Waste Management Solutions for Mumbai

Project III Report

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Acknowledgments

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To the nameless others I have interviewed, spoken to and gotten encouraged by, thank you for your efforts.

Declaration

I declare that this written submission represents my idea in my own words and where other ideas or words have been included, I have adequately selected and referred the original source.

I also declare that I have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any ideas / data / facts / sources in my submission.

I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources that have not been properly cited, or from whom proper permission has not been sought.

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Name:

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Approval

Industrial Design Project III

"Solutions for Solid Waste Management for Mumbai"

By: Avinash Jayakumar

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External Examiner

Internal Examiner

Project Guide

Chairperson

Abstract

Solid Waste management is a global issue requiring urgent attention. It is a particularly severe problem in Indian cities like Mumbai as the overwhelming population and continuous growth combined with poor management strategies by local government leads to visible garbage pile-up almost everywhere, causing reduction in quality of life for citizens.

Existing 'pick-up and dump strategies' are ineffective due to the lack of space, and negative environmental side effects of landfills. There is an urgent need to reduce the quantity of waste being sent to landfills.

The study undertaken by this project has shown that littering is also common because existing dustbin solutions are not user-friendly, have no visibility and are poorly deployed.

This project studies the context of the current problem and offers implementable design solutions to allow more effective solid waste management through increased segregation to reduce landfill waste, proper disposal of solid waste by citizens through higher bin visibility, and improving civic sense through education.

Contents

1 Background

1.1 Global Scenario

Solid Waste management is one of humanity's greatest challenges. World waste production is roughly 2 billion tonnes per year, and is increasing every year. The world spends approximately $210 billion to collect, segregate, transport and dump waste every year.[1]

Developed countries account for the majority of waste generation in per capita output, but developing nations such as India are increasing their contribution to world waste generation. India produces 55 million tonnes of waste per year.[2]

1.2 Waste in Mumbai

An interview was conducted with Mr.Rishi Aggrawal of the Observer Research Foundation - a non-profit organization that conducts research on various aspects of public life in India. From this we learnt a few facts regarding the scale of waste generation in Mumbai, and some of the drawbacks in the present waste management strategies.

Mumbai generates 10,000 tonnes of waste per day of which about 70-80% is transported to the landfills around the city. The Municipal Corporation of Greater Mumbai has a budget of Rs.1000 crores per year, the majority of which is spent on transporting unsegregated waste to landfills.[3]

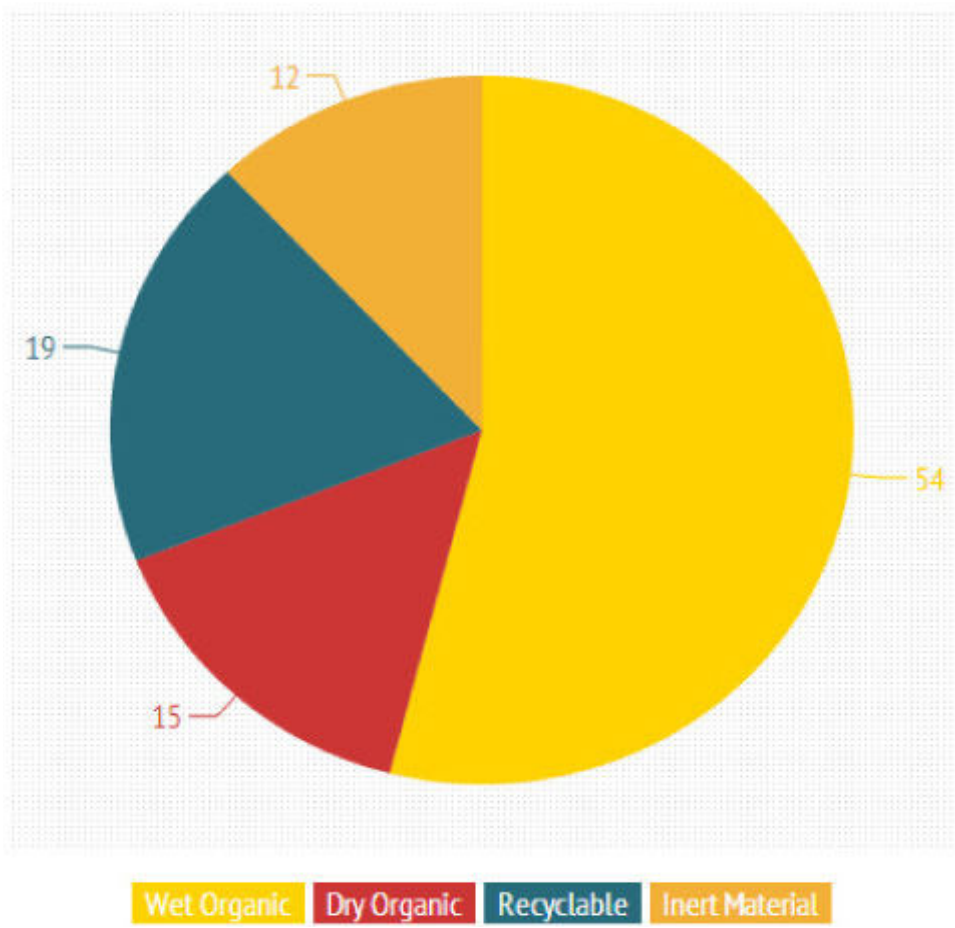


Fig 2: Solid Waste Composition in Mumbai

1.3 Types of Waste

Waste can be classified broadly as Wet waste and Dry waste and Inert waste.

1. WET WASTE

Wet waste is primarily organic in nature and consists of kitchen waste such as vegetable peels, fruit waste, cooked food, garden waste and any other organic biodegradable waste with high water content.

Wet waste generally attracts the maximum amount of pests and scavengers due to its edible nature (for animals).

2.DRY WASTE

Dry waste is made of both organic and inorganic wastes, both recyclable and non-recyclable that contain very little water, or no water. Items such as wood, cloth, paper, plastics, metals, glass, etc. all form the bulk of dry waste. Dry waste is generally recyclable and can be sorted and prevented from reaching the landfill.

3. INERT WASTE

Inert waste is mainly construction debris from cement, stone, brick, paving tiles, ceramic, etc. that generally takes up volume but is of little use unless it is ground up and re-processed.

The composition of solid waste generation in Mumbai is given in figure 2, showing the percentage of each type of waste.[4]

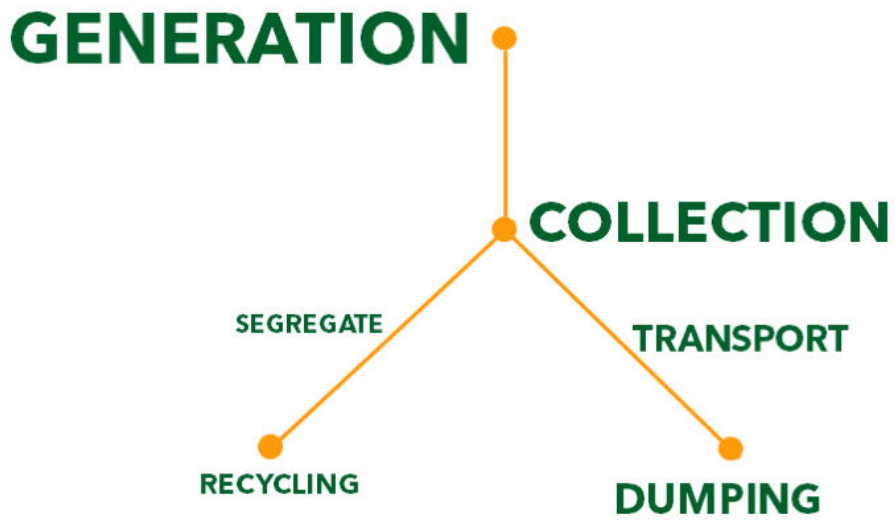


Fig 3: Journey of Solid Waste

1.4 Journey of Solid Waste in Mumbai

Research was done on the current process or "life cycle" of solid waste in Mumbai. It was found that it is not really a cycle model, but instead an unsustainable "pick-up-and-dump" method of dealing with solid waste that has led to catastrophic damage to the environment.

1. GENERATION

Waste is generated at four primary sources in Mumbai.

Domestic waste is primarily wet waste, mixed with some dry waste such as packaging, etc. and is made up of kitchen waste (cooked and uncooked food waste), garden waste and bio-medical waste (sanitary napkins, diapers, etc.). Some electronic waste such as old consumer electronics and batteries is also present.

Commercial waste is primarily dry waste arising from packaging and wet waste from restaurants and similar establishments. This source can also contribute electronic waste, similar to domestic category.

Industrial waste is generated by factories that manufacture goods, and can consist of chemical, biological, medical, electronics,etc.

This type of waste is usually dealt with by the concerned industry before joining the waste stream headed to landfills.

Bio-medical waste from hospitals and clinics, pharmacies,etc. form the fourth stream of waste that usually ends up in landfills.[5]

Fig 4: 660L Plastic Bin

Fig 5. 1100L Metal Bin

Fig 6. 120L Plastic Bin

Fig 7: Compactor Lorry

1.4 Journey of Solid Waste in Mumbai

2. COLLECTION

Domestic and Commercial waste make up the bulk of waste generation within the limits of Mumbai city. In wards such as C-Ward in South Mumbai (Marine Lines-Chandanwadi area) the commercial establishments and subsequent floating populations generate huge amount of waste that is often difficult to deal with. The city is in the process of trying segregate waste into wet and dry at source, but current bins do not offer such facilities.

To understand the basic collection means, a study was done in C-Ward of MCGM and the main collection mechanisms were understood. The primary means of collection include the following:

1. Community Waste Bins

The 5800+ community waste bins in Mumbai are usually 120L, 240L and 660L plastic bins (fig. 4,6) or 1100L metal bins (fig.5). These are serviced upto 2-3 times a day by a team of garbage compactor lorries (shown fig.7) that are designed to lift, dump and place the bins using a hydraulic arm.

All these bins are designed for European standards and as such have been procured in large quantities by the MCGM. The larger bins have wheels which break due to mis-handling by MCGM staff, being overturned by cows and humans, traffic accidents etc. The bin wheels also break during lorry-based operations, because the hydraulic arm lifts the bin and then smashes it into the ground (as opposed to gently placing it on the ground) after dumping has occurred. This is due to poor maintenance of the vehicles, and poor training of personnel.

Fig 8: Public Bin 1

Fig 9: Public Bin 2

Fig 10: Public Bin 3

Fig 11 Public Bin 4

1.4 Journey of Solid Waste in Mumbai

2. Public Bins

Bins of smaller capacity are also located around Mumbai in various areas ranging from roadside eateries to parks and tourist attractions. MCGM has also started installing small capacity (20-25L) waste bins across the city.

The common problems with such bins is that there is no consistency in their deployment. Bins in South Mumbai differ from those in the suburbs, and bins used by private parties have no standard design or visual appeal. They range from being user friendly for service personnel, to extremely poorly designed to almost prohibit garbage collection.

A few new bins around the city offer two compartments - one for dry waste and one for wet waste. There appears to be no consistency in labelling them, no discernable colour code or other means of visually separating the two streams of waste.

There is also no labelling to inform users as to what constitutes wet waste and what constitutes dry waste, for the purposes of street/pedestrian level collection.[5]

1.4 Journey of Solid Waste in Mumbai

Fig 12: Sweeping

Fig 13: Piling + Scooping

3. Street Sweeping

The city has an army of street sweepers who roam the streets during the morning hours and sweep the streets. A typical beat is about 500 m to 1 km for street sweepers.

The daily work done by these persons ensures that the regular pile up of waste is reduced at street level. The primary tools used to do this job include a wheel-cart or wheel barrow, a bamboo or cane broom, pieces of cardboard or any flat material salvaged from waste is used to scoop piled up debris.

This method is extremely inefficient, and ergonomically unsafe and causes workplace injuries and poor quality of life for the workers who keep the streets clean.

Fig 14: Transporting

Fig 15: Dumping

The process shown on the left is within the IIT Bombay campus, but a similar procedure is followed by workers of MCGM. The wheel barrow is often substituted with a trolley with four rectangular bins made of plastic, which are then manually lifted and dumped into a truck or community waste bin.

In IIT Bombay the wheel barrow is emptied into an open landfill area, or brown waste piles across campus.

Fig 16: Narrow Gullies

Fig 17: Narrow gullies with water pipes

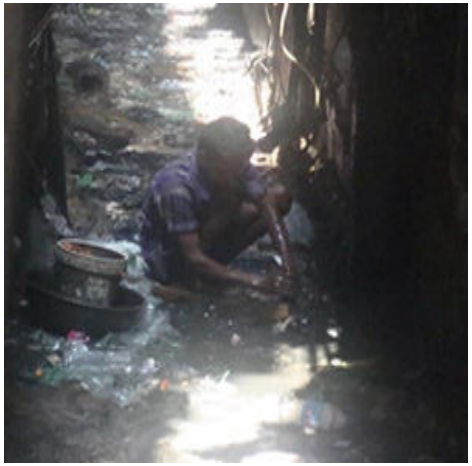


Fig 18: Manual Gathering

Fig 19: Waste pile during collection

1.4 Journey of Solid Waste in Mumbai

4. Gully Cleaning

An important yet forgotten aspect of city cleaning is Gully cleaning.

Gullies lie inbetween closely spaced buildings, especially in the old city (South Mumbai). Occupants of these buildings often have low-to no civic sense unfortunately, and dump garbage out of their windows into the gully below.

The responsibility falls on MCGM to clean these areas and ensure the disease spreading pests are kept to a minimum. The process of cleaning it is notoriously difficult , and workers often have no protection or tools apart from flat sheets used for scooping and plastic gamelas.

Occupants of the buildings to the sides have such little care for the gully areas that they show no restraint in throwing waste even on the workers who are engaged in cleaning the area.

A few pictures are shown to illustrate the difficulty of gully cleaning.

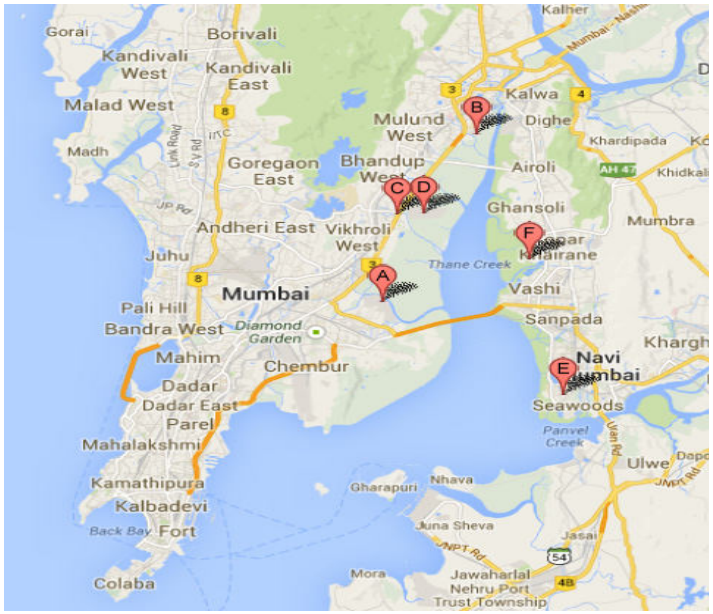


Fig 20: Landfill sites map

Fig 21: Mobile Compactor Lorry

1.4 Journey of Solid Waste in Mumbai

3. TRANSPORTATION

After collection, mixed waste is currently loaded on tricycles, small trucks and other smaller carts. The contents of these are then transferred to mobile compactor lorries that use hydraulics to compact the waste.

Community bins are also emptied into compactor lorries. This is done by position the bin such that hydarulic arms can lift, tip and empty the contents of the bin into the storage area of the lorry.

Following this, loaded lorries are dispatched to either the transfer station in Mahalaxmi, or any one of the landfill sites across Mumbai. Gorai, Mulund, Kanjurmarg and Deonar are the four main dump sites around Mumbai city.

Fig 22: Manual loading on to Mobile Compactor

Fig 23: Mulund Landfill

Fig 24: Layers of landfill waste

1.4 Journey of Solid Waste in Mumbai

4. DUMPING

The main landfill areas of the city are mostly well beyond their 20-30 year service life. Also, they have exceeded their initial boundaries, leading to several lawsuits being launched against the authorities by the residents of the surrounding area.[3]

Landfills have some very dangerous consequences, apart from just odours and land value degradation. The huge quantities of waste piled on top of each other start causing the release of toxic leachate - a liquid substance that oozes from the waste pile into the surround ing ground and can seriously harm human beings and animals via water supplies.

The landfills also release a lot of methane gas due to bacterial action and subsequent decomposition. This methane gas can be captured and used for power generation. [5]

One thing that was observed at landfills is that scores of people live and depend on the landfills. The conditions at the landfills are extremely poor, begining with the odour problem, uncontrollable pests like rats thrive in large colonies, and they are open to the spread of diseases in such filthy conditions. They earn a living salvaging recyclable products and selling them for scrap.

Fig 25: Rag Picker

Fig 26: Rag Picker Collection

1.4 Journey of Solid Waste in Mumbai

5. SEGREGATION

Segregation of waste into landfill, recyclable materials, compost,etc. is something that generally happens in a disorganized manner right from source of waste through collection, transportation and even after dumping.

Usually the best level at which to segregate waste material is at the source, where the waste is fresh, of lower quantity and can be salvaged easily. However, most waste in Mumbai is not segregated at source. Value is gained by waste generators who follow the old tradition of "Raddhi / Kabbadiwallahs" and sell their recyclables for money (newspapers, bottles, etc.). There is little formal support for such Raddhi / Kabbadiwallahs currently in the system, leading to a decline in the number of such businesses. Indian sensitivities towards segregation are very low at the moment, and getting people to even dump waste correctly in a bin is a challenge. However, this situation is slowly improving, with MCGM following other major cities like Bangalore, Pune, etc. and introducing collection of waste at source in homes as a pilot programme in a few wards.

Waste scavenging happens at every level throughout the process from source to landfill. Rag pickers commonly are seen upsetting entire bins to sort through a mix of wet and dry waste. A rag picker family in South Mumbai makes approximately 300 rupees a day by scanvenging recyclable goods from trash dumps. This is a very time consuming and filthy process, and can be made more efficient if a better way to segregate waste is possible at home or business, and at street level. [6]

Fig 27: Sorting plastic in Dharavi

Fig 28: Sorted plastic 1

Fig 29: Sorted plastic 2

1.4 Journey of Solid Waste in Mumbai

6. RECYCLING

Post Collection, segregated waste is taken by rag pickers to be sold to a number of middle men who in turn sell it to larger recyclers. There are an approximate 100,000-150,000 rag pickers in Mumbai city alone. [6]

A lot of the recyclables, especially plastics, lands up in Dharavi. There is a huge micro-industry of recyclers that has grown in Dharavi based on this economy. Teams of workers sit in small spaces, break up products and scavenged waste into components. These are further segregated by eye, smell, touch etc. according the type of plastic.

These are then ground up into small pellets to be used in recycled plastic products. Items like styrene foam (thermocol) are heated, melted and made into small beads used in making jewellry etc.

The workers in the recycling industry often learn the trade through their family. Currently the second to third generation of recyclers are in business in Dharavi. An apprentice recycler typically takes between 2-5 years to learn the nuances of sorting out 10-15 different types of plastic using only his or her judgement. [7]

2.0 Project Focus

Based on my observations and research, I was able to identify an area for contribution in this field with many problems to fix. My project will focus on dealing with street level waste - i.e. the collection of waste from pedestrians, addressing some problems faced with the current community waste bins and public bins.

2.1 Project Goals

1. REDUCE LANDFILL WASTE

Unsegregated garbage causes severe problems due to a lot of recyclable, reusable material being dumped along with unreclaimable material. As we run out of space for landfills, the western practice of picking-and-dumping is not a sustainable model for us to follow. Hence, the amount of waste that is taken to the landfills must reduce from any and every input stream.

2. IMPROVED LIVING ENVIRONMENT

Another project goal is to design a solution that will encourage hygeinic deposition of waste, leading to reduced incidents of improper dumping, and thus less animal scavengers and pests such as rodents.

3. SHIFT BALANCE OF RESPONSIBILITY

Currently the average citizen does not feel accountable for the litter he or she creates. In fact, the entire responsibility of dealing with any waste outside private property falls onthe municipal corporation. This leads to reckless dumping and poor waste management practices by citizens. The “someone else’s problem” attitude has only led to a steady decline in public hygiene standards.

4. BETTER WORK ENVIRONMENT FOR WORKERS

It is important to improve the work environment of the garbage collectors and in order to raise their productivity. Doing this will allow the municipal corporation to do more public maintainance with existing resources, while leading to decreased illnesses and work related injuries for waste management workers.

5. IMPLEMENTABLE SOLUTION

There is need to design an implementable solution to ensure that the problems in the field can actually be dealt with immediately. The system currently is in a very bad state, and thus requires solutions that can contribute to it to be implemented in a short time frame.

Fig 30: Cattle rummaging through litter

Fig 31: Corroded Metal Bin

Fig 32: 120L Bin & Lid

Fig 33: Bin in Park

2.2 Challenges to Solve

1. COMMUNITY BINS

Community bins are extremely heavy to handle and difficult. This is because the large capacity bins are currently made from sheet metal and have a large dry weight (empty weight). The 660 L bins however are easier to manouver due to their plastic construction. The bins are abused by cows, traffic, as well as poor operating procedures for the hydraulic lorries that slam the bins on the ground and break the wheels. The fact that there is no designated space for these bins also causes them to be moved around.

These bins are also open to the weather leading to corrosion, and spreading of litter.

2. PUBLIC BINS

The smaller capacity public bins currently do not adequately require segregation. There is no consistent visible identity that will build recognition amongst the public, as well as no consistent deployment strategy.

The lids of the bins (if present) are also filthy and most persons will prefer not to touch these lids to open the bins before dumping the waste. This contributes to the waste build up around the bin, increasing the chances of peripheral littering.

2.3 Design Brief

With the learnings from the background research and observations it was necessary to form a comprehensive design brief that will effectively direct ideation, conceptualization and final development.

Design & Build a waste collection system for public areas that allows / improves / promotes:

1. HYGIENE: Will promote hygienic deposition of waste
    - reduces access to scavengers and pests
2. SEGREGATION: Allows dry and wet waste segregation
    - by increasing awareness
3. USABILITY: Is simple to use, service & maintain
    - reduces human effort, more safe and hygienic interaction, with more efficient collection
4. FEASIBLE: Is implementable, realistic
    - To meet the immediate need in Mumbai

3.0 Existing Solutions

Fig 34: Waste Bin Array in Japan

Fig 35: Waste Bin Array in Japan

Countries such as those in Europe, USA, Canada, Japan etc. have different approaches to waste management. One thing that is common however is that these countries have a more mature approach to waste collection and management, although not necessarily to waste generation.

3.1 Japan

The Japanese approach to waste management is exhaustive as public areas have a high number of waste-bin arrays. These arrays consist of anywhere between four to 8 bins that require segregation by material and recycling process. For example, separate bins exist for coloured glass and white glass, cardboard and paper products, packaging, different plastics and electronic wastes.

The bins are extremely well labelled and colour coded for easy visibility and legibility. Considering the high level of literacy in Japan, using language to distinguish waste is not a grave issue. To supplement the presence of bins around public spaces, children are taught their civic responsibilities at a very young age.

Members of the general public take great pride in informing new comers about properly segregating their waste, and fines and/or disdain will be levied on those who dispose their waste incorrectly.

Fig 36: Waste Bin Array in USA

Fig 37: Bins for UK, Made in India

Fig 38: Pedal Operated Trash Bin in Canada

3. 2 North America

North American cities in USA and Canada strictly enforce waste segregation at the houshold level. Every household within a community is issued a waste bin and recycling bags. This means that there is a fixed garbage allowance per household per week.

The responsibilty to stick to this allowance is on the citizen, as additional charges will be incurred if a household exceeds the allotted quota. The bins and vehicles used here are similar to those used in by municipal corporation of Greater Mumbai.

Public bins take a similar approach to Japan albeit without as many subdivisions.

Designers have also incorporated different shapes for the openings to guide the behaviour of the user to correctly put the intended waste in the appropriate bin, such as shown in Fig.31

Mechanisms such as bin lids and pedals are also often used to allow for hands free operation of the devices for better hygiene.

Fig 39: Distinct Bins used in some parts of Italy

Fig 40: Underground Bag system

Fig 41: Hydraulic lift Bins

3.3 Europe

There are some design features that are common to waste bins used in developed nations. European public bins often have interesting forms and brightly coloured shapes that set them apart from rectangular boxes used in Japan or North America (although some exceptions exist).

However, the main differences in Europe are in community storage where a lot of Europeans don't have door-to-door garbage pick up like USA or Canada, but take their garbage to the nearest community bin. These bins are increasingly placed underground, allowing for safe, odour-free and out of sight garbage storage. These are serviced by 1 to 2 person teams that operate a compactor lorry similar to those in Mumbai, albeit more efficiently.

The lorries have a remote-controlled crane attached that assist in either removing a large storage bag from underground, or raise a hydraulic platform of 1100L storage bin to ground level so that they may be emptied into the compactor.

These systems are patented and expensive, althought there is definite merit in storing waste underground.

3.4 Summary of Relevant Design Features

There are some design features that are common to waste bins used in developed nations, to help guide our own designs.

1. COLOUR CODING

The bins are usually brightly coloured and follow a consist colour coding. The bright colours used help differentiate the bins from far away, as well as make the bins more visible in an urban cityscape.

2. CLEAR LABELLING

Some bins do this better than others, but in general waste bins are well labelled as to what type waste should be deposited in there. Pictorial labelling is more helpful than text based labelling, as it comprehended easier and does not require language literacy.

3. LARGER DEPLOYMENT

Most public bins (not community bins) have a larger capacity than the average outdoor public bin in India. These are also more frequently deployed allowing them to be used by more people, while the larger capacity allows for less frequent servicing for each bin.

4. PEST PROOF / RESISTANT

Most designs abroad have bins which are sealed using doors or other means to prevent pests from getting access to their contents. It is worthy of study to understand their suitability to the Indian context.

4.0 Ideation

4.1 System Approach

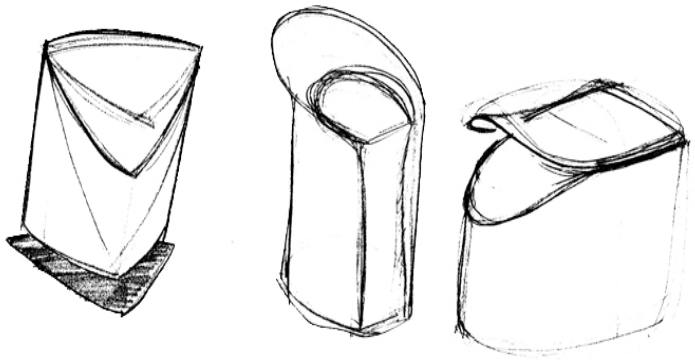
In order to start ideation and generate concepts, it is important to identify directions in which to pursue ideas. The waste bin as a product was broken into two key components - storage and the interface.

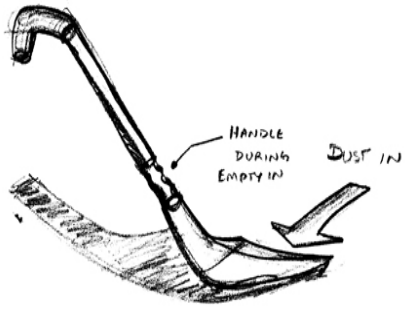
Ideation was done based on different ways to achieve the desired functions of the storage and the interface, while still satisfying the basic design brief directions. This led to ideation brainstorming and ideation concepts based on different choices for strorage + retrieval, and interface ideas (functionality driving design).

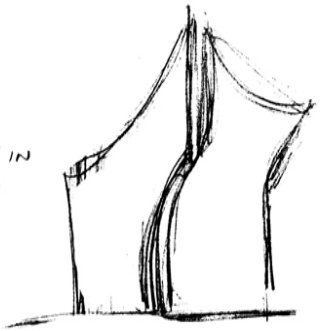
4.2 Interface Directions + Sketches

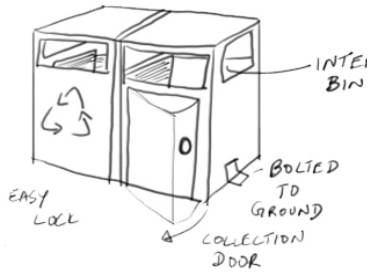
Some research was undertaken to explore the possibility of using materials for a different approach to the interface and storage.

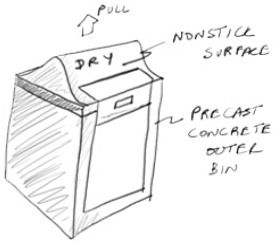
A few interface level materials considered were papier mache cast bins, cardboard / disposable bins, wire mesh bins, transparent acrylic or poly-carbonate bins, etc.

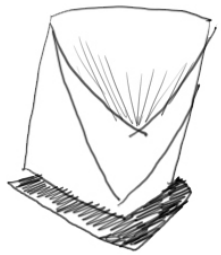


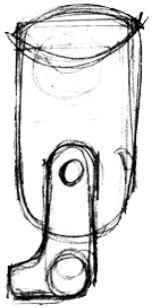


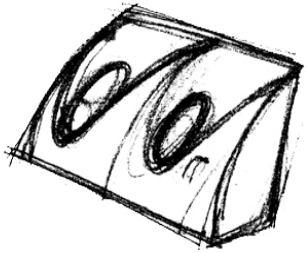


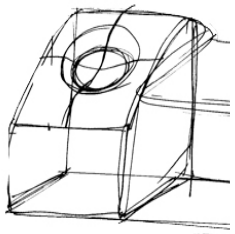


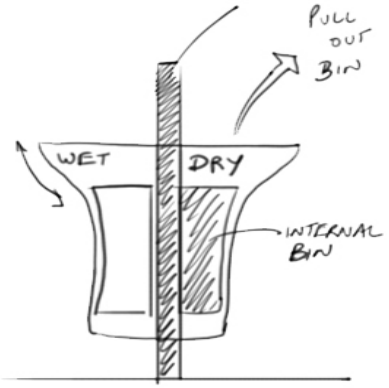


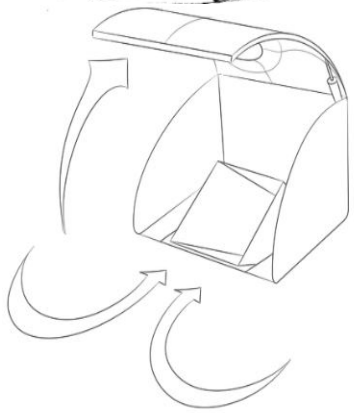


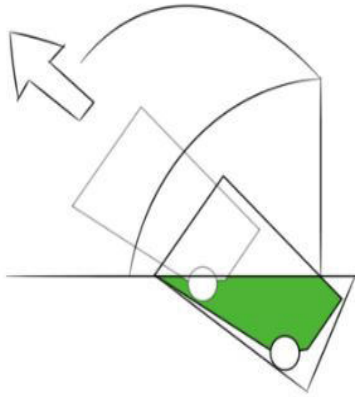


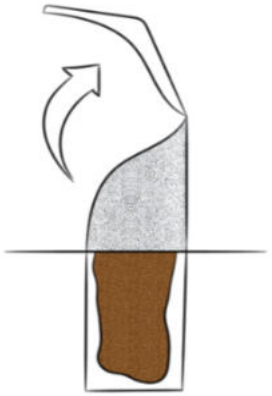


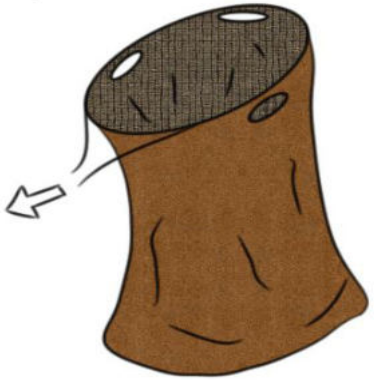






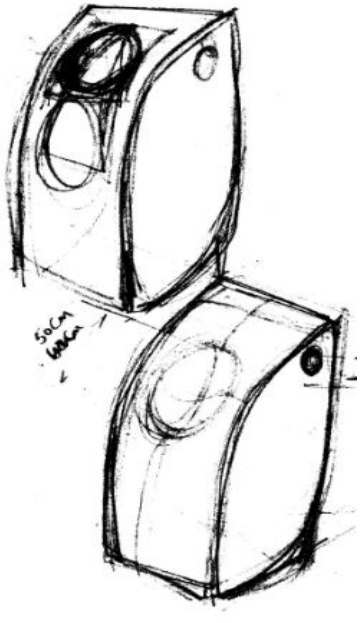


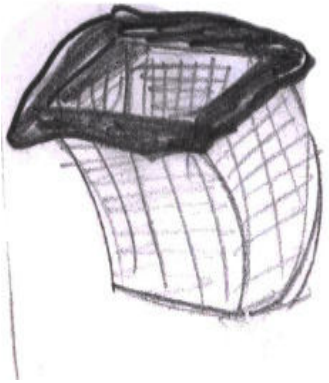




4.3 Storage Directions + Sketches

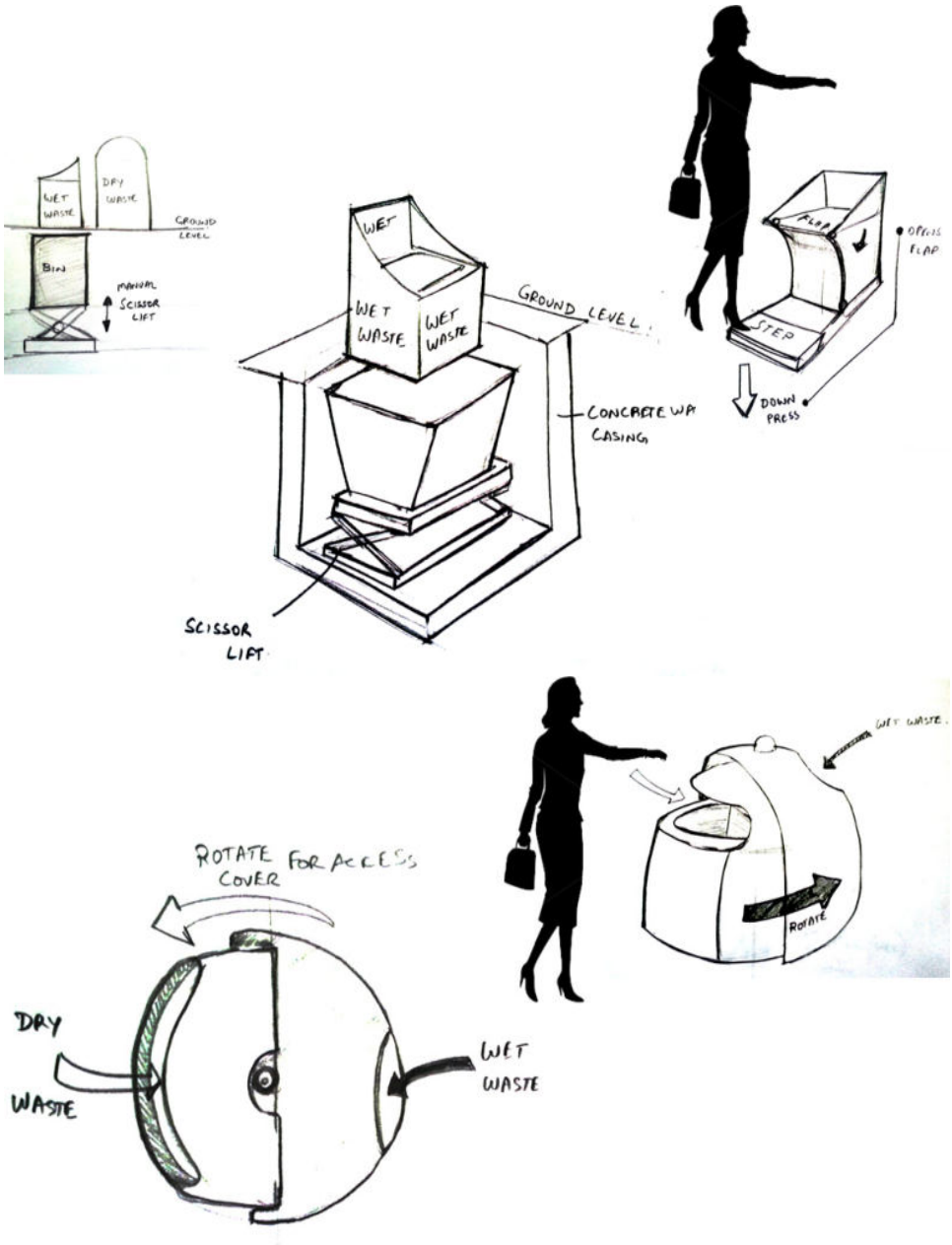
Storage directions considered were underground storage, ground-level storage and above ground storage. Functionality drove ideation in this case. Brainstorming was done on different methods that can viably raise storage bins that are underground. Pole mounted bins for above ground, or suspended bins were also thought of, for example. Bins that can be rolled directly to the lorry, or bins that are entirely dumped for compaction, or replaced everytime. An interesting material that was examined was rubber-coated jute. This material was developed jointly by the National Jute Board of India and IIT-Kharagpur. The material can be used to make high capacity jute sacks, be compostable, while gaining improved strength and water. This material was later rejected due to excessive cost.

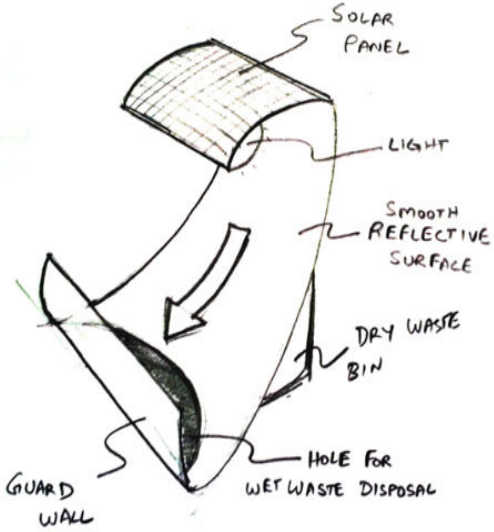


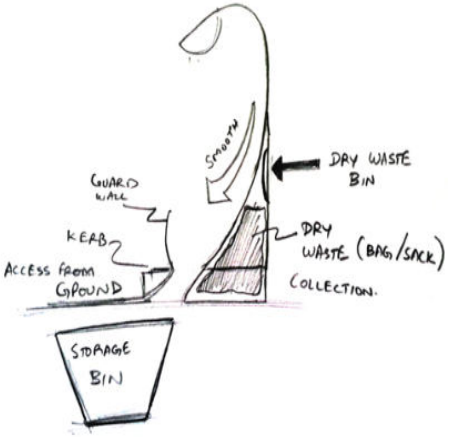


4.4 Concept Directions + Sketches

A few storage and interface directions were combined into directions for concepts. Interesting solutions like this opened up the possbitlies for new concepts.







5.0 Concepts

The ideas from the ideation exercise were examined and qualitatively evaluated through discussions with the project guide, experts from MCGM, and peers from my batch. Criteria such as robustness of the solution, simplicity, ease of use, implementability, pest resistance, resistance to moisture/rain played a key role during the discussions to evaluate the suitablity of each idea.

Combining the best led to a few combinations of Interface and storage solutions that seemed favourable. The top combinations were chosen to make concepts for further design and development.

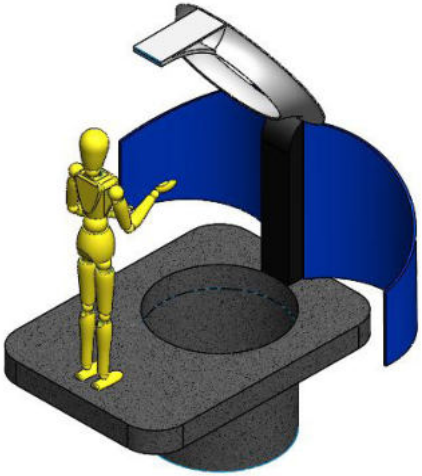
Four main concepts were created, and explored. Many iterations were performed for each concept in order to improve them and take them closer to implementation.

The following pages show each concept and its evolution, with some information.

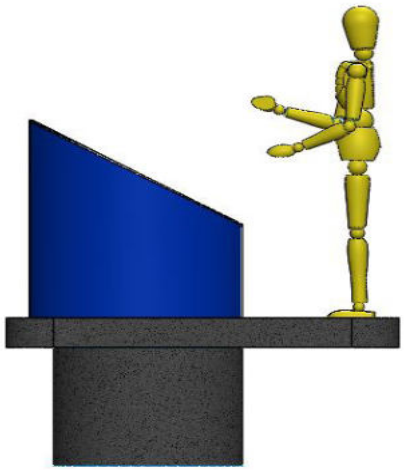
5.1.1 Concept 1 - Iteration 1

The first concept is based on an undergound storage space for waste combined with a pole-mounted three door interface that opens up to give full access to the storage area.

Step 1



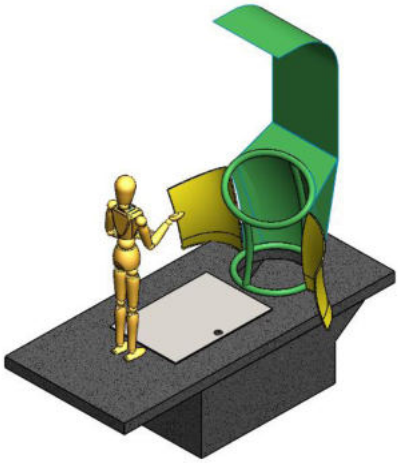
Step 2



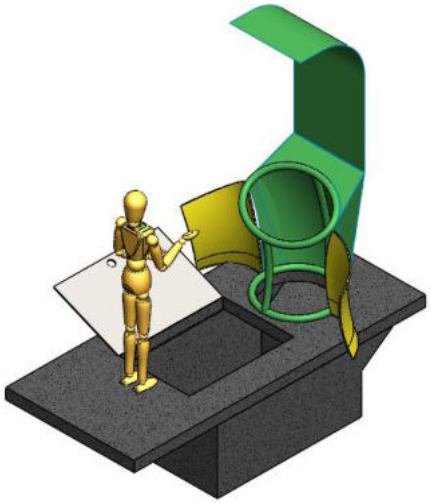
Step 3

5.1.2 Concept 1 - Iteration 2

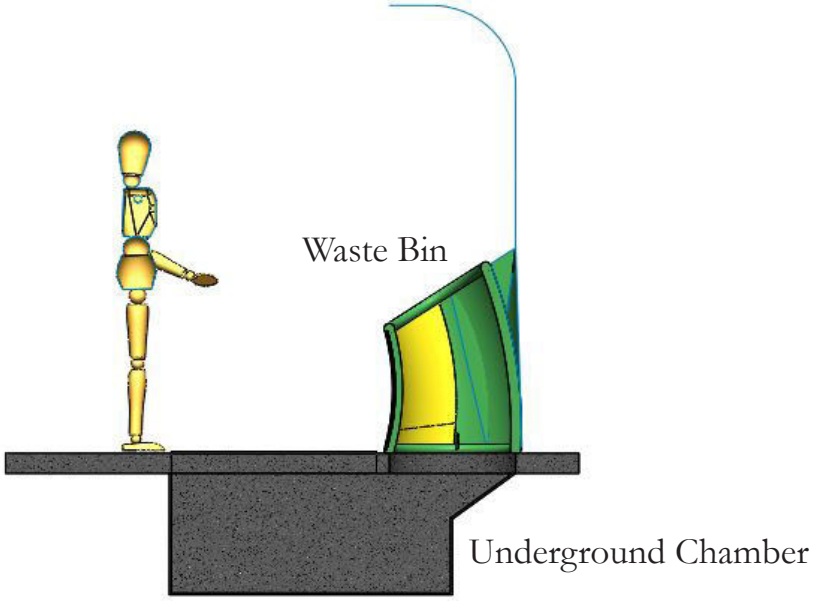
The second iteration explored the possibility of having the storage area not right under the mouth of the interface, but instead in front of it. The chamber underneath the ground could either be used to have a collection bag or a bin that would be hoisted up by a small crane or hand winch.

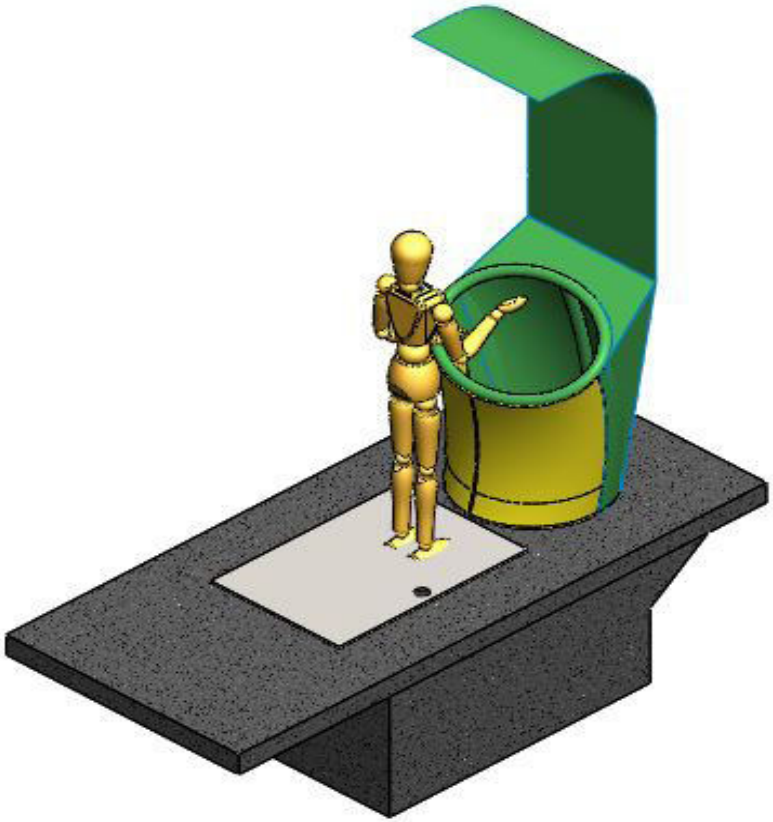


Step 1



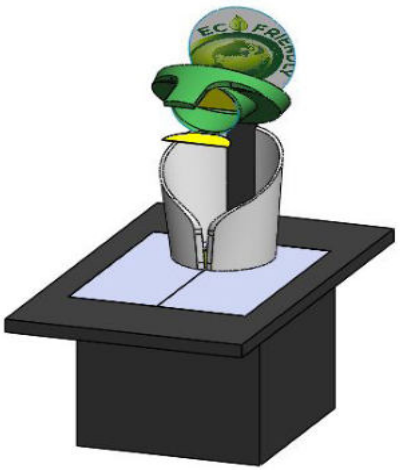
Step 2



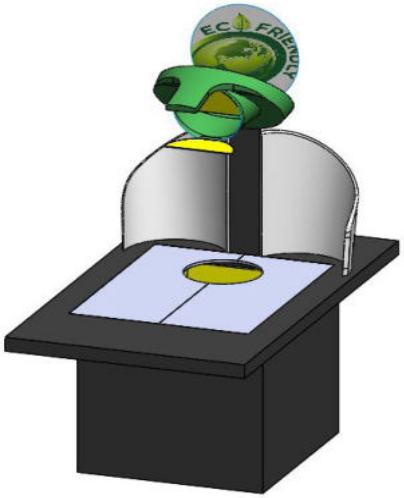


5.1.3 Concept 1 - Iteration 3

The third iteration uses an interface similar to the first, but has a much larger bin capacity. The bin used is also the same size as the current waste bins in use in Mumbai, and as such would be compatible with current waste removal infrastructure. This was made in order to understand how this concept could be made more implementable.



Step 1



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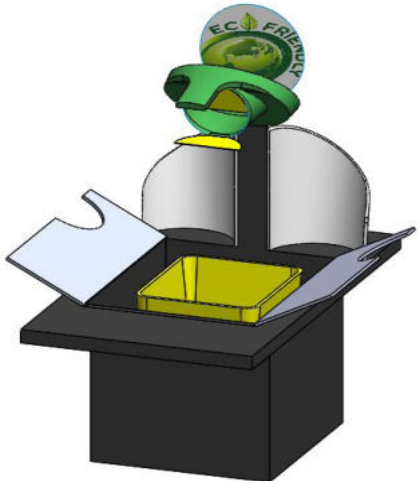
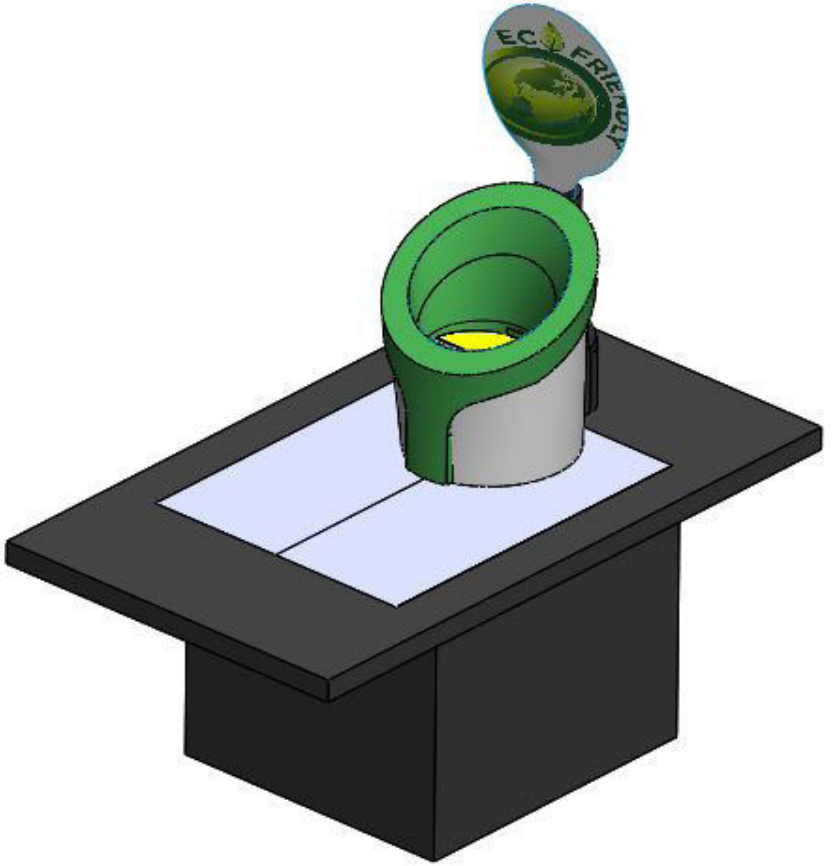
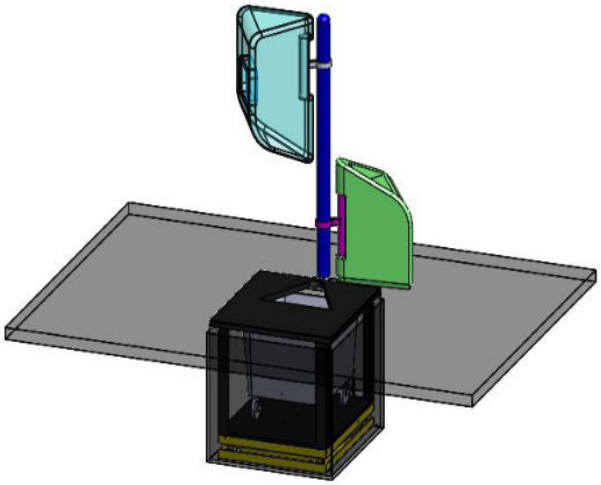
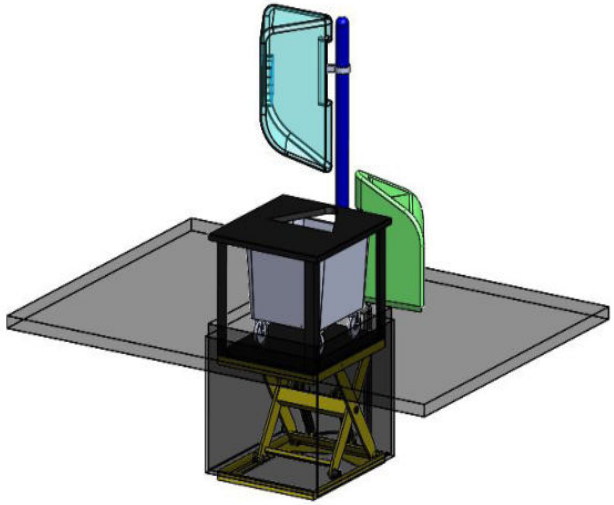


Step 3





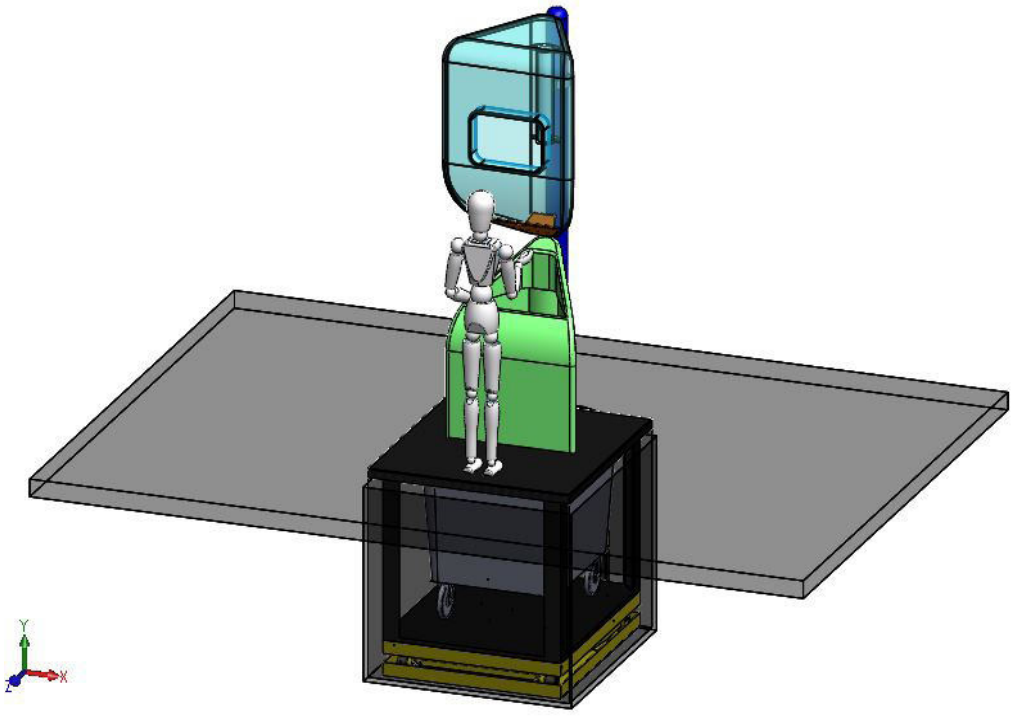
Step 1



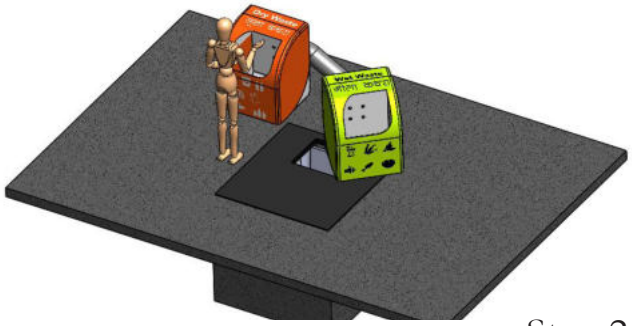
Step 2

5.1.4 Concept 1 - Iteration 4

The fourth iteration of the undersground concept was born out of the need to make the system of two bins more compact. Dry waste is generally lighter than Wet waste. Wet waste needed to be stored underground, away from scavengers. So based on the hypothesis that users can see the different between dry and wet waste better, if dry waste bin was at eye level, and wet waste bin was lower, the single, swivel based pole mounted design iteration was made.



Step 1



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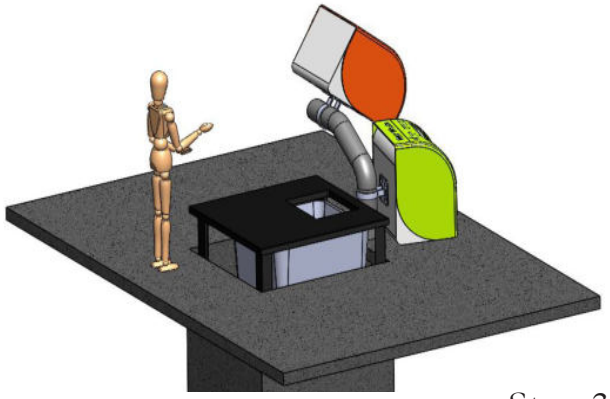

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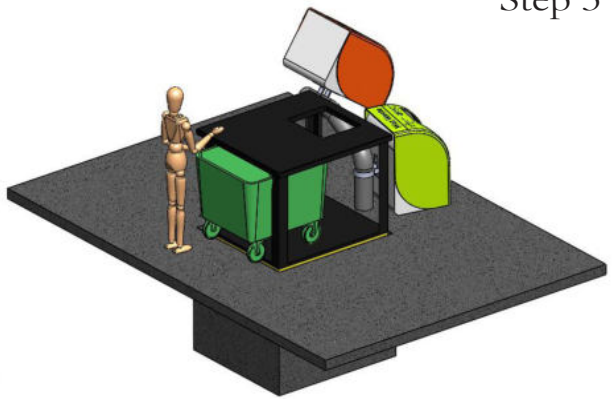
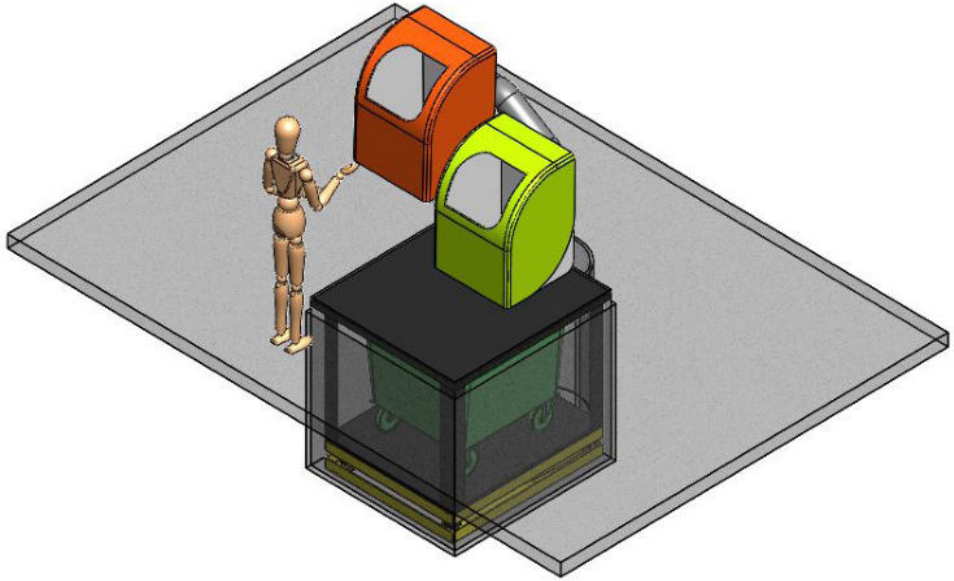


5.1.5 Concept 1 - Iteration 5

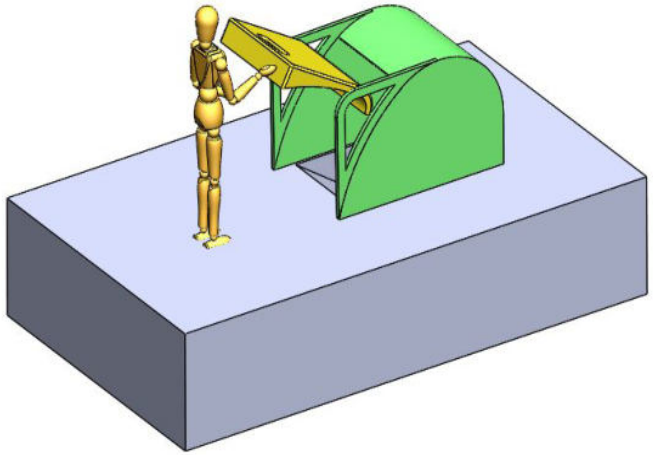
The final iteration of the underground concept was a summation of the learnings of the first 4 iterations. It features an underground storage large enough for the existing waste bins, elevated dry waste receptacle for easier segregation, mechanical lift for raising the underground bin and a single pole, swivel mount for easily moving the bins out of the way.

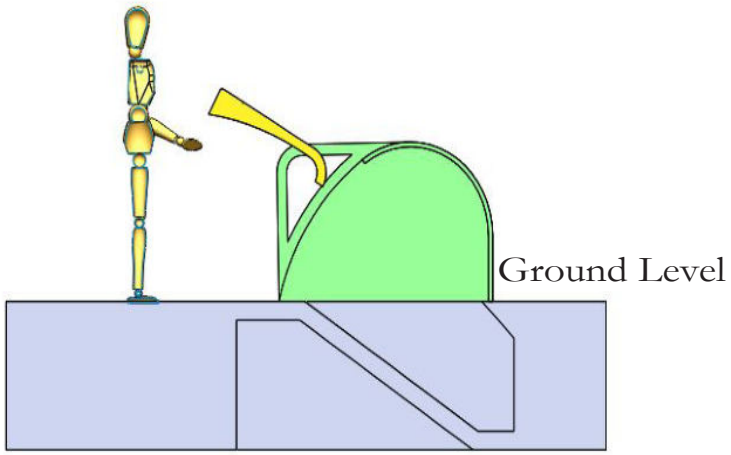
This was one of the three concepts presented for concept evaluation.

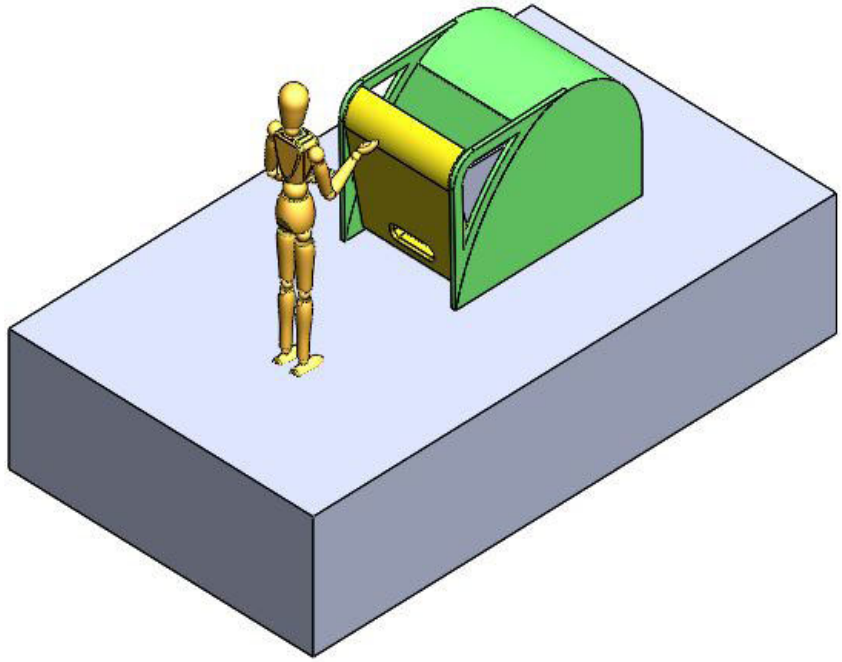


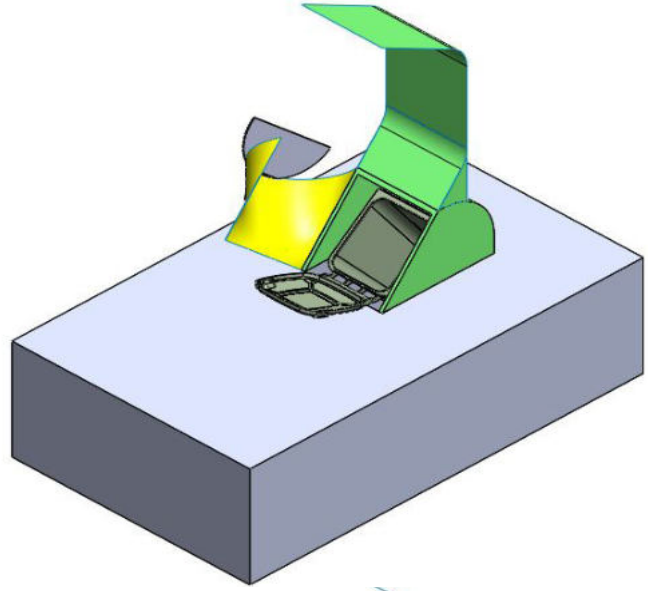
5.2.1 Concept 2 - Iteration 1

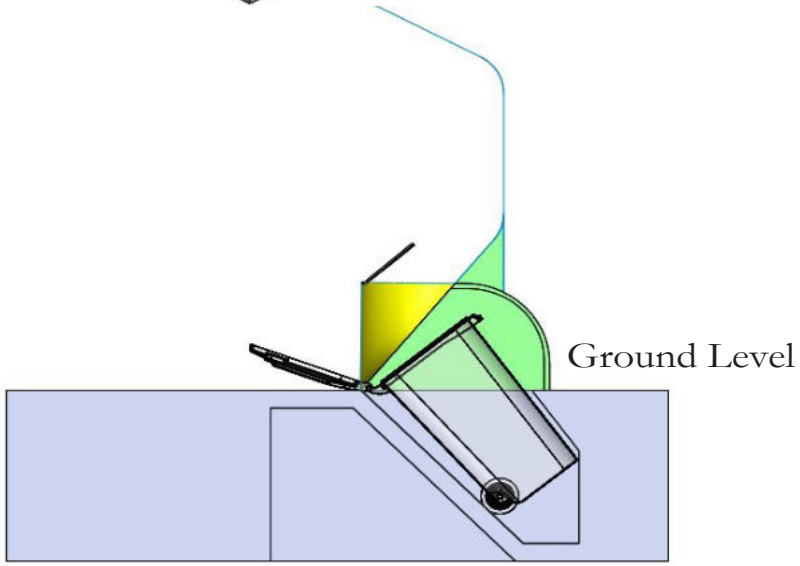
The second concept is based on a partiallyunderground storage concept. The concept provides a space for the existing small wheelie bin (120Land 240L) to be used for collection of waste. The door swivels up to provide access for bin retrieval.





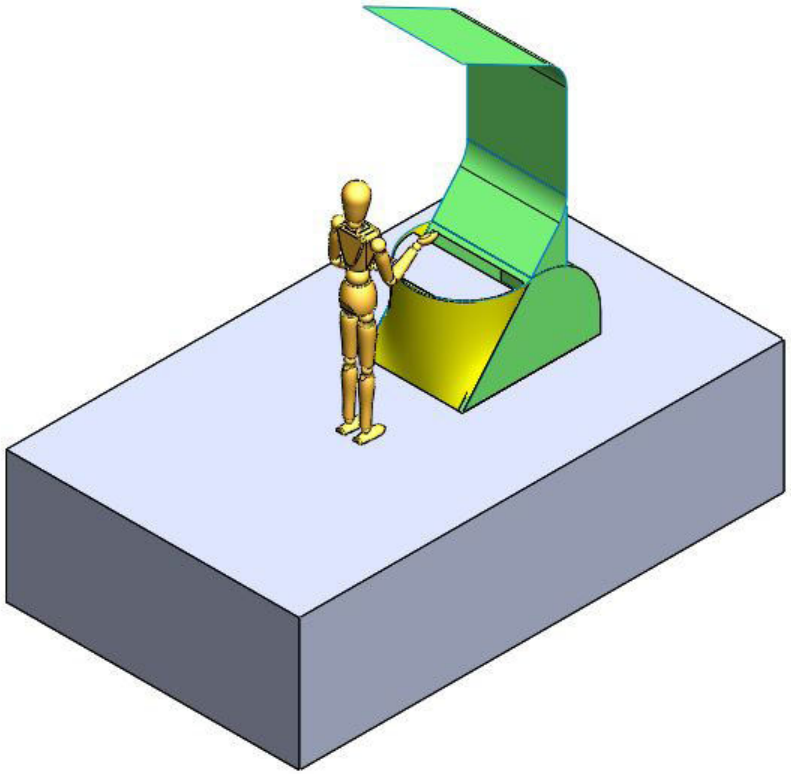


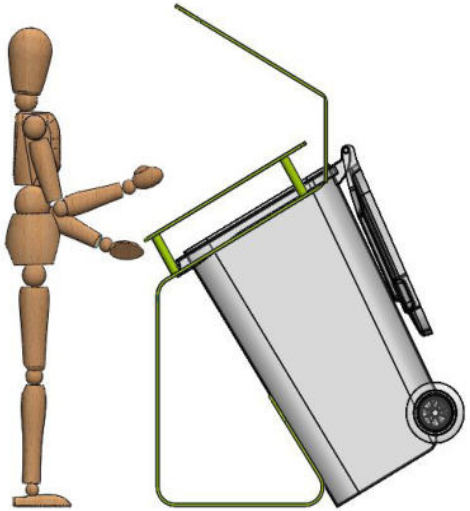


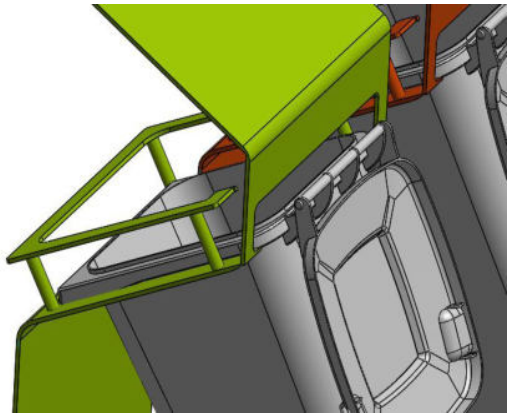


5.2.2 Concept 2 - Iteration 2

The second iteration of Concept 2 has much much user friendly interface, which a flap attached to the access door. The concept also introduces flat surfaces to provide space for advertising and waste segregation labelling. The position underground also allows for lowering the bin height so that persons can use it much more easily.



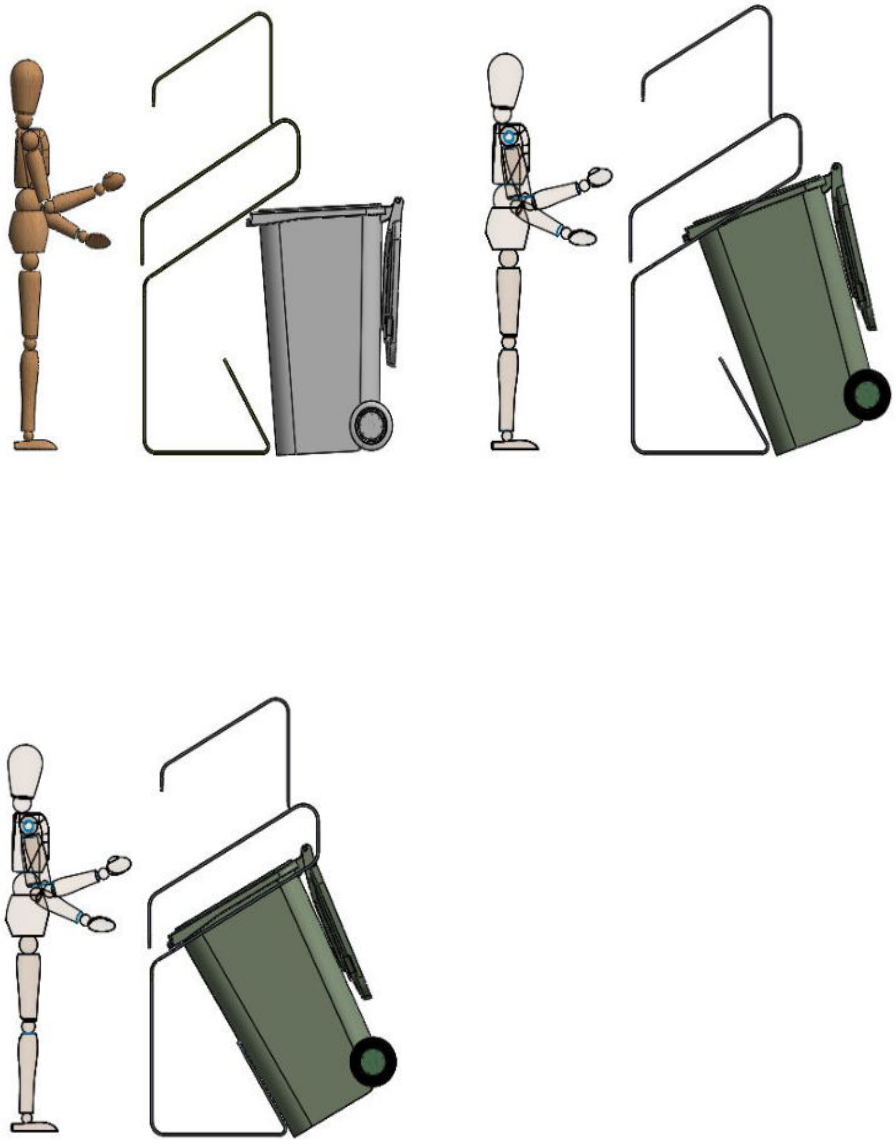




5.2.3 Concept 2 - Iteration 3

The third iteration of Concept 2 removes underground storage approach due to the complex nature of its construction that will be difficult to accurately replicate in the field. Instead, the height of the bin was lowered slightly by putting it an angle. This iteration was also made to be much more manufacturable and easy - made from very few components and operations.

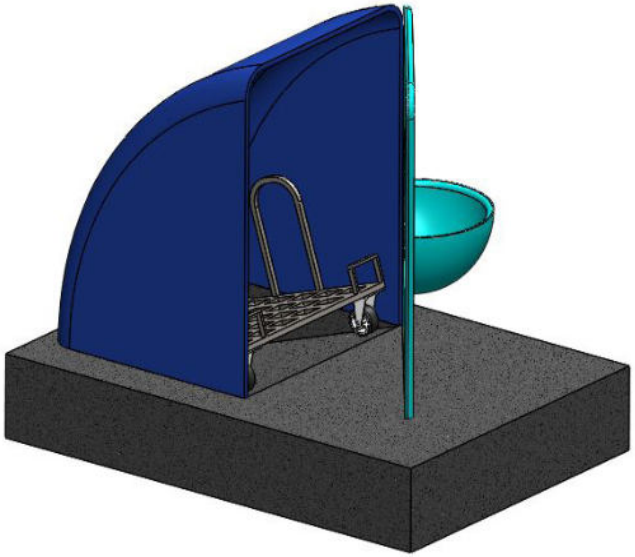
The idea of encouraging segragation based on colour and labelling was taken forward in this iteration, as shown.

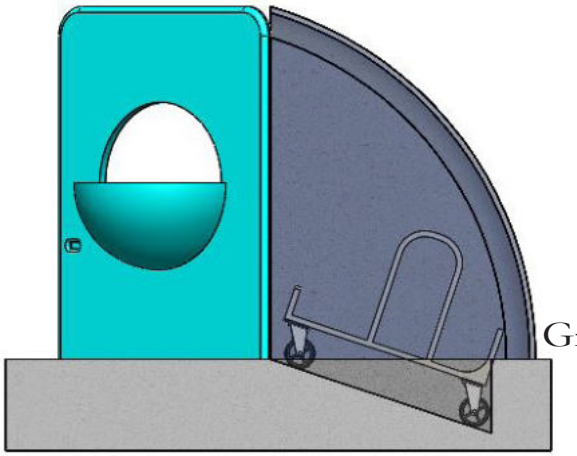


5.2.4 Concept 2 - Iteration 4

The fourth iteration of Concept 2 made the entire structure manufacturable from one sheet of metal, using bends, cuts and welds. No fasteners of any kind are needed, and the entire form was improved to have a more consistent feel.

This iteration was evaluated as the final Concept 2.

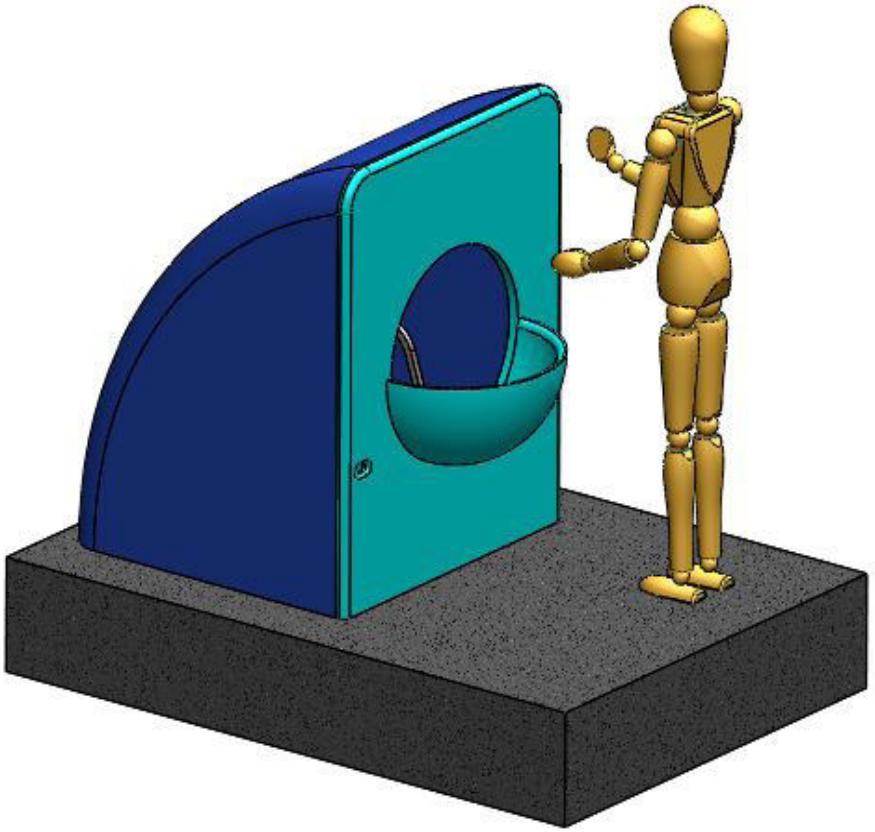


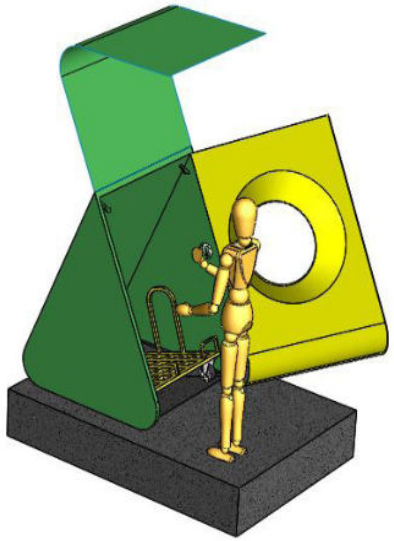


5.3.1 Concept 3 - Iteration 1

The third concept is based on an above ground approach to larger capacity waste collection. This iteration uses a wheeled trolley that can seat a a large sack or bag for waste storage.

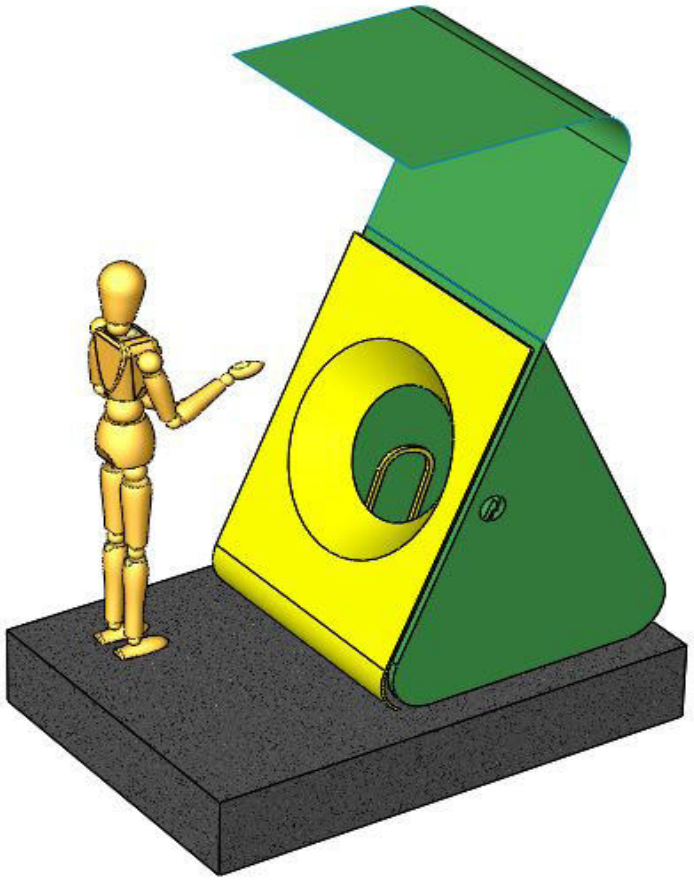
As mentioned earlier, the bag idea was rejected ultimately due to the price of replacing each bag every day.

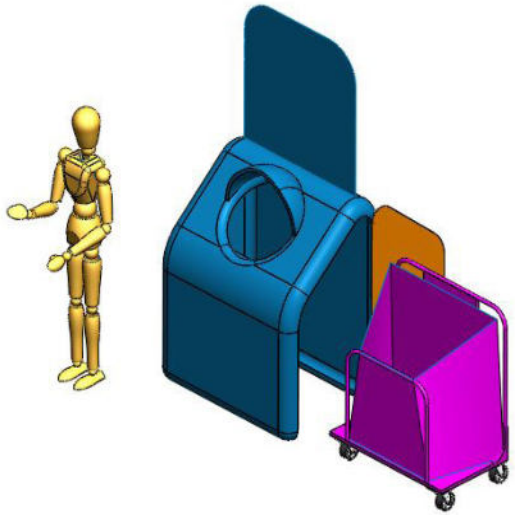




5.3.2 Concept 3 - Iteration 2

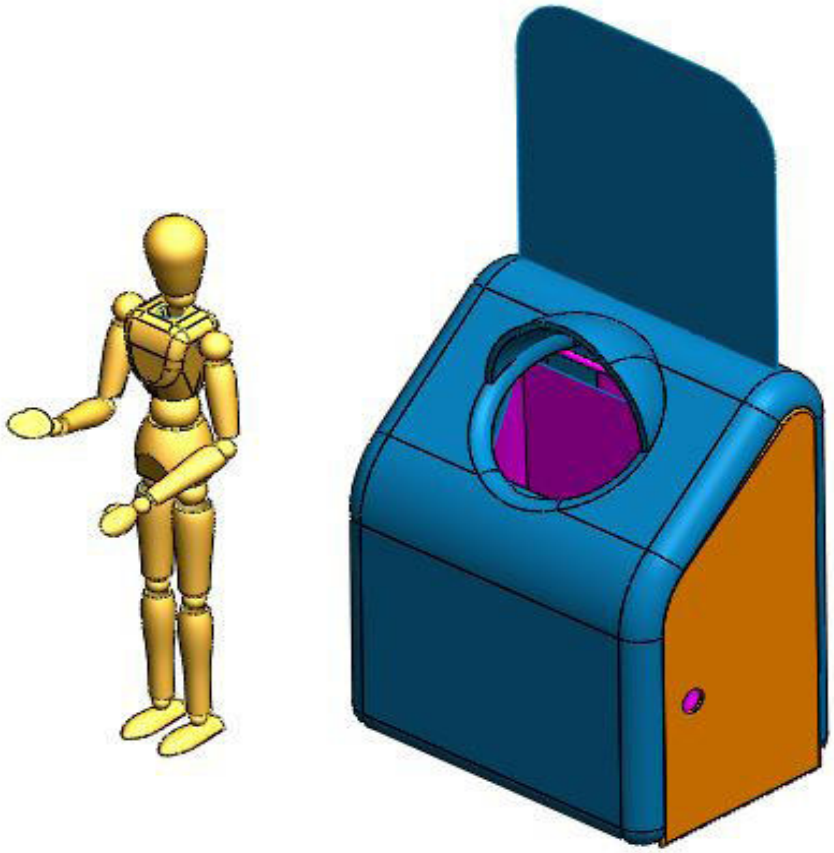
This iteration improved the interface as it was now less likely to act as a rain water collection unit. A hood and flat surface were added to act as protection as well as provide space for advertising / signage.

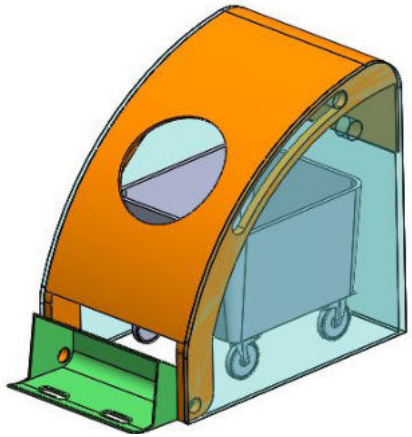




5.3.3 Concept 3 - Iteration 3

The third iteration packages the trolley and bag concept in a different way, and removes the need for partially underground positioning. The trolley height is such that it can be picked up and dumped by existing hydraulic arms on the mobile compactors, making it more implementable.

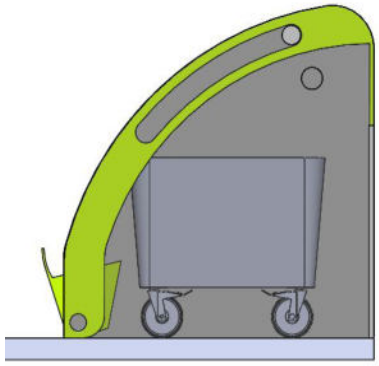


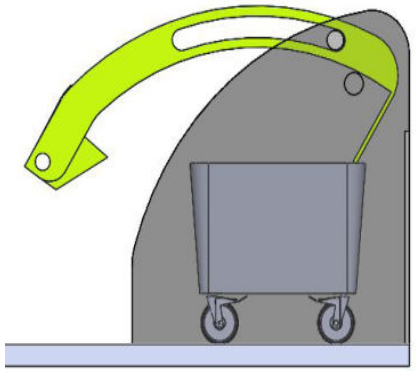


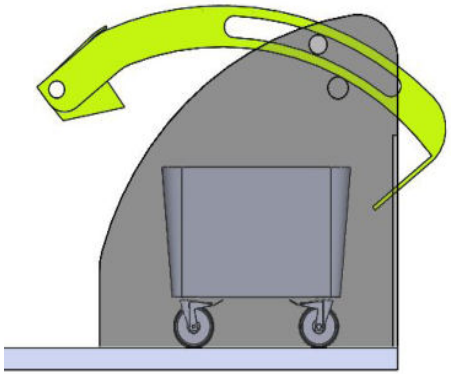
5.3.4 Concept 3 - Iteration 4

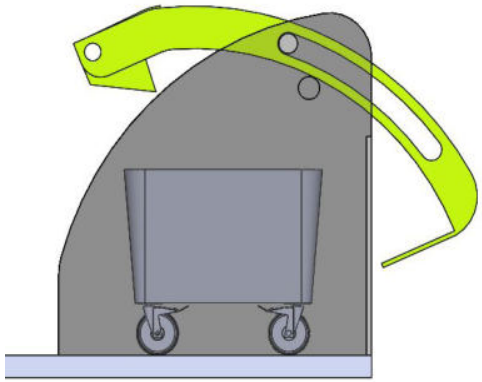
The fourth iteration of this concept incorporated an innovative bucket at the bottom of the door, to deal with surrounding waste. A big reason for people dumping waste outside was because the current bins were too high. The door-bucket mechanism relies on a pin-slot method to allow the door to be raised with a full bucket, to dump it into the storage bin.

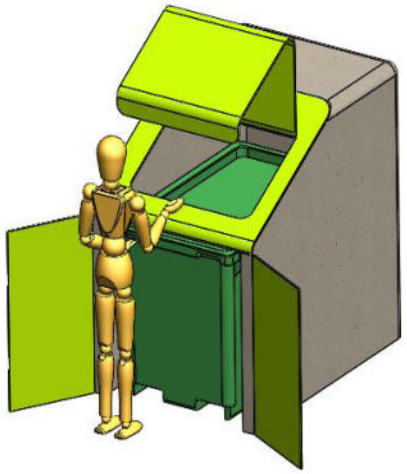
Raising the door also allows for the egress of the waste bin, big enough for the exisitng bin containers.

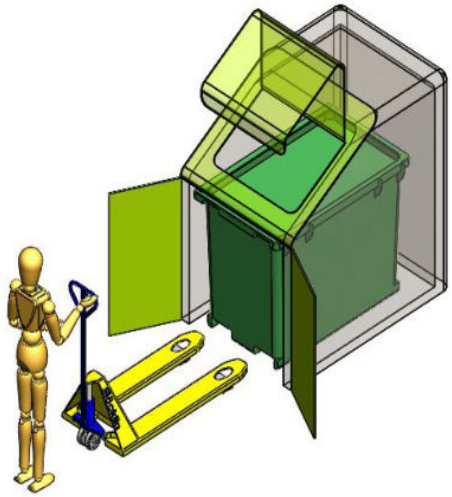


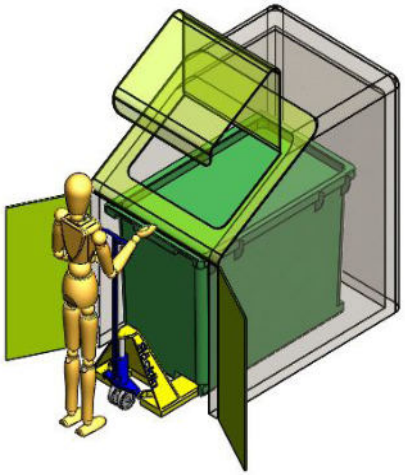








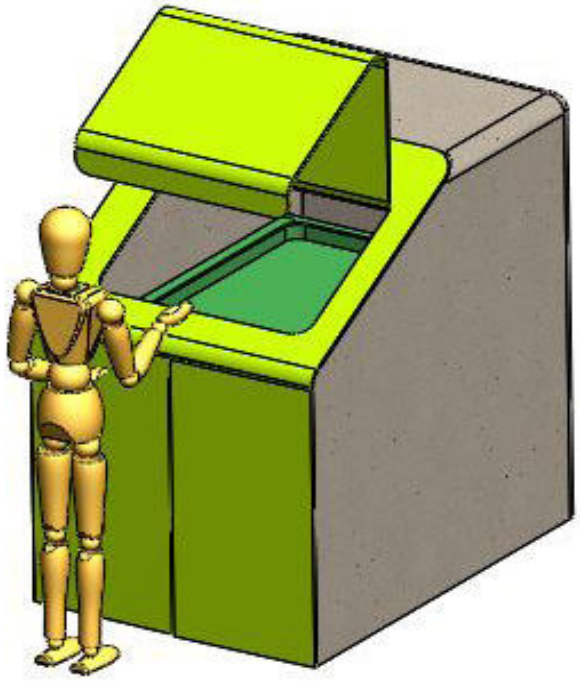




5.3.4 Concept 3 - Iteration 5

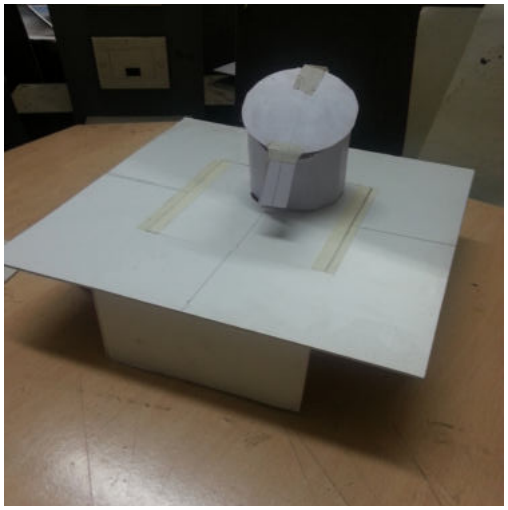
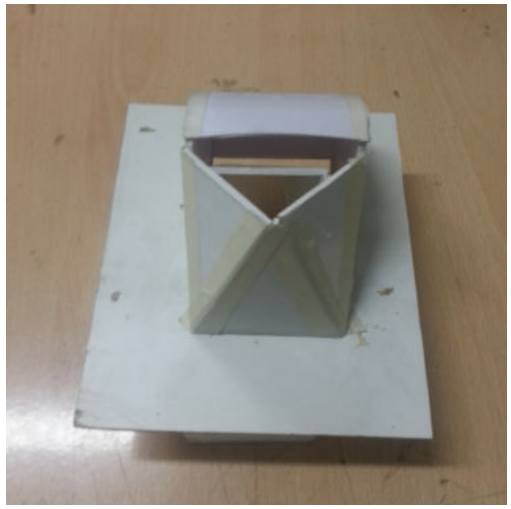
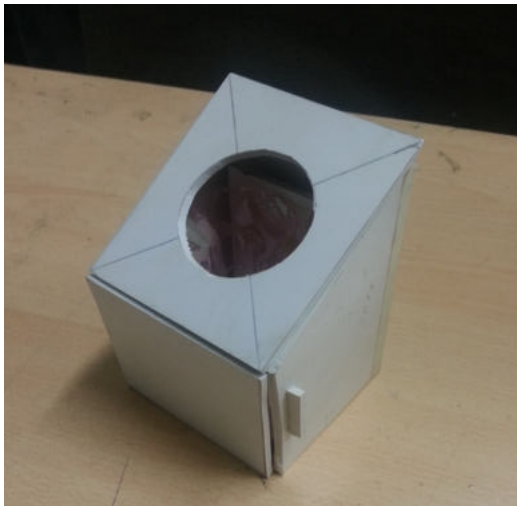
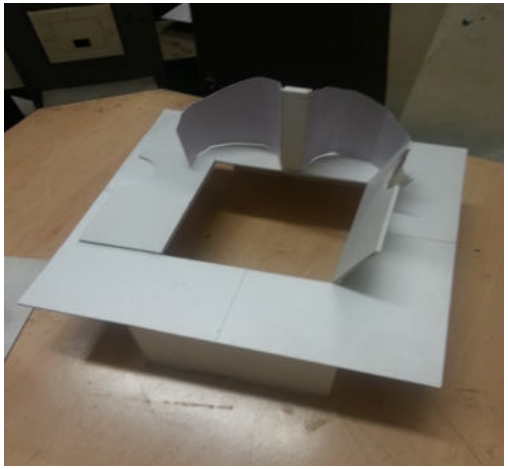
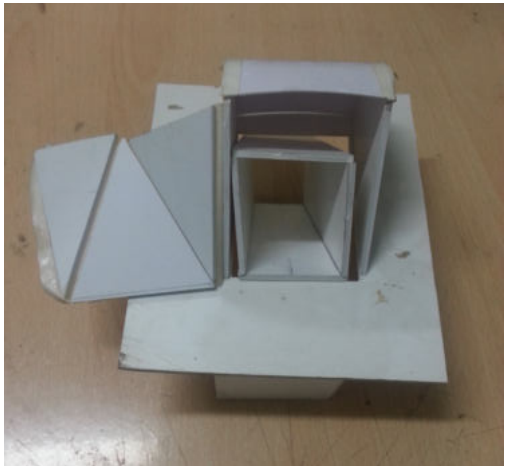
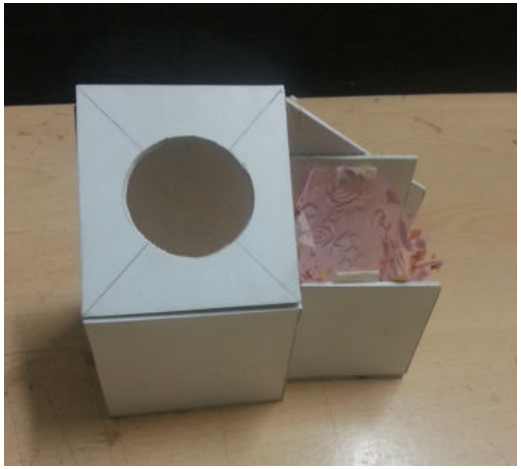
The fifth iteration of this concept is a much simplified version that allows for using the current bins, with a slight modification. The current bins' height was dropped by removing the wheels, hence removing the chance for damage done to them. This also drops the height of the bin to usable levels, reducing the chances of incorrect dumping.

It is proposed that a pump-hand truck be issued to every collection team so that they may lift, move and dump the contents of the bin with minimal manual effort. This iteration was included in the concept evaluation.



5.4 Scaled Mock-ups

Role playing was done with a 1:10 scale mock-up to understand the steps for clearing, and find any usability issues that might arise.

6.0 Concept Evaluation

The concepts were evaluated against the design brief criteria, judged by answering the following questions during discussions with project guide, and feedback from MCGM advisors.

(1)Hygienic

- Does the design appear to be pest resistant?

- Does the design require user contact to dump?

(2) Promoting Segregation

- Does the design allow for adequate signage?

- Does the design allow two units to be placed side by side with minimum space?

(3) Usability

- The designs were presented to the Asst. Engineer and another experienced person from C-WARD, MCGM and were judged against this criteria by their feedback. The feedback of the guide was also included in this rating.

(4) Feasible

- Does the design have any parts requiring long lead time for manufacture?

- Does the design have any expensive components?

- Is the design complex?

Each of the designs and iterations were evaluated based on MCGM officials as well as peers rating the final three concepts out of 5 in the categories listed. An average rating table is shown on the next page.

6.0 Concept Evaluation

As can be seen from the table Concept 2 scored the highest, followed by Concept 3. Concept 2 has thus, been chosen for final development, due to its easy implementability, and ability to use existing wheelie bins., while allowing for better signage, and awareness of segregation.

Hygiene (25%)	3	3	3
Segregation (25%)	4	3	3
Usability (30%)	2	5	3
Feasibility (20%)	3	5	4
	2.95	**4**	**3.2**

The four categories from the design brief - Hygiene, Segregation, Usability, Feasiblity of implementation are all important to this design problem. However, some categories are higher prority than others due to the overall nature of the problem. For example getting trash off the streets is a more important issue than segregation, and a usable design is more desirable than a less feasible design (feasiblity rating will come down with complexity and cost, but still be achievable). A weighted rating scheme was devised after consultation with peers, this is given below:

(1) Hygiene (25%)

(2) Segregation (20%)

(3) Usability (30%)

(4) Feasibility (25%)

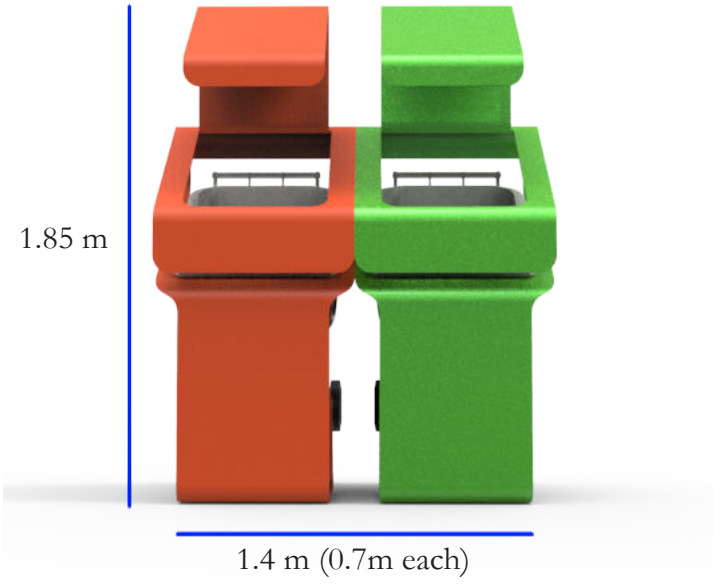
The weighted average score out of 20 determines the selection of the final score.

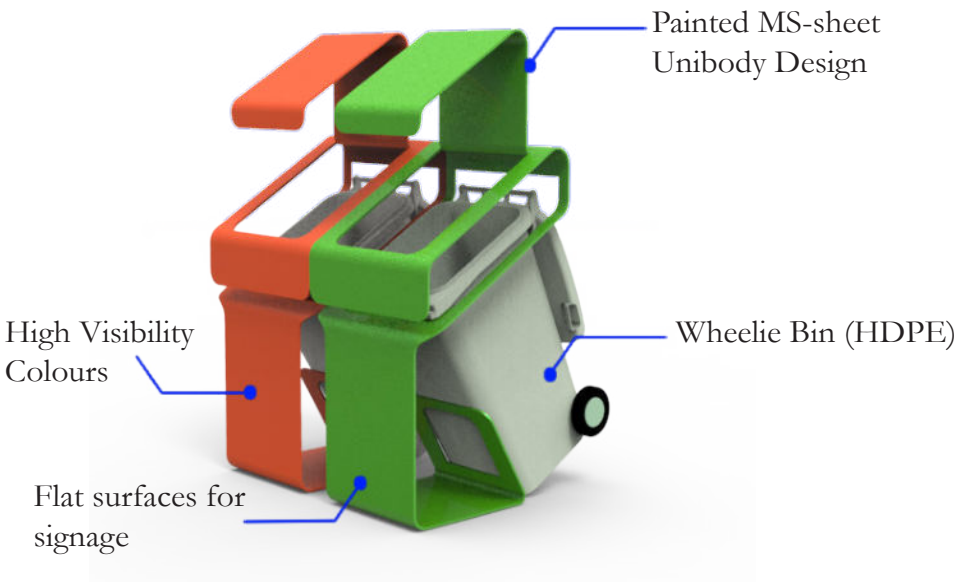
7.0 Final Concept

The final concept is shown here to give an idea about its intended use.

This concept is of a lower capacity, but intended to be matched by higher deployment to create more awareness about segregation and waste management. This concept also allows for easy installation, and no moving components, leading to a robust design that will last much longer in the field.

The concept render is shown below, with rig and prototype manufacture taking place over the next two weeks.





7.0 Final Concept

8.0 Test Rig & Prototyping

A mockup rig of the chosen design is being constructed in plywood in order to verify the geomery on a full scale, as well assess the usability aspects of the design. Following this, the model will be detailed and sent for prototype manufacture, to be sent for field validation trials.

9.0 References

Image References

fig10, 11: Google images, “public trash can india” search query – //exact link lost// Accessed: Feb 2nd 2014

fig 20: Landfill Sites map – Google Maps, accessed : 24th Feb 2014

fig 34, 35: http://www.deepjapan.org/a/1213 , Accessed: 12th Feb 2014

fig 39: www.wikipedia.org /waste_sorting, Accessed 10th Feb 2014

fig 40, 41: http://www.molok.com/Accessed: 15th March 2014

Factual References

[1] World Bank: http://wwwwds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/07/25/000333037_20120725004131/Rendered/PDF/681350WP0REVIS0at0a0Waste20120Final.pdf

[2] Live Mint: http://www.livemint.com/Politics/XsXf3cmvKjaoHPnlo31Y0H/South-Asia-to-become-fastest-waste-producer-by-2025.html

[3] Interview with Mr.Rishi Aggrawal, ORF, Dated: Jan 2014.

[4] Rishi Aggarwal (Observer Research Foundation): http://www.slideshare.net/Rishi10; Accessed 5th Jan 2014

[5] Interview with Mr.S.Mudhe, MCGM C-Ward; Dated March 2014

[6] Interview with RagPicker, Fort, Mumbai

[7] Inteview with Mr. Yusuf, Recycler, Dharavi