स्वयंसेवी अभियान नेपाल
Volunteers Initiative Nepal

# Water Quality Research in Kavresthali Ward 6
## July 2016

By: Morgan Mercer
Environment and Conservation Internship
June and July 2016

In Partnership with:

Volunteers Initiative Nepal
Balaju, Kathmandu, Nepal

Davidson College
Davidson, North Carolina, USA

Freeman Foundation

Supervisor: Dr. Laxmi Ghimire

# Table of Contents



Image 1: Water Storage Tanks and In-Home Taps

# Introduction

Throughout June and July, VIN volunteers conducted water quality research in Kavresthali Ward 6. In June, volunteers were surveying households in the area, and in July, the remaining volunteer was testing water samples from villages within Ward 6.

Kavresthali is a town in the Northern part of the Kathmandu valley. There are 3 different wards in Kavresthali: Wards 4, 5, and 6. Ward 6 consists of 5 villages: Thumka, Karkithok, Thali, Kaura, and Devithan. Combined, there are approximately 220 households in Ward 6.

Over the course of July, water from different areas in Ward 6 was tested for physical, chemical, and biological parameters. These tests include tests for pH, conductivity, turbidity, ammonium, nitrite, chlorine, fluoride, and thermo tolerant e-coli.

The goal of the testing is to determine the level of contaminants in drinking water in Ward 6. Tests needed to be done to discover if the sources or storage containers (or both) are contaminated. This will help when informing villagers about the water quality and ways to prevent and treat contaminated water.

# Previous Research

Kavresthali is a new area for VIN, and this is one of the first projects in the area. There is not any previous water research in this area, but VIN has completed water research projects in other areas, like Jitpur Phedi and Okhaldhuga.

Previous volunteers have found that water samples' physical and chemical parameters meet health standards, but e-coli colonies are present in drinking water. After further testing, these volunteers determined that the water sources are safe and contaminant free, and drinking water is being contaminated in the homes in private gagris. These volunteers did not test water during the monsoon season, though, so my results are slightly different from theirs. It is still important to note the differences between testing water samples during monsoon season since the additional rainfall greatly affects the water quality.

# Methods

VIN provides a water testing kit for water quality tests. The Potakit tests for physical, chemical, and biological aspects of the water, including tests for pH, conductivity, turbidity, ammonium, chlorine, nitrite, nitrate, fluoride, and thermo tolerant e-coli. The battery for the Potakit biological test is broken, so the biological test only works when the power is on for more than 14 hours. This means the results of the biological tests are approximations based on the color of the samples, instead of the specific number of e-coli colonies of the usual results.

Water samples were collected at at least 1 source, 1 public tap, and 2 private taps in each village, with the exception of Devithan. Because of heavy rains and lack of time, I was unable to collect water samples from Devithan. Private taps were randomly selected for testing, but each private tap comes from a different source. This means that in each village, two different source waters are being tested through the private taps.

Because it was found that the water in the public and private taps was already contaminated, I also began testing source water. At least one source was tested in each of the four villages. In Thumka, three sources were tested because Thumka has a higher number of sources than the other villages. Kaura's source was also tested twice, once during normal weather and then again after a big storm that caused several landslides.

After discovering sources were contaminated by the heavy rainfall of monsoon season, different water treatment methods, like boiling water and filtering water, were tested to deem their success at removing contaminants and e-coli from drinking water. Four different treatment methods were tested: Biosand filter, metal filter, boiled water, and rainwater collection.

Overall, 23 different samples were collected, including 4 public taps, 8 private taps, 7 sources, and 4 types of treated water.

Household surveys were also completed throughout the month of June in order to establish water treatment methods, hygiene habits, and water source mapping in Ward 6. More information on the surveys and survey results can be found in my June 2016 report.

Image 2: Public Tap in Thumka

## Nepal's Water Quality Standards

| Group | Parameter | Unit | Maximum Concentration Limits |
|---|---|---|---|
| Physical and Chemical | **Turbidity** | **NTU** | **5 (10)**** |
| | **pH** | | **6.5-8.5*** |
| | Color | TCU | 5 (15)** |
| | Total Dissolved Solids | mg/l | 1000 |
| | **Electrical Conductivity** | **µs/cm** | **1500** |
| | Iron | mg/l | 0.3 (3)** |
| | Manganese | mg/l | 0.2 |
| | Arsenic | mg/l | 0.02 |
| | Cadmium | mg/l | 0.003 |
| | Chromium | mg/l | 0.05 |
| | Cyanide | mg/l | 0.07 |
| | **Fluoride** | **mg/l** | **0.5-1.5*** |
| | Lead | mg/l | 0.01 |
| | **Ammonia** | **mg/l** | **1.5** |
| | **Chloride** | **mg/l** | **250** |
| | Sulphate | mg/l | 250 |
| | Nitrate | mg/l | 50 |
| | Copper | mg/l | 1 |
| | Total Hardness | mg/l | 500 |
| | Calcium | mg/l | 200 |
| | Zinc | mg/l | 3 |
| | Mercury | mg/l | 0.001 |
| | Aluminum | mg/l | 0.2 |

| | | | |
|---|---|---|---|
| | Residual Chlorine | mg/l | 0.1-0.2* |
| Biological | **E-Coli** | **MPN/100ml** | **0** |

Note: *Indicates minimum and maximum limits.

** Numbers in parenthesis indicate upper ranges of the standards recommended.

Figures in bold are parameters included in my tests and results.

Source: Environment Statistics of Nepal 2008, Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics, Kathmandu, Nepal

# Results

## *Psychical Parameters*

### pH

Nepal's drinking water standard requires water to be within a 6.5-8.5 pH range. In general, the water samples tested are within this range, but there are two samples, Karkithok's source and public tap, that are below this range.

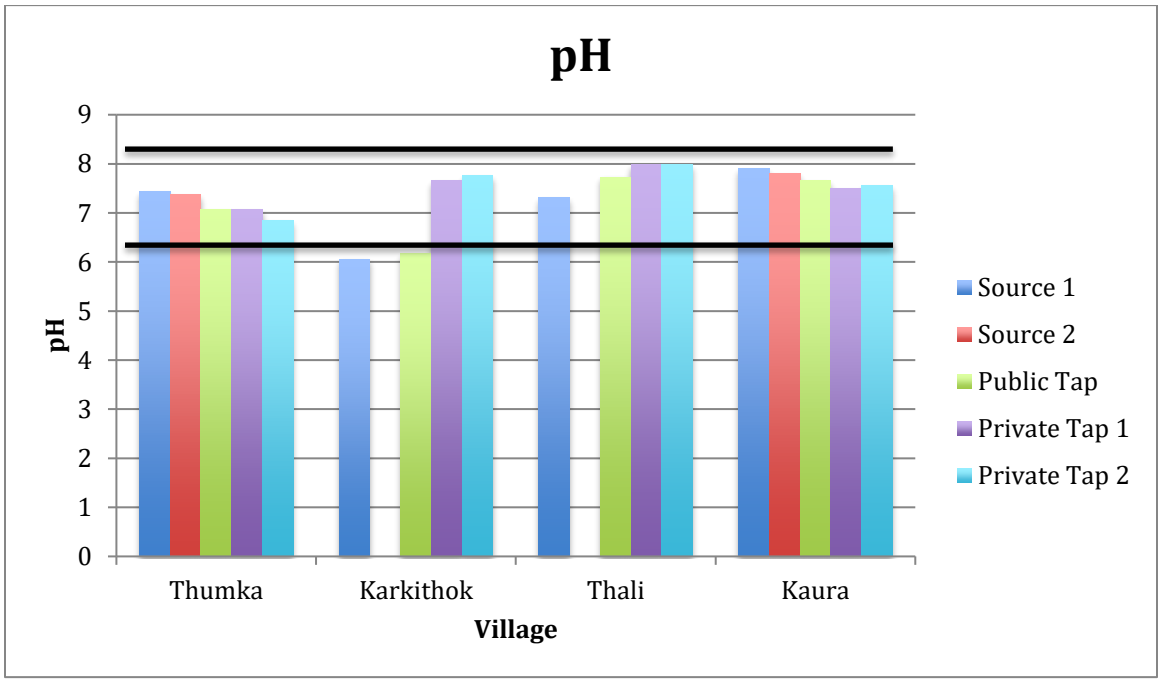



Figure 1: pH Ranges of Samples with Lines to Indicate Nepal's Drinking Water pH Standard

### Conductivity

The conductivity of all of the samples is within healthy drinking water standards. The maximum conductivity rating is 1500 µs/cm, and the samples collected are all well under this number. The

average conductivity of the samples is 63.45 µs/cm. The highest conductivity reading is 170.4 µs/cm, and the lowest is 19.6 µs/cm.

Turbidity

Turbidity measures the clarity of water. Drinking water should be clear, with an ideal turbidity of less than 5 NTU. All of the samples, except for one, have a turbidity of less than 5. This one sample is the Kaura source.

The Kaura source was tested twice: once with minimal rain in the preceding days and once after a big rainstorm that caused several landslides. The Kaura source had a turbidity of less than 5 during the first test, but after the big rainstorm and landslides, the Kaura source had a turbidity of 60. The landslides of the preceding day increased the amount of debris in the water, lowering the clarity. This is the only exception to the turbidity limitation, and it depends largely on the weather conditions at the time of testing.

## *Chemical Parameters*

Ammonia

Ammonia occurs as a result of the breakdown of nitrogenous material in natural waters. Ammonia contamination is most commonly caused by fertilizer runoff and runoff from animal feedlots. Excessive ammonia is toxic to aquatic life, and its toxicity varies depending on the pH of the water. The WHO does not regulate the amount of ammonia in drinking water because studies have shown that ammonia does not have any long-term health effects for humans. Ammonia can irritate respiratory tracts, though, and it is also very corrosive to copper plumbing systems.

Nepal's drinking water standards require ammonia to be below 1.5 mg/l. All of the samples tested are well below this range. The average amount of ammonia in the samples is 0.14 mg/l, and more than half of the samples have an ammonia concentration of 0 mg/l.

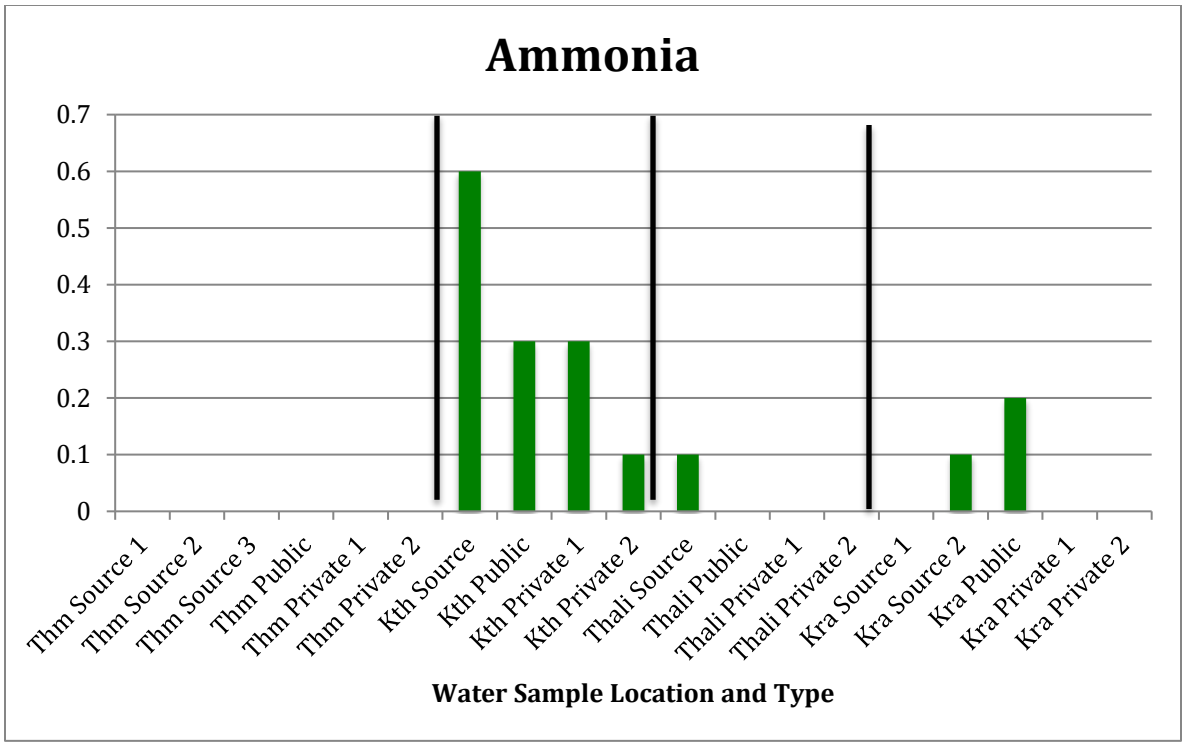



Figure 2: Ammonia Levels in Each Village's Test Locations With Divisions Between Different Villages

**Note:**

| | |
|---|---|
| Thm Source 1 | Thumka Water Source #1 – running stream water in the forest |
| Thm Source 2 | Thumka Water Source #2 – running stream water in the forest |
| Thm Source 3 | Thumka Water Source #3 – deep puddle of pooled water in the forest |
| Thm Public | Thumka Public Tap near Kalidevi Upper School |
| Thm Private 1 | Private Tap in Thumka |
| Thm Private 2 | Private Tap in Thumka |
| Kth Source | Karkithok Source – cement structure with pooled water |
| Kth Public | Karkithok Public Tap, uphill from village |
| Kth Private 1 | Private Tap in Karkithok |
| Kth Private 2 | Private Tap in Karkithok |
| Thali Source | Thali Source – large pipe that leads into the village |
| Thali Public | Thali Public Tap, at fork between Thali and Karkithok |
| Thali Private 1 | Private Tap in Thali |
| Thali Private 2 | Private Tap in Thali |
| Kra Source 1 | Kaura Source – running stream by the side of the road |
| Kra Source 2 | Kaura Source #1 after a big rainstorm and landslides |
| Kra Public | Kaura Public Tap, on the side of the road |
| Kra Private 1 | Private Tap in Kaura |
| Kra Private 2 | Private Tap in Kaura |

Chlorine

Chlorine is often used for disinfecting drinking water and swimming pools, for controlling microbiological growth in cooling waters, and in other forms of water treatment. As an additive to the water, chlorine helps control microbes, but high levels of chlorine in drinking water can cause eye and nose irritation and stomach discomfort. Chlorine as chlorine dioxide can also cause anemia, and in young children and infants, it can have nervous system effects.

All of the chlorine samples are well within the range for safe drinking water. The maximum amount of chlorine is 250 mg/l, and all of the samples are below 1 mg/l. These are tests for total chlorine levels. The Potakit has the ability to test for free, combined, and total chlorine levels, but since the total chlorine levels were so low, it was deemed unnecessary to test for free and combined chlorine.

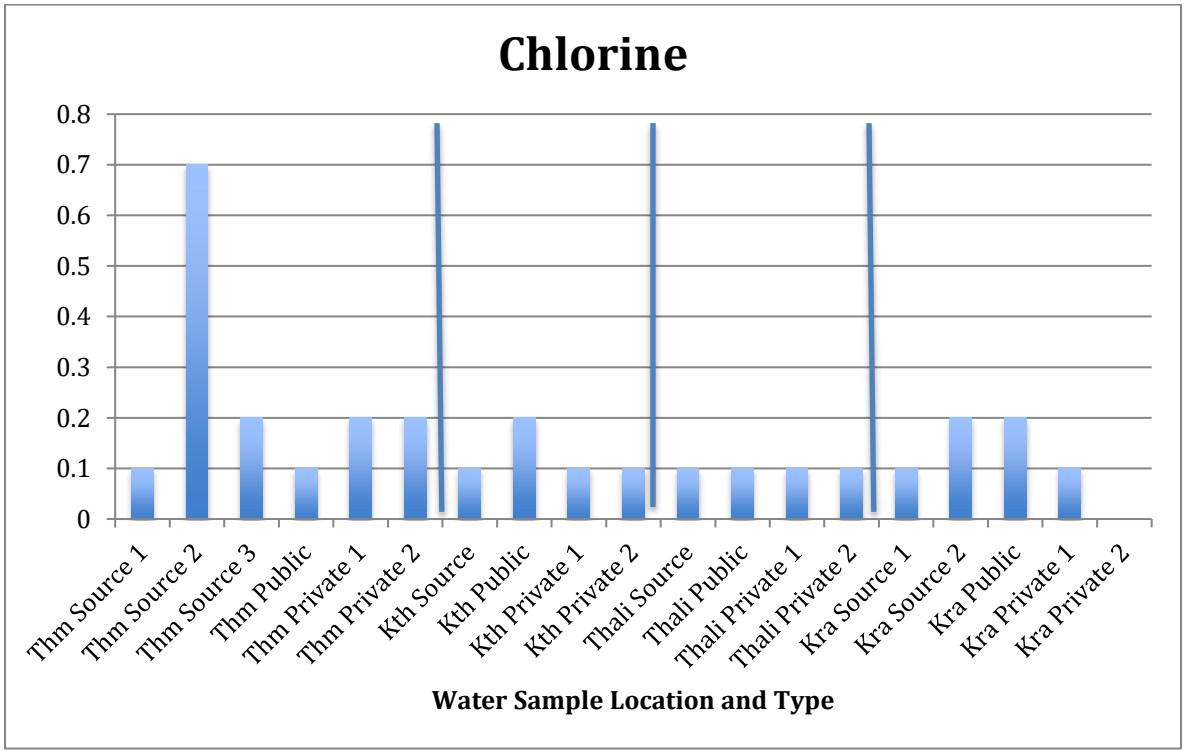



Figure 3: Chlorine Levels in Each Sample with Divisions Between Different Villages

Nitrite

Nitrites are found in natural water sources as an intermediary result in the nitrogen cycle. Excess nitrite can also be introduced to the environment through fertilizer runoff, leakage from septic tanks, sewage, and erosion of natural deposits. High amounts of nitrite have the greatest effect on infants. Infants below the age of 6 months are at the risk of serious illness and death if they drink contaminated nitrite water in excess. Symptoms include shortness of breath and blue-baby syndrome.

Although Nepal's drinking water standards do not have a number for nitrite, the nitrite levels found in the samples is perfectly safe to drink. The Potakit manual has a guideline limit of 3 mg/l of nitrite in water samples, and the United States has a limit of 1 mg/l. None of the samples come close to either of these limits, and none of the samples are above 0.05 mg/l.

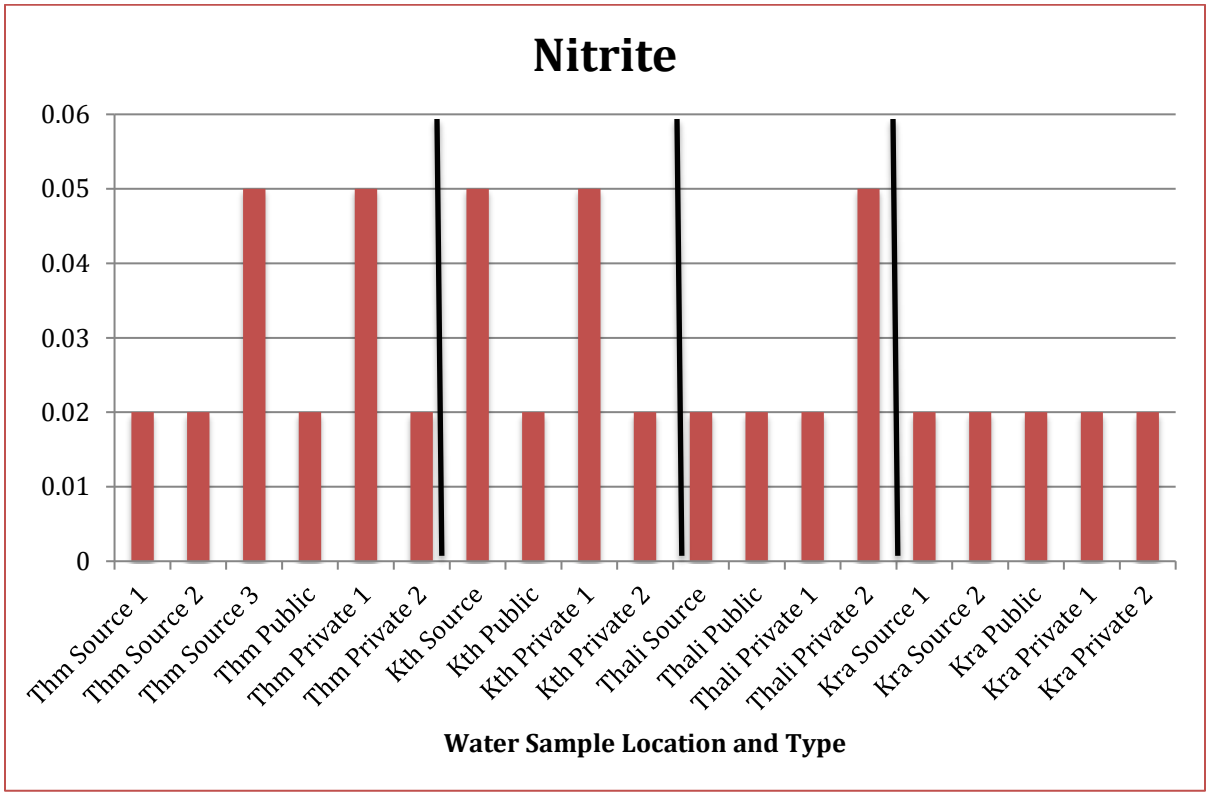



Figure 4: Nitrite Levels in Water Samples with Division Between Different Villages

Fluoride

Naturally, fluoride occurs in some ground waters, and it is often put in drinking water to help prevent tooth decay. The erosion of natural deposits and discharge from fertilizers and aluminum factories can also cause fluoride to be present in water. High concentrations of fluoride can cause bone disease, pain and tenderness of the bones, teeth discoloration, and mottled teeth in children.

Nepal's drinking water standards place desirable levels of fluoride between 0.5-1.5 mg/l. The results for Fluoride are a bit unusual because they vary greatly depending on the date the water was tested. Water tested late June and early July has lower amounts of Fluoride than the water tested after large amounts of rain later in July. Rainwater was also tested (shown below in the water treatment section), and it also has a high amount of fluoride (1.5 mg/l).

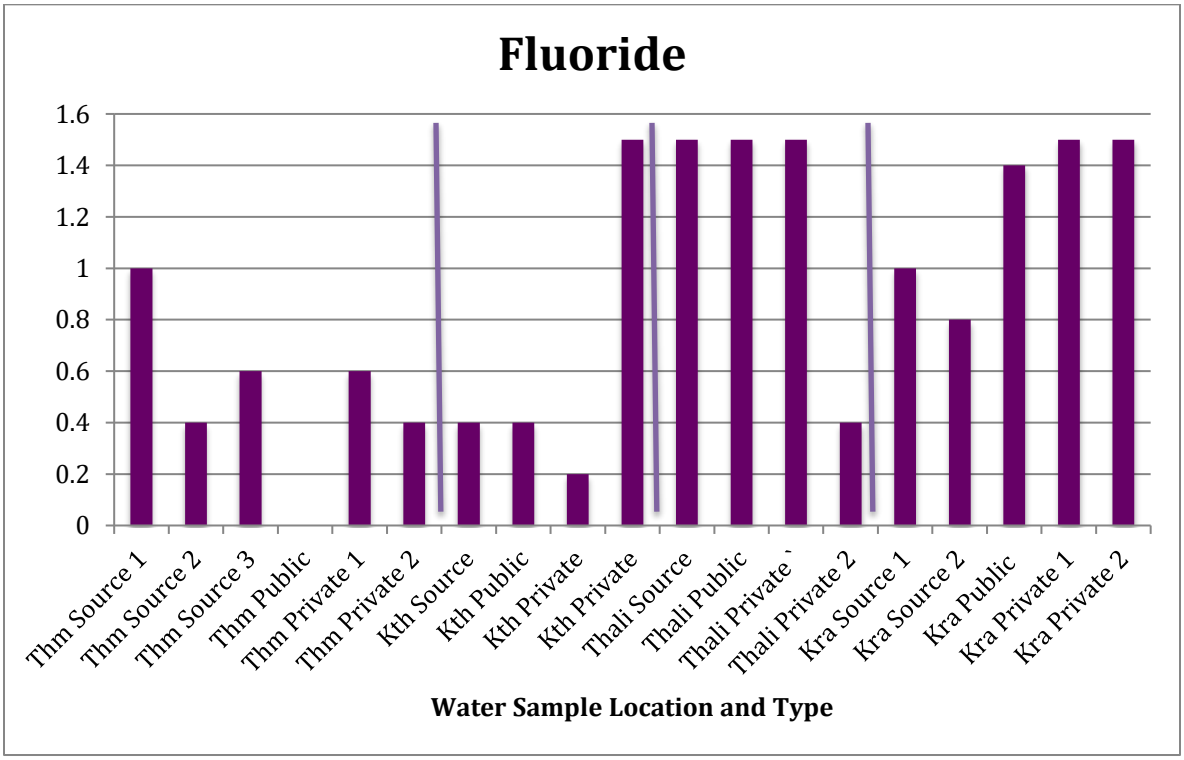



Figure 5: Fluoride Levels in Water Samples with Divisions Between Different Villages

## *Biological Parameters*

E-coli

Escherichia coli, more commonly known as e-coli, is a bacterial strain that is known to cause problems in the gastrointestinal tract of infected humans and animals. E-coli is naturally present in the intestinal flora and fauna of humans and animals, but when it comes in contact with other parts of the body, e-coli can cause illness and disease. E-coli water contamination indicates that the water is contaminated with human and animal fecal waste. E-coli pathogen can cause diarrhea, fever, abdominal cramps, nausea, and headaches, and they are especially harmful to young children, babies, and people with weak immune systems.

The battery for the biological test incubator is broken, so without 24-hour power, the machine does not work properly. Biological test results are thus approximations for the amount of e-coli in a sample based on the color of each sample after the 14+ hour incubation period. Pictures were taken of all of the biological tests to serve as a reference since counting e-coli colonies was not possible.

In the pictures below, yellow denotes the presence of e-coli colonies. The more yellow in a sample, the more e-coli is present in that water sample. The pink color indicates water without e-coli and safe drinking water. The pictures below are also only a few of the biological tests conducted. The pictures below show a series of different samples, including several private taps, public taps, sources, and a water treatment method.

The pictures in Image 5 of the water treatment method also include a test of the tap water before it was filtered. This image shows that there is a significant decrease in the number of e-coli colonies after filtering the water. The same can be seen in Image 4 with the boiled water. The boiled water sample has less yellow in the sample than the other samples present. The small amount of yellow in this sample could be contributed to contamination while handling the sample and not to contamination of the water. Additional tests would be necessary to determine whether the yellow is due to handling the samples or the water itself.

Image 3: 8 July tests

Image 4: 22 July tests

Image 5: 27 July tests

**Note:**

*8 July*

Sample 1 – Thumka Private Tap 1

Sample 2 – Thumka Private Tap 2

Sample 3 – Karkithok Source (after rain)

Sample 4 – Karkithok Public Tap

*22 July*

Sample 1 – Boiled Water

Sample 2 – Karkithok Source (before big rain)

Sample 3 – Thumka Public Tap

Sample 4 – Kaura Source (before big rain)

Sample 5 – Kaura Public Tap

*27 July*

Sample 10 – Metal Filter (from Michelle's Tap)

Sample 4 – Michelle's Tap

Sample 9 – Kaura source (after big rain)

Sample 1 – Kaura Private Tap 1

Sample 5 – Kaura Private Tap 2

It is important to note that the amount of yellow, and thus e-coli, in each sample greatly varies depending on the amount of rain before the tests. In the pictures above, the Kaura source and the Karkithok source are displayed twice, once before and once after a big rainstorm. Both of these tests show that there is an increased amount of e-coli and yellow present in the samples taken a day after a big rainstorm. The more it rained right before a sample was collected, the more e-coli was present in the sample. This proves that more rain leads to more e-coli contamination.

## *Water Treatment Method Descriptions*

After determining that water sources were contaminated by the heavy rains of monsoon season, tests were also conducted on different water treatment methods. This was to determine which treatment method is the most effective against the higher contamination during monsoon months.

### Biosand Filter

Biosand filters are similar to sand filters, and they can be created using materials at home, or they can be purchased from a range of companies. Biosand filters are concrete or plastic containers filled with specially prepared sand and gravel. Water is poured into the top of the Biosand filter and a diffuser plate evenly distributes the water over the sand layer. The water then travels through the sand bed and passes through several layers of gravel before it collects at a plastic pipe at the bottom of the filter. The clean water exits from this pipe, and then can be collected for use by the family.

All but two of the households in Thumka have a Biosand filter. After the 2015 earthquake, Best Paani, a water treatment company, distributed Biosand filters to every house in Thumka.

### Metal Filter

Metal filters were seen in many of the houses during surveys. The most common brand of this filter is a Euro filter, although little else is known about the filters. It was possible to collect water samples form these filters, but none of the families were able to adequately explain how the filter works. Outside of Thumka, where almost every family has a Biosand filter, the most common filtration method is a metal filter.

Image 6: Metal Filter in Michelle's House

### Boiling Water

Boiled water involves heating large amounts of water until it reaches a boiling point. Water must be

boiled for at least five minutes to ensure that the water has been treated thoroughly. Boiling water is a cheap and easy way to treat water since it does not require any additional equipment, like a filter, and it is commonly used to treat drinking water.

Rainwater

Rainwater collection is the collection of copious amounts of rainwater that can be then be used for drinking, cooking, washing, and other household purposes. Rainwater collection requires large containers to store water, and it can be difficult to fund and build large storage tanks. Rainwater is viewed as safe drinking water since it has yet to be contaminated by e-coli and fecal matter on the ground, but rainwater storage can become contaminated by bacteria and chemicals present in the storage container.

The physical and chemical tests for rainwater were conducted twice: once at the beginning of July and once at the end of July. The biological test for rainwater was completed during the second chemical tests.

Solar

Because of the consistent daily rains, I was unable to test solar water treatment. Solar water treatment is one of the easiest and cheapest water treatment methods, but because of the rain and cloudy weather during monsoon months, it is not the best water treatment method during the rainy months.

## *Water Treatment Results*

Physical Parameters: pH, Conductivity, and Turbidity

Of the five samples of water treatment, only three are within Nepal's drinking water standards. The pH for boiled water was over 9.0 pH, and the pH for the Biosand filter was just above the limit at 8.73.

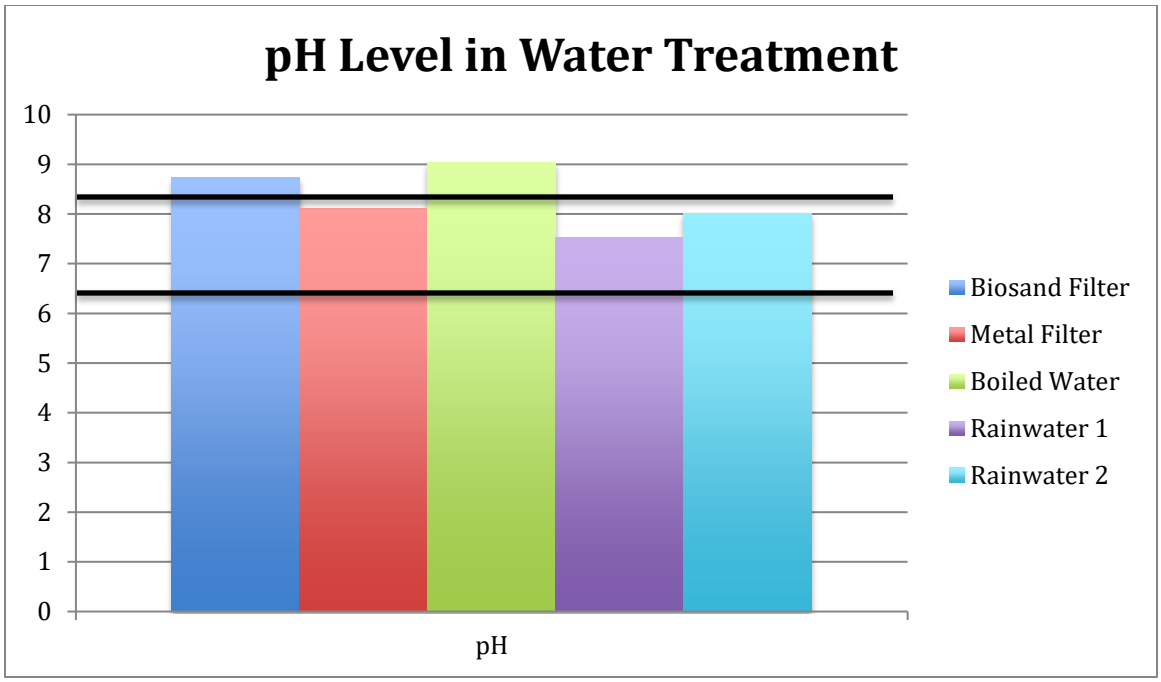



Figure 6: pH Levels of Various Water Treatment Samples

The conductivity of each of the samples is well within the range. This means the conductivity of all of the samples is within the parameter for safe drinking water.

The turbidity of each of the water treatment samples is also within safe drinking standards. All of the standards were below 5 NTU, which means they have clear visibility and have no cloudiness or visible fogginess.

Chemical Parameters of Water Treatment

The chemical parameters of the various water treatments tested are within Nepal's drinking water standards. The water treatment samples do have unusually high amounts of some of the chemicals, like ammonia and fluoride, although these unusually high amounts are still safe to drink. I included the average concentration of each chemical on the below graph to serve as a reference when comparing the results of water treatment to untreated water.

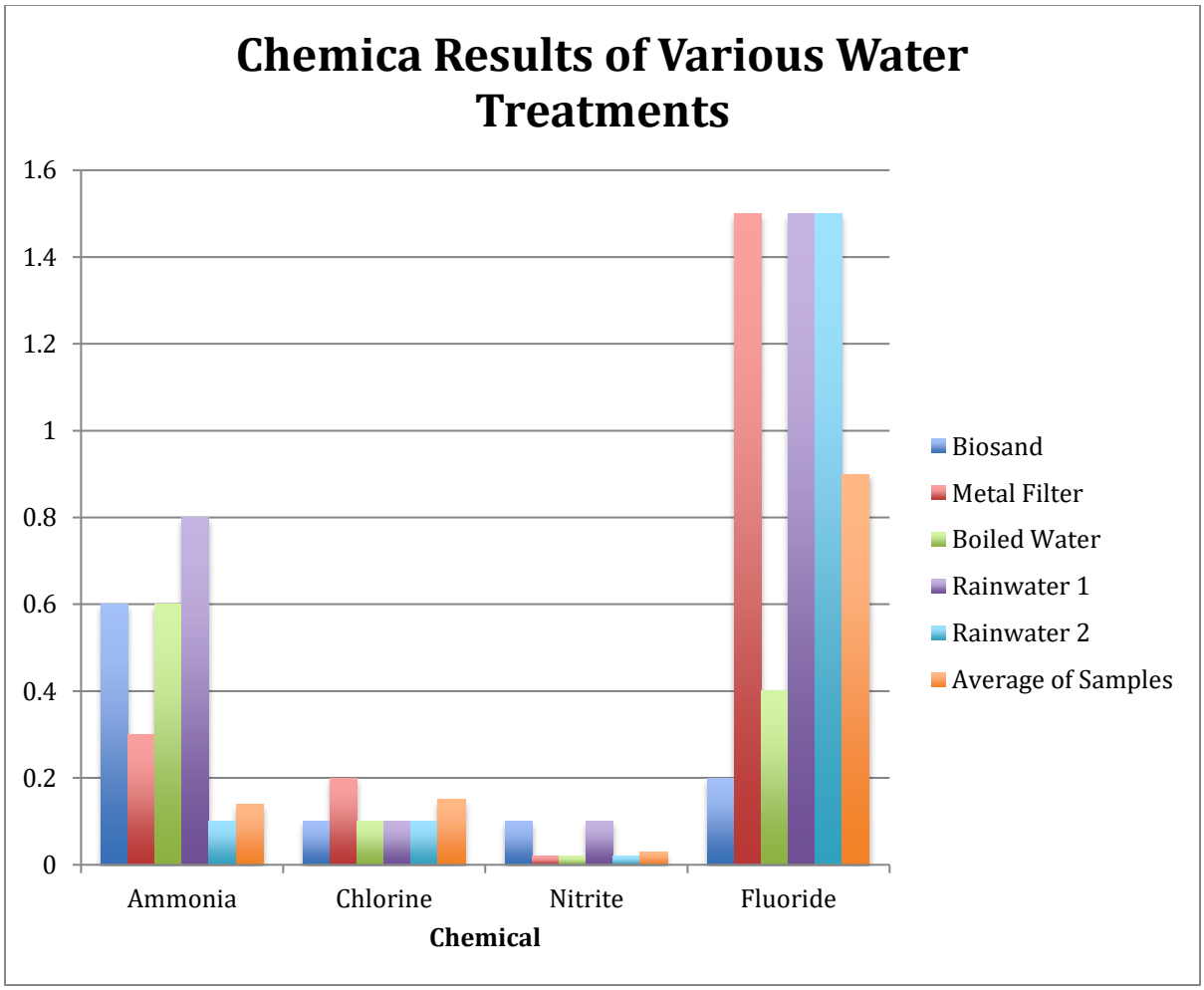



Figure 7: Chemical Results for Water Treatment Types

Biological Parameters of Water Treatment

Biological testing was conducted on three water treatment methods. I was unable to biologically test rainwater because it was never raining at the time I was conducting biological tests. Of the three water treatments I tested, I started by testing the tap water prior to treatment then the treatment method. In all three of the tests, the water was considerably cleaner and had fewer e-coli colonies after treatment. A good example is shown above in the biological treatment section in Image 5 that shows water before and after being treated with the metal filter. Of all of the water samples tested, the water treatment methods had the least amount of yellow and the fewest number of e-coli colonies. This proves that treating water removes harmful pathogens and makes water safer to drink.

# Discussion

## *Physical and Chemical Parameters*

Similar to past water research reports, the physical and chemical parameters of the water are generally not an issue. There is little variance between the chemical concentrations. There were two samples whose pH was too low, but other than those two, everything fits into Nepal's safe drinking water standards. The only irregularity came from the fluoride concentrations.

Water testing began in late June and continued throughout the month of July, and samples tested later have higher amounts of fluoride. The amount of fluoride increased with the intensifying rains, and chemical tests of rainwater also show that rainwater has a fluoride concentration of 1.5 mg/l. This is still within Nepal's safe drinking water standards since the fluoride concentration should not exceed 1.5 mg/l. It is interesting that rainwater increases the amount of fluoride in the water since previous volunteers and tests in June do not reveal high amounts of fluoride in the natural environment. This means the monsoon rains are bringing in water from other sources that are causing the fluoride concentrations to spike. Again, this is not unhealthy or excessively contaminating the water, but it is a surprising irregularity.

## *Biological Parameters*

The biggest issue with water is e-coli contamination. Even though the incubation machine did not work properly, it still gives a good idea about the amount of e-coli in each sample. It is clear that the heavier and more consistent rains during monsoon months are contaminating water sources. Previous water research reports have shown that source water is generally free of contaminants, and the water is being contaminated in the gagris used to store water. This was not the case over the past, and the water is already contaminated before it reaches the in home gagris.

Most of the water sources are open streams and ponds, so monsoon rains are washing contaminants and fecal matter into the open sources. The rains are able to wash human and animal waste into the water sources, contaminating the water in the public and private taps. This makes it important to filter water, and it also makes it essential for each household to use a proper toilet. From survey results, we found that 10% of villagers in Ward 6 use their fields as a toilet, and this only increases the potential for e-coli contamination. Temporary toilets built after

the 2015 earthquake are also problematic because many of them are build too close to streams, and temporary toilets often dispose of waste poorly, so it seeps into the water source. Proper toilets are necessary to help decrease the amount of e-coli in the water that is linked to human waste.

## *Water Treatment Methods*

Because of the widespread contamination due to the heavy rains in the monsoon season, it is necessary to look into the effectiveness of different water treatment techniques. While conducting surveys in June, several households spoke about the increased rate of sickness during monsoon season. It is important to look at the pros and cons of different water treatment methods to determine which is the most effective at combating the increased pathogens and higher rate of disease during monsoon months.

Four different water treatment methods were tested, and rainwater was tested twice. Filtering by a cloth was also tested, although it is not included here as a viable water treatment method. An evaluation of the strengths and weaknesses of each water treatment method is below.

Biosand Filter

Biosand filters are an effective way to treat water and combat disease-bringing pathogens. Water testing shows that the Biosand filter kills almost all of the e-coli colonies, and the chemical components of the water are within Nepal's safe drinking water standard. The Biosand filter can also filter a large quantity of water, and it is a good way for a family to filter enough drinking water for the whole family.

The Biosand filter is not perfect, though. The pH of the Biosand filtered water was slightly over Nepal's upper limit of 8.5 pH. The Biosand filter is also one of the more expensive water treatment methods because it requires more materials to make. It also needs a specific combination of sand and gravel, so a person who is knowledgeable about the filter has to help set up the filter (or they can be bought). The Biosand filter is also large, and it takes up a lot of space.

Metal Filter

The metal filters are able to treat most of the e-coli colonies in the water. The Biosand filter filters out ore of the e-coli colonies than the metal filters, but the metal filter still treats the water well. The metal filter's physical and chemical parameters are safely within healthy drinking water standards, and the metal filter is small and does not take up much room in a kitchen or living room.

Water testing results did show that the metal filter had a higher than normal rate of fluoride. This means that the metal filter is either not filtering out the fluoride, or it is introducing more fluoride into the sample. The fluoride amount is still within safe drinking water standards, but it is important to note that the filter did not treat the higher concentration of fluoride. The metal filters are also the most expensive water treatment method since they cannot be made at home; they can only be purchased. They do last for a long time, and do not need to be replaced often, but the higher initial expense is always something to keep in mind.

Boiling Water

Boiling water is one of the easiest and most cost efficient water treatment methods. Each family already has the materials necessary to boil water, and of the water treatments tested, it killed the most e-coli colonies. The chemical parameters of the boiled water are also good and within Nepal's drinking water standards.

Boiling water can be difficult, though, when trying to boil water for large amounts of people. Boiling water takes time, and it can be difficult to boil enough drinking water for a whole family for an entire day. Boiled water also has a high pH, and it had the highest pH of all of the water samples. The pH does lower slightly as the water cools, but it is still relatively high when compared to all of the other samples.

Solar Treatment

It was difficult to test solar water treatment because of the lack of consistent direct sunlight. Although solar treatment is inexpensive and does not require many materials, it is not the most efficient water treatment method during monsoon season. Solar water treatment requires at least

6 hours of direct sunlight, and direct sunlight is not consistent enough during monsoon season to rely on it for safe to drinking water.

Rainwater

Direct rainwater is some of the cleanest and safest water to drink. All of the chemical and physical parameters are normal and safe to drink, and there are not e-coli present in rainwater.

The problem with rainwater is the storage system. Rainwater storage requires large tanks to be build to store rainwater over long periods of time. These storage tanks are expensive to build, and it can be difficult to find space to build them. It is also easy for the tanks to be dirty, which fosters pathogens instead of treating them. The logistics of creating a rainwater storage system are difficult, and keeping the tanks clean can be difficult, but if these problems are combated, rainwater storage is a great source for clean water.

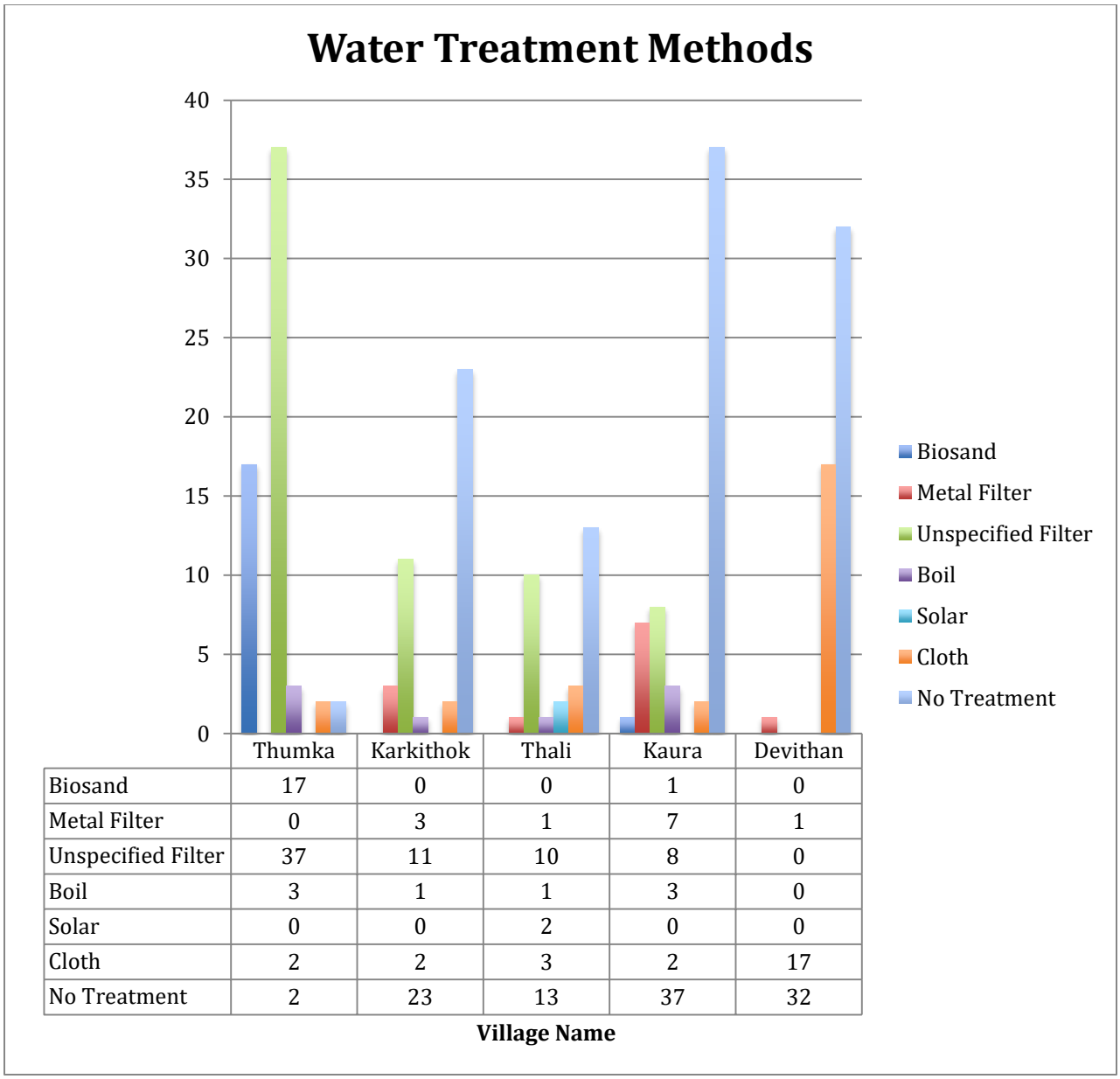
**Summary of Pros and Cons of Various Water Treatment Methods**

| | Pros | Cons |
|---|---|---|
| **Biosand Filter** | • Filters out almost all of the e-coli pathogens<br>• Chemicals are good – filters these as well<br>• Can filter a lot of water | • High pH<br>• Harder to build yourself, requires special sand and gravel |
| **Metal Filter** | • Filter out most of the e-coli<br>• Chemical concentrations are within health standards | • Higher than normal amount of fluoride – this means the filter increases fluoride contents or doesn't filter out the fluoride |
| **Boiling Water** | • Inexpensive<br>• Houses already have necessary supplies<br>• Chemical Concentrations are good | • High pH<br>• Takes a lot of time to boil enough water for an entire family's daily use |

| | | |
|---|---|---|
| | • This method filtered out the most e-coli | |
| **Solar Treatment** | • Inexpensive<br>• Easy to teach and explain<br>• Does not require a lot of additional supplies | • Lack of Sunlight during monsoon |
| **Rainwater** | • Probably the cleanest source of water<br>• Chemicals are within health standards<br>• Little to no e-coli | • Rainwater storage requires funds and manpower to build the storage tank necessary<br>• Rainwater not always available and reliable |

Figure 8: Positive and Negative Aspects of Various Water Treatment Methods

From survey results collected in June, it was discovered that approximately 48% of households treat their water in some way. Survey results also show which water treatment methods are most common in each of the five villages in Kavresthali. The most common water treatment varies greatly depending on the village. In Thumka, almost every household has a filter, but in Devithan, only 2 households properly treat their water. The chart below helps identify which villages are in the most need of water treatment methods and campaigns during monsoon season. It is important to reiterate the need to treat water, but in villages like Devithan and Kaura, where few houses treat their water, it is necessary to do health and hygiene campaigns to inform them on the health benefits of boiling their drinking water.




| | Thumka | Karkithok | Thali | Kaura | Devithan |
|---|---|---|---|---|---|
| Biosand | 17 | 0 | 0 | 1 | 0 |
| Metal Filter | 0 | 3 | 1 | 7 | 1 |
| Unspecified Filter | 37 | 11 | 10 | 8 | 0 |
| Boil | 3 | 1 | 1 | 3 | 0 |
| Solar | 0 | 0 | 2 | 0 | 0 |
| Cloth | 2 | 2 | 3 | 2 | 17 |
| No Treatment | 2 | 23 | 13 | 37 | 32 |

Figure 9: Water Treatment Habits in Kavresthali Ward 6

## Next Steps

Future action is necessary in this area to help ensure water is safe to drink, especially in the monsoon season. I recommend:

- Building toilets for households that are using their fields. This will decrease the amount of fecal matter in the environment, and thus, should decrease the amount of e-coli colonies to surrounding water sources. Information about which houses in the village do not have toilets can be found in my June report.

- Do water treatment campaigns in Ward 6. Since my results show that water is especially contaminated during monsoon season, it is important to tell villagers to treat water during the rainy months. A volunteer and local volunteer should go around to villages, especially Karkithok and Thali, and instruct villagers to boil water before drinking.
- Do more testing of water treatment methods. This report has preliminary results for water treatment methods, but more testing is required to deem the viability and strength of each treatment method, especially during monsoon season.
- Test water quality at schools and the health clinic in and around Kavresthali. Since these places have large groups of people in one place, it easy for disease to spread. It is important to make sure schools and the health post have safe drinking water to cut down on the possibility of illness easily spreading at these places.
- Survey households and do water testing in Kavresthali Ward 4. This will require a volunteer who is here for at least 8 weeks.

Image 7: Public Tap in Karkithok

# Conclusion

Because of the heavy rains of monsoon season, fecal matter and other contaminants are being washed into water sources, contaminating the source, taps, and drinking water throughout the villages in Ward 6. The physical and chemical aspects of the water are fine, and well within Nepal's drinking water standards, but the e-coli contamination of the water causes illness and disease, especially during the monsoon months.

It is important to inform households about the necessity of treating water during the monsoon. Villages, like Kaura, where few people are treating their water, could benefit from health and hygiene campaigns and information about the need to boil water. Water treatment campaigns would be beneficial in each village, even in the villages where almost everyone treats water, because it is important for people to have a greater awareness of the safety of their drinking water. Treating water is incredibly important during the monsoon rains, and boiling water is the best solution during the heavy rains. Boiling water killed all of the e-coli colonies present in the sample, and it is cost efficient and relatively easy to do. When doing campaigns, make sure to inform houses to boil their drinking water.

Toilet construction in the area is also a good next step after learning that the heavy rains are washing human and animal waste into the water sources. Around 15% of households in Ward 6 do not have toilets, and even more houses are using temporary toilets as their permanent toilet. Helping these houses build proper toilet facilities would greatly decrease the amount of human waste that is being washed into water sources.

Overall, the results of water testing enforce the importance of treating drinking water, especially during the monsoon season. There are several methods for water treatment, and all of the treatment methods are effective methods of cleaning drinking water.

## Acknowledgements

I would like to thank the following people for their help throughout my summer experience:

- Davidson College and the Freeman Foundation for providing the grant that has funded my summer experience.
- Fellow volunteers, Vaiva and Michelle, for helping me in different stages of this project.
- My host sister, Jyoti, for being a great local volunteer and translator. I would not have been able to complete this project without her.
- And, I would like to thank my host family for taking care of me and welcoming me into their family over the past two months.

## References

Pure Water Occasional, "Ammonia," Pure Water Gazette Water Treatment Issues, accessed August 1, 2016. http://www.purewateroccasional.net/wtiammonia.html

US EPA, "Table of Regulated Drinking Water Contaminants," US Environmental Protection Agency, Last Updated July 15, 2016. https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants

Wagtech WTD. "Potakit WE10030 Instructions." Wear, England: A Halma Company.

The Water Project, "How Biosand Filtration Systems Work," The Water Project.org, accessed August 1, 2016. https://thewaterproject.org/biosand_water_filtration

World Health Organization. "Guidelines for Drinking Water Quality: Fourth Edition." Malta: Gutenberg, 2011.