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THE IMPACT OF *BOSCIA SENEGALENSIS* ON CLAY TURBIDITY IN FISH PONDS: A CASE STUDY OF CHILANGA FISH FARM.

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ABSTRACT

The research was carried out at Chilanga Fisheries located in Chilanga District of Lusaka Province of the Republic of Zambia. The total duration for the research project spanned over a period of sixty days beginning 10th April, 2018 to 8th June, 2018. The main aim of the project was to establish the impact of *Boscia Senegalensis* on clay turbidity in fish ponds.

The project was accomplished in two stages. The first part was the preparation of the *Boscia Senegalensis* solution, the leaves were pounded, mixed with pond water and allowed to settle over a specific period in order to yield a solution. The solution was refined through decanting and filtration and later preserved in the refrigerator before application. The solution was stored in a 5 litre container. The second part involved the use of three identical (*2m x 1m x 1m*) concrete experimental ponds labelled A, B and C. All the three ponds were filled with pond water to the same level. The preparation of the clay induced source followed immediately after. The experiment was then conducted using ponds “B” and “C”, with pond “B” as a control. The clay induced solution obtained from pond “A” was then added to ponds “B” and “C”. The *Boscia Senegalensis* solution was added to pond “C” only.

The parameters were then monitored, using a ‘Digital Water Quality Metre’ and a seechi disk, for duration of six (06) hours in which two (02) hourly readings were obtained and recorded.

Key words*: turbidity, Boscia senegalensis, supernatant,*

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INTRODUCTION AND BACKGROUND

Zambia is a landlocked country in the southern-central part of Africa with a rapidly growing economy. It has a vision of growing the economy by the year 2030 according to Republic of Zambia, Vision 2030. (2006). It has a population of 17, 639, 130 based on the latest United Nations estimates (Central Statistical Office (CSO) 2006. Zambia). The main economic activity over the years has been mining. As a way of realizing the vision of growing the economy, steps have been taken to diversify from mining to agriculture.

Agriculture has been in existence at both commercial and small scales. However, not much has been done to develop the sector to meet the demands of the increasing population and the diminishing mining industry. Under agriculture, more attention has been paid to crop farming as opposed to other forms of farming. Through studies, government has put in place various initiatives to promote and develop other forms of farming in order to realize the vision. One such potent form of agriculture considered was fish farming. Previously, lucrative fish production was based on what nature provided and only in areas where natural water bodies existed. Over time, unregulated fishing (over fishing) and the increasing demand has resulted in the depletion of fish stocks in most naturally stocked water bodies and this has been a source of concern. The government of Zambia identified the gap created by these activities and one of the intervention measures put in place is to promote and develop fish farming. They have identified that the sector has a huge potential due to ready market availability arising from the ever-rising demand and fair margins of profitability capable of alleviating poverty within the grass root and mid ranges. The sector would not only provide the population with food rich in the much-needed protein but it also has the capacity to provide employment. As such, the government has embarked on training people in fish farming and in response to governments calls, many people in country have ventured into fish farming both at small scale and commercial levels. However, most small-scale farmers encounter problems with the clearance of clay turbidity in a cost-effective manner pertaining to their scales of operation. Conventional means of achieving effective clearance of clay turbidity using chemicals favors large scale operations and the chemicals used are quite expensive.

Turbidity is simply the measurement of water clarity which may be due to suspended solids, algae and other dissolved organic materials. The most common cause of pond turbidity is the presence of suspended particles, mainly clay in ponds, hence the term “Clay Turbidity”. Turbidity can also be referred to as the ‘cloudiness’ in the pond water, according to Voichick N. (2014)

Figure 1. Clay turbidity in fish ponds. Source: Lynch William E. 2001

Clay turbidity may arise from extremely small size of the clay particles which often result in continual re-suspension due to changes in water temperature, wind, and water movement. However, the primary source of suspended clay particles is largely due to soil erosion, caused by heavy rainfall, unnecessary uprooting of plants near ponds or rivers, trampling of livestock trampling of the shoreline and wading in the ponds and overfeeding the fish. (Yard, M.D. 2011). When the cloudiness or turbidity remains longer than a few days, an indication of a more serious problem that should be addressed quickly is born. The impairment of the water quality in a pond may lead a serious decrease in overall production yield (losses) and as such has to be treated within the shortest possible time effectively and efficiently (Lynch, William E. 2001).

Clay turbidity is a global problem in aquaculture. The suspended clay particles inhibit plankton growth by binding with mineral nutrients from water as well as plankton cells. Planktons are small often microscopic aquatic plants (phytoplankton) and animals (zooplankton) found suspended in water column. Phytoplankton forms the base of the food chain while zooplankton forms the second link in the chain in aquatic systems such as ponds. In addition to their role as food for fish in ponds, phytoplankton produce large amount of oxygen for the pond during the day by photosynthesis providing dissolved oxygen (DO) in ponds. Low phytoplankton density in ponds means less food and DO for the fish. On the other hand, too much algal bloom leads to maximized sunlight penetration causing algal deaths. Therefore, if turbidity increases, the amount of light available to

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submerged aquatic vegetation (SAV) decreases. Without enough light, photosynthesis will stop, and the submerged aquatic vegetation will no longer produce dissolved oxygen, as earlier stated. (Benjamin E. C. 1990). Oxygen however, is the most important gas dissolved in water and is called Dissolved oxygen as stated earlier. Dissolved oxygen is essential for respiration and decomposition.

All in all, Clay turbidity causes acidity, low nutrient levels and limited light penetration for photosynthesis (Boyd 1990) and thus results in reduced primary production. In order for the fish not to decrease in production, it is necessary for the ponds to be treated, (Diaz A. 1999). However, water quality is the most important factor affecting fish health and performance in aquaculture production systems. Good water quality refers to what the fish wants and not what the farmer thinks the fish wants. This means that farmers must understand the water quality requirements of the fish under culture very well. Fish live and are totally dependent on the water they live in for all their needs.

High turbidity can significantly reduce the aesthetic quality of lakes and streams, having a harmful impact on recreation and tourism. It can increase the cost of water treatment for drinking and food processing. For the fish that remain in the turbid environment, suspended sediment can begin to physically affect the fish. Fine segments can clog the fish gills and lower organism's resistance to disease and parasites. Some fish can consume suspended solids, causing illness and exposing the fish to potential toxins or pathogens on sediment. If the consumed sediment does not kill the fish, it can alter the organism's blood chemistry and impair its growth. However, we can say that high turbidity acts directly on fish, killing them or reducing their growth rate, such waters can also promote undesirable growth of blue algae and bacteria which can cause infections on the fish. It prevents successful development of fish eggs and larvae.

High turbidity can harm fish and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function. There are several ways in which fish can be affected by high turbidity. The natural movements and migrations are modified, meaning that suspended solids disrupt the movements and migrations aquatic population. Fish that rely on sight and speed to catch their prey are especially affected by high turbidity levels. Since high turbidity reduces light penetration, which eventually affects rate of photosynthesis, primary production in aquatic system is disturbed hence causing reduction in the amount of food available. As fish famers cannot see clearly the fish available in ponds, this affects the efficiency of methods for catching fish. In addition to that, high turbidity levels can diminish visibility and often feeding behaviours. (Lloyd D. 1987).

It is therefore very important for fish producers to ensure that the physical and chemical conditions of the water remain, as much as possible, within the optimum range of the fish under culture all the time. Outside these optimum ranges, fish will exhibit poor growth, erratic behaviour, and disease symptoms or parasite infestations. Under extreme cases, or where the poor conditions remain for prolonged periods of time, fish mortality may occur. Clay turbidity does not only change the water pH and acidity but also the temperature changes which would affect the growth and fertilization of fish. Fish are "cold-blooded" and therefore assume the temperature of the water they live in. Water temperature is therefore the most important physical factor for fish survival and growth. Body temperature, and thus the water temperature, has an effect on level of activity, behaviour, feeding, growth, and reproduction of the fish. When water temperatures are outside the optimum range, fish body temperature will either be too high or too low and fish growth will be affected or the fish will even die.

On a large-scale conventional chemical have been used such as *Aluminum Sulphate* to clear clay turbidity in ponds, (Kaggwa R. C. 2001). *Aluminium Sulphate* is quite expensive. Besides, it changes the pH of water which may harm aquatic life depending on the quantities used. Once the pH values are disturbed due to use of *Aluminium Sulphate*, Calcium Hydroxide will be applied to improve the pH levels. These conventional chemicals may prove to be expensive to small scale farmers in the rural areas. While a commercial farmer can manage to buy conventional chemicals to clear clay turbidity, a farmer in the rural area may struggle to raise money to spend on the resolution of this common problem.

Apart from aluminium sulphate and other conventional chemicals used to clear turbidity, coagulation is carried out through the use of materials known as natural coagulants. Okra (Abelmoschus esculentus), known in many English-speaking countries as ladies' fingers, bhindi, bamia, ochro or gumbo, is a flowering plant in the mallow family. It is valued for its edible green seed pods. The geographical origin of okra is disputed, with supporters of West African, Ethiopian, and South Asian origins.

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Figure 2. Okra Source: Ghebremichael (2005)

Figure 3. Okra seeds Source: Ghebremichael (2005)

According to the information available in the literature, okra has been found not only to be edible but also used as a coagulant in wastewater treatment. In fact, some researchers have used this same plant, and some other natural coagulants, for wastewater treatment in the past.

For instance, Ghebremichael (2005) used okra seed for treatment of tannery effluent and they found that okra seed was able to act as a very effective flocculent, capable of removing more than 95 percent suspended solid and 69 percent dissolved solid from the effluent.

In some cases some scientists have carried out a research on *Moringa Oleifera* seeds, by crushing the seeds and soaking them in water, the filtered water was used to clear clay turbidity, hence, this gave a positive result on water clarification. However, *moringa oleifera* seeds have been used to clear clay turbidity, as *moringa* acts as a natural coagulant. (Ghebremichael. K. 2004)

Figure 4. Moringa olefeira pods   Source: Ghebremichael (2005).

Figure 5. Moringa Oleifera seeds   Source: Ghebremichael (2005).

Apart from moringa oleifera seeds and Okra seeds, Nirmali, seed beans, red maize, cactus latifera and seed powder of prosopis julifora, have been found to be effective coagulants. (Ghebremichael KA. 2004), *Boscia Senegalensis* is also one of the plants that are said to contain natural coagulants that can be used to clarify water sources. Not much has been reviewed about this plant in clearing turbidity. The research study will determine how much impact Boscia senegalensis has in clearing clay turbidity. In Zambia, the plant *Boscia Senegalensis* is commonly found in semi-arid mountainous areas of the Zambezi Escarpments especially such as Chirundu and parts of Kafue. The plant (sample) used in this study was obtained from Kafue District from the foot of a mountain in Kalundu View, a few meters from the Kafue-Lusaka road.

Boscia senegalensis is a member of the family Capparaceae. The plant originated from West Africa. Still a traditional food plant in Africa, this little-known fruit has potential to improve nutrition, boost food security, foster rural development and support sustainable land care. *B. senegalensis* is a perennial woody plant species of the *Boscia* genus in the caper (Capparaceae) family. This plant is classified as a dicot. Native to the Sahel region in Africa, this evergreen shrub can grow anywhere from 2 to 4 m in height under favourable conditions. The leaves of the plant are small and leathery. Leaves are alternative, petiolate; laminas oblong-ellaptic**, (**Braam van W. 2014).

Figure 6: Boscia senegalensis tree   Source: Author, 2018.

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Boscia senegalensis is recognized as a potential solution to hunger and a buffer against famine in the Sahel region due to the variety of useful products it yields. It produces products for consumption, household needs, and medicinal and agricultural uses. (Booth F. 1988).

Other common names for *Boscia senegalensis* include: *aizen* (Mauritania), *mukheit* (Arabic), *hanza* (Hausa), *bere (Bambara)*, *ngigil (Fulani)*, and *mandiarha (Berber)*, (*National* Resource Centre NRC. 2008).

This project introduces the use of *Boscia Senegalensis* to see whether it will effectively and efficiently clear the pond clay turbidity.

METHODOLOGY.

MATERIALS

The materials used were;

- ✓ Boscia senegalensis leaves
- ✓ Pounding motor
- ✓ Pestle
- ✓ Clay
- ✓ Stop watch
- ✓ Seech disk
- ✓ Water digital quality metre
- ✓ 2x1x1 experimental ponds
- ✓ 2 Empty buckets
- ✓ 2 Empty containers (5 litres)

METHOD

The project was accomplished in two stages. The first part was the preparation of *Boscia Senegalensis* solution while the second part was the preparation of clay induced source solution and conducting of the actual experiment.

Boscia Senegalensis leaves were collected and pounded using a pounding motor and pestle. The pounded leaves were weighed and 100g of pounded Boscia senegalensis was obtained.

Figure 7: Pounded Boscia senegalensis leaves   Source: Author, 2018.

5 litres of water was added to the crushed leaves of *Boscia Senegalensis*. The suspension was vigorously shaken and soaked overnight. The following day the suspension was passed through filter paper. The fresh solution was collected and refrigerated to prevent any ageing effects, such as change in pH, viscosity and coagulation activity. Solutions were shaken vigorously before use.

Figure 8: Boscia senegalensis solution   Source: Author, 2018.

The second phase was preparation of synthetic water. Clay particles were collected in Kafue near the police camp. It was dried and pounded into powder form.

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Pond A, B and C were filled with pond water. 3 kilograms of the clay material was weighed and mixed with some pond water, and then added to pond A.

Figure 9: 2mx1mx1m experimental ponds   Source: Chilanga Fish Farm 2018.

Experimental Procedure

The three ponds were labelled as pond A, pond B and pond C. Clay materials were added to some pond water in a bucket. Then the clay solution was poured in pond A. The suspension was mixed about 1 hour to achieve a uniform dispersion of clay particles. Then it was allowed to settle for at least 24 hours for complete hydration of the clay materials. The supernatant suspension of synthetic turbid water was collected and added to pond B and pond C to achieve the desired turbidity just before coagulation.

Figure 10: *Pond A with induced clay solution* Source: Chilanga Fish Farm 2018.

Clay solution was added to pond A to produce a synthetic turbid water, to be used in ponds B and C in the experiment.

Figure 11: *Pond B as a control experiment Source*: Chilanga Fish Farm, 2018.

20 litres of supernatant solution were added to Pond B. Pond B was a control experiment meaning that no Boscia senegalensis was added to it.

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Figure 12: *Pond C as an experiment with Boscia senegalensis added* Source: Chilanga Fish Farm, 2018.

20litres of synthetic turbid water from pond A was also added to pond C. Turbid water was allowed to settle for an hour before the coagulant was added. After an hour dissolved oxygen (DO), pH and clarity readings were taken before the *Boscia Senegalensis* solution was added.4 litres of *Boscia Senegalensis* solution was added to the suspension in pond C. Immediately after Boscia senegalensis was added to pond C, the digital water quality metre and seechi disk was immersed in the ponds and readings were recorded immediately for DO, temperature and pH. Clarity was measured using a seech disk.

The readings were recorded for both pond B and pond C, repeatedly, after every 2 hours and then results were recorded in the tables shown on page below.

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RESULTS

Before Boscia senegalensis was added to pond C, readings were taken and immediately the Boscia senegealsnis solution was added, the changes in the readings on the water digital quality metre and seech disk were recorded, for both the control and experiment. the clarity for the control was from 7cm to 11.4cm and that of the experiment it was from 7cm to 21cm.

As for the dissolved oxygen, the control changed from 13.3mg/l to 7.0mg/l and that of the experiment it changed from 7.2mg/l to 5.0mg/l.

Boscia senegalensis did not affect the temperature as such as the readings were almost in the same range. At the beginning it was 19.4degrees celcius to 19.4 degrees celcius in the control. Nothing changed much. The same with the experiment, t was from 19.4 degrees Celsius to 19.7 degrees Celsius.

The pH remained constant for both control and experiment. The control was 8.15 to 8.50 and for the experiment it was 7.17 to 7.19.

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DISCUSSION

The differences in the readings for clarity between the treatment and control can only be attributed to the presence of natural coagulants contained in *Boscia Senegalensis*. Results and data analysis indicate that *Boscia Senegalensis* reduced clay suspended solids by improving water clarity from 7cm to 21cm. The average reading of the control was 7.1 and that of the experiment it was 14.5cm, giving us a difference of 7.4cm in clarity. However, the control had more turbid whilst the experiment had less turbid hence giving us the clarity at 21cm.

However, the slightly improvement in clarity shown by the control is attributed to natural settling down of suspended particles in the water which is why it is important to allocate enough time to allow for complete hydration of clay and other particles, which otherwise could have continued to settle down and account for the natural clarity from 7cm to 11.4cm. The dissolved oxygen (DO) is an important factor for aquatic life because organisms like fish solely depend on the dissolved oxygen for respiration. (Khuhawar 2009). Dissolved oxygen was seen to improve in the experiment from 7.2mg/l to 5.0mg/l, giving us an average of 5.93mg/l. In the control Dissolved oxygen improved slightly but did not reach the required amount of dissolved oxygen needed in ponds as it remained at 7.0mg/l. this was an indication that there was less dissolved oxygen in the control pond B.

Considering the findings obtained from data analysis, *Boscia Senegalensis* had no significant impact on pH as it was neutral upon addition of *boscia senegalensis* upto the end of the experiment. This was observed in the control as the pH remained static at 8.15, hence giving us the average reading to be 8.43. The pH value is however, the measure of its acidity or alkalinity. The pH value was alkaline in the control and neutral in the experiment.

Temperature was not considered because the experiment was conducted in an open environment, defeating the idea of attributing any noticeable changes in temperature to the introduction of *Boscia Senegalensis* alone. The temperature reading remained constant.

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CONCLUSION

Using locally available natural coagulants, for example Boscia senegalensis, significant improvement in removing turbidity was found. Maximum turbidity reduction was found for highly turbid water. After dosing water-soluble extract of Boscia senegalensis, it reduced turbidity from 7cm to 21 cm. In conclusion, the findings confirm that *Boscia Senegalensis* has the ability to clarify clay turbidity from water sources, without changing the pH in a given water sample. The significant of this development regarding problem statement is that, comparative to conventional chemicals which are expensive and not environmentally friendly, natural coagulants have no human health danger and are cost effective alike since they are locally available in most rural communities. Natural coagulants have a bright future and concerned by many researchers because of their abundant course, low price, environment friendly, multifunction and biodegradable nature in water purification. It is easy to process and use and it does not change the pH of water. It provides an alternative means of removing clay turbidity from fish pond cheaply as opposed to the conventional means.

The use of *Boscia senegalensis* has an added advantage over the chemical treatment of water because it is biological and has been reported as edible. It is in this light that this research was carried out to confirm the effectiveness of Boscia senegalensis on clay turbidity.

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TABLES

Table 1 - *Sample 'A' Pond Water induced with clay turbidity*

Test Parameter	Reading(s) obtained
pH	8.15
DO	13.3mg/l
Temp.	19.4^{0}c
Clarity	7cm

Source: Author, 2018.

Table 2 - *Sample B and sample C drawn from sample 'A' (20 litres each).*

Test Parameter	SAMPLE 'B'	SAMPLE 'C'
Ph	8.15	8.15
DO	13.3mg/l	13.2mg/l
Temp.	19.4°C	19.4°C
Clarity	7cm	7cm

Source: Author, 2018.

Table 3 - *Boscia Senegalensis is added to Sample C and sample B is the control experiment (reading immediately after application)*

Test Parameter	SAMPLE B	SAMPLE C
pH	8.15	7.17
DO	13.3mg/l	7.2mg/l
Temp.	19.4°C	19.4°C
Clarity	7cm	7cm

Source: Author, 2018.

Table 4 - ***Results (After 2 Hours of Application)***.

Test Parameter	SAMPLE B	SAMPLE C
pH	8.53	7.12
DO	7.6mg/l	6.3mg/l
Temp	18.2°C	19.3°C
Clarity	9cm	12cm

Source: Author, 2018.

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Table 5 - *Results (After 4 Hours of Application).*

Test Parameter	**SAMPLE B**	**SAMPLE**
pH	8.55	7.12
DO	7.11mg/l	5.2mg/l
TEMP	18.89°C	19.4°C
CLARITY	11cm	18cm

Source: Author, 2018.

Table 6 - Results *(After 6 Hours of Application).*

Test Parameters	**SAMPLE B**	**SAMPLE C**
pH	8.50	7.19
DO	7.O1mg/l	5.0mg/l
TEMP	19.4°C	19.7°C
CLARITY	11.4cm	21cm

Source: Author, 2018.

Table 7- CLARITY (cm)

S/N	**Control (cm)**	**Treatment (cm)**
1	7	7
2	9	12
3	11	18
4	11.4	21
Total	**28.4**	**58**
Average	**7.1**	**14.5**

Source: Author, 2018.

Table 8: DISSOLVED OXYGEN (mg/l)

S/N	**Control (mg/l)**	**Treatment(mg/l)**
1	13.3	7.2
2	7.6	6.3
3	7.3	5.2
4	7.0	5.0
Total	**35.2**	**23.7**
Mean	**8.8**	**5.93**

Source: Author, 2018.

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Table 9: TEMPERATURE (°C)

S/N	Control (°C)	Treatment(°C)
1	19.4	19.4
2	18.2	19.3
3	18.89	19.4
4	19.4	19.7
Total	**75.89**	**77.8**
Mean	**18.97**	**19.45**

Source: Author, 2018.

Table 10: pH

S/N	Control	Treatment
1	8.15	7.17
2	8.53	7.12
3	8.55	7.12
4	8.50	7.19
Total	**33.73**	**28.6**
Mean	**8.43**	**7.15**

Source: Author, 2018.

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GRAPHS

Graphs showing both control and treatment

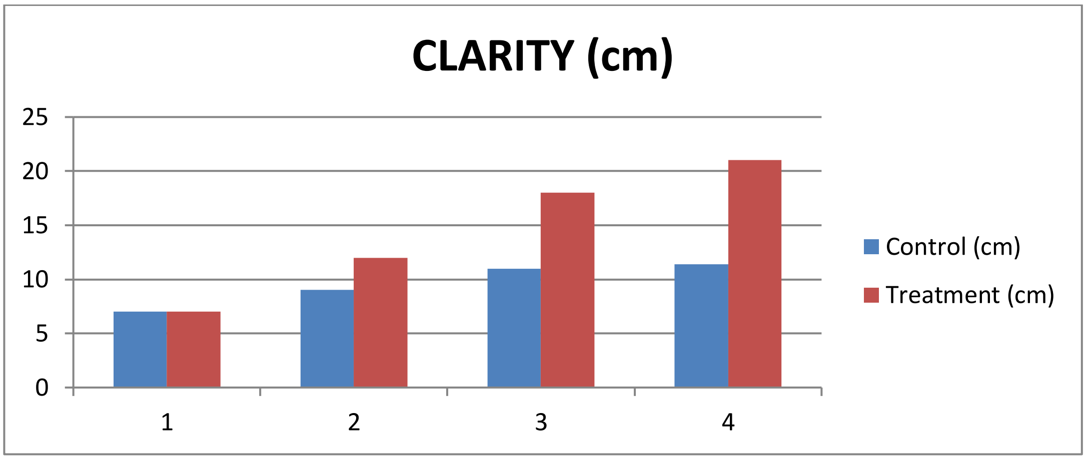

Figure 13: Graph showing clarity. Source: Author, 2018.

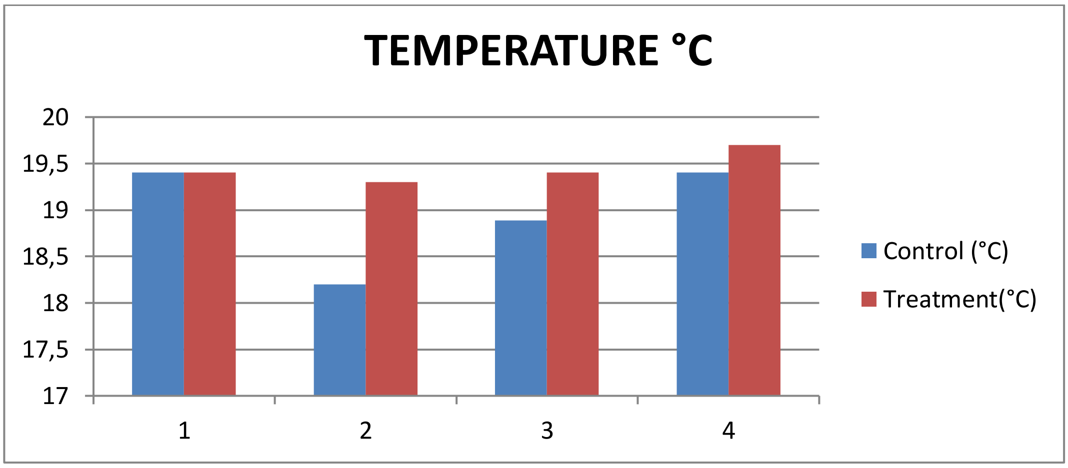

Figure 14: Graph showing Temperature. Source: Author, 2018.

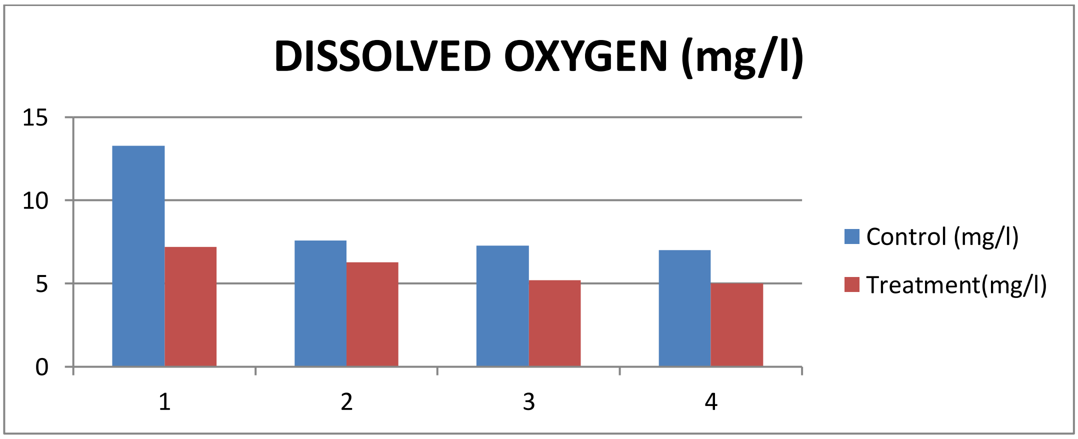

Figure 15: Graph showing dissolved oxygen. Source: Author, 2018.

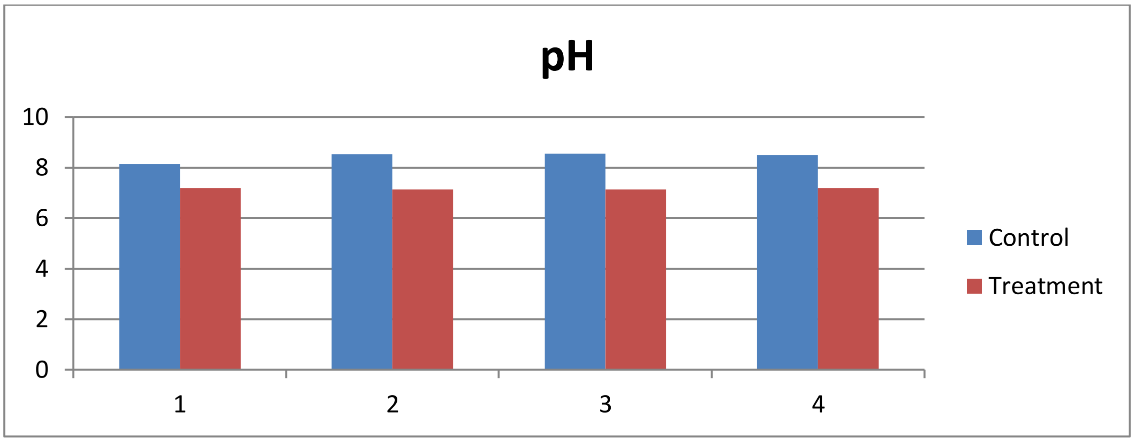

Figure 16: Graph showing the pH Source: Author, 2018.