EFFECTS OF DOSAGE ON SELECTED WATER QUALITY PARAMETERS USING *MORINGA OLEIFERA* SEED AND ALUM

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FACULTY OF SCIENCE AND NATURAL RESOURCES
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DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excepts, equations, summaries and references, which have been duly acknowledged.

15 August 2018 .....

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ABSTRACT

Drinking water needs to be treated in order to satisfy the drinking water requirement according to World Health Organization. This project was aimed to compare the treatment efficiency of *Moringa Oleifera* seed to that of aluminum sulphate regarding their treatment efficiency. The study was conducted using Jar Tests. Data obtained from the experiments are analyzed using Microsoft Excel Office Professional Plus 2013 and Pearson Correlation using Statistical Package for the Social Sciences (SPSS). *Moringa oleifera* as coagulant reduced the initial turbidity reading of 30.90 ± 1.35 NTU to 3.17 ± 0.3 NTU at 150 mg/l while alum to 6.64 ± 0.92 NTU at 50 mg/l. The treatment efficiency of both coagulants are as follows; *Moringa oleifera* with 89% and aluminum sulphate 78%. The initial acidic groundwater pH of 5.07 ± 0.06 was raised to 6.87 ± 0.09 using *Moringa oleifera* while alum cause the initially acidic water to higher acidity level with 3.24 ± 0.06 being recorded as the lowest. The final conductivity of both coagulants is still within WHO standard, which is 113.33 ± 5.77 uS/cm and 236.67 ± 11.55 uS/cm for *Moringa oleifera* and alum respectively. *Moringa oleifera* at 150 mg/l reduced the total coliform reading from 162.00 ± 86.02 CFU/100ml to 5.00 ± 1.15 CFU/100ml while alum at 200 mg/l was reduced to 25.00 ± 2.65 CFU/100ml. The treatment efficiency for *Moringa oleifera* is 96% and alum 84%. For faecal coliform, the initial reading of 142.00 ± 5.51 CFU/100ml was reduced to 9.00 ± 1.53 CFU/100ml for *Moringa oleifera* at 450 mg/l and alum to 34.00 ± 2.52 CFU/100ml at 500 mg/l. The treatment efficiency for *Moringa oleifera* is 93% and alum 76%. The nutrient analysis using *Moringa oleifera* and alum for sulphate, initial reading of 4.00 ± 1.33 mg/l was decreased to 1.33 ± 0.58 mg/l at 50 mg/l for *Moringa oleifera* while alum increased to 87.00 ± 3 mg/l at the highest. For phosphate, the initial reading of 1.90 ± 0.10 mg/l decreased to 0.25 ± 0.02 mg/l at 350 mg/l for *Moringa oleifera* while alum decreased to 0.03 ± 0.02 mg/l at 200 mg/l. Nitrate analysis show initial reading of nitrate in the water, 2.90 ± 0.2 mg/l was reduced to 1.50 ± 0.2 mg/l at 250 mg/l for *Moringa oleifera* while alum decreased to 0.17 ± 0.12 mg/l at 150 mg/l. Three out of nine heavy metals analysed in this study was found to be out of the permissible limit for drinking water but however at their optimum dosage, *Moringa oleifera* were able to reduce the readings to being in the permitted standard for drinking water. Lead at initial reading of 0.04 ± 0.02 mg/l was reduced to 0.0015 ± 0.001 mg/l using *Moringa oleifera* at 200 mg/l while using alum reduced to 0.02 ± 0.005 mg/l at 250 mg/l. For iron, their initial reading of 0.45 ± 0.003 mg/l was reduced to 0.24 ± 0.002 mg/l using *Moringa oleifera* at 500 mg/l while using alum reduced the initial reading to 0.34 ± 0.003 mg/l at 500 mg/l. Cadmium initial concentration in the water, 0.0056 ± 0.0004 mg/l was reduced to 0.0009 ± 0.00004 mg/l using *Moringa oleifera* at 250 mg/l while using alum reduced the initial reading to 0.0050 ± 0.00006 mg/l at 50 mg/l.

ABSTRAK

KESAN DOS KEPADA PARAMETER KUALITI AIR YANG TERPILIH MENGGUNAKAN BIJI MORINGA OLEIFERA DAN ALUM

Air minuman perlu dirawat untuk memenuhi garis panduan mengikut World Health Organization (WHO). Projek ini bertujuan untuk membandingkan kecekapan rawatan benih Moringa Oleifera kepada aluminium sulfat berkenaan dengan kecekapan rawatan mereka. Kajian ini dijalankan menggunakan Jar Test. Data yang diperoleh daripada eksperimen dianalisis dengan menggunakan Microsoft Excel Office Professional Plus 2013 dan Korelasi Pearson menggunakan SPSS. Moringa oleifera sebagai koagulan mengurangkan bacaan kekeruhan awal 30.9 ± 1.35 NTU kepada 3.17 ± 0.3 NTU pada 150 mg/l manakala alum kepada 6.64 ± 0.92 NTU pada 50 mg/l. Kecekapan rawatan kedua-dua koagulan adalah seperti berikut; Moringa oleifera dengan 89% dan aluminium sulfat 78%. Bacaan awal pH air perigi, 5.07 ± 0.06 dinaikkan kepada 6.87 ± 0.09 menggunakan Moringa oleifera manakala aluminium sulfat menyebabkan air turun ke tahap keasidan yang lebih tinggi dengan 3.24 ± 0.06 dicatatkan sebagai yang terendah. Kekonduksian terakhir kedua-dua koagulan masih dalam standard WHO, iaitu 113.33 ± 5.77 uS/cm dan 236.67 ± 11.55 uS/cm untuk Moringa oleifera dan alum. Moringa oleifera pada 150 mg/l mengurangkan bacaan coliform dari 162.00 ± 86.02 CFU/ 100ml hingga 5.00 ± 1.15 CFU/100ml manakala alum pada 200 mg/l dikurangkan kepada 25.00 ± 2.65 CFU/100ml. Kecekapan rawatan untuk Moringa oleifera adalah 96% dan alum 84%. Bagi koloni faecal, bacaan awal 142.00 ± 5.51 CFU/100ml dikurangkan kepada 9.00 ± 1.53 CFU/100ml untuk Moringa oleifera pada 450 mg/l dan alum kepada 34.00 ± 2.52 CFU/100ml pada 500 mg/l. Kecekapan rawatan untuk Moringa oleifera adalah 93% dan alum 76%. Analisis nutrien menggunakan Moringa oleifera dan alum untuk sulfat, bacaan awal 4.00 ± 1.33 mg/l turun kepada 1.33 ± 0.58 mg/l pada 50 mg/l untuk Moringa oleifera manakala alum meningkat kepada 87.00 ± 3 mg/l pada tahap tertinggi . Untuk fosfat, bacaan awal 1.90 ± 0.10 mg/l menurun kepada 0.25 ± 0.02 mg/l pada 350 mg/l untuk Moringa oleifera manakala alum menurun kepada 0.03 ± 0.02 mg/l pada 200 mg/l. Analisis nitrat menunjukkan bacaan awal nitrat dalam air, 2.90 ± 0.2 mg/l dikurangkan kepada 1.50 ± 0.2 mg/l pada 250 mg/l untuk Moringa oleifera manakala alum menurun kepada 0.17 ± 0.12 mg/l pada 150 mg/l. Tiga daripada sembilan logam berat yang dianalisis dalam kajian ini melebihi had yang dibenarkan untuk air minuman tetapi dengan dos optimum, Moringa oleifera mampu mengurangkan bacaan untuk berada di dalam standard yang dibenarkan untuk air minuman. Logam berat plumbum pada bacaan awal 0.04 ± 0.02 mg/l dikurangkan kepada 0.0015 ± 0.001 mg/l menggunakan Moringa oleifera pada 200 mg/l manakala menggunakan alum dikurangkan kepada 0.02 ± 0.005 mg/l pada 250 mg/l. Bagi logam berat besi, bacaan awal 0.45 ± 0.003 mg/l dikurangkan kepada 0.24 ± 0.002 mg/l menggunakan Moringa oleifera pada 500 mg/l manakala menggunakan alum mengurangkan bacaan awal kepada 0.34 ± 0.003 mg/l pada 500 mg/l. Kepekatan awal logam berat kadmium dalam air, 0.0056 ± 0.0004 mg/l dikurangkan kepada 0.0009 ± 0.00004 mg/l menggunakan Moringa oleifera pada 250 mg/l manakala menggunakan alum mengurangkan bacaan awal kepada 0.0050 ± 0.00006 mg/l pada 50 mg/l.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES/ PHOTOS

LIST OF ABBREVIATIONS AND SYMBOLS

CFU	Colony Forming Unit
°C	Degree Celcius
g	Gram
l	Liter
µS/cm	microSiemens
mg	Milligram
mg/L	Milligram per liter
mL	Milliliter
NTU	Nephelometric Turbidity Unit (NTU)
%	Percentage

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of study

The world consist mostly of water and for that reason, the usage of water are limitless as they are used for various purposes such as for domestic and industrial applications. It is also known as one of the most required human needs since they are essential to maintain the body regulation. Without enough water intakes, our body would be less likely to survive. Water is widely consumed as clean drinking water that is needed to sustain the life of the living things. Surfaces water such as river water, lake water and ground water is the major contributor to provide humans with drinking water but unfortunately, even in our 20th century, water quality is still considered a main problem everywhere in the major part of the world. Many countries that are still lacking water treatment facilities cannot seem to provide their citizens with a clean and acceptable quality that follows the minimum requirement of a drinking water and this is definitely a worrisome factor considering that water is essential for humans and without a clean drinking water, a human body can only take so much. Therefore it is necessary to treat the drinking water to remove impurities and bacteria in the water in order to meet the quality guidelines which satisfy the standard for drinking water requirement according to World Health Organization (2004).

Nowadays, the water is majorly affected by the pollution due to the urbanization and other internal and external factors. It was said that a safe drinking water is one of the basic needs of humans, and hence it needs to be treated and purified before its consumption became safe. This directly affects the usage of water treatment chemicals where they are needed in a larger scale to treat the water. Unfortunately, this leads to an increase in the cost of treatment that the

water treatment companies cannot cope with, and as a result, the drinking water that is supplied to the consumer is not treated fairly (Ali *et al.*, 2009). In expanding countries which is also categorised as Third World countries such as Asia, Africa, Ocenia, and Latin America, the cost of treatment plants are expensive, the payment of services is minimal and the both the skills and technology are usually deficient (Ghebremichael, 2004). According to Kalbamatten & Burns (1983), poorly treated water resulting from lacking water treatment facilities has been said to cause waterborne diseases that kills people every day while others suffers from the side effects. Waterborne diseases are known as the diseases that arise due to the directly transmitted pathogenic micro-organisms when the contaminated drinking water is consumed. It was caused by multiple and various kinds of microorganisms such as protozoa, viruses, bacteria, and intestinal parasites.

Due to this waterborne disease outbreaks, water that is to be consumed for drinking must undergo purification process before they can be considered as safe. Since disease-causing agents and toxic chemicals might be present in the drinking water, systematic water quality monitoring and surveillance are required to control the risks to public health (Nand *et al.*, 2012). As stated by Ndabigengesere & Narasiah (1998), among the most used water treatment method in the water treatment industry before distributing them to the consumers in the past is coagulation-flocculation that is followed by sedimentation, filtration and disinfection, which is usually done using chlorine. But nowadays, in the water treatment latest technology, they are using chemicals such as aluminium sulphate which is a synthetic coagulant to enhance the water purification.

Water that is infected can spread waterborne-diseases that could lead to unexceptionally high medical costs that would leave even an individual or even the country penniless while battling over the illness (Ali *et al.*, 2009). All of these could be easily minimized by treating the water effectively at first hand using aluminium sulphate. But however, alum is an expensive chemical and some countries are unable to afford it which then leaves the country even more in despair (Hendrawati *et al.*, 2016). It was also known that water treated with Alum will have some side effects towards human health (Egbuikwem & Sangodoyin, 2013). This basically just

brought the overall costs into a whole new level than the current cost since additional cost are going to be added to the health costs that has been mentioned earlier and also, the life of the citizens are also at stake.

Other than synthetic coagulants, other existing chemical coagulants that have been used in water treatment processes include inorganic coagulants, synthetic organic coagulants and naturally occurring coagulants. The coagulant types are used according to their chemical properties for different reasons (Fatoki & Ogunfowokon, 2002). According to World Health Organisation (2004), the number of chemicals that has been detected present in the drinking water supplies can go up to thousands and is more likely to be hazardous at some point when their concentration are comparatively high. This has become some of the disadvantages of using synthetic coagulants. Unlike aluminium salts, the probability of replacing *Moringa oleifera* with the conventional chemical coagulant is getting more interests nowadays. *Moringa oleifera* seeds have the potential to be very convincing in water treatment industry as primary coagulant that is comparable to Alum as it is safer and does not cause negative effects towards lives.

Other than its cost, among the reasons why there should be a plant-based coagulant to replace synthetic coagulants is due to Alum threatening properties in drinking water. As stated in Martyn *et al*. (1989), coagulants that occurred naturally are regarded as safe in terms of health for human while synthetic coagulants, especially aluminium salt, has probability inducing Alzheimer's disease. But however, unlike aluminium salts, *Moringa oleifera* has a lot of promising benefits which makes them as an ideal substitute for Alum. One of the reasons why *Moringa oleifera* is popular is due to their medicinal and pharmalogical properties. It has been proven that *Moringa oleifera* possessed an antispasmodic property which is a property that is able to relieve immediate involuntary muscular contraction movement. Among other great properties of *Moringa oleifera* are such as anti-ulcer, hepatoprotective, anti-bacterial, anti-fungal, anti-hypertensive, anti-tumor, anti-cancer activities, and last but not least, diuretic and cholesterol lowering activities (Anwar *et al*., 2006).

According to Ndabigengesere *et al.* (1998), *Moringa oleifera* is known as one of the plant species that can grows quickly at low altitudes and on soils that has low humidity. It is also durable as well. Their seeds are an organic natural polymer that has coagulation property (Muyibi & Evison, 1995). It is one of the vegetables of the Brassica order and is grouped in the family of Moringaceae and unsurprisingly, there has been a lot of research done on *Moringa oleifera* in terms of their nutritional and medicinal interest. This plant is said to possessed crucial components with nutraceutical properties which makes them an ideal nutritional supplement (Razis *et al.*, 2014). They are also said to possess medicinal purposes providing necessary antioxidants, antibiotics and as well as nutrients. However, their properties for water treatment have not been fully explored yet. The advantages of using naturally occurring coagulants such as *Moringa oleifera* seeds instead of aluminium salts are cheaper treatment cost, lesser production of sludge and the availability of reagents (Arnoldsson *et al.*, 2008). This therefore has led many researchers to find another route of alternatives for the water to be treated using naturally occurring coagulants such as *Moringa oleifera* so that the world will not be short in water supply in terms of their quality and that the water is safe to be consumed and satisfies the WHO standard for portable water.

1.2 Problem statement

According to World Health Organization (WHO), their aim is to deliver safer water for better health by improving the water, sanitation and hygiene by supporting drinking water quality management in developing the water quality standard for rural people. Physical parameters such as turbidity, chemical parameters such as heavy metals and major nutrients for instance sulphate, phosphate and nitrate and also microbiological parameters such as coliform are important and part of water safety, since water that exceeded the standard is considered polluted and needs to be treated for consumption. Surface water usually encounters drastic changes in their quality since there are a lot of factors that could contribute to the changes such as flood and climatic factors while for groundwater, the presence of aquifers usually buffers those drastic changes. The water usually is filtered slowly as the

water flows through the columns of soils, sands and layers of sedimentary rocks. However this also means since the flow is slow, the contaminants can stayed underground for years without disturbance and cause problems to water quality.

There are problems in using the groundwater in rural area such as Kota Belud when used for consumption and early investigation shows that the quality of the water was contaminated since their readings exceeded the standard for portable water by World Health Organization (WHO) and hence needing further treatment using coagulants. The water that was sampled was used as a real source of drinking water by the people living in the area and this could lead to health problems when prolonged consumption from the water continued. *Moringa oleifera* as a naturally occurring coagulant which can be found in abundance growing in Kota Belud can be used for the water treatment. Since the earlier documented works on *Moringa oleifera* focuses more on turbidity removal from the water but less on their biological and chemical parameters such as coliform, nutrients and heavy metals from the water, this study will also research on these parameters to discover their effects when used for water treatment. Replacement of aluminum sulphate with *Moringa oleifera* is more cost effective since they are cheaper and its usage might be able to provide safer water with minimum health risks that could threaten human. Thus, this study will investigate the efficiency of using an organic-based coagulant such as *Moringa oleifera* to treat the water and compare their performance in reducing the parameters to comply with World Health Organization (WHO) standard for safe consumption with synthetic coagulant such as aluminium sulphate.

1.3 Objectives of the study

The treatment of the water in this study was undertaken with the following objectives:

i. To compare the treatment efficiency of *Moringa oleifera* with aluminum sulphate in terms of turbidity removal and their effects on pH and conductivity.

ii. To analyse the efficiency of *Moringa oleifera* compare to aluminum sulphate when used for treating coliform in water.

iii. To study *Moringa oleifera* performance when used for nutrients removal in water such as sulphate, phosphate and nitrate compare to aluminum sulphate.

iv. To determine the trace elements in the water and compare the performance of *Moringa oleifera* with aluminum sulphate in reducing the heavy metals in water.

1.4 Research questions

Among the questions that seek to be answered in this study to help clarify more of the objectives of the study are:

i. What is the efficiency of *Moringa oleifera* compared to aluminum sulphate when used for water treatment in terms of removal for turbidity, coliform, nutrients and heavy metals?

ii. How dosages used will affect the efficiency of *Moringa oleifera* and aluminum sulphate on the water sample quality?

1.5 Scope of study

This scope of study is inclusive of the following:

1) The sample used is known as *Moringa oleifera* and throughout this experiment, only the seeds which have been removed from its pod and is brown in colour are used. According to Ndabigengesera *et al.*, (1998) this is due to their higher coagulation activity in the brown pods compared to the green pods.

2) The raw water is collected from location located only in Sabah and is only inclusive of ground water. This is because the water sample collected is more common to be drinking water source in the rural area where they were obtained and represent real life case study instead of laboratory case study.

3) The dosage that should be applied to the water according to guidelines for turbidity that is less than 50 NTU is 50 mg/l (Mangale *et al*., 2012). However, since water possess different characteristics which are influenced by a number of factors and have varied quality, it is hard to apply the same standard. Hence the dosages used in this study will be modify according to the water performances when treated using *Moringa oleifera* and aluminum sulphate.

1.6 Significance of study

From this study, the expected result that is to be researched in this study is how the use of *Moringa oleifera* seeds can improve the quality of the water that is commonly used for drinking water in terms of physical, biological and chemical parameters. The findings from this study will mostly benefit the society that lacks of water treatment facilities in rural area that receives affected water resource supply from untreated water source. In conclusion, the findings from this study can lead to new water treatment facilities development that use plant-based coagulant that is cheaper and safer instead of aluminum sulphate.

CHAPTER 2

LITERATURE REVIEW

2.1 Problems that rise associated with Aluminium sulphate as coagulant

As it has been stated before, water as one of the major elements of the earth is a requirement for all life and clean drinking water is needed for sustaining life. Treatments are necessary to get rid of the impurities and bacteria in the water so that it would be safe to be consumed. In the 20th Century where pollution has affected the water quality badly, an efficient coagulant was researched for alternative. Aluminium Sulphate or alum which is a type of widely used synthetic coagulant was used to treat turbid water with increasing turbidity level. However, a rise in the turbidity level means increase in the dosages used to reduce the turbidity, and the high amount of dosages needed in a larger scale to treat the water leads to rise in the cost of treatment that the companies cannot cope with, which then results in a poorly treated drinking water. The poorly treated water caused waterborne diseases outbreaks, which were transmitted by multiple and various kinds of microorganisms such as protozoa, viruses, bacteria, and intestinal parasites that take away people lives every day. On top of that, the high dosage of Alum will also need pH adjustment to neutralize the acidic water by adding lime and this too is considered as another added cost for water treatment companies (Ali *et al.*, 2010).

In Third World countries, treatment plants are expensive, the services payment is minimal and the both the skills and technology are usually deficient (Ghebremichael, 2004) and according to World Health Organisation (2004), one of the problems with synthetic coagulants are the detection of higher number of chemicals in drinking water that is hazardous at higher concentration. It was also known that water treated with Alum will have some side effects towards human

health. This is supported by other studies by Garcia-Foyas *et al*. (2010) where rising health risks was mentioned from drinking the water with residual aluminium left in it such as neurodegenerative illness. According to Srinivasan *et al.*, (1999), the discussions about the possible health effects from the presence of Alum in drinking water has arose due to its suspected connection with Alzheimer's diseases or dialysis encephalopathy. Another study from has shown that under controlled conditions in which the animals were exposed to Alum, there is a connection between the neuropathological disorders and intake of Alum.

An observation also has been made between the relationship of Alum and both Alzheimer's disease and dialysis encephalopathy in humans as stated by Crapper and Boni (1980). Another researcher, Davidson *et al*. (1982) has found that the patients who has kidney dialysis who dialysis fluid has Alum concentration of 80 mg/l was affected with dementia. The symptoms of dementia subsidise when the Alum is removed from the fluid prior to dialysis. Driscoll and Letterman (1988) has also stated that patients exposed to high Alum might exhibit dialysis enchepholopathy, and/or bone mineralisation disorders such as dialysis osteodystrophy according to the results from their dialysis. According to Martyn *et al*. (1989) the Alzheimer's disease rate was 1.5 times higher in districts where the mean aluminium concentration is above 0.11 mg/l than in districts where concentrations were less than 0.01 mg/l based on the survey. Although the toxicity of Alum is categorized as low, and the data for chronic exposure are limited, it was believed that Alum are more likely to interferes with absorption of phosphorus, and cause weakness, bone pain and anorexia. Other severe disadvantages of the usage of Alums other than that has been mentioned regarding health concerns include large amount of sediment production, the change in pH water and poor coagulation performance in cold weather.

2.2 Water treatment system

Generally, water treatment system used coagulation, flocculation and clarification universally. Impurities in water or also known as suspended solids are results of particulate and dissolved impurities in water caused by erosion of land, minerals