# Intellectual property, Standards, Benchmarking and Userneeds Review

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## 1 Executive Summary

This executive summary is concerned with 4 components.

**Patent review**: This section provides analysis and comments on patents relating to the concept chosen (see section 2.). The 6 analysed patents present various concept solutions to filter the water from pollution. It is important to note that some patents are currently active while others are expired allowing the use and market of it. In most cases, patents are non-renewable.

**Standards review**: This involves cross checking and combing through many standards articles in case the solution is at risk of infringing on any existing standards if progress runs unchecked. This part of the report is about identifying any possible issues or safety criterion regarding the solution.

**Benchmarking**: This section uses a set model of competitive benchmarking to identify, understand, and analyse competitors' best product features to help form a basis of what a product requires to be successful in the water pollution industry. Three main competitors products are thoroughly discussed, analysed and ranked according to a set of subjective criteria which were deemed as imporant with respect to the an 'ideal' products design.

**User-based Need-finding**: This presents the findings of several large-scale research related to the pollution of water with litter. These research papers all correlate on the importance to tackle water pollution issue from its main source, i.e. bodies of water (rivers, canals, marinas, etc.). This part also identifies and classifies in terms of importance the need specifications for our device.

### 2 Idea of Concept

#### **Problem statement**

Governments need to extract litter from water ways in urban areas as litter damages ecosystems

#### Facts

"Only 16% of Ireland's waterways are clean "A survey conducted by Irish Business Against Litter (IBAL) shows that only 16% of coastal areas and waterways are clean, with the River Tolka, the River Barrow and Cork Harbour being 'heavily littered'."

#### Concept

A smart device that prevents pollutants entering water ways. Pollutants meaning a substance introduced into the environment that has undesired effects. In this instance the environment of interest is water ways ie, canals, rivers, marinas and lakes.

### 3 Patent Review

### 3.1 Gravity-flow filtration cartridge for the removal of contaminants - US6524477B1

#### 3.1.1 Description

The filtration cartridge includes a liquid porous plastic filter, which has pore diameters large enough to let water pass at acceptable flow rates under only the force of gravity, while the matrix creates a tortuous path which traps parasites and other microorganisms that are typically in the approximately 3-9 micron size range. The filter may include interstitial carbon and other additives to improve performance. The filter may be shaped to provide a large surface and an optimised wall thickness for providing beneficial filter capacity and water flow rate.



#### 3.1.2 Status

Application was granted in 2003 and has since expired in 2019.

#### 3.2 Cleaning water pollution trap - US7037436B2

#### 3.2.1 Description

A chamber having an inlet for receiving polluted storm water runoff and an outlet for the storm water to flow out. Within the chamber are a screen, one or more baffles, a collection reservoir, and a pivotal filter. The screen is elevated for separating and suspending miscellaneous debris such as vegetative matter, paper, and plastic. The baffles increase storm-water residence time to encourage settling of particulate matter such as sand and grit. The collection reservoir has an adjustable weir for skimming off floating matter such as motor oil, other hydrocarbons, and detergents. And the pivotal filter catches clay during typical storm flows and pivots out of the way during higher flows. In addition, a method for maintaining the pollution trap includes removing the screen for cleaning, suctioning out the particulate matter and oil, and replacing the pivotal filter member.



#### 3.2.2 Status

Active - application granted 2006. Anticipated expiration - 2022.

#### 3.3 Storm water treatment apparatus - US20040069715A1

#### 3.3.1 Description

A liquid purification and separation apparatus, separating pollutants in storm water runoffs. This apparatus utilises gravitational separation and tortuosity, resulting from a plurality of baffles both perpendicular and oblique to the primary water flow direction, to trap substances less-dense and more-dense than water. The apparatus features improves resistance to pollutant remobilisation through treatment of water volume rather than flow rates, using vertically stacked water columns of varying depths to settle small particles. An overflow structure diverts excessive liquid without interfering with purification and separation, this can be placed integrally within or external to the apparatus receptacle.



#### 3.3.2 Status

Granted - 2004 Current status - unknown

### 3.4 Mobile pollution trap - US6951607B2

#### 3.4.1 Description

A mobile chamber has an inlet for receiving polluted water and an outlet for pollution-free water to flow out. A mobile trap operating system includes an output pump, an input pump, a pollution tank, and a liquid tank, all connected to the chamber. Within the chamber is a collection reservoir with a skimming edge for skimming off floating pollutants such as motor oil, other hydrocarbons, and detergents. Alternative embodiments include a screen, baffles, and/or pivotal filter for further separating the pollutants from the water. A method for separating the pollutants from the water includes directing the water from the water tank at the pollutants and into a collection pool of polluted water, drawing the polluted water into the chamber, receiving the skimmed pollutants from the collection reservoir into the pollution tank, and receiving the pollutant-free liquid from the chamber into the liquid tank.



#### 3.4.2 Status

Active - application granted 2005. Anticipated expiration 2022.

## 3.5 Operating river purifier - JP4057224B2

#### 3.5.1 Description

A water level adjusting weir provided in rivers. The water intake is on the upstream side of the water level adjusting weir. Purification canals port back to the downstream side. Purification equipment is used in the clean canal and the water intake passes through a dust screen which removes the dust of the water flowing into the clean canal and a movable water weir, stopping the flow of river water to clean canals. This operates as a river purifier.



The earth and sand from the river is stopped from entering.



#### 3.5.2 Status

Expired - application granted 2008, funding issue in 2019.

### 3.6 Rubbish blocking device in the water intake - JP3193953B2

#### 3.6.1 Description

A number of discs installed in multiple cylindrical screens that are fixed to a rotating shaft at the intake of the waterways. Multiple rotary discs are constructed adjacent and arranged in specific intervals. The flow velocity intake reduces the flow rate of the river downstream at the mouth. The intake of flow by the roadside stops particles from entering. A dust blocking device at the intake lies on the rear outer peripheral surface.

#### 3.6.2 Status

Expired - 2019

## 4 Standards Review

### 4.1 Introduction

This Systematic standards review is concerned with safety standards regarding a smart device to help the environment, in particular, removing litter from water ways such as canals and rivers in urban areas. The objective of this background check is to verify that our mechanism does not violate any safety standards and is deemed safe. The review will examine and obey safety standards set out by numerous standards bodies. The mechanism will be stopping/ removing litter via grates or nets, the second step includes removing the waste, this will be done by sensor or water mill.

### 4.2 Methodology

The potential physical parts that will form our solution will be cross checked with a database for safety standards. In order to identify these standards the following National standards bodies will delve into are seen in fig. 1 shown below

National standards bodies	In regards to	
NSAI	National standards authority of Ireland	
BSI	British standards institute	
CEN-CENELEC	European committee for standardization	
ISO	International organization of standardization	
ETSI	European telecommunications standards institute	
IEC	International electrotechnical commission	

Fig.1 National standards bodies

These bodies have been harmonized into one database which Trinity College Dublin provides access to via the i2i platform. This platform is provided by S.A.I. global, a global information services company and largest providers of Standards management solutions in the world. Using this search engine, keywords were linked to standards. These standards were then combed through and the relevant information were taken note of.

Since there involves a lot of combing through different standards that may not be applicable or have negligible effect on the components a simple ranking system of 1- 5 has been applied. 1 being of least importance, 5 being very applicable.

### 4.3 Parts

Since this project is still in early stages, a very broad and general approach has been taken. There are a few ideas that need to be clarified in conceptual design but overlapping components have appeared. This mechanism will be in an urban area so safety is of paramount importance. These components are displayed below in fig 2.

Possible component	Use	
Nets	Removing debris and allows current to pass through	
Sensors	Detects motion	
Newton meter (electrical)	Measure tension in cords	
Arduino	Run, store and execute code	
Wiring	Pass electrical current	
Grates	Stop heavy debris while allowing current to pass through	
Water jet	To manipulate and move debris	
Water mill	Turn kinetic energy into electrical	
Floats	Keep mechanism above water line	

#### Fig.2 Potential components

As noted this is a very broad scope of tools, it is better to have all possible components covered allowing greater freedom and creativity to thrive without having to double back further down the line.

### 4.4 Results

#### 4.4.1 Nets

#### Keywords: "Fishing nets", "Nets", "Mesh size"

The main function of nets will be to trap litter and prevent it travelling further down stream. The use of nets requires no input energy wise as it depends on currents. The main concerns with using nets is infringing on standards net out to limit mesh size. Greater mesh density allows smaller particles to be extracted from water ways. Most fish and other aquatic life will not be present as they can't survive in the polluted waters in question. If there is an off chance and risk of entangling fish the nets can be shorted to allow passage below. The majority of litter will be present towards the surface of the water way. [?]

Standard : Name	Code	Relevance
Fishing nets - Description and designation of knotted nets	EN ISO 1530: 2003 CE	4
Fishing Nets - Netting - basic terms and definitions	EN ISO 1107: 2017	5
Fishing Nets - Determination Of Mesh Breaking Force Of Netting	EN ISO 1806 : 2002	2

fig 3. standards for nets.

These standards articles have provided some specifications and limits as to be expected. These standards are applicable to any single or double yarn system. The common knots include:

-Weaver knot Z - type -Weaver knot s - type -Weaver knot Double

-Reef knot

On a side note the minister of agriculture, food and marine has set the codend meshes size from 70mm to 80mm as of 2016, as of S.I. No. 510/2016. Size

As of ISO 1107:2017, 3.4, the length of any mesh times the number of meshes in the same direction must be equal or less than length of netting. Meshing sizes are done as a function of linear density rather than size.

ISO 1530: 2003 provides more clarity as the types of mesh structures are displayed below in fig.4

Mesh type	Characteristics
Diamond	4 sides, all of equal length
Square	Adjacent sides at right angles
Hexagonal	6 sides

fig.5 types of meshes./

Mesh side length - Distance between 2 adjacent knots when yarn is fully extended. "Distance between the center 2 knots must be the same when fully extended in the other axis". Below is an example of a "2 inch mesh", this can be seen in fig. 6



fig.6, 2 inch mesh (square)

#### Materials

This is very open, no material is specified or disqualified. Common materials include simple

yarn and twine.

#### 4.4.2 Floats.

#### Keywords: "Floats", "Buoy", "Flotation device"

There is a high probability that some element of the mechanism/solution will sit on top of the water, hence a check of standards was conducted in this field.

Standard : Name	Code	Relevance
Inland navigation- floating landing stages and floating bridges on inland water	I.S. EN 14504: 2019	3
Small Craft - Personal Watercraft - Construction And System Installation Requirements	I.S. 13590	1

fig. 7 Relevant standards reports.

As noted by relevance this doesn't have much effect on the requirements of the mechanisms floating abilities. This is due to the fact that our mechanism wouldn't contain an internal combustion engine which is within the definition of a small craft by I.S. 13590.

#### Safety requirements.

There is a general requirement set out by I.S. EN 14504 which demands a safety factor of at least 1.0.

Properties of draught level	Requirement	
Free board	Minimum of 15cm	
Safety distance	Minimum of 30cm	
Heeling angle	No more than 10 degrees	

fig. 8 Draught level requirements.

#### Damage stability.

It shall be ensured that the mechanism will stay afloat/ resist capsizing if one of the air chambers is breached/damaged. Residual free board and a residual safety distance of more than 0.1m should be maintained.

#### anchorage

This is quite applicable to the solution and the information was retrieved from I.S. EN 14504: 2019. In general the device must not be displaced by currents. The system of anchorage must comply with one of the options seen in fig.9 below.

Option A	Option B
Chains Steel rope Fibre ropes as of EN ISO 1140 Pier anchorage of appropriate strength Connecting bridge	Attached top guides or dolphins in accordance to 4.5.3.

fig. 9, possible options.

#### Structural requirements.

Floating establishment must be able to adapt to rising tides. This isn't a huge issue as it's only a matter of finding how slack the ropes need to be.

#### Materials.

Any floatation device should contain closed pores, any Polystrene according to EN ISO 13163. Water absorption characteristics according to EN ISO 12087 may not expand by more than 5% when immersed in water.

#### **Electrical Equipment**

Any electrical equipment close to water must have a minimum of a IP55 degree of protection. In fig.10, the specified safety standard can be examined.

IP52	Protected from limited dust ingress.	Protected from water spray less than 15 degrees from vertical.
IP53	Protected from limited dust ingress.	Protected from water spray less than 60 degrees from vertical.
IP54	Protected from limited dust ingress.	Protected from water spray from any direction.
IP55	Protected from limited dust ingress.	Protected from low pressure water jets from any direction.
IP56	Protected from limited dust ingress.	Protected from high pressure water jets from any direction.

fig. 10, Chart of IP.

#### 4.4.3 Propeller.

#### Keywords: "Propeller", "Water Propeller"

The mechanism may include a propeller as a way of moving or generating electrical energy from kinetic energy of the current. As seen in fig. 11, only one standard could be found in regard to propellers emersed in water.

Standard : Name	Code	Relevance
Propeller of diameter between 0.8m and 2.5m	ISO 484 -2	3

fig. 11 Standards relating to a propeller in water.

Below I have compiled the relevant tables and specifications of a propeller set out by ISO 484-2.

Class	Manufacturing accuracy
S	Very high accuracy
I	High accuracy
II	Medium accuracy
III	Wide tolerances

Table 1 — Accuracy of manufacturing

#### Table 2 — Pitch tolerances

Designation of nitch	Class			
Designation of pitch	S	Ι	II	III
a) Local pitch	±1,5 %	±2 %	±3 %	
with a minimum of	±10 mm	±15 mm	±20 mm	
b) Mean pitch per radius of each blade	±1 %	±1,5 %	±2 %	±5 %
with a minimum of	±7,5 mm	±10 mm	±15 mm	±25 mm
c) Mean pitch per blade	±0,75 %	±1 %	±1,5 %	±4 %
with a minimum of	±5 mm	±7,5 mm	±10 mm	±20 mm
d) Mean pitch for propeller	±0,5 %	±0,75 %	±1 %	±3 %
with a minimum of	±4 mm	±5 mm	±7,5 mm	±15 mm
NOTE The tolerances of <u>Table 2</u> are expressed as percentages of the design pitch corresponding to the radius for designations a) and b) and the mean design pitch for designations c) and d).				

#### Table 3 — Pitch measurement locations

Class	Radii
S and I	A section near the hub – 0,4 <i>R</i> – 0,5 <i>R</i> – 0,6 <i>R</i> – 0,7 <i>R</i> – 0,8 <i>R</i> – 0,9 <i>R</i> – 0,95 <i>R</i>
II and III	A section near the hub – 0,5 <i>R</i> – 0,7 <i>R</i> – 0,9 <i>R</i>

#### Table 5 — Blade thickness tolerance

Specification	Class			
	S	Ι	II	III
Plus tolerances	+2 %	+2,5 %	+4 %	+6 %
but not less than	2 mm	2,5 mm	4 mm	6 mm
Minus tolerances	-1 %	-1,5 %	-2 %	-4 %
but not less than	–1 mm	–1,5 mm	-2 mm	-4 mm

Specification	Class			
	S	I	II	III
Tolerance	±1,5 %	±2 %	±3 %	±5 %
But not less than	7 mm	10 mm	13 mm	15 mm

#### Table 6 — Blade length tolerances

This provides the class of propeller. Different propellers are used for different functions. This is nothing to infringe upon but is good knowledge if a propeller is in the solution.

#### 4.4.4Motion sensors.

Т

#### Keywords: "Motion sensor:", "Sensor".

Motion senors will be a stable in the solution as moving litter on top of still water is in one plane of motion and easily could be identified by a motion sensor. Most standards reports that were found were concerned with testing and minimum requirements of such devices. The motion sensor used for this solution will most likely by purchased hence already meet these specifications. In fig. 12 the standards applicable to motion sensors include:

Standard : Name	Code	Relevance
Occupancy motion sensor standards	NEMA WD7	1
Maritime & radio communication equipment and systems - shipborne radar	IS EN 62388	4

fig.12 Containing the standard applicable.

This standard originated from the association of electrical equipment and medical imaging manufacturers. For a device to deemed as a motion detector it must be accurate within 1%of the range scale. This test can be taken out on any platform.

#### 4.4.5Wiring.

#### Keywords: 'Electrical outdoors safety', Electrical water safety'

With sensors there inevitably involves wiring. This is always a large safety concern when you have an electrical current flowing beside a large mass of water. The standards are seen in fig.13 below

Standard : Name	Code	Relevance
Information technology Equipment - safety part 22- Equipement to be installed outdoors	EN I.S. 60950-22-2017	4
Household and similar electrical appliances - Safety Part 2-21: Particular requirements for storage water heaters	IEC 60335-2-21:2002	3

fig. 13, standards involving electrics beside waterways.

#### location.

Protection from the weather and other outdoors influences provided by a building or other structure is limited, is the definition of the electrical circuits outdoors. To combat this there must be some effort to cover and protect wiring using insulating tape or some other means.

#### Ambient temperature.

Electrical circuits must be able to function between -33 degrees and +44 degrees. This isn't a huge problem as Ireland only tends to range between -10 degrees and +28 degrees.

#### Voltage.

Voltage may not exceed: -15V a.c., 21.2V peak or 30V d.c. under normal operating conditions.

-15V a.c., 21.2V peak or 30V d.c. for longer than 0.2 seconds under single fault conditions.

### 4.5 Conclusion.

There are standards in place to keep the general public safe. In this case there is no real threat to the public as they won't have much of an interaction with our product. Saying this, one must keep in mind safety regarding electrical currents beside water ways.

No standards could be found on:

-Water jets

-Newton meters

-Grates

-Water mill

-Arduino

### 5 Competitive Benchmarking

**Benchmarking** is the search for the best industry strategies, functions, processes, products or services which will lead to exceptional performance through the implementation of these best practices [1]. Benchmarking requires a process of continuously identifying, understanding, and adapting competitors' best practices to help an organization improve its own performance. Organizations that practice benchmarking have a better chance of survival and success as they are conscious of competitive advantages which they may seize.

#### 5.1 Models

There are various models of benchmarking. The model which most concerns our needs is competitive benchmarking. This form of benchmarking focuses on competitors' products and services which are most successful. Most models of benchmarking process have structured steps in place to maximize benchmarking effectiveness. Many of these models, including competitive benchmarking, follow these steps [2]:

- 1. **Planning:** Identifying the strategic intent of the business or product to be benchmarked.
- 2. **Collecting:** Collect data and gather information on the strengths of competitors and best of the products.
- 3. Analysing: Assess the data with regards to the companies current position. This stage determines the current competitive gap.
- 4. **Integration:** Establish specific goals that integrate these goals into the company's formal planning processes.
- 5. Action: Implement the findings from the data and determine plan of action to match competitors' best products.

#### 5.2 Plan

The benchmarking planned here is preemptive and aims to gather information on the best industry products that can aid the design and concept selection process for our idea before it has been finalized. The goal of this benchmarking is to identify the market leading products that address the issue of water pollution and to understand why they are successful. This benchmarking report will only consider 3 main competitors. Too many competitors will over complicate the benchmarking and valuable insights may be lost by lack of in-depth analysis of individual products [3]. The main focus of this benchmarking will be on the criteria of design, functionality and cost.

The data gathered will be purely from online resources and will be limited to the restricted information and specifications permitted for public access. Nonetheless, the data will contain valuable insights into the best industry products that are in line with our problem statement, 'a device that prevents pollutants entering water ways and oceans'. The goals set in place for

the purpose of this benchmarking are to understand if a specific products needs to be made by harness and improving upon the best features of individual products or can we improve upon an idea by adding new elements onto it.

#### 5.3 Competitors



Figure 1: Mr. Trash Wheel

1) Mr. Trash Wheel: is a semi-autonomous trash interceptor that is placed at the end of a river, stream or other outfall. It is powered by water wheels and solar cells, and places trash onto an onboard conveyor belt which routes it into dumpsters on the vessel.

Mr.Trash collects rubbish from the streets that is washed down storms drains and emptied into the river. Mr. Trash Wheel is located at the mouth of the harbour where the device funnels the plastic onto its conveyor belt and stored into a floating barge.

- 1. **Design:** The massive device uses purely renewable energy (water and solar) but requires specialists to design, takes months to build and is only suitable for mouth of rivers. The device is mainly powered by a 14 foot steel wheel that draws energy from the current of the river, and backup power is provided by an array of 30 solar panels that pump water onto the steel wheel when the current is sluggish[4].
- 2. Functionality: Mr. Trash Wheel removes floating debris using rotating forks that rake litter out of the water which then places the trash onto a conveyor belt which moves it into a dumpster sitting on a separate floating barge. The water wheel can also be controlled via the internet. The device can collect up to 50,000 pounds of rubbish in a single day, and can collect rubbish of any size and weight even as heavy as shopping trolleys
- 3. Cost: The unit can cost anywhere of \$750,000 upwards, and needs constant maintenance and repairs which is costly.



Figure 2: StormX

2) StormX: is a netting trap that captures gross pollutants that are swept by stormwater runoff into lakes and rivers at most urban hot spots. This device is economical solution to litter and debris in storm-water runoff areas and is highly effective for "first flush." [5]

The StormX is attached to pipes by first installing a large metal sheathing around the concrete pipe. The net is then firmly secured to the pipe and stretched out. When the storm water passes through the netting plastics and pollutants get caught while the water continues to filter through.

- 1. **Design:** The StormX comes in various standard sizes to accommodate all different pipes diameters and widths. The metal sheathings are made from stainless steel which are anchored into concrete. The nets are reusable and are constructed from commercial grade high-strength plastic. The commercial grade HDPE nets are durable, reusable and easily maintained.
- 2. Functionality: Captures pollutants as small as 5mm, as well as organic materials (such as leaves) that could reduce the levels of phosphorous and nitrogen. Also, the device is easily emptied with truck mounted crane or two man crew and does not require specialist personnel.
- 3. Cost: The cost of this device varys depending on the size of the pipe and difficulty of installation but the average StormX is estimated to cost around \$10,000 each. When the nets get full, they can be mechanically lifted by crane or manually replaced by a 2 man team which entails continuous maintenance costs.



Figure 3: SeaBin

3) SeaBin: is a floating garbage bin that skims the surface of the water sucking rubbish and pollutants into it's container by pumping water into the device. The device can intercept: floating debris, macro and micro plastics and even oil when additional absorbent pads are installed to absorb petroleum-based surface oils. The SeaBin can also clean the water from contaminated organic material such as leaves and seaweed. The water is sucked in from the surface and passes through a catch bag located inside the Seabin. The water is then pumped out the end of the device leaving litter and debris trapped in the catch bag.

- 1. **Design:** The Seabin is a small-scale plastic and pollutant interceptor in the shape of a standard household bin. The device needs to be plugged directly into a power source (either a 110V or 220V outlet) which powers submersible water pump capable of displacing 25.00 litres per hour and cannot be further than 6m from the power source [6]. The pump moves an inner basket up above the water's surface and then down below it, which pulls in the water and filters the rubbish. The bin filters are made from fine mesh polypropylene plastics.
- Functionality: The Seabin can catch approximately 1.5 kilograms of floating debris and plastics per day or 0.5 tons per year, including micro plastics down to 2 mm small [7]. The catch bag inside of the Seabin can hold a maximum of 20kg. The device can not collect larger sized debris or rubbish that exceeds the diameter of the bin opening.
- 3. **Cost:** The Seabin comes in one standard size and model which can cost 3,300 euros for a single unit. The device also needs daily maintenance to change bin filters and ensure there are no blockages.

#### 5.4 Analysis:

Competitors Features				
	Mr.Trash Wheel	StormX	SeaBin	
Location	Suitable for only river mouths	Storm pipes leading into rivers	Versatile use but mainly rivers	
Materials	Majority con- structed of wood	Metal sheath- ing and plastic HDPE net	HDPE body build with polypropylene plastics mesh	
Power	Renewable en- ergy (solar and water)	No power source needed	Direct power source (either a 110V or 220V outlet)	
Pollutants	Small-Large sized trash and rubbish	Small-Medium sized rubbish	Small sized rubbish, micro- fibres, micro- plastics and oil-spillages	
Cost	\$750,000 plus maintenance costs	\$10,000 plus maintenance costs	3,300 plus main- tenance costs	

#### Discussion:

The data recorded in the table above shows a basic overview of the competitors respective products features. The products each tackle the problem of water pollution with a new and intuitive approach, and are specifically designed in a manner that maximizes efficiency for this respective approach. However, from this data there are certain boundaries that are set in place for the scope of this project which limit the creative potential of a product that could extract the best features of all the individual products. For example, the shear size and engineering complexity of Mr.Trash wheel increase it's price far beyond the available budget for a project of this size. However, the pro's of each device can be still identified, analysed and quantified to form a basis of what an 'ideal' water pollution prevention device would encompass.

The three main criteria that were being consider could be deconstructed into 5 sub-criteria which were easy to analyse and quantify. Design was deconstructed into 'Location' and 'Materials', Functionality was broken down into 'Power' and 'Pollutants' and Cost remained the same. These new five categories would better represent the data and allowed for more analytical consideration of the multifaceted dynamics of the products.

#### Points scored



Figure 4: Weighted Criteria Features

The competitors features can be weighted based on their importance to the overall build of the products. The weighting is subjective and reflects the relative importance of the criteria on the 'ideal' product. The total overall rankings will rate the products out of 10.

- 1. Location- 20%
- 2. Materials- 15%
- 3. **Power-** 25%
- 4. **Pollutants-** 30%
- 5. Cost- 10%

It can be seen from Figure 4 that the overall winner of the weighted criteria is the StormX with a score of 7.25 out of 10. This product was closely followed Mr. Trash Wheel with just 0.15 in the difference in score between the two. According to these criteria StormX is the product that should be most considered when selecting a concept for our design. This is not to say that the other products don't contain significant features that should be ignored. For example, the product which received the best score for pollutant was Mr.Trash Wheel which shows that there are aspects in the design of products that could be adapted and used into a new design.

#### 5.5 Summary:

Environmental awareness is only becoming mainstream in recent years and it is still not a highly profitable sector to venture into for companies. These businesses are mainly crowd or third party funded and are not fully commercialized businesses as of yet. Still however, these products are still engineered to high quality and the facts are there to prove their effectiveness. The products all have given valuable insight into what features a product needs to possess if it were to compete with other products that deal with the issue of water pollution. This competitive benchmarking report has highlighted some critical design characteristics and attributes that should be implement into a potential design depending on feasibility such as,

#### **Ideal Product Features:**

- 1. Location: A versatile device that could be adapted to different locations.
- 2. Materials: Sustainable materials that do not harm the environment.
- 3. **Power:** Harness energy from renewable sources would make it a environmentally friendly and green device. Even more so, if the device did not need power to function.
- 4. **Pollutants:** Collect rubbish of various sizes ranging from small to large and potential to collect other water contaminants.
- 5. Cost: A device that is cost effective and low maintenance.

## 6 User-based Need-finding

### 6.1 Research papers review

• The main source of litter is plastic; therefore the sensors of our product are primarily focusing on it.

The majority of these materials does not break down or break down slowly. This phenomenon can also be observed on the seabed, where 90% of the waste taken in bottom trawls are plastic and this figure can reach 100% for waste on the surface of the water.[6.1]

• The awareness rise and demonstrative message to people has been proven to be effective ; therefore the product needs to be visible in its action of litter collection.

A study carried out in Argentine over 102 observations showed that litter weight ranged from 0 to 53 g/visitor/day on rivers beaches. Littering per visitor was reduced an average of 35% due to cleaning up interventions in front of visitors. An increase in littering with crowding was also observed.[6.2]

• Laws and regulations force responsible organizations (whether private or public) to reduce the amount pollution ; the product has therefore a high market potential

A study carried out in Indonesia emphasized on the legal sanctions in protection of water resources from pollution in the form of administrative law sanctions (Articles 76-82), civil law sanctions (Articles 87-92), as well as criminal law sanctions (Articles 97-120). These sanctions are widely adopted in most of the countries currently.[6.3]

#### • The product needs to tackle litter in canals, rivers and marinas

The plastic thrown into the rivers, major source of pollution of the oceans. Plastic waste thrown into rivers, mainly in Asia, is one of the biggest sources of ocean pollution around the world, according to a study by Dutch researchers. Rivers discharge between 1.15 and 2.41 million tons of plastics each year in the oceans, about 50 kg per second, said AFP Jan van Ewijk, Ocean Cleanup's communications officer. Developing new technologies to clean the oceans of this waste goes by targeting rivers and canals first. Two thirds of this global pollution comes from the twenty most polluting rivers, according to a study published in the journal Nature Communications. And 86% of these plastic detritus are emitted by Asian streams, said researchers Ocean Cleanup. Located in China, the Yangtze River, one of the largest rivers in the world, "is the watershed that contributes the most" to global ocean pollution, spilling no less than 330,000 tonnes of plastic into the East China Sea.[6.4]

#### 6.2 Our survey and interviews

Two analytical approaches are carried out to precisely determine the needs of the users of our product. First, a global data analysis based on previously published large-scale research and surveys. Secondly, a more detailed small-scale survey of organizations in charge of canals, marinas and lakes. It is important to distinguish the following categories in the term 'users': - Potential investors of our product, namely, governmental or private organizations that will reduce pollution - Individuals involved in the pollution passively (victim of it) or actively (who create it voluntarily or accidentally) - Observers (providing additional data to our analysis)

#### Detailed Results to be published in additional upcoming report.

Device need specifications	[Influence]
Detects litter through both air and water mediums	[Necessary]
Floats on the surface of water	[Major]
Is remote controlled and/or autonomous	[Medium]
Is equipped with shock-absorber	[Minor]
Can be opened so that "collector" take out the litter from the device	[Necessary]
Sorts out the litter on material type (e.g. metal vs non-metal, light vs heavy)	[Minor]
Is powered by a motor (air or water propulsion)	[Major]
Easy to take out of the water for the "collector"	[Medium]
Is autonomous in knowing its location a well-know or not mapping	[Minor]
Provides the "collector" with its precised location	[Medium]
Differentiates between litter and a larger element out of its capacity	[Major]
Collected waste/litter is compacted	[Minor]
Lets the wildlife through the device	[Major]
Collected waste/litter is trapped and cannot get out of the device	[Necessary]
Operates on a very-well defined area (e.g. along the walls of a canal)	[Major]
Has an optimised shape in order to reduce energy consumption	[Medium]
Is affordable to invest in (entering in the organisation's budget)	[Major]
Slows down when approaching heavy-marine-traffic areas	[Minor]
Is powered with environment-friendly source of energy (e.g. solar panel, current)	[Major]

Table 6.1 Specifications from survey analysis

**Method** : The influence is ranked as follow from the most important to the least : Necessary, Major, Medium, Minor. N.B. : "collector" refers to the person responsible of the device when used.

#### 6.3 Conclusion

The needs specifications solving or in other word the concept solutions selection process will have to take into consideration the well-functioning of the device in both air and water as well as as potential external perturbations. From the review of research papers, it is clear that there is a strong potential to fulfill a need of governmental and private organisations to clean their bodies of water thanks to our device. A further investigation will provide evidence of that in the coming weeks.

### 7 References

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