How can we provide communities in the rural Ethiopian lowlands with clean water to minimize the threat of COVID-19?

Interdisciplinary solution development by:
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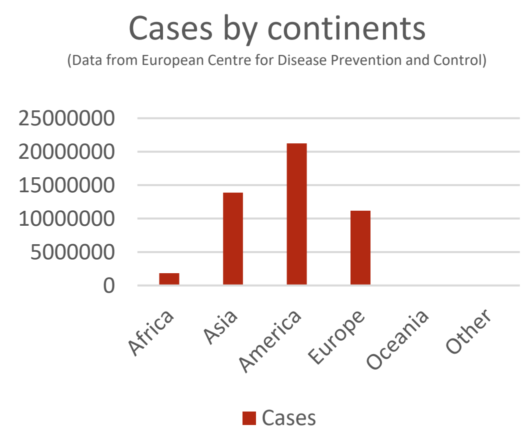
1. Introduction

A year ago, the first human was infected by the Covid-19 virus (Ciotti et al., 2020). Meanwhile, it has grown to a global pandemic that affects everyone and endangers millions of lives. Almost 50 million cases and over 1.2 Million Deaths have been reported worldwide (Johns Hopkins University)[1].

While Africa has far lower case numbers than all the other continents (see Figure 1), it differs significantly by country. Some countries are within the 15 countries with the most reported cases (Johns Hopkins University). Furthermore, according to experts, the numbers in Africa are a significant underestimation due to a lack of testing in many areas (C. Anna, 2020).



With 97.881 reported cases, Ethiopia is one of the five most affected countries in Africa (ECDC). As shown in *Figure 2*, the cases raised exponentially during the first wave and started rising again.

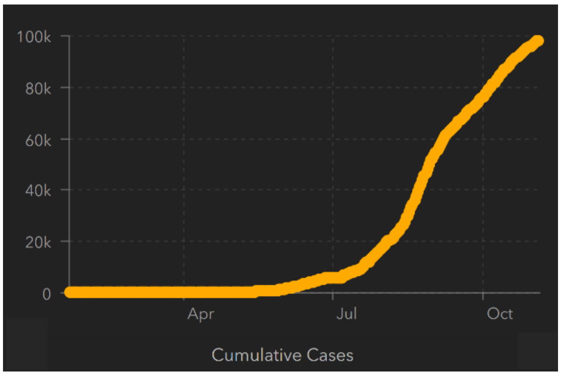


Figure 1 (ECDC)

Since Ethiopia is one of the countries that are most affected by Tuberculosis (TB), the virus causes an even bigger threat compared to other countries. This is mainly because an infection with TB and COVID-19 simultaneously is extremely life-threatening, but also since TB treatment centers are closing due to the Pandemic (Mohammed et al., 2020). To prevent the disease from spreading, the Ethiopian government took several measures, including travel restrictions, quarantining, and a campaign to raise awareness for the

[1] All data relating to COVID cases is from 05. November 2020

disease and the necessity of hygienic practices (Shigute et al., 2020). Mainly the latter has been found to be a very effective and cost-efficient method (Oqubay, 2020).

According to the World Health Organisation (2020), frequent handwashing with clean water and safe drinking water is crucial to prevent the spread of the virus and avoid secondary infections, which increase the lethality tremendously. This leads to an increase in water demand by 9 to 12 Liters per person and day during the COVID-19 pandemic (ESCWA, 2020).
While over 90 percent of Ethiopia's urban population has access to improved water sources, the rural areas in the south of the country provide less than 30 percent of its inhabitants with access to adequate water sources. Nearly 75 percent of the population lives from unsafe surface water that is highly contaminated with human and animal feces (UNICEF Ethiopia, 2020).
Earlier pandemics have shown that poorly developed water and sanitation systems are a key determinant for the rapid spread of diseases and the high number of deaths (Anim & Ofori-Asenso, 2020).
Therefore, our team attempts to design a product that helps to provide communities in the rural Ethiopian lowlands with clean water to minimize the threat of COVID-19.
Such a product would be used for hygienic practices and drinking to ensure the prevention of and mitigation of the virus.

To design an appropriate solution, we have to understand the stakeholders and their surroundings. Therefore, this text aims to analyze the hydrology of the Ethiopian lowlands as well as the stakeholders and their needs.
Furthermore, different technologies and existing initiatives will be assessed in terms of success and suitability for the context. Lastly, a few concepts of design ethics and design philosophy will be used to evaluate aspects relevant in order to design a valuable product.

2. Geography and Hydrology

Topographically the regions of Ethiopia are very heterogeneous, with the highest point of 4.620 meters at Ras Dashan and the lowest point at 115 meters beneath sea level in the Denakil Depression (FRD, 2004). The most common categorization is the division into high- and lowlands. Hundredths of deep canyons and valleys fissure the country, making it extremely difficult to travel between locations (Mehretur & Marcus, 2019). The great rift valley divides the highlands into an eastern and western part and builds a hydrological separation of the western and eastern drainage system. (Mehretur & Marcus, 2019).

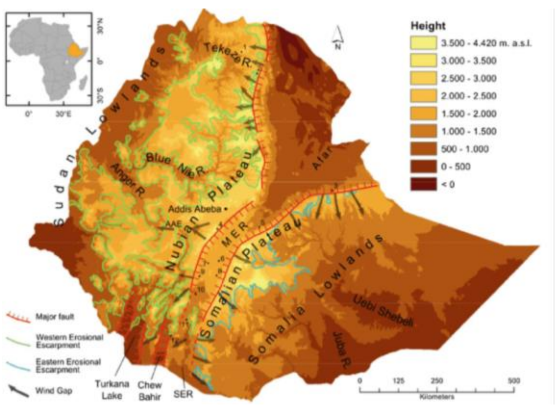


Figure 2: Topographical map of Ethiopia (www.researchgate.net)

The lowlands (below 1500 meters) constitute 60% of the country's geography but only 10-12% of the population. Due to the low habitation density, these arid and semi-arid areas are characterized by a severe lack of basic infrastructure (World Bank Group & U.K. Department of International Development, 2019).

The hydrology and climate of Ethiopia vary hugely between the regions due to the heterogeneous topography. While the western highlands have high annual rainfall and moderate temperatures, the eastern lowland consists mostly of arid steppes or arid deserts with significantly higher temperatures and low humidity (Kebede et al., 2020).

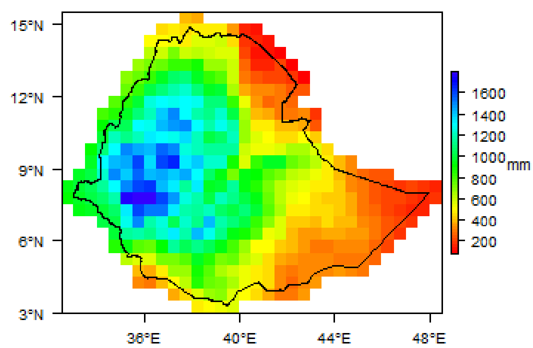


Figure 3: Rainfall in Ethiopia (Kebede et al., 2020)

As mentioned above, Ethiopia has several drainage systems. In general, it consists of the eastern, the western, and the great rift system. The rivers mostly originate in the highlands and drain into the lowlands (FRD 2004). The western system, incorporating the biggest single lake Tana is the source of the Blue Nile (Vijverberg et al., 2009), and the eastern system drains into Kenya and Somalia (FDR, 2004). The Awash river flows east through the great rift valley and "disappears into saline lakes in the Denakil Depression" (FDR, 2004, p.5). While the highlands have several permanent surface water sources, below 1500m, hence in the lowlands, nearly no perennial rivers and lakes exist. (Kebede et al., 2020).

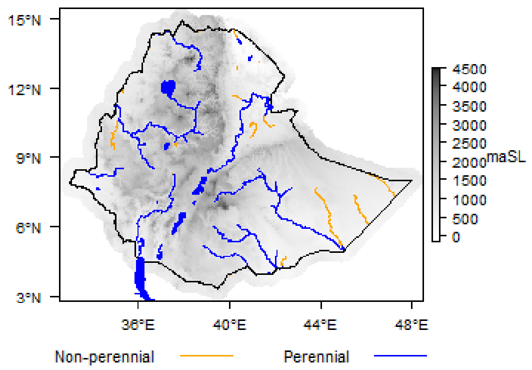


Figure 4: Surface water (Kebede et al., 2020)

According to Sebastian Brandis (CEO of the NGO "Menschen für Menschen), the amount and quality of groundwater in Ethiopia are barely documented, making it challenging to build sustainable wells. However, prior findings show that it varies considerably from region to region. So far, it has been found that the groundwater in the highlands has a significantly higher quality than in the lowlands. While most of the reservoirs in the highlands incorporate drinkable or almost drinkable water, the reservoirs in the lowlands are mostly brackish, salted, and full of unhealthy minerals, which makes it unsuitable for most activities without further filtration (World Bank Group & U.K. Department of International Development, 2019)

3. ACCESS TO WASH SERVICES:

The overarching technical theme that has influenced the challenge's framing can be described with the acronym WASH, which stands for 'Water, Sanitation, and Hygiene'. It is the primary focus of the UN Sustainable Development Goal 6 (SDG 6), which aims to create access to safe water and sanitation services and to create sustainable water management(United Nations, 2020).

A Lack of WASH services is among the biggest issues in Ethiopia. Only 65 percent of the population has access to improved water sources and only 6.3 percent to improved sanitation. Seventy thousand children under five die from diarrhea every year, and only 16 percent of people live in healthy environments with improved hygiene behaviors (UNICEF Ethiopia, 2020). Furthermore, "60-80 percent of communicable diseases are attributed to limited access to safe water and inadequate sanitation and hygiene services" (UNICEF Ethiopia). This includes COVID-19 since current evidence shows that the lack of water and sanitation heightens the risk of the spread of COVID-19 in sub-Saharan Africa (Ekumah et al., 2020), which makes it an even more pressing problem right now.

While the average in Ethiopia is already very low, the statistics regarding the inequality between the different regions show an even more shocking picture (Azage et al., 2020). While 93% of the population in the urban areas in the Highlands have access to improved water sources, in the rural Lowlands, only 27% have this privilege (Kebede et al., 2020, UNICEF Ethiopia, 2020). For the given design challenge, this means that solution development must start from almost nothing and create the necessary water supply for a healthy life.

4. STAKEHOLDERS

The stakeholders are mainly the end-users in the Ethiopian lowlands. NGOs, governments, and others might be interested in purchasing the product. However, the priority is to bring maximal functionality, inclusiveness, and ease of use to the people who urgently need access to safe water. Hence this text focuses on the rural Ethiopian lowlands and its inhabitants.

4.1. DEMOGRAPHICS:

Ethiopian average age is 19.8 years, caused by the high birth rate of 4.14 children per woman and a relatively low life expectancy of 67.5 years, which leads to a population growth rate of 2.56% (CIA, 2020). While the population is rapidly growing, the population density outside the cities and especially in the lowlands is still very low, with less than ten people per square kilometer (Schmidt & Dorosh, 2020).

Ethnicity and religion in Ethiopia differ per region. Nevertheless, the focus will be on the lowlands, mainly the eastern lowlands (the western lowlands are very small). In this region, ethnicity is mainly Somali and Afar, and the religion mostly Muslim (see figure 6).

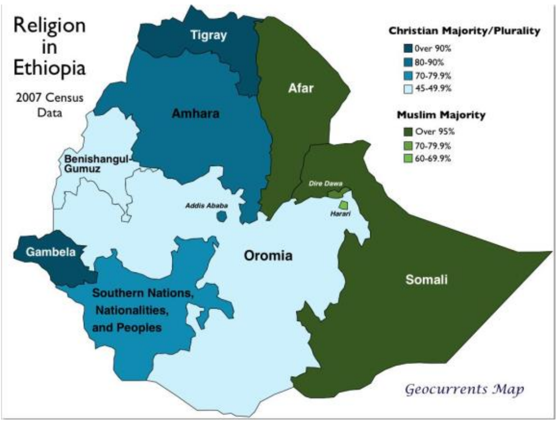


Figure 5: religion ethiopia (maps-ethiopia.com)

The lowlands are culturally subdivided into clans and subclan territories. This division influences the precise distribution and access of, amongst other things, water resources (Whitley et al., 2019).

The educational level in Ethiopia has improved rapidly within the last years. While the total literacy of 51.8% is relatively low, we can see a clear trend between the generations. Older adults only have a total literacy of 15%, with a significant discrepancy between the sexes. The literacy rate of the 15 to 24-

year-olds, on the other hand, is over 70% and improving. Furthermore, it is almost equally distributed between men and women (UNESCO, 2020). Despite the educational system's growth, participation in tertiary education of 8.1 percent is still meager (Trines, 2018).

4.2. Daily life

While other income sources increasingly gain importance (Birch, 2018), pastoralism and agriculture are still the primary income source for most primary stakeholders (World Bank Group & U.K. Department of International Development, 2019). As shown in the following table, depending on their activities, the degree of mobility differs. While some of the rural Ethiopians settled in order to grow crops, others use their independence from agriculture to find the best grazing areas for their livestock (Gebremedhin et al. 2017)

The dominant income source for both rich and poor inhabitants of these areas still is livestock, especially milk (Rettberg et al., 2017). However, the combination of various livelihoods becomes more and more common (Birch, 2018). As the following map shows, those other income sources differ within the lowlands and are mainly Gifts, Remittances, Wood/Charcoal, Gums and resins, and other bush products.

'Pure' pastoral household; no permanent residence; 100% income from livestock; no crop growing; no other income generation activities	51.0	36.1	5.6	0.0	**23.6**
Pastoral household; mobile livestock moved regularly to agreed grazing areas within the *woreda*;[5] milking/weak animals kept around settlement; no crop-growing; no other income-generation activities	11.2	34.8	13.8	29.4	**22.2**
Agro-pastoral household; mobile livestock moved regularly to agreed grazing areas within the *woreda*; milking/weak animals kept around settlement; crop-growing; no other income-generation activities	10.5	18.1	43.9	40.9	**28.3**
Agro-pastoral household; mobile livestock moved regularly to agreed grazing areas within the *woreda*; milking/weak animals kept around settlement; crop-growing; other income-generation activities	3.1	4.6	1.6	4.8	**3.4**
Agro-pastoral household; members own livestock but do not move them from their private land (i.e. livestock are kept in enclosures); crop-growing; other income-generation activities	24.1	6.5	35.2	25.0	**22.5**

Figure 6: Proportion of households by livelihood type (%) (Gebremedhin et al. 2017, p. 16)

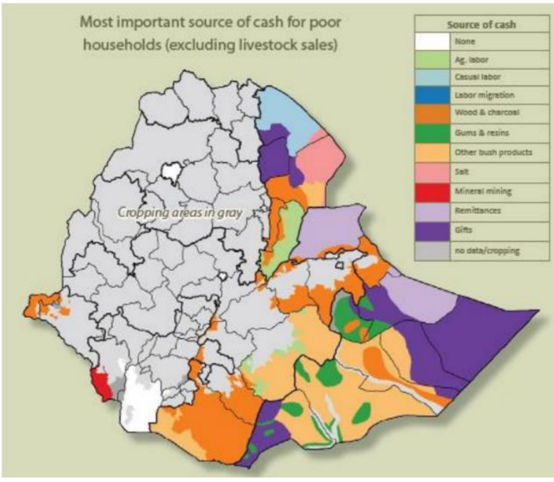


Figure 7: other income sources per region (Birch, 2018)

In the rural areas of the lowlands, role division between the sexes is still a very present concept. While men are in charge of both marketing and care of larger animals, women have active roles in the marketing and care of young and weak animals (World Bank Group & U.K., 2019). Water-related labor work is likewise gendered (Whitley et al., 2019). The women take care of water for domestic use and young animals, while the men take care of larger animals.

Therefore the main stakeholders are women since hygiene and drinking water is part of the domestic use of water. Water quality for livestock is also essential to keep the animals, hence their primary asset, healthy. However, since it is not directly affected by the current disease, it will not be the product's primary purpose.

In summary, the stakeholders are (agro-)pastoralists living in small communities, experiencing a severe lack of infrastructure, health and WASH-services, as well as an underdeveloped economy. Their culture is mainly influenced by islamic values, their clan, and the traditional task division between the sexes.

5. Other considerations

The targeted niche for innovating is Ethiopia's rural water supply, which involves several political factors that should be considered. The management of the rural water supply in Ethiopia is decentralized. It was founded based on a community management model. Ethiopia consists of 805 woredas (districts). Within each woreda, the WASHCO (Water and Sanitation Committees) of that community is responsible for their district's water supply. WASHCOs are in charge of collecting fees, defining by-laws, liaising with local administration, and managing water access for each water point (Pichon, 2019).

Furthermore, the Ethiopian government has developed different strategies to achieve the sustainable development goal number 6 of "clean water and sanitation" (defined by the United Nations, 2015). Those strategies include the second "Growth and Transformation Plan" (GTP II) and the "One WASH National Program II". Those plans are not only based on the UN goal to "Ensure availability and sustainable management of water and sanitation for all", but also on the Ethiopian constitution, which states: "policies shall aim to provide all Ethiopians access to public health and education, clean water, housing, food and social security" (FAOLEX, 1994).

The Second Growth and development Plan, made by the National Planning Committee, is an important milestone towards the country's aim of being a low middle-income country by 2025 and set guidelines and goals for various aspects. One of those aspects is the water supply across the country, specifically the development and efficient use of water resources. The long-term objective is to guarantee access to safe and sustainable water sources for everyone. The set goal in the GTP II was to increase rural water supply coverage from 59% in 2014–2015 to 85% in 2019–2020. However, a report from the World Bank shows that in 2019, water access varies from 39–61%. Hence even though the government shows interest and engagement, external help is needed.

Based on the GTP II's goals, aims, and standards, the One WASH National Program II was developed. This program has an in-depth focus on sustainable and resilient water supply. Regarding the Lowlands, it explicitly states that more diverse technologies are needed since focusing on springs and wells limits the usage of rain- and surface water. Especially the latter is often available in the lowlands but barely used for improved water sources so far. The OWNP II furthermore explains the necessity for water supply systems to be maintainable by the WASHCOs.

As part of the ONWP, the sub-program "Development of Sustainable Water Supply, Sanitation, and Hygiene Program in Drought Prone Areas of Ethiopia" was developed, emphasizing the importance of water conservation and water utilization efficiency in the lowlands.

These are, of course, only a selection of the policies that are relevant for the challenge. However, since most other policies are based on these documents, they will not be covered in this text.

6. Design ethics & design philosophy

To develop a valuable product, multiple aspects of design ethics have been considered. Design philosophy provides the underlying concepts for those considerations. Among others, those concepts included technological mediation, inclusivity, and Nussbaum's capability approach.

6.1. Technology, humans, and the world

Technology connects us, humans, to the world we live in, in one form or another. A pair of glasses enhances our vision; a VR headset alters our perceived reality; a thermometer informs us about a specific aspect of the world (temperature), to name a few. In the theory of technological mediation, according to Verbeek (2006), technology is not a passive, neutral tool but plays an active role in shaping – *mediating* – humans' relationship with the world.

There are many ways this so-called mediation or relationship can take shape. A pair of glasses is an example of an *embodiment* relation. We see the world *through* the glasses, rather than looking *at* the glasses themselves, and in normal circumstances, we do not even notice that the glasses are there. The artifact's withdrawal from your attention can be described as 'ready-to-hand'. Only when they stop functioning correctly (e.g., fogged-up) will they call for your attention – it is then 'present-at-hand' (Heidegger, 1927; Verbeek, 2006). A ready-to-hand artifact disburdens your attention so that you can redirect it to more important things (in the example of a pair of glasses, seeing the world clearly).

Extending on this concept of mediation, technological artifacts can be seen as having 'scripts'. A script of a product is a set of embedded instructions to be communicated – whether implicitly or explicitly – to its intended users to influence certain behavior. A classic example is the speed bump, which has a script 'slow down or your car's shock absorbers may get damaged'. Designers anticipate potential interactions with their product and inscribe scripts to encourage desired interactions and discourage undesired interactions. In the same example, the responsibility of making sure people do not drive too fast is 'delegated' by the designers to the speed bump (Akrich, 1992; Latour, 1992; Verbeek, 2006).

The examples mentioned serving to reinforce the idea that technology is not a neutral entity. From a design ethics perspective, we – as designers of our product – are responsible for creating our design's morality. Since technology actively shapes human behavior and perception, designers need to think carefully about the potential mediating power the technology they are designing could have. Thinking about these potential mediations helps identify the ethical implications of creating certain technology, which can then be addressed by well-formulated scripts, minimizing the possibility of undesirable interactions (Verbeek, 2006).

6.2. Appropriateness and inclusivity

Appropriateness is a relational quality; it measures the technology in relation to its user. A technological artifact that is appropriate means that it should be functional in the context in which it is used (Oosterlaken, 2012). For example, a bicycle is only appropriate when the user has the physical abilities to ride that bicycle. It is related to the concept of inclusive design, which revolves around the idea of being specific about *who* we are designing for (Oosterlaken, 2012). For example, a sophisticated, high tech design that worked flawlessly would not be useful if it required years of technical experience to operate. Hence it would not be an appropriate solution for the main stakeholders in the Ethiopian lowlands who do not have the capability to do so.

6.3. Capability sensitive design

The capability approach is a theoretical framework that revolves around the idea that it is not the matter of what you *have* but rather what you *can* do – i.e., your capability (Oosterlaken, 2012; Robeyns, 2011). It was first proposed by Amartya Sen in 1980 and was a stark contrast to the traditional method of using Gross Domestic Product (GDP) – or other economic variables – to measure growth, development, and wealth. It has a strong emphasis on human-centricity, sustainable development, and human diversity (Oosterlaken, 2012).

In this framework, there are three basic types of capabilities:

1. ***Basic capabilities.*** Innate human abilities such as bodily health.

2. ***Internal capabilities.*** Developed abilities that required practice and training, such as physical strength and agility.

3. ***Combined capabilities.*** Internal capabilities combined with external conditions such as local laws and environment.

The framework's main idea is that possession of a set of capabilities is required to achieve well-being. While being in possession of the set of capabilities does not guarantee that a person will achieve well-being, capabilities provide opportunities which the person can take to move forward in life (Nussbaum, 2001; Oosterlaken, 2012; Sen, 2008).

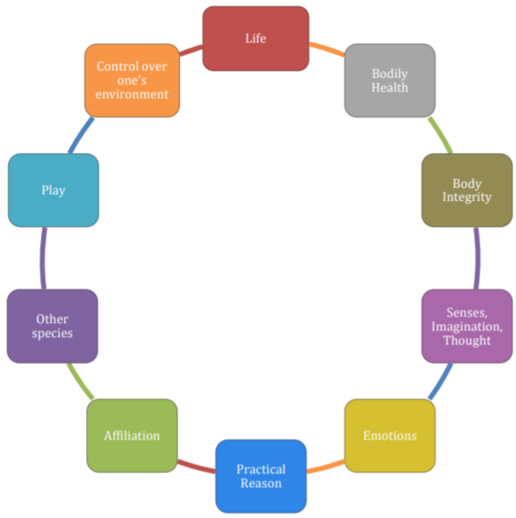


Figure 8: Ten basic human capabilities proposed by Nussbaum (2001)

To illustrate, a fitness app, for example, would not be useful to paralyzed patients, for they lack the basic capability of bodily health and control over their bodies. Similarly, a fast car would not be useful to someone who knows how to drive (internal capability) or lives in a place with extremely heavy traffic (environment; combined capability).

Technology can extend and expand human capabilities, which is what our design aims to achieve. However, it is also essential that we consider whether or not our stakeholders possess the capability to use our design.

The given design challenge aims to address the following basic capabilities as defined by Nussbaum (2001):

- ***Life.*** Being able to live to the end of human life of normal length; not dying prematurely, or before one's life is so reduced as to be not worth living.
- ***Bodily health.*** Being able to have good health, including reproductive health; to be adequately nourished; to have adequate shelter.
- ***Senses, imagination, and thought.*** Being able to use the senses, to imagine, think, and reason […] in a way informed and cultivated by an adequate education [including] literacy and basic mathematical and scientific training. Being able to use imagination and thought [and produces self-expressive work without political ramifications]. Being able to [search for the meaning of life, to have pleasurable experiences], and to avoid non-necessary pain.
- ***Play.*** Being able to laugh, to play, to enjoy recreational activities.

7.TRANSLATING STAKEHOLDERS' NEEDS INTO DESIGN REQUIREMENTS

Access to safe water is one of the world's biggest issues and occurs in every part of the world (United Nations, 2020). Therefore, our team has a strong belief in inclusivity and accessibility. Our goal is to make the product accessible for as many people as possible. It has to be usable in every region of the Ethiopian lowlands independent of age, gender, and ethnicity.

Based on these core values and the context and stakeholders' analysis, design requirements for a potential solution have been formulated, using the concepts of design ethics mentioned above. The capabilities our design aims to enhance, together with the context analysis, translate to basic needs, which then evolve into more specific needs, which are then translated into design requirements of our product. Apart from these four capabilities, we also focus on accessibility. We aim to make our product appropriate for and accessible to all our stakeholders (end users of our design), considering their lifestyle and living conditions.

LIFE AND BODILY HEALTH

ACCESS TO SANITATION FACILITIES AND SAFE WATER

As discussed, the lack of access to adequate sanitation facilities and safe water (basic needs) contributes to the spread of communicable diseases. In times of pandemic, this problem is even more critical as handwashing with clean water is crucial to limit the virus's spread. Therefore, in this context, the capabilities of life and bodily health are severely hampered by the pandemic.

The basic need for safe water can be broken down further. For the end-users to drink the water (and use it for other purposes, such as hand washing), the water must be potable after being filtered by our product. This is ensured by the requirement of the treated water being clean according to the Compulsory Ethiopian Standard.

After the product has filtered the water, it is expected that people wash their hands and/or drink the water by opening the tap. Considering the risk of contagion when touching infected surfaces, it follows that the use of the tap must not contribute to the spread of the COVID-19 virus.

As the product is going to be actively used by communities and clans, we estimate the requirements to ensure adequate provision of clean water, such that the design must be able to provide clean water for a community of 100 people; 25 liters per person per day; 110 liters of treated water available every hour.

Safe to use

The end users must not be harmed by using our technology. For this, the product shall not have hot surfaces, emit any harmful gases, or contain no sharp edges. Additionally, the tap cannot be too high as it would not be accessible to children and would require a lot of effort to put water into the system, leading to people stopping using the technology altogether.

Senses, imagination, thought, and play

Many would agree that the pandemic has been the leading cause of stress and anxiety, even in developed countries. For people in Ethiopian lowlands, the combined weight of having to worry about contracting the virus from untreated water plus their already subsistence lifestyle would severely limit their capabilities of senses, imagination, thought, and play.

Less time spent on water provision

If the stakeholders did not have to spend a lot of time getting access to and/or worrying about clean water, they would have more time to follow educational paths and develop their intellectual skills. Hence the basic capability of senses, imagination, and thought would be restored. Furthermore, with more time at their disposal, the stakeholders would have more opportunities to engage in recreational activities, thereby more play capability.

Extending on the basic need to spend less time on water provision, an adequately large storage system incorporated into our design would alleviate the need to gather water frequently. As previously mentioned, the product aims to provide water for a community of 100 people. For this, we estimate that storage space has to hold at least 5,000 liters of water. Should these requirements not be satisfied, conflicts between families could arise as people fight for the limited resource of clean water. The storage itself also has to be completely sealed from the environment to prevent the exchange of harmful particles such as those mentioned in the Compulsory Ethiopian Standard.

Since access to clean water and WASH services is severely limited in Ethiopian lowlands, water use efficiency is essential. The design shall, therefore, incorporate a recycling system that allows for treated water to be reused. The retreated water shall also conform to the Compulsory Ethiopian Standard.

Accessibility to All

Usability

To account for diversity amongst end-users, an emphasis is placed on maximum discoverability to encourage correct usage via scripts (technological mediation). For this, the intended usage must be self-explanatory; the design shall be intuitive and transcend cultural and language barriers.

To account for different age groups – especially children (aged 14 and under) – and hence varying heights, the tap (outflow) should be reachable to all. Based on the average height of children, we estimate that the tap shall be positioned between 0.6 and 1.1 meters, measured from the ground.

As the main stakeholders are women, the design should accommodate for the generally lower bodily strength compared to men. We estimate the maximum permissible amount of force required to operate the product to be 50N.

Portability and Adaptability

The primary source of income of the stakeholders is livestock. This naturally involves moving between areas to find good pasture. Given their nomadic lifestyle, the design must not be permanently fixed in one location. Taking into account the estimated size – and mass, respectively – required for 5,000 liters of storage, the product (while empty) shall be portable by six people.

To secure water provision across different environments, the design shall incorporate a universal water input that accepts input from multiple sources (e.g., rainwater, water pumped from a lake, etc.). Moreover, to ensure that the product will work in areas outside the national electrical grid, the design shall self-provide electricity (if needed) – e.g., through the use of solar panels or manual labor.

Economics

Critical components, such as the filtering system or the storage unit, could break after years of intense use, and hence the provision of clean water would no longer be guaranteed. Therefore, the product – or at the very least, critical components that are most prone to breaking – shall be repairable with local resources and without specialized prior knowledge or experiences. This will reduce the end-users' dependence on the designers and manufacturers and allow them to be more self-reliant.

This relates to the affordability of use and maintenance. In this aspect, more research into the economy of Ethiopian lowlands and the average income of people there is needed to determine what the end users can financially afford. This will affect the maximum permissible total production costs and the maximum permissible costs of maintenance over time.

Water quality standard

It is intended for the treated water to be used for both handwashing and drinking. As previously mentioned, it follows that our design's treatment system must be able to output water that meets specific standards to be safe for consumption by humans.

The design requirements consider drinking water specifications in the Compulsory Ethiopian Standard (CES) published by the Ethiopian Standards Agency (ESA), which are mainly based on ISO standards of relevant domains. The International Organization for Standardization (ISO) is an international organization that specifies and publishes standards in virtually all domains – from water quality to food safety to healthcare. ISO standards aid in creating high-quality, safe, and reliable products and services and safeguard end-users (ISO, n.d.).

Results from a socio-economic survey conducted in 2016 on water quality in Ethiopia give insights into even more specific aspects of water quality that should be in focus. Based on this knowledge, the CES that are relevant to our geographical context are identified. We aim to design our technology such that the treated water complies with the selected specifications to ensure our stakeholders do not suffer any health complications.

Main specifications for treated drinking water (Ethiopian Standards Agency, 2013)

Fecal organisms (E. Coli, streptococci, and coliform organisms) must not be detectable.

Fecal contamination is one of the most serious health hazards when it comes to drinking water. A standard method of determining fecal contamination of water is detecting a fecal bacteria E. Coli in a 100ml sample. Results from the survey indicate the presence of E. Coli in high-risk water sources in Ethiopia, such as surface water and unprotected springs (Central Statistical Agency of Ethiopia, 2017), and hence is relevant to the safety of our stakeholders.

Turbidity must not exceed 5NTU.

Turbidity measures the 'cloudiness' of water. While turbidity on its own does not affect quality, high turbidity is often caused by suspended chemical or biological particles, which can have health implications (WHO, 2017). Sources with high turbidity include surface water and unprotected dug wells, which are associated with high to very high E. Coli risk. As our stakeholders might collect surface water, this specification is highly relevant.

Fluoride must not exceed 1.5mg/l.

While only 3.8% of the Ethiopian population uses water with fluoride concentration higher than the maximum permissible level (Central Statistical Agency of Ethiopia, 2017), this specification is still relevant as excessive fluoride intake is known to cause permanent damage to teeth (WHO, n.d.).

Intended mediation

Overall, the relation between our design and stakeholders/end users can be described as an alterity relation. In this type of relation, humans interact with technologies as their equals, with the world in the background (Ihde, 1990). End users (human beings) interact with our design (technology) to get clean water (from the world, through the technology).

As discussed earlier, technological mediation is inevitable, and our design is no exception. As with most technological artifacts, we aim for our product to disburden end users. In this case, by fulfilling the basic needs as previously discussed – by mediating the people in Ethiopian lowlands and their access to clean water.

When ideating prototypes, the ready-to-hand characteristic will be pursued. The most obvious example is the tap. An end-user may, for example, fill a container with clean water released from the tap. While turned on, the tap can be considered ready-to-hand as the element that will call for the user's attention will be the container and the water, and not the tap itself.

Mediations can be designed through scripts. Using the example of the tap, different activation mechanisms' designs can play a role in how effective the product is. For example, if a foot pedal activates the tap, the pedal has the script that says 'step on me'. This can minimize the chance of undesired interactions – in this case, the touching of potentially infected surfaces. More in-depth analysis of mediations will be covered in the next phase of the project – design and prototype – when design concepts are more concrete and better defined.

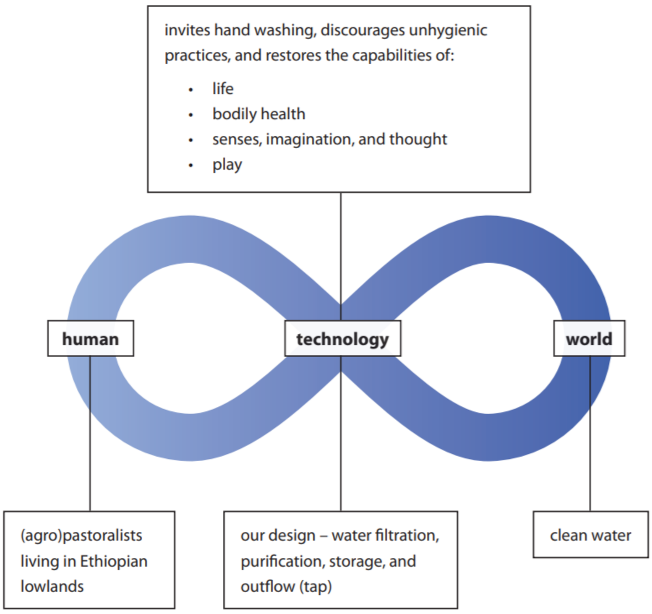
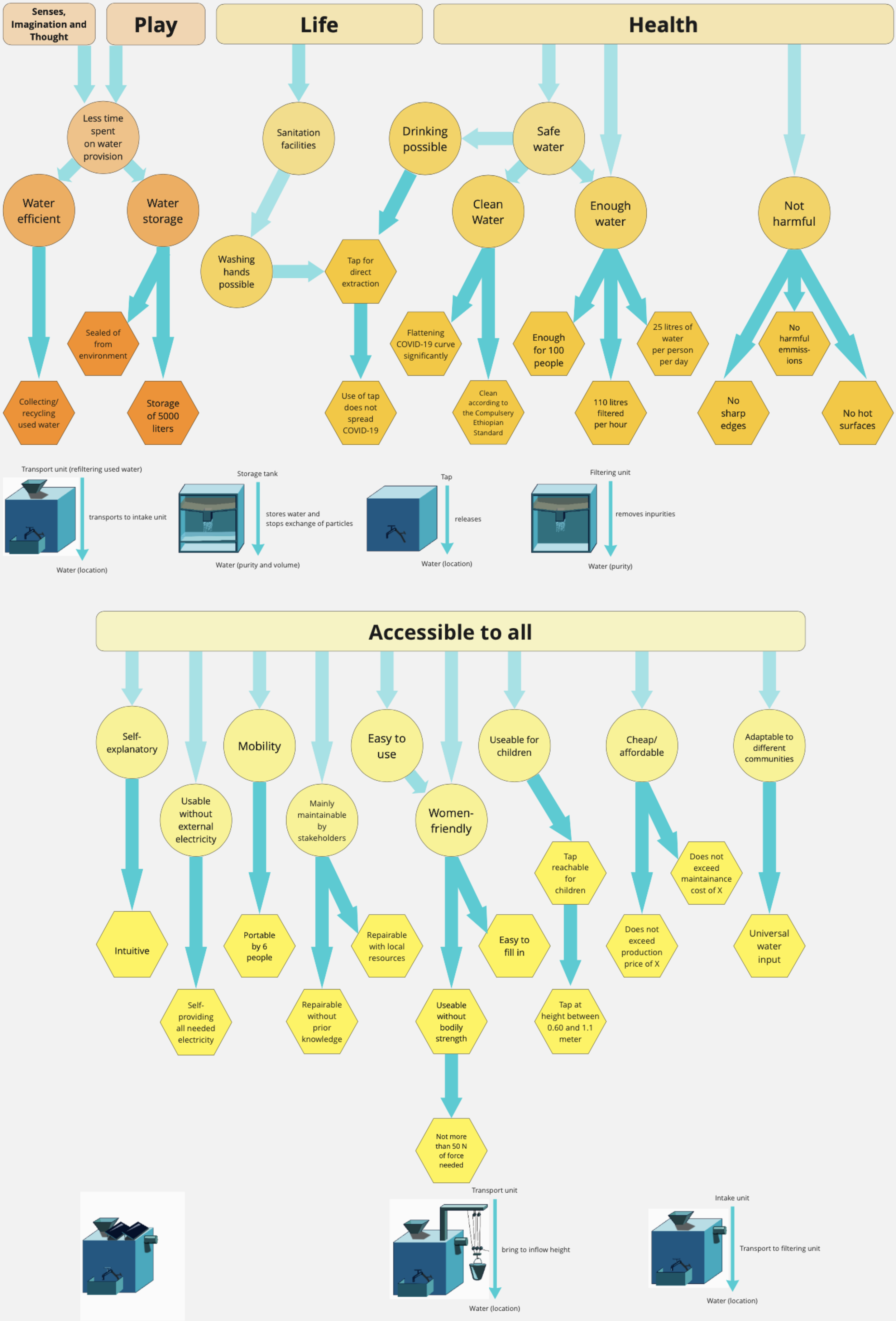


Figure 9: human–technology–world lemniscate – overview of the interplay of mediation

Capabilities, needs, requirements, and functions

The following visualization shows the links between the capabilities, stakeholders' needs, and our design's requirements and functions. Moreover, it builds the bridge between the context of the challenge and the potential solution.


Senses, Imagination and Thought
Play
Life
Health
Less time spent on water provision
Sanitation facilities
Drinking possible
Safe water
Water efficient
Water storage
Washing hands possible
Tap for direct extraction
Clean Water
Enough water
Not harmful
Sealed of from environment
Flattening COVID-19 curve significantly
Enough for 100 people
25 litres of water per person per day
No harmful emmiss-ions
Collecting/ recycling used water
Storage of 5000 liters
Use of tap does not spread COVID-19
Clean according to the Compulsery Ethiopian Standard
110 litres filtered per hour
No sharp edges
No hot surfaces
Transport unit (refiltering used water)
transports to intake unit
Water (location)
Storage tank
stores water and stops exchange of particles
Water (purity and volume)
Tap
releases
Water (location)
Filtering unit
removes inpurities
Water (purity)
Accessible to all
Self-explanatory
Usable without external electricity
Mobility
Mainly maintainable by stakeholders
Easy to use
Women-friendly
Useable for children
Cheap/ affordable
Adaptable to different communities
Tap reachable for children
Does not exceed maintainance cost of X
Intuitive
Portable by 6 people
Repairable with local resources
Easy to fill in
Does not exceed production price of X
Universal water input
Self-providing all needed electricity
Repairable without prior knowledge
Useable without bodily strength
Tap at height between 0.60 and 1.1 meter
Not more than 50 N of force needed
Transport unit
bring to inflow height
Water (location)
Intake unit
Transport to filtering unit
Water (location)

8. Existing initiatives and their shortcomings:

Several initiatives are trying to enhance access to improved water sources in Ethiopia. The NGOs "Charity: water", "Drop of water", and "Menschen für Menschen" are just some examples of the numerous organizations who try to work on this problem.

All those initiatives mainly rely on wells and springs since this seems to be a good and relatively cheap method to get safe water without using extensive filtering methods (Zimmermann, 2020). The latter have multiple disadvantages, such as short lifetime, complex cleaning, and expensive materials (SWWFS, 2020). However, considering the context of the Ethiopian lowlands, those technologies have to be re-evaluated. As mentioned above, the groundwater in those regions is often brackish, salty, and full of unhealthy minerals. Furthermore, due to a lack of groundwater mapping, wells and springs are often unsustainable and groundwater systems are drained quickly. While some initiatives such as "SweetSense" and the Oxford-based REACH project try to develop such groundwater mapping systems, today's state of the art is still insufficient (Brandis, 2020). Hence, using other available water sources such as surface water might be more sustainable in the Ethiopian lowlands.

9. Inspiring technologies:

Several different alternative technologies - traditional and innovative - for water sourcing and water purification exist and have been evaluated regarding their suitability for the context of our challenge.

9.1. Water sourcing techniques:

Water sourcing, in this case, refers to the transformation of inaccessible water resources to usable water. The most common form of inaccessible water is air humidity, which can be transformed into liquid water using different technologies.

Figure 10: Fog-catcher in Tenerife (Prisco, 2016)

So-called Fog-collectors use vertically arranged thin meshes to condensate fog humidity into bigger droplets. These clean water drops are collected at the bottom of the mesh and stored in a tank (Gebregiorgis, 2020). Depending on the material and the weather conditions, such systems can produce up to 13.4 liters per m2/day. This traditional technique has several advantages: relatively cheap production, independence from electricity, easy maintenance, and high water quality (CTCN, 2020). However, since fog-harvesting is highly dependent on foggy weather, it is not a very promising solution for the dry lowlands.

Unlike Fog-collectors, atmospheric water harvesting technology is barely dependent on weather. So called atmospheric water generators (AWGs) use active cooling elements to condensate the water vapor contained in the atmospheric air. Additional filters guarantee potability (Genaq, 2020).

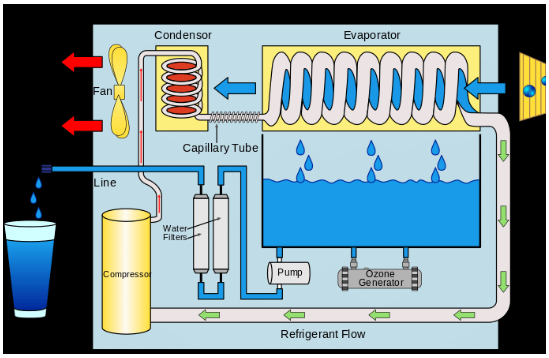


Figure 11: operating principle of an AWG (Bodamyalızade, 2018)

Such systems operate in a wide temperature range and a high air humidity range, but the effectiveness increases with temperature and humidity. Even though external electricity is needed, the amount can be minimalized by precooling the air using already cold water (this hypothesis was developed during the brainstorming phase and still has to be tested but relies on simple physic principles). This technology can be powered by solar energy and is suitable for the climate of the Ethiopian lowlands. However, it is not suitable for the stakeholders' context since such devices' maintenance requires profound knowledge in engineering. As described above, our stakeholders barely participate in tertiary education, and therefore such knowledge cannot be expected.

A similar yet more promising atmospheric water harvesting system uses so-called Metal-Organic-Frameworks (MOFs) to absorb humidity and release it in the form of water. MOFs are modified molecules combining organic and inorganic components to increase the porosity and perform specific tasks (Zhou 2012).

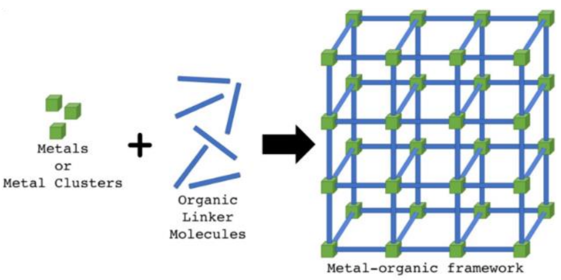


Figure 12: Schematic of Metal-Organic Frameworks (Wilmerlab, 2020)

Omar Yaghi and his colleagues at UC Berkeley developed the so-called MOF-303, which has such high porosity that one gram has the same surface area as a football field. This characteristic is used to absorb water out of the air at night. The water is released during the day due to the sun's heat and collected using a sealed box.

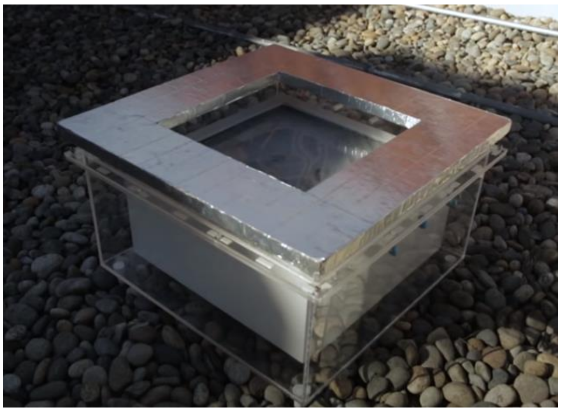


Figure 13: MOF-303 based water harvesting device (Sander, 2019)

Due to the artificial design of the aluminum-based MOF-303, only the pure water will be absorbed, and no contaminations have been found in the produced water. Using additional solar technology, a small refrigerator-sized device could provide 200 to 250 liters per day (Sanders, 2019). This technology is more than promising for our context but has not reached the market yet. Therefore, it will probably not be accessible before the end of the pandemic.

9.2. Water purification techniques:

Water purification is a very complex topic involving multiple parameters such as degree and type of contamination. Different principles are used and often combined in order to get the best treatment, including heating, filtering, UV treatment, and others.

9.2.1 Heat treatment:

According to the World Health Organisation (2011), heating water above 80 degrees Celsius for a few minutes eliminates nearly every pathogen. Covid-19 is already killed at 65 degrees Celsius at a rate of around 10000 units per 15 min (higher temperature would rapidly increase the rate) (WHO 2020). While this makes heat treatment a promising method, it comes with the drawback of high amounts of required energy. In order to provide this energy, different technologies are used.

Burning wood, charcoal, coal, or other fossil fuels is common, especially in off-grid regions, to generate the needed heat. While wood and charcoal are accessible in the Ethiopian Lowlands, getting those materials is very time consuming/expensive, and it is an unsustainable method (S. Brandis, 2019).

Another common technology used in heat treatment are electrical heating modules. While those modules are far more sustainable and cost-efficient, the lack of infrastructure in the focus areas makes it unsuitable for the purpose (World Bank Group & U.K. Department of International Development, 2019).

A more promising alternative is the use of solar energy to heat the water. Over the last few years, multiple promising purification systems have been developed in this field (Duff & Hudgson, 2005). Such systems are cheap, durable, and effective; hence this technology is one of the most promising for the purpose.

In order to minimize the required energy, advanced heat exchange technology can be used. This can tremendously increase the efficiency and reduce the required energy (Shah & Sekulic, 2003).

Furthermore, it cools the outflow down, which prevents the danger of hot water from touching the skin.

9.2.2. Filtration:

"Filtration is a process used to separate solids from liquids or gases using a filter medium that allows the fluid to pass through but not the solid. The term "filtration" applies whether the filter is mechanical, biological, or physical." (Helmenstine, 2020)

A distinction is made between surface filtration and depth filtration. Surface filtration uses a thin layer that retains most of the particles on the surface of the media. Thus, a layer of particles builds up over time, which continuously increases the filter's efficiency and reduces the flow rate. Such filters have lower efficiency at the start and require frequent cleaning to keep a certain flow rate but have the advantage of being lightweight. In-depth filtration uses a thick layer of porous material and encapsulates contamination within the layer. Such filters have almost constant efficiency and a typical initial value of 95 to 99 percent (FDPP,2020).

One of the easiest yet quite effective filtering system are so-called slow-sand filters. This depth filter uses the porosity of different sized sand layers and an additional biolayer to encapsulate dirt, pathogens, and minerals. In a container, gravels and fine sand are arranged in multiple layers. Using those materials' natural porosity, different sized contaminations get trapped in the pores (Huisman & Wood 1974). Suppose the water has a continuous type of organic contamination and continuously keeps the sand under a 10-15cm layer of water. A biological layer develops, which helps to eliminate bacteria and viruses and absorb toxic minerals. It has been found that such filters can remove up to 99 percent of bacterial and viral pathogens (Huisman & Wood,1974, Low-tech lab, 2020). This technology has several advantages, such as low maintenance costs, local material usage, and very high water quality. The drawbacks, on the other hand, are low flow rates (one square meter filters ca. 0.5 Liters per minute), hence large required space, thickness (at least 1m), hence high weight, and sensibility of the biological layer (Huisman & Wood, 1974). Since space is not a problem in the Ethiopian lowlands, this method is definitely suitable, as long as adequate maintenance is guaranteed.

Another method, widely used for water purification, is Carbon-filtering. It takes advantage of the unique characteristics of activated charcoal. Due to its extremely high porosity (3000 m^2/g (Dillion et al., 1989), it binds toxins to its surface and therefore significantly reduces water contamination (WFA, 2020). It effectively removes/reduces over 120 toxic chemicals, 26 common pesticides and herbicides, and over 30 organic contaminations (Magnus, 2020). However, it does not eliminate the threat of viruses and small bacteria. Hence it is not suitable for this context. It could be used in addition to other methods, as prefiltering techniques or for efficiency improvement. However, by itself, carbon filtering is not sufficient to ensure a safe drinking water supply in the Ethiopian lowlands.

Of course, multiple other filtering technologies such as reverse osmosis and several chemical filters exist, but due to the lack of infrastructure and money in the Ethiopian lowlands, none is suitable for the context.

9.2.3. UV treatment:

By exposing the microorganism in the water to high-intensity UV light, the DNA gets destroyed. Without their DNA, bacteria and viruses are unable to reproduce and therefore are not harmful anymore. This method can effectively eliminate every organic pathogen from the water. The UV treatment can either be implemented with UV lamps or utilize sunlight. Thus, it is a very suitable solution for the Ethiopian lowlands, but prefiltering is necessary for this context. Without prefiltering, the water's turbidity will reflect most of the UV light and thereby hinder full penetration of the water.

9.3 Other:

Another purification method that utilizes natural organisms is based on the unique characteristics of the Moringa Oleifera tree. The seeds of this tree contain ionized proteins, which, resolved in water, act as an effective coagulant (Shan et al.,2017). This means that it binds the contaminations into larger floc, which can easily be removed. Treating water with crushed Moringa seeds significantly reduces the amount of turbidity, coliform count, and bacteria. This has been found specifically for Ethiopia (over 97% coliform reduction) (Delelegn & Husen, 2018). Research has furthermore proven the efficacy for certain viruses (Samineni et al., 2019). It uses the principle of electric attraction to attach to certain parts of bacteria/viruses. Hence it has to be tested for every bacterium of the contaminated water before declaring it as a safe purification method. It furthermore has the disadvantage of constantly needing new coagulant material. Therefore, it is not really suitable for the context.

Similar approaches use aluminum-phosphate (alum) or synthetic glues to get the same coagulant effect (Shan et al., 2017). This method is even less suitable due to the cost and availability of those materials.

A not yet researched conceptual device[2] could use electrolysis and fuel cells to purify water. Using solar energy, water could be split into hydrogen and oxygen by electrolysis. Afterward, it could be transformed back to water using a fuel cell. Since the electrolysis generates pure hydrogen/oxygen, the water should be 100% pure afterward. The fuel cell would recover energy in the form of electricity, hence tremendously increase energy efficiency.

Furthermore, it could act as power storage and release electricity even at night. While this system might have several drawbacks,

[2] This concept was developed by the authors based on basic physics knowledge and has not been tested or profoundly researched.

such as inefficiency, corrosion of the anode, and inappropriate amounts of engineering knowledge since it is only a theoretical concept, experiments have to be conducted before evaluating its suitability for the context. However, since the pandemic demands quick action, it is not a feasible solution.

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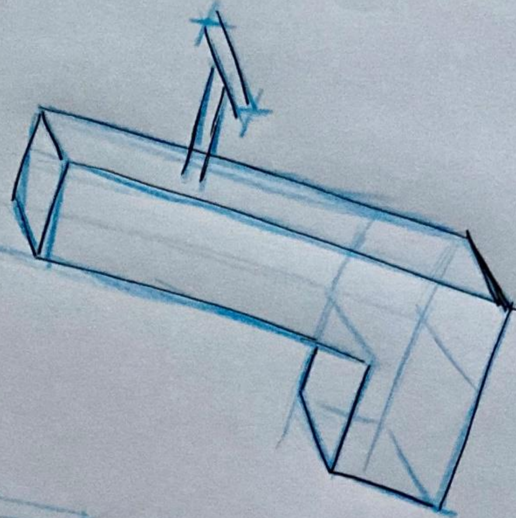
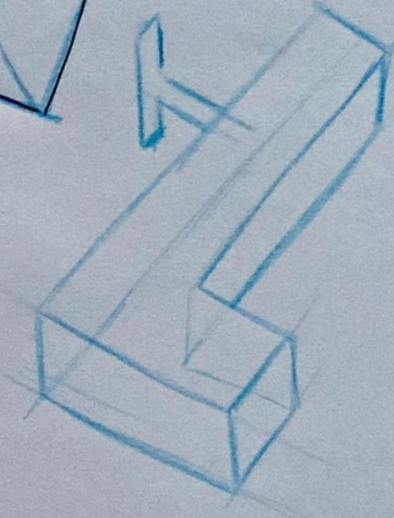
10 Design Exploration

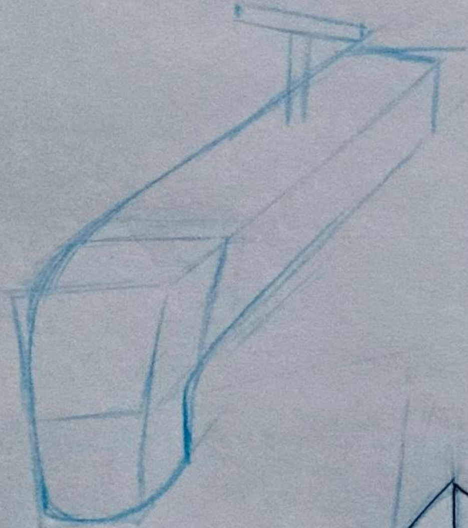
10.1 Preliminary sketches

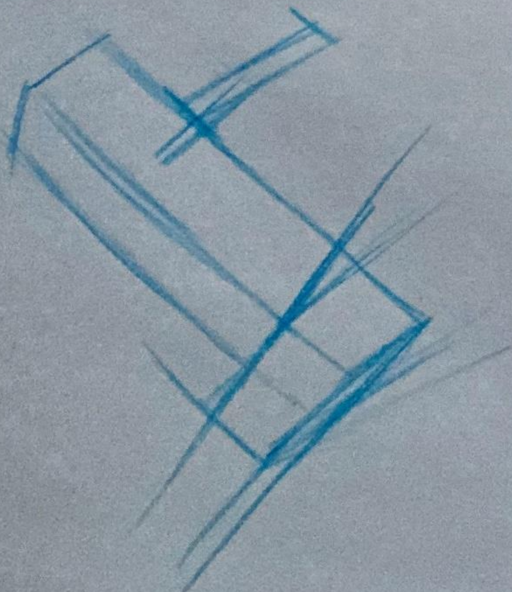
Now that the existing initiatives have been explored, it is time to think about an actual potential solution to our challenge. First, some general exploratory sketches were made. These will be visible in the next section and will be marked with an orange label.

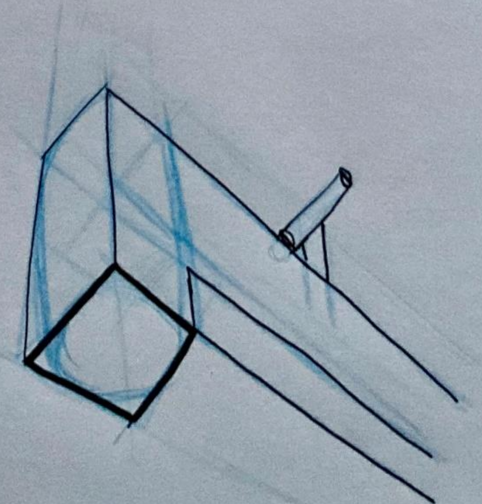
NEW TRIAL ON TAPS,
STARTING WITH RectANGLES
INSTEAD OF cylinders

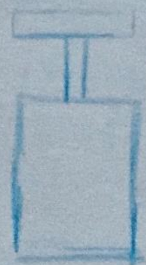




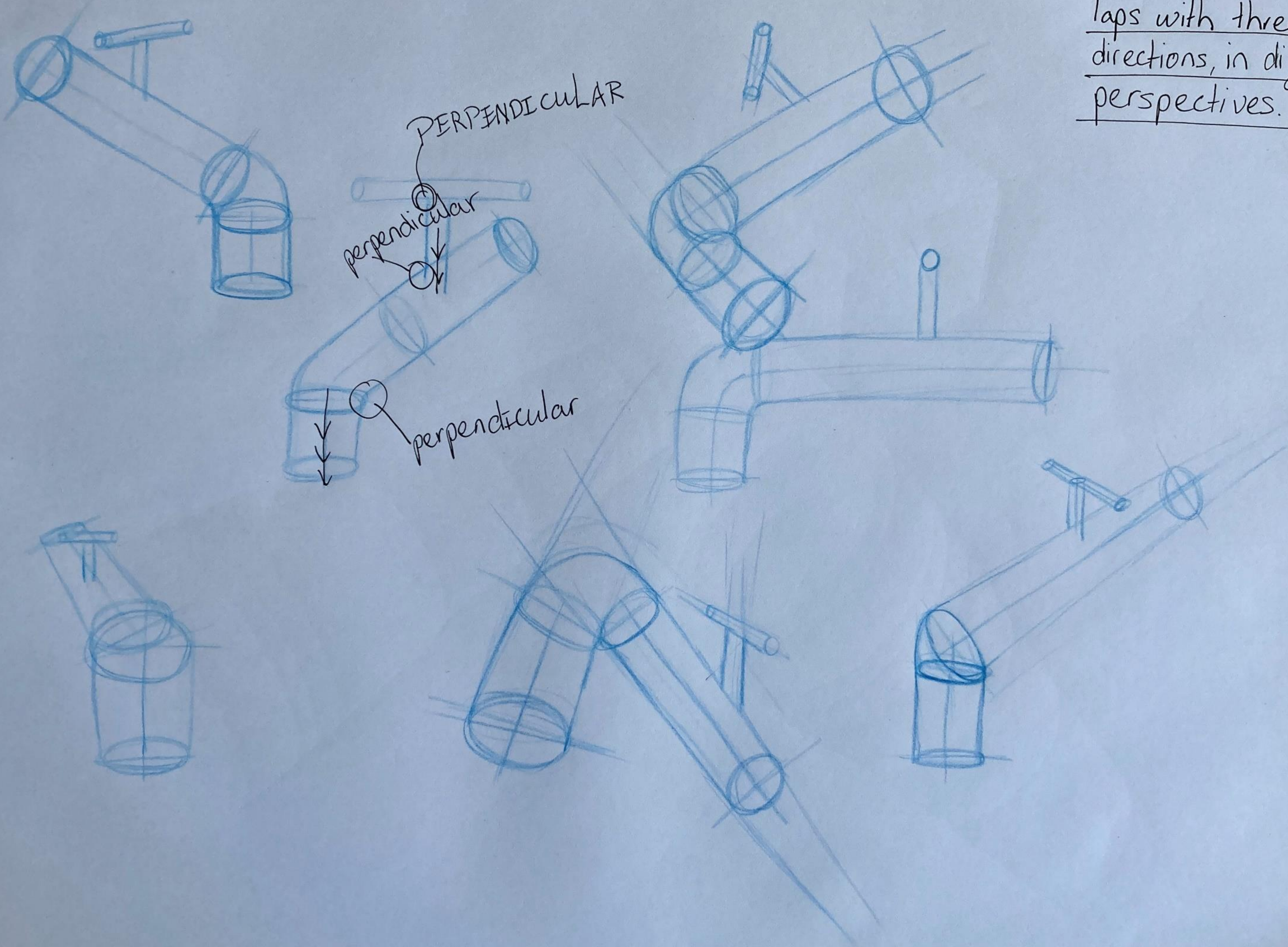




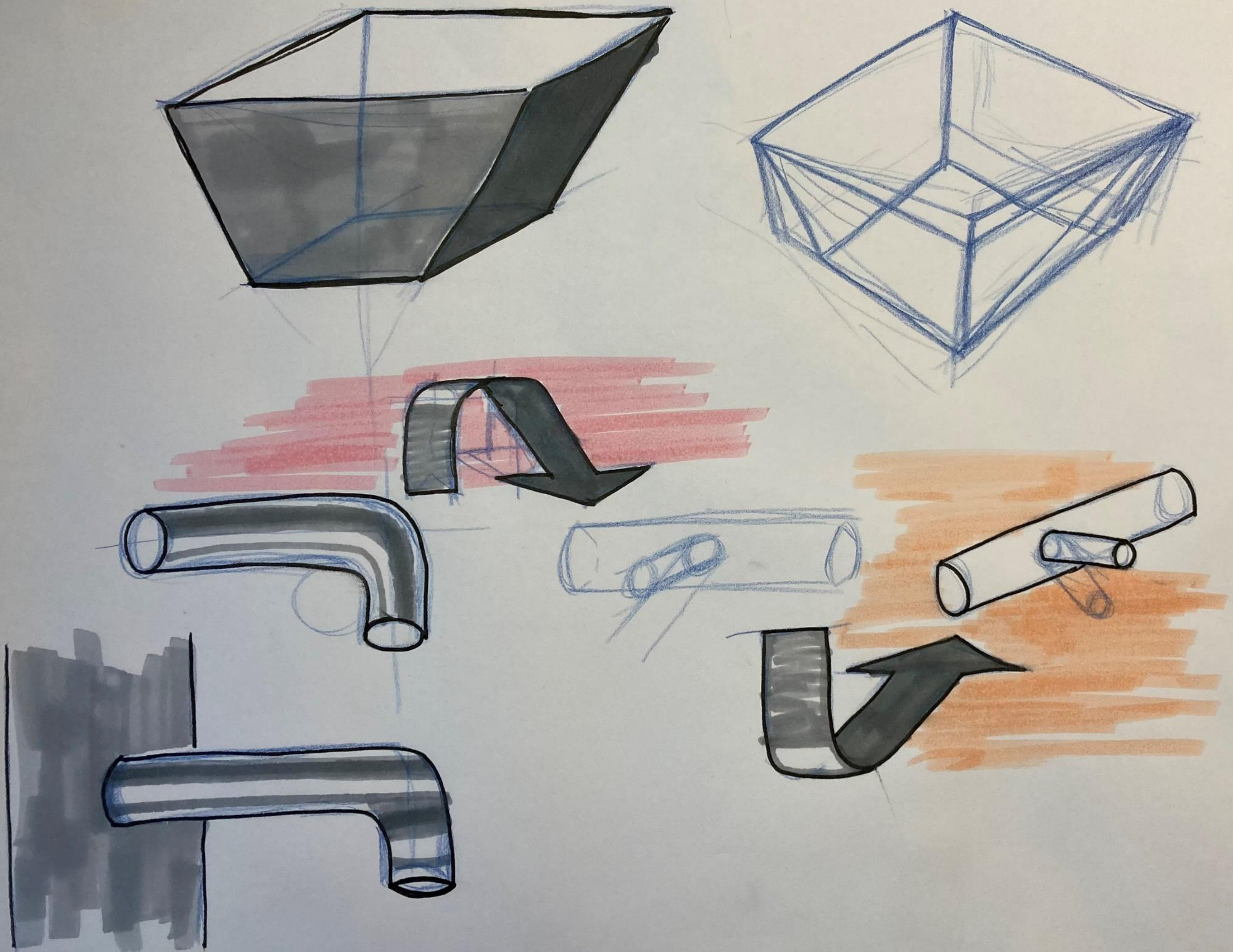




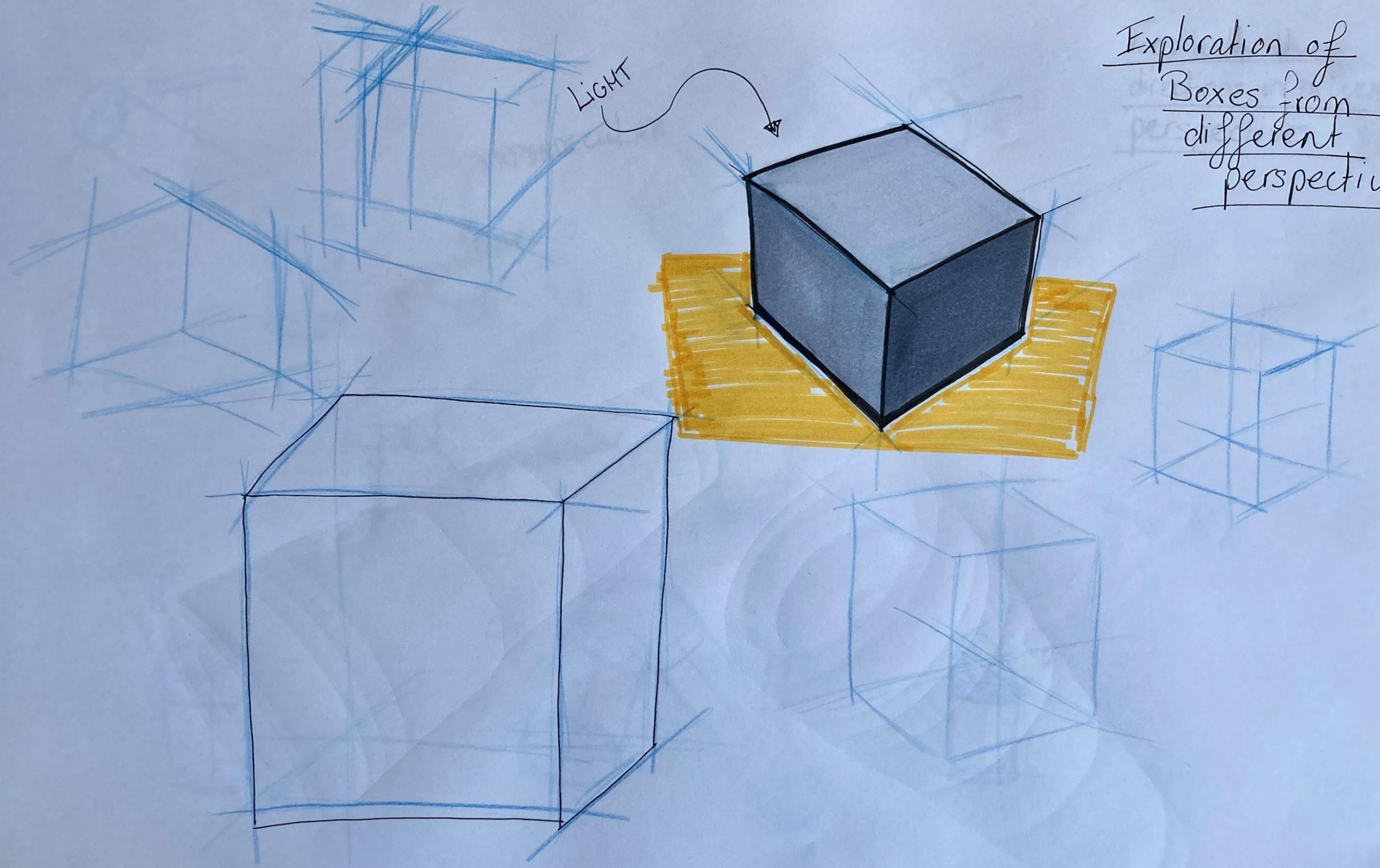
Taps with three directions, in different perspectives.



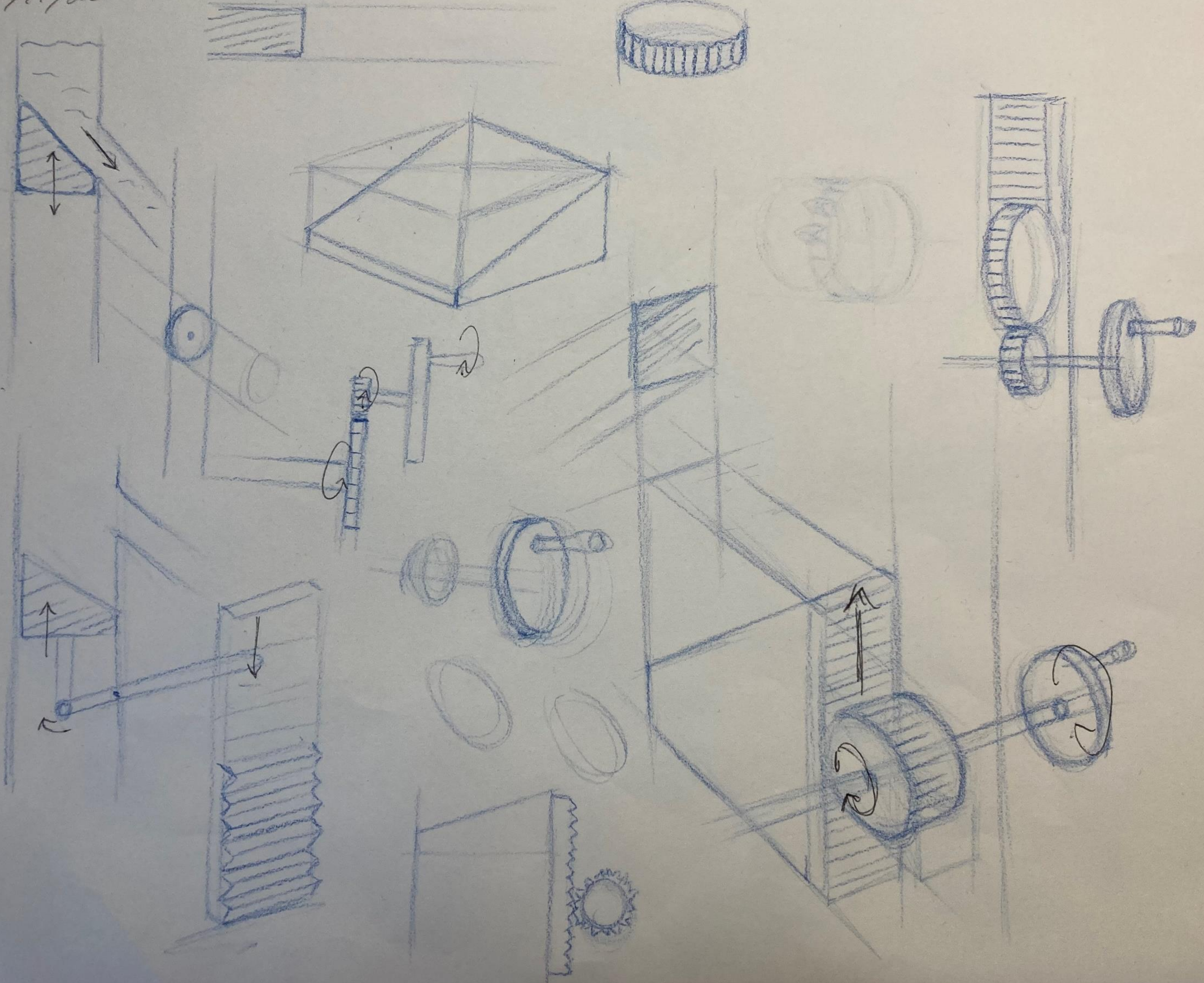
TAP
+
FUNNEL
EXPLORATION



Exploration of Boxes from different perspectives



10/11/20

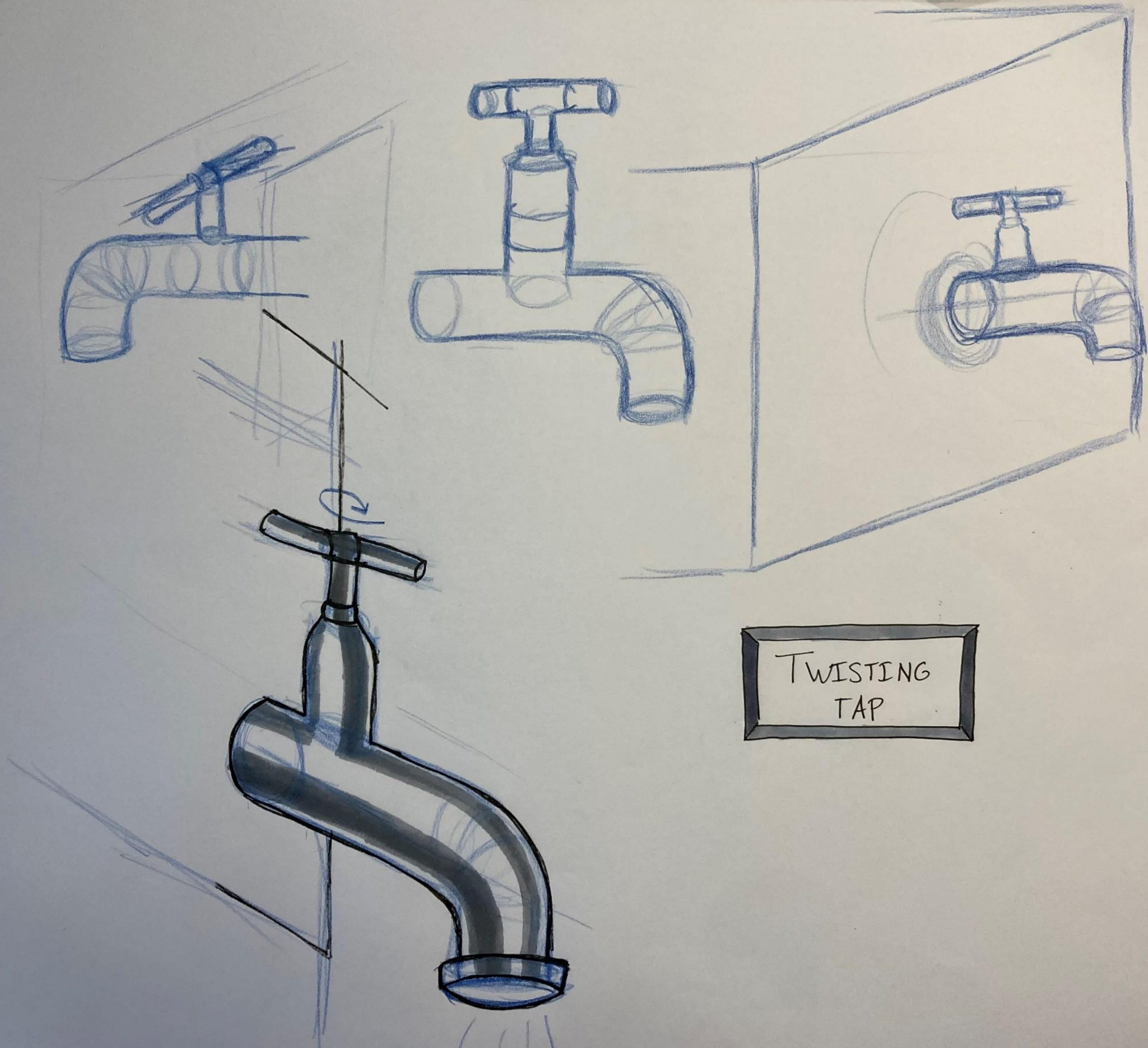


10. 2 Exploring different parts of our design

After the solution was roughly explored by some preliminary sketches, the solution was divided into different parts:

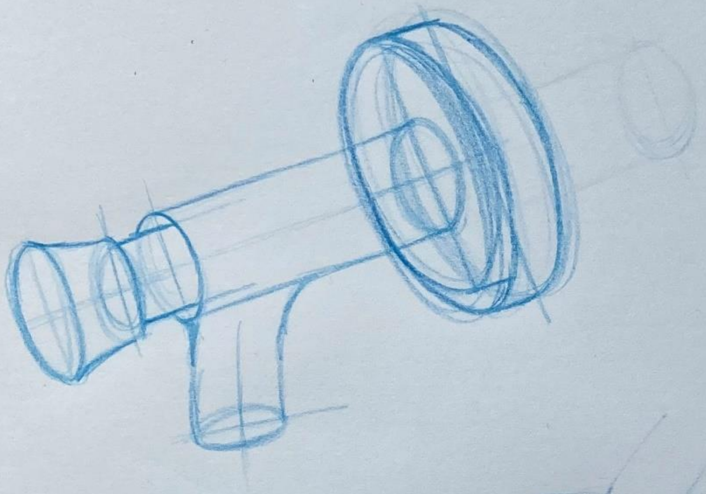
- The **tap** where the water will flow out
- The overall **shape** of the design
- **Filtering systems** to clean the water
- A system to facilitate water **inflow**
- A system to **recycle** used water
- **Internal structure** of the design

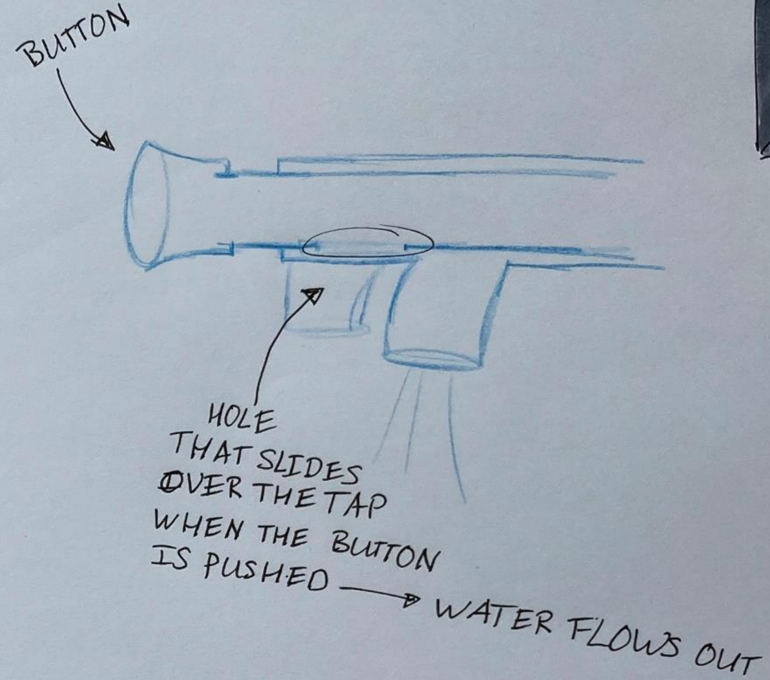
Per category, different options were explored in different drawings, which will be pictured in the corresponding sections. Each sketch is marked with its corresponding colour.

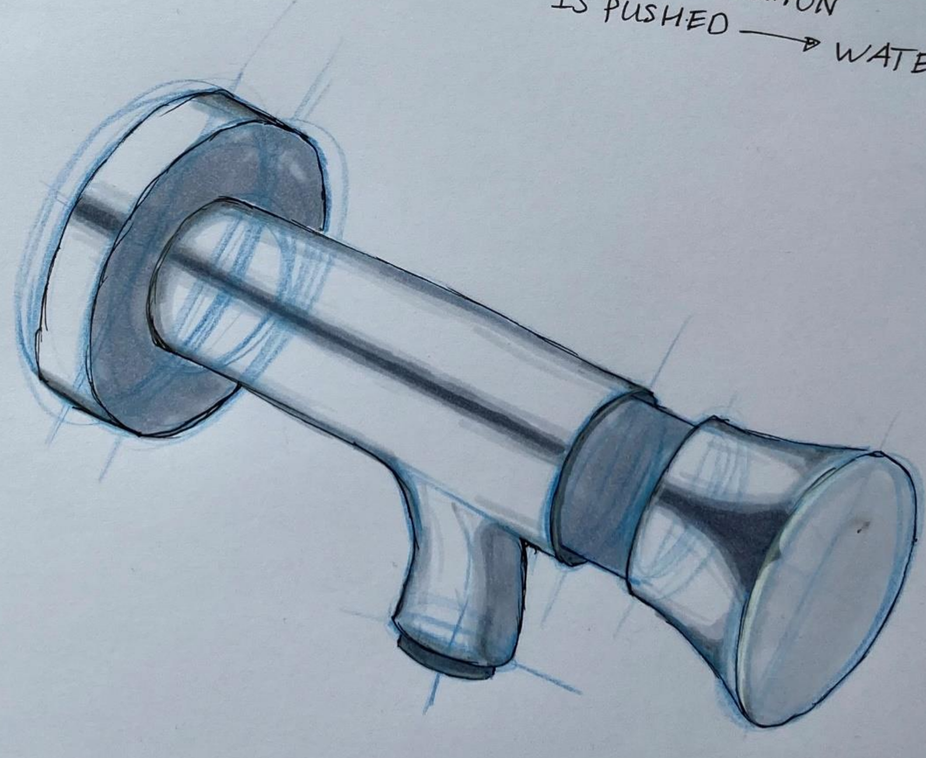

TWISTING
TAP

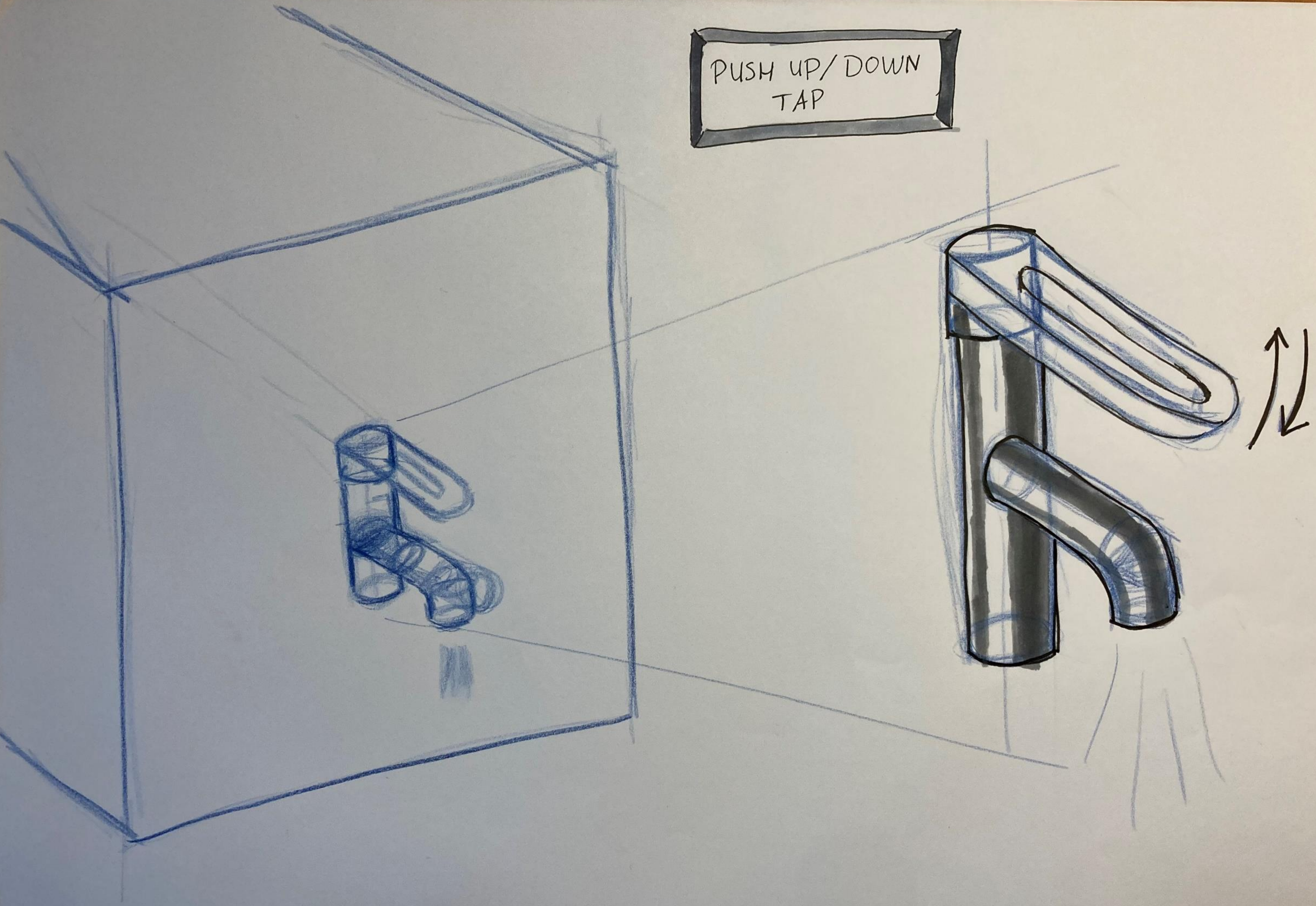

SENSOR TAP
1
SENSOR
2

TAP WITH BUTTON

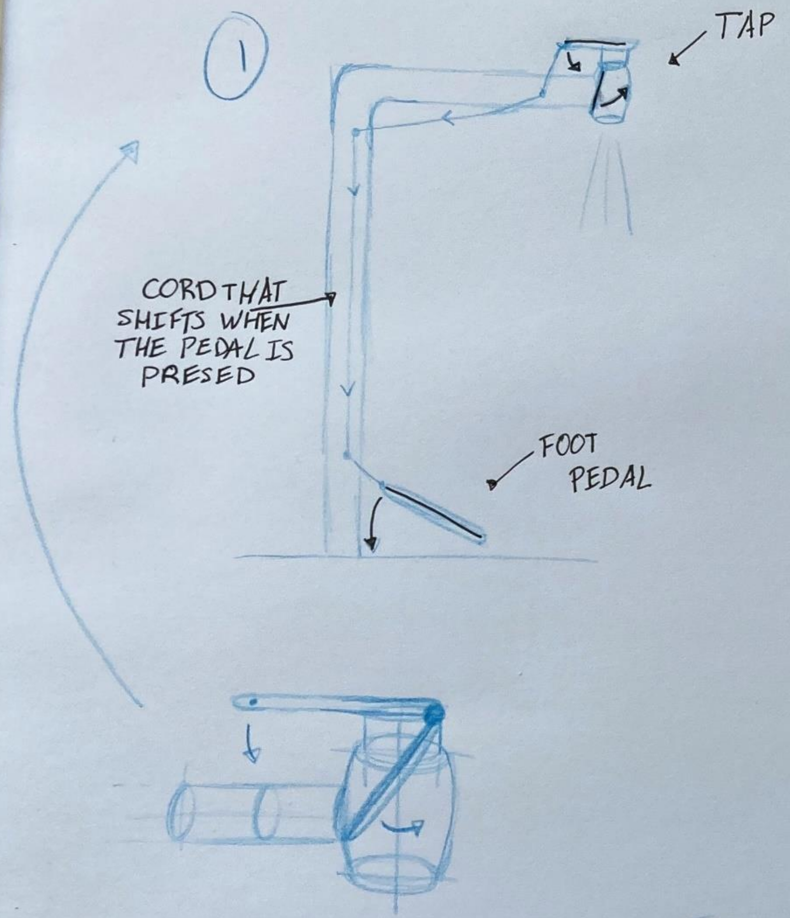


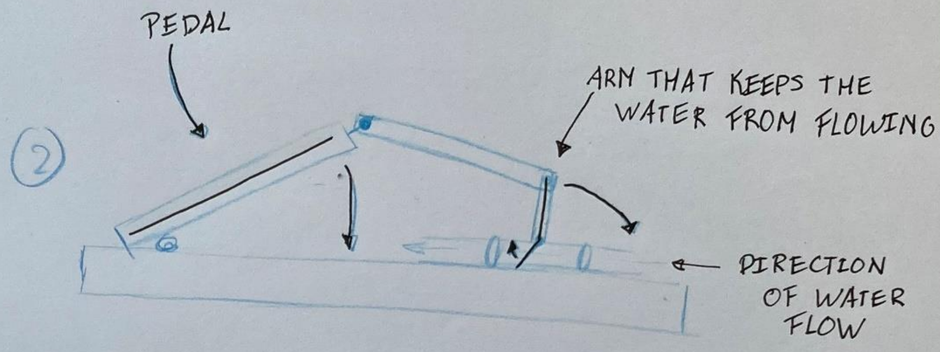


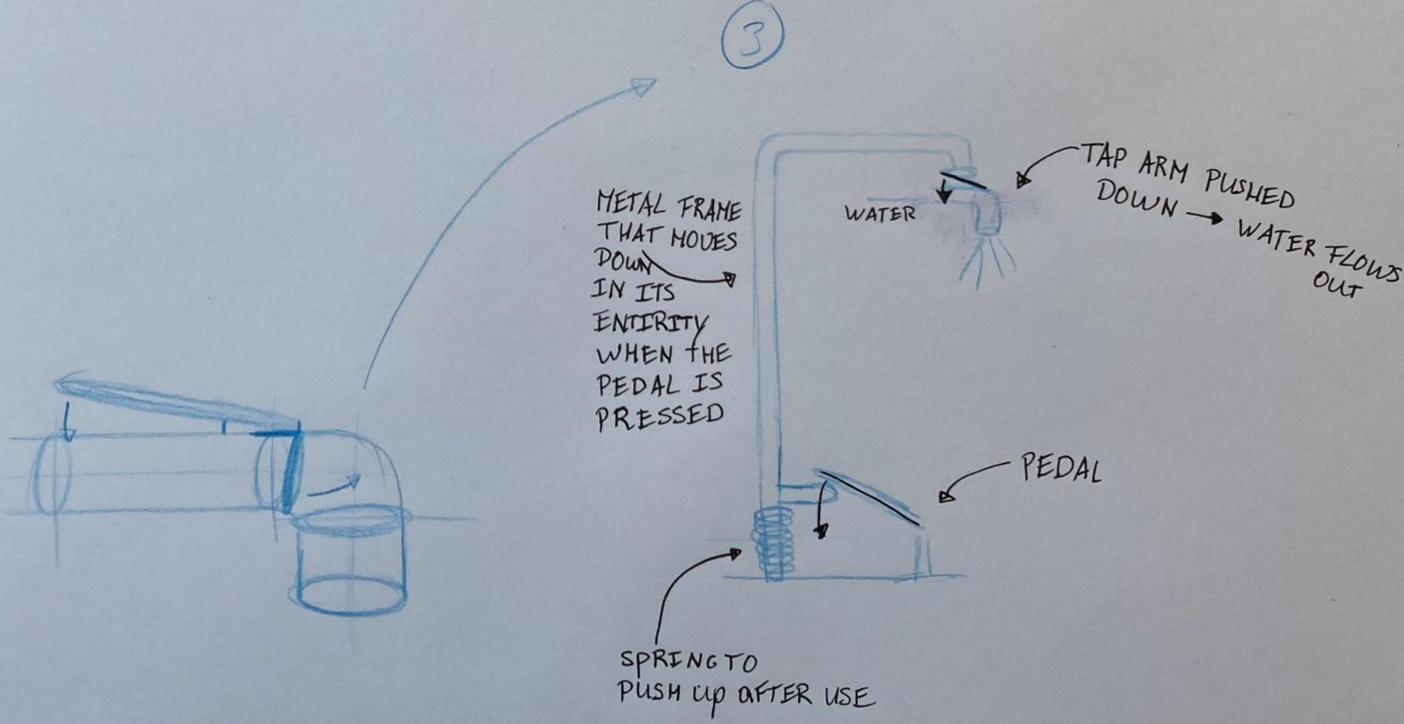



PUSH UP/DOWN
TAP

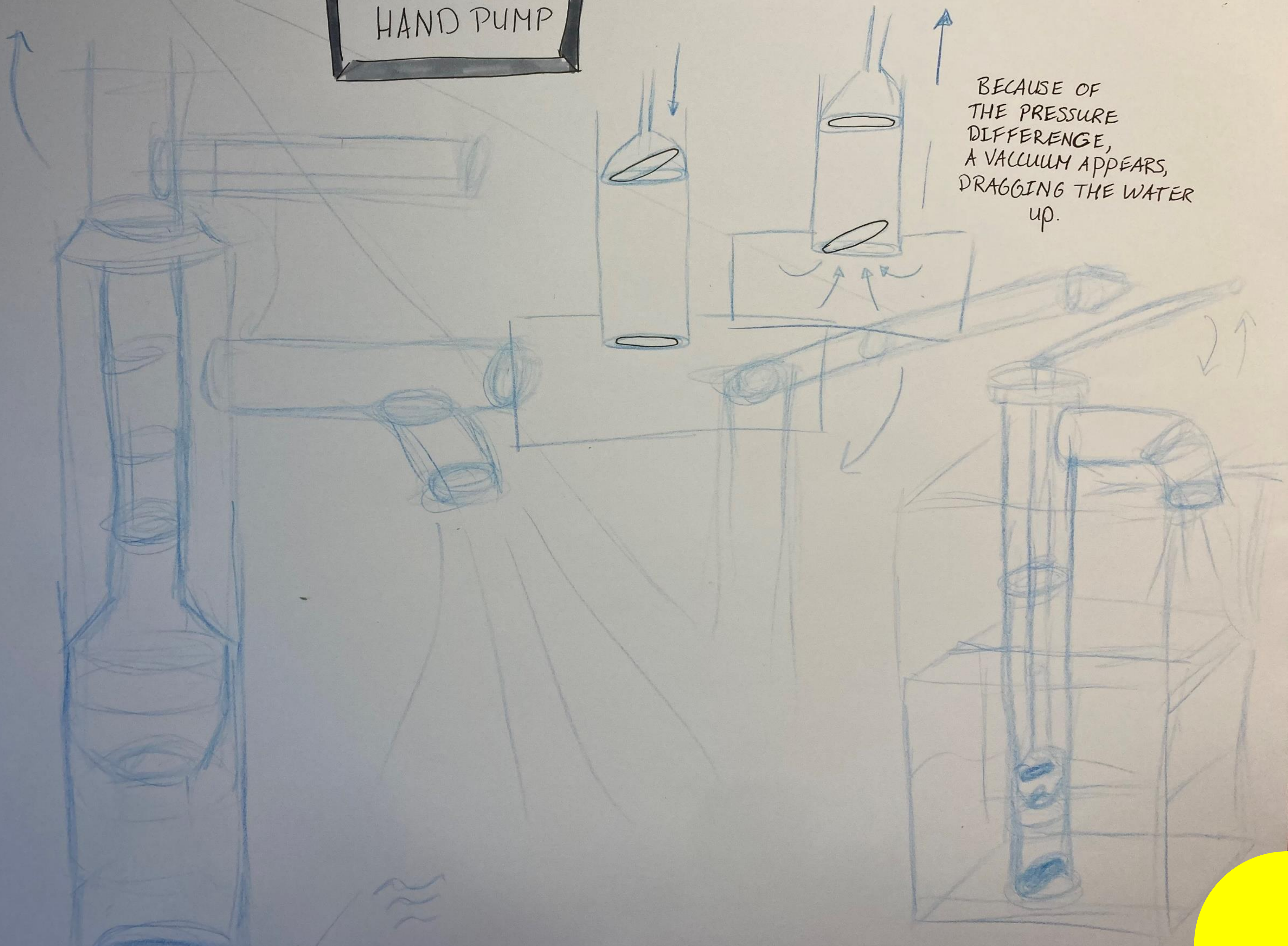
DEFFERENT FOOT PEDAL WATER TAPS





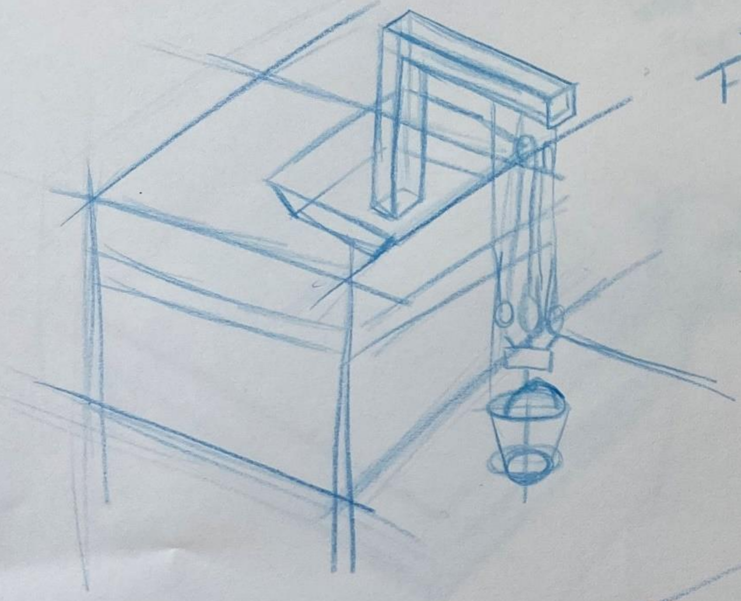


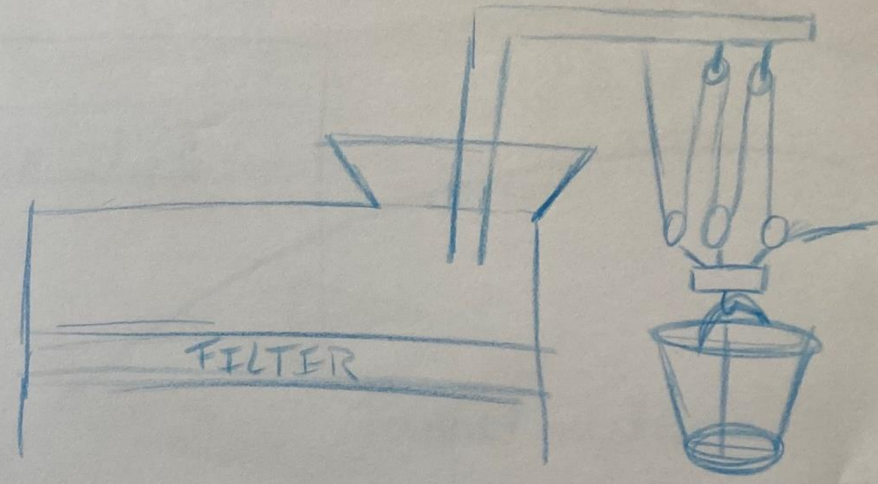
HAND PUMP


BECAUSE OF
THE PRESSURE
DIFFERENCE,
A VACUUM APPEARS,
DRAGGING THE WATER
UP.

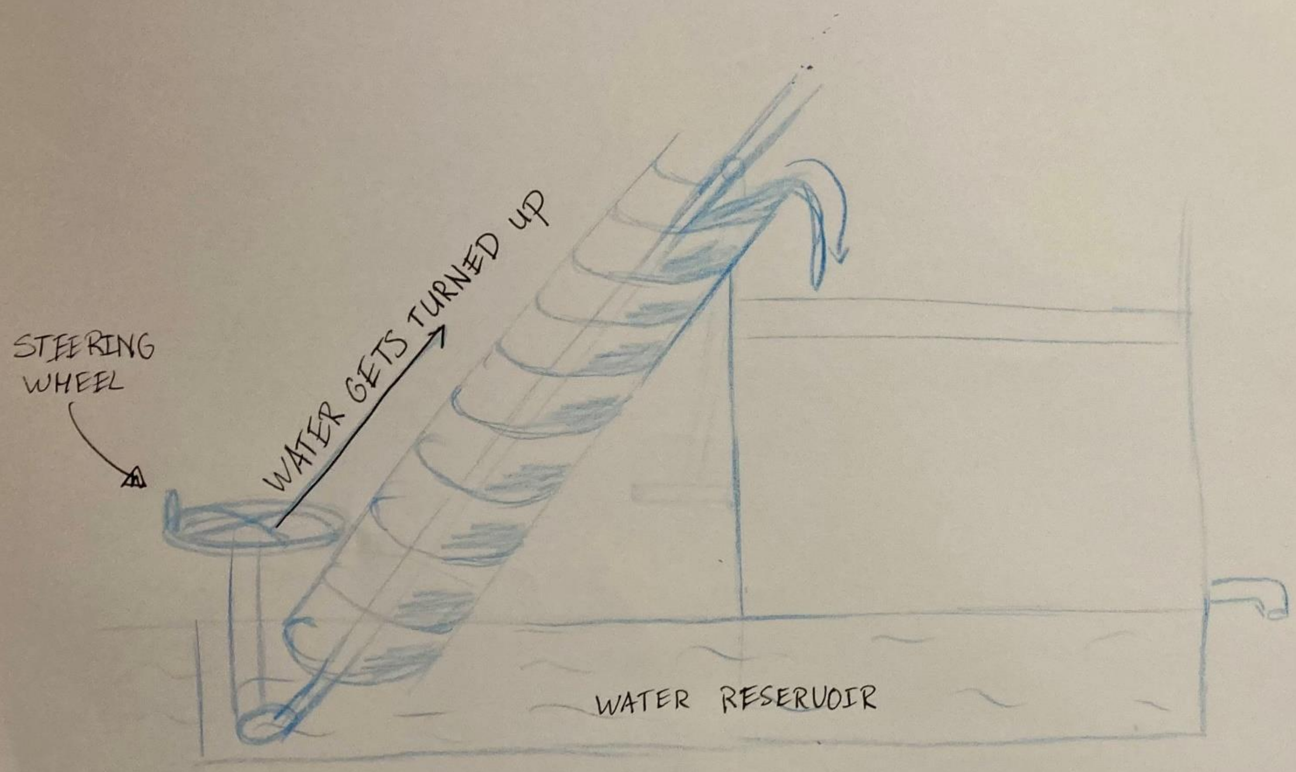
(5)

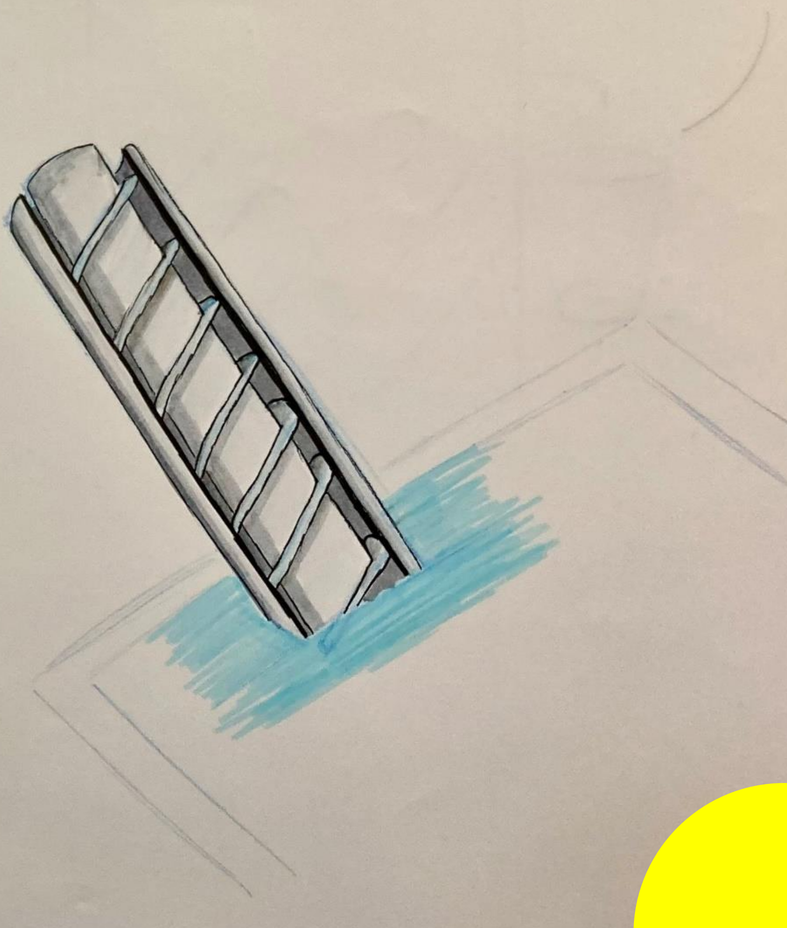
HOIST
+
FUNNEL



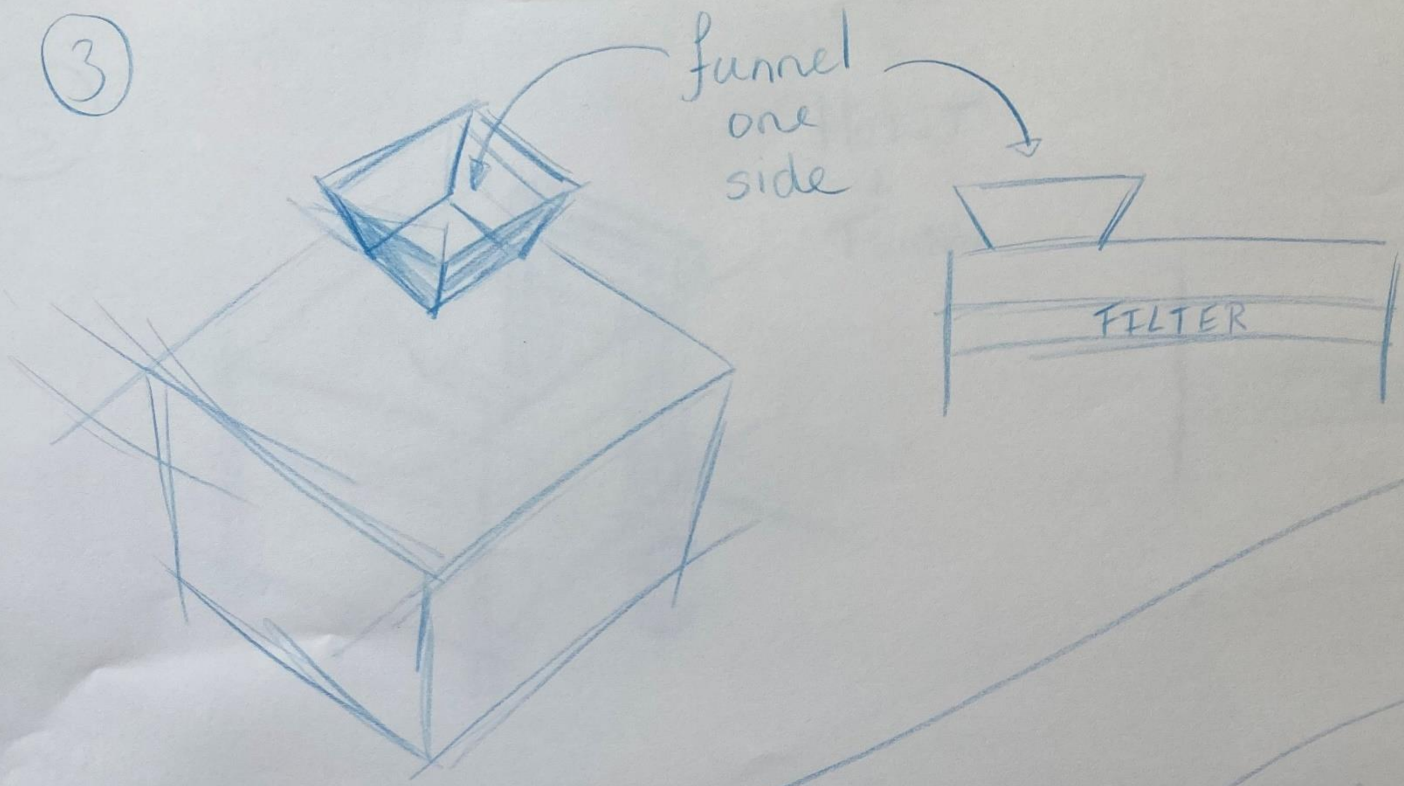


ARCHIMEDES SCREW PUMP





3



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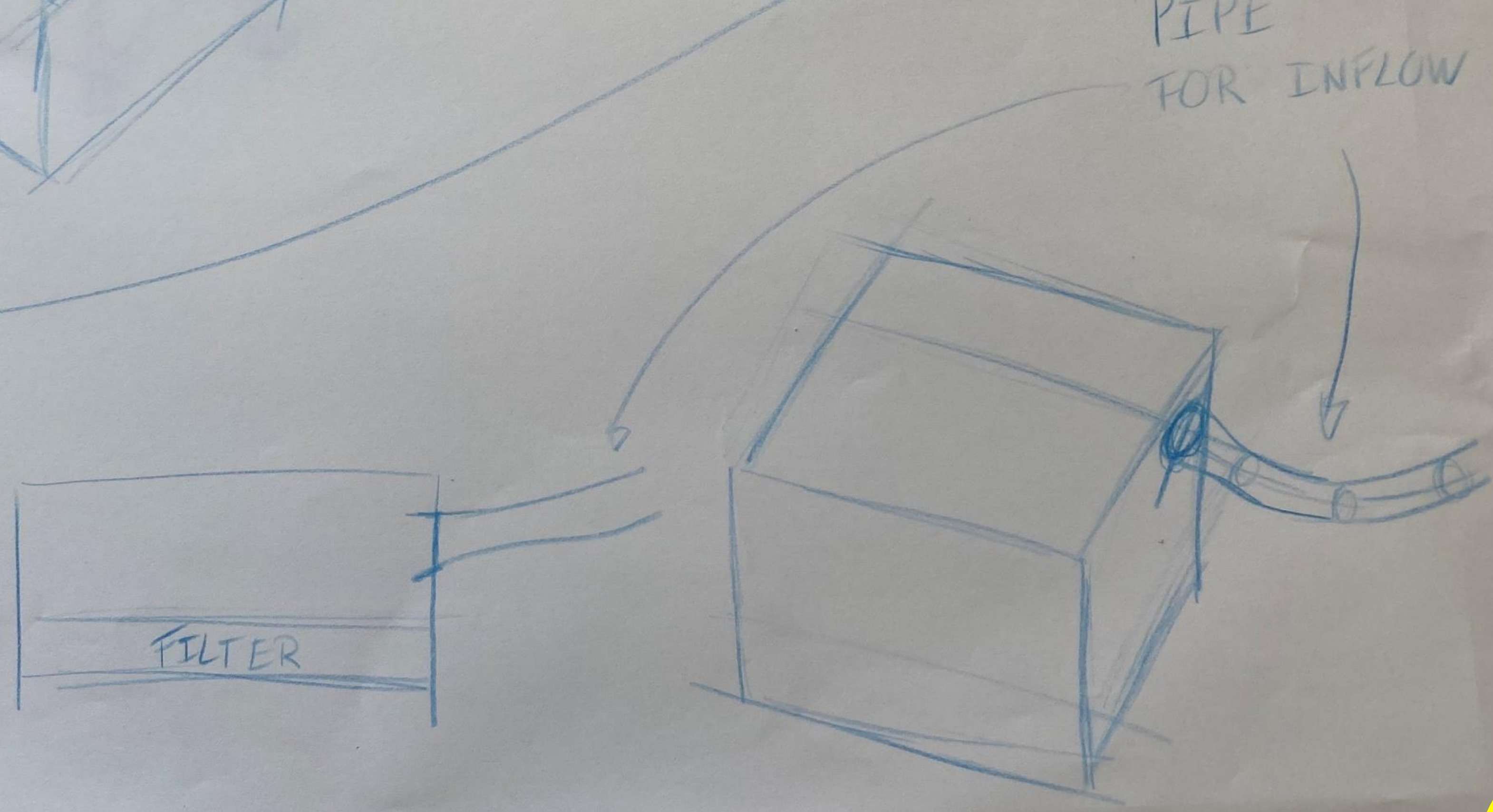
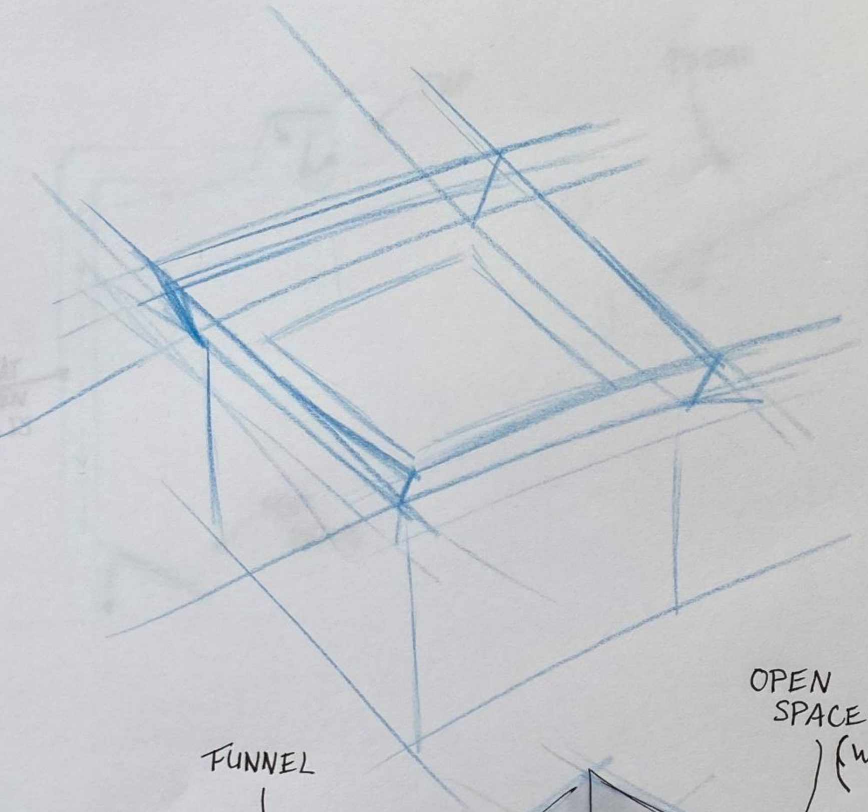
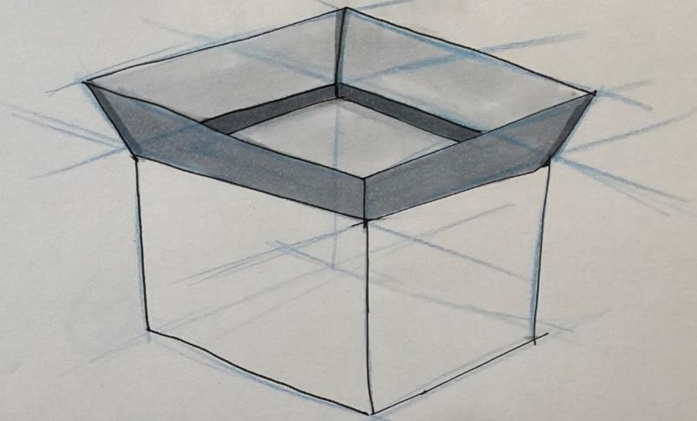
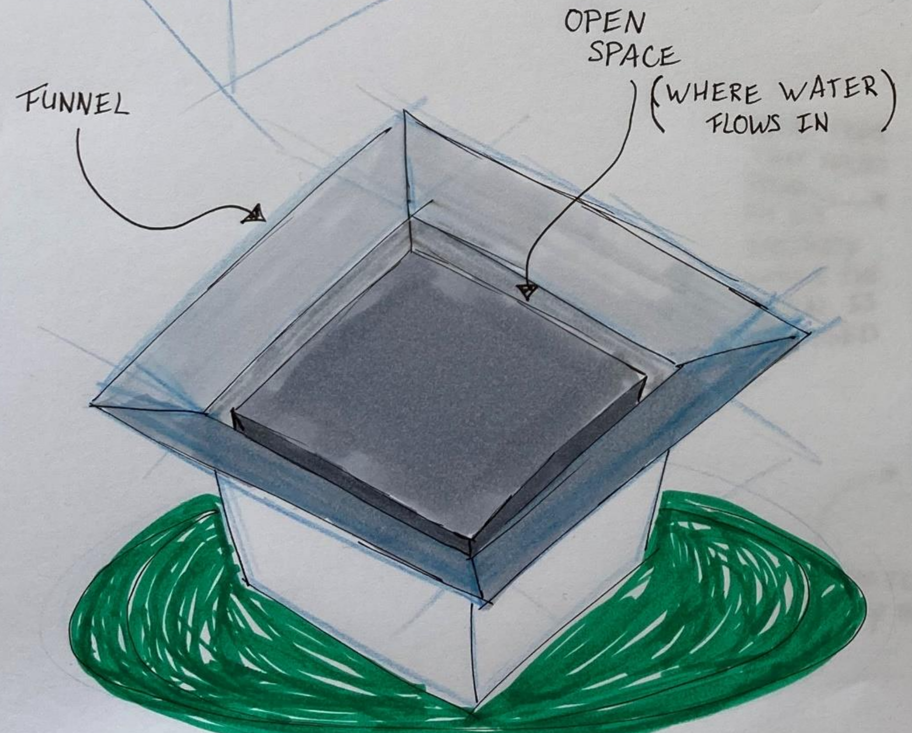


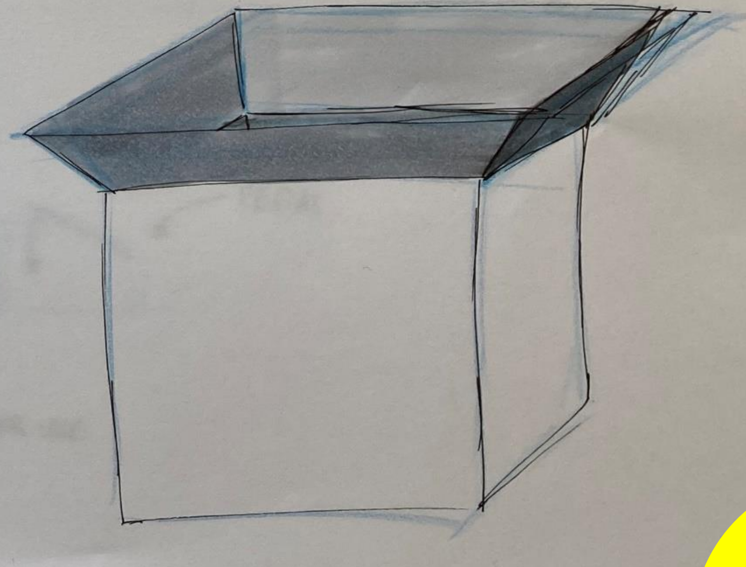
BIG FUNNEL WITH CLOSED MIDDLE

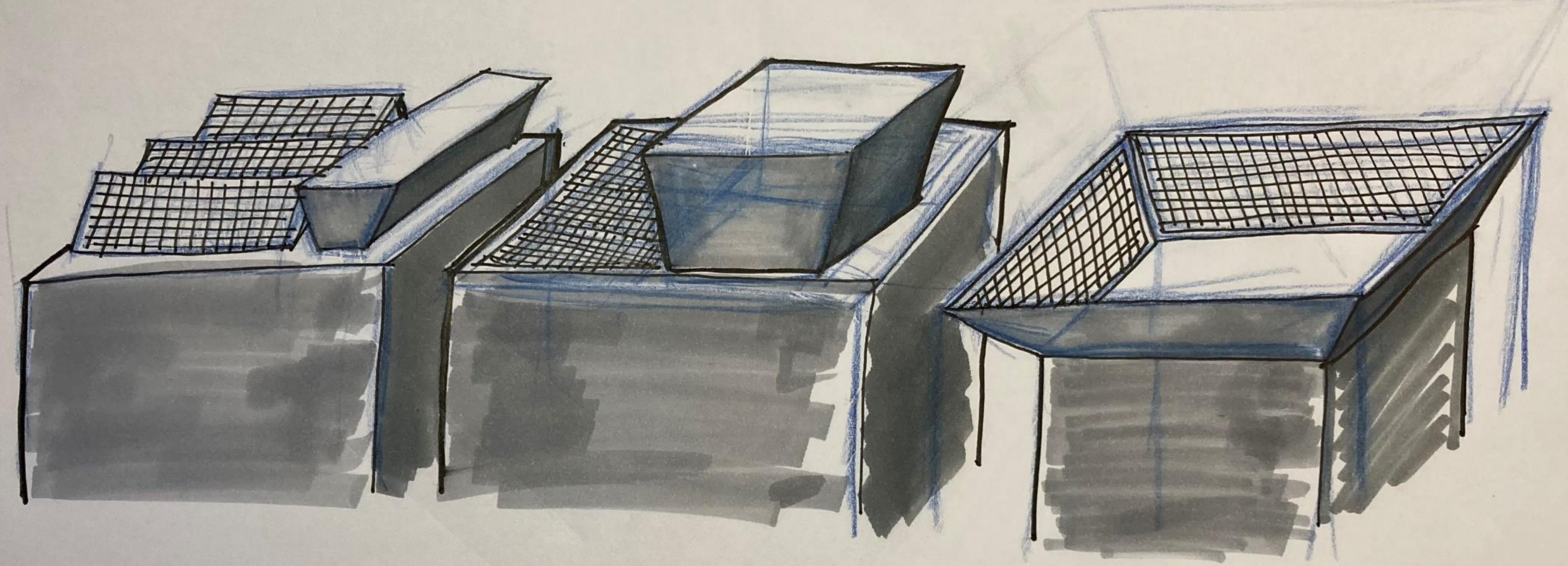
YOU CAN THROW IN WATER EVERYWHERE, BUT THE MIDDLE IS CLOSED TO KEEP OUT MOST DIRT AND PREVENT EVAPORATION



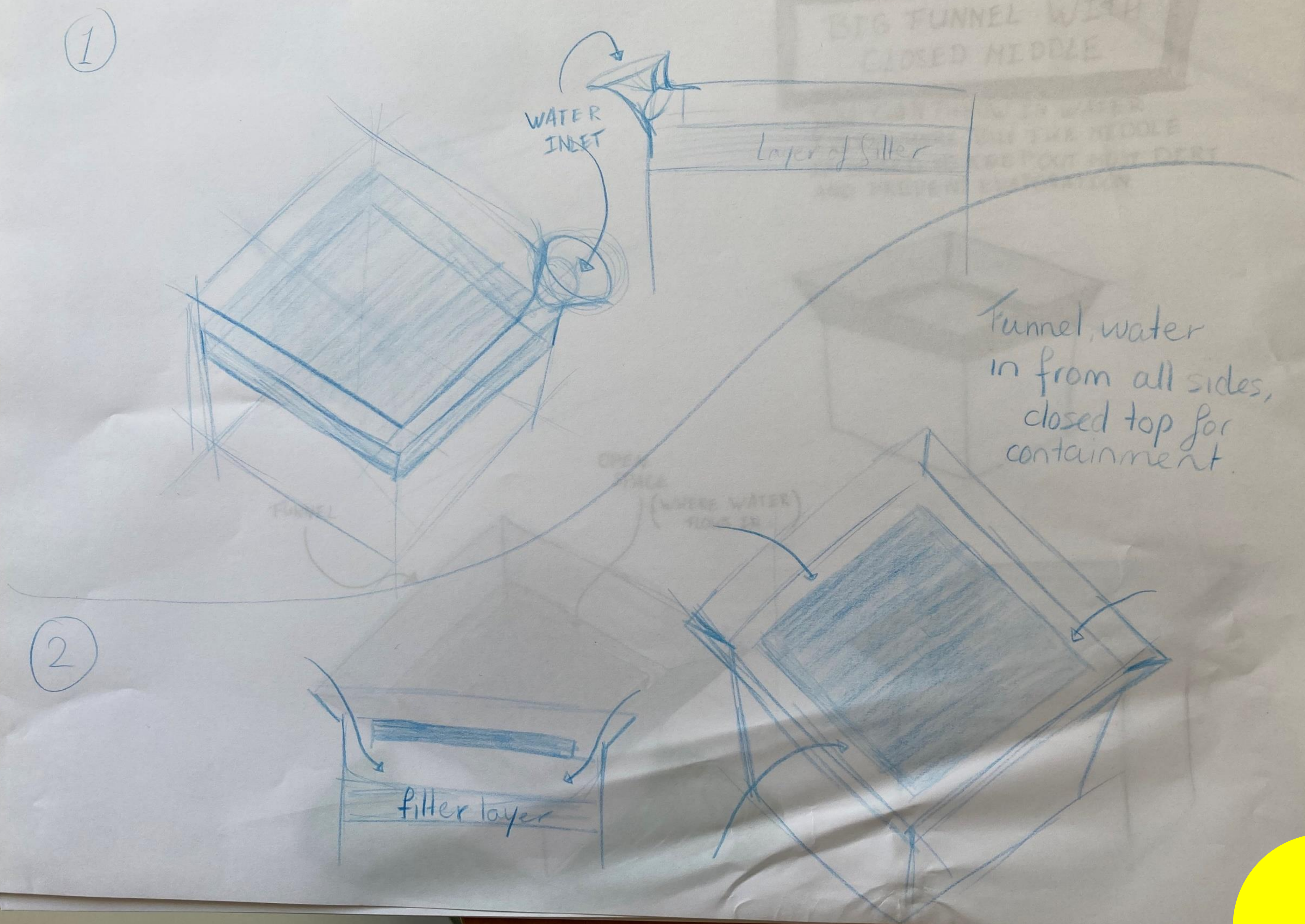






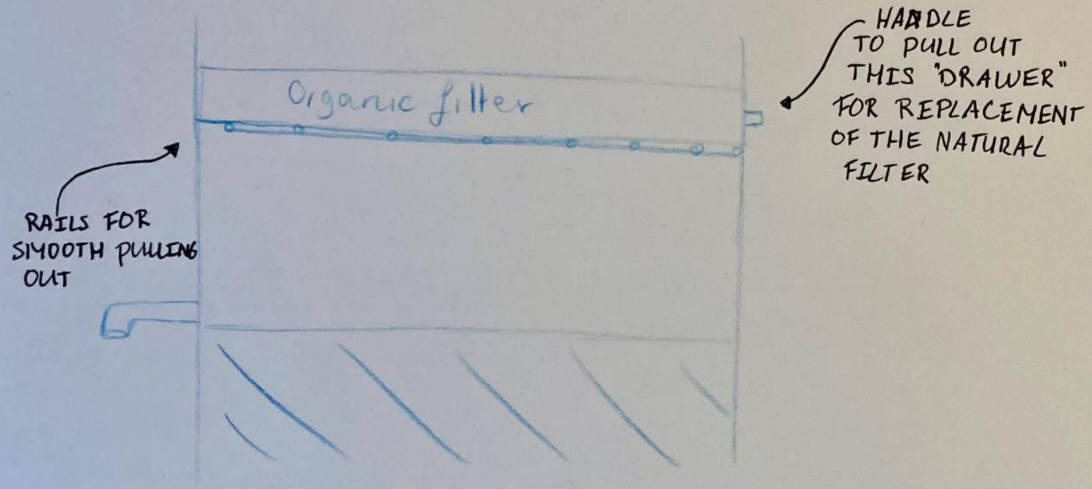


SOLAR PANEL
POSITIONINGS


1
WATER INLET
Layer of filter
Funnel, water in from all sides, closed top for containment
2
filter layer

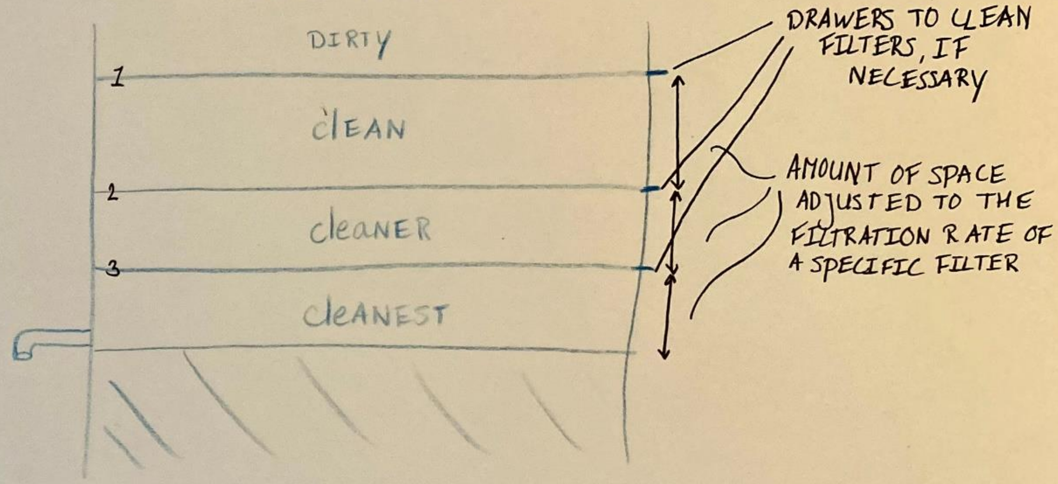
FILTRATION METHODS AND INSIDE OF BOX

THICK ORGANIC FILTER LAYER

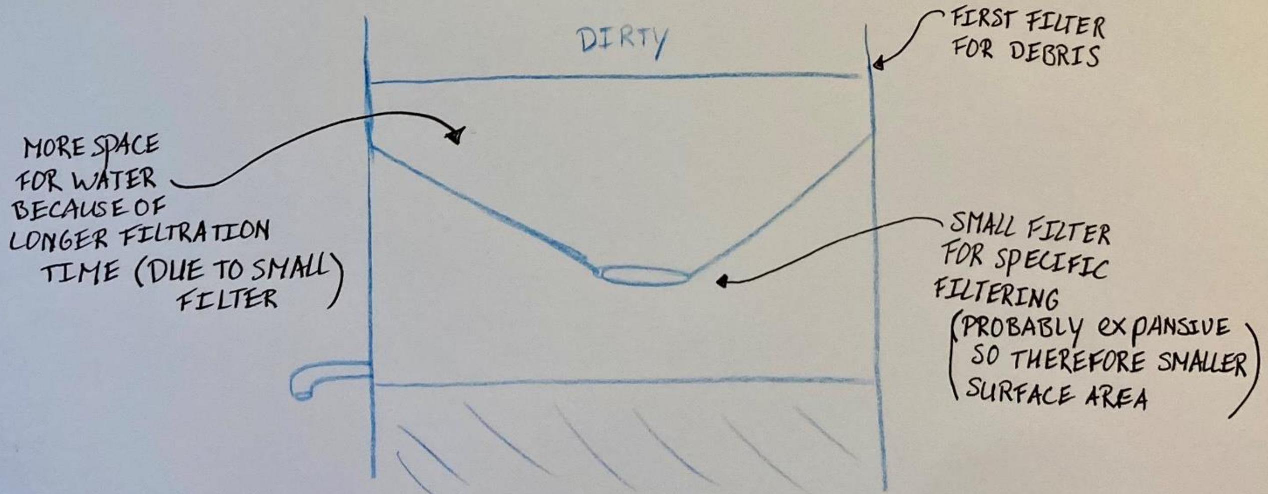


MULTIPLE FILTER LAYERS

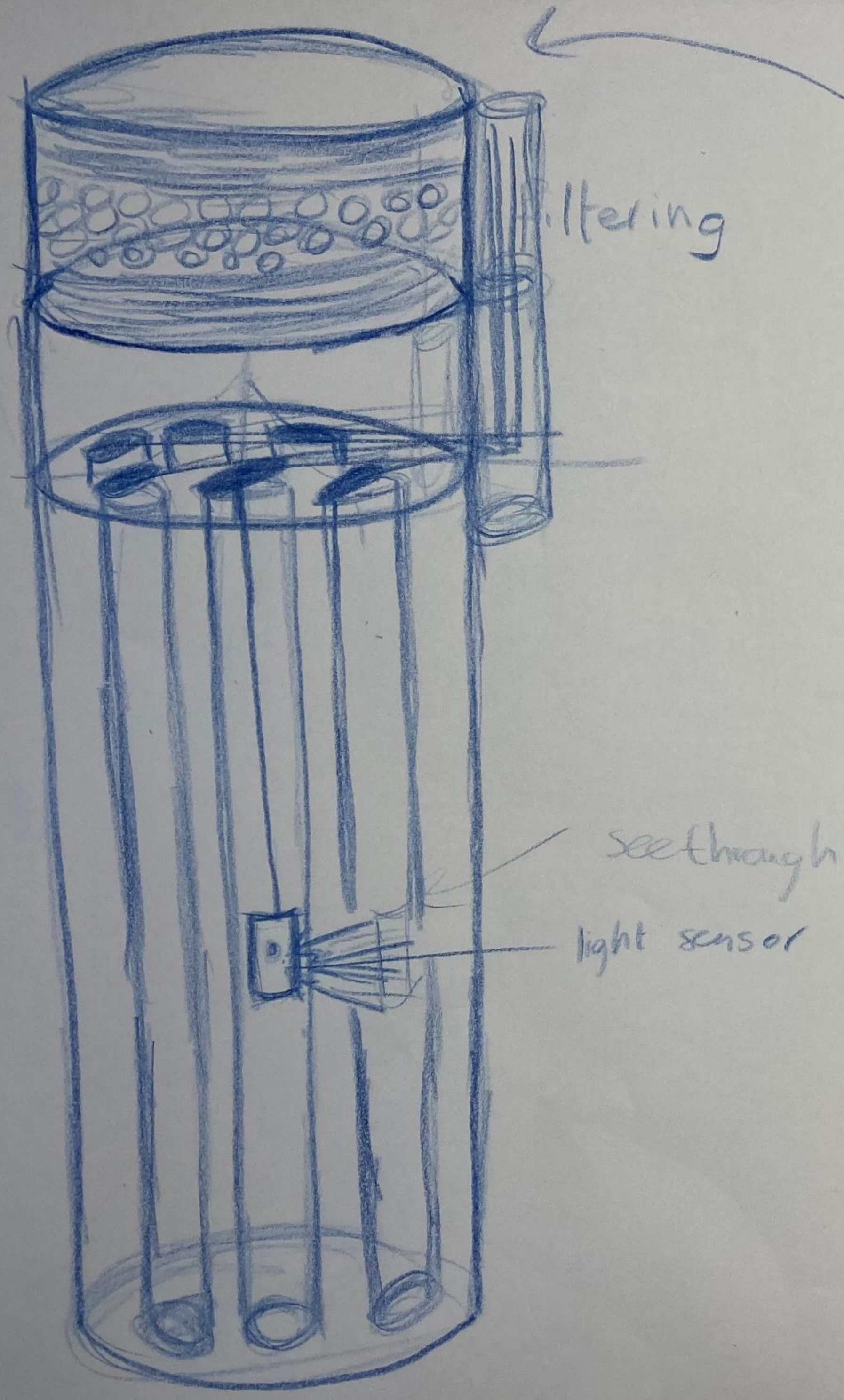
MORE PROFESSIONAL THIN FILTER LAYERS

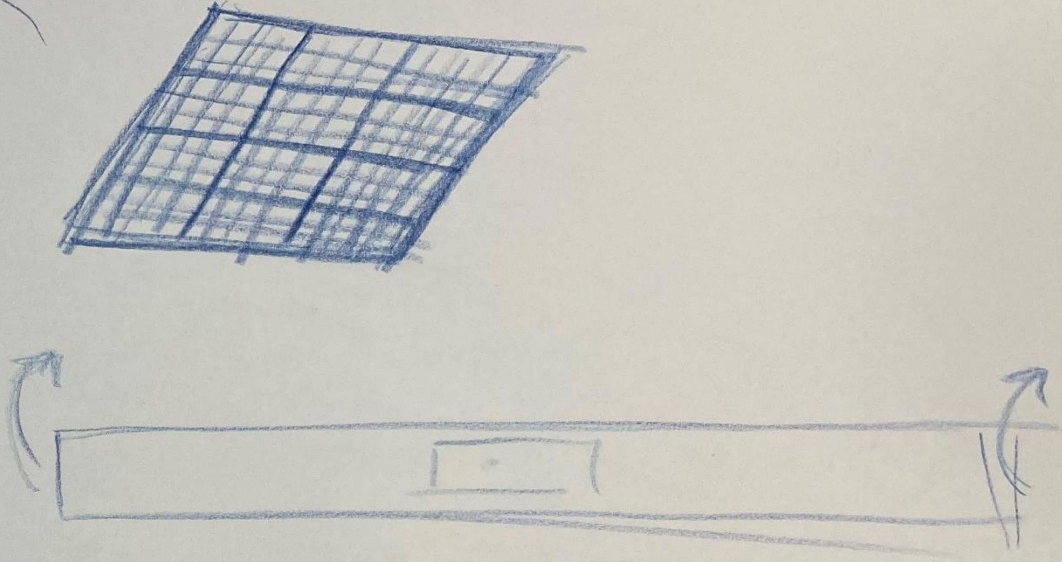


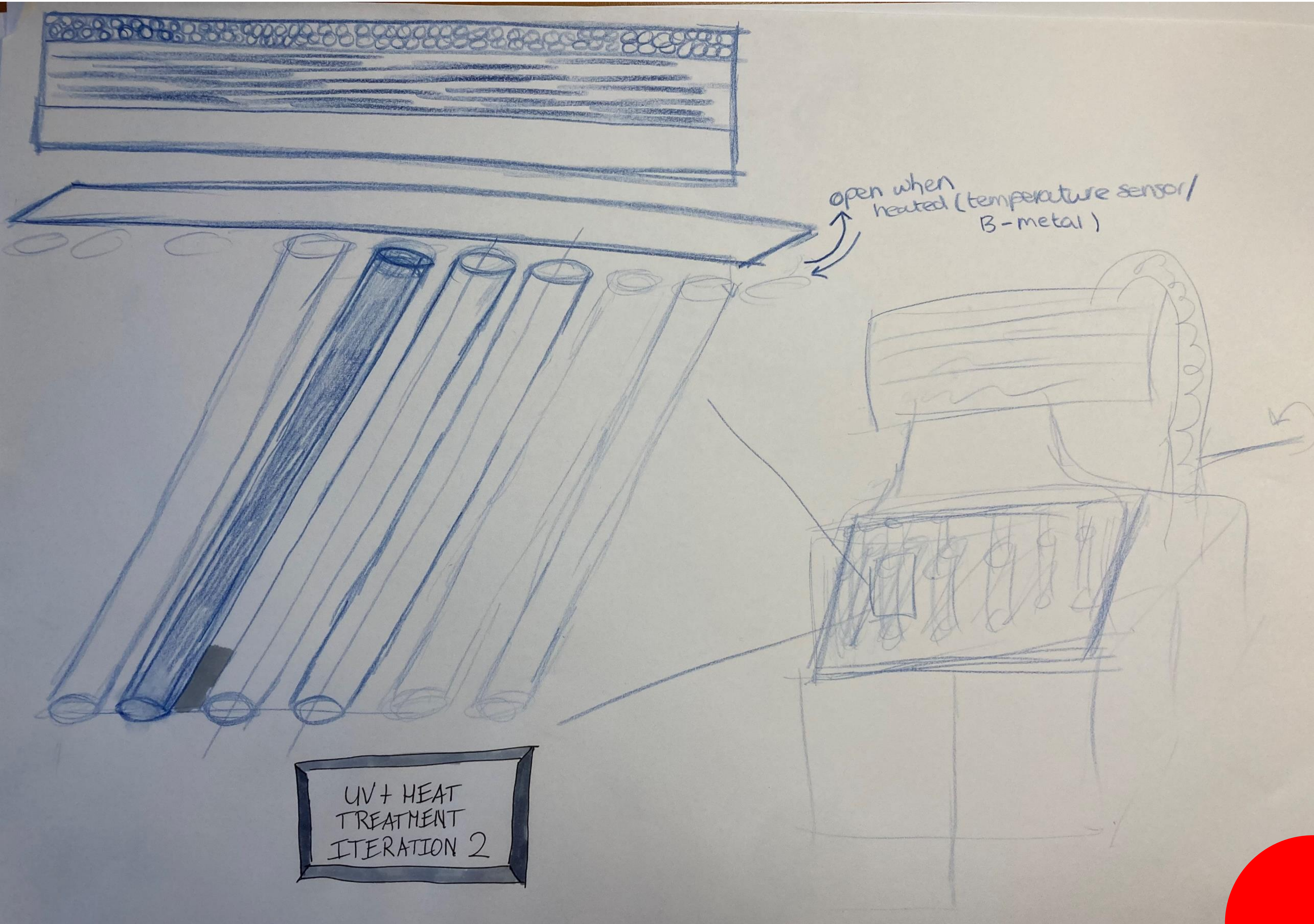
FUNNEL FILTER



UV+ HEAT TREATMENT ITERATION 1

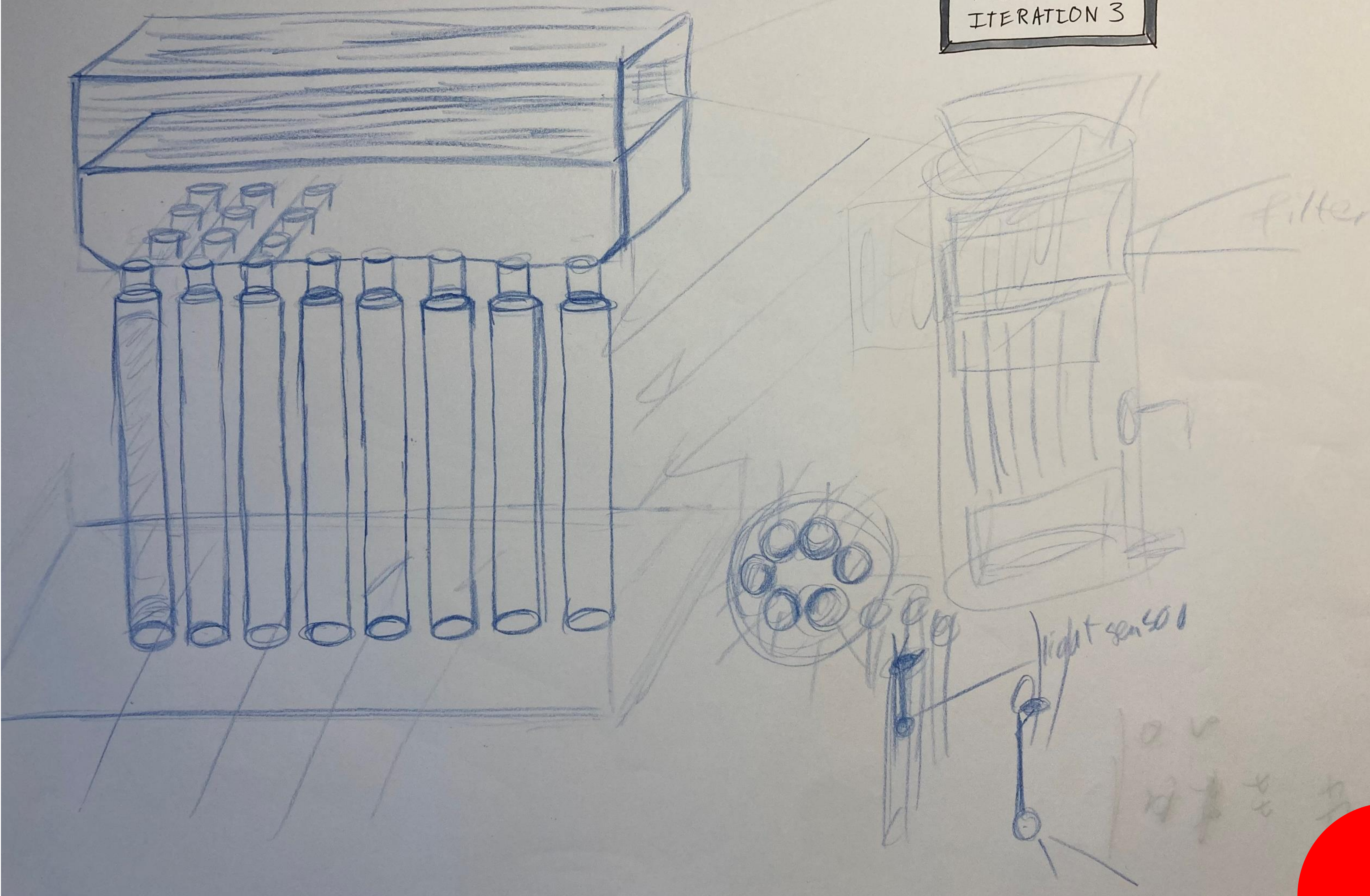


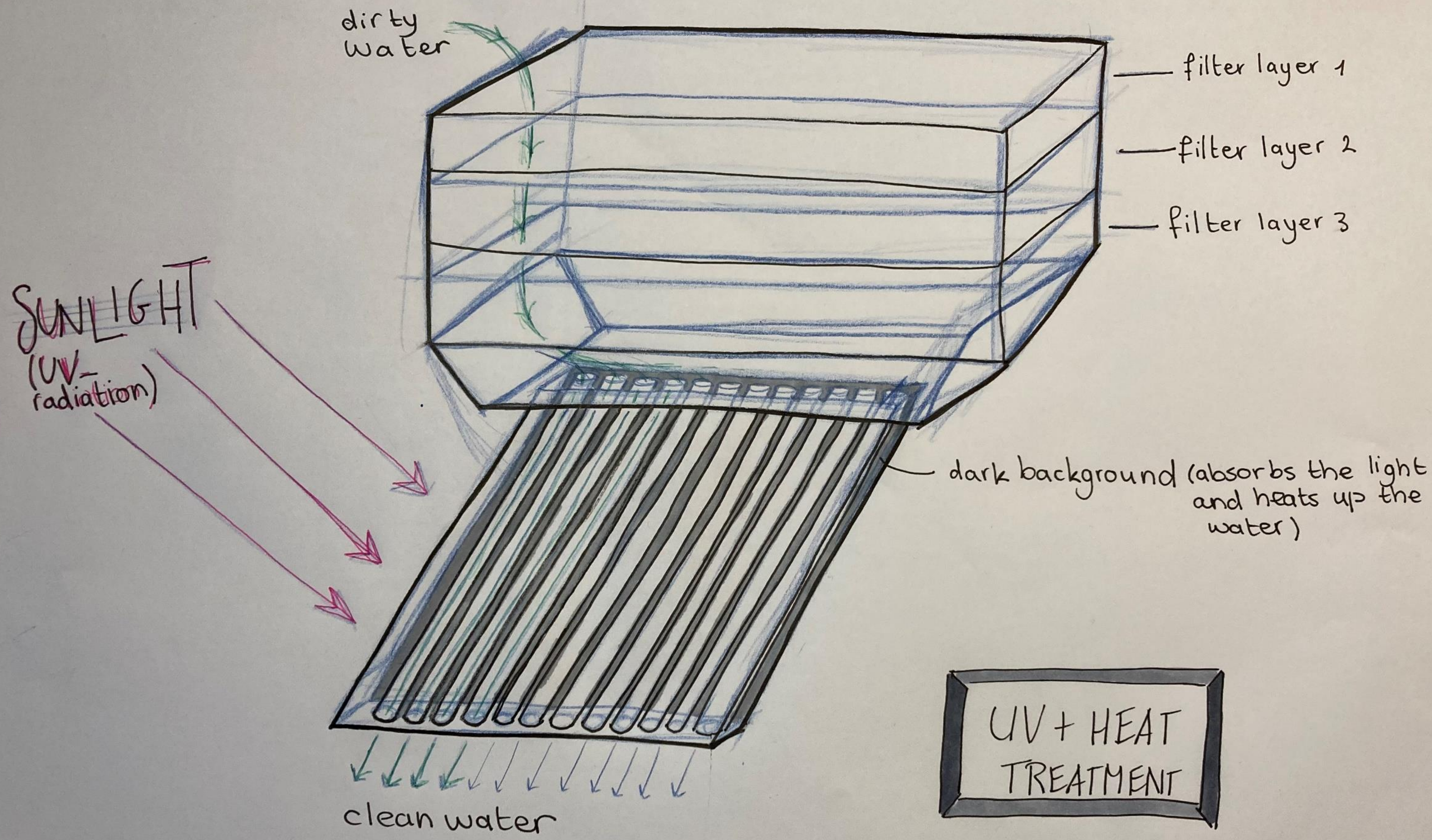




UV+ HEAT
TREATMENT
ITERATION 2

UV + HEAT
TREATMENT
ITERATION 3

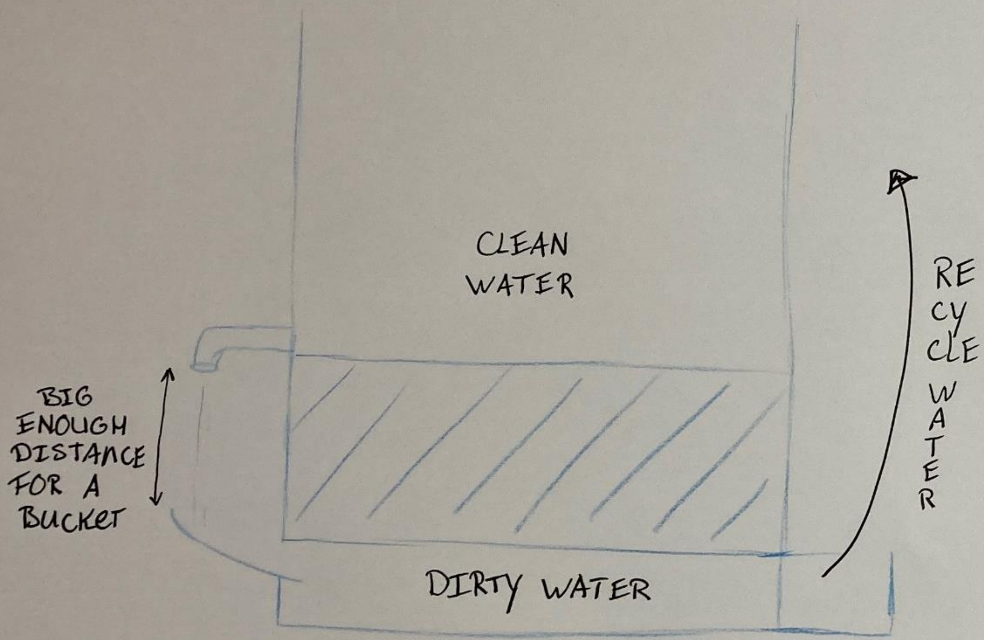




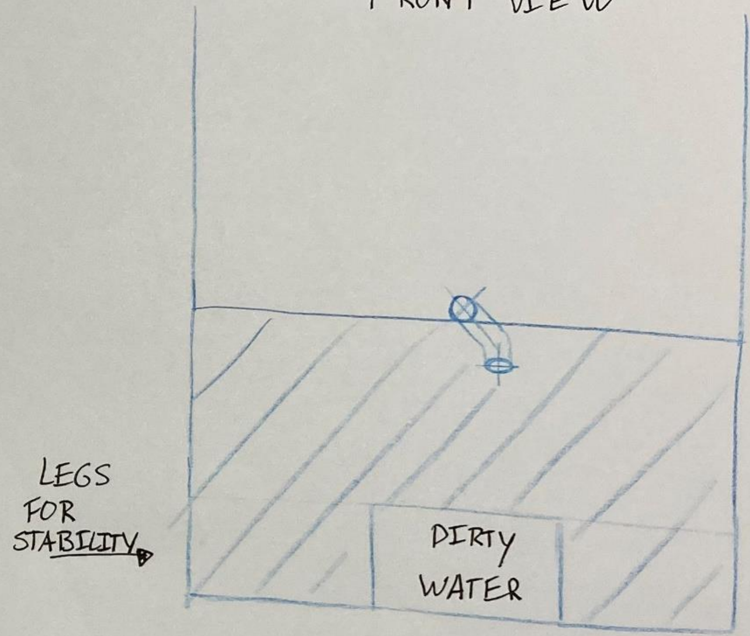
dirty water
filter layer 1
filter layer 2
filter layer 3
SUNLIGHT (UV-radiation)
dark background (absorbs the light and heats up the water)
clean water
UV + HEAT TREATMENT

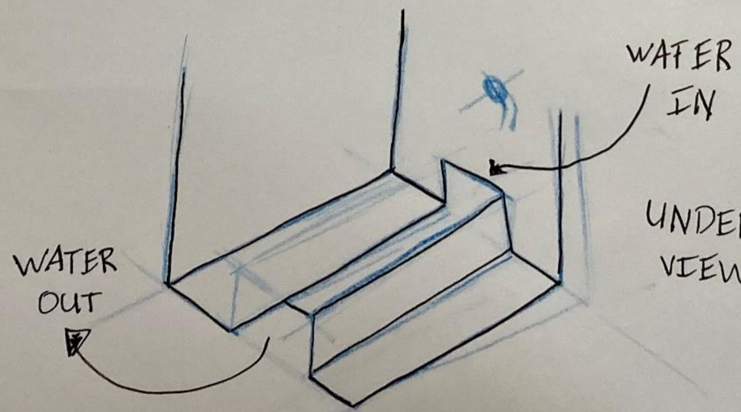
RECYCLING COMPARTMENT

SIDE VIEW



FRONT VIEW

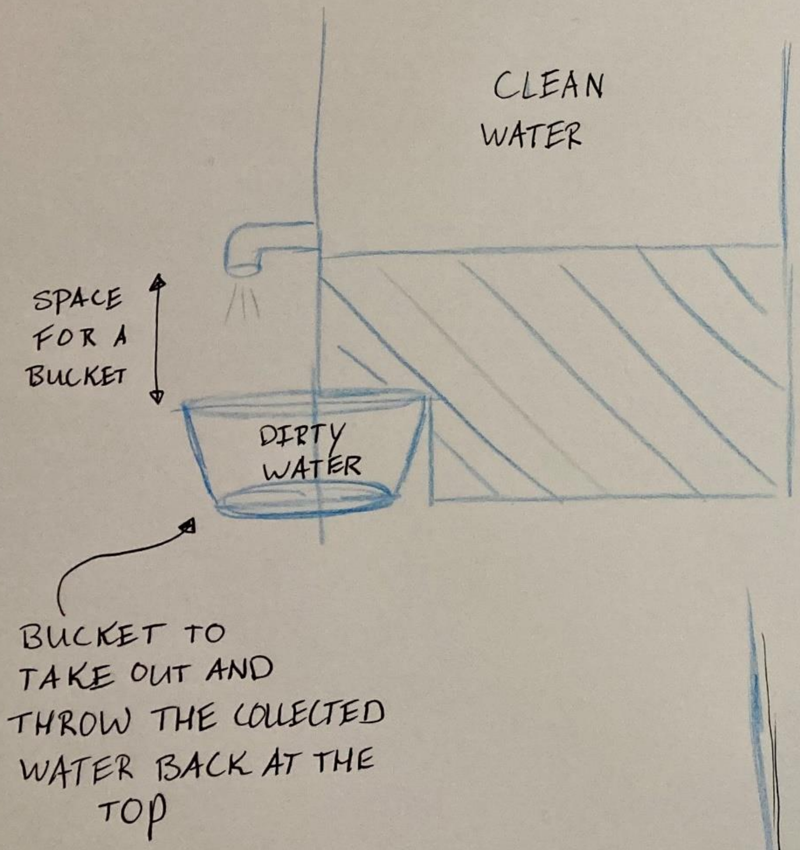




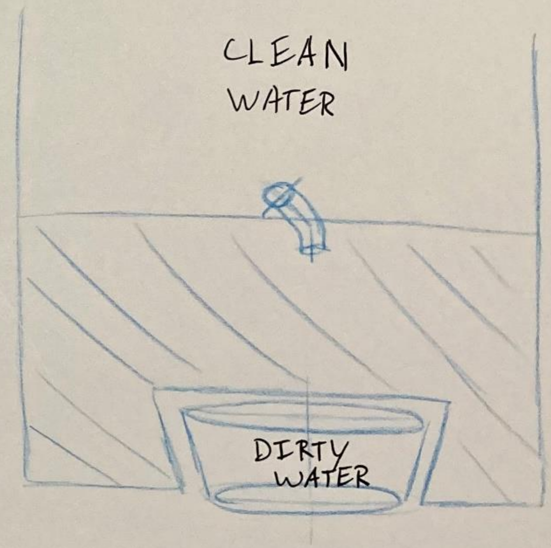
UNDER VIEW

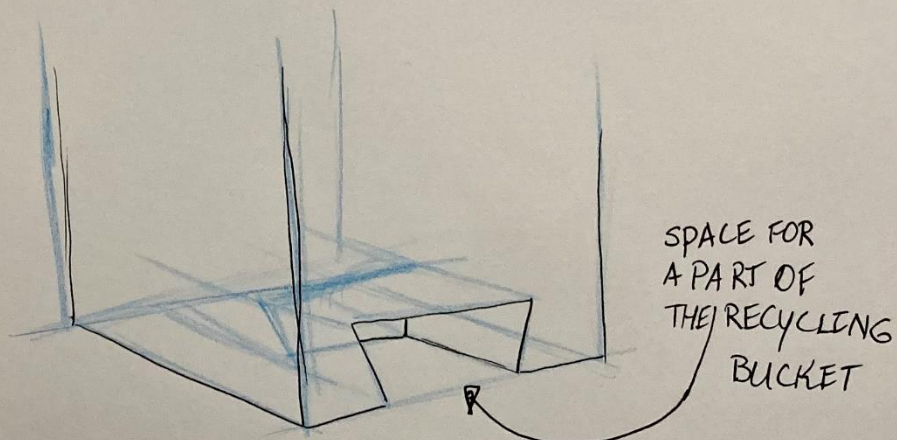
RECYCLING BUCKET

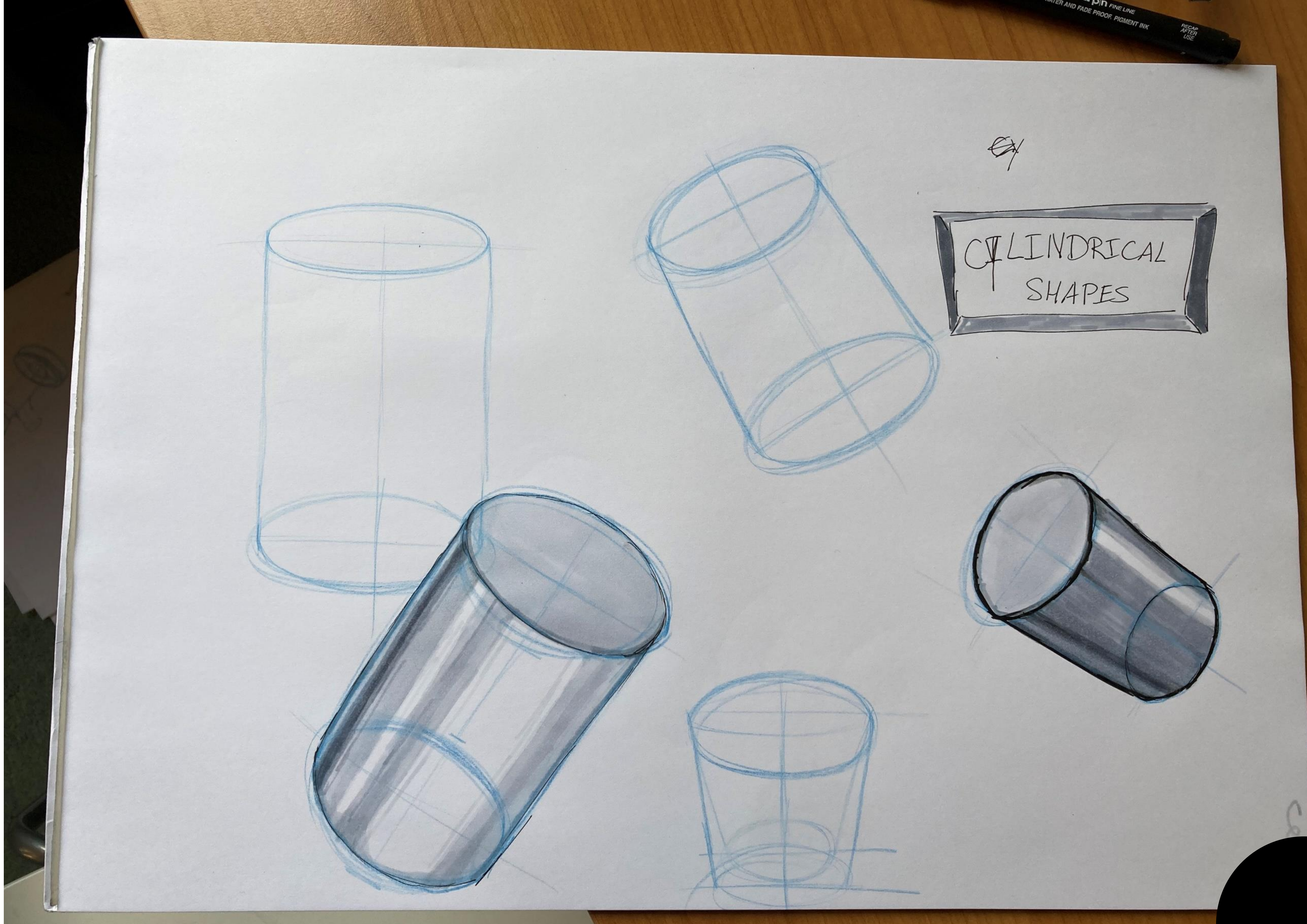
SIDE VIEW



FRONT VIEW





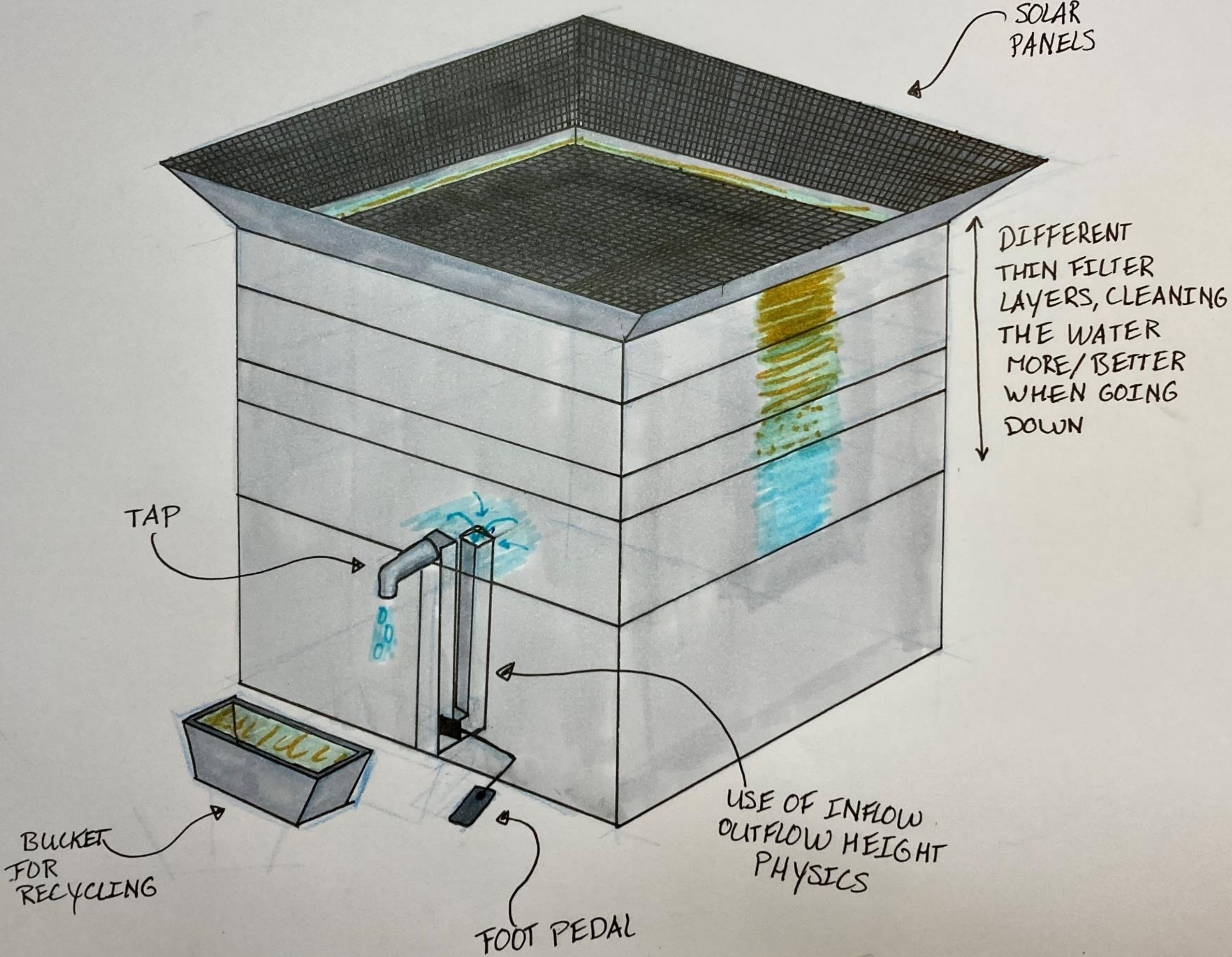

CYLINDRICAL
SHAPES
FINE LINE
ATER AND FADE PROOF. PIGMENT INK
RECAP
AFTER
USE

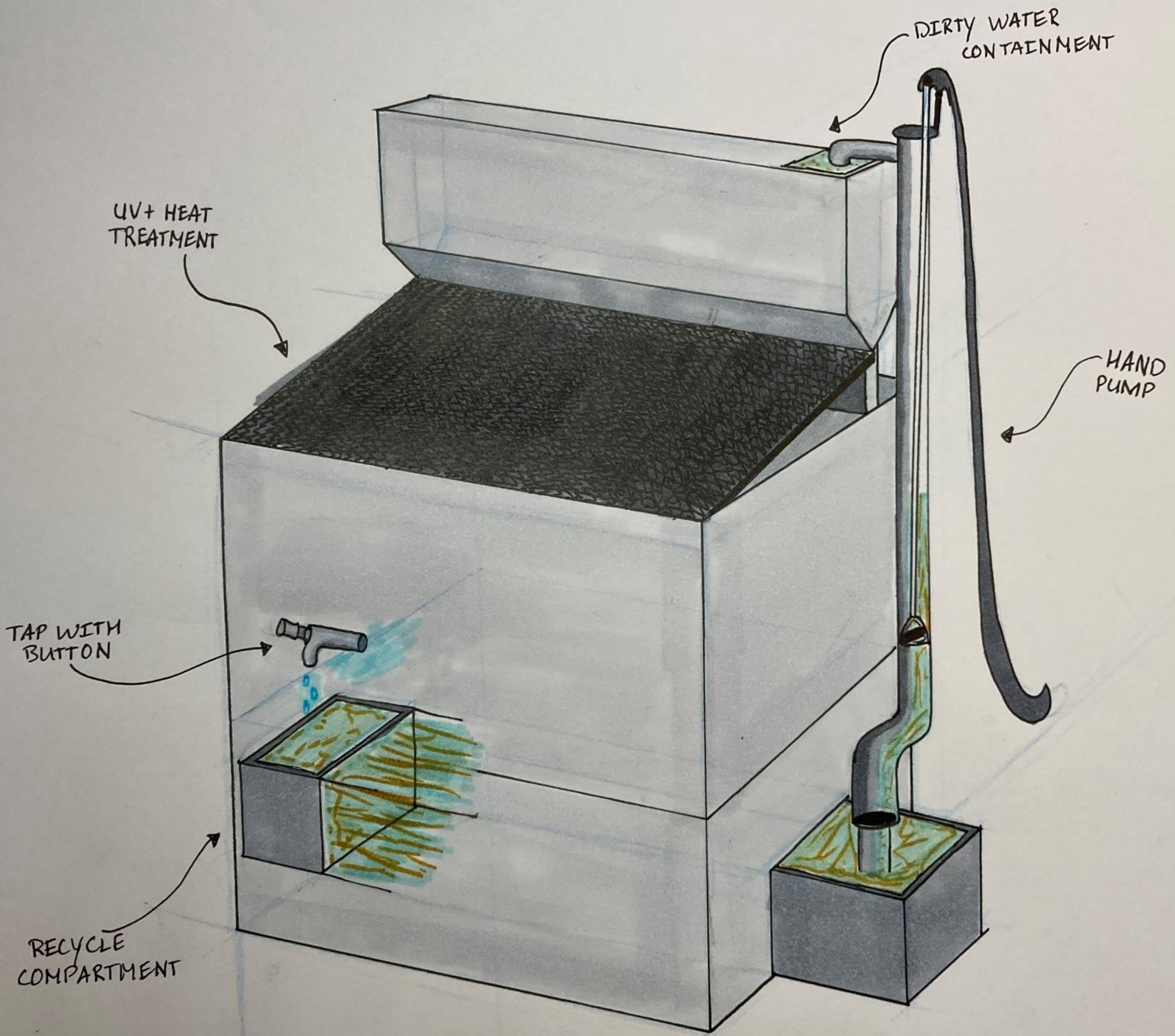
10. 3 Prototypes

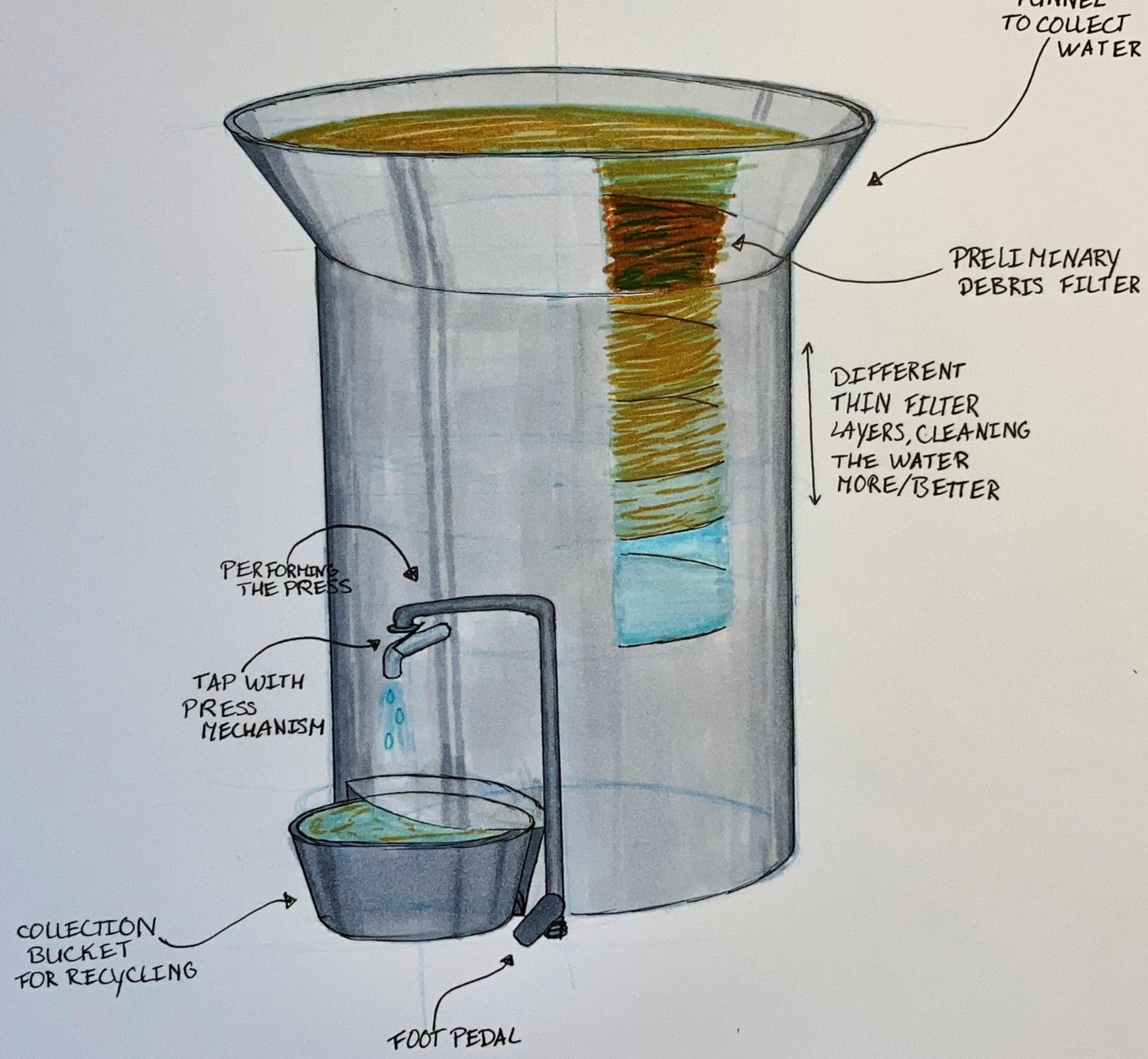
After exploring different options, 5 prototypes, each consisting of different elements were created.

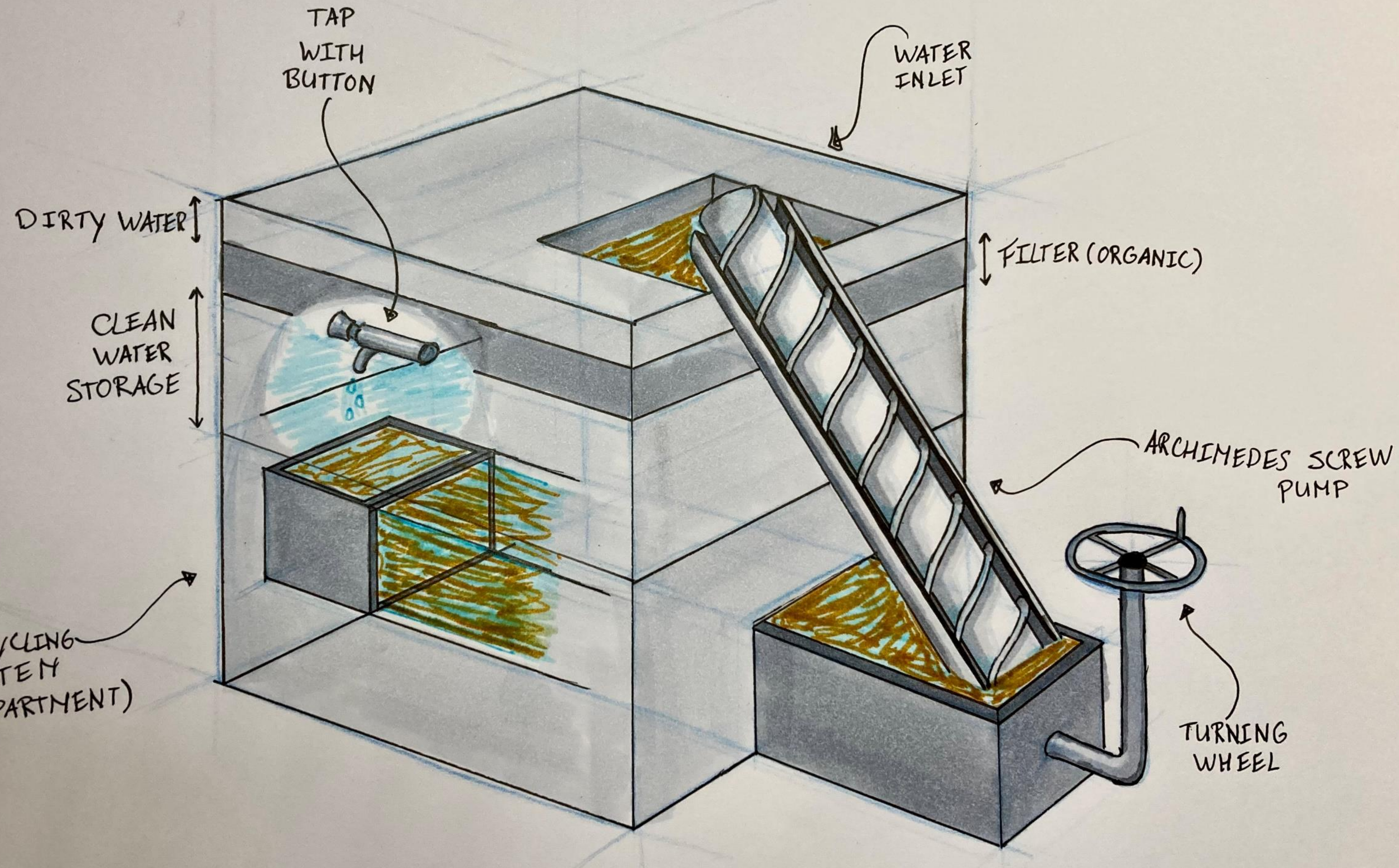
The prototypes respectivly contain:

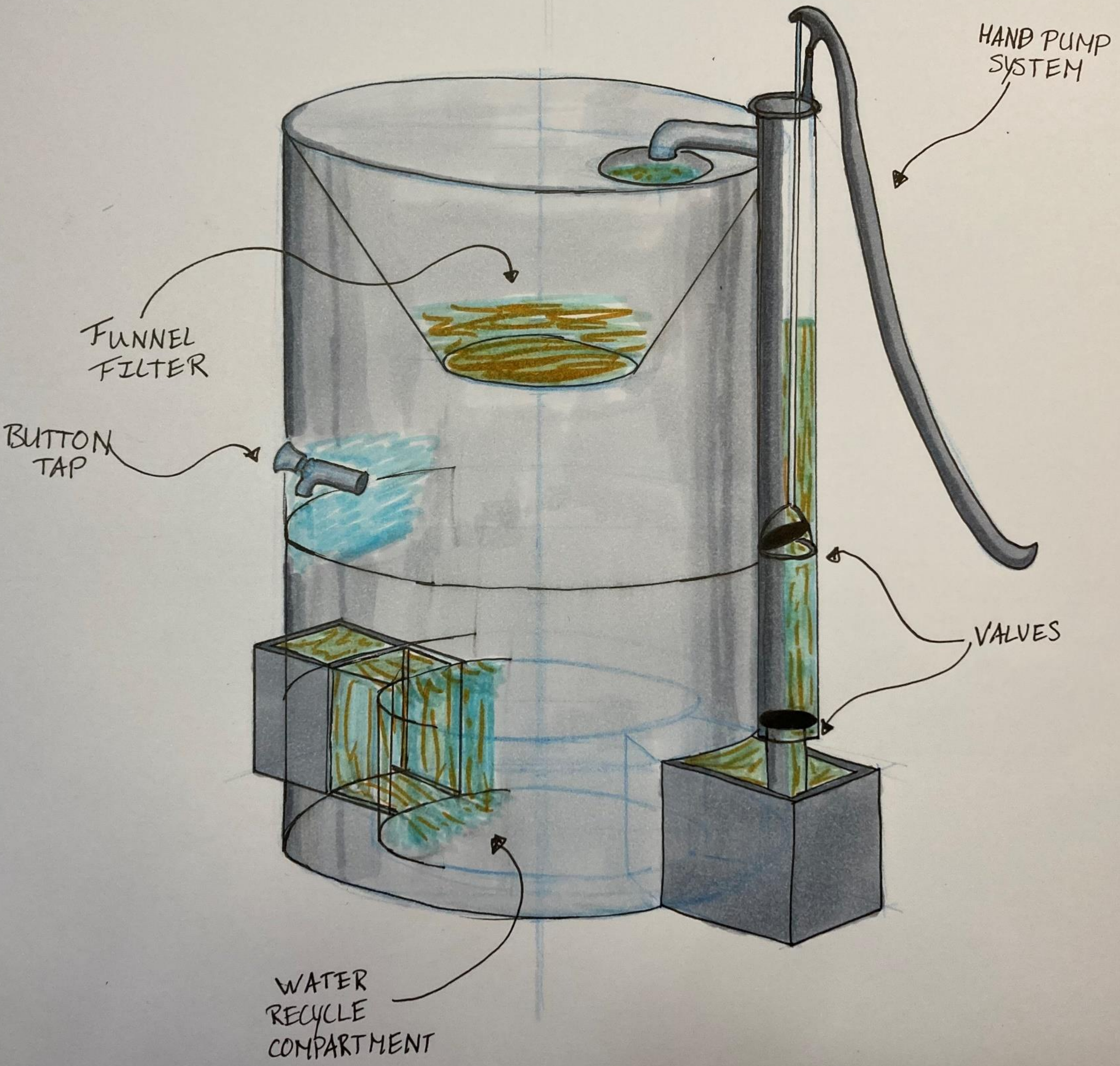
Prototype	**Shape**	**Tap**	**Inflow system**	**Recycling system**	**Filtering system**
1	Box	Foottap	Big funnel + solar panels	Bucket	Professional filter
2	Box	Button tap	Lever arm pump	Compartment	UV/heat treatment
3	Cylinder	Foottap	Big funnel/pipe	Bucket	Professional filter
4	Box	Button tap	Cylindrical pump	Compartment	Organic filter
5	Cylinder	Button tap	Lever arm pump	Compartment	Funnel shaped


SOLAR PANELS
DIFFERENT THIN FILTER LAYERS, CLEANING THE WATER MORE/BETTER WHEN GOING DOWN
TAP
USE OF INFLOW OUTFLOW HEIGHT PHYSICS
BUCKET FOR RECYCLING
FOOT PEDAL


DIRTY WATER
CONTAINMENT
UV+ HEAT
TREATMENT
HAND
PUMP
TAP WITH
BUTTON
RECYCLE
COMPARTMENT


FUNNEL
TO COLLECT
WATER
PRELIMINARY
DEBRIS FILTER
DIFFERENT
THIN FILTER
LAYERS, CLEANING
THE WATER
MORE/BETTER
PERFORMING
THE PRESS
TAP WITH
PRESS
MECHANISM
COLLECTION
BUCKET
FOR RECYCLING
FOOT PEDAL


TAP
WITH
BUTTON
WATER
INLET
DIRTY WATER
FILTER (ORGANIC)
CLEAN
WATER
STORAGE
ARCHIMEDES SCREW
PUMP
RECYCLING
SYSTEM
(COMPARTMENT)
TURNING
WHEEL

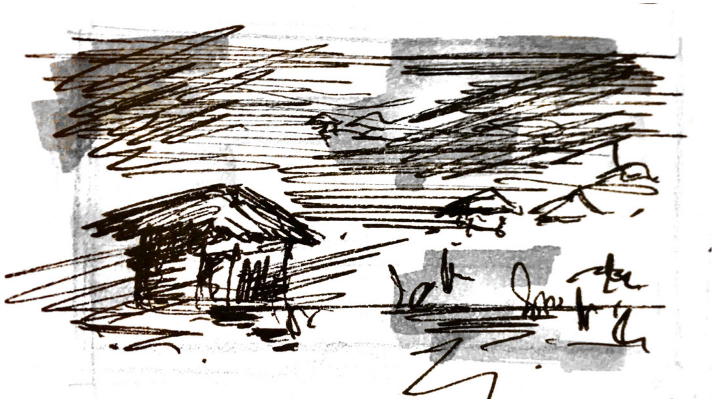

HAND PUMP
SYSTEM
FUNNEL
FILTER
BUTTON
TAP
VALVES
WATER
RECYCLE
COMPARTMENT

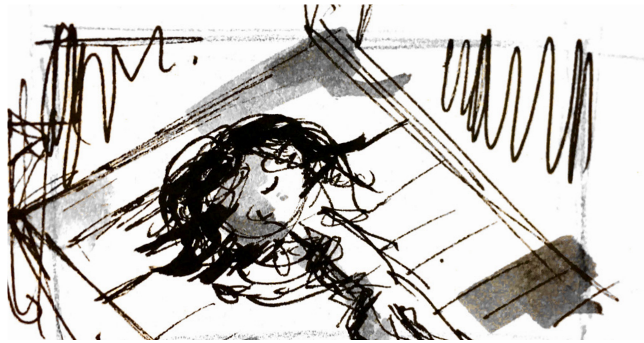
11 Storyboard

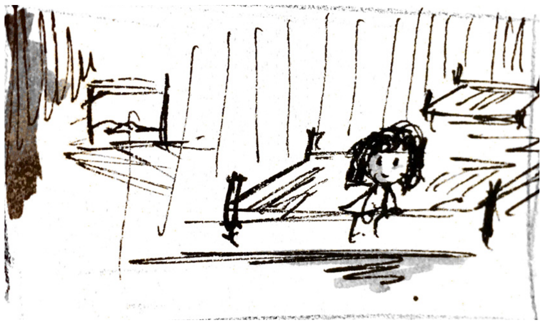
Visualisation of stakeholders and a potential solution to the design challenge

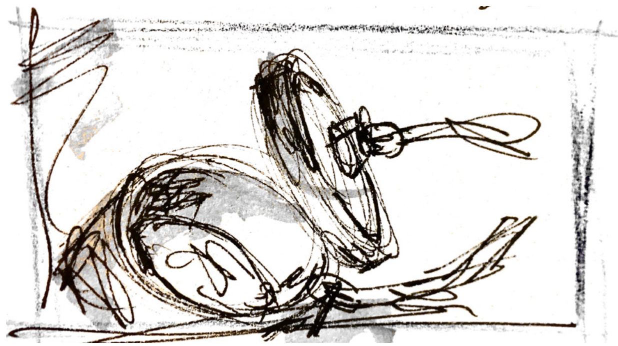
In a small community of nomadic (agro) pastoralists in the Somali region, Ethiopia…

Zala slowly opens her eyes to the soft, amber glow of the early morning. The sun has barely risen and the inside of her thatched hut is comfortably warm.



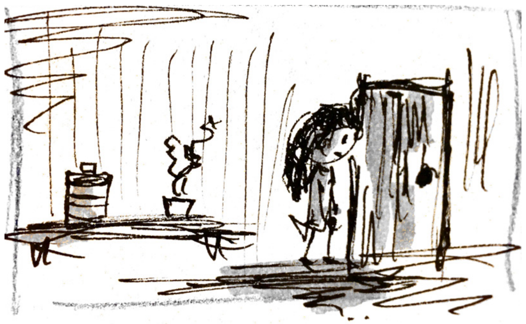


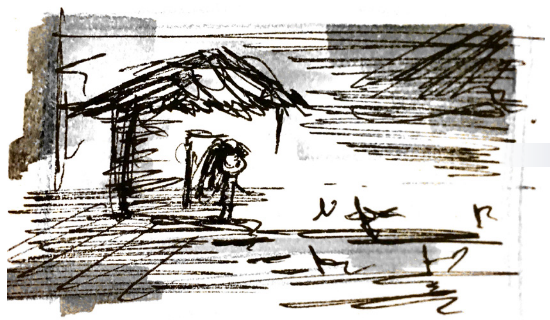




Her throat feels raw and dry after hours without water.

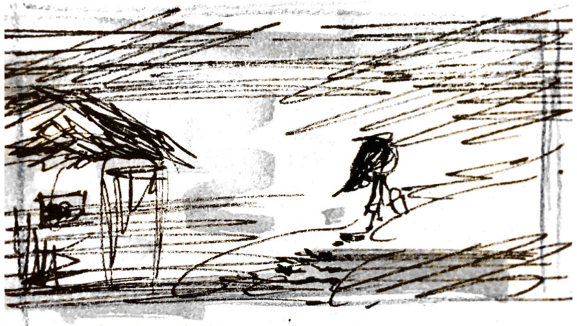
She drags herself up from her makeshift bed and groggily makes her way towards a small plastic tank a few steps away. She lifts up the lid and peers inside – it appears to be empty.



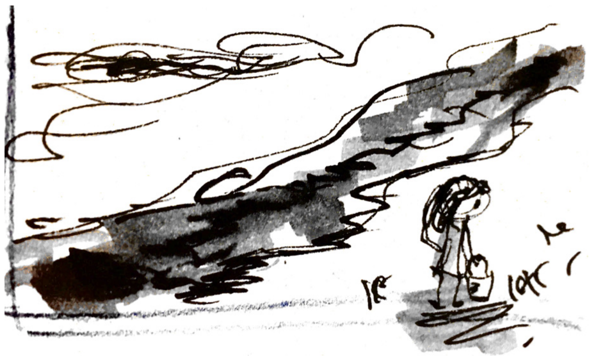


The bucket is empty save for layers of soot and dirt at the bottom that have accumulated over the years.

Even though the sun is still just a thin line on the horizon, the heat is already pressing. *What would I give for a cold shower?*, Zala thinks.

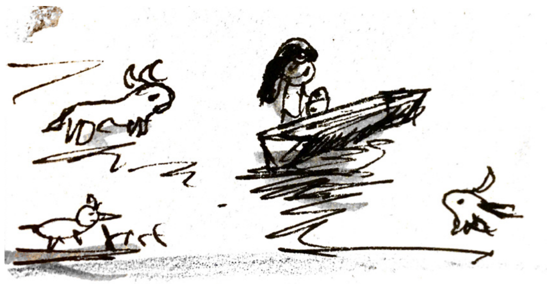


The water is very dirty, but it’s the best we have. What else can I do?

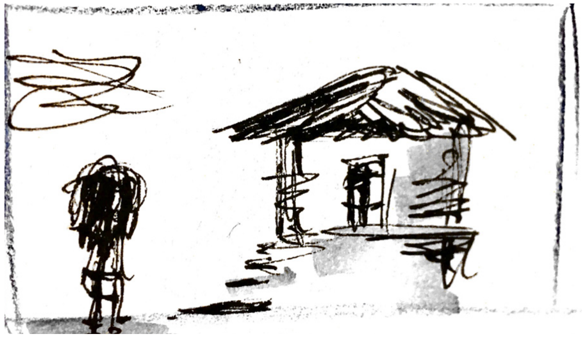


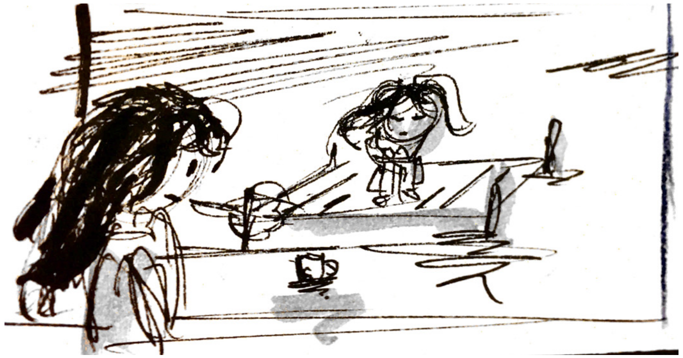
Her worn sandals slip and bend with each step; sharp edges of rocks digging through the thinning soles.

She’s used to it by now. She's long since accepted this daily monotonous cycle – maybe has even developed some sort of twisted fondness for the routine, but she still can't help but wonder if things could be different.



I can't even see the bottom of the trough anymore.

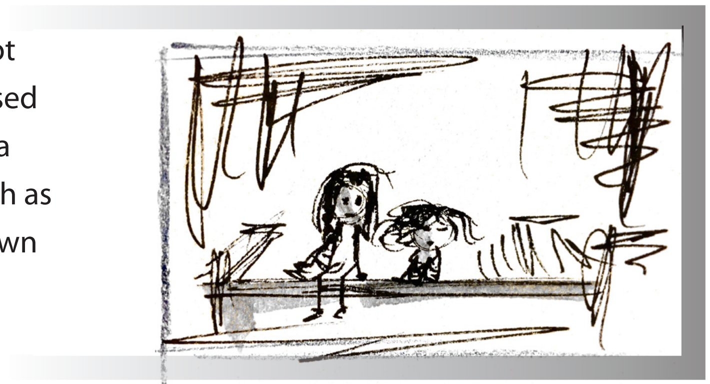




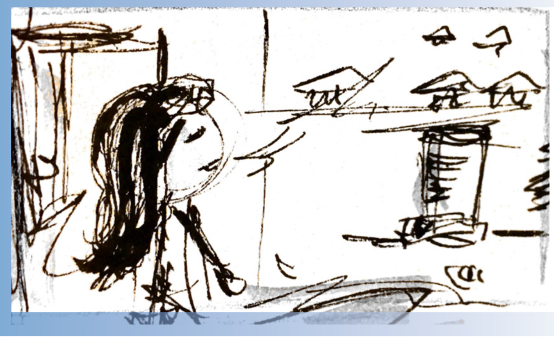
Maya is curled up on the smaller cot and coughing violently. Cold sweat glistens on her face; her eyes sunken and her skin sallow.

A mud-caked plastic cup of brown water stares at her from across the cot.

Zala does not seem surprised but lets out a defeated sigh as she flops down next to her sister.



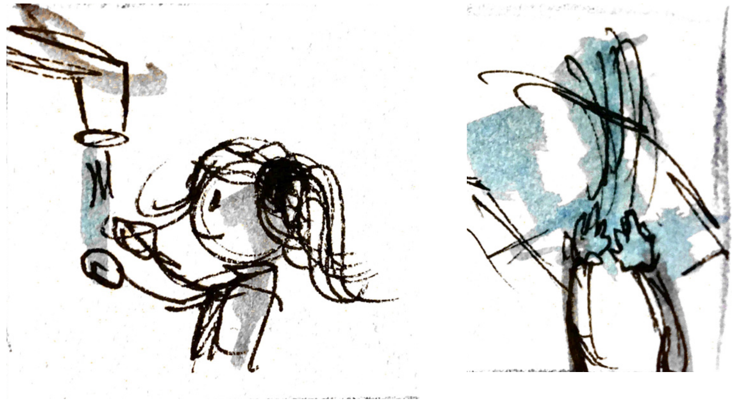
What if it doesn't have to be this way? What if technology could help alleviate the issue of access to clean water and restore to Zala and Maya the capabilities of health, life, imagination, and play?



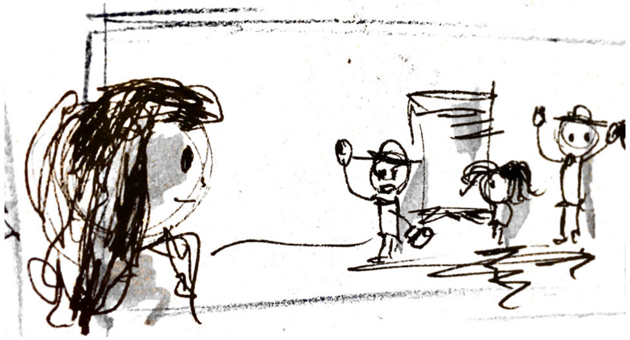
Zala takes a deep breath and closes her eyes gently, enjoying the peacefulness.

The sound of rocks and sand against shoes interrupts her mid-thought; she turns around to see Maya skipping towards the new central water storage that sits not far away.

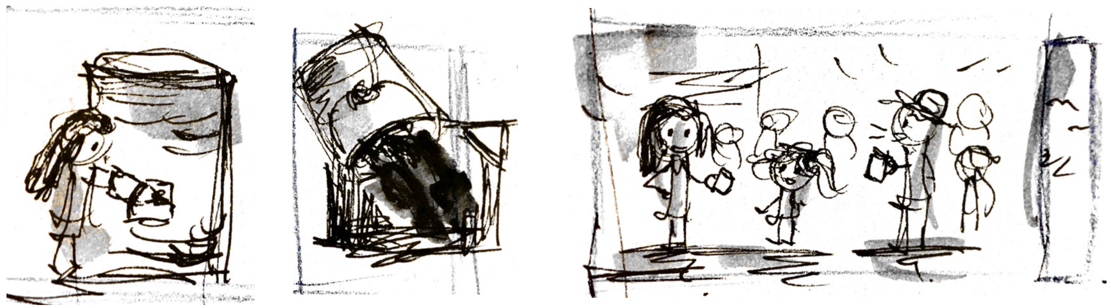
Clear water streams out into the jug and it doesn't take long before it is filled to the brim and Maya switches the tap off.



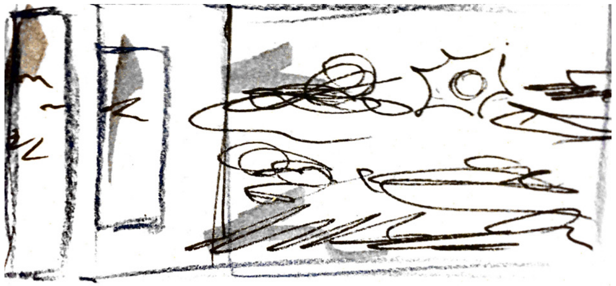
An hour has passed…Zala arrives at the clan with a bucket filled with water from the lake.



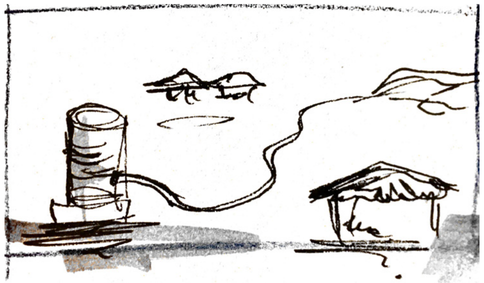
The crowd part with cheerful greetings as Zala approaches with the bucket.



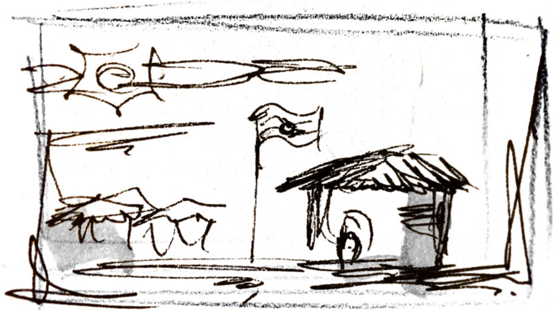
She pours the murky water into an opening at the back of the tank and happily rejoins her family and friends.

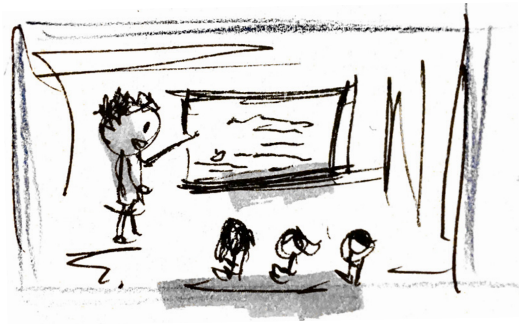


Weeks have passed…

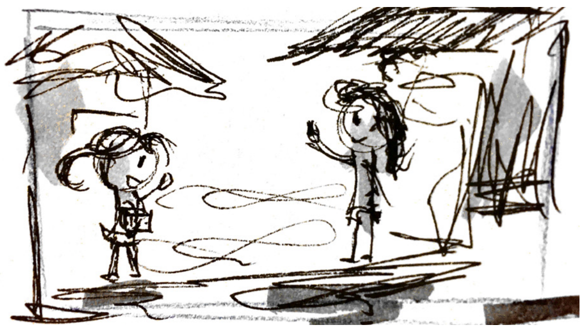


Zala and Maya's father Meleak led an installation of a water pump that connects the central tank to the lake.

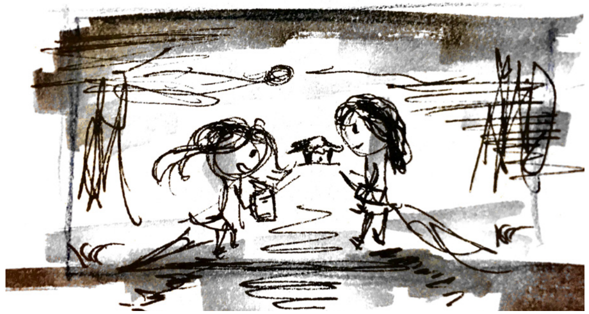


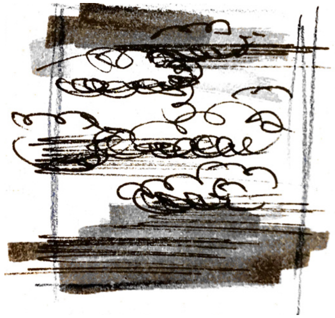


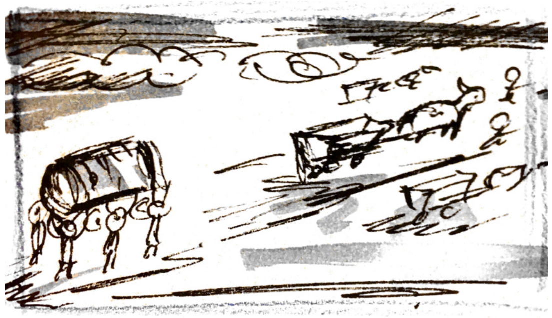
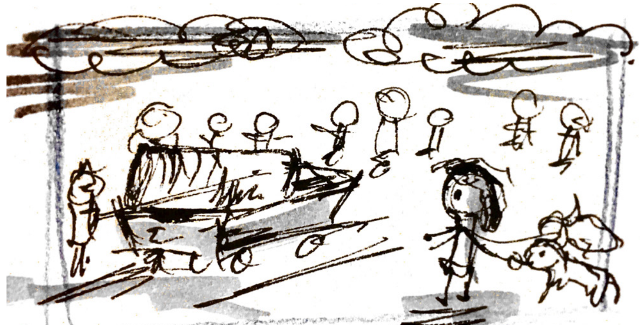
Now that finding water has become a thing of the past, she and her sister spend more time than ever before at school.

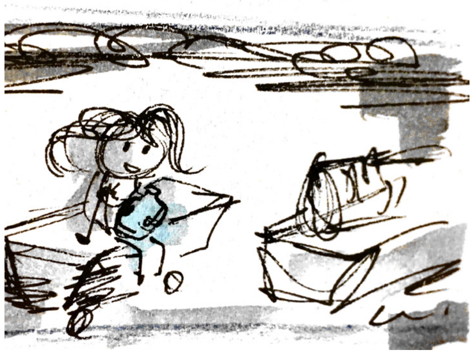


Class has just finished; Maya gathers her books and exits the classroom and runs into Zala who has also just finished her class. With books in hands, the two make their way back home all the while joyfully talking to each other.

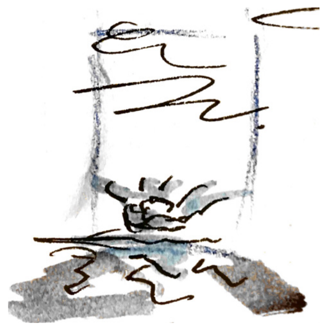


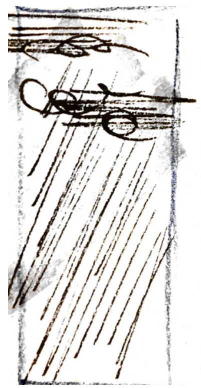


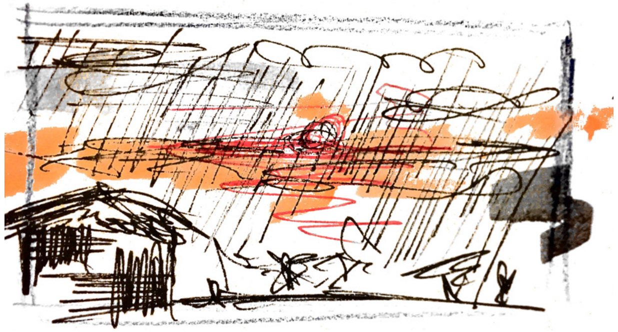


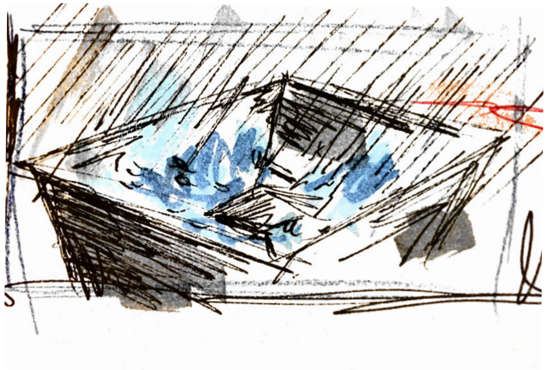
Another two months have passed…the overcast sky rumbles; the rain season has arrived and as always, it is time to move.

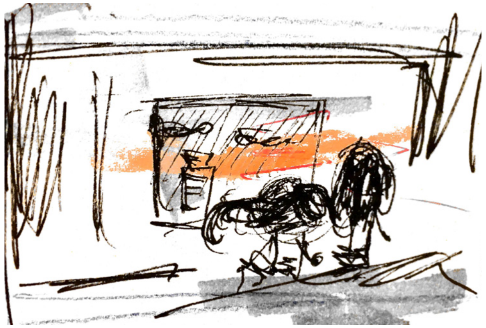



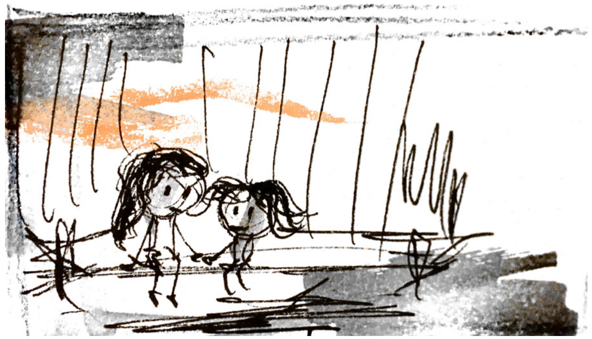

It is six in the evening. The warm orange expanse stretches far and wide. Raindrops fall steadily outside.







A few people are guiding cattle and a few more are taking turns filling up their containers with water from the central tank. The tank looks slightly different – there is now a large funnel at the top where rainwater falls in.



Remember those days when we would get sick almost every week – they feel so far away.

And as the last of the warm glow gives way to darkness, Zala and Maya look out beyond the horizon and wonder what tomorrow will bring.

COMPLETE STORY

In a small community of nomadic (agro)pastoralists in the Somali region, Ethiopia…

Zala slowly opens her eyes to the soft, amber glow of the early morning. The sun has barely risen and the inside of her thatched hut is comfortably warm. Her throat feels raw and dry after hours without water. As her eyes adjust to the dim light, she drags herself up from her makeshift bed and groggily makes her way towards a small plastic tank a few steps away. She lifts up the lid and peers inside – it appears to be empty. Disappointed, she replaces the lid and prepares to head outside to begin her day as usual.

The smaller cot next to hers is empty – *Maya must have woken up extra early today and already left to get more water*, she thinks. Zala is 19 years old and lives with her parents, her little sister Maya who is 14, and the rest of the clan. It is the dry season and the clan have just recently settled down not far from a lake. Zala pushes the plank door open and steps outside—

—not forgetting to grab a worn-out, aluminium bucket on her way out. The bucket is empty save for layers of soot and dirt at the bottom that have accumulated over the years. Zala begins her trek towards the lake…

About half an hour has passed. Even though the sun is still just a thin line on the horizon, the heat is already pressing. *What would I give for a cold shower?*, Zala thinks. She bends down to fill the battered bucket with murky water from the lake and prepares to head back home. *It's the best we have*, she tells herself again for the thousandth time. Deeply, though, Zala is quite concerned for the well-being of herself and her sister. She heard that the coronavirus is spreading fast and good hygiene is more important than ever, *but what else can I do?*

She raises the bucket and lets it rest on top of her head, supporting it with one hand, and starts walking. It is just the beginning of another day. Her worn sandals slip and bend with each step; sharp edges of rocks digging through the thinning soles. She's used to it by now. She's long since accepted this daily monotonous cycle – maybe has even developed some sort of twisted fondness for the routine, but she still can't help but wonder if things could be different.

Another half an hour later and Zala arrives at the clan. The dry, scorching heat of the early-July sun beats down relentlessly, dragging her down with every agonising step. In the distance, her father, Meleak, and her elder brother, Aman, are feeding the cattle. *Father and mother have always liked Aman better than me*, she thinks, sadly, and recalls that one time Aman was running a high temperature; Meleak didn't hesitate to take him to the Health Centre yet when Zala herself was sick, she was only given a handful of dried herbs to drink. She sweeps aside the nauseating thought and continues walking.

Zala makes a stop at a small fenced area where injured cattle and smaller animals live and empties half of the bucket into a rusty trough. The water runs murky and brown; she can't even see the bottom of the trough anymore. With the half-filled bucket in one hand, she labours back to her hut.

The weather-worn door is ajar and it lets out a pathetic creak as Zala pushes it open. Ashen-faced, Maya is curled up on the smaller cot and coughing violently. Cold sweat glistens on her face; her eyes sunken and her skin sallow. A mud-caked plastic cup of brown water stares at her from across the cot. Zala does not seem surprised but lets out a defeated sigh as she flops down next to her sister.

What if it doesn't have to be this way? What if technology could help alleviate the issue of access to clean water and restore to Zala and Maya the capabilities of health, life, imagination, and play?

—INTO THE CRISP MORNING AIR AND nascent rays of the rising sun. She takes a deep breath and closes her eyes gently, enjoying the peacefulness. In a few minutes, her family and friends will wake up and the day will officially begin. The sound of rocks and sand against shoes interrupts her mid-thought; she turns around to see Maya skipping towards the new central water storage that sits not far away.

They share a smile and as Zala walks over to join her sister, Maya pulls out a small plastic jug, sets it down on a stool below the tap, and steps on the pedal. Clear water streams out into the jug and it doesn't take long before it is filled to the brim and Maya switches the tap off. Maya offers Zala the jug which she happily accepts and takes a big gulp to relieve the thirst.

An hour has passed…Zala arrives at the clan with a bucket filled with water from the lake. A few people have gathered around the water tank; most are carrying some sorts of containers filled with water. Maya is amongst the group in front of the tap, washing her hands. Clear water runs through her fingers into a rack underneath the tap which appears to flow back into the lower part of the tank. The crowd part with cheerful greetings as Zala approaches with the bucket. She pours the murky water into an opening at the back of the tank and happily rejoins her family and friends.

Weeks have passed and the clan are thriving. Zala and Maya's father Meleak led an installation of a water pump that connects the central tank to the lake. Now that finding water has become a thing of the past, she and her sister spend more time than ever before at school, learning about all sorts of things; from history to mathematics to sciences. Class has just finished; Maya gathers her books and exits the classroom and runs into Zala who has also just finished her class. With books in hands, the two make their way back home all the while joyfully talking to each other.

Another two months have passed…the overcast sky rumbles; the rain season has arrived and as always, it is time to move. A group of six men are disassembling the water tank and carrying the parts towards a series of bullock carts in the distance. Zala follows behind, guiding a few cows by the leashes. The clan gather around the loaded carts. Maya is sitting in one of the carts, holding on to her plastic jug. The clan are jubilant; people are chatting excitedly. As the first raindrops fall from the sky of grey onto the cracked soil, the caravan departs…

The golden expanse stretches far and wide;

raindrops still fall steadily outside. Zala and Maya sit side by side in their hut, staring out from a small opening. A few people are guiding cattle and a few more are taking turns filling up their containers with water from the central tank, which looks slightly different – there is now a large funnel at the top where rainwater falls in. *Remember those days when we would get sick almost every week – they feel so far away.* And as the last of the warm glow gives way to darkness, Zala and Maya look out beyond the horizon and wonder what tomorrow will bring.

Appendices:

These appendices contain all the deepenings of each member of the team.
Each member focussed on a certain topic within the overal scope of the project, and identified it's own intended learning outcomes.

Contents

DIFFERENT APPROACHES TO CLEAN WATER

an analysis of different water sourcing and purification technologies based on the hydrology and context of Ethiopia

Kaspar's deepening

Introduction

Different technologies and techniques have been developed and used in order to provide clean water. All of them deliver peak performance in particular applications. Hence it is crucial to precisely analyze what solution is the most appropriate for a specific task. This deepening aims to analyze different technologies/techniques - traditional and innovative – that have been used to purify and source water. Furthermore, those technologies will be analyzed regarding their suitability and appropriateness for the rural Ethiopian lowlands. The geography, hydrology, climate, and life of the Stakeholders will be thoroughly investigated to ensure the analysis's validity.

In addition, at least one conceptual water purification/sourcing technologies will be developed, based on scientific research. This theoretical solution will be analyzed regarding possible shortcomings and promising aspects in general and the Ethiopian lowland's context.

To effectively display and communicate the outcomes of this exploration, an informative presentation will be prepared and delivered. This format has been chosen due to the high complexity of some of the technologies. To ensure understanding among the audience combination of pictures/videos, text, and the possibility for questions is most effective. Hence a presentation is more effective than a submitted document of any kind.

Intended learning outcomes:

Several skills are intended to be improved by implementing this analysis, and certain knowledge is intended to be acquired.

By researching the context of the Ethiopian lowlands, research skills and knowledge will be improved. The development of research skills includes the critical analysis of source credibility, precise paraphrasing, correct citation, and combining of different sources. The acquired knowledge will include geography, hydrology, and climate of the

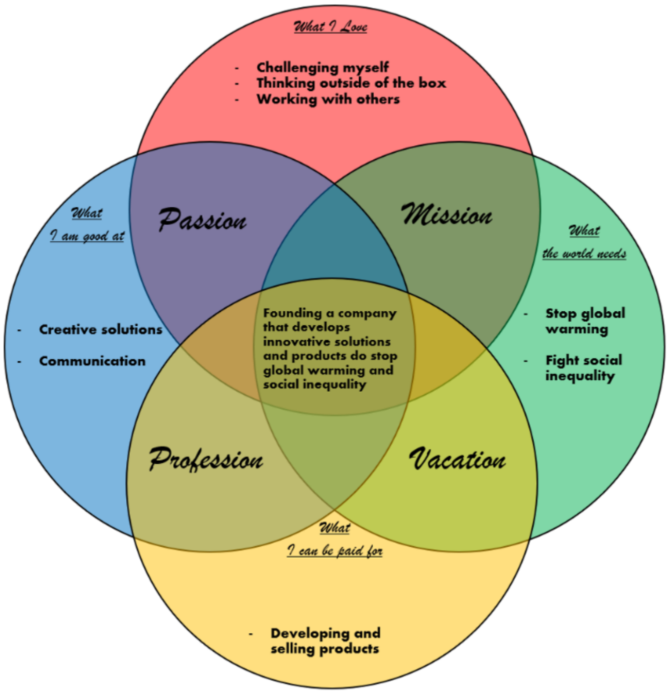
Ethiopian lowlands, and the inhabitants' values, culture, economy, and daily lives.

The exploration and analysis of different technologies will result in a considerable amount of knowledge in technology, engineering, and physics and help improve critical thinking. Critical thinking in this particular case refers to the constant testing of possible solutions and hypotheses from different perspectives. It also incorporates empathy towards the stakeholders, which is crucial to test the appropriateness of solutions.

Therefore the following intended learning outcomes can be formulated!

1. Ability to conduct well-reflected research, combining multiple credible sources
2. Thorough knowledge of water sourcing and purification technologies
3. Thorough knowledge regarding the Ethiopian Lowlands
4. Ability to mindfully analyze possible scenarios and to foresee occurring problems and possible solution
5. Ability to use scientific knowledge to develop an innovative technology (in theory)
6. Ability to effectively communicate complex technology to a non-expert audience
7. Ability to prepare a coherent, compelling visual support for the verbal communication

Relevance



This exploration is clearly connected to my ikigai. It addresses most of the things mentioned in my Ikigai diagram, including:

- Challenging myself
- Thinking outside of the box
- Creative solutions
- Communications
- Fight social inequality

It is also directly connected to my central Idea of "Founding a company that develops innovative solutions and products do stop global warming and social inequality", since it goes through the cycle of:

1. Analyzing the problem and context
2. Investigate existing technologies
3. Innovate new solution
4. Test solution
5. Adapt solution
6. Go to 4.

Which would be the primary working method of such a company. Therefore this deepening is closely connected to my life purpose and is therefore extremely relevant for me.

My team and the given design challenge will equally profit from this deepening. Analyzing different technologies regarding their fit for the challenge is one of the crucial steps in product development. I will furthermore use my expertise to develop innovative ideas for possible solutions that might exceed already existing techniques. Lastly, my research regarding hydrology, geography, and the stakeholders will improve the overall understanding of the challenge and help formulate needs requirements and functions of the product.

Evidence

Evidence of the research so far can be found in multiple places over this document. In the context study, the complete section of "Inspiring technologies" is a product of this deepening. Also, considerable amounts of the sections about Geography, hydrology, and the overall context emerged from this deepening. Furthermore, my expertise was used to develop some of the Ideas for the Prototypes.

MENS SANA IN CORPORE SANO

Jorijn's deepening

Topic: *"Mens sana in corpore sano"* is a Latin phrase which means: "a healthy mind in a healthy body". In my deepening, I want to extend my knowledge about the neurological effects of a SARS-Cov-2 virus and the lack of (clean) water.

Introduction on the topic

While people may think our brains control all our processes in our body, the body itself should not be forgotten either. In fact, some mental health issues may be caused due to our bodily health. Thinking about the context of our challenge, we can think of dehydration. This can be a reason for depression, since dehydration impedes your brains serotonin production, of which a lack is often linked to depression. Furthermore, dehydration can also be linked to anxiety and/or panic attacks (Crowell, n.d.)

Not only the lack of water, but also the water itself can cause mental affects. For example, research has shown that water contaminated with arsenic negatively effects mental health. Arsenic may effect certain brain cells and could thereby increase the chance on a depression, but feeling sick because of the contaminated water worsens mental health as well. (Chowdhury et al., 2016).

Lastly, viral viruses could also have an impact on people's mental health. Although further research is still needed, several influenza viruses, hepatitis C and human immunodeficiency virus are certainly connected to feeling anxious or depressed (Coughlin, 2012).

And, most importantly, research from Liotta et al. in 2020, showed that neurological manifestations indeed occur in most hospitalized COVID-19 patients. Although there is not much evidence yet, research from e.g. Paterson et. al in 2020 indicates as well that the SARS-Cov2-virus is associated with neurological and neuropsychiatric illnesses.

Why does it matter to me?

As a person, I have always been interested in psychology and mental health. I like reading small articles in magazines about psychological research and discovering how the human brain works. Last year, I took a social psychology course, and I really liked the fact I could immediate apply what I learned and that I was therefore able to better understand the world around me.

But, apart from understanding the human world, I love to learn about the natural world as well. Discovering how chemical processes work, or learning about physics. Lastly, I am interested in the link between our body and our thoughts and feelings, which is actually a combination of my first two interests. This link is something I also experience myself, for example having a headache when I am stressed. Therefore, regarding our challenge, I would like to learn more about the other side as well: how our mental health is affected by our bodily health. The information I will gain will contribute to the challenge, but will be also be applicable in my personal life.

Why is it important to the challenge?

One of the capabilities our final design will reinforce is bodily health. But, what are the effects of a better bodily health on our stakeholders? Of course, being sick less often or not having corona will improve their overall life quality. However, does this effect their mental health as well? How will our final design therefore implicitly mediate between our stakeholders and the way they see their world? These are questions I want to answer in my deepening. The answers will provide our team with a better understanding of the effects of our design on our stakeholders. Not regarding the functionality, but regarding the change in mental state because of our stakeholders' healthier bodies.

Format

I would like to present my deepening writing an essay, combined with pictures. This will allow me to share a lot of information, and convey my findings to others in an appealing way.

Intended Learning Outcomes

In this deepening, I would like to dive into the field of the neurological side of SARS-Cov2. I am not only interested in the effects this virus has on one's bodily health, but also on one's psychiatric state. I will therefore first research COVID-19 in the Ethiopian Lowlands, then the SARS-Cov2 in general, to better understand the context. From there on, I will research the neurological effects of this virus. This translates into my first intend learning outcome:

1. *To gain knowledge about the neurological effects of SARS-Cov2.*

Second, I am going to research what the status of the water in the Ethiopian Lowlands is like, and from there on I look into the effects on these contaminants on the mental health of our stakeholders. This brings us to my second intended learning outcome:

2. *To gain knowledge about the effects of a lack of (clean) water on our stakeholders' mental state.*

In order to convey to the outer world what I learned, I have to effectively communicate my findings in a visual and textual appealing way. This will most likely be something I will discover during the process of collecting and synthesizing my information. I will also use skills I obtained during the design visualisation course for this. This then translates into my final intended learning outcome:

3. *To learn how to effectively communicate my findings into a compelling visual and textual representation.*

Evidence

To start of my exploration, I started looking into the actual virus itself: the Sars-Cov-2 virus. In the following section, I will represent some of my findings.

Taxonomy

The current pandemic is caused by a virus called SARS-Cov-2, with SARS meaning Severe Acute Respiratory Syndrome. Looking at the taxonomy of SARS-Cov-2, we find this virus is part of the genus of betacoronavirus, which is part of the subfamily coronavirinae, which is part of the family coronaviridae (ICTV, 2019). Within this family, there are several other viruses that are known to be pathogenic to humans, which means they have the property of causing a disease when humans are infected with them. HCoV-OC43, HCoVHKU1, HCoV-NL63, and HCoV-229[E], are all viruses with low pathogenicity (Walls et al., 2020). Next to this, SARS-CoV and MERS-Cov, both within the same genus as SARS-Cov-2, are known of causing deadly pneumonia (lung inflammation caused by a virus) to humans. The latter emerged in the Arabian Peninsula in 2012, spread to 27 countries, infected roughly 2500 people and caused 858 deads. Just like SARS-Cov2, SARS-Cov, most likely originated in bats. This virus spread to 5 continents, infected 8098 people and caused 774 deads (Walls et al., 2020).

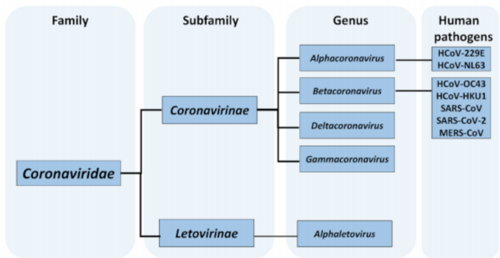


Figure 1 The taxonomy of the family Coronaeviridae and its human pathogens (figure retrieved from Wartecki et al,, 2020)

Properties of SARS-Cov-2

Coronaviruses are known to have a crown-shaped appearance. This is caused by spiked glycoproteins on the outer layer of the cells (Cascella et al.,2020). These glycoproteins mediate the entry of the viral particle into the host cell, in this case, a human cell.

Research from e.g. Walls et al. in 2020 showed that SARS-Cov-2, just as SARS-Cov, uses the same receptor to enter the target cells, called ACE2 (angiotensin-converting enzyme 2). The fact that both viruses bind with similar high affinity to human ACE2, explains why this virus spreads so efficiently among humans. This is the reason why it is very unlikely to believe SARS-Cov-2 was created by purposeful manipulation. The binding optimality is so high that it could only be caused due to natural selection (Anderssen et al., 2020) This similarity in binding could be benefiting for developing a vaccine, since polyclonal antibodies inhibit from SARS-Cov inhibit the entry from SARS-Cov-2 mediated by the spike glycoproteins into cells. (Walls et. al, 2020)

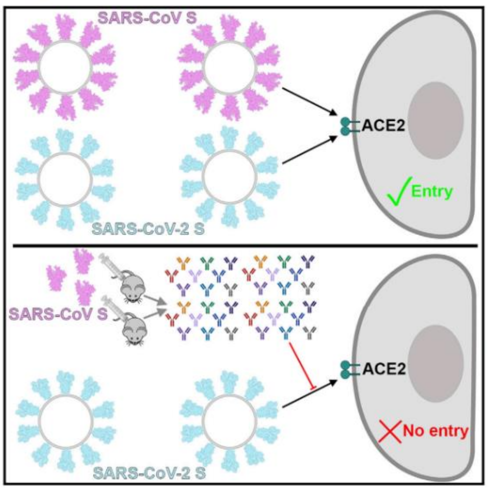


Figure 2 A graphical representation of SARS-Cov-2 (not) entering its target cell. (Retrieved from Walls et al., 2020)

If we look more specifically into SARS-Cov-2, we find that this virus is often has a round or elliptical shape, and a diameter between 60-140 nm (Cascella et. al, 2020). However, due to the fact that the lipophilic envelope of the virus (the outer layer of the cell which has affinity of lipids) can integrate different kinds of proteins, the cell is really flexible, which leads to a pleomorphic shape (Schneller et al., 2020)

There are many more specifics to find about SARS-Cov-2, such as the specific structure of its genome, a single stranded RNA string, it's molecular weight etc. For now, I will go a bit more into depth into the chemical properties of SARS-Cov-2, since these will be useful while designing a potential solution to our challenge.

In general, high temperature leads to a decrease in growth for any type of virus, including SARS-Cov-2. The research from Cascella et al. indeed states that like other coronaviruses, SARS-Cov-2 is sensitive to heat and UV-light, although it is relatively stable (Schneller et al., 2020).

Heilingloh et al. in 2020 investigated this susceptibility and reported the following:

"A viral stock with a high infectious titer of $5*10^6$ $TCID_{50}$/mL was completely inactivated by UVC irradiation after nine minutes of exposure. The UVC dose required

*for complete inactivation was 1,048 mJ/cm." (*Heilingloh et al. , 2020, p. 1273)

This shows that SARS-Cov-2 is highly susceptible to UVC light, which has wavelengths from 200-280 nm covers the UV-light spectrum together with UVA and UVB (Schneller et al., 2020).

Pasteurino et al. in 2020 researched heat inactivation on SARS-Cov-2 at different temperatures, and found that at lower temperatures, the virus could be inactivated, but was still infectious after an hour. But, they found that heating for 15 minutes at 92 degrees Celsius, drastically reduced the amount of detection.

Neurological effects of SARS-Cov-2

I already did some general research on the possible neurological effects of SARS-Cov-2 and selected some papers I want to study further in the coming weeks. These papers indicate there are indeed neurological effects of COVID-19., but do not always explicitly explain how these effects occur. I will therefore use these papers as my starting point, and dive deeper into this topic from there on.

Water in the Ethiopian Lowlands

I already spent some time on researching the water quality in the Ethiopian Lowlands, however, there was not much information I could find. This is also in accordance with the research of The World Bank Group and the UK's Department for International Development in 2019, which indeed reported there was not much information available about the water quality in the lowlands. I will therefore proceed to look into the mental effects of water scarcity and will also try to look at different diseases as a result of the unhealthy water, instead of looking into the water itself.

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THE SIMPLICITY OF DESIGN SKETCHING

Merijns's deepening

Introduction

In order for a product to appear, it has to appear visually. In the first stages of developing and iterating a new solution, this happens in the form of design sketches. Therefore, design sketching is a very useful skill to have in the process of designing. It makes your ideas come to life. Sometimes, an image speaks more, than a thousand word could ever say.

For my deepening I want to dive into design sketching. I will do this by experiencing myself how the learning and thought process of design sketching happens. By following the design sketching course, I laid the grounds for my development of my own sketches. In my deepening I want to broaden my skillset and develop my sketching skills. I especially want to look at simplicity. How do you create a clear prototype, with a minimal skillset and minimal amount of lines and visuals?

The format of my deepening will be a crash course on simple design sketching. This will be either in the form of a pencast video or a presentation. I will use this format because I can portray the simplicity and quickness of the theory of basic design sketching in a coherent and dense way. I came up with this, since I have been helping classmates the last weeks with design sketching, where I tried to explain the theory as concise as possible, but still understandable. I got good feedback on my method and therefore want to explore whether I can take it further. Further from a one-to-one scale to a course that can be used by everyone.
This format will be good because I believe that if you can explain something in a good, understandable way, you know you master the theory. Therefore, this format will show my competences in the field of design sketching.

Intended Learning Outcomes

First of all, I want to develop my design sketching skills. I want to develop my work with perspective, shape definitions, foreshortening and shading. I want to develop and define my style in sketching.

Moreover, I want to learn how to make the information dense and understandable for people without any background knowledge or skills. This will require some research into learning techniques and some exploration of different methods to bring the information across.

Intended Learning Outcomes

1. Develop basic design sketching skills, focussing on the simplicity of the sketches.

2. Classify different quick and concise learning/teaching strategies and learn how to use them

3. Design a clear and concise crash course on the basics of design sketching

Relevance

As I describe in my Personal Development Plan for ATLAS and will be doing for my Personal Pursuit, I am interested in education. Talking about education gives me energy. Learning about education gives me energy. Providing education gives me energy. However, there is still a lot to learn and a lot of skills I want to develop in terms of providing education. I provided many tutoring sessions in my high school, I'm in EduCo, I do my PP about educational models and systems, I help prepare the Thursday project lectures and I don't want to stop there.
All my life I have been drawing and tinkering. I've always been exploring my creative and artistic side, but this stopped about three years ago. I said I was too busy with my schoolwork, but I discovered during ATLAS, that that is a very bad argument. Drawing and sketching makes me happy and therefore I want to do it more often. Moreover, I belief sketching is a skill that is really useful for conveying a message. In my drawings, there is

always a story. With design sketching, you also tell a story. You tell the story of a product, a product which has the potential to become a solution for any identified problem. This power intrigues and interests me. Therefore, I want to learn more about this skill.

In light of the project, I think design sketching as a deepening would benefit the team, because I will learn more about design sketching, and therefore can implement that into our prototyping. For prototyping, it is very important that the sketch in clear and correct, because from there we can evaluate it much better and iterate our solution. Moreover, as a team we had some struggles with the simplicity of sketches. Sometimes the sketch gets lost in the enormous amount of lines and details, cramped up next to each other. If I learn about this, it will benefit the team because I can pass my knowledge on to them and incorporate it in my sketches.

Evidence and Results

So far, I have mostly been working on my own sketching. I started with this, because I think you can only pass information on, if you first master it yourself. Therefore, the work I have done so far concerns my first ILO. The evidence for this is incorporated in the deliverable. I have made most of the preliminary sketches, and for the ones I have not made, I delegated and explained exactly what the person concerned had to do. Moreover, I made all the prototype sketches, where I explicitly focussed on simplicity.

Conclusion

My deepening has changed a lot since the beginning. I was always trying to fit it to the project, to serve my teammates as good as possible. Only recently I realised that this should not be the approach. My deepening is something I want to do. Of course, there is still a clear link to the project, and my deepening will definitely contribute to and benefit the project.

However, my mindset towards it has shifted, making me way more excited about it, because my deepening now suits me, and what I want to do. Although I have not done or accomplished many of my learning outcomes yet, I am positive I will accomplish them.

PHILOSOPHY OF TECHNOLOGY AND DESIGN

Pookhao Chinpongsuwan

PHILOSOPHY IS A CONCEPTUAL discipline. Philosophy seeks to understand 'how things in the broadest possible sense of the term hang together in the broadest possible sense of the term' (Sellars, 1963). Simply put, it is not defined by one particular subject, but by its methodology of critical reflection – it concerns general and fundamental questions. Do we have free will? What is the best moral system? Is there life after death? These are some of the classic philosophical questions.

Philosophy of technology, as the name implies, revolves around technology and how it 'hangs together' with other things – mainly people and society. The discipline dates back to ancient Greek but has seen a significant progress in development in the 20th century after World War II following the invention and proliferation of digital technology. In the same way, philosophy of design seeks to understand the various interplays between design and society.

To put it in perspective, a large part of the theoretical framework of our design challenge is based on the 'postphenomenological' approach, which revolves around the relations between humans and technological artefacts – the idea that technologies are not only functional tools but active mediators of how we perceive the world and how the world is presented to us (Rosenberger & Verbeek, 2015). The theory of technological mediation, as discussed earlier in the paper follows closely on this concept. How do technological artefacts influence our behaviour? How can we, as designers, weld the power of inscribing scripts into our design responsibly? The capability approach also relates to this. How can we design mediations to best enhance the capabilities in our stakeholders?

Final outcome

I plan on creating an academic poster or an infographic as the final outcome of my deepening. This format will allow to me to summarise most important concepts and theories in a visual and intuitive way but also allows for more in-depth explanation in writing, similar to a text essay. The fields of philosophy of technology and design are rather complex so it is only useful if different traditions and subbranches are presented in a visual way that clearly showcases their similarities and key ideas. I believe this format will also be useful for future students as an introduction to the fields.

Intended learning outcomes (ILOs)

In my deepening, I want to study the interactions of technology and design with people and society and the implications. I formulated the following ILOs to structure my learning process.

- ***ILO 1*** understand various ways technology interacts with people and society
- ***ILO 2*** understand various ways designers can control these interactions

- ***ILO 3*** understand the ethical concerns and implications and how designers can best address them.

Across all three ILOs, I will develop analysis & critical thinking skills and research & information skills, which correspond to the ILOs of the Semester Project course. By developing these skills and gaining knowledge in the fields, I will be able to apply them to our design challenge and hence also progress on my semester goal: 'systematically and in collaboration with peers design a targeted solution for a sociotechnical problem'.

Additionally, the creation of my final outcome will also allow me to develop my communication skills, which corresponds to one of the Semester Project ILOs.

Personal reflection

I have been interested in technology since a rather young age. I believe that technology is and will be one of the main driving forces to a more efficient and sustainable society of the future. More recently, having been exposed to various new academic fields, philosophy is something that I find fascinating because it deals with questions that cannot be answered by science – questions that cannot be answered with pure objectivity or logic.

With my broad interests and adaptability, I have been considering entrepreneurship as a possibility for my future career. Entrepreneurship offers the freedom and flexibility of working on solving some of the most complex, globally-significant problems (e.g., climate change, barriers to education, and large scale conflicts and wars). Philosophy of technology and design complements this interest; the combination of the two fields will enable me to see the world and consider global problems not only from the objective perspective of science but also from a more subjective, human-centric, and empathetic point of view of philosophy.

Relevance to the design challenge

As we are designing a product that will be used by people, it is important to consider the responsibility of us – as designers – to create a design that is not only functional but appropriate and ethical in the context of our stakeholders – agro(pastoralists) living in Ethiopian lowlands.

A philosophical concept which I find interesting is the allegory of the cave by Greek philosopher Socrates. The allegory describes a group of people who have spent their whole lives imprisoned in a cave, facing an empty wall. They observe a shadows of objects outside the cave projected on to the wall. To them, the shadows are their reality and they have no desire to discover the true nature of the outside world, 'for they know no better life' (Ferguson, 1922). Could this be applied to our stakeholders, or people living in hardship for all the lives in general? What if they could not handle a huge change to their lifestyles – even a positive one – caused by our innovation?

It is important to consider alternatives perspectives such as the one above. It is important to raise difficult philosophical questions like this in order to be aware of the possible unintended outcomes that our design could create. This relates to the theory of design mediation as previously discussed. Designs do not end merely when the artefact has been delivered. What if our design – despite our good intentions – turned out to have the opposite mediating effects to what we intended?

Progress and evidence

So far, I have studied broadly concepts and theories, such as the postphenomenological approach & theory of technological mediation and the capability approach. For these, I contributed to the the following sections of Deliverable B, which I present as evidence of my progress:

- 6 Design ethics & design philosophy
- 9 Translating stakeholders' needs into design requirements.

On 4–7 November 2020, I attended the Philosophy of Human–Technology Relations conference to learn more about the state of the art of the field. I was introduced to a number of new relevant concepts such as:

- material pragmatism
- dark design
- paternalism and autonomy
- social appropriateness.

Compared to last month, my deepening has definitely become clearer and better defined. Nevertheless, the field of philosophy in general is still mostly new to me. To get a good overview, I plan on starting by looking into a few classical philosophers – Aristotle, Heraclitus, and Plato – whose ideas and methodology form the bases for modern philosophy of technolgy and design.

Afterwards, I plan on consulting the following literature to delve deeper into the philosophy of technology and design, as opposed to just philosophy in general:

- *What Things Do: Philosophical Reflections on Technology, Agency, and Design* by Peter-Paul Verbeek
- *Technology and the Lifeworld* by Don Ihde
- *Nudge* by Sunstein and Thaler
- *The Question Concerning Technology* by Martin Heidegger.

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