design- Iteration III

The 3^{rd} iteration was designed keeping in mind, the problems faced by the previous iterations like, submerging problems, usage of external pump and the external storage unit for the separated solid waste.

The above design shows that a mesh is being used to separate the solid waste from the liquid water at a point that allows gives sufficient space for the separated solid wastes to accumulate and allow the water to flow further.

Since the collector is submerged with the lower compartment of the frame, as discussed earlier, usage of an external pump to drive the water through the inlet is eliminated. Since the part of the frame to which the collector is mounted also submerges in the water, there is no requirement for any additional mounting bars.

5.1.3 Oil skimmer

The principle of the oil skimmer as explained in the previous chapter and the reference form the previously performer projects were used to design the oil skimmer. There were two iterations in case of the oil skimmer design,

1. Iteration I

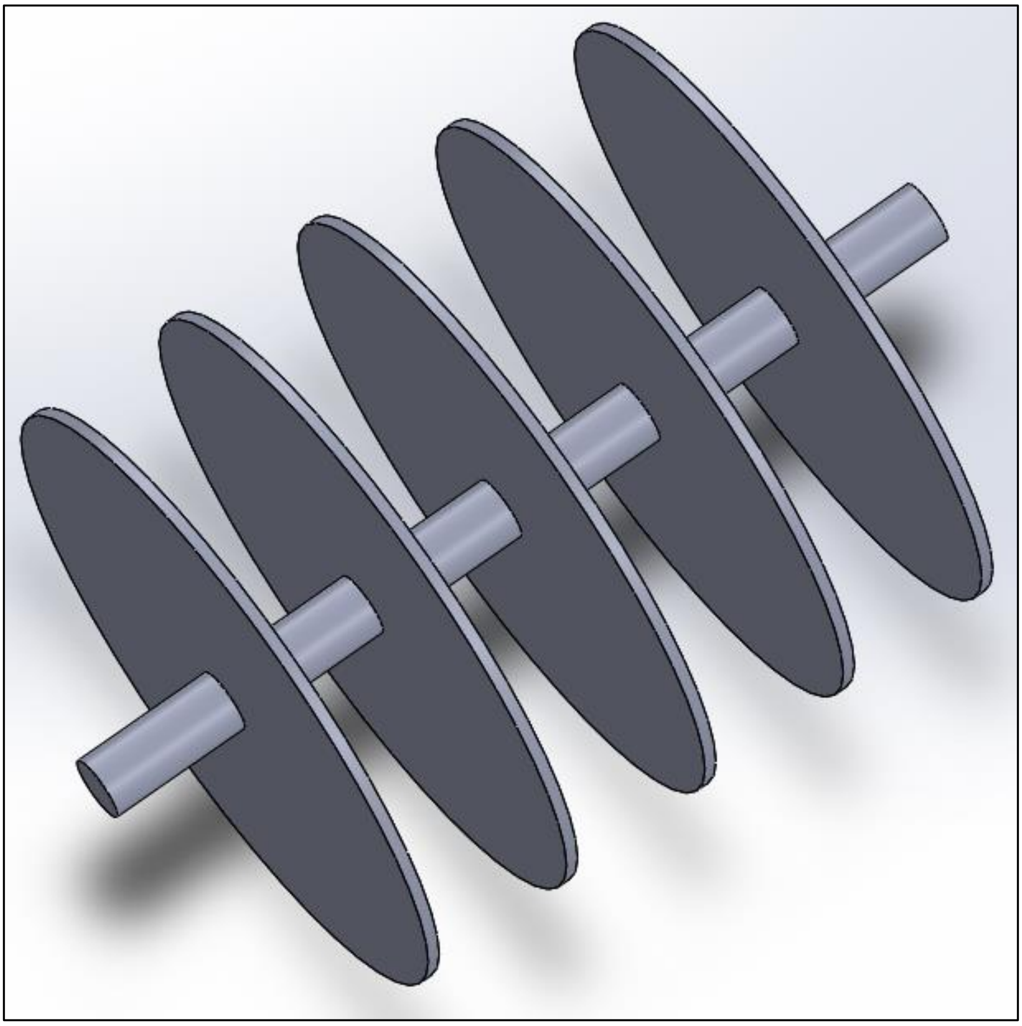

Fig 5.7: Oil skimmer design- Iteration I

This design shows that the number of plates attached to a shaft acts as the adsorbing surface for the oil. The problems faced in this was that, it required a scrapper for each plate and on both sides for effective skimming of the oil. This would create complications in mounting the scrappers and then directing all of them to a single collection tank. Another problem faced was that the plates would bend due to the heat produced from welding them to the shaft.

2. Iteration II

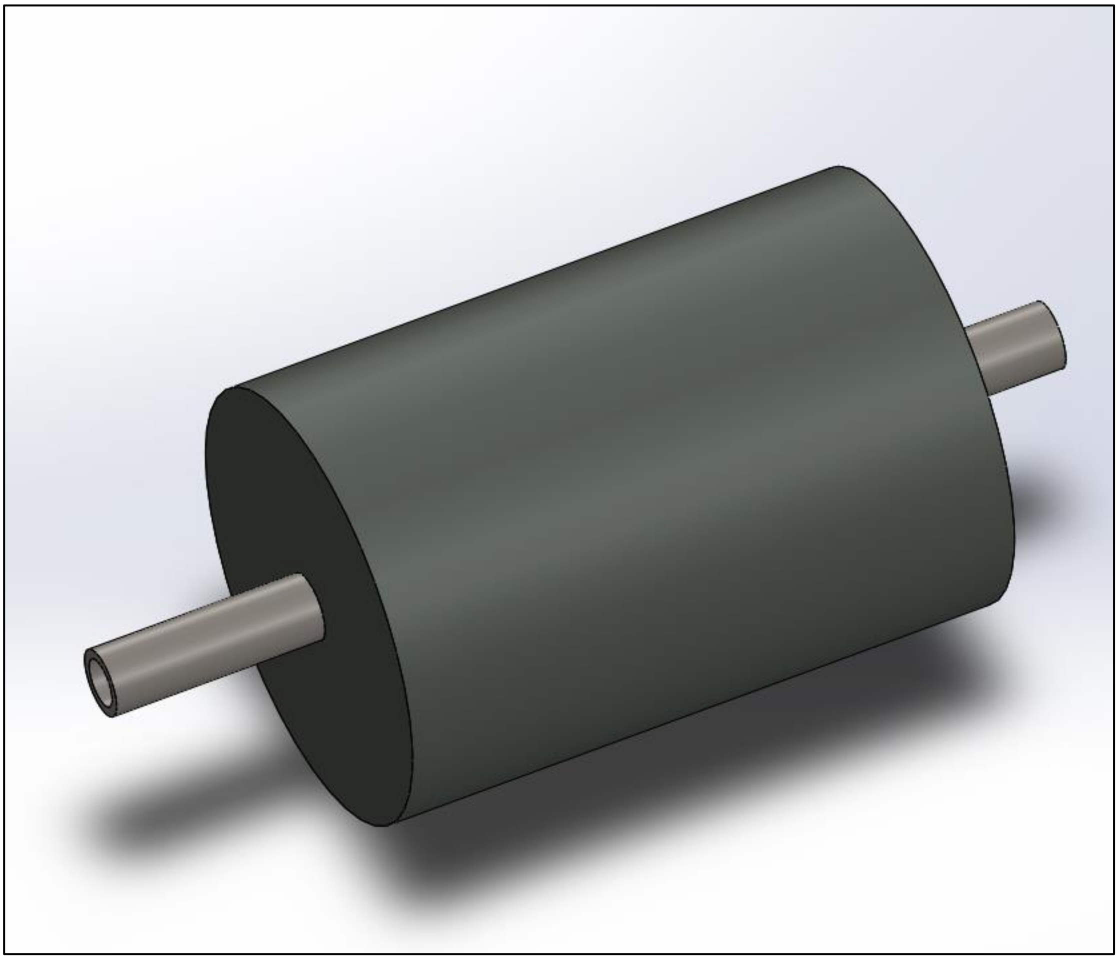

Fig 5.8: Oil skimmer design- Iteration II

The above design shows a cylinder mounted onto a shaft which acts as the adsorbing surface for the oil. This design of the oil skimmer was finalised as it overcame the problems faced by the skimmer from the previous iteration.

This skimmer requires only one scrapper on the circumference of the cylinder. Since the design employs a cylinder instead of plates, only one cylinder is enough to cover the area on the water. Since only one scrapper is used, it easy to mount it to the frame and also easy to direct it to the collection tank.

5.1.4 Foam Fractionator

The foam fractionator did not require any iterations as for the components discussed before as the previous work on the component was sufficient for creating a final design of the component that would fulfil all the requirements like, ease in mounting and working as per expectation.

The design of the foam fractionator is as below;

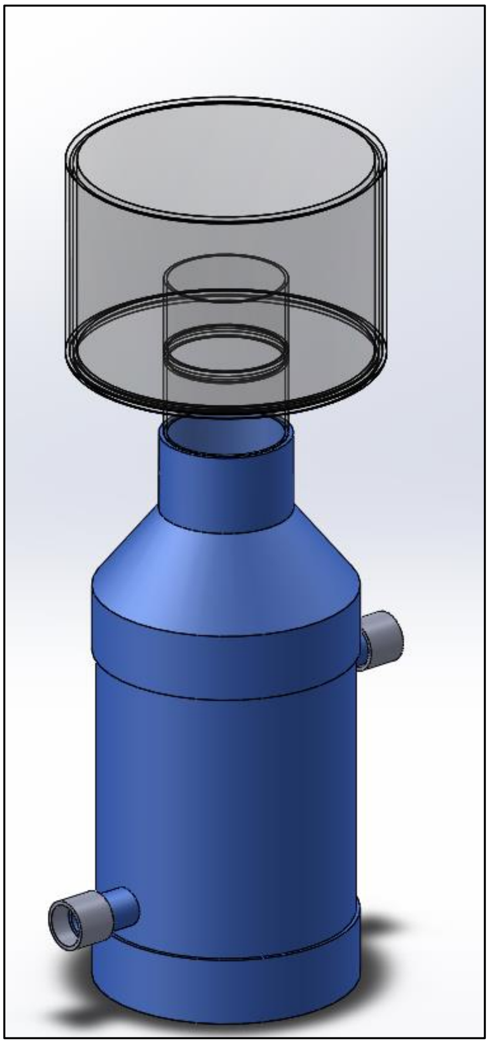

Fig 5.9: Foam fractionator design

The design consists of a cylindrical tower on which an open container acting as the collecting cup for the foam is mounted. The inlet and outlet of the water is on the top and the bottom parts of the tower respectively.

5.1.5 Assembly

Once the individual components are designed, assembling the components onto the frame is important to decide the most efficient way of placing the components for the highest outcome.

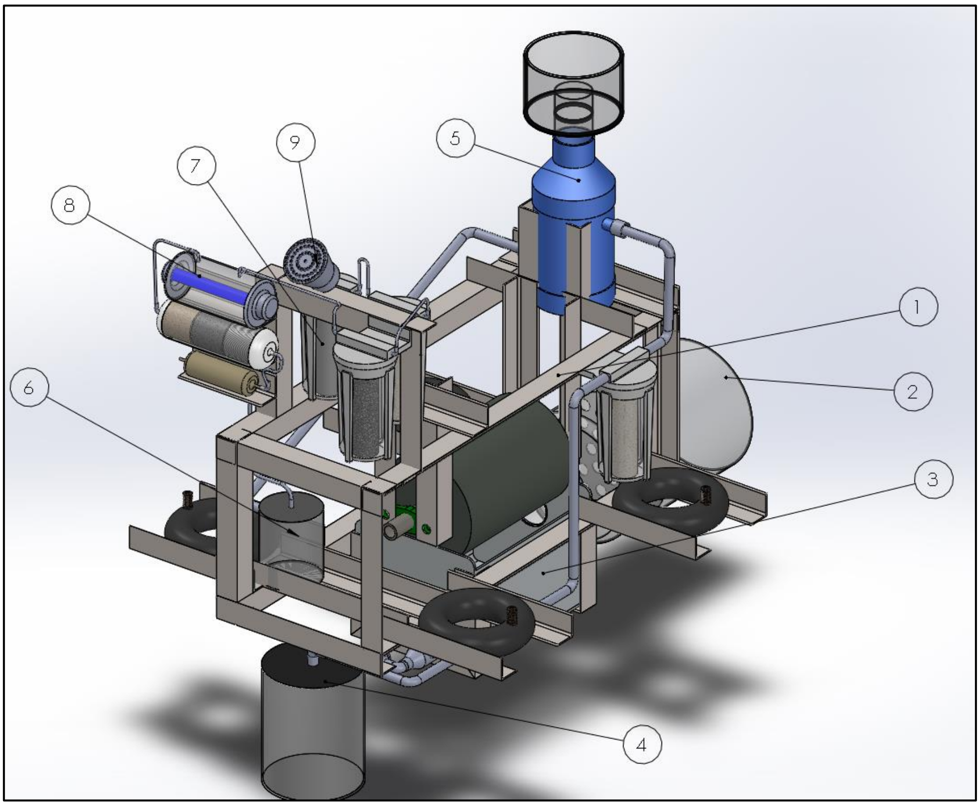

Fig 5.10: Final CAD assembly

Table 5.1: Components of CAD assembly

COMPONENT NUMBER	COMPONENT NAME
1	FRAME
2	SOLID WASTE COLLECTOR
3	OIL SKIMMER
4	SURGE TANK-1
5	FOAM FRACTIONATOR
6	SURGE TANK-2
7	MINERAL FILTERS
8	UV CLARIFIER
9	SHOWER
10	ELECTRICAL CONSOLE BOX

5.2 FABRICATION PHASE

Based on the designs of the components in the previous section, the fabrication of the components was started.

5.2.1 Frame

Keeping the 3-D model as the base, the frame was built using a L-angled MS plates. The reason for using these plates as the frame material is that they have high load carrying capacity and due to the density, it easy to submerge the lower compartment of the frame, but also keep the upper compartment afloat using air filled tubes fixed at an appropriate height on the frame. The L-angled plates used already have holes at regular intervals which eliminates the need to weld the joints in order to build the frame.

Fig 5.11: Fabricated Frame

Table 5.2: Frame Dimensions

Frame	Length	**965.2**
	Breadth	**609.6**
	Height	**863.6mm**

5.2.2 Solid waste collector

For the solid waste collector, we have used a 25L water container and removed base, making it the inlet for the water to flow into the device from the water body.

A mesh is fixed inside the container to separate the floating solid waste from the liquid water. This mesh makes sure that anything flowing beyond it is only liquid, as the solid contaminants are separated at this point. The container itself acts as a collector of the solid waste separated from the water. Once the container is filled with the solid waste, it has to be removed manually to allow the next batch of the solid waste to get collected.

Table 5.3: Solid waste collector dimensions

Solid Waste Collector	Container	Inlet Diameter: **260mm**
		Outlet Diameter: **50mm**
		Length: **480mm**
	Mesh	Hole size: **1x1mm**

Fig 5.12: Fabricated Solid waste collector

5.2.3 Oil skimmer

As mentioned in the methodology chapter, we are using a drum type oil skimmer to remove floating oil from the water.

A poly vinyl chloride sheet is wrapped around a metallic drum connected to a hollow shaft. The drum is submerged in a tank that receives the water from the solid waste collector. A motor runs the shaft and a rotates the drum. The part of the drum that comes in contact with the surface of the water allows the oil to get adhered onto its surface and carries the oil to the top. Here, a scrapper is used to skim the oil from the drum surface and guides the oil into a collection tank away from the tank and the process repeats till most of the oil if removed from the surface of the water.

Table 5.4: Oil skimmer specifications

<table>
<tr><td rowspan="7">Oil Skimmer</td><td rowspan="3">Drum</td><td>Diameter: 24cm</td><td rowspan="4">Tank</td><td>Length: 32cm</td></tr>
<tr><td>Width: 26 cm</td><td>Width:23cm</td></tr>
<tr><td>Material: PVC sheet wound over MS drum</td><td>Height: 23cm</td></tr>
<tr><td rowspan="4">Shaft</td><td>Diameter: 25.4 cm</td><td>Material: Stainless Steel</td></tr>
<tr><td>Length: 65cm</td><td>AC Motor</td><td>1/12th HP</td></tr>
<tr><td rowspan="2">Material: Mild Steel</td><td rowspan="2">Scrapper</td><td>Length: 30cm</td></tr>
<tr><td>Material: Rubber tip SS scrapper</td></tr>
</table>

Fig 5.13: Fabricated Oil skimmer

5.2.4 Foam Fractionator

The foam fractionator we have designed is a counter current fractionator, that is the air bubbles move in the opposite direction to that of the water. The water from the oil skimmer flows into a surge tank which stores the water and is pumped to the fractionator using a centrifugal pump.

The fractionator is a PVC pipe with an end cap at the bottom and an inlet and outlet ports for the water movement.

Water enters the fractionator tower from the top, and creates turbulence due to the fall. The air bubble created from the air stone which uses an air pump to pump high pressure air into the fractionator. The turbulence and the air from the air stones create bubble in the water. The hydrophobic organic pollutants adhere onto the surface of the water bubbles and rises to the surface of the water creating froth. This froth rises and then gets collected in a collection cup fitted at the top of the fractionator. The water below the surface, is mostly free from the organic pollutants and flows to the next component for further purification.

Table 5.5: Foam fractionators specifications

FOAM FRACTIONATOR	Tower	Diameter: **17 cm**
		Height: **74cm**
		Material: **PVC**
	Collection Cup	Diameter: **17 cm**
		Height: **10 cm**
		Material: **Plastic**
	Air Pump	**150W**
	Air Stones	**2 x 5cm**
	Submersible Pump	**18W, 1.85m Head**

Fig 5.14: Fabricated Foam fractionator

Fig 5.15: Air pump

Fig 5.16: Air stone

Fig 5.17: Centrifugal water pump

5.2.5 Mineral Filters

Water from the foam fractionator flows into another surge tank which houses a diaphragm pump. A pump is used at this stage to create high pressure water flow which is required to push the water through the mineral filters

Mineral filters are mainly used to remove excess metal ions that act as pollutants in the water bodies. There a series of filters used to remove a particular class of minerals before allowing the water to flow in the succeeding filter. Some mineral filters have activated carbon in them and have a membrane through which the water has to flow leaving the minerals on the other side of the membrane.

Table 5.6: Mineral filter dimensions

Mineral Filter	Sediment Filter, Carbon Filter, Post Carbon Filter, Alkaline filter	**25 x 15 x 5 cm (3nos)**

Fig 5.18(a): Carbon filter & Sediment filter

Fig 5.18(b): Sponge filters

Fig 5.18(c): Alkaline filter

5.2.6 Ultra-Violet Clarifier

Ultra-Violet Clarifier (UVC), is a chamber which houses a UV lamp with high intensity. The purpose of using this component in our device is to de-activate and inhibit the bacterial activity in the water before allowing it to flow back to the water body.

A shower is also used for aeration of the water so that the water comes in contact with the atmosphere for a prolonged period, thus reducing the foul smell.

Fig 5.19: UV Clarifier

Fig 5.20: KDF filter

Table 5.7: UV clarifier specifications

<table>
<tr><td rowspan="2">UV Clarifier</td><td rowspan="2">UV lamp & Chamber</td><td>26.86 x 5.08 cm</td></tr>
<tr><td>11 W UV lamp</td></tr>
</table>

5.2.7 Assembled device

Based on the design assembly, the components were fixed on the pre-determined positions for the efficient flow of water in, through and out of the system. The final assembled device is as shown below;

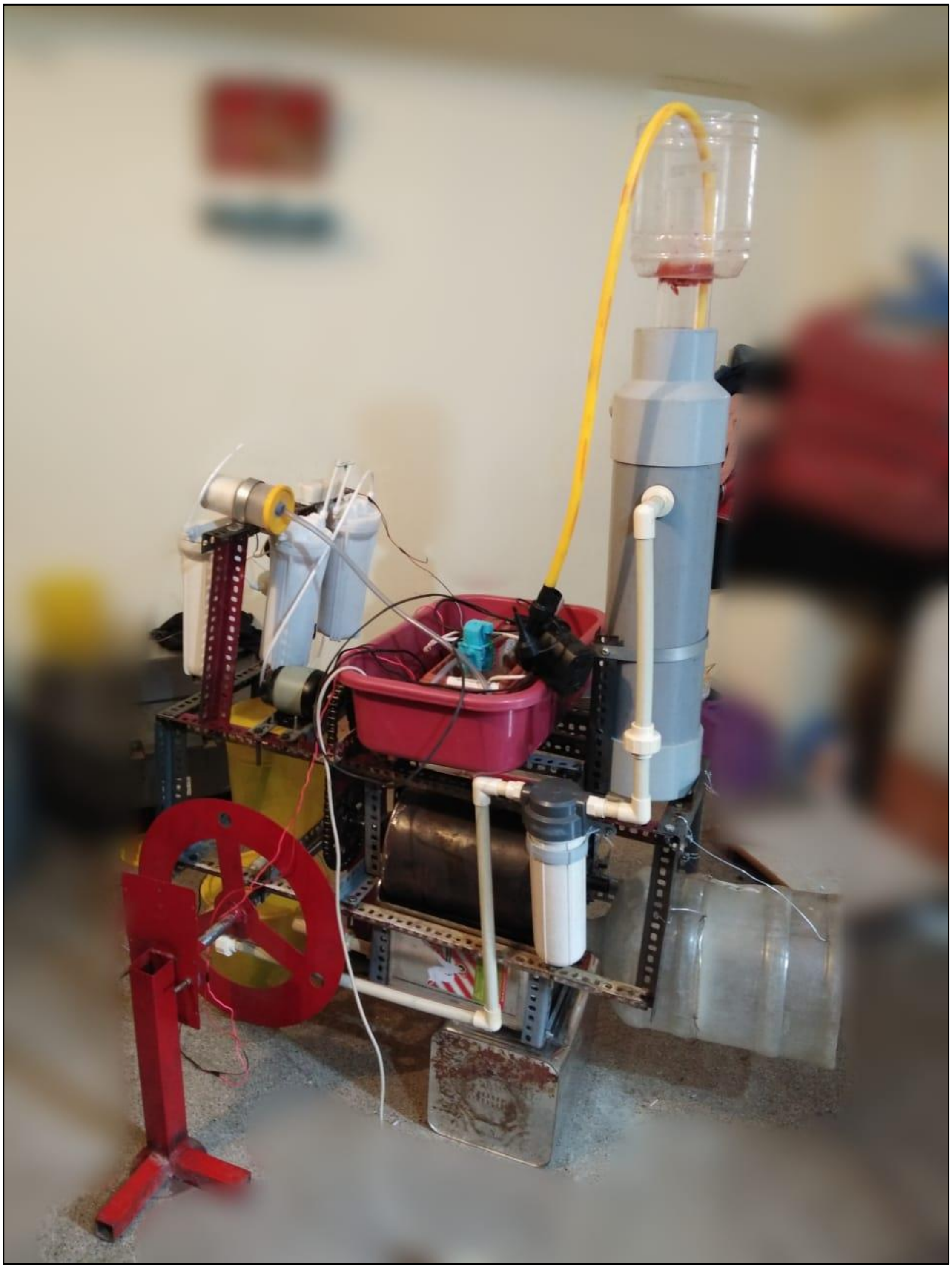

Fig 5.21: Assembled device

CHAPTER 6
TESTING & RESULTS

6.1 TESTING

Testing of component being produced in the real world is imperative as there might be changes in the environment without human knowledge. In case of the current device, testing is the only way to validate it's working.

The testing was done in two different phases, one by testing the individual component by supplying the water with only the pollutants that was expected to be removed from that particular component and the other by testing the whole device with all the components mounted on the frame and check whether all components can work in harmony without human intervention, once the process begins.

6.1.1 Individual component testing

Each of the component being fabricated, were tested immediately after their fabrication.

- **Solid waste collector**

The solid waste collector, which is made using a 25L water tank and fitted with a mesh did not require a lot of testing, but was still tested to prove its working.

- First it was held upside down and was poured with water from the bottom to make sure there was no leakage in any part of the tank and there was only one inlet and one outlet for the water to flow through.
- In the later stages, the tank was filled with a particular amount of solid wastes that were commonly found to be floating in the water bodies like, shreds of paper, plastic cover, bottles, etc.
- Water was poured again into the tank to check whether the solid wastes would get through the mesh and enter the system.

- **Oil skimmer**

The oil skimmer which is a combination of an oil tank for storing water and an oil drum for adsorbing the oil is used.

- For testing the oil skimmer, the tank in which the oil drum was fitted was filled with water and the inlet and outlet ports were sealed.
- Oil was poured into the tank and the drum was rotated manually to check the adsorbing of the oil onto the circumference of the drum.
- A scrapper made of a cut CPVC pipe was held to check the scrapping capabilities of the drum.

- **Foam Fractionator**

The foam fractionator, made from a PVC pipe of 6” diameter, with the bottom sealed with a PVC cap and the top was fitted with a 6” to 3” diameter collar is used. A Transparent pipe made of acrylic is fixed to the collar and a collection cup is fixed to the acrylic pipe that acts as the collection cup is being used.

- For testing the foam fractionator, water mixed with organic pollutants like detergents, fish waste, sand particles, was poured into the fractionator.
- An air pump fitted with an air stone, used to produce bubbles in the water was immersed into the water. The inlet and outlet ports were closed.
- The air pump was switched ON to check whether the organic wastes would adsorb onto the surface of the bubbles and raise to the top of the foam fractionator and get collected in the collection cup.

➢ **Mineral filters**

A series of filters that include, a sediment filter, a sponge filter, a carbon filter, an alkaline filter, an ultra-filter and a UV clarifier are used for the final stage of filtration. At the end, a KDF filter which also acts as the shower and outlet of the water from the device.

- The mineral filters were arranged in the order, sediment filter → sponge filter → carbon filter → UV clarifier → alkaline filter → ultra-filter → KDF filter(shower).
- The order of the mineral filters was decided by consulting with a water filter expert.
- Water was pumped using a diaphragm pump first through the sponge filter and the through other filters and finally through the KDF filter and out of the system.
- The water flowing out of the KDF filter was collected and total dissolved solids level (TDS) was tested using a TDS tester.

6.1.2 Device Testing

The components, after their individual testing were mounted on to the frame in their predefined spots which would gain their highest efficiency.

Once the components were mounted onto the frame, the assembled device was tested to check the working harmony of the components together without human intervention.

The device was placed into an artificial pool built using plastic sheets and filled with predefined amount of polluted water.

Due to the unavailability of resources, the device was not fitted with air filled tubes, but, to substitute its function, a platform was built inside the pool where the device was placed on which would submerge the lower compartment of the frame as expected and the process would run as expected.

Water with the floating solid wastes, flows in through the solid waste collector without the aid of an external pump, due to the difference in pressure between the device and the pool. The water enters the oil skimmer and flows to a surge tank which is fixed at a lower level than the skimmer. This allows to water to flow into the surge tank using gravity. A centrifugal pump placed in the surge tank pumps the water to the foam fractionator through a sediment filter to remove any un-skimmed oil from the oil skimmer.

The water from the foam fractionator flows to another surge tank which is placed at a lower level than the fractionator. A diaphragm pump pumps the water from the surge tank through the series of mineral filters and out through the shower cum KDF filter.

The water flowing out of the shower was collected to check for values of Total dissolved solids (TDS), pH and Hardness.

6.2 RESULTS

Results obtained after conducting the test are highlighted below;

- In stage 1, the floating solid wastes with dimensions larger than 10 mm was filtered through in the solid waste collector and liquid water flows to the next component.

- In the initial phase of stage 2, oil was separated from the water in the oil skimmer and was successfully scraped from the oil drum and guided to a collection tank. Small dust particles which did not separated in the solid waste collector were also removed from the water with the oil, as it got adhered to the oil drum with the oil.

- The surge tank also acted as a filter, when the water was not pumped to the foam fractionator, the denser particles in the undisturbed water formed sediments at the bottom of the tank.

- The sponge filter between the 1st surge tank and the foam fractionator was successful in removing and excess oil or dust particles that did not get removed in the oil skimmer.

- Due to hydrophilic nature of the organic pollutants in the water, the foam fractionator was able to remove most of them using the bubble created in them by the air pump and air stone. The collected foam was removed in the final phase of stage 2.

- The mineral filters removed and leftover salts, maintained the levels of some minerals in the water, as minerals in excess amounts might act as pollutants themselves.

- Finally, the mineral filters and the process of showering the outlet water reduced the odour/foul smell from the water.

- Due to the above-mentioned reasons, the froth created in the water body reduced gradually after repeated cycles of filtration.

- The total dissolved solids (TDS) was measured from the collected water before entering the system and the water coming out of the system. The water flowing out of the system was measured for each cycle and the obtained results are listed below;

Table 6.1: Total dissolved Solids values

TOTAL DISSOLVED SOLIDS			
Initial Feed water (ppm)	Water collected at the outlet, for each cycle (ppm)		
	Cycle-1	Cycle-2	Cycle-3
525	384	223	144

- The pH value was measured from the collected water before entering the system and the water coming out of the system, at room temperature. The water flowing out of the system was measured for each cycle and the obtained results are listed below;

Table 6.2: pH values

pH VALUES			
Initial Feed water	Water collected at the outlet, for each cycle		
	Cycle-1	Cycle-2	Cycle-3
5.21	5.81	6.51	6.7

- Hardness of the water indicates the amount dissolved calcium carbonate in it. It is important to remove the high levels of calcium carbonate, as it causes ill effects in human beings. The hardness of the water was tested and the following results are tabulated below;

Table 6.3: Hardness of water

Hardness of water	
Initial Feed water (ppm of $CaCO_3$)	Water collected at the outlet (ppm of $CaCO_3$)
9,900	5,568

- Chemical Oxygen Demand (COD) of water indicates the water and waste water quality. The COD test signifies the efficiency of a treatment plant. The results of COD were obtained and tabulated below;

Table 6.4: COD of water

Hardness of water	
Initial Feed water (mg per litre)	Water collected at the outlet (mg per litre)
294.988	219.856

Fig 6.1: Clarity of water

CHAPTER 7
CONCLUSION & FUTURE SCOPE

7.1 CONCLUSIONS

The following conclusions are based on the tabulated results in the results chapter.

- The device was able to remove the floating solid wastes completely from the water surface.
- Due to the reduction in the foam on the surface of the water, it was concluded that the concentration of organic pollutants was reduced.
- The device was able to produce clear water after filtration in contrast to the water before filtration. (refer fig 6.1):
- The odour from the water was observed to have reduced due to the removal of excessive organic wastes.
- The water shower sprayed at the end of the filtration process proved to be effective in removing the already formed froth on the water surface in the water body and also helped in odour control.
- Due to the reduction in the froth on the surface, larger surface area of water was exposed to atmosphere for greater levels of oxygen dissolution.
- The concentration of the total dissolved solids was reduced by around 52.76%. The pH was reduced from 10.6 to 8.8.
- The concentration of Calcium carbonate in the water was reduced by around 43.7%.
- The Chemical oxygen Demand in the water is reduced from 294.988 mg per litre to 219.856 mg per litre, which is approximately 25.4%.
- The values obtained from the tests conducted signifies that filtered water can be used for domestic purposes.

7.2 FUTURE SCOPE

- Solid waste collector can be automated using suction pumps and sensors to monitor the waste collected.
- Incorporate more skimmer drums to increase Oil Removal Rate in the oil skimmer. Also, by using sensors and circuits the rpm of the drive can be controlled according to the water inflow.
- The efficiency of the foam fractionator can be increased by using powerful air blowers and automated foam fractionator can help in controlling the inflow and monitor the foam generation. Also, the valve actuation can be automated.
- Electrically aided alkaline mineral filters can be used for more effective metallic ion removal by ion exchange process.
- To make the device more self-reliant, a solar panel can be used to generate electricity, required to run the device.
- Sensors can be used after every stage to determine the dynamic water quality index and to record the amount of impurities and pollutants removed.
- The overall device can be configured onto to a movable platform to cover a larger area of the water body.

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