Multi Disciplinary Project

The installation of two M-100 Chlorinators at the border of the Amazon in Tena, Ecuador

H.Drost B.Kurstjens R.Rutgers

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by

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TU Delft

Preface

To obtain 15 ECTs for our Masters programme, we did a multi disciplinary project in Ecuador. The goal was to install two water chlorinators nearby Tena, a small city at the border of the Amazon rain forest in Ecuador. Apart from the main goal, we wanted to learn a lot about the country, its communities, culture, and way of work. During the project, we visited different parts of the country, each with its own characteristics, culture and people. Gaining insight in this, it made it easier for us to cooperate with the locals and therefore, increasing the interdisciplinary aspect of the project. It became clear that not only engineering insights are needed for such a project, but that one needs to understand to cooperate with the locals and use local resources to enhance the success of a development project in a foreign country.

We would like to give a special thanks to our local supervisor Miguel Andrés Guerra for helping us realising the project and helping us to get in contact with the locals. Speaking about, we would like to thank Jessica Vaca and Neyson Vaca for arranging community visits in Tena, showing us the local habits and supplying us with local resources. We would like to thank the Engineers Without Borders team for their support in this project. Also, we would like to thank Ronny Almeida for being our fourth team member and allowing us to do this project. Lastly, we would like to thank Eva Lantsoght and Jeroen Hoving for making time to help us doing this project on behalf of the Technical University of Delft.

H.Drost B.Kurstjens R.Rutgers
Delft, April 2024

Contents

1 Introduction

1.1. The team

This report has been written on behalf of a project team composed of four students who carried out a multidisciplinary project. The team consists of three master students of the TU Delft in the Netherlands and one graduate student of USFQ in Ecuador. The three TU Delft students are specialized on hydraulic and offshore structures, while the USFQ student is specialized on environmental engineering. The project is part of their studies and is a full-time commitment during one semester. The team collaborates with an organisation called Engineers Without Borders (EWB), consisting of five USFQ students. Their student chapter is part of Engineers Without Borders International, a global organisation with teams worldwide.

1.2. The project

The University San Francisco Quito (USFQ) has been provided with two WaterStep water chlorinators by an organisation in Canada. These water chlorinators are used to turn contaminated or dirty water into clean drinking water. The main goal of the project is to install these chlorinators in two informal communities located in Ecuador that are in need of clean drinking water. This project builds upon a previous project that took place during September to November 2023, which was also a multidisciplinary project executed by students of the TU Delft in collaboration with the members of EWB. During their project, they had to spend much of their time in finding suitable communities for installing the chlorinators, meaning for this project this was less of an issue.

1.2.1. The communities

As the team arrived in Ecuador, their supervisor of USFQ had been in contact with a local residence of Tena, a city located in the centre east of Ecuador. The city is also called 'the gate to the Amazon'. Around the city of Tena, the local contact person knew about four possible communities that would benefit from the installation of a water chlorinator. The focus was mainly on schools and universities within the community / village. Before visiting the communities, the project team conducted literature studies on international engineering in informal communities and on community selection. This was done to gain more knowledge and insights on how to successfully implement an engineering application in an informal settlement. More information on the literature studies is provided in Chapter 2.

1.2.2. The water chlorinator

As mentioned before, a water chlorinator is used to create clean drinking water out of contaminated water. It does so by creating chlorine gas out of salted water. The chlorinator has two tubes that are connected to the tank of contaminated water, one for the input and one for the output. A pump inside the tank pumps the contaminated water into the chlorinator. Then, the chlorine gas is added to the in-flowing water, and consequently pumped back into the tank. This process continues for one to a few hours, depending on the size of the tank, until the chlorine level of the water reaches 3 ppm. After this, the treated water needs to sit for one hour and once the chlorine level reaches between 2 and 5 ppm, the water is safe to drink. By adding chlorine to the contaminated water, unhealthy bacteria will be eliminated. The water chlorinator is not able to remove salt or chemicals from the contaminated water. Figure 1.1 provides an overview of the set up of the water chlorinator and the water tank. In this case, the electricity for the chlorinator is provided by a battery, but it can also be connected to the main electricity network. More information on the power supply and usage of the chlorinator can be found in Chapter 4 and Appendix B respectively.

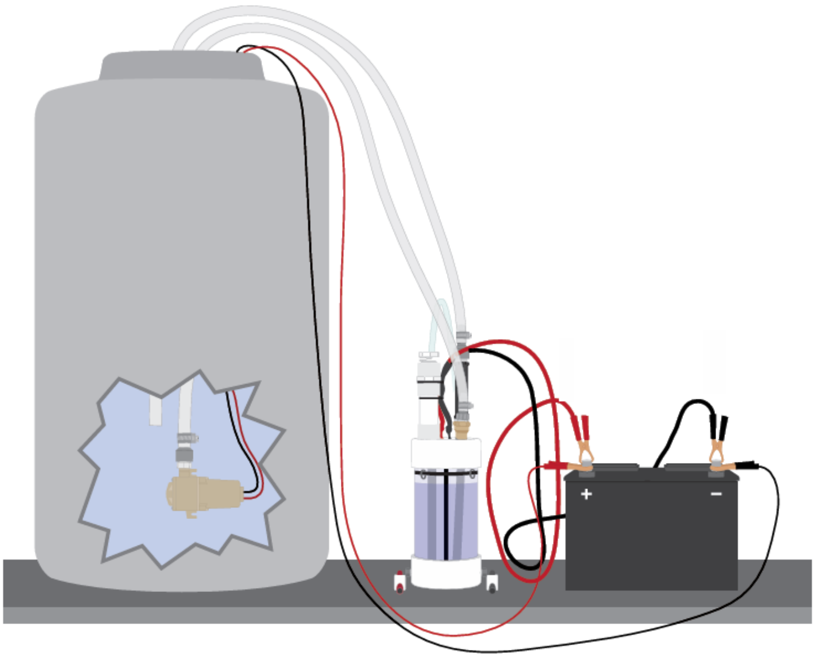

Figure 1.1: Set up of water chlorinator

1.3. The objectives

Together with the local supervisor, the project team came up with four objectives as part of their multidisciplinary project in Ecuador. These are:

1. Conduct a comprehensive literature review on *Influential factors of international engineering on informal communities* and *Selection process of informal communities in need of international engineering*.
2. Conduct service trips, followed by community selection and installation of two water chlorinators at two different schools / villages.
3. Registration of the student chapter Engineers Without Borders at Engineers Without Borders International.
4. Present a colloquium for students of USFQ on topics related to hydraulic and offshore structures.

1.4. Report structure

This report firstly elaborates upon the literature review that was conducted to improve the chances of the project being successful, in Chapter 2. In Chapter 3 and Chapter 4, the service trips and the installation of the two chlorinators are described. Chapter 5 briefly covers the objectives of the EWB registration and the colloquiums. Lastly, the overall project and experience is reviewed in Chapter 6.

2

Literature on international engineering in informal communities

Many international students, international engineering companies or Non-Governmental Organisations will come to a country, that they are not familiar with, and try to apply their knowledge on development problems in countries that are often underdeveloped. This international help is often referred to as Humanitarian Engineering (or International Engineering). Humanitarian engineering involves the application of engineering principles and methods to address pressing global challenges, particularly those affecting marginalized communities and vulnerable populations. It aims to develop sustainable solutions that improve quality of life, enhance resilience, and promote social justice. It is often the case that an engineer's expertise is adequately being used in such communities, but as soon as the engineer leaves the project site, the solution that was imposed, is being neglected by the community's members or the community members aren't educated properly on how to work with the solution.

2.1. Influential factors on conducting service engineering trips

To ensure the project team delivers a project that is beneficial on the short-term and long-term, the students needed to gain more knowledge about the habits, the culture, the ethical standards and the smaller communities in South-America and Ecuador. But also on the success factors of humanitarian engineering projects and how to ensure the project will continue to be successful on the long-term, even when the project team is not able to visit the selected community anymore. That is why, to kick-off the project, the project team conducted a literature study on international engineering and the influence of such projects on informal communities. The main takeaways from this literature study will be discussed below, for the full paper see [H. Drost, 2024b].

The literature study examined numerous cases of international engineering applications in informal communities to gain knowledge on this topic. Specifically, recurring factors influencing the success or failure of these projects were identified. It came out that effective co-production and communication between external entities and local communities are essential factors. They ensure that insights and expertise from all parties are valued and that community needs and issues are clearly understood. Successful implementation leads to efficient service delivery, improving community health and living environments while addressing their needs. Given the threats posed by natural hazards, climate adaptation solutions are imperative for community protection. Environmentally-based engineering applications, centrally implemented, provide affordable services to local residents. Local initiatives have demonstrated improvements in community economics through income generation and cost reduction, even reducing carbon footprints. External funding from sources like local governments, universities, NGOs, and companies is often crucial for realization. By incorporating these factors with a fit-for-purpose approach, international engineering applications can effectively address the needs and issues of informal communities.

The literature study mainly focused on the key factors that optimizes the goal of such humanitarian engineering projects. However, relying solely on these takeaways cannot guarantee the success of a project. The process of community selection should be undertaken carefully as well. It is recommended that each unique project comes up with a selection procedure to identify suitable informal settlements.

2.2. The selection process of informal communities in need of humanitarian engineering

Managing a community selection process in a foreign country can be challenging. Therefore, to drive the success of this project, a second literature study is conducted on the selection process of informal communities in need of humanitarian engineering. A short overview of this study can be read below. The full paper can be read here [H. Drost, 2024a]. Only the theory behind the selection process is summarized here, the application and the results of the selection process on this project is reported in chapter 3.

Community selection involves the systematic evaluation of various potential locations for project implementation or international engineering initiatives. The process involves two phases. The first phase entails setting up the selection framework by gathering all the data and information on the target communities. The second phase is the actual selection of the community.

2.2.1. Phase one: setting up the selection framework

Firstly, the indicator system commonly employed for community selection in small areas offers a viable selection approach. This system encompasses exclusion, suitability, and demand indicators, each assigned scores for every alternative. Exclusion indicators play a pivotal role in primary community selection, identifying areas unsuitable for construction due to legal, regulatory, or experiential factors. These criteria serve to disqualify or exclude certain options, streamlining the selection process. Following the exclusion phase, secondary community selection begins, focusing on remaining locations and prioritizing those best aligned with project objectives. Secondary selection relies on suitability and demand indicators. Suitability indicators gauge the appropriateness of a community, considering infrastructure, environmental factors, socioeconomic status, and community readiness. They assess whether a community possesses the necessary characteristics and resources for project implementation. Demand indicators evaluate the level of need or interest within a community for project services, analyzing factors like population density, health, and community preferences. By leveraging these indicators, engineers gain insights into the specific requirements and priorities of the community.

The three types of indicators were determined by reviewing literature and were subsequently used in this project. All the indicators are enumerated below and are letter-numbered for convenient purposes. Note that these indicators are only applicable on this specific project and should be adjusted accordingly to the scope of the project.

- *Frequent supply of water (A)*
  To ensure the effectiveness of the chlorinator installation and usage, a non-continuous but frequent water supply is essential. The tank should be ready to be refilled whenever it is close to being empty.
- *Chlorine level (B)*
  It is self-evident that if the water is chlorinated already, the installation of a chlorinator would be otiose. Specifically, the chlorine level in the water should be lower than 0.1 ppm.
- *No other contaminants (C)*
  In addition to chlorine, the water should be evaluated for other contaminants, as a chlorinator cannot eliminate all types of pollutants. First, the water should be evaluated on Coliform and E. coli. These substances can be eliminated by a chlorinator. If the water contains for example nitrate, the water cannot be treated with just a water chlorinator.
- *Non-continuous system (D)*
  The chlorinator that is used in this specific project does not work on continuous water systems. The chlorinator needs a non-continuous system since there should not be more water added to the tank when the chlorination process has started.
- C*entral location (E)*
  A central location is preferable, so that the majority of people can use it and the distance to be covered is minimal.
- *Access to electricity (F)*
  The used chlorinator needs electricity to work. Access to electricity would avoid the use of an external battery. Which will reduce the cost and provide a continuous access to electricity.

- *Safety (G)*
  The need of a location where the chlorinator can be installed securely, avoiding theft or damaging the chlorinator. This also includes environmental hazards.

- *Local responsibility (H)*
  After the installation of the chlorinator, the community takes responsibility of the maintenance. At least two persons, a group or a board should be appointed and take the responsibility over the chlorinator, since it must be refilled and maintained regularly.

- *Population density (I)*
  The population density should be high to increase the number of people that benefit from the chlorinator. As it can chlorinate a large amount of water every time.

- *Health conditions (J)*
  Settlements with higher rates of waterborne diseases or poor health outcomes related to water quality may have greater demand for water chlorination.

- *Financial conditions (K)*
  Settlements with higher levels of poverty or limited access to resources may have greater demand for affordable water chlorination solutions.

The indicators A-D are exclusion indicators, indicators E-G are suitability indicators, and H-K are demand indicators. To measure the importance of each indicator, the Analytical Hierarchy Process (AHP) was used. The AHP is a decision-making method to rank alternatives based on pairwise comparisons. The AHP starts off with a nine-point scale pairwise evaluation on all the criteria and alternatives. After the pairwise comparison, an *n x n* matrix, with *n* being the number of criteria is created to calculate the relative weights of all criteria and alternatives. To do this, the matrix is first normalized by dividing each value with the sum of the columns. The next step is to calculate the eigenvector, which will automatically give us the relative weight of each criterion. This is simply done by summing the row and dividing them by the number of criteria. This is an iterative process and will stop once the difference between two iterations is exceedingly small. An overview of relative weights and final weights are given in table 2.1.

Table 2.1: Relative and final weights of the indicators using the Analytical Hierarchy Process.

	A	B	C	D	E	F	G	H	I	J	K	FINAL WEIGHT
A	1	1	1	1	9	9	9	9	9	9	9	0.199
B	1	1	1	1	9	9	9	9	9	9	9	0.199
C	1	1	1	1	9	9	9	9	9	9	9	0.199
D	1	1	1	1	9	9	9	9	9	9	9	0.199
E	1/9	1/9	1/9	1/9	1	1/4	1/7	1/5	1/6	1/6	1/5	0.010
F	1/9	1/9	1/9	1/9	4	1	1/7	1/5	1/6	1/6	1/5	0.013
G	1/9	1/9	1/9	1/9	7	7	1	5	4	5	4	0.064
H	1/9	1/9	1/9	1/9	5	5	1/5	1	2	2/3	1/2	0.024
I	1/9	1/9	1/9	1/9	6	6	1/4	1/2	1	1/3	1/2	0.023
J	1/9	1/9	1/9	1/9	6	6	1/5	3	3	1	5	0.042
K	1/9	1/9	1/9	1/9	5	5	1/4	2	2	1/5	1	0.027

Another way of determining the best location is by using Geographic information systems (GIS) combined with the AHP. GIS are computer-based tools used to store, visualize, analyze and interpret geographic data, which are attached to a unique location. It starts with collecting various types of data, including spatial data (coordinates, boundaries, distances, etc.) and non-spatial/ attribute data (population, infrastructure, health, etc.). These are than placed into the GIS system as layers. These layers (coordinates, population, health, etc.) can then be stacked upon each other and by using the AHP from the previous paragraph, the different layers can be given a weight. By using the variety of tools and techniques GIS enables users to visualize complex spatial relationships. In summary, GIS works by combining spatial data and attribute data to create layers of information that can be analyzed, visualized and interpreted to gain insight into space patterns and relationships, supporting informed decision making. The downside of GIS is that you need all the data, which are often not available in informal settlements. To accumulate all the data takes a long time, which usually is not available in a humanitarian engineering project in an informal settlement.

2.2.2. Phase two: selecting the community

With phase one completed, a decision support tool can be used to make a final decision. The decision-making tool in this paper is a multi-criteria analysis (MCA) which uses the indicators and relative weights generated in phase one. A MCA helps to compare and rank multiple alternatives that involve unequal attributes. This means, a MCA is well suited for ranking different communities in need of international engineering. It can help stakeholders to decide on what community suits best. By grading all indicators for all different communities and summing the multiplication of the grade times the determined relative weight, the scores of all different communities can be calculated.

When done wright, this community selection process empowers you to make a well-informed decision framework which will determine the communities that are in most need of international/ humanitarian engineering. Finding a suitable community does not guarantee automatic success when executing the project. For this, various other factors must be taken into consideration, which were discussed in section 2.1. Using this community selection framework and combining it with the factors that are generally important will result in the highest chance of a successful project.

3

Service trips and community selection

A month before the installation, the project group conducted service trips in four different informal communities in the surroundings of Tena. This is crucial in the process in order to get to know the communities and fully understand their unique needs. During the trip the team mainly focused on the indicators of the MCA, as discussed in chapter 2.

3.1. Service trips

The team visited the four different schools together with the local contact person and her brother, and two people working for the municipality of Tena and in the department of clean drinking water. The main goal of the trip was to get to know the communities, their needs and their current situation. The team focused on the nine points of the MCA. During the service trips, careful consideration was given to the influential factors that increase the likelihood of success for international engineering projects within informal communities. Therefore, communicating with them and understanding their needs and situation was key. Also their environmental situation and potential natural hazards were looked at during the trip.

An important activity was of course to test the water they currently used for cleaning and sometimes for drinking as well. The water samples were tested at the municipality of Tena. The results are shown in appendix A. At each community, the team spoke with the president to ask questions about where they get their water from and how clean it is. Some of them mentioned people got ill by drinking the water and a few even died because of it. Three of the four collected their water directly from a close by river, and one of them pumped it out of a well. During the visit the team looked for a suitable location for the water chlorinator and simultaneously thought of ways how the water tank could be connected to the current water distribution system. It was favored to have the water tank and chlorinator as close as possible to the school and at a central location.

3.2. Community selection

Based on the gained knowledge on the communities during the service trips, the project team could know make a selection at which two schools the two water chlorinators were to be installed. The Multi Criteria Analysis had a big contribution in this choice. Based on engineering intuition and common sense, the four different communities have been graded on each criteria. Table 3.1 provides an overview of the scores of the MCA and from this it can been concluded that community 1 and 3 gained the best result.

Table 3.1: Multi-Criteria table for 4 different informal communities in need of a water chlorinator.

	Weight	Community 1		Community 2		Community 3		Community 4	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score
Frequent supply of water	0.199	9	1.791	9	1.791	9	1.791	9	1.791
Chlorine level	0.199	9	1.791	9	1.791	9	1.791	9	1.791
No other contaminants	0.199	9	1.791	9	1.791	9	1.791	9	1.791
Non-continuous system	0.199	9	1.791	9	1.791	9	1.791	9	1.791
Central location	0.010	7	0.07	5	0.05	8	0.08	3	0.03
Access to electricity	0.013	7	0.091	8	0.104	9	0.117	5	0.065
Safety	0.064	7	0.448	9	0.576	9	0.576	7	0.448
Responsible supervisor	0.024	8	0.192	7	0.168	8	0.192	7	0.168
Population density	0.023	6	0.138	7	0.161	9	0.207	3	0.069
Health conditions	0.042	9	0.378	5	0.21	8	0.336	4	0.168
Financial situation	0.027	9	0.243	3	0.081	6	0.162	6	0.162
Sum			**8.7**		**8.5**		**8.8**		**8.3**

Community 1 and 3 are also the ones where the water chlorinators have been installed. The MCA alone was not decisive, as the conversations with the presidents and the overall impressions of the communities played an important part as well. Some scores that stand out in the MCA will be explained.

Both community 1 and 3 scored significantly high on the current health conditions. In community 1, four people have died over the past few years because of the contaminated water they drank. Due to their inability to afford clean drinking water, they are compelled to continue consuming the contaminated water extracted from the ground/well. This also leads to the high rating on the financial situation. In community 3, they consume water directly from a nearby river, which has resulted in continuous illnesses among students. Consequently, they are unable to attend classes and pursue their studies, forcing them to stay at home. The university has 350 students who will all benefit from the chlorinator. This is a huge amount compared to the 30 pupils of the school in community 4. Community 2 and 4 score relatively low on the indicator 'Central location'. This is because the only current water tap point is located just outside of the community. This means that installing the water chlorinator at this point, it would not be easily accessible for elderly, disabled and pregnant women. Community 2 also scores low on the indicator 'Financial situation'. This is because they are currently buying their drinking water from vendors, which means they have the financial resources for it (in comparison to community 1, where they are forced to drink contaminated water).

4 Installation of chlorinators

After the service trips had been conducted and the two communities had been selected, the installation plan could be created. This chapter describes the process of the installation from sketch to final result.

4.1. Initial installation plan

During the service trips, the project team focused on finding a location for the water tank and the chlorinator, and how these could be connected to the current water distribution network. Things as, distance to a water tap point, distance to an electricity tap point, accessibility, central location, protection from rain and sun, and safety all played a role in finding a optimal location.

4.1.1. Community 1: Pioculín

The first community, Pioculín, has a population of about 120 people. The school is located centrally in the community and has one of the only few water tap points in the community. The water is coming from the river downhill and is pumped to a large water tower, which distributes the water over several communities in the surrounding area, see 4.1. In figure 4.2 a sketch has been provided of the area around the water tank and chlorinator and its position within the community. The distances indicated in the sketch were only meant to estimate the purchases and are not up to scale.

Figure 4.1: Photo of the water tower in Pioculín which distributes the water from the river over several surrounding communities.

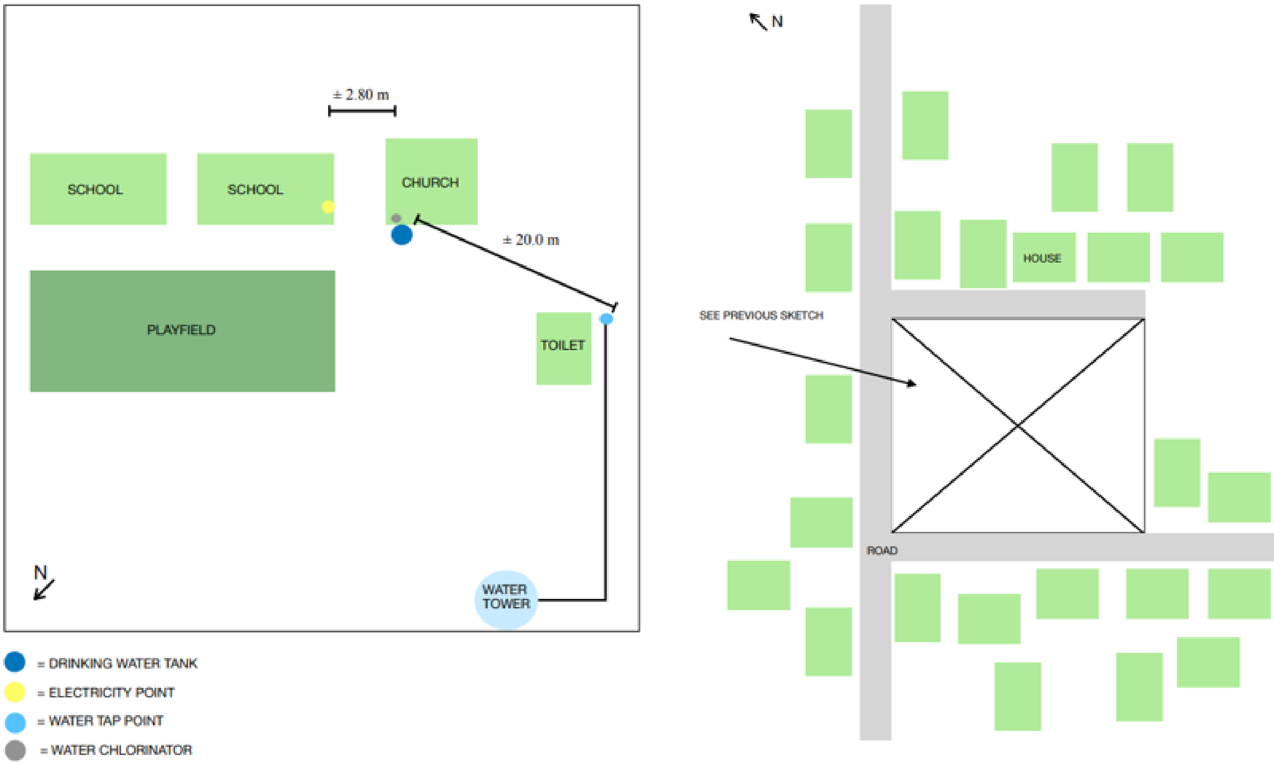

Figure 4.2: Sketch of the area around the Chlorinator (left) and the whole community 1 (right).

For the project team it was the most logical solution to implement the system in front of the church, as it ticked most of the boxes. However, there were some doubts as it could be contradicting the ethical standards of the community members. Implementing the water system in front of their 'holy ground' could maybe lead to some problems. The contrary happened after talking to the president of the community. He said that it was a good location, and that it even had a nice symbolical thought behind it: God giving clean drinkable water to the community. So the project team continued the plan for this location.

The water tank needs to be connected to the water network to be able to fill the tank. As there was already a 500L water tank available at the university, and the community had a bit over 100 inhabitants, the project team reserved this tank for the first community. The system has to include a valve since the chlorinator needs to be connected to a discontinuous system. In the sketch the water tap point is indicated by a navy blue dot. The tap point and the water tank are connected by PVC pipes. To be able to make turns in the pipes, 45- and 90 degree adapters were ordered as well. As the chlorinator and the water pump require electricity to work, the project team decided to connect them to the electricity network by connecting both to a power adapter containing a plug, which could easily be plugged in a socket close-by. A power adapter comes together with the chlorinator package. This adapter is delivered as a charger for a 12V car battery (this is done as a lot of the communities in need of clean drinkable water do not have access to electricity), but the team decided to skip the battery and just connect the chlorinator and pump directly to the electricity network. This option is way cheaper than buying a car battery, and it will be easier for the community to use as they just have to connect the plug to the socket, instead of charge the battery every time. Furthermore, both the risks of connecting the wires of the chlorinator to the wrong side of the battery and getting an electric shock are eliminated.

4.1.2. Community 2: Talag

The second selected community, Talag, has about 500 inhabitants, with more than 300 people being students or workers at the school. The school is surrounded by many houses and therefore considered centrally located. The only water tap point near the school is located next to the toilets. It was therefore logical to place the chlorinator and tank in a close perimeter around the water tap point. In figure 4.4 the conceived location of the chlorinator and water tank is sketched and in photo 4.3 the real-life planned location can be seen.

Figure 4.3: Planned location of the water tank and chlorinator in Talag (where Bastiaan and Hidde are standing.)

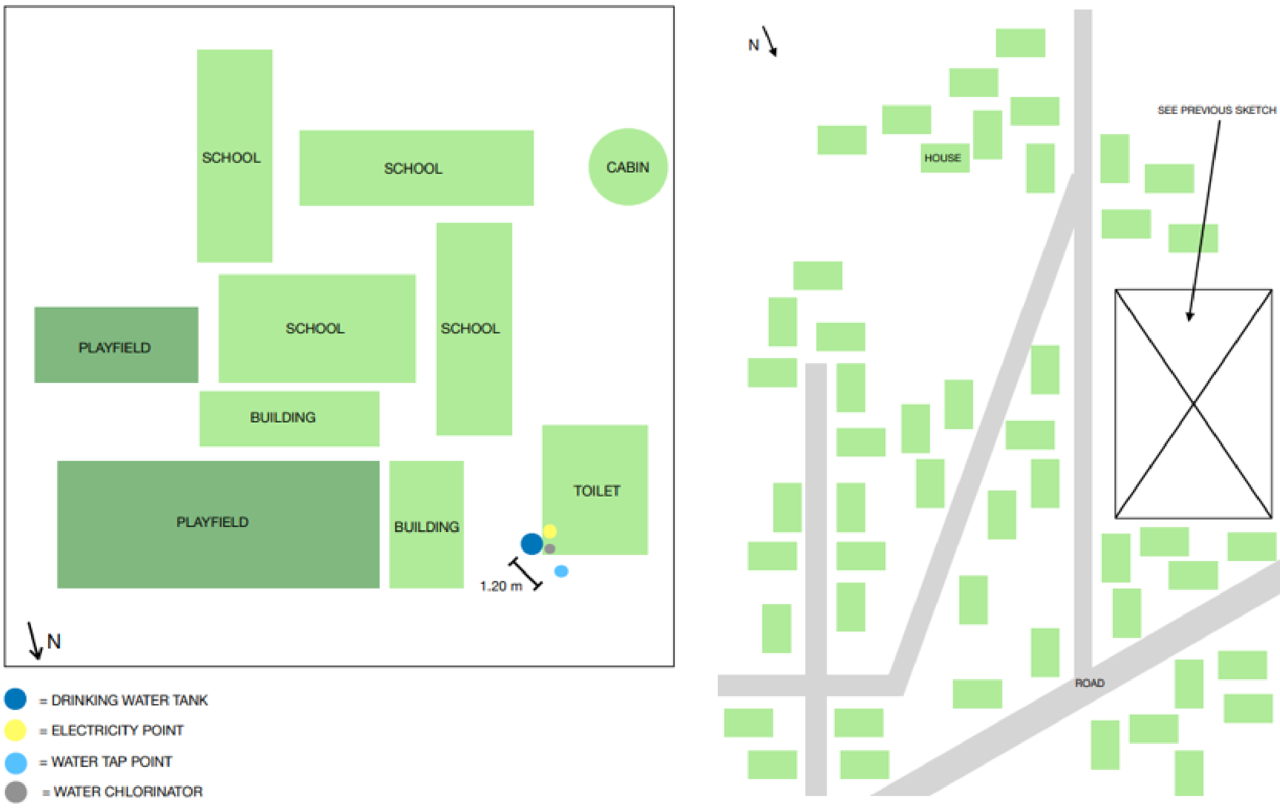

Figure 4.4: Sketch of the area around the Chlorinator (left) and the whole community 3 (right).

Since the community Talag has more inhabitants than the first community, the project team planned to install an 1100L water tank, which was the largest available in the hardware store. Also for this installation a discontinuous system was needed and therefore it can be said that the installation plan was somewhat similar as it was for community 1. Again, the team would add a 3-way splitter to the current existing water pipe and then add a valve to create a discontinuous system. The problem in this community was that the water was taken directly from the river and the height difference was relatively low so the water pressure wasn't big enough to fill the 1100L water tank. Therefore a small pump had to be installed next to the chlorinator. In photo 4.3 it can be seen that there was a socket available in the toilet building. The rector of the school told the project team that there was electricity available in this building and therefore chose to avoid using a car battery once again.

4.2. Installation

For the installation, the project team put together a group of people consisting of student volunteers, three professors and two local residents of Tena, both with expertise in construction. The complete group can be seen in figure 4.5. Prior to the installation, the project team arrived in Tena to link up with the local residents Jessica Vaca and Neyson Vaca. These two days prior to the installation were meant to build the foundations for the water tanks and chlorinators, but also to ensure everything is ready for the installations whenever the volunteers and professors arrive. Concrete blocks, cement, sand, wood and tools were bought to install the foundations and security boxes for the chlorinators.

Figure 4.5: The project team together with the group op student volunteers, professors and two local resident of Tena, both with expertise in construction.

4.2.1. Community 1: Pioculín

During the days prior to the installation, the project team first visited the community Pioculín. The team had a chat with the rector of the school, who was not in favor of installing the system in front of the church as it was too easily accessible for the little kids playing around, underscoring the fact that the kids might play with it and damage it. After thinking of other solutions, the project team, together with the locals, came across an empty concrete rain basin behind the school. After consultation with the rector of the school and the president of the community, the team decided to use this basin as a foundation for the system. As can be seen in figure 4.6, the location of installation is more difficult for kids to access. Also, it was not necessary anymore to build a foundation, thus saving time and money. Note that there is not a roof on the basin, and thus not protecting the system from rain and solar radiation. In consultation with the community, the community members insisted to build this the days after the installation.

Figure 4.6: Photo of the concrete rain basin in community 1 that was used as a foundation

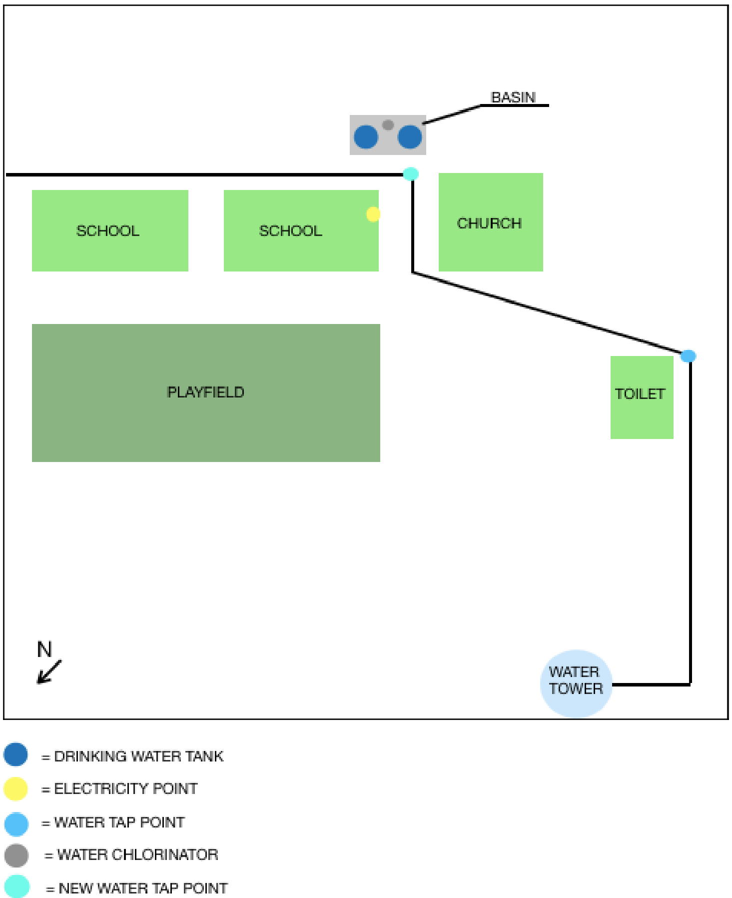

Figure 4.7: Actual sketch of the installation site

In figure 4.7 the adjusted installation site sketch is given. Note that there are some changes on this sketch compared to the initial installation plan sketch. Firstly, there are two water tanks instead of one. This is due to the fact that there was already a water tank available at the community. The president of the community only told the project team about this tank two days before the installation. The water tank was not being used, as there was no clean water to store. And after the installation of the water tower (see figure 4.1), there was no need to use this tank anymore to store any other water. The president of the community kindly asked the project team to use this water tank as well, so that extra drinkable water can be stored. There was no problem installing this tank in series with the other water tank, therefore, this request was accepted. But more about the installation later. The following thing to note is that the electricity tap point is shifted inside the school, this is simply because there were multiple sockets inside the school and this socket was the closest to the basin. The last change to note compared to the previous sketch is the new water tap point in front of the basin (this water tap point is actually underneath the basin, but for clarity purposes it is drawn in front of the basin). This water tap point was not present at first, but made during the installation. The water tap point was made by cutting the present water tube and installing a T-split at the location. This way the water can continue in its original direction of the tube and one direction can be used to fill the water tanks.

Another part of the installation process was to ensure that the chlorinator was stored securely and thus protected against potential theft. The idea was to create a wooden storage, but the local contacts advised us to use another material as they warned us that the area was too humid and the wood would not survive for too long. Therefore, the locker was made out of concrete blocks (see figures 4.8 and 4.9). This was masoned the day before the rest of the installation. The top of the box was sealed by a wooden door containing a lock. Holes were created in the wooden door so the chlorinator tubes and electrical wire could stay connected and the community would not have to disconnect them every time they closed the box.

Figure 4.8: Installing the chlorinator security box, prior to the installation.

Figure 4.9: End result of the chlorinator security box (without the wooden door).

For the full system installation, see the figures below. In the top right of figure 4.11 one can see the inflow of water, with a valve, to the first tank (visible as the upper tank) coming from the water tube below, as previously discussed. The two tanks are connected by the red tube at the bottom of the tanks. Once the two tanks are filled with water, the valve can be closed. The chlorinator, located in the secured box, can now start circulating the water by pumping it out of the first (upper) tank, letting it flow through the chlorinator while adding chlorine gas, pumping it back in the second (lower) tank, after which the water will again circulate through the upper tank and the chlorinator. Once the water is at the desired level of chlorine, this circulation can be stopped, and the water is drinkable! The water can exit the tank from the left side of the first (upper) tank through the red tube, as visible in figure 4.12. The red tube leads, through a hole in the basin, to a valve at the outside of the basin. The drinkable water can be tapped here, see figure 4.13. At the outlet of the tank, one tube is connected to the tap, while another tube goes up, which can clearly be seen in 4.13. The tube going up has been added as it shows the water level inside the tank.

Figure 4.10: Photo of the system after installation (1).

Figure 4.11: Photo of the system after installation (2)

Figure 4.12: Photo of the system after installation (3)

Figure 4.13: Photo of the system after installation (4)

4.2.2. Community 2: Talag

Two days prior to the installation, the project team conducted a second visit to the community of Talag. The purpose of this visit was to explain the installation plan and build the foundation for the tank. Upon arrival, the team engaged with the rector of the school to present, explain and discuss the proposed installation plan and the intended location. The rector then approved the plan and its location, so the project team could build the foundation. The foundation has been laid with concrete blocks, just like the box protecting the chlorinator in both communities, and is shown in 4.14.

Figure 4.14: Finished foundation before the lit is added.

Figure 4.15: The roof and lit that protect respectively the basin and the security box.

Compared to the community of Pioculin, this location had the advantage of having a roof. This roof would protect the chlorinator and basin against rain and solar radiation. However, not having the lifted rain basin as a foundation brought some challenges with it. Considering the high number of students and the location close to the toilet, which all students used, the security of the chlorinator and the pump were very important. Therefor the team constructed a foundation of four concrete blocks in height for the tank and six blocks for the chlorinator and pump. This allowed all students access to the valve while ensuring that the safety box remained inaccessible to younger students. By adding a lit and a big lock, only the rector had access to the chlorinator and pump. The roof and the security box with its lit can be seen in figure 4.15.

On the day of installation, the team started of with a setback. Attempting to install an outlet using the existing electrical wiring from the wall, they discovered that these wires were not connected to the electricity circuit and that the rector was wrong. However, the solution was found quickly. Next to the chlorinator on the east side, there was a classroom with electricity. So, the project team extended the existing power cord of the chlorinator with electricity wires so they could reach the power outlet in the classroom. The rector told us that he would ask a local expert from his village to fix the power outlet at the toilets so that they can connect the chlorinator and pump to this outlet.

The adjusted installation site can be seen in figure 4.16. The first step was to attach a 3-way splitter to the existing water pipe, as illustrated in figure 4.17. Subsequently, a hole was made in the security box so the 3-way splitter could be connected to the pump. The pump was then linked to the tank to enable water filling. Lastly, the chlorinator was connected to a in and outlet situated at the top of the tank. The outlet, connected the pump inside the tank with the chlorinator where the inlet was connected to the chlorinator's output, facilitating water return. A scheme of this situation can be seen in figure 4.18. After everything was connected, the lit was placed and connected on top of the security box with a lock. Once everything is connected, the valve can be opened, the tank can be filled and once the tank is filled the chlorinator can start circulating the water. If the water reaches the desired chlorine level, it is drinkable! At the bottom of the tank, there is a tap so the water is easily accessible for all students. Some pictures of the final result and the process of installation are added on the next page (4.19, 4.20, 4.21, 4.22):

Figure 4.16: Adjusted installation plan

Figure 4.17: Installation of the 3-way-splitter by the student volunteers.

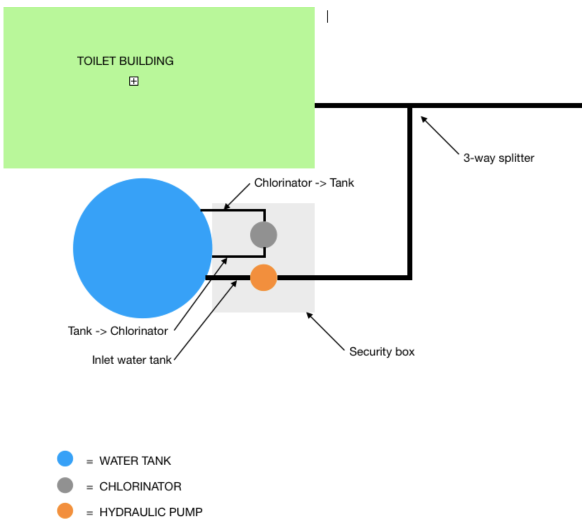

Figure 4.18: Schematic presentation of the chlorinator, pump and the water circuit.

Figure 4.19: Making cement to finish the security box.

Figure 4.20: Student volunteers working on the 3-way-splitter and pipes.

Figure 4.21: Drilling the holes to secure the lid and lock.

Figure 4.22: Final result of the installation of the water chlorinator in community Pioculin.

4.2.3. Power supply issue

The water chlorinator originally came with a 12V battery charger. In the original manual and as described in 1.2.2, the chlorinator was intended to be powered by a 12V car battery. The project team decided not to use a car battery for the power supply but instead directly connect both the chlorinator and the water pump to the electrical grid. This approach offers two significant advantages. Firstly, it eliminates the need to purchase a costly car battery. Secondly, it greatly reduces the risk of electric shock for community members using the chlorinator, as they can simply plug it into a standard electrical socket without fear. Using clamps to connect to a battery carries the risk of electric shock, as well as the potential for incorrect wiring polarity (+ or -).

Before installation, the set up of connecting the pump and chlorinator directly to the electrical grid was tested in the lab at the university. The clamps battery charger, chlorinator and pump were all connected to each other and the plug of the charger was plugged in the socket. All chlorinators and pumps were successfully tested, demonstrating functionality. At the communities, the sockets were too far away from the chlorinator to use the same set up as in the lab. To be able to cover the length, the battery charger was connected to an (extension) electricity wire, which in turn connected to both the chlorinator and pump. This was done by cutting of the clamps, and connecting the wires by using screw terminals. The set up is schematised in figure 4.23. However, this setup encountered two significant issues. Firstly, the extension wire required a minimum of 100V to function, whereas the battery charger only supplied 12V. Even in the lab, the setup failed to function without the extension wire, prompting the project team to investigate further. Upon consultation with an electrical engineering student, it was determined that measuring the amperage requirements of the chlorinator and pump was necessary. Subsequent measurements revealed that the chlorinator only required 0.075A, while the pump demanded 2.4A, exceeding the capability of the 0.75A output of the battery charger. An electrical engineering professor clarified that while the setup initially seemed to function during testing, the power adapter was being overtaxed due to the pump's higher amperage requirements. This led to the gradual deterioration of the charger's functionality, ultimately reducing its output to a mere 0.01 amperes instead of the required 0.75A.

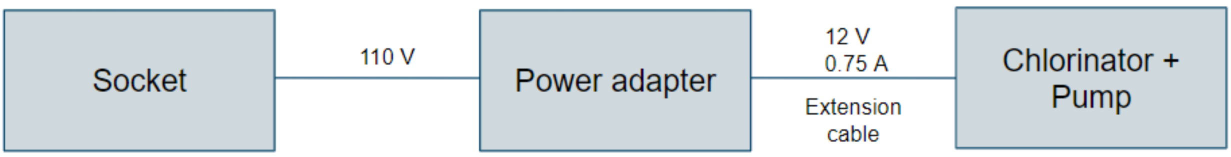

Figure 4.23: Scheme of the power supply resulting in issues

To resolve the issue, two power adapters supplying 12V and capable of delivering up to 5 amps each were purchased. Additionally, a plug has been attached to one end of the extension cable. The other end of the cable is connected to the power adapter, which in turn connects to both the chlorinator and the pump. The extension cable can now be plugged in the socket and the system functions properly. Both chlorinators have been successfully tested in the lab. Figure 4.24 provides a scheme of the new set up.

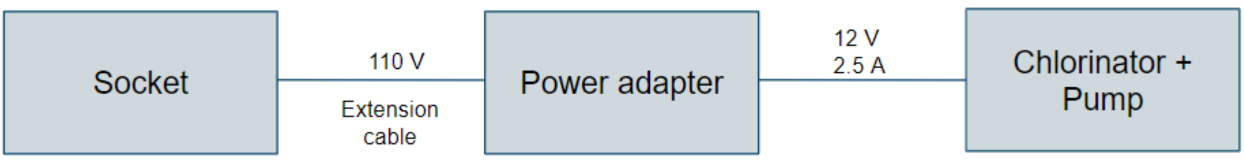

Figure 4.24: Scheme of the resolved power supply

5

Registration of EWB and the colloquiums

5.1. Registration

Upon arrival one of the initial points of discussion was that the Engineers Without Borders (EWB) chapter from USFQ lost there international registration with Engineers Without Borders-International (EWBI) due to inactivity because of the COVID-19 pandemic. It was mentioned that being an Approved Member Association of EWBI will provide you support and guidance to become a fully fledged non-governmental/ non-profit organisation. Which would really help the EWB USFQ Chapter grow.

The team started off by contacting many individuals within the EWB-International and EWB-USA to gather information regarding the process of re-registration, which was not clearly mentioned on their websites. After obtaining the information, the team connected with Joachim Schneider, the Secretariat and Programs Director of EWBI. Joachim provided the team with the requirements and facilitated the re-registration process. By this registration the USFQ chapter is now the leading chapter for Ecuador, which means they will be the contact person and main student chapter representing Ecuador within EWBI. One of the main requirements was to update their socials, which the team did by updating all their projects and photo's. Additionally, the TU Delft team instructed the EWB board to keep their socials updated to keep local communities in Ecuador and the EWBI informed about ongoing activities and progress, ensuring their work is visible.

Lastly, the TU Delft team, when contacting EWB-USA, came in contact with the EWB Chapter at the Ohio State University (OSU), recognized as the third largest university in the United States. This chapter is engaged in a project to construct a school in Carrera, Ecuador. They wanted to partner/ collaborate with EWB USFQ to have local expertise when building the school. The team introduced the EWB board to explore opportunities for partnership and assistance in the OSU school construction project.

5.2. Colloquiums

The three TU Delft students were tasked with presenting a colloquium for students at USFQ. The aim was to discuss a topic related to the Hydraulic and Offshore Structures track, and is not typically covered in the civil engineering program at USFQ. The three colloquiums took around 30 minutes each, in front of a fully filled classroom. It was a new experience, normally attending lectures to gain knowledge, but this time having the opportunity to share the knowledge gained by attending lectures with students from a different university. The topics each student presented were:

Hidde:	Hydraulic Structures
Rafael:	Offshore Structures
Bastiaan:	Floating and Submerged Structures

The students were rather enthusiastic about the topics, and even afterwards the project team and students had some discussions about specific aspects that were mentioned during the colloquiums.

Figure 5.1: Colloquium talk of Rafael about Offshore Structures

Figure 5.2: Colloquium talk of Hidde about Hydraulic Structures

6 Review

Being able to plan and execute a project in collaboration with local students in Ecuador has been a special and exhilarating experience. Also to work together with local people from around the communities and inhabitants of the communities was very unique and exciting at the same time. If felt like we were truly integrated within Ecuador and the people around us. Although the water has not yet been chlorinated, the idea of being able to help people and improve their living environment by providing them with clean drinking water is a special feeling. Moreover, it has been fun to get involved with the children, playing football with them and including them in some installation tasks.

Of course it has been an educational experience and several lessons were learned from it. One of the aspects we were aware of before going to Ecuador is the cultural difference between our group and the people we worked with in Ecuador. Some examples are differences in communication styles and punctuality. We learned that in some cases you should be even more on top of someone than we are used in The Netherlands to ensure they do not forget to fulfill their tasks. But on the other end, it felt we still had the same ideas on how to tackle problems and there were not many issues collaborating and sharing ideas when working together with the local students.

The collaboration with both students and a supervisor from USFQ, as with local contacts from Tena, ensured a smoother progression of the project. It was much easier to arrange practical things with their local expertise and knowledge. Examples are the gathering of needed building materials, arriving to and connecting with the local communities, as well as understanding the culture and values of Ecuadorian people. Right from the beginning, we were welcomed openly by our supervisors and the students of the EWB board. We spent time together and arranged activities like playing football at the university, which made it easy for us to adapt quickly to the new country and environment we found ourselves in.

The project also showed us that it is very important to include different disciplines and backgrounds within a project team. Creating a multidisciplinary project team allows us to cover aspects of a project that are not related to civil engineering or even engineering at all. Also aspects like communication, collaboration, problem-solving, adaptability, leadership and time management within a project team can enhance the success of a project. Apart from these so called soft skills, expertise in a wide range of disciplines can work in your favor in such a project. During this project, we had backgrounds from civil engineering, bio medicals, environmental engineering, economics, architecture, and language instructors, which we think enhanced the overall project team. Yet you can never have enough different disciplines, which became clear during this project. The electrical part of the installation was actually a small detail that we didn't worry about too much, but it became the biggest issue we had. If we included someone with electrical engineering background, the project team would have been complete.

It was getting out of our comfort zone as the project itself has been very practical, which is different to projects and methods we are used to at the TU Delft. During our study we have done a lot of practicums, and covered a lot of theory. But doing a project from literature study, to design phase, to execution of the project was new to us. And adapting to this, in a different country, on a different continent, with little knowledge about the subject was a difficult task for us. It was a challenge because minor faults in our design would result in the communities drinking contaminated water which could impact their health. Having the full responsibility over the design and execution phase was new and challenging, but ultimately gave a very fulfilling feeling. It also made it easier to understand and visualize how we will apply our knowledge on projects once working as a professional, and that projects do not always go as planned.

Ultimately, we realized that executing such a project is not a short-period project and that it needs ongoing commitment. In addition to the responsible supervisor, the whole community needs training about safe drink water. Furthermore, it is essential for the EWB board to maintain regular contact with the communities so they can address any issues with the chlorinator to the board. Because frequently, the communities lack the resources or expertise to resolve such issues individually. This again shows the importance of co-production and good communication within a humanitarian engineering project.

To conclude, the journey to Ecuador was not just about implementing the project and technical skills. It has also been a profound lesson in cross-cultural collaboration, adaptability, and the significance of multidisciplinary approaches in engineering applications. Our integration into Ecuadorian life and the close collaboration with local residents and students turned out to be incredibly beneficial, and significantly helped us in many different aspects. Above all, the experience of being able to help and contribute to the lives of people living in a community whose living standards are nowhere near to what we are used to in the Netherlands, has been truly unique and profoundly fulfilling.

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A
Water tests results

Below in table A.1, the substances present in the water and the required outcomes of the substances to use the chlorinator are given. These values are based on the handover document created by the previous project group of TU Delft, as mentioned in chapter 1.2. On the following pages in this appendix, the water test results are shown from the water taken at the communities Pioculín and Talag. The results are shown in Spanish and are facilitated by the municipality of Tena, Ecuador.

Table A.1: Substances and the required outcomes of the substances needed for the use of the chlorinator.

Substance	Needed value/requirement for Chlorinator
Chlorine	< 0.01 [ppm]
Nitrate	< 50 [mg/l]
Salt	Sweet water
Coliform & E. Coli	Coliform or E. Coli present

INFORME DE MUESTREO Y ANÁLISIS DE AGUA

PROYECTO: "ANÁLISIS DE LA CALIDAD DEL AGUA DE LA COMUNIDAD PIOCULÍN, CANTÓN TENA, PARROQUIA PUERTO NAPO"

INFORME INF LAB. CCA 26444

INFORME: INFORME LAB. CCA 26444

DIRECCIÓN: COMUNIDAD PIOCULÍN, CANTÓN TENA, PARRQUIA PUERTO NAPO

FECHA: MARZO 2024

TENA
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INFORME DE MUESTREO Y ANÁLISIS DE AGUA
MUESTREO SISTEMA DE AGUA COMUNIDAD PIOCULÍN INF. LAB. CCA 26444

1. DATOS INFORMATIVOS:

INSTITUCIÓN:	GAD MUNICIPAL DE TENA
DIRIGIDO EN ATENCIÓN A:	ING. GEOVANY NAVARRETE
NOMBRE DEL PROYECTO:	ANÁLISIS DE AGUA SISTEMA DE AGUA COMUNIDAD PIOCULÍN
DIRECCIÓN DEL PROYECTO:	CANTÓN TENA/PARROQUIA PUERTO NAPO/COMUNIDAD PIOCULÍN
MUESTREO REALIZADO POR:	ECON. NEYSON VACA
FECHA DE MUESTREO	MARTES , 19 DE MARZO DE 2024
FECHA DE RECEPCIÓN DE MUESTRAS:	MARTES , 19 DE MARZO DE 2024
LUGAR DE ANÁLISIS:	LABORATORIO DE CONTROL DE CALIDAD COLONSO
FECHA DE ANÁLISIS:	LUNES, 25 DE MARZO DE 2024

2. IDENTIFICACIÓN DE LAS MUESTRAS:

CÓDIGO DEL LABORATORIO	IDENTIFICACIÓN DE LA MUESTRA			
	REFERENCIA DE MUESTREO	MATRIZ	HORA DE MUESTREO	TEMPERATURA AMBIENTE
INF. LAB. CCA 26444	ML. AGUA NATURAL, SIN TRATAMIENTO RECOGIDA EN RED DE DISTRIBUCIÓN DEL SISTEMA DE AGUA DE LA COMUNIDAD PIOCULÍN	AGUA LIQUIDA	16H00	29.50 ºC

3. DATOS MUESTREO:

DIRECCIÓN	CANTÓN TENA/ PARROQUIA PUERTO NAPO/RED DE DISTRIBUCIÓN DEL SISTEMA DE AGUA POTABLE DE LA COMUNIDAD PIOCULIN

DIRECCIÓN	X	Y	ALTURA
	LATITUD: 1.083894	LONGITUD: 77.812567	-

4. DESCRIPCIÓN DE LA MUESTRA:

CÓDIGO DEL LABORATORIO	DESCRIPCIÓN DE LA MUESTRA		
	REFERENCIA	OBSERVACIONES GENERALES	OTROS
INF. LAB. CCA 26444	ML. AGUA NATURAL, SIN TRATAMIENTO RECOGIDA EN RED DE DISTRIBUCIÓN DEL SISTEMA DE AGUA DE LA COMUNIDAD PIOCULÍN	Según definición de la Norma INEN 1108, Agua Potable, Requisitos, el ***agua cruda*** o natural es el agua que se encuentra en la naturaleza y que no ha recibido ningún tratamiento para modificar sus características: físicas, químicas o microbiológicas.	Para el muestreo se requiere 1 envases de plástico de 1 L 4 envases estériles de 150 ml Hielo pH – metro

5. RESULTADOS EXAMEN FÍSICO

PARÁMETRO	UNIDAD	VALOR MEDIDO EN LA MUESTRA		
		INF. LAB. CCA 26444		
		AGUA CRUDA	TABLA 1: CRITERIOS DE CALIDAD DE FUENTES DE AGUA PARA CONSUMO HUMANO Y DOMÉSTICO	OBSERVACIONES CUMPLE/NO CUMPLE
COLOR	Unidades Escala Pt-Co	37	75	CUMPLE

TURBIEDAD	NTU	0.59	0 - 100	CUMPLE

RESULTADOS EXAMEN FISICOQUÍMICO

6. RESULTADOS:

PARÁMETROS ANALIZADOS	UNIDAD	INF. LAB. CCA 26444		
		AGUA CRUDA	TABLA 1: CRITERIOS DE CALIDAD DE FUENTES DE AGUA PARA CONSUMO HUMANO Y DOMÉSTICO	OBSERVACIONES CUMPLE/NO CUMPLE
Temp. Agua	°C	23.6	< 30	CUMPLE
Conductividad	µs/cm	70.6	400	CUMPLE
SST	mg/L	35.3	200	CUMPLE
pH	-	6.8	6 – 9	CUMPLE
Dureza Total	mg/L	38	< 500	CUMPLE
Alcalinidad	mg/L	36	< 40	CUMPLE
Hierro	mg/L Fe	0.04	< 1	CUMPLE
Nitrato	mg/L N-NO3	0.24	1	CUMPLE
Nitrito	mg/L N-NO2	< 0.600		CUMPLE
Cloro residual	mg/L	-	0	
Manganeso	mg/L	0.05	0.1	CUMPLE
Fosfato		<0.10	<0.1	CUMPLE
Sulfato	mg/L	1	400	CUMPLE

*¿Sin observaciones?

7. RESULTADOS MICROBIOLÓGICOS:

PARÁMETROS ANALIZADOS	UNIDAD	INF. LAB. CCA 26444		
		AGUA CRUDA	TABLA 1: CRITERIOS DE CALIDAD DE FUENTES DE AGUA PARA CONSUMO HUMANO Y DOMÉSTICO	OBSERVACIONES CUMPLE/NO CUMPLE
Índice de coliformes totales	UFC/100 ml	10	< 1000	CUMPLE
Índice de coliformes fecales	UFC/100 ml	1	<1000	CUMPLE
Aerobios mesófilos	UFC/100 ml	0	<100	CUMPLE

8. CONCLUSIONES:

8.1. Los resultados solo se refieren a las muestras analizadas.

8.2. Los parámetros físicos analizados de la muestra de agua del punto de muestreo en la red de agua de la comunidad Pioculín, cumplen con los valores permitidos, comparados con los valores indicados en la TABLA 1: criterios de calidad de fuentes de agua para consumo humano y doméstico, del Texto Unificado de Legislación Ambiental ecuatoriano.

8.3. Los resultados del análisis de parámetros químicos en la muestra de agua de la red de distribución de la comunidad Pioculín, cumplen con los estándares para consumo humano y doméstico según la normativa ambiental ecuatoriana.

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8.4. Para el análisis microbiológico, se utilizó la aplicación de ImageJ, software de uso común en la investigación científica, automatiza el proceso y reduce los errores humanos en la interpretación de los resultados. Aunque puede proporcionar resultados cuantitativos, la precisión de la interpretación depende de la calidad de las muestras y del cumplimiento de los protocolos estándar. Se destaca la importancia de comparar los resultados con los estándares de calidad del agua para evaluar la sostenibilidad del recurso hídrico.

8.5. Los parámetros microbiológicos analizados de la muestra de agua, de la red de distribución de la comunidad Pioculín, CUMPLEN con los valores permitidos, comparados con los indicados en la TABLA 1: criterios de calidad de fuentes de agua para consumo humano y doméstico, del Texto Unificado de Legislación Ambiental ecuatoriano.

8.6. En la muestra de agua existe un 10 % de bacterias E coli, la norma ambiental registrada en la TABLA 1: criterios de calidad de fuentes de agua para consumo humano y doméstico, del Texto Unificado de Legislación Ambiental ecuatoriano, indica que este parámetro no debe superar el 40%.

9. RECOMENDACIONES:

9.1. La calidad del agua de la muestra tomada en la red de agua de la comunidad de Pioculín, cumple los parámetros físicos, químicos y microbiológicos, según la norma ambiental registrada en la TABLA 1: criterios de calidad de fuentes de agua para consumo humano y doméstico, del Texto Unificado de Legislación Ambiental ecuatoriano.

9.2. Se recomienda establecer estrategias para la conservación de la fuente hídrica, como declarar áreas protegidas en la captación de agua o un proyecto de protección, restauración y reforestación a fin de garantizar la sostenibilidad del servicio.

9.3. En el proyecto, considerar un sistema efectivo de desinfección del agua para garantizar la calidad microbiológica y la salud de la población con la finalidad de evitar enfermedades vinculadas con el consumo de agua.

9.4. Se recomienda la colocación de un sistema de desinfección, para garantizar la calidad microbiológica del agua e invertir en su sostenibilidad, adquirir o preparar un producto o insumo de desinfección del agua de manera permanente.

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Ing. Alba Almeida
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INFORME DE MUESTREO Y ANÁLISIS DE AGUA

PROYECTO: "ANÁLISIS DE CALIDAD DEL AGUA DEL SISTEMA DE ABASTECIMIENTO TALAG, CANTÓN TENA, PARROQUIA TALAG"

INFORME INF LAB. CCA 26446

INFORME: INFORME LAB. CCA 26446

DIRECCIÓN: RED DE AGUA DE TALAG, CANTÓN TENA, PARRQUIA TALAG

FECHA: MARZO 2024

TENA
Alcaldía de la DIGNIDAD

INFORME DE MUESTREO Y ANÁLISIS DE AGUA
MUESTREO SISTEMA DE AGUA TALAG INF. LAB. CCA 26446

1. DATOS INFORMATIVOS:

INSTITUCIÓN:	GAD MUNICIPAL DE TENA
DIRIGIDO EN ATENCIÓN A:	ING. GEOVANY NAVARRETE
NOMBRE DEL PROYECTO:	ANÁLISIS SISTEMA DE AGUA TALAG
DIRECCIÓN DEL PROYECTO:	CANTÓN TENA/PARROQUIA TALAG/RED DE DISTRIBUCIÓN TALAG
MUESTREO REALIZADO POR:	ECON. NEYSON VACA
FECHA DE MUESTREO	MARTES , 19 DE MARZO DE 2024
FECHA DE RECEPCIÓN DE MUESTRAS:	MARTES , 19 DE MARZO DE 2024
LUGAR DE ANÁLISIS:	LABORATORIO DE CONTROL DE CALIDAD COLONSO
FECHA DE ANÁLISIS:	LUNES, 25 DE MARZO DE 2024

2. IDENTIFICACIÓN DE LAS MUESTRAS:

CÓDIGO DEL LABORATORIO	IDENTIFICACIÓN DE LA MUESTRA			
	REFERENCIA DE MUESTREO	MATRIZ	HORA DE MUESTREO	TEMPERATURA AMBIENTE
INF. LAB. CCA 26446	ML. AGUA NATURAL, SIN TRATAMIENTO RECOGIDA EN RED DE DISTRIBUCIÓN DEL SISTEMA DE AGUA DE TALAG	AGUA LIQUIDA	16H50	29.50 ºC

3. DATOS MUESTREO:

DIRECCIÓN	CANTÓN TENA/ PARROQUIA TALAG/RED DE DISTRIBUCIÓN DEL SISTEMA DE AGUA DE TALAG

DIRECCIÓN	X	Y	ALTURA
	LATITUD: 1.071601	LONGITUD: 77.897706	-

4. DESCRIPCIÓN DE LA MUESTRA:

CÓDIGO DEL LABORATORIO	DESCRIPCIÓN DE LA MUESTRA		
	REFERENCIA	OBSERVACIONES GENERALES	OTROS
INF. LAB. CCA 26446	ML. AGUA NATURAL, SIN TRATAMIENTO RECOGIDA EN RED DE DISTRIBUCIÓN DEL SISTEMA DE AGUA DE TALAG	Según definición de la Norma INEN 1108, Agua Potable, Requisitos, el ***agua cruda*** o natural es el agua que se encuentra en la naturaleza y que no ha recibido ningún tratamiento para modificar sus características: físicas, químicas o microbiológicas.	Para el muestreo se requiere 1 envases de plástico de 1 L 4 envases estériles de 150 ml Hielo pH – metro

5. RESULTADOS EXAMEN FÍSICO

PARÁMETRO	UNIDAD	VALOR MEDIDO EN LA MUESTRA INF. LAB. CCA 26446		
		AGUA CRUDA	TABLA 1: CRITERIOS DE CALIDAD DE FUENTES DE AGUA PARA CONSUMO HUMANO Y DOMÉSTICO	OBSERVACIONES CUMPLE/NO CUMPLE
COLOR	Unidades Escala Pt-Co	64	75	CUMPLE
TURBIEDAD	NTU	11.20	0 - 100	CUMPLE

RESULTADOS EXAMEN FISICOQUÍMICO

6. RESULTADOS:

PARÁMETROS ANALIZADOS	UNIDAD	INF. LAB. CCA 26446		
		AGUA CRUDA	TABLA 1: CRITERIOS DE CALIDAD DE FUENTES DE AGUA PARA CONSUMO HUMANO Y DOMÉSTICO	OBSERVACIONES CUMPLE/NO CUMPLE
Temp. Agua	°C	23.9	< 30	CUMPLE
Conductividad	µs/cm	24.10	400	CUMPLE
SST	mg/L	12.05	200	CUMPLE
pH	-	6.5	6 – 9	CUMPLE
Dureza Total	mg/L	12	< 500	CUMPLE
Alcalinidad	mg/L	32	< 40	CUMPLE
Hierro	mg/L Fe	0.17	< 1	CUMPLE
Nitrato	mg/L N-NO3	0.43	1	CUMPLE
Nitrito	mg/L N-NO2	< 0.015		CUMPLE
Cloro residual	mg/L	-	0	
Manganeso	mg/L	0.047	0.1	CUMPLE
Fosfato		<0.10	<0.1	CUMPLE
Sulfato	mg/L	0	400	CUMPLE

7. RESULTADOS MICROBIOLÓGICOS:

		INF. LAB. CCA 26446		
PARÁMETROS ANALIZADOS	UNIDAD	AGUA CRUDA	TABLA 1: CRITERIOS DE CALIDAD DE FUENTES DE AGUA PARA CONSUMO HUMANO Y DOMÉSTICO	OBSERVACIONES CUMPLE/NO CUMPLE
Índice de coliformes totales	UFC/100 ml	98	< 1000	CUMPLE
Índice de coliformes fecales	UFC/100 ml	19	<1000	CUMPLE
Aerobios mesófilos	UFC/100 ml	20	<100	CUMPLE

8. CONCLUSIONES:

8.1. Los resultados solo se refieren a las muestras analizadas.

8.2. Los parámetros físicos analizados de la muestra en la red de distribución de agua de la cabecera parroquial de Talag, cumplen con los valores permitidos, comparados con los valores indicados en la TABLA 1: criterios de calidad de fuentes de agua para consumo humano y doméstico, del Texto Unificado de Legislación Ambiental ecuatoriano.

8.3. Los resultados del análisis de parámetros químicos en la muestra de agua de la red de distribución de la cabecera parroquial de Talag, cumplen con los estándares para consumo humano y doméstico según la normativa ambiental ecuatoriana.

8.4. Para el análisis microbiológico, se utilizó la aplicación de ImageJ, software de uso común en la investigación científica, automatiza el proceso y reduce los errores humanos en la interpretación de los resultados. Aunque puede proporcionar resultados cuantitativos, la precisión de la interpretación depende de la calidad de las muestras y del cumplimiento de los protocolos estándar.

Se destaca la importancia de comparar los resultados con los estándares de calidad del agua para evaluar la sostenibilidad del recurso hídrico.

8.5. Los parámetros microbiológicos analizados de la muestra de agua, de la red de distribución de la cabecera parroquial de Talag, CUMPLEN con los valores permitidos, comparados con los indicados en la TABLA 1: criterios de calidad de fuentes de agua para consumo humano y doméstico, del Texto Unificado de Legislación Ambiental ecuatoriano.

8.6. En la muestra de agua existe un 19.4 % de bacterias E coli; la norma ambiental registrada en la TABLA 1: criterios de calidad de fuentes de agua para consumo humano y doméstico, del Texto Unificado de Legislación Ambiental ecuatoriano, indica que este parámetro no debe superar el 40%.

9. RECOMENDACIONES:

9.1. La calidad del agua de la muestra tomada en la red de agua de la cabecera parroquial de Talag, cumple los parámetros físicos, químicos y microbiológicos, según la norma ambiental registrada en la TABLA 1: criterios de calidad de fuentes de agua para consumo humano y doméstico, del Texto Unificado de Legislación Ambiental ecuatoriano.

9.2. Se recomienda establecer estrategias para la conservación de la fuente hídrica, como declarar áreas protegidas en la captación de agua o un proyecto de protección, restauración y reforestación a fin de garantizar la sostenibilidad del servicio.

9.3. En el proyecto, considerar un sistema efectivo de desinfección del agua para garantizar la calidad microbiológica y la salud de la población con la finalidad de evitar enfermedades vinculadas con el consumo de agua.

9.4. Se recomienda la colocación de un sistema de desinfección, para garantizar la calidad microbiológica del agua e invertir en su sostenibilidad, adquirir o preparar un producto o insumo de desinfección del agua de manera permanente.

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LABORATORISTA DEL SISTEMA DE AGUA POTABLE
GAD MUNICIPAL DE TENA

B

Usage of water chlorinator

In this appendix it is described how the communities will use the chlorinator in their daily lives. The chemical reaction of the chlorinator is elaborated upon as well.

B.1. The chemical reaction

In a water chlorinator, saltwater, chemically known as sodium chloride (NaCl), is used to produce chlorine gas through electrolysis. The chlorinator applies electrolysis to separate the desired chlorine from sodium chloride. The following equations describe the chemical reactions that occur [Lenntech, n.d.]:

Cathode:

$$2\mathrm{H}^{+}(aq) + 2\mathrm{e}^{-} \rightarrow \mathrm{H}_2(g)$$

Anode:

$$2\mathrm{Cl}^{-}(aq) \rightarrow \mathrm{Cl}_2(g) + 2\mathrm{e}^{-}$$

Overall reaction:

$$2\mathrm{NaCl} + 2\mathrm{H}_2\mathrm{O} \rightarrow \mathrm{Cl}_2 + \mathrm{H}_2 + 2\mathrm{NaOH}$$

As described in 1.2.2, the chlorine gas is added to the contaminated water. The chlorine eliminates all unhealthy bacteria, making the water drinkable, as long as the chlorine level is between 2 and 5 ppm.

B.2. Instruction manual and water testing

To effectively guide the responsible inhabitants of the communities, the project team has developed a manual outlining each step to follow when using the chlorinator. Additionally, a chlorine test kit has been provided for measuring the chlorine level in the water. This test is simple: one adds water to the tester, followed by a drop of Orthotolidine, then shakes the tester to mix. The tester indicates the chlorine level using colors. By comparing the color of the water with the colors on the tester, users can determine the chlorine level in the water. In the manual a visualisation of the chlorine tester can be found. The manual has been added to this paper below and is written in English, while the communities received a manual in Spanish.

Chlorinator Manual

Step 1

Open the valve of the dirty water supply to fill the tank.

Step 2

When the tank is filled until the maximum line (blue zip tie on top of the tank) close the valve of the untreated water supply.

Step 3

1. Make sure the drain tubes (red and black) at the bottom of the M-100 are clamped shut by the pinch clamps.
2. Confirm the “vent” hole on the chlorine side is unobstructed.
3. Make sure the Chlorine gas tube is disconnected from the injector.

Step 4

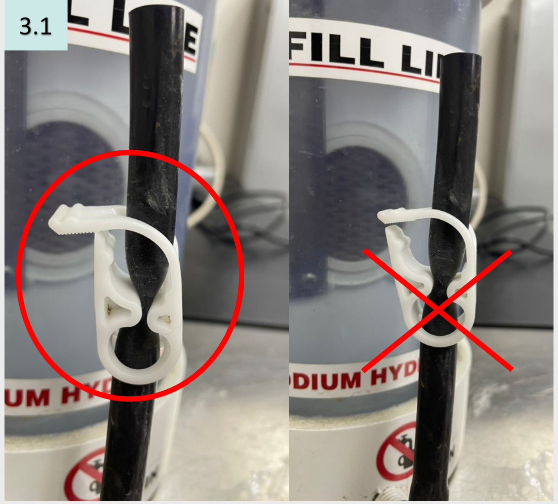
1. Place **600ml** of untreated water into the empty water bottle.
2. Fill the metal measuring cup to the top with table salt.
3. Add the cup of salt to the **600ml** water in the water bottle and shake well until all the salt is dissolved.

Step 5

1. Remove the plug from the fill tube that says: ‘add salt water here’.
2. Pour the salt water mixture into the tube using the funnel.
3. The water in the fill tube should reach the maximum line. Place back the plug.

Step 6

1. Fill the water bottle again with untreated water, **550ml,** and add this to into the oval-shaped hole at the top of the M-100 until the maximum line is reached.
2. Now add half a teaspoon of salt into the oval-shaped hole.



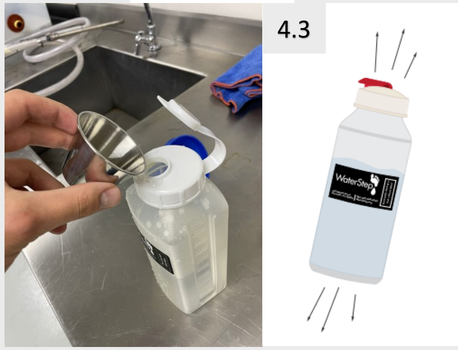
3.1

3.3

3.3

4.1

4.2



4.3

5.1

5.2

5.3

6.1

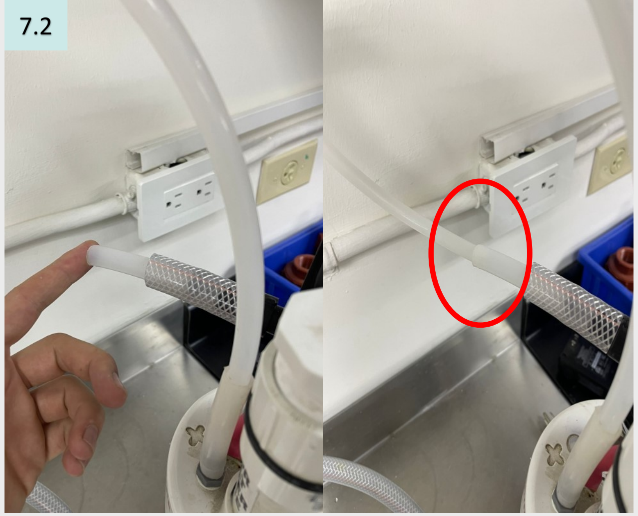
Page 2

Step 7

1. Plug the power adapter of the chlorinator into the wall socket to start the chlorinator and the water pump. Once water is fowing through the system, check for any water leaks. If leaks or drips are found, adjust the tubing.
2. Hold your finger against the opening of the small tube coming from the injector to check if there is suction. If there is suction, connect the Chlorine gas tube to the injector.

7.1

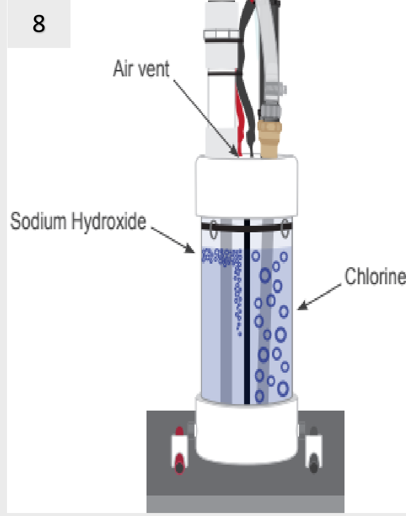
7.2



Step 8

Once the water is flowing, and the M-100 is running, look for bubbling action in the Chlorine side and small bubbles forming in the Sodium Hydroxide side. This indicates that the M-100 is working correctly.

8

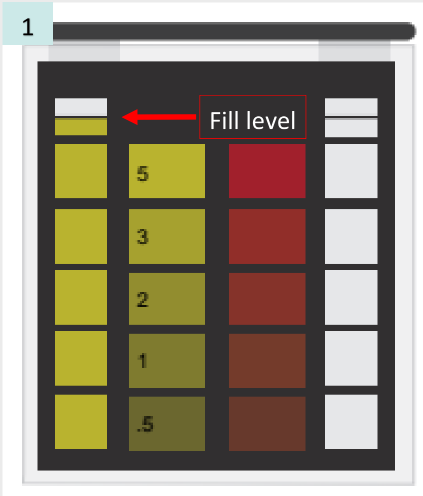


Chlorine Testing

Step 1

Use the chlorine test kit to test chlorine levels in the water. Get a sample from the tap at the bottom of the tank. (Let the water run for 5 seconds before taking a sample.) Add one drop of Orthotolidine and shake the tester to mix. Match the color of the water with the color standard on the tester.

1



1

1

Step 2

Continue running the chlorinator until the chlorine level reaches **3 PPM (Parts Per Million)**. The first couple of times you use this system it is important to test the water every 5 minutes. After you have gone through the process several times, you will be able to better judge how long it takes for your water to become chlorinated and how often you need to test it.

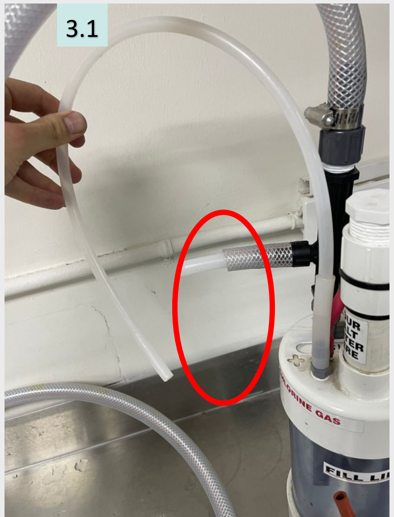
NOTE

If your test kit is no longer yellow and has turned orange or red, there is too much chlorine in the water.

Step 3

1. When the chlorine level reaches 3 PPM, remove the 1/4” (6mm) chlorine tube from the injector.
2. Then, remove the plug of the power adapter from the wall socket to stop the chlorinator.

3.1



3.2

Page 3

Step 4

Allow the treated water to sit for one hour and then re-check the chlorine levels. Levels should be 2 PPM or more. If the chlorine level is lower than 2 PPM, turn the chlorinator on again and allow the water to stand for one additional hour and re-test. If the chlorine levels are between 2 and 5 PPM, it is safe to drink.

Cleaning Chlorinator

Step 1

Loosen and remove the plug at the top of the fill tube on the CHLORINE side. Keep your face away from the fill tube and **DO NOT INHALE THE CHLORINE GAS!**

Step 2

1. Insert the (red) drain tube at the bottom of the Chlorine side of the Chlorinator into the top of the empty container that has the word **WASTE WATER** on it. Release the pinch clamp and let all the chlorine pour into the container. Keep your face away from the opening of the empty container and **DO NOT INHALE THE CHLORINE GAS!**
2. Insert the (black) drain tube at the bottom of the Sodium Hydroxide side of the Chlorinator into the top of the same container with the label **WASTE WATER** on it. Release the pinch clamp and let all the sodium hydroxide pour into the container.

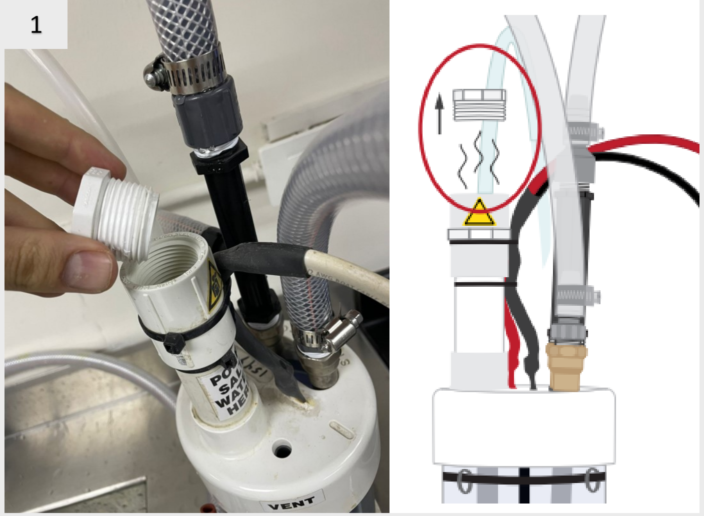
Step 3

1. Squeeze/engage the pinch clamps.
2. Fill the water bottle with plain water and pour into the chlorine side of the M-100. Refill and drain this side three times. Collect rinse water in the same container (**WASTE WATER**).
3. Repeat the process for the Sodium Hydroxide side, pouring the rinse water into the oval-opening on top of the M-100. Collect the rinse water in the same container.

Step 4

Wipe down the exterior of the M-100 and the tank with a cloth to remove dirt and moisture.

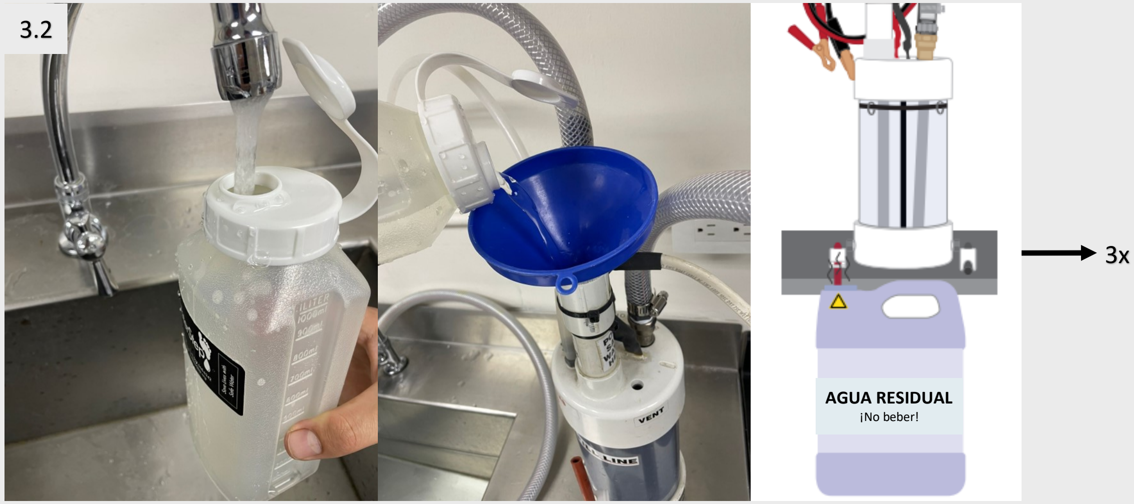
1



2.1

3.1

3.2



WARNING

Always protect your eyes and skin. Keep all solutions out of eyes and avoid breathing fumes. Keep all solutions away from children. Store solutions in a safe place.

IMPORTANT

- Clean the chlorinator after every time you used it.
- Clean the water tank with a water hose when it seems dirty, but at least every 2 months.

WHAT TO DO WITH THE BY-PRODUCTS (WASTE WATER)

If the by-products are not going to be used, both solutions can be poured into the same container. They will neutralize each other into saline water and can be safely disposed of on the ground. This neutralized solution will not harm the environment.