بسم الله الرحمن الرحيم

SUDAN UNIVERSITY OF SCIENCE AND TECNOLOGY

College of Graduate Studies

Environmental Engineering Program

Comparing Poly Aluminum Chloride and Moringa Seeds as Alternative for Water Coagulations

مقارنة بين البولي ألمونيوم كلورايد وبذور المورينقا بدائلاً لترويق الماء

A Thesis Submitted In Partial Fulfillment of the Requirements for the Degree of Master of Science in Environmental Engineering

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Nov 2019

الآيـــــة

أَلَمْ تَرَ أَنَّ اللَّهَ يُزْجِي سَحَابًا ثُمَّ يُؤَلِّفُ بَيْنَهُ ثُمَّ يَجْعَلُهُ رُكَامًا فَتَرَى الْوَدْقَ يَخْرُجُ مِنْ خِلَالِهِ وَيُنَزِّلُ مِنَ السَّمَاءِ مِنْ
جِبَالٍ فِيهَا مِنْ بَرَدٍ فَيُصِيبُ بِهِ مَنْ يَشَاءُ وَيَصْرِفُهُ عَنْ مَنْ يَشَاءُ ۖ يَكَادُ سَنَا بَرْقِهِ يَذْهَبُ بِالْأَبْصَارِ (43) يُقَلِّبُ اللَّهُ
اللَّيْلَ وَالنَّهَارَ ۚ إِنَّ فِي ذَٰلِكَ لَعِبْرَةً لِأُولِي الْأَبْصَارِ (44) وَاللَّهُ خَلَقَ كُلَّ دَابَّةٍ مِنْ مَاءٍ ۖ فَمِنْهُمْ مَنْ يَمْشِي عَلَىٰ بَطْنِهِ
وَمِنْهُمْ مَنْ يَمْشِي عَلَىٰ رِجْلَيْنِ وَمِنْهُمْ مَنْ يَمْشِي عَلَىٰ أَرْبَعٍ ۚ يَخْلُقُ اللَّهُ مَا يَشَاءُ ۚ إِنَّ اللَّهَ عَلَىٰ كُلِّ شَيْءٍ قَدِيرٌ (45)

النور

Acknowledgements

I would like to express my special thanks of gratitude to my supervisor ***Dr. Basheer Mohamed Alhassan*** for his guidance and direction during the course of this work.

I would also like to thank the *National public Health Lab – Food & Water Microbiology Dep.* for conducting the microbiology tests of this research, also the University of Khartoum for conducting the Other tests.

I do not forget to thank my family, my brothers *Eng. Ahmed Abdelelah, Eng.Abdelraheem, Eng.Adil, Eng.Huzayfa and Eng.Omer* for their continued support for me.

Abstract

This study was conducted on the Blue Nile water in order to compare the effect of polyaluminium chloride (PAC) and Moringa seeds extract on some physical, chemical and biological properties.

Poly Aluminum Chloride (PAC) is a chemical used to treat water and is highly effective, non-toxic and easily dissolved in water and is a sterilizer with a high capacity and activity to sinter pollutants in water, can be used immediately or after diluting in water at a determined dose on the other hand Moringa seeds are rich in potassium, calcium and other important elements. Studies have shown that Moringa seeds have a high ability to purify water by adding it to water tanks after extracting oil from them.

Four gram of moringa seeds were immersed in a total volume of 100 mL after screening, where it was diluted twice to have three concentrations and an equal dose of three concentrations (6 mL) was taken to make a dose test to determine the ideal concentration, and the optimal dose was determined based On these tests, different concentrations of poly aluminum chloride were selected based on information from the Mogran Station and the optimal dose of the poly aluminum chloride was determined.

After knowing the optimal dose of Moringa seeds and poly aluminum chloride, physical, chemical and biological tests were carried.

The results obtained indicated a clear effect of both coagulant on physical, chemical and biological properties on the Blue Nile water samples where there was a decrease in turbidity and total number of bacteria, coliform and E. coli, while pH, water hardness, electrical conductivity and water dissolved salts were not affected significantly.

المستلخص

أجريت هذه الدراسة على مياه النيل الأزرق بهدف المقارنة بين تأثير البولي ألمونيوم كلورايد (الباك) ومستخلص بذور المورينجا على بعض الخواص الفيزيائية والكيميائية والبيولوجية وتم اختيار موقع لأخذ عينة عشوائية من مياه النيل الازرق.

البولي ألمونيوم كلورايد (باك) هو مادة كيميائية تستخدم لمعالجة المياه وهي ذات فعالية عالية وغير سامة ويذوب بسهولة في الماء ويعتبر من المعقمات ذات القدرة والنشاط العالي على تلبيد الملوثات في المياه، ويمكن استخدامه مباشرة أو بعد تمييعه في المياه بناءَ على جرعة يتم تحديدها عن طريق الاختبارات والتجارب، أما بذور المورينجا هي بذور غنية بالبوتاسيوم والكالسيوم وغيرها من العناصر المهمة ، واثبتت الدراسات ان لبذور المورينجا قدرة عالية على تنقية المياه عن طريق اضافتها لخزانات المياه بعد استخلاص الزيت منها.

تم غمر 4 جرام من بدرة بذور المورينجا في حجم كلي 100 ملليتر وذلك بعد غربلتها حيث التخفيف مرتين ليصبح لدينا ثلاثة تراكيز وتم أخذ جرعة متساوية من الثلاثة تراكيز (6ملليتر) لعمل تجربة تحديد الجرعة (الجار تست) لتحديد التركيز المثالي، وتم تحديد الجرعة المثالية بناءَ على هذه الاختبارات، وفي المقابل تم اختيار تراكيز مختلفة للبولي ألمونيوم كلورايد بناءَ على معلومات من محطة المقرن وعليه تم تحديد الجرعة المثالية للبولي ألمونيوم كلورايد.

وبعد معرفة الجرعة المثالية لبذور المورينجا والبولي ألمونيوم كلورايد تم عمل الاختبارات الفيزيائية والكيميائية والبيولوجية.

النتائج التي تم الحصول عليها اشارت الى وجود تأثير واضح لكلا المروبين على الخواص الفيزيائية والكيميائية والبيولوجية على عينة مياه النيل الأزرق حيث هنالك انخفاض في العكورة والعدد الكلي للبكتريا وبكتيريا الكوليفورم والايكولاي، بينما الأس الهيدروجيني، عسر الماء، الموصلية الكهربائية والأملاح الذائبة في المياه لم تتأثر بشكل كبير.

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Chapter one

1.1 Introduction:

Water is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of living things. As a chemical compound, a water molecule contains one oxygen and two hydrogen atoms that are connected by covalent bonds. Water is a liquid at standard ambient temperature and pressure, but is often co-exists on Earth with its solid state, ice; and gaseous state, steam (water vapor).

Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack access to adequate sanitation. There is a clear correlation between access to safe water and gross domestic product per capita. However, some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability.

Natural water bodies are contaminated by chemical, physical, radioactive or pathogenic microbial substances means. Adverse alteration of water quality presently produces large scale illness and deaths, accounting for approximately 50million deaths per year worldwide, most of these deaths occurring in Africa and Asia.

Waterborne diseases are pathogenic micro-organisms which are directly transmitted when contaminated drinking water is consumed. Contaminated drinking water used in the preparation of food can be the source of food borne disease through consumption of the same micro-organisms. According to the World Health Organization, diarrheal disease accounts for an estimated 4.1 % of the total daily global burden of disease and is responsible for the deaths of 1.8 million people every year. It was estimated that 88% of that burden is attributable to unsafe water supply, sanitation and hygiene and is mostly concentrated on children in developing countries.

However recent studies have pointed out several serious drawbacks of using chemical salts in water purification and disinfection, Therefore, where cheaper alternatives can be found, to replace the conventional treatment chemicals. The use of moringa seeds extract would be such benefit for people in less developed countries, as a coagulant for water and wastewater treatment.

Water is used for several purposes by humans but the level of purity of the water being consumed is very crucial since it has a direct effect on health. The conventional method of water purification using aluminum sulphate (alum) and calcium hypochlorite puts pressure on the nation’s over-burdened financial resources since they are imported thereby making treated water very expensive in most developing countries and beyond the reach of most rural folks. Hence, they resort to sources such as dams, dug outs, streams, rivers, and lakes. Water from these sources is usually turbid and contaminated with micro-organisms that cause many diseases including guinea worm and bilharzia. According to Post note (2002), water-borne diseases are one of the main problems in developing countries; about 1.6 million people are compelled to use contaminated water and more than a million people (of which two million are children) die from diarrhea each year.

Earlier research findings of Crapper et al. (1973) and Miller et al. (1984) showed that the chemicals used for water purification can cause serious health hazards if an error occurs in their administration during the treatment process. These reports suggested that a high level of aluminum in the brain is a risk factor for Alzheimer’s disease. However, Davis (2006) found no conclusive evidence linking aluminum with Alzheimer’s disease. Also, studies by workers (Letterman and Driscoll, 1988; Malle vialle et al., 1984; Miller et al., 1984) have raised doubts about the advisability of introducing aluminum into the environment by the continuous use of aluminum sulphate as a coagulant in water treatment.

There is therefore the need to investigate the use of non-chemicals which would be available locally in most developing countries.

The high cost of treated water makes most people in the rural communities to resort to readily available sources which are normally of low quality exposing them to waterborne diseases. It is in this light that this research was carried out to confirm the effectiveness of powder extracted from mature-dried Moringa oleifera seeds which is commonly available in most rural communities of Africa.

Raw water contains impurities, suspended substances and microorganisms. Water properties may not meet specifications. In this case, water must be treated before consumption.

The suspended impurities need coagulation process to be settled in sedimentation tanks, suspended mud, microorganisms and organic substances which are produced from degradation of aquatic plants and human wastes.

1.2 Problem statement:

The process of removing the impurities is known as purification, it is done by adding coagulant. Although these coagulants are efficient enough in sedimentation, they are too expensive and they cause a significant disease (Alzheimer's disease and similar health related), so it is necessary to look for a cheaper alternative which are extracted from natural resources such as Moringa seeds.

In this research PAC and Moringa seeds will be compared together based on cost, efficiency of sedimentation, dose and the physical and chemical properties after adding the coagulant to the water.

1.3 Importance of research

This research leads to determine the best alternatives for cralification and coagulation including the cost and efficiency.

1.4 Objectives:

1.4.1 Main objective:

Comparing Moringa seeds and PAC as coagulants in different conditions (PH, temperature).

1.4.2 Specific objectives:

- Determine the optimum PH for Moringa seeds and PAC.
- Determine the optimum dose for Moringa seeds and PAC.
- Identify the effects of using Moringa seeds and PAC in water characteristics (Turbidity, PH, TDS, Conductivity, Hardness and microbial).

1.5 Research hypotheses

Moringa seeds have a positive effect on water quality.

1.6 Previous studies:

A lot of studies have been done by researchers, Wadah (2014) says in his study “adding the powder of Moringa seeds is effective in turbidity removing but its effect was slight in killing bacteria and germs” and Eman and others say in their study in 2015 “The results obtained indicated that the extract obviously affected physical, chemical, and microbiological properties of water. There were decreases in pH and turbidity of water treated with different level of Moringa seeds extracts as compared with raw water; while there is increase in EC. The treatment with the extract also increased Total Hardness (TH), TH as Ca, TH as Mg because Moringa seeds are good source of minerals.

Chapter two

Literature Review

2.1 Introduction:

Water is one of the most abundant molecules on Earth. There are approximately 350 million cubic miles (1.4 billion cubic kilometers) of water on the planet. Nearly 97% of all water is found in the oceans, which cover two-thirds of the surface area of the planet. About 90% of all fresh water is frozen in the ice in the North and South Poles and glaciers (large slow-moving masses of ice). Less than 1% of all the water on Earth is available for consumption, and most of it is found in aquifers (porous rock chambers holding fresh water) underground. . (Lerner & Lerner, 2005).

2.2 Water (chemical formation and types):

JUST TWO H'S AND ONE O

Cavendish was able to separate the two main constituents that make up water. All that remained was for him to put the ingredients back together again. He accomplished this by mixing a measured volume of inflammable air with different volumes of its vital counterpart, and setting fire to both.

He found that most mixtures burned well enough, but when the proportions were precisely two to one, there was an explosion and the walls of his test tubes were covered with liquid droplets. He quickly identified these as water.

Cavendish made an announcement: Water was not water. Moreover, water is not just an odorless, colorless, and tasteless substance that lies beyond the reach of chemical analysis. Water is not an element in its own right, but a compound of two independent elements, one a supporter of combustion and the other combustible. When united, these two elements become the preeminent quencher of thirst and flames.

It is interesting to note that a few years later, the great French genius Antoine Lavoisier tied the compound neatly together by renaming the ingredients hydrogen— "the water producer"—and oxygen. In a fitting tribute to his guillotined corpse (he was a victim of the French Revolution), his tombstone came to carry a simple and telling epitaph, a fitting tribute to the father of a new age in chemistry—just two H's and one O.

Somewhere between 0° and 105°

We take water for granted now. Every high-school level student knows that water is a chemical compound of two simple and abundant elements. And yet scientists continue to argue the merits of rival theories on the structure of water. The fact is we still know only little about water. For example, we don't know how water works.

Part of the problem lies in the fact that no one has ever seen a water molecule. It is true that we have theoretical diagrams and equations. We also have a disarmingly simple formula—H2O. The reality, however, is that water is very complex. X-rays, for example, have shown that the atoms in water are intricately laced.

It has been said over and over again that water is special, strange, and different. Water is also almost indestructible. Sure, we know that electrolysis can separate water atoms, but we also know that once they get together again, they must be heated up to more than 2900°C to separate them again.

Water is also idiosyncratic. This can be seen in the way in which the two atoms of hydrogen in a water molecule (see Figure 2-1**)** take up a very precise and strange (different) alignment to each other. Not at all at angles of 45°, 60°, or 90°—oh no, not water. Remember, water is different. The two hydrogen atoms always come to rest at an angle of approximately 105° from each other, making all diagrams of their attachment to the larger oxygen atom look like Mickey Mouse ears on a very round head (see Figure 2-1; remember that everyone's favorite mouse is mostly water, too).

This 105° relationship makes water lopsided, peculiar, and eccentric—it breaks all the rules. You're not surprised, are you? One thing is certain, however; this 105° angle is crucial to all life as we know it. Thus, the answer to defining why water is special, strange, different, and vital, lies somewhere between 0 and 105°.

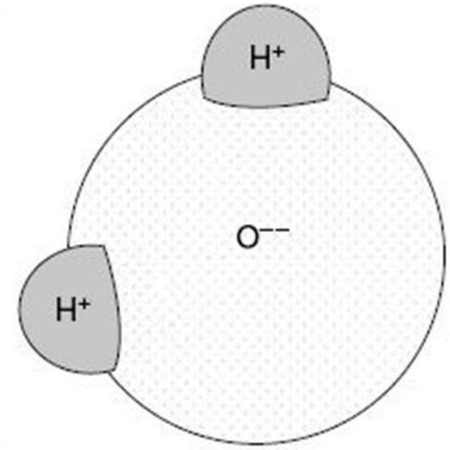


Fig. 2—1 water molecule

(Spellman, 2008)

2.3 Hydrological cycle and aquatic balance:

Hydrology is a branch of Earth Science. The importance of hydrology in the assessment, Development, utilization and management of the water resources, of any region is being increasingly realized at all levels. It was in view of this that the United Nations proclaimed the period of 1965-1974 as the International Hydrological Decade during which, intensive efforts in hydrologic education research, development of analytical techniques and collection of hydrological information on a global basis, were promoted in Universities, Research Institutions, and Government Organizations.

2.4 WORLD'S WATER RESOURCES

The World's total water resources are estimated at 1.36 × 108 ha -m. Of these global water resources, about 97.2% is salt water mainly in oceans, and only 2.8% is available as fresh water at any time on the planet earth. Out of this 2.8% of fresh water, about 2.2% is available as surface water and 0.6% as ground water. Even out of this 2.2% of surface water, 2.15% is fresh water in glaciers and icecaps and only of the order of 0.01% is available in lakes and streams, the remaining 0.04% being in other forms. Out of 0.6% of stored ground water, only about 0.25% can be economically extracted with the present drilling technology (the remaining being at greater depths).

It can be said that the ground water potential of the Ganga Basin is roughly about forty times the flow of water in the river Ganga.

2.5 Hydrologic cycle

Hydrologic cycle is the water transfer cycle, which occurs continuously in nature; the three important phases of the hydrologic cycle are: (*a*) Evaporation and evapotranspiration (*b*) precipitation and (*c*) runoff and is shown in Figure 2-2 The globe has one-third land and Two-thirds Ocean. Evaporation from the surfaces of ponds, lakes, reservoirs. Ocean surfaces, etc. and transpiration from surface vegetation *i.e.*, from plant leaves of cropped land and forests, etc. take place. These vapours rise to the sky and are condensed at higher altitudes by condensation nuclei and form clouds, resulting in droplet growth. The clouds melt and sometimes burst resulting in precipitation of different forms like rain, snow, hail, sleet, mist, dew and frost. A part of this precipitation flows over the land called runoff and part infilters into the soil which builds up the ground water table. The surface runoff joins the streams and the water is stored in reservoirs. A portion of surface runoff and ground water flows back to ocean. Again, evaporation starts from the surfaces of lakes, reservoirs and ocean, and the cycle repeats. Of these three phases of the hydrologic cycle, namely, evaporation, precipitation and runoff, it is the ‘runoff phase’, which is important to a civil engineer since he is concerned with the storage of surface runoff in tanks and reservoirs for the purposes of irrigation, municipal water supply hydroelectric power etc.

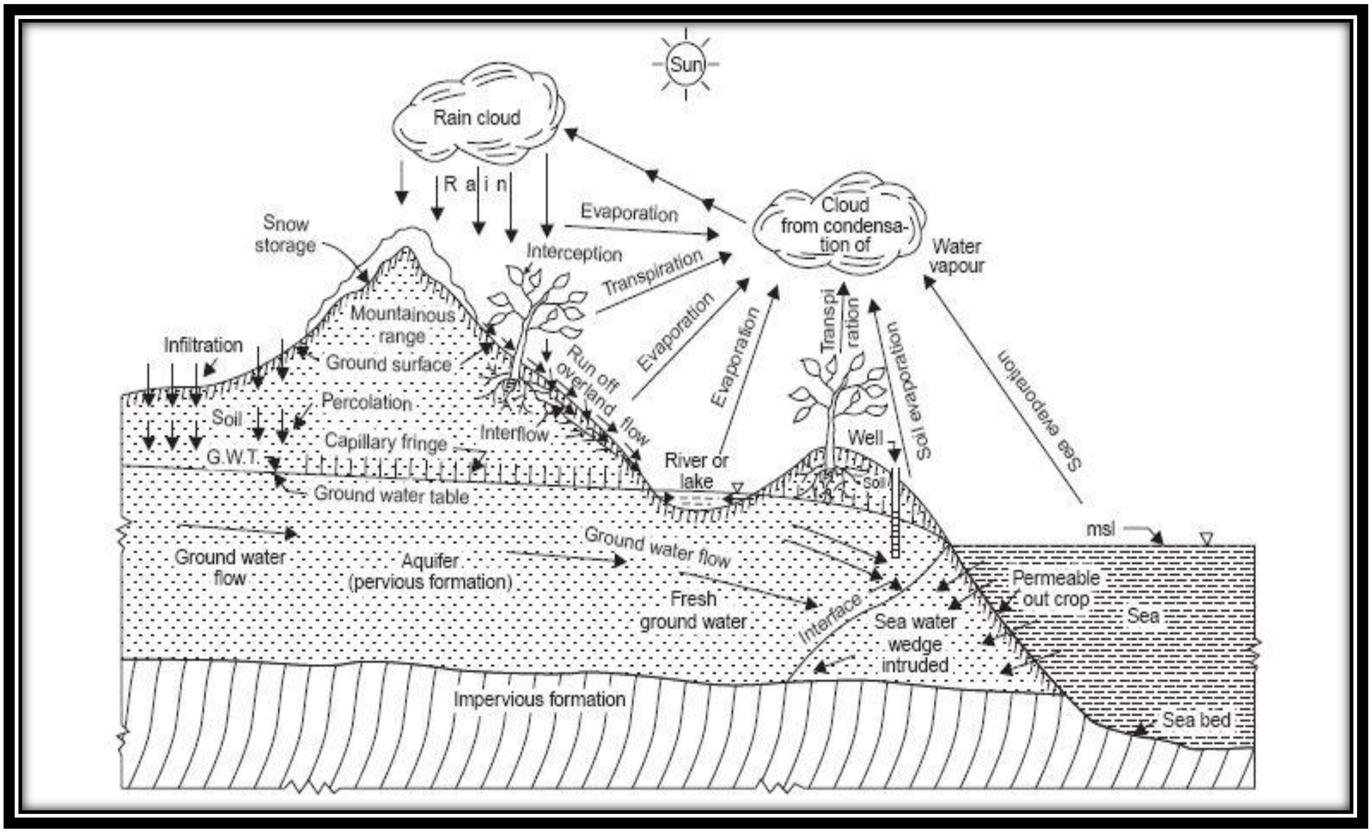


Fig. 2—2 Hydrologic cycle

(Raghunath, 2006)

2.5.1 Surface water

Surface water is that water that is open to the atmosphere and results from overland flow (i.e., runoff that has not yet reached a definite stream channel). Put a different way, surface water is the result of surface runoff.

For the most part, however, surface (as used in the context of this text) refers to water flowing in streams and rivers, as well as water stored in natural or artificial lakes, man-made impoundments such as lakes made by damming a stream or river, springs that are affected by a change in level or quantity, shallow wells that are affected by precipitation, wells drilled next to or in a stream or river, rain catchments, and muskeg and tundra ponds.

Specific sources of surface water include:

- Rivers
- Streams
- Lakes

- Impoundments (man-made lakes made by damming a river or stream)
- Very shallow wells that receive input via precipitation
- springs affected by precipitation (flow or quantity directly dependent upon precipitation)
- Rain catchments (drainage basins)
- Tundra ponds or muskegs (peat bogs)

Surface water has advantages as a source of potable water. Surface-water sources are usually easy to locate, unlike groundwater. Finding surface water does not take a geologist or hydrologist and normally it is not tainted with minerals precipitated from the Earth's strata.

Ease of discovery aside, surface water also presents some disadvantages: surface-water sources are easily contaminated (polluted) with microorganisms that can cause waterborne diseases (anyone who has suffered from "hiker's disease" or "hiker's diarrhea" can attest to this), and from chemicals that enter from surrounding runoff and upstream discharges.

2.5.2 Groundwater

Groundwater sources are replenished from a percentage of the average approximately 3 ft of water that falls to the Earth each year on every square foot of land. Water falling to the Earth as precipitation follows three courses. Some runs off directly to rivers and streams (roughly 6 in. of that 3 ft), eventually working back to the sea. Evaporation and transpiration through vegetation takes up about 2 ft. The remaining 6 in. seeps into the ground, entering, and filling every interstice, hollow, and cavity. Gravity pulls water toward the center of the Earth. That means that water on the surface will try to seep into the ground below it. Although groundwater comprises only one sixth of the total (1,680,000 miles of water), if we could spread out this water over the land, it would blanket it to a depth of 1000 feet.

2.5.3 Aquifers

As mentioned, part of the precipitation that falls on land infiltrates the land surface, percolates downward through the soil under the force of gravity, and becomes groundwater. Groundwater, like surface water, is extremely important to the hydrologic cycle and to our water supplies. Almost half of the people in the United States drink public water from groundwater supplies. Overall, more water exists as groundwater than surface water in the United States, including the water in the Great Lakes. But sometimes, pumping it to the surface is not economical, and in recent years, pollution of groundwater supplies from improper disposal has become a significant problem.

We find groundwater in saturated layers called aquifers under the Earth's surface. Three types of aquifers exist: unconfined, confined, and springs.
A confined aquifer is sandwiched between two impermeable layers that block the flow of water. The water in a confined aquifer is under hydrostatic pressure. It does not have a free water table (see Figure 2.5).

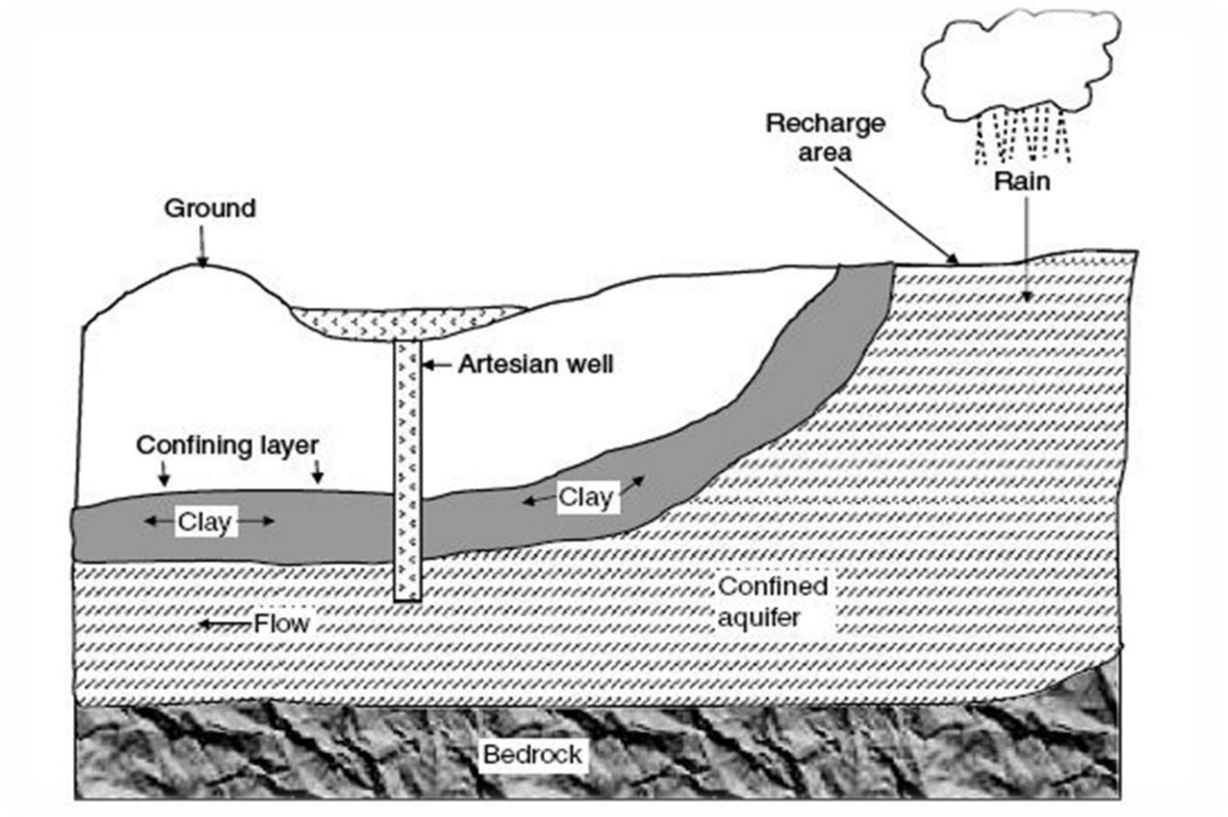


Fig. 2—3 : Confined aquifer

(Spellman, 2008)

The Water Budget

In theory, accounting for the water resources of an area is simple. The basic procedure involves the evaluation of each component of the water budget so that a quantitative comparison of the available water resources with the Known or anticipated water requirements of the area can be made. In practice, however, the evaluation of the water budget is often quite complex, and extensive and time-consuming investigations are generally required.

Although a water supply may be adequate for present needs, it may not be capable of supporting future demands for the resource. Forecasts of future water requirements are needed as are those of changes in dependable water supplies. Factors considered in making such forecasts include population, industrial development, agricultural practices, water policy, technology, and water management practices.

Very crudely, the water budget may be represented by the following equation:

$$I - O = \Delta S$$

Where the inflows (I) are all sources of water, natural and human-made, entering the region; the outflows (O) are all movements of water out of the region, including evaporation, transpiration, seepage, and stream flows; and the change in change in storage (ΔS) is the increase or decrease in storage over time for all natural (surface and underground) and all artificial reservoirs.

(Jr & Hammer, 2005)

2.6 Water uses

Water- Using Sectors

Decisions on developing and allocating water resources must be based on availability, quality, type and rate of use of the resource. A complication is that source waters must usually be allocated to numerous competing uses. When supplies are limited, conflicts among users may become intense and tradeoffs will have to be made.

2.6.1 Agriculture

Water is critical to agriculture. In arid and semiarid regions without a dependable water supply, there is little chance of achieving success in agricultural operations. In humid areas, rainfall is often adequate to produce good crops, but even there, supplemental irrigation is being relied on more and more to prevent crop failures and to improve the quality of the products produced. In the eastern United State, the increasing use of supplemental irrigation highlights the importance of sustainable water supplies for crop production.

Irrigation water requirements are generally seasonal, varying with climate and type of crop. In humid regions, water withdrawals for irrigation may range from about 10% of the total annual demand in May to 30% in September, while in arid and semiarid locations, rates of withdrawal are nearly uniform during the irrigation season. The quantities and timing of water uses for irrigation conflict with many other uses.

2.6.2 Thermoelectric Power

The principal use of water in electric generating facilities is for cooling to dissipate rejected heat. The amount of cooling water withdrawn depends on plant size, generator thermal efficiency, cooling heat transfer efficiency, and institutionally regulated limits on effluent temperatures. In 2000, generation of electricity ranked first in total water withdrawals in the United State (fresh plus saline water). A bout 70% of the amount used was from freshwater sources. If the demands for cooling water increase, limitations on freshwater resources will probably stimulate even greater interest in developing coastal sites with their potential for once-through cooling using saline water.

Once-through cooling is the passage of water through cooling units followed by direct release to a receiving body of water without any recycling through water cooling facilities. Withdrawals for once-through cooling are large, but little water is used consumptively.

2.6.3 Industry:

From 1970 to 1980 manufacturing accounted for about 17% of total U.S freshwater withdrawals. In 1995, industrial withdrawals represented only about 7% of the total withdrawals for all categories of water use. This decline is attributed mainly to recycling and process changes. Manufacturing uses vary with the product produced, but they generally include both process waters and cooling waters. From about 1955 to 1975 the amount of fresh and saline water withdrawn for manufacturing purposes almost doubled. This water was recycled about twice before being returned to the source and diminished somewhat less than 10% by evaporation and incorporation into products.

Although manufacturing water use is expected to increase in the future, recycling is also predicted to increase substantially, with the prospect that actual water withdrawals for this purpose will continue to show a decline. Consumptive use will increase, however.

2.6.4 Natural systems

Providing water for the preservation and benefit of fish and wildlife, protection of marshes and estuary areas, and for other environmentally oriented purposes is now considered a necessity. But such water uses are often in conflict with traditional uses, and resolving these conflicts is destined to become an increasingly common task. The Everglades restoration project in south

Florida are an excellent example. Estimation of the quantities of water needed for environmental protection and restoration is difficult. Scientific data needed to make good determinations are often lacking, and this presents special problems since the quantities of water involved can be substantial.

(Jr & Hammer, 2005)

2.7 Water properties

2.7.1 Physical Properties

The physical characteristics of concern in drinking water are temperature, color, turbidity, sediments, taste, and odor.

2.7.1.1 ***Temperature***

Because of its hydrogen bonds and molecular structure, water has an unusual trait—the density of its solid phase (ice) is lower than that of its liquid phase (water). Because of this trait, ice floats, and pipes and plant tissues rupture when the water within them freezes and expands.

The rates of chemical and metabolic reactions, viscosity and solubility, gas-diffusion rates, and the settling velocity of particles depend on temperature. Metabolism, reproduction, and other physiological processes of aquatic organisms are controlled by heat-sensitive proteins and enzymes (Ward 1985). A 10 °C increase in temperature will roughly double the metabolic rate of cold-blooded organisms and many chemical reactions. A permanent 5 °C change in temperature can significantly alter the structure and composition of an aquatic population (MacDonald and others 1991, Nathan son 1986). Temperature increases also decrease DO concentrations but can increase the oxidation rate and efficiency of certain biological, wastewater treatment systems.

The temperature of water naturally varies with time of day, season, and the type of water body. Changes in surface water temperatures reflect seasonal changes in net radiation, daily changes in air temperature, and local variations in incoming radiation. Temperature variations in ground water are less than in surface water. Except in the winter, surface water is usually warmer than ground water, and most anthropogenic activities increase water temperatures.

Removal of vegetative canopies over streams influences water temperatures by affecting energy inputs, evaporative cooling, and the way water flows across the landscape. The cooling rate for surface water depends on heat transfer to the atmosphere.

Seasonal and spatial variations in the temperature in water supply reservoirs can have large effects on the quality of raw municipal water (Cox 1964). Water in deep reservoirs is commonly divided into three zones: the upper circulating zone, the middle transition zone, and the deepest zone of stagnation. Water in the upper surface zone is aerated and mixed by wind action and typically has abundant DO. In contrast, the deepest, stagnant water contains little or no DO because it has been removed during the oxidation of organic matter. The breakdown of organic matter also makes deep water acidic and rich in carbonic acid. Consequently, stagnate, deep water has the chemical conditions necessary to dissolve iron, manganese, sulfur, and other taste- and odor-producing substances. To avoid the objectionable taste and odor of the deep water, municipal water is usually drawn from the surface of the reservoir. However, when the temperature of the surface water falls rapidly, it can become denser than the bottom water, causing the entire water column of the reservoir to mix or "turn over." During these mixing events, the DO content of the entire lake can decrease, causing massive fish kills and foul smelling and poor tasting water. Similar mixing can occur in stratified lakes or estuaries during periods of intense runoff.

2.7.1.2 *Color and Turbidity*

Pure water is colorless in thin layers and bluish green in thick layers. Particulates and insoluble compounds typically add color and reduce transparency. Consequently, the presence of light-dependent aquatic organisms can affect esthetic appeal and taste of water as well as the effectiveness of certain wastewater treatment processes. Turbidity is an optical property related to the scattering of light and clarity. It is typically controlled by the presence of suspended particles or organic compounds. Turbidity itself is not injurious to human health. Approximately 50 percent of the total incident light is scattered or transformed into heat within the first meter of water. As turbidity increases, it reduces the depth of sunlight penetration, thereby altering water temperature and stratification, the photosynthesis of aquatic organisms, the DO content of the water body, and the cost of water treatment. In addition, turbid water can contain particulate of soil or fecal matter that harbors microorganisms and/or carries absorbed contaminants. The removal of particulates by gravity or by addition of chemicals is typically the first step in treating water for human consumption. The sedimentation of particles and the bleaching action of sunlight during reservoir storage can reduce both the color and turbidity of water .
(Cox, 1964)

2.7.1.3 ***Taste and Odor***

Taste and odor are human perceptions of water quality. Human perception of taste includes sour (hydrochloric acid), salty (sodium chloride), sweet (sucrose) and bitter (caffeine). Relatively simple compounds produce sour and salty tastes. However, sweet and bitter tastes are produced by more complex organic compounds. Odor is produced by gas production due to the decomposition of organic matter or by substances added to the wastewater. Odor is measured by special instruments such as the Portable H2S meter which is used for measuring the concentration of hydrogen sulfide.

Since the electrical conductivity is a measure to the capacity of water to conduct electrical current, it is directly related to the concentration of salts dissolved in water, and therefore to the Total Dissolved Solids (TDS). Salts dissolve into positively charged ions and negatively charged ions, which conduct electricity.

2.7.1.4 ***Sediment (solids)***

Sediment is a major water-quality concern because of its ability to transport harmful substances and its impacts on the cost of water treatment and the maintenance of water distribution systems. While sediment is derived during the natural weathering and sculpturing of the landscape, accelerated levels of erosion and sedimentation are associated with many anthropogenic activities.

The general term sediment includes both organic and inorganic particles that are derived from the physical and chemical weathering of the landscape. Individual particles are eroded, transported, and deposited. Erosion can be either physical or chemical. Transport can be by wind, gravity, or water. In water and air, particles can be transported in suspension (suspended load) or along the substrate (bed load). Sediment load is the total quantity of sediment that is transported through a cross-section of a stream during a specific time period. The actual amount of sediment transported at any place or time depends on the supply of sediment and the transport capacity of the stream. Sediment is usually measured as mass per unit area (tons per acre per year or metric tons per hectare per year), concentration (parts per million or milligrams per liter), or lowering of the landscape (inches per 1,000 years or millimeters per 1,000 years). In general, high sediment loads increase water treatment costs and reduce the storage volume and life span of water storage facilities.

2.7.1.5 *TDS AND ELECTRICAL CONDUCTIVITY*

Since it is difficult to measure TDS in the field, the electrical conductivity of the water is used as a measure the electrical conductivity of the water can be determined in a quick and inexpensive way, using portable meters.

Distilled water does not contain dissolved salts and, as a result, it does not conduct electricity and has an electrical conductivity of zero. Nevertheless, when the salt concentration reaches a certain level, electrical conductivity is no longer directly related to salts concentration. This is because ion pairs are formed. Ion pairs weaken each other's charge, so that above this level, higher TDS will not result in equally higher electrical conductivity.

2.7.2 Chemical Properties

Water is formed by the covalent union of two hydrogen (H) atoms and one oxygen (O) atom. These atoms are joined in an unsymmetrical arrangement where the hydrogen end of the molecule has a slight positive charge and the oxygen end a slight negative charge. This arrangement of unbalanced electrical charges creates the dipolar characteristic that gives the molecule the remarkable ability to act as both an acid and a base and be a solvent for cations, anions, and some types of organic matter. This arrangement also allows water molecules to form hydrogen bonds with adjacent water molecules. These bonds are responsible for water’s high viscosity, high cohesion and adhesion, high surface tension, high melting and boiling points, and the large temperature range through which it is a liquid.

As water travels across the landscape, it interacts with its environment through a variety of chemical processes. In the process, it picks up and transports dissolved gases, cations and anions, amorphous organics, trace metals, and particulates. The most common positively charged ions, or cations, include calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^{+1}), potassium (K^{+1}), and ammonium ($NH4^{+1}$).

The most common anions, or negatively charged ions, include nitrate ($NO3^{-1}$), sulfate (SO_4^{-2}), chloride (Cl^{-1}), and several different forms of phosphorus (P). Most amorphous substances are organic carbon-based compounds that readily adsorb and exchange cations. Common particulates include mineral particles, i.e., inorganic sediment, organic debris, and microscopic organisms (plankton, diatoms, etc.). Both the chemical behavior and the origin of contamination vary with the type of chemical contaminants.

2.7.2.1 ***PH, acidity and alkalinity***

The pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body and all processes associated with water supply and treatment. When measuring the effects of an effluent discharge, it can be used to help determine the extent of the effluent plume in the water body.

The pH is a measure of the acid balance of a solution and is defined as the negative of the logarithm to the base 10 of the hydrogen ion concentration. The pH scale runs from 0 to 14 (i.e. very acidic to very alkaline), with pH 7 representing a neutral condition. At a given temperature, pH (or the hydrogen ion activity) indicates the intensity of the acidic or basic character of a solution and is controlled by the dissolved chemical compounds and biochemical processes in the solution. In unpolluted waters, pH is principally controlled by the balance between the carbon dioxide, carbonate and bicarbonate ions as well as other natural compounds. The natural acid-base balance of a water body can be affected by industrial effluents and atmospheric deposition of acid-forming substances. Changes in pH can indicate the presence of certain effluents, particularly when continuously measured and recorded, together with the conductivity of a water body. Diel variations in pH can be caused by the photosynthesis and respiration cycles of algae in eutrophic waters.

The pH of most natural waters is between 6.0 and 8.5, although lower values can occur in dilute waters high in organic content, and higher values in eutrophic waters, groundwater brines and salt lakes.

(Chapman, 1996)

2.7.2.2 ***Hardness***

The hardness of natural waters depends mainly on the presence of dissolved calcium and magnesium salts. The total content of these salts is known as general hardness, which can be further divided into carbonate hardness (determined by concentrations of calcium and magnesium hydro carbonates), and non-carbonate hardness (determined by calcium and magnesium salts of strong acids). Hydro carbonates are transformed during the boiling of water into carbonates, which usually precipitate. Therefore, carbonate hardness is also known as temporary or removed, whereas the hardness remaining in the water after boiling is called constant.

Hardness may vary over a wide range. Calcium hardness is usually prevalent (up to 70 per cent), although in some cases magnesium hardness can reach 50-60 per cent.

Seasonal variations of river water hardness often occur, reaching the highest values during low flow conditions and the lowest values during floods. Groundwater hardness is, however, less variable. Where there are specific requirements for water hardness in relation to water use it is usually with respect to the properties of the cations forming the hardness.

2.7.2.3 ***Dissolved Gases***

The most abundant dissolved gases in water are nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), methane (CH_4), hydrogen sulfide (H_2S), and nitrous oxide (N_2O). The first three are abundant in the Earth’s atmosphere. The second three are typically products of biogeochemical processes that occur in nonaerated, low oxygen environments. The solubility of most gases increases with decreasing water temperature and decreases with increasing concentrations of chlorides or other salts. The concentration of dissolved oxygen (DO) is essential to aquatic life and can effect the water’s color, taste, odor, and chemistry. Unpolluted surface waters are generally saturated with DO because of reaeration and the production of oxygen during photosynthesis by submerged aquatic plants. Ground water systems tend toward oxygen depletion and reducing conditions because the oxygen consumed during hydro chemical and biochemical reactions is not replenished by the atmosphere. Polluted surface waters tend to have lower DO concentrations because of oxygen consumption during the decomposition of organic matter.

The concentrations of DO strongly influence the solubility and stability of elements that readily gain or lose electrons including iron (Fe^{+3}), manganese (Mn^{+3}), nitrogen, sulfur (S), and arsenic (As^{+3}). When dissolved iron and manganese are exposed to air, they form insoluble precipitates that make water turbid, cause stains in laundry, and impart a bitter taste. (Cox, 1964)

In water with little or no oxygen, iron minerals are reduced, and adsorbed phosphorus and other elements can be released into the water. The solubility of most arsenic and arsenic-sulfur compounds depends on the presence of DO and can have concentrations in water above the primary standard of 0.05 milligrams (mg) per liter (L).

2.7.2.4 ***Organic Compounds***

Organic compounds have carbon and usually hydrogen and oxygen as the main components in their structural framework. They are typically nonpolar, have relatively low solubility, and are degraded by microorganisms, hydrolysis, oxidation-reduction, and volatilization. In natural waters, they are transported as dissolved phases and attached to particulates.

Commonly occurring natural organic compounds include plant and animal tissue and the products of their decomposition.

Synthetic organics found in water include petroleum products, pesticides, and herbicides. Most synthetic toxic organic compounds originate from coal mining, petroleum refining, and manufacture of textile, wood pulp, and pesticides. In the environment, they are usually associated with roadways and industrial, urban, and agricultural land uses. Disinfecting some organic-rich waters with chlorine may also result in the formation of carcinogenic organic compounds such as trihalomethanes. Highly soluble, potentially carcinogenic organic compounds from gasoline spills and emissions are also found in water supplies and can make water distasteful and undrinkable.

2.7.2.5 *Trace Metals and Nonmetals*

Primary and secondary water-quality standards have been developed for common trace metals and nontrace elements. Most of these elements occur in natural, uncontaminated waters in concentrations below 1 mg per liter. Metals have relatively low solubilities. Solubilities are usually lowest at neutral acidity and increase with increasing acidity and increasing alkalinity. A characteristic feature of metals is their tendency to form hydrolyzed species and inorganic and organic complexes. These complexes typically absorb to suspended particulates or form insoluble precipitates. Therefore, the transport of metals across the landscape is often related to acidity, the presence of organic compounds, and the transport of sediment. While trace metals and nonmetals occur naturally, their concentrations can be greatly increased over background levels by mining activities, waste dumps, acidic runoff, tanneries, and other industries. Some metals, such as copper and cadmium, are associated with automobiles and are concentrated on streets, parking lots, and industrial areas. Major sources of lead include urban soil, lead-based paint, and some hair-coloring cosmetics.

Fluorine (F) is a trace nonmetal that occurs as fluoride and is under saturated in nearly all-natural water. Because it can have beneficial effects on dental health, fluorine is added to some municipal water supplies. Arsenic is a soluble trace nonmetal that can be naturally present in water from areas of recent volcanism. It is widely used in pigments, insecticides, herbicides, and metal alloys.

Selenium (Se) is a toxic nonmetallic element that has geochemical properties similar to sulfur. It can occur in appreciable concentrations in coal, uranium ore, certain shales, and discharges from petroleum refineries and mines. Like sulfur, it forms strong chemical bonds on the surface of minerals and can be reduced by anaerobic bacteria.

2.7.3 Biological Properties

Aquatic organisms are usually grouped into those that (1) obtain the carbon they need for biosynthesis from carbon dioxide (autotrophs) and (2) use existing organic compounds as their carbon source (heterotrophs). Generally, autotrophs increase DO concentrations in water through photosynthesis, while heterotrophs are responsible for breakdown and recycling of dead organic materials and decreased DO concentrations.

Most microbial contaminants in water are caused by heterotrophs that are transmitted to a water system via human and animal fecal matter. Most waterborne pathogenic microorganisms are bacteria or viruses that survive in sewage and septic leachate.

Bacterial pathogens are generated by both animal and human sources, while viral pathogens are usually only generated by human sources. Viruses that infect animals normally do not cause illness in humans. However, animal sources for some viruses that effect humans are suspected, particularly viruses that infect the respiratory system like the sin number virus, Hantavirus, influenza virus, and Ebola virus.

Common bacterial diseases spread by aquatic microorganisms include Legionnaire’s disease, cholera, typhoid, and gastroenteritis. Waterborne viral diseases include polio, hepatitis, and forms of gastroenteritis. Waterborne parasitic diseases include amoebic dysentery, flukes, and giardiasis.

Giardia spp. and Cryptosporidium spp. are parasitic protozoans that are transferred between animals and humans via the fecal-oral route and are significant sources of gastrointestinal illness. They are common in surface water in back-country areas, including in many national forests and parks. These back-country areas, which provide animal habitat, experience low human use. Unfortunately, some parasitic protozoans are not removed in most water treatment plants because they are small enough to pass filtration systems and are very resistant to disinfectants.

The analytical procedures for detecting waterborne viral diseases are costly and time consuming. Therefore, most drinking and recreational waters are routinely tested for microbes that are easier to detect but whose presence is highly correlated with human health hazards. Coliforms are the most common type of microbes used in this type of testing. All coliforms are aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose. Their presence and abundance in raw water is used to screen for fresh fecal contamination.

Their presence in treated water is used to determine treatment plant efficiency and the integrity of the distribution system.

Many environmental factors can affect the transport of microbes across the landscape. Relatively coarse-grained or sandy soils are poor absorbers of microbes. Fine-textured clay soils or soils with abundant colloidal organic material are very adsorbent because their negatively charged surfaces and large surface area per-unit volume increase the number of potential adsorption sites for microbial contaminants. As a result, clay soils slow the migration but can enhance the survival of certain microbes. In contrast, the absorption of viruses to organic soils or in environments with high concentrations of dissolved organic matter or organic acids is relatively poor, probably because of competition for adsorption sites. The presence of humic and fulvic acids may reduce virus infectivity.

The acidity and ionic strength of liquids percolating past adsorbed microbes can influence their sorption and desorption. Moreover, a reduction in the ionic strength of pore water weakens the virus-soil adsorption forces and increases their entrainment and concentrations in percolating water. Therefore, natural rainwater with its extremely low ionic strength can mobilize and transport viruses that have sorbed to the upper layers of the soil.

Fecal contamination of surface and ground water can occur by several pathways. The concentration of microbes in surface runoff is generally higher in warmer months and higher in runoff from grazed rather than ungrazed land. Lawns and residential streets are important sources of fecal coliforms from domestic animals. Leaking sewer lines and failed septic systems are also common sources, and water distribution systems can harbor bacterial or fecal contamination. This contamination enters distribution systems when controls fail or when negative pressure in a leaking pipe allows contaminants to infiltrate.

Storage in reservoirs can increase or decrease the microbial content of surface water. Sedimentation of particles with adsorbed microbes and the germicidal action of sunlight can lower microbial content. However, these effects are spatially and seasonally variable and are influenced by microclimate and the morphology and chemistry of a water body. Eutrophic conditions that reduce DO concentrations or produce toxic blue-green algae blooms may decrease water quality.

2.7.3.1 ***Total coliforms***

The term "total coliforms" refers to a large group of Gram-negative, rod-shaped bacteria that share several characteristics. The group includes thermotolerant coliforms and bacteria of faecal origin, as well as some bacteria that may be isolated from environmental sources.

Thus the presence of total coliforms may or may not indicate faecal contamination. In extreme cases, a high count for the total coliform group may be associated with a low, or even zero, count for thermotolerant coliforms. Such a result would not necessarily indicate the presence of faecal contamination. It might be caused by entry of soil or organic matter into the water or by conditions suitable for the growth of other types of coliform. In the laboratory total coliforms are grown in or on a medium containing lactose, at a temperature of

35 or 37 °C. They are provisionally identified by the production of acid and gas from the fermentation of lactose.

2.7.3.2 ***Thermotolerant (faecal) coliforms***

The term "faecal coliform" has been used in water microbiology to denote coliform organisms which grow at 44 or 44.5 C and ferment lactose to produce acid and gas. In practice, some organisms with these characteristics may not be of faecal origin and the term "thermotolerant coliform" is, therefore, more correct and is becoming more commonly used. Nevertheless, the presence of thermotolerant coliforms nearly always indicates faecal contamination.

Usually, more than 95 per cent of thermotolerant coliforms isolated from water are the gut organism Escherichia coli, the presence of which is definitive proof of faecal contamination.

As a result, it is often unnecessary to undertake further testing to confirm the specific presence of E. coli.

In the laboratory thermotolerant coliforms are grown on media containing lactose, at a temperature of 44 or 44.5 °C. They are provisionally identified by the production of acid and gas from the fermentation of lactose.

Nutrient-rich environments may encourage the growth or persistence of some species of thermotolerant coliform other than E. coli. This possibility should be considered when, for

example, an unusually high result is obtained from water that was thought to be relatively clean. In such a case, the advice of a microbiology laboratory should be sought for the determination of the more specific indicator, E. coli.
(Bartram, 1996)

2.8 Water standards

2.8.1 The Importance of Safe Public Drinking Water

The U.S. Congress justified passing the Safe Drinking Water Act Amendments of 1996 (SDWA) (Public Law 104–182) codified at 42 U.S.C. sec. 300j–14, by stating “safe drinking water is essential to the protection of public health.” For over 50 years, a basic axiom of public health protection has been that safe drinking water reduces infectious disease and extends life expectancy. Although most U.S. residents take safe public drinking water for granted, assuring its safety remains a high national priority. Large investments are made by all levels of government to maintain and upgrade our public water systems.

2.8.2 Nitrogen

Nitrogen, a major nutrient for vegetation, plays a dominant role in many biochemical reactions. However, in certain chemical forms, it can adversely affect humans, ecosystems, and water supplies. Since preindustrial times, fertilizer production and other human activities have more than doubled the global input of nitrogen to terrestrial ecosystems. This increase has made nitrogen the most common water pollutant in the United States. In the Northeastern United States alone, anthropogenic activities have apparently increased the nitrate concentrations in major rivers threefold to tenfold since the early 1900’s.

Anthropogenic alteration of nitrogen cycles has also affected forest and aquatic productivity and increased acid rain, photochemical smog, and greenhouse gases.

Certain nitrogen compounds can have toxic effects at relatively low concentrations. Methemoglobinemia (bluebaby syndrome) in bottle-fed babies and the elderly is a human health hazard associated with nitrite (NO_2^{-1}) in drinking water. Nitrate in water can also present similar health hazards as can nitrate in many foods. Bacteria residing in vertebrate digestive tracts can convert the relatively benign nitrate into the toxic nitrite. Ammonia dissolved in drinking water is not toxic to humans but can be toxic to some aquatic invertebrates and fish depending on the concentration of DO temperature, acidity, and salinity, and the carbon dioxide-carbonic acid

equilibrium of water. Because all forms of inorganic nitrogen are nutrients to green plants, excessive concentrations in water can lead to algal blooms, excessive growth of submerged aquatic plants, and eutrophication, particularly in coastal and marine ecosystems. The global nitrogen cycle consists of three major reservoirs:
(1) the atmosphere, (2) the hydrosphere, and (3) the biosphere. The flow between these reservoirs occurs in many forms and pathways. Inorganic nitrogen can be transported in water as dissolved nitrous oxide or nitrogen gas, ammonia, and cations or as anions of nitrite or nitrate. The concentrations of these compounds are low in most unpolluted freshwater and high in waters contaminated by organic wastes, sewage, or fertilizers. Worldwide, pristine rivers have average concentrations of ammonia and nitrate of 0.015 mg per liter and 0.1 mg per liter, respectively. Nitrate concentrations > 1 mg per liter generally indicate anthropogenic inputs. The lowest concentrations are generally found in deep ground water and surface waters draining pristine wild lands. The highest levels are associated with surface runoff and ground water from fertilized agricultural and urban areas. In undisturbed watersheds, annual yields increase with annual runoff, and yields from savanna and rangeland are less than from forest.

Organic nitrogen is converted to inorganic nitrogen in a process called mineralization in the following oxidation sequence: organic nitrogen and ammonium to nitrite to nitrate. In water that is strongly oxidized, nitrate is the stable phase and is very mobile. As redox potential declines, nitrate is reduced or denitrified to nitrous oxide or nitrogen gas. Because of the potential adverse ecosystem and health effects associated with nitrites and nitrates, denitrification is desirable for water quality. Generally, the amount of net mineralization is directly related to the total content of organic nitrogen and carbon (Schlesinger 1997, Vitousek and Melillo 1979). Nitrification tends to be lower in soil with low acidity, low soil oxygen, low soil moisture, and low temperature, and high litter carbon to nitrogen ratios. At the watershed scale, rates of denitrification vary with landscape positions. In general, relatively high denitrification rates are found in riparian forests and at the base of slopes where water, carbon, nitrogen, and phosphorus are readily available. Because nitrogen is essential to the growth of plants, seasonal differences in plant uptake can cause measurable variations in the concentration of nitrogen in soil and surface water. In general, the lowest nitrogen levels in surface or ground water occur during the early growing season when plant uptake is greatest. Maximum nitrogen concentrations typically occur in the winter when plant uptake is reduced, and the dissolved fraction is concentrated in unfrozen water. However, seasonal trends can be reversed or diminished in areas with large anthropogenic inputs.

2.8.3 Phosphorus

The presence of phosphorus in drinking water is not considered a human health hazard, and no drinking water quality standards are established for phosphorus. Nevertheless, phosphorus can affect the water's color and odor and indicate the presence of other organic pollution. Furthermore, because phosphorus can accelerate the growth of algae and aquatic vegetation, it contributes to the eutrophication and associated deterioration of municipal water supplies. Whereas excess nitrogen is responsible for most of the coastal and marine eutrophication, agricultural sources of phosphorus dominate the eutrophication processes in many freshwater aquatic systems.

Nearly all the phosphorus in terrestrial ecosystems is originally derived from the weathering of minerals.

The most common phosphorus-rich mineral is apatite, a calcium orthophosphate that is present in some igneous rocks and marine sediments. In natural freshwater, phosphorus exists in both dissolved and particulate fractions.

Dissolved phases typically originate from excretions by organisms, whereas particulate fractions can have organic or inorganic origins. In streams, a large fraction of phosphorus is adsorbed on and transported with organic and inorganic particulates. In lakes, a large proportion of the phosphorus in oxygen-rich surface waters is held in plankton biomass. In deeper, anoxic lakes, phosphorus is adsorbed to sediments and particulates but can be released during the reduction of iron compounds. Unlike nitrogen, carbon, and hydrogen, phosphorus does not have a significant gaseous component.

2.8.4 Chemical Evolution of Water

As water moves across the landscape, it interacts with the surfaces it contacts and chemically evolves toward the composition of seawater.

In general, the evolution of deep ground water typically involves increases in dissolved solids and decreases in DO, organic waste, pesticides, phosphorus, and nitrogen. In contrast, the concentrations of organic waste, pesticides, phosphorus, and nitrogen increase as surface water travels across the landscape and interacts with both natural and anthropogenic systems.

Fresh, young water that has had little contact with its surroundings is generally low in total dissolved solids and rich in bicarbonate anions derived from soil carbon dioxide and the dissolution of carbonate minerals. Sulfate anions tend to dominate in intermediate age ground water while chloride anions dominate in older, deep ground water that has traveled long distances. These sulfate and chloride anions are derived from the dissolution of soluble sedimentary minerals. Because these minerals are present only in small amounts in most rocks, water usually has to travel considerable distances before it is dominated by either sulfate or chloride anions.

The DO content and redox potential tend to decrease as water travels across the landscape. Rain and snow are exposed to atmospheric oxygen and have relatively high DO and redox potentials. As water passes through organic-rich forest litter and soil, the DO is removed, redox potential declines, and large amounts of organic acids are generated.

Nutrient immobilization predominates in the upper layers of fresh litter, while mineralization of nitrogen, phosphorus, and sulfur is usually greatest in the upper mineral soil. As water travels through the subsurface, all the DO is consumed by bacterially catalyzed reactions that oxidize organic matter. Eventually the aerobic bacteria involved in these reactions can no longer thrive, and anaerobic conditions prevail. Then ammonia, manganese, ferrous iron, and sulfate become oxidizing agents.

Cation concentrations in water vary considerably in space and time and do not follow well-defined, theoretically based sequences like anions or redox potentials. Nevertheless, cations enter the aquatic system from the weathering of minerals and the breakdown of organic materials. Their concentrations typically increase with travel distance in both surface and ground water. The most abundant cations in water supplies are calcium and magnesium, which can be removed by chemical treatments to prevent scaling of pipes and to reduce the amount of soap needed for washing.

(Dissmeyer, 2000)

2.9 Water purification

2.9.1 Quantity and Quality FACTORS (Q and Q)

While potable water practitioners must have a clear and complete understanding of the natural water cycle, they must, as previously mentioned, also factor in two major considerations (Quantity and Quality—the Q and Q factors): (1) providing a “quality” potable water supply—one that is clean, wholesome, and safe to drink; and (2) finding a water supply available in adequate “quantities” to meet the anticipated demand.

Two central facts important to our discussion of freshwater supplies are: (1) water is very much a local or regional resource, and (2) problems of its shortage or pollution are equally local problems. Human activities affect the quantity of water available at a locale at any time by changing either the total volume that exists there, or aspects of quality that restrict or devalue it for a particular use. Thus, the total human impact on water supplies is the sum of the separate human impacts on the various drainage basins and groundwater aquifers. In the global system, the central, critical fact about water is the natural variation in its availability.

(Spellman, 2008)

2.9.2 Water quality

Although water quality and water quantity are inextricably linked, water quality deserves special attention because of its implications for affecting public health and quality of life. Even with the large federal investments in pollution control since 1972, the president's Council on Environmental Quality reports that the nation's waters continue to be damaged by pollution and misuse. Pollutants reach water bodies from both point and nonpoint sources. Municipal wastes, urban and agricultural runoff, and industrial wastes are principal offenders. Of special importance are the vestiges of past toxic and hazardous material that are now being transported by surface water and groundwater systems. The impacts of polluting activities are widespread and they affect the public health, the economy, and the environment.

Finally, the threat of introduction of harmful substances into water supplies through acts of terrorism must be taken into consideration. Safeguards for water treatment plants and water supply reservoirs are called for.

2.9.3 Screening and Strainers

Coarse strainers with openings between 2 and 8 centimeters are used at surface water inlets to prevent the inlet of large objects which would otherwise lead to congestion in pipes or the damage of pumps or other machines.

Bar screens or trash rakes are coarse strainers consisting of round or rugged steel grids, which are connected by strips and which are placed at a slight Angle from the vertical.

The coarse openings retain only the very large material. These allow for minimal cleaning either by hand or by mechanical means, on a daily basis or less. The cleaning frequency is further reduced by a low entrance rate, using either a large strainer Width and/or smaller angle of the bars.

Most often, leaves and duckweed also have to be retained by finer strainers. The smaller openings (0.5 - 2 cm), however, require more frequent or Continuous cleaning. Openings of 0.5 mm seem very small, but even Then, they are about 5 to 15 times larger than the granular filter bed pores. Because of their opening size, strainers can only slightly relieve the load on the subsequent sand filters a better result can be obtained by a micro strainer (Figure 40) being spun with a very fine mesh. The micro strainer is continuously rotated while being backwashed from the top.

2.9.4 pH adjustment

Pure water has a pH close to 7 (neither alkaline nor acidic). Sea water can have pH values that range from 7.5to 8.4 (moderately alkaline). Fresh water can have widely ranging pH values depending on the geology of the drainage basin or aquifer and the influence of contaminant inputs (acid rain). If the water is acidic (lower than 7), lime, soda ash, or sodium hydroxide can be added to raise the pH during water purification processes.

Lime addition increases the calcium ion concentration, thus raising the water hardness. For highly acidic waters, forced draft Degasifies can be an effective way to raise the pH, by stripping dissolved carbon dioxide from the water.

Making the water alkaline helps coagulation and Flocculation processes work effectively and also helps to minimize the risk of lead being dissolved from lead pipes and from lead solder in pipe fittings. Sufficient alkalinity also reduces the corrosiveness of water to iron pipes Acid (carbonic acid, hydrochloric acid or sulfuric acid) may be added to alkaline waters in some circumstances to lower the pH Alkaline water (above pH 7.0) does not necessarily mean that lead or copper from the plumbing system will not be dissolved into the water. The ability of water to precipitate calcium carbonate to protect metal surfaces and reduce the likelihood of toxic metals being dissolved in water is a function of pH, mineral content, temperature, alkalinity and calcium concentration.

2.9.5 Water coagulation

Coagulation and flocculation

One of the first steps in a conventional water purification process is the addition of chemicals to assist in the removal of particles suspended in water. Particles can be inorganic such as Clay and silt or organic such as algae, bacteria, viruses, protozoa and natural organic matter in organic and organic particles contribute to the turbidity and color of water.

The addition of inorganic coagulants such as aluminum sulfate (or alum) or iron (III) salts such as iron (III) chloride cause several simultaneous chemical and physical interactions on and among the particles. Within seconds, negative charges on the particles are neutralized by inorganic coagulants. Also, within seconds, metal hydroxide precipitates of the aluminum and iron (III) ions begin to form. These precipitates combine into larger particles under natural processes such as Brownian motion and through induced mixing which is sometimes referred to as flocculation. The term most often used for the amorphous metal hydroxides is "floc." Large, amorphous aluminum and iron (III) hydroxides adsorb and enmesh particles in suspension and facilitate the removal of particles by subsequent processes of sedimentation and filtration.

Aluminum hydroxides are formed within a fairly narrow pH range, typically: 5.5 to about 7.7. Iron (III) hydroxides can form over a larger pH range including pH levels lower than are effective for alum, typically: 5.0 to 8.5.

In the literature, there is much debate and confusion over the usage of the term's coagulation and flocculation—where does coagulation end and flocculation begin? In water purification plants, there is usually a high energy, rapid mix unit process (detention time in seconds) where the coagulant chemicals are added followed by flocculation basins (detention times range from 15to 45 minutes) where low energy inputs turn large paddles or other gentle mixing devices to enhance the formation of floc. In fact, coagulation and flocculation processes are ongoing once the metal salt coagulants are added.

Organic polymers were developed in the 1960s as aids to coagulants and, in some cases, as replacements for the inorganic metal salt coagulants. Synthetic organic polymers are high molecular weight compounds that carry negative, positive or neutral charges. When organic polymers are added to water with particulates, the high molecular weight compounds adsorb onto

Particle surfaces and through inter particle bridging coalesce with other particles to form floc. Poly DADMAC is a popular cationic (positively charged) organic polymer used in water purification plants.

2.9.6 Sedimentation

Waters exiting the flocculation basin may enter the sedimentation basin, also called a clarifier or settling basin. It is a large tank with low water velocities, allowing floc to settle to the bottom.

The sedimentation basin is best located close to the flocculation basin so the transit between the two processes does not permit settlement or floc break up. Sedimentation basins may be rectangular, where water flows from end to end, or circular where flow is from the Centre outward. Sedimentation basin outflow is typically over a weir so only a thin to player of water—that furthest from the sludge-exits.

In 1904, Allen Hazen showed that the efficiency of a sedimentation process was a function of the particle settling velocity, the flow through the tank and the surface area of tank.

Sedimentation tanks are typically designed within a range of overflow rates of 0.5 to 1.0 gallons per minute per square foot (or 1.25 to 2.5 meters per hour). In general, sedimentation basin efficiency is not a function of detention time or depth of the basin.

Although, basin depth must be sufficient so that water currents do not disturb the sludge and settled particle interactions are promoted. As particle concentrations in the settled water increase near the sludge surface on the bottom of the tank, settling velocities can increase due to collisions and agglomeration of particles. Typical detention times for sedimentation vary from 1.5 to 4 hours and basin depths vary from 10 to 15 feet (3 to 4.5 meters).

Inclined flat plates or tubes can be added to traditional sedimentation basins to improve particle removal performance. Inclined plates and tubes drastically increase the surface area available for particles to be removed in concert with Hazen's original theory. The amount of ground surface area occupied by a sedimentation basin with inclined plates or tubes can be far smaller than a conventional sedimentation basin.

2.9.7 Sludge storage and removal

As particles settle to the bottom of a sedimentation basin, a layer of sludge is formed on the floor of the tank which must be removed and treated. The amount of sludge generated is significant, often 3 to 5 percent of the total volume of water to be treated. The cost of treating and disposing of the sludge can impact the operating cost of a water treatment plant. The sedimentation basin may be equipped with mechanical cleaning devices that continually clean its bottom, or the basin can be periodically taken out of service and cleaned manually.

2.9.8 Floc blanket clarifiers

A subcategory of sedimentation is the removal of particulates by entrapment in a layer of suspended floc as the water is forced upward. The major advantage of floc blanket clarifiers is that they occupy a smaller footprint than conventional sedimentation.

Disadvantages are that particle removal efficiency can be highly variable depending on changes in influent water quality and influent water flow rate.

2.9.9 Dissolved air flotation

When particles to be removed do not settle out of solution easily, dissolved air flotation (DAF) is often used. Water supplies that are particularly vulnerable to unicellular algae bloom sand supplies with low turbidity and high color often employ DAF. After coagulation and flocculation processes, water flows to DAF tanks where air diffusers on the tank bottom create fine bubbles that attach to floc resulting in a floating mass of concentrated floc. The floating floc blanket is removed from the surface and clarified water is withdrawn from the bottom of the DAF tank.

2.9.10 Filtration

After separating most floc, the water is filtered as the final step to remove remaining suspended particles and unsettled floc.

2.9.10.1 *Rapid sand filters*

The most common type of filter is a rapid sand filter. Water moves vertically through sand which often has a layer of activated carbon or anthracite coal above the sand. The top layer removes organic compounds, which contribute to taste and odor. The space between sand particles is larger than the smallest suspended particles, so simple filtration is not enough. Most particles pass through surface layers but are trapped in pore spaces or adhere to sand particles. Effective filtration extends into the depth of the filter. This property of the filter is key to its operation: if the top layer of sand were to block all the particles, the filter would quickly clog.

To clean the filter, water is passed quickly upward through the filter, opposite the normal direction (called back flushing or backwashing) to remove embedded particles. Prior to this step, compressed air may be blown up through the bottom of the filter to break up the compacted filter media to aid the backwashing process; this is known as air scouring. This contaminated water can be disposed of, along with the sludge from the sedimentation basin, or it can be recycled by mixing with the raw water entering the plant although this is often considered poor practice since it reintroduces an elevated concentration of bacteria into the raw water.

Some water treatment plants employ pressure filters. These work on the same principle as rapid gravity filters, differing in that the filter medium is enclosed in a steel vessel and the water is forced through it under pressure.

Advantages:

- Filters out much smaller particles than paper and sand filters can.
- Filters out virtually all particles larger than their specified pore sizes.
- They are quite thin and so liquids flow through them fairly rapidly.
- They are reasonably strong and so can withstand pressure differences across them of typically 2–5 atmospheres.
- They can be cleaned (back flushed) and reused.

2.9.10.2 *Slow sand filters*

Slow "artificial" filtration (a variation of bank filtration) to the ground, Water purification plant Káraný, Czech Republic

A profile of layers of gravel, sand and fine sand used in a slow sand filter plant.

Slow sand filters may be used where there is sufficient land and space, as the water must be passed very slowly through the filters. These filters rely on biological treatment processes for their action rather than physical filtration. The filters are carefully constructed using graded layers of sand, with the coarsest sand, along with some gravel, at the bottom and finest sand at the top. Drains at the base convey treated water away for disinfection. Filtration depends on the development of a thin biological layer, called the zoogloeal layer or Schmutzdecke, on the surface of the filter. An effective slow sand filter may remain in service for many weeks or even months if the pre-treatment is well designed and produces water with a very low available nutrient level which physical methods of treatment rarely achieve. Very low nutrient levels allow water to be safely sent through distribution systems with very low disinfectant levels, thereby reducing consumer irritation over offensive levels of chlorine and chlorine by-products. Slow sand filters are not backwashed; they are maintained by having the top layer of sand scraped off when flow is eventually obstructed by biological growth.

A specific "large-scale" form of slow sand filter is the process of bank filtration, in which natural sediments in a riverbank are used to provide a first stage of contaminant filtration. While typically not clean enough to be used directly for drinking water, the water gained from the associated extraction wells is much less problematic than river water taken directly from the major streams where bank filtration is often used.

2.9.10.3 *Membrane filtration*

Membrane filters are widely used for filtering both drinking water and sewage. For drinking water, membrane filters can remove virtually all particles larger than 0.2 um—including giardia and cryptosporidium. Membrane filters are an effective form of tertiary treatment when it is desired to reuse the water for industry, for limited domestic purposes, or before discharging the water into a river that is used by towns further downstream. They are widely used in industry, particularly for beverage preparation (including bottled water). However, no filtration can remove substances that are actually dissolved in the water such as phosphorus, nitrates and heavy metal ions.

2.9.10.4 *Removal of ions and other dissolved substances*

Ultra-filtration membranes use polymer membranes with chemically formed microscopic pores that can be used to filter out dissolved substances avoiding the use of coagulants. The type of membrane media determines how much pressure is needed to drive the water through and what sizes of micro-organisms can be filtered out.

Ion exchange: Ion exchange systems use ion exchange resin- or zeolite-packed columns to replace unwanted ions. The most common case is water softening consisting of removal of Ca^{+2} and

Mg^{+2} ions replacing them with benign (soap friendly) Na^+ or K^+ ions. Ion exchange resins are also used to remove toxic ions such as nitrite, lead, mercury, arsenic and many others.

Precipitate softening: Water rich in hardness (calcium and magnesium ions) is treated with lime (calcium oxide) and/or soda ash (sodium carbonate) to precipitate calcium carbonate out of solution utilizing the common-ion effect.

Electrode ionization: Water is passed between a positive electrode and a negative electrode. Ion exchange membrane sallow only positive ions to migrate from the treated water toward the negative electrode and only negative ions toward the positive electrode.

High purity deionizer water is produced continuously, similar to ion exchange treatment. Complete removal of ions from water is possible of the right conditions are met. The water is normally pretreated with a reverse osmosis unit to remove non-ionic organic contaminants, and with gas transfer membranes to remove carbon dioxide. A water recovery of 99% is possible if the concentrate stream is fed to the RO inlet.

2.9.11 Disinfection

Pumps used to add required amount of chemicals to the clear water at the water purification plant before the distribution. From left to right: sodium hypochlorite for disinfection, zinc orthophosphate as a corrosion inhibitor, sodium hydroxide for pH adjustment, and fluoride for tooth decay prevention.

Disinfection is accomplished both by filtering out harmful microorganisms and also by adding disinfectant chemicals. Water is disinfected to kill any pathogens which pass through the filters and to provide a residual dose of disinfectant to kill or inactivate potentially harmful microorganisms in the storage and distribution systems. Possible pathogens include viruses, bacteria, including

Salmonella, Cholera, Campylobacter and Shigella, and protozoa, including Giardia lamella and other cryptosporidium. Following the introduction of any chemical disinfecting agent, the water is usually held in temporary storage – often called a contact tank or clear well to allow the disinfecting action to complete.

2.9.11.1 ***Chlorine disinfection***

Main article: Water chlorination the most common disinfection method involves some form of chlorine or its compounds such as chloramines or chlorine dioxide.

Chlorine is a strong oxidant that rapidly kills many harmful microorganisms. Because chlorine is a toxic gas, there is a danger of a release associated with its use. This problem is avoided by the use of sodium hypochlorite, which is a relatively inexpensive solution that releases free chlorine when dissolved in water. Chlorine solutions can be generated on site by electrolyzing common salt solutions. A solid form, calcium hypochlorite, releases chlorine on contact with water. Handling the solid, however, requires greater routine human contact through opening bags and pouring than the use of gas cylinders or bleach which are more easily automated.

The generation of liquid sodium hypochlorite is both inexpensive and safer than the use of gas or solid chlorine. All forms of chlorine are widely used, despite their respective drawbacks. One drawback is that chlorine from any source reacts with natural organic compounds in the water to form potentially harmful chemical by-products. These by-products, tri halo methane's (THMs) and halo acetic acids (HAAs), are both carcinogenic in large quantities and are regulated by the United States Environmental Protection Agency (EPA) and the Drinking Water Inspectorate in the UK. The formation of THMs and halo acetic acids may be minimized by effective removal of as many organics from the water as possible prior to chlorine addition. Although chlorine is effective in killing bacteria, it has limited effectiveness against protozoa that form cysts in water (Guardia and Cryptosporidium, both of which are pathogenic).

2.9.11.2 ***Chlorine dioxide disinfection***

Chlorine dioxide is a faster-acting disinfectant than elemental chlorine. It is relatively rarely used, because in some circumstances it may create excessive amounts of chlorite, which is a by-product regulated to low allowable levels in the United States. Chlorine dioxide can be supplied as an aqueous solution and added to water to avoid gas handling problems; chlorine dioxide gas accumulations may spontaneously detonate.

2.9.11.3 ***Chloramines disinfection***

The use of chloramines is becoming more common as a disinfectant. Although chloramines are not as strong an oxidant, it does provide a longer-lasting residual than free chlorine and it will not readily form THMs or halo acetic acids. It is possible to convert chlorine to chloramines by adding ammonia to the water after addition of chlorine. The chlorine and ammonia react to form chloramines. Water distribution systems disinfected with chloramines may experience nitrification, as ammonia is a nutrient for bacterial growth, with nitrates being generated as a by-product.

2.9.11.4 ***Ozone disinfection***

Ozone is an unstable molecule which readily gives up one atom of oxygen providing a powerful oxidizing agent which is toxic to most waterborne organisms. It is a very strong, broad spectrum disinfectant that is widely used in Europe. It is an effective method to inactivate harmful protozoa that form cysts. It also works well against almost all other pathogens. Ozone is made by passing oxygen through ultraviolet light or a "cold" electrical discharge. To use ozone as a disinfectant, it must be created on-site and added to the water by bubble contact. Some of the advantages of ozone include the production of fewer dangerous by-products and the absence of taste and odor problems (in comparison to chlorination). Another advantage of ozone is that it leaves no residual disinfectant in the water. Ozone has been used in drinking water plants since 1906 where the first industrial ozonation plant was built in Nice, France. The U.S. Food and Drug Administration has accepted ozone as being safe; and it is applied as an anti-micro biological agent for the treatment, storage, and processing of foods. However, although fewer by-products are formed by ozonation, it has been discovered that ozone reacts with bromide ions in water to produce concentrations of the suspected carcinogen bromated. Bromide can be found in fresh water supplies in sufficient concentrations to produce (after ozonation) more than 10 parts per billion (ppb) of bromated — the maximum contaminant level established by the USEPA.

2.9.11.5 ***Ultraviolet disinfection***

Ultraviolet light (UV) is very effective at inactivating cysts, in low turbidity water. UV light's disinfection effectiveness decreases as turbidity increases, a result of the absorption, scattering, and shadowing caused by the suspended solids. The main disadvantage to the use of UV radiation is that, like ozone treatment, it leaves no residual disinfectant in the water; therefore, it is sometimes necessary to add a residual disinfectant after the primary disinfection process. This is often done through the addition of chloramines, discussed above as a primary disinfectant. When used in this manner, chloramines provide an effective residual disinfectant with very few of the negative effects of chlorination.

2.9.12 Portable water purification

Portable water purification devices and methods are available for disinfection and treatment in emergencies or in remote locations.

Disinfection is the primary goal, since aesthetic considerations such as taste, odor, appearance, and trace chemical contamination do not affect the short-term safety of drinking water.

2.9.13 Additional treatment options

1. Water fluoridation: in many areas’ fluoride is added to water with the goal of preventing tooth decay. Fluoride is usually added after the disinfection process. In the U.S., fluoridation is usually accomplished by the addition of hex a Fluor silicic acid, which decomposes in water, yielding fluoride ions.

2. Water conditioning: This is a method of reducing the effects of hard water. In water systems subject to heating hardness salts can be deposited as the decomposition of bicarbonate ions creates carbonate ions that precipitate out of solution.

Water with high concentrations of hardness salts can be treated with soda ash (sodium carbonate) which precipitates out the excess salts, through the common-ion effect, producing calcium carbonate of very high purity. The precipitated calcium carbonate is traditionally sold to the manufacturers of toothpaste. Several other methods of industrial and residential water treatment are claimed (without general scientific acceptance) to include the use of magnetic and/or electrical fields reducing the effects of hard water.

3. Plumb solvency reduction: In areas with naturally acidic waters of low conductivity (i.e. surface rainfall in upland mountains of igneous rocks), the water may be capable of dissolving lead from any lead pipes that it is carried in. The addition of small quantities of phosphate ion and increasing

the pH slightly both assist in greatly reducing plumb solvency by creating insoluble lead salts on the inner surfaces of the pipes.

4. Radium Removal: Some groundwater sources contain radium, a radioactive chemical element. Typical sources include many groundwater sources north of the Illinois Riverine Illinois. Radium can be removed by ion exchange, or by water conditioning. The back flush or sludge that is produced is, however, a low-level radioactive waste.

5. Fluoride Removal: Although fluoride is added to water in many areas, some areas of the world have excessive levels of natural fluoride in the source water. Excessive levels can be toxic or cause undesirable cosmetic effects such as staining of teeth. Methods of reducing fluoride levels is through treatment with activated alumina and bone char filter media.

Problems related to chemical salt in water purification

However recent studies have pointed out several serious drawbacks of using chemical salts in water purification and disinfection.

- The cost of procuring these chemicals is increasing rapidly and most developing countries are finding it difficult to cope.
- Alzheimer’s disease and similar health related
- Problems possibly associated with residual aluminum in treated water.
- It produces large sludge volumes.
- It requires pH Alkalinity adjustment.
- Low efficiency in coagulation of cold water.

Alternatives to chemicals

Therefore, where cheaper alternatives can be found, to replace or supplement the conventional treatment chemicals, their use would be a welcome benefit for the poorer less developed countries.

Coagulation-flocculation followed by sedimentation, filtration and disinfection, often by chlorine, is used worldwide in the water treatment industry before the distribution of treated water to consumers.

However recent studies have pointed out several serious drawbacks of using Aluminum salts.

2.10 Moringa and its parts, types, scientific name

2.10.1 **Moringa oleifera**:

Its tropical plant belonging to the family Moringaceae. Seeds are brown, and the kernels are white Crushed whole seed or press cake remaining after oil extraction as a coagulant for water and wastewater treatment (H.M, 2001).

Moringa oleifera is the most widely cultivated species of the genus Moringa, which is the only genus in the family Moringaceae. English common names include: Moringa, drumstick tree (from the appearance of the long, slender, triangular seed-pods), horseradish tree (from the taste of the roots, which resembles horseradish), Ben oil tree, or benzoic tree (from the oil which is derived from the seeds). It is a fast-growing, drought-resistant tree, native to the southern foothills of the Himalayas in northwestern India, and widely cultivated in tropical and subtropical areas where its young seed pods and leaves are used as vegetables. It can also be used for water purification and hand washing, and is sometimes used in herbal medicine.

M. oleifera is a fast-growing, deciduous tree. It can reach a height of 10–12 m (32-40 ft) and the trunk can reach a diameter of 45 cm (1.5 ft.). The bark has a whitish-grey color and is surrounded by thick cork. Young shoots have purplish or greenish white, hairy bark. The tree has an open crown of drooping, fragile branches and the leaves build up a feathery foliage of trip innate leaves.

The flowers are fragrant and bisexual, surrounded by five unequal, thinly veined, yellowish-white petals. The flowers are about 1.0-1.5 cm (1/2”) long and 2.0 cm (3/4”) broad. They grow on slender, hairy stalks in spreading or drooping later flower clusters which have a length of 10–25 cm.

Flowering begins within the first six months after planting. In seasonally cool regions, flowering only occurs once a year between April and June. In more constant seasonal temperatures and with constant rainfall, flowering can happen twice or even all year-round.

The fruit is a hanging, three-sided brown capsule of 20–45 cm size which holds dark brown, globular seeds with a diameter around 1 cm. The seeds have three whitish papery wings and are dispersed by wind and water.

In cultivation, it is often cut back annually to 1–2 m (3-6 ft) and allowed to regrow so the pods and leaves remain within arm's reach.

2.10.1.1 ***Leaves:***

Average yields of 6 tons/ha/year in fresh matter are can be achieved. The harvest differs strongly between the rainy and dry seasons, with 1120 kg/ha per harvest and 690 kg/ha per harvest, respectively. The leaves and stems can be harvested from the young plants 60 days after seeding and then another seven times in the year. At every harvest, the plants are cut back to within 60 cm of the ground. In some production systems, the leaves are harvested every 2 weeks. The cultivation of M. oleifera can also be done intensively with irrigation and fertilization with suitable varieties. Trials in Nicaragua with 1 million plants per hectare and 9 cuttings/year over 4 years gave an average fresh matter production of 580 metric tons/ha/year, equivalent to about 174 metric tons of fresh leaves.

2.10.1.2 **Oil:**

One estimate for yield of oil from kernels is 250 l/ha.[15] The oil can be used as a food supplement, as a base for cosmetics, and for hair and the skin.

2.10.1.3 **Pests and diseases:**

The Moringa tree is not affected by any serious diseases in its native or introduced ranges. In India, several insect pests are seen, including various caterpillars such as the bark-eating caterpillar, the hairy caterpillar or the green leaf caterpillar. The budworms Noctuid are known to cause serious defoliation.

Damaging agents can also be aphids, stem borers, and fruit flies.

In some regions, termites can also cause minor damage. If termites are numerous in soils, insect’s management costs are not bearable.

The Moringa tree is a host to Lamellula Taurica, a powdery mildew which causes damage in papaya crops in south India. Cultivation management should therefore be checked.

(Parrotta, 1993)

Advantage of Moringa oleifera coagulant over chemicals:

- It is natural, completely non-toxic.

- The M. Oleifera seed extract appears to have.
- Natural buffering capacity so, no pH alkalinity.
- Adjustments are required.
- Beside level of turbidity it reduces the level of microorganism in water.

2.10.2 Uses of moringa

2.10.2.1 Nutritional content of fresh moringa leaves

Moringa oleifera leaves belong to the family of dark green leafy vegetables, a food group particularly rich in nutrients. In particular, Moringa oleifera leaves are a good source of proteins, calcium, iron, ß-carotene (converted to vitamin A in the human body), vitamin C and vitamin E.

In addition, Moringa oleifera leaves have a high dry matter content (around 20-25%) compared to most other plant food sources (generally around 10%). This makes it even more beneficial as a fresh vegetable since 100 grams of fresh leaves will bring twice as much nutritive material as 100 grams of most other vegetables.

Indeed, 100 grams fresh Moringa oleifera leaves are enough to cover:

• 30 to 100% of the daily recommended intake of calcium (30 to 50% for teenagers,

40 to 60% for adults, children and pregnant and breastfeeding women, 80 to 100% for young children below 3 years old)

• 25 to 80% of the daily recommended intake of iron (25% for pregnant women, 40-60% for teenagers and women, 50 to 100% for men and children).

As for vitamins, the recommended daily intake for vitamin A varies from 400 µg retinol equivalents (young children) to 1,000 µg retinol equivalents (breastfeeding women).

Therefore, 100 grams of fresh Moringa oleifera leaves could theoretically cover 100% of daily needs, but this is highly variable depending on storage conditions and how they are eaten, as vitamin A degrades over time and when exposed to light or heat.

Similarly, 100 grams of fresh Moringa oleifera leaves could cover 100% of the vitamin C requirements, for which the recommended daily intake varies from 60 mg (young children) to 130 mg (breastfeeding women), but this vitamin degrades quickly with time and during cooking.

For optimal nutrient retention, it is advised to consume fresh leaves shortly after harvesting and to cook the leaves for a short time (a few minutes only), or even to eat them raw if they are young and tender.

Table 2-1 Nutritional content of fresh moringa leaves in 100 grams (Dr.Seewu Noamesi, 2010)

Dry matter	20-25%
Proteins	5-7 grams
Total ash (= total minerals)	2-3 grams
Minerals	
Calcium (Ca)	350-550 mg
Potassium (K)	200-500 mg
Magnesium (Mg)	80-120 mg
Phosphorus (P)	50-120 mg
Iron (Fe)	5-8 mg
Manganese (Mn)	1.2-2.5 mg
Zinc (Zn)	0.4-0.6 mg
Copper (Cu)	0.2-0.3 mg
Vitamins	
Vitamin C	120-200 mg
Vitamin A (as β-carotene)	1500-4000 µg eq. retinol
Vitamin E (as α-tocopherol)	150-200 mg

2.10.2.2 Nutritional content of dry moringa leaf powder

Another way of consuming Moringa oleifera leaves is to dry them and reduce them into powder, making it easier to store and use at any time. To ensure the good nutritional and microbiological quality of the leaf powder, its water content has to be lower than 7%, the drying time should be as short as possible and the drying temperature not too high (no more than 50-55°C).

Even if a large amount of the vitamins are lost during drying and storage, the leaf powder still constitutes a very rich nutritional supplement, since it is a concentrate of the leaves.

Table 2-2Nutritional content of dry moringa leaf powder in 100 grams (Dr.Seewu Noamesi, 2010)

Dry matter	90-95%
Proteins	20-26 grams
Total ash (= total minerals)	8-11 grams
Minerals	
Calcium (Ca)	1600-2200 mg
Potassium (K)	800-1800 mg
Magnesium (Mg)	350-500 mg
Phosphorus (P)	200-600 mg
Iron (Fe)	18-28 mg
Manganese (Mn)	5-9 mg
Zinc (Zn)	1.5-3 mg
Copper (Cu)	0.7-1.1 mg
Vitamins	
Vitamin C	15-100 mg
Vitamin A (as β-carotene)	4000-8000 µg retinol eq.
Vitamin E (as α-tocopherol)	80-150 mg

(Dr.Seewu Noamesi, 2010)

Our particular interest in Moringa oleifera concerned its role as 'clarifier tree' (shagarat al rauwãq) in the northern Sudan. After scientific confirmation of the flocculating properties of the seeds, which the village women had so far mainly used to treat the highly turbid water of the

Nile, systematic search for natural coagulants was also extended to seeds from other Moring species.

As with Moringa oleifera seeds, all investigated seed types contained primary coagulants comparable to the conventional coagulant alum. Applied in doses of 30 to 200 mg/liter in accordance with raw water quality, the Moringa seed powder suspensions could clarify different types of tropical surface waters with low, medium and high turbidities to tap-water quality within one to two hours.

As efficient elimination of turbidity is accompanied by a 98-99 percent elimination of indicator bacteria, domestic water treatment with Moringa seeds became a low-cost technology to be utilized in improving water and health in rural communities of tropical developing countries.

The main objective for cultivation trials with Moringa oleifera and its relatives was therefore to find out which Moringa species could provide the essential raw material for water purification in the shortest time and with maximum yield.

Table 2-3 the types and uses of most Moringa species and its location (Jahn, et al., 2012)

Use	**Moringa oleifera**	**Moringa peregrine**	**Moringa stenopetala**	**Moringa longituba**	**Moringa drouhardii**	**Moringa ovalifolia**
Vegetable	Asia, Africa, America (Leaves green pods. flowers roasted seeds)		S. Ethiopia N. Kenya (leaves)			Namibia (roots)
Spice	Asia, Africa (mainly roots)		Kenya (bark)			
Oil (cooking, cosmetics, miscellaneous)	Asia, Madagascar, Africa,(seeds)	Near East			S. Madagascar	Lab. test, Angola
Water Coagulant	Sudan (trad., seeds) Indonesia (new project)	Lab. test	Lab. & field tests	Lab. & field tests	Lab. & field tests	Lab. tests
Honey clarifier	Sudan (trad., seeds)					
Honey tree	Recent Indian studies					
Medicinal Plant	Asia, Africa, Central America (all plant organs)	Near East as far as Sudan (seeds)	Kenya (bark, root, leaves)	Somalia (root)	S. Madagascar (bark, root)	Pounded seeds have also "horseradish smell"
Nematocide	Experiments in Philippines (roots)					
Fodder	India, Indonesia, (leaves)					Namibia (roots: game; leaves and fruits: giraffes)

Fences and Wind sheds	Asia, Africa, Central America		New suggestion in Sudan			
Supports for cultivation of climbers	Asia					
Firewood	Recent Indian project; Togo (trad.)					
Ornamental	Central & South America, USA, Africa	Saudi Arabia, Near East	Kenya		S. Madagascar	Namibia

(Jahn, et al., 2012)

The medicinal uses/benefits of Moringa cannot be exhausted. This is because almost all parts of the tree have been utilized within traditional medical settings. The flowers, leaves and roots are used for the treatment of ascites, rheumatism and venomous bites and as cardiac and circulatory stimulants in folk remedies. The oil is applied externally for skin diseases.

The roots of the young tree and also root bark are rubefacient and vesicant. Leaf juice is used in hiccough (emetic in high doses); cooked leaves are given in influenza. The root-bark is used as antiviral, anti-inflammatory, analgesic.

Stem-bark and flowers are hypoglycemic. Infusion of seed is anti-inflammatory, antispasmodic and diuretic, also given in venereal diseases. Moringa support a healthy cardiovascular system, promote normal blood-glucose levels, neutralize free radicals that causes cancer, provide excellent support of the body’s anti-inflammatory mechanisms, enrich anemic blood and support immune system. It also improves eyesight, mental alertness and bone strength. It has potential benefit in malnutrition, general weakness, lactating mothers, menopause, depression and osteoporosis.

(The Mother's Best Friend, 2015)

2.10.2.3 Economical value

Moringa fits best as inter crop, alley crop, fence line crop, stray trees and also as ornamental avenues. It is used for animal forage, biogas production, dye extraction, gum collection, rope making, pulp for papermaking, tannin extraction and soap making. The powdered seed is commercially used for water clarification (Geoff Folkard et al., 200 I); Nearly 21 eatable products are prepared for diet from many parts of moringa. The hypocholesterolemia. effect of leaves, antifertility effect of roots, hypotensive, antitumor and antispasmodic activity of leaf extract, antinucleonic effect of flower buds etc. have been well established for commercial application.

Moringa is in cultivation for fleshy pods in India, for seeds to extract oil and prepare flocculent with dried powder in Tanzania and for edible leaf harvest in Nigeria. Both the social appeal owing to its nutritive richness and medicative properties and commercial appeal in view of the use of seed powder in water purification and oil of ben in lubrication industries, have gained a status for moringa cultivation in recent times.

In most of the countries in Africa, South America and Far East and most of the states in India, the perennial ecotypes similar to Jaffna and Moolanur are husbanded in wild with little cultural interventions. They are maintained almost organic and the productivity is at its lowest. The area expansion was not fast owing to the fact that those perennial ecotypes respond only to vegetative propagation and long-distance transportation of cutting is not possible.

(Beaulah, 2001)

Almost all parts of the plant are useful for food and animal feed. It can also be regarded as a vegetable tree. The leaves in particular have a distinctive strong, mustard-like taste. These could be, eaten as a supplement to major staple foods and considered to be a good source of provitamin A, vitamins B and C, minerals (particular iron) and protein. Due to the numerous products from, it has been considered to be a money generating tree.

Moringa has found wide acceptance in various markets of developed countries of the world where herbal and nutritional food and drugs have to pass through screening and regulation to ensure product safety before distribution and consumption. An example is the United States, where US Moringa products are available in the markets for human consumption. This to some extent confirms the safety of Moringa products for consumption.

Packaging Moringa leaf for consumption can come in various end-products based on available technology, scale of production and consumers’ preference. As identified by various authors

(Animashaun, et al., 2012 and Williams et al., 2012), some of the identified consumers preferred options in Nigeria for Moringa include:

- Powderised Moringa leaf
- Moringa leaf powder in Teabag
- Moringa fortified fruit juice/honey
- Moringa in capsule/tablets
- Moringa fortified confectionaries
- Moringa fresh leaf

A cost and return analysis by the same authors further revealed that Moringa plantation in the guinea savanna region from a planting density of 4,444 plants/ha (1.5m by 1.5m) resulted in the following estimates table:

Table 2-4 Estimated Average Annual Cost Analysis of Moringa Leaf Production/ha (Animashaun, 2013)

Items	**Cost(₦)\ha Annum**	**%of total Investment cost**	**Total**
Revenue			
Sales of 110kg of processed dried Moringa powder			**2,200,000**
Investment Fixed Cost			
Land-lease estimates	15,000	5.42	
Land clearing	9,600	3.47	
Factory house rent	120,000	43.38	
Plantation management and logistic	84,710	30.62	
Pest and disease control	30,000	10.85	
Blender/leaf grinder	15,000	5.42	

Knapsack sprayer	2,000	0.72	
Spade	200	0.07	
Machetes	200	0.07	
Hand trowels	250	0.09	
Total Investment cost	276,960	100	
Operating Cost			
Seedlings (N100 each)	444,400	40.6	
Labour (2permanent worke for weeding, harvesting and processing) N18,000 each/month	432,000	39.5	
Utility bills	30,000	2.7	
Labeling and Packaging	120,000	11	
Fertilizer (@N100/kg)	15,000	1.4	
Fertilizer application 2 man-day	2,000	0.1	
Miscellaneous expenses @ 4% of cost	51,000	4.8	
Total Operating Cost	1,094,400	100	
Total Production Cost (TPC)			**1,371,360**
Net Profit			**828,640**

(Animashaun, 2013)

2.11 PAC

PAC is a polymer of aluminum which is a new type of coagulant as a result of research and development of water treatment technologies. As the element is essentially aluminum and aluminum is associated with other elements to form repeating units in a molecule chains long enough. Thus the PAC combines neutralization and bridging capabilities particles - coagulation of colloidal particles that lasted more efficient. PAC has a long polymer chain, a high positive electrical charge and has a large molecular weight, the PAC has a high coefficient so as to minimize floc in the clarified water even in excessive doses. PAC faster formed floc than coagulant unusual, because the PAC has a positive electrical charge so high that PAC can easily neutralize the electrical charge on the surface of colloidal and can cope with and reduce the force repel electrostatically between particles as small as possible, thus allowing the particles -colloidal particles are approaching each other (covalent attractive forces of attraction) and forming clots / yamg larger mass. The positive aspect is the use of PAC to PAC pH range is 6 -9. Power PAC better coagulation and floc generated comparatively less besar.Konsumsi PAC so that the cost of water purification is smaller per unit time. As a direct result of the purification process is shorter overall water purification capacity (from an existing installation) will increase. While the negative aspects of the use of PAC is a PAC liquid storage conditions require maximum temperature of 40°C.

PAC is not cloudy when its use is excessive, while the primary coagulant (such as aluminum sulfate, ferric chloride and ferrous sulfate) when excessive doses for the water to be murky, as a result of excessive floc. Then the usage of PAC in the field of water purification is more practical. PAC faster formed floc than usual coagulant. PAC is a class of Aluminium Chloride, which are known in complex organic chemical compounds with hydroxyl ions (OH) and ion - aluminum ion standard chlorination different as polynuclear form. The general formula PAC is (Al2 (OH) nCl6-n) m. PAC is used as coagulant and flocculant in a water treatment process.

Applications PAC is basically divided into two parts, namely:

- In the processing of surface water for the purposes of clean water, drinking water and water for industrial processes (taps, paper industry, textile industry, steel industry, wood industry, etc.).
- In industrial liquid waste processing, among others: the pulp and paper industry, textile industry, sugar industry, food industry, and others - others.

Characteristics of the PAC:

a. Freezing point = -18 ° C,
b. Boiling point = 178 ° C,
c. Empirical formula = (Al2 (OH) 6-n) m with 1 <n <5 and m <10 and
d. Specific gravity = 1.19 (20 ° C).

3 Chapter three
Material and Methods

3.1 Material and Methods

Solution of Moringa seeds powder will be added to twelve samples with a different concentration and the results of tests will be recorded. The samples will be collected beside the Blue Nile Bridge, the tests of PH, Turbidity, conductivity and TDS will be proceeded to the samples.

3.2 Preparation of various solid Moringa seed doses

Before crushing the Moringa oleifera seeds, the wings and brown coats were removed from each seed as well as any kernel that shows any signs of damage. The seeds were then crushed in a blender into a fine powder. 50grams were taken from the powder. The sample was extracted with water.

Different weights (5, 10 and 20mg) were used for sample. Each weight was placed in a small cloth, which was then dropped into a beaker containing the turbid water (1 liter) to promote coagulation and flocculation, using the jar testing method.

3.3 Preparation of Moringa Solution:

The dry Moringa oleifera seeds samples were obtained from Sudan. The outer two coats were removed manually, after selection of high-quality seeds their respective kernels were grounded to fine powder. Three concentrations of Moringa solution was prepared (20 gm, 10 gm and 5 gm of seeds’ powder was weighed and mixed with 1000 ml distilled water for 3 minutes). The solution was then stirred for 30 minutes using a magnetic stirrer, and finally filtered through fiberglass filter. Resulting stock solution was having approximate concentration of 1000mg/L (1%). Fresh stock solution was prepared every day for the experimental run in order to avoid ageing effects.

3.4 Preparation of PAC solution:

The PAC solution was prepared by dissolving 1 g of PAC in distilled water until a volume of 100 ml was reached. 1 mL of this stock solution gives concentration of 10 mg/L when added to 1 L of water.

3.5 Required tests:

3.5.1 pH Test:

Plate 3—1 PH meter

http://matest.com/Cms_Data/Import_Data_Image/Metaprodotto/_4412_V215-02.jpg

3.5.1.1 Materials required:

1. pH meter
2. Beaker
3. Wash bottle
4. Tissue paper
5. Stander flask
6. Funnel
7. Magnetic starrier
8. Forceps**.**

3.5.1.2 Chemical required:

1. distilled water
2. buffers solutions of pH 4.01 ,7.0 ,9.2
3. Potassium chloride.

Calibrate the pH meter device with buffers, after calibrating the device, add 100 ml of sample in 150 ml dry beaker, put the electrode in the sample, read the result after having a stable reading. Wash the electrode with the distilled water.

(Abdalelah, 2017)

3.5.2 Conductivity

3.5.2.1 Principle:

This method is used to measure the conductance generated by various ions in the solution/water.

Rough estimation of dissolved ionic contents of water sample can be made by multiplying specific conductance (in mS/cm) by an empirical factor which may vary from 0.55 to 0.90 depending on the soluble components of water and on the temperature of measurement.

Conductivity measurement gives rapid and practical estimate of the variations in the dissolved mineral contents of a water body.

3.5.2.2 Apparatus and equipment:

a) Self-contained conductance instruments: (Conductivity meter). These are commercially available.
b) Thermometer, capable of being read to the nearest 0.1°C and covering the range 10-50°C.
c) Conductivity Cells: The cell choice will depend on the expected range of conductivity and the resistance range of the instrument. Experimentally check the range of the instruments assembly by comparing the instrumental results with the true conductance of the potassium chloride solution.

3.5.2.3 Procedure

Conductivity can be measured as per the instruction manual supplied with the instrument and the results may be expressed as mS/m or m S/cm. Note the temperature at which measurement is made.

Conductivity meter needs very little maintenance and gives accurate results. However, few important points in this respect are:

a) Adherent coating formation of the sample substances on the electrodes should be avoided which requires thorough washing of cell with distilled water at the end of each measurement.
b) Keep the electrode immersed in distilled water
c) Organic material coating can be removed with alcohol or acetone followed by washing with distilled water.

(Central Pollution Board, 2011)

3.5.3 Jar Test Operations:

A conventional jar test apparatus was used for this experiment to coagulate water samples collected from the Blue Nile River at Borre. Series of experiments for determining turbidity removal by PAC, Moringa extract, effect of Moringa dosage on TDS, EC and final pH were conducted and repeated three times to confirm the obtained results.

All tests were carried out with 1 L sample in 1.5-L beakers. These beakers were filled with 1000 mL of water with identical turbidity level, and placed on each slot in a jar tester. Moringa extract stock solution which was prepared previously was added into beakers for testing turbidity. The water samples were mixed homogenously before the operation. All beakers were agitated at 120 rpm for 2 min, and then mixing speed was reduced to 35 rpm for 10 min. After sedimentation for 40 min, a sample of the treated water from the mid depth of the beaker was used for analysis.

3.6 Analytical Methods:

3.6.1 Turbidity Measurement:

Turbidity measurements were conducted using a Turbidity Meter instrument (Model-2100 P, HACH, USA). After the sedimentation phase, samples of turbidity measurements were collected from the upper depth of the water samples. Sample vial was washed with distilled water and then with the treated water before recording the turbidity. In order to eliminate any differences in turbidity due to different sedimentation times, two samples were taken and after repeating the test three times the average value was recorded.

3.6.2 Microbiological analysis:

3.6.2.1 Total Bacterial Count:

The plate count technique is relying on visible bacterial colonies on agar medium. Samples were collected from treated water and serially diluted and plated on nutrient agar plate. The colonies formed were counted as Colony Forming Unit (CFU).

3.6.2.2 Total Coli form (TC) Enumeration:

MPN method (Multiple Tubes Test) for TC counts a series of five fermentation tubes of lauryl sulphate broth (LSB) (Merck) were inoculated with appropriate volumes of 10-fold dilutions of water samples, and incubated at 37°C for 48h. All gas positive LSB tubes were sub-cultured to tubes of brilliant green lactose bile broth (BGLB) (Merck) and incubated at 37°C for 48h. Gas-positive BGLB tubes were considered positive for the presence of TCs.

3.6.3 Total hardness:

Total hardness tools were washed well with distil water then burette was fill with (EDTA) 5ml was taken from treated water sample and added to 2ml buffer and tittered with eirochrom till color changed to pink then further the mixer was tittered till the color changed to blue.

3.6.3.1 Ca^{++}:

Tools were washed well with distil water then burette was fill with EDTA. 5ml of treated water sample was measured and added to 2ml NaOH and tittered with myriad till color changed to pink, then the mixer was further tittered till color changed to violet.

T.H = (V*M*W*100)/ (ml water sample)

V: Burette volume

M: EDTA molarities (0.01)

W: Molecular weigh

(Abdlmageed & , 2015)

4 Chapter four

4.1 Results and Discussion

After preparing three different concentrations of moringa solution (10, 20 and 40 g/L) the jar test was done for three sample of raw water, the results are shown below:

Table 4-1 demonstrates the effect of changing concentration of moringa solution in minimizing turbidity

NO	Moringa Seeds (g/L)	PH	Temp	Dose(mL)	Turbidity
1	Raw	7.7	25.2˚c	——	1764(after dilution)
2	10	7.5	29.3˚c	6ml	3.63
3	20	7.5	28.8˚c	6ml	3.53
4	40	7.4	29.1˚c	6ml	8.1

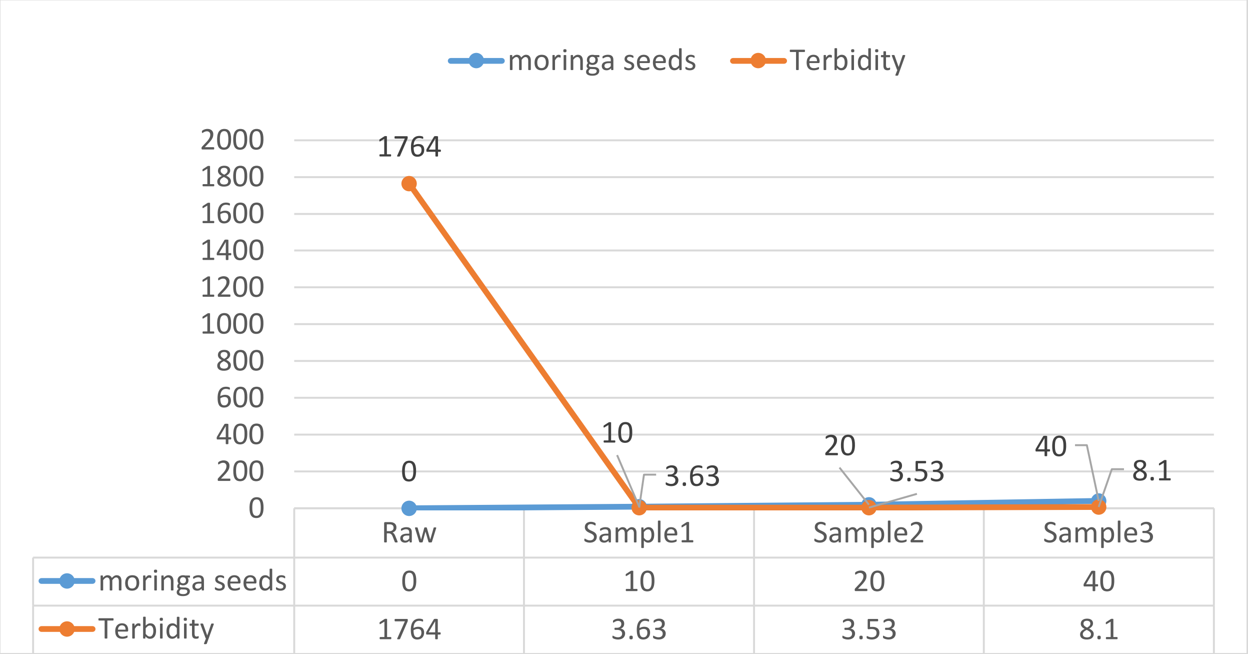
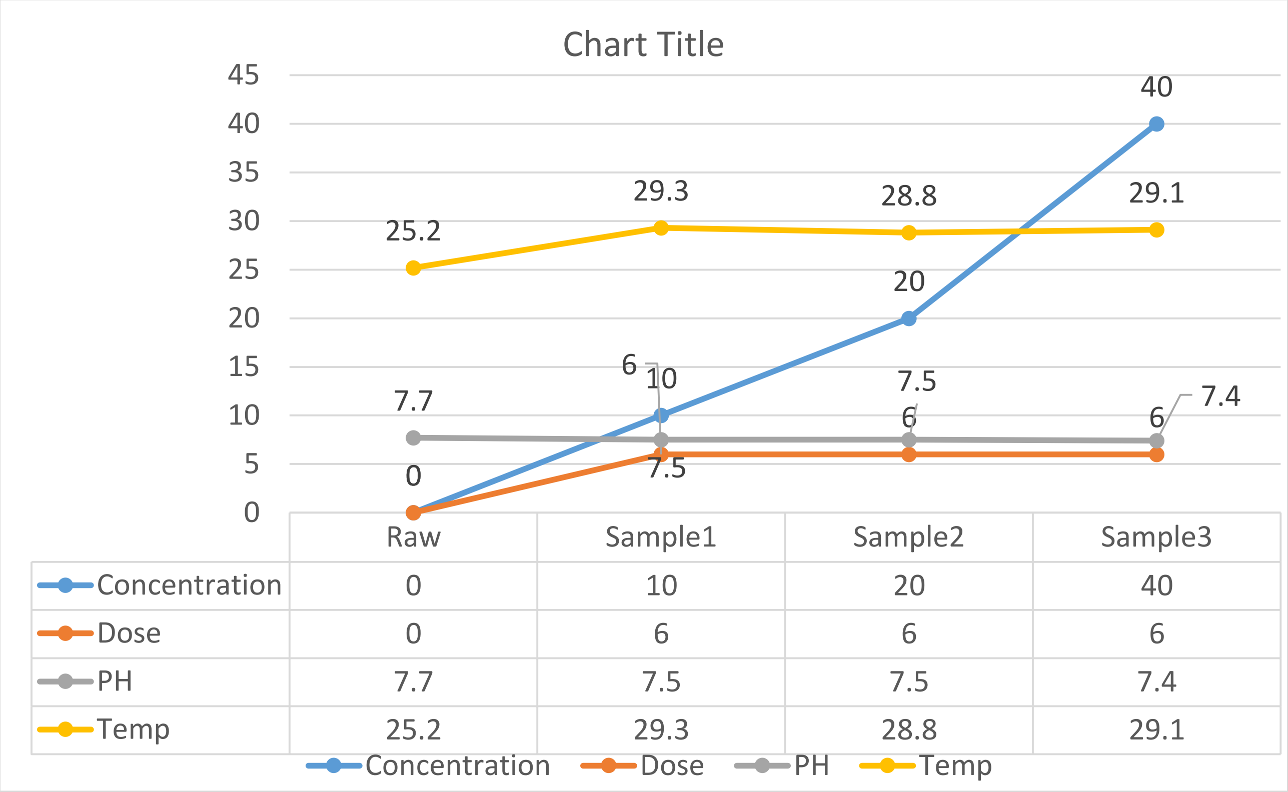


Figure 4—1 demonstrates the effect of changing concentration of moringa solution in minimizing turbidity



	Raw	Sample1	Sample2	Sample3
Concentration	0	10	20	40
Dose	0	6	6	6
PH	7.7	7.5	7.5	7.4
Temp	25.2	29.3	28.8	29.1

Figure 4—2 demonstrates the effect of changing concentration of moringa solution in minimizing turbidity

The effect of increasing the concentration for the moringa solution is minimizing the amount of turbidity till certain limit after that the effect will be reverse.

The next chart shows the relationship between concentration and turbidity removal.

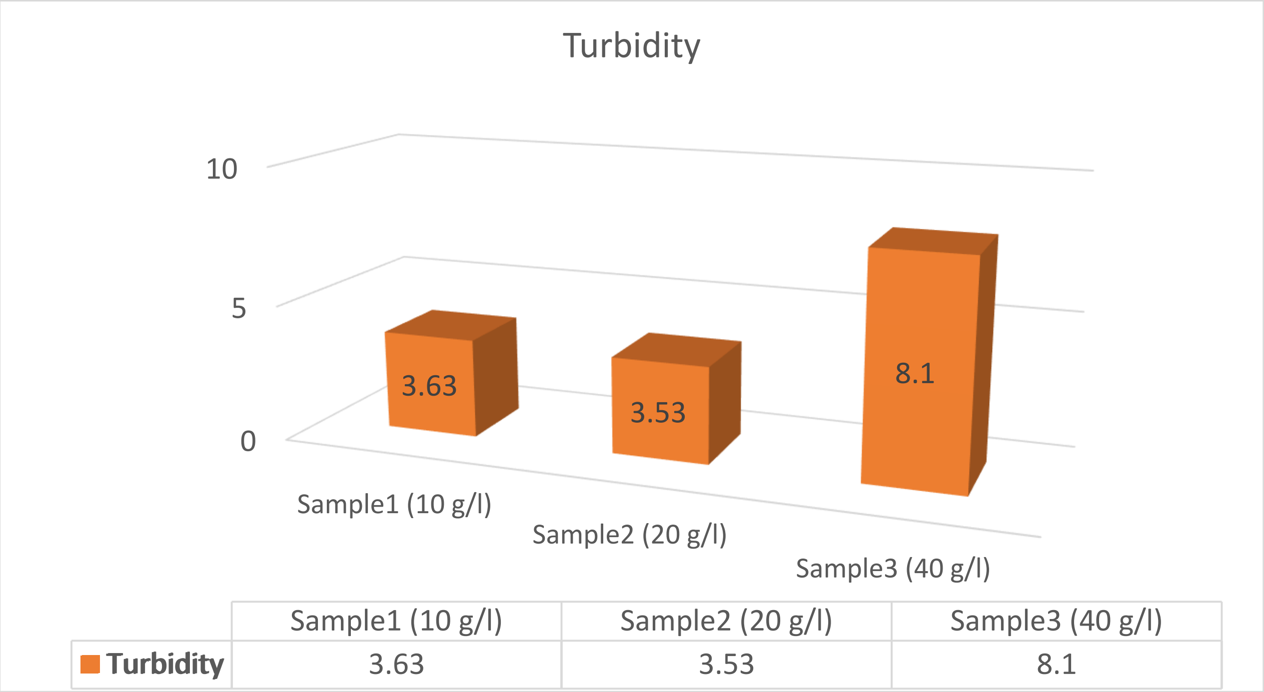


Figure 4—3 The relationship between concentration and turbidity removal

According to the previous chart the concentration 20 g/l has been selected as an optimum concentration.

Table 4-2 different doses with a concentration of 20 g/l and its effect on turbidity

NO	Moringa Dose (mL)	PH	Temp	Turbidity
1	Raw	7.7	25.2˚c	1764(after dilution)
2	1	7.5	28.4 ˚c	80.3
3	2	7.5	28.2 ˚c	35.4
4	4	7.4	28.1 ˚c	10.4
5	6	7.3	28.3 ˚c	6.7
6	8	7.4	28.4 ˚c	4.53
7	10	7.5	28.3 ˚c	4.03

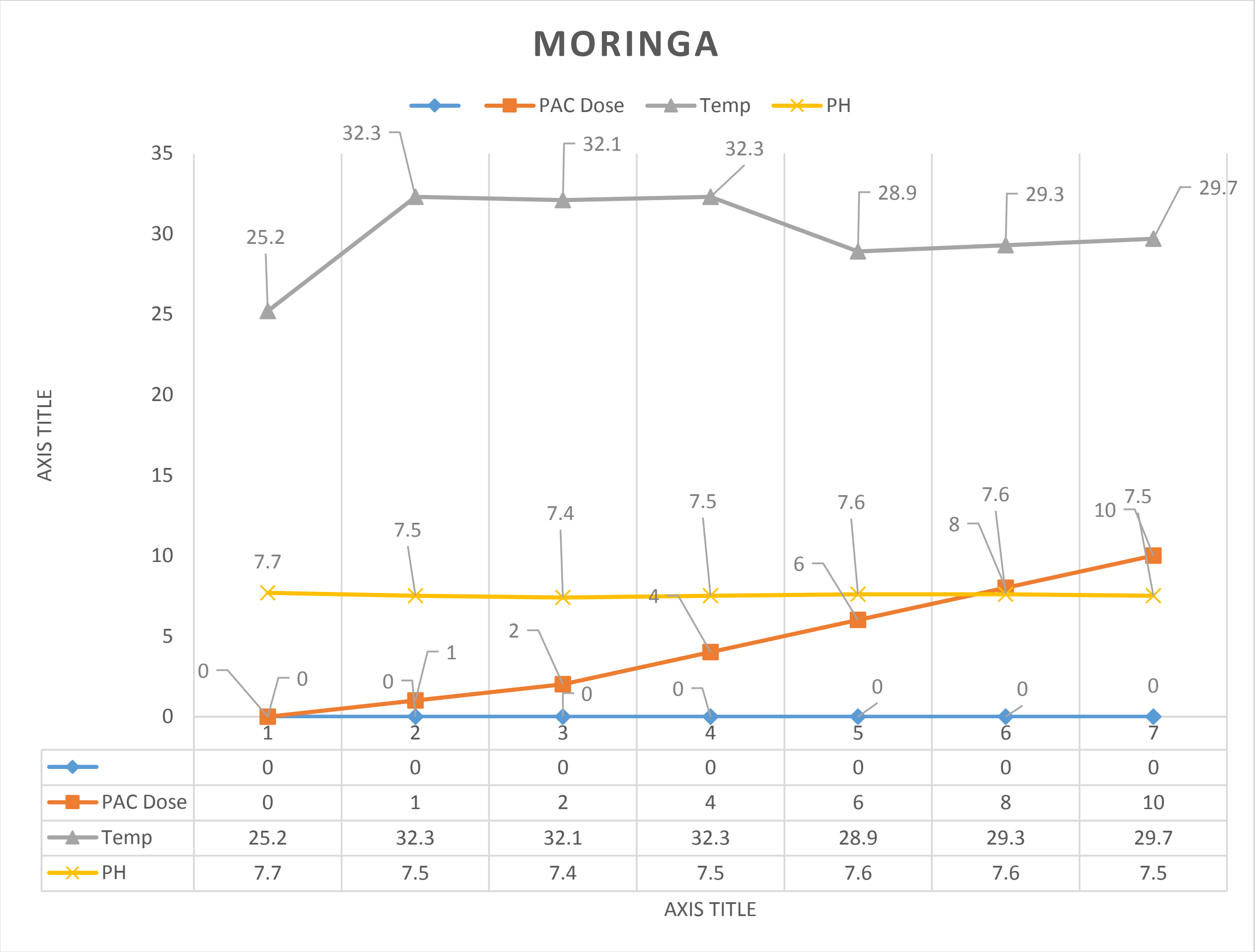


Figure 4—4 different doses with a concentration of 20 g/l and its effect on turbidity

It is obviously clear that the moringa solution has a direct effect on water properties especially turbidity, the increasing of added solution directly decreases the amount of turbidity, PH slightly affected by adding moringa.

Table 4-3 different doses of PAC solution and its effect on turbidity

	PAC Dos (mL)	Temp	Turbidity	PH
1	Raw	25.2˚c	1764(after dilution)	7.7
2	1 ppm	32.3 ˚c	1.57	7.5
3	2 ppm	32.1 ˚c	1.07	7.4
4	4 ppm	32.3 ˚c	1.22	7.5
5	6 ppm	28.9 ˚c	2.32	7.6
6	8 ppm	29.3 ˚c	1.76	7.6
7	10 ppm	29.7 ˚c	1.6	7.5

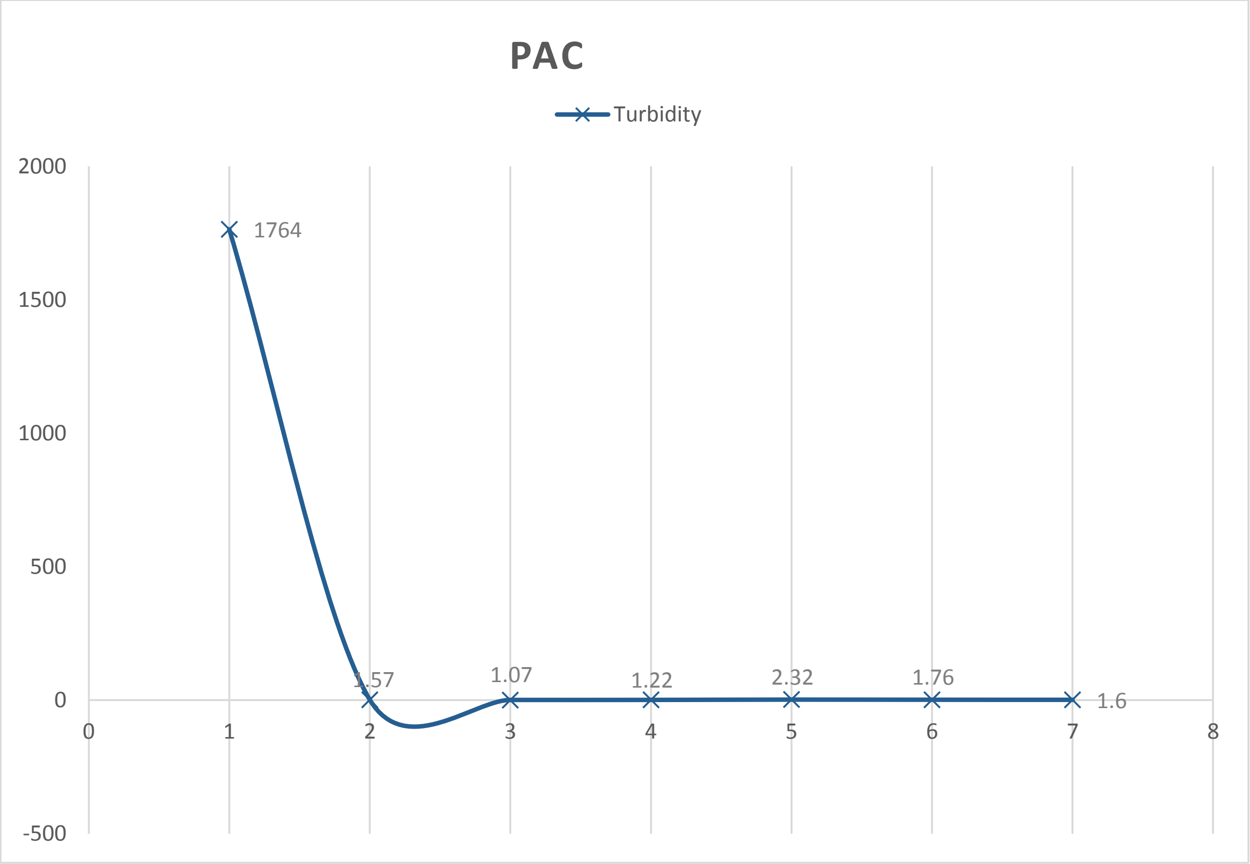
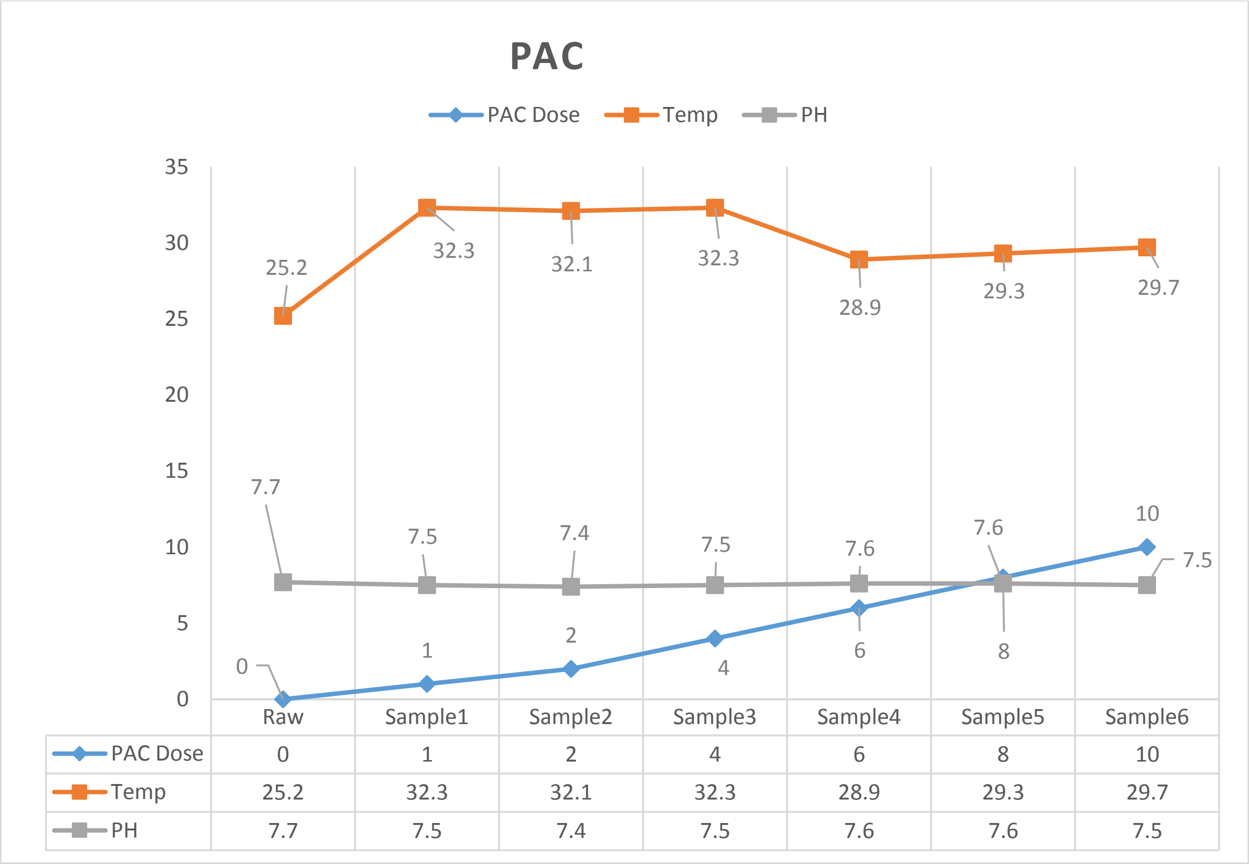


Figure 4—5 different doses of PAC solution and its effect on turbidity



	Raw	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
PAC Dose	0	1	2	4	6	8	10
Temp	25.2	32.3	32.1	32.3	28.9	29.3	29.7
PH	7.7	7.5	7.4	7.5	7.6	7.6	7.5

Figure 4—6 different doses of PAC solution and its effect on turbidity

The addition of PAC solution minimizes the amount of turbidity

The efficiency of removing turbidity is high in the beginning of adding PAC solution but it goes less by adding more of PAC solution and it goes good once again, the next chart demonstrates the PAC effect.

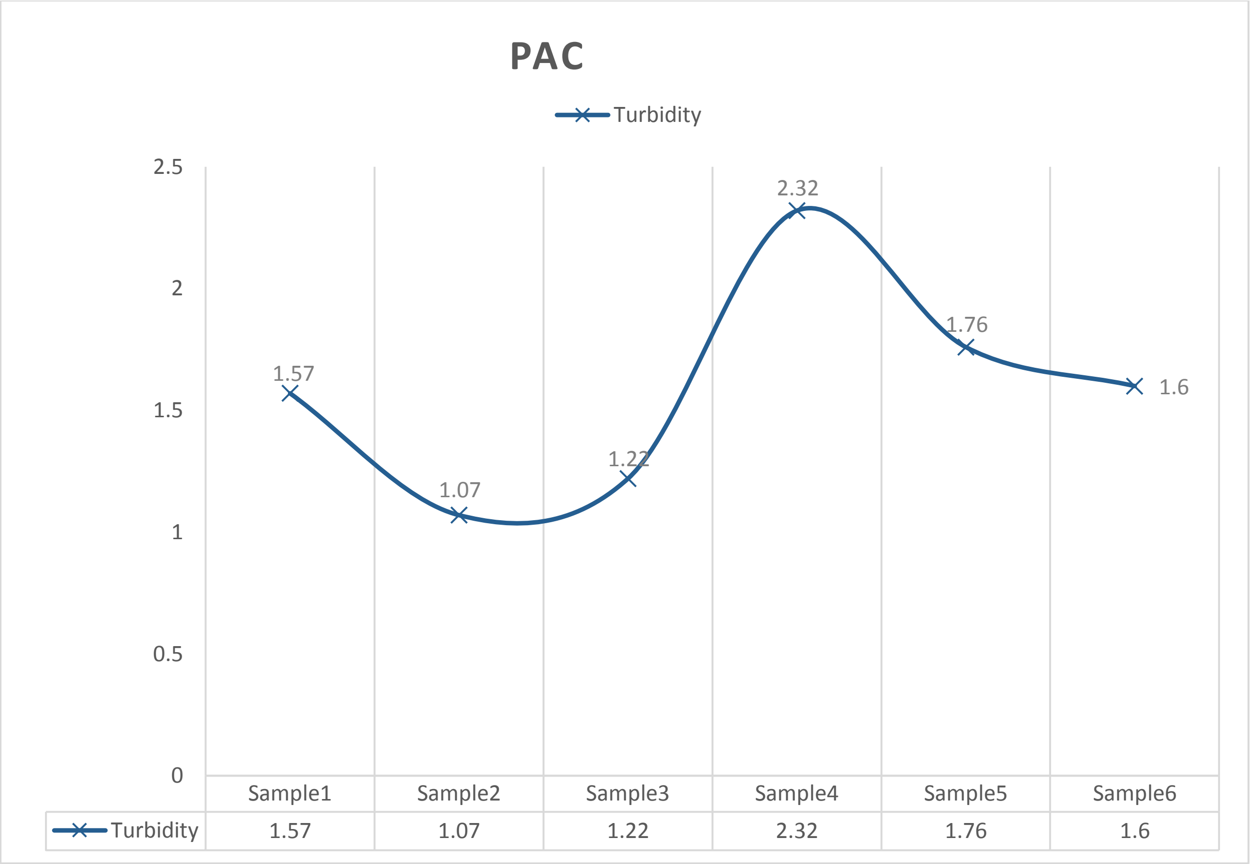
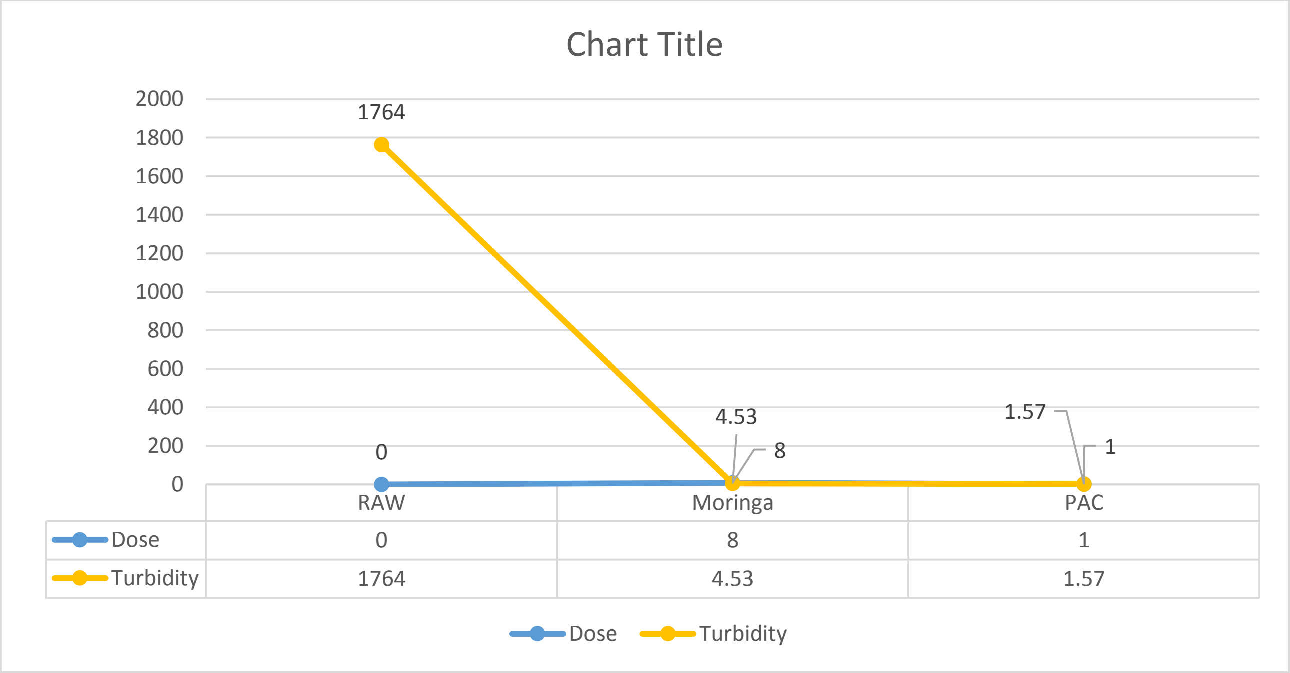


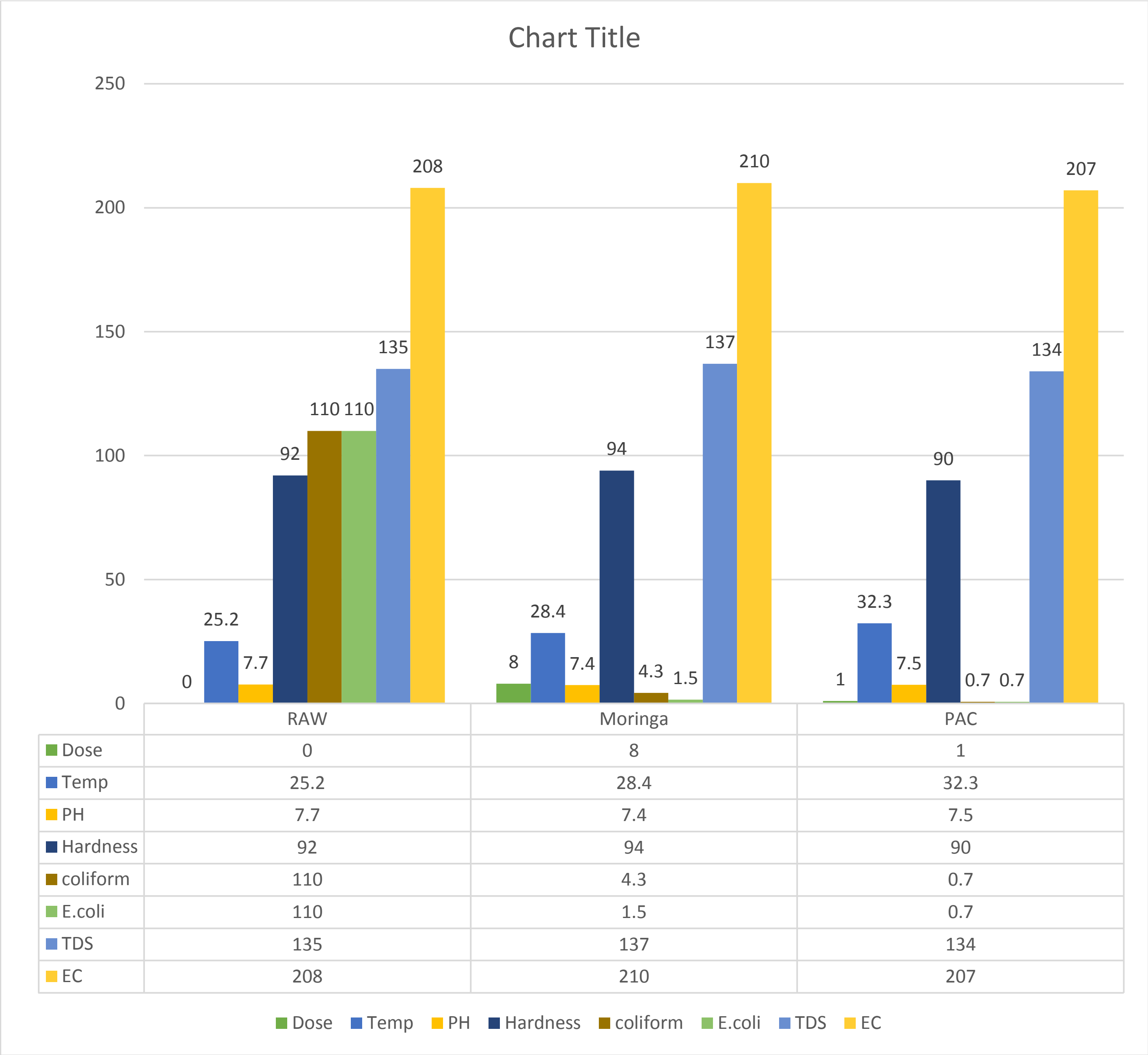
Table 4-4 comparison between the optimum doses of both Moringa and PAC in physical, chemical and biological characteristics

	Dose	Temp	PH	Turbidity	Hardness	EC	TDS mg/l	Thermotolerant Coliform (P/A/100ml)	Thermotolerant E. coli (P/A/100ml)
RAW	0	25.2˚c	7.7	1764(after dilution)	92	208	135	>110	>110
Moringa	8 ml	28.4	7.4	4.53	94	210	137	4.3	1.5
PAC	1 ppm	32.3	7.5	1.57	90	207	134	0.7	0.7



	RAW	Moringa	PAC
Dose	0	8	1
Turbidity	1764	4.53	1.57

Figure 4—7 comparison between the optimum doses of both Moringa and PAC in physical, chemical and biological characteristics



	RAW	Moringa	PAC
Dose	0	8	1
Temp	25.2	28.4	32.3
PH	7.7	7.4	7.5
Hardness	92	94	90
coliform	110	4.3	0.7
E.coli	110	1.5	0.7
TDS	135	137	134
EC	208	210	207

Figure 4—8 comparison between the optimum doses of both Moringa and PAC in physical, chemical and biological characteristics

Generally, the change in water properties was significant in turbidity, coliform and E. coli and insignificant in PH, Hardness, EC and TDS.

5 Chapter five

Conclusion and recommendations

5.1 Conclusion

- The study was conducted during July 2019; which was conducted during the Blue Nile flooding period.
- The addition of Moringa seeds solution to the samples has shown an effective impact on the purification process.
- The comparison between the addition of PAC and Moringa seeds solution has shown that the Moringa seeds solution could be a suitable alternative of PAC from view point of cost and availability.
- The relationship between the Moringa solution dose and the characteristics is not liner, as the effect of Moringa solution on the PH and turbidity will be reversed when reaching a certain concentration.
- According to microbial tests (Total Coliform and E-colli) the Moringa solution minimized the number of bacteria observed effectively, while the rest of characteristics (PH, Hardness, EC and TDS) were not affected.

5.2 Recommendations

- The Moringa seeds solution can be used as a coagulation agent in remote areas, while it can be used beside PAC as pre-purification step in the water treatment plants; which can minimize the quantity of PAC that should be added during the treatment process.
- Besides using Moringa for purification purpose only, the leaves could also be used as a food supplement, which it will reduce the total cost.
- A comprehensive studies should be implemented in a wide range to insure that the addition of Moringa solution with a huge quantities doesn't affect in color, odder and taste of treated water, also preventing forming of foam, and if it can be used as an alternative to the disinfection stage.
- Interest in the cultivation of Moringa as a multi-purpose economic crop.
- Further study of Moringa extracts in water purification process.
- Studying and measuring the elements in the composition of Moringa (Ca, Mg, No_3, No_2, etc.).

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Appendices

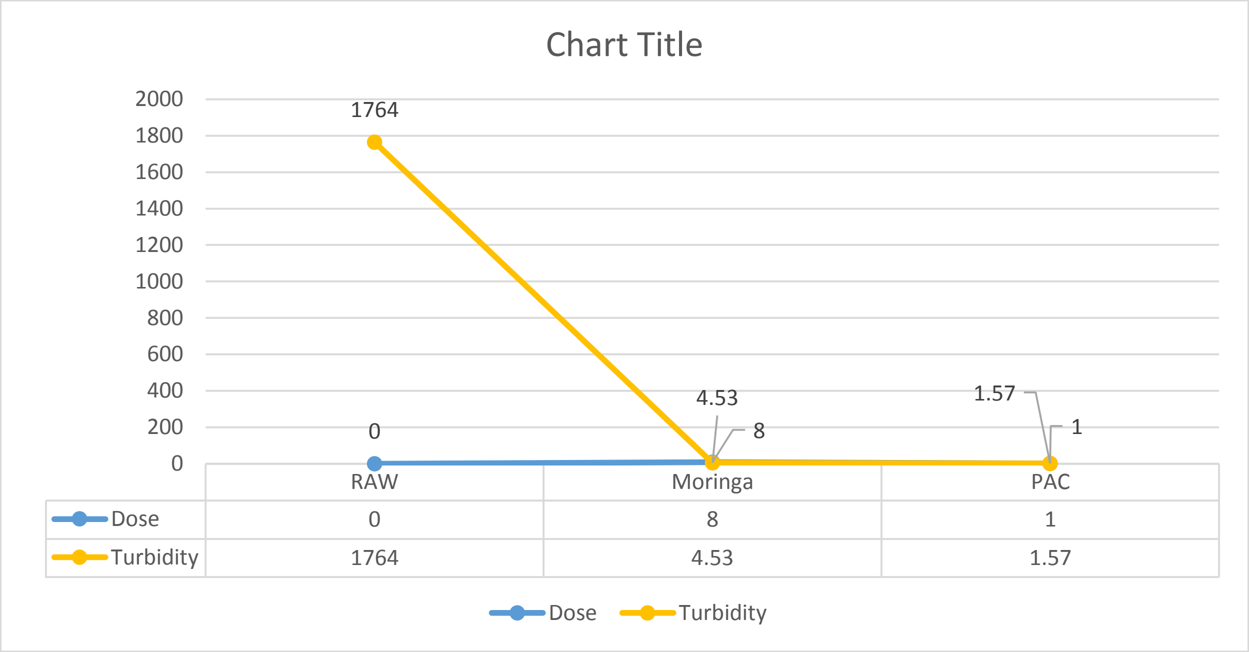
Chart Title
2000
1800
1600
1400
1200
1000
800
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200
0
1764
0
4.53
8
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RAW
Moringa
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Dose
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8
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Turbidity
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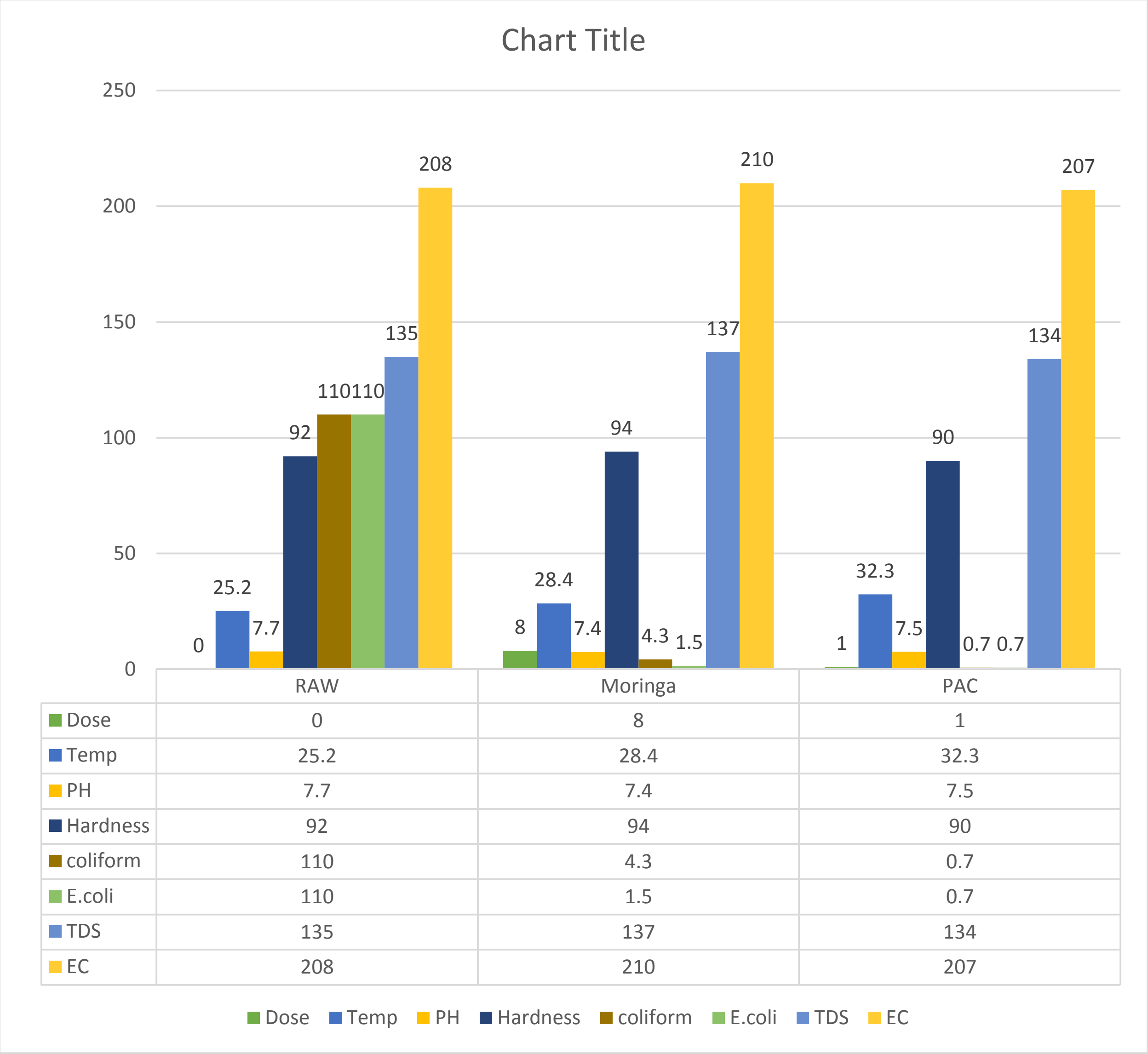
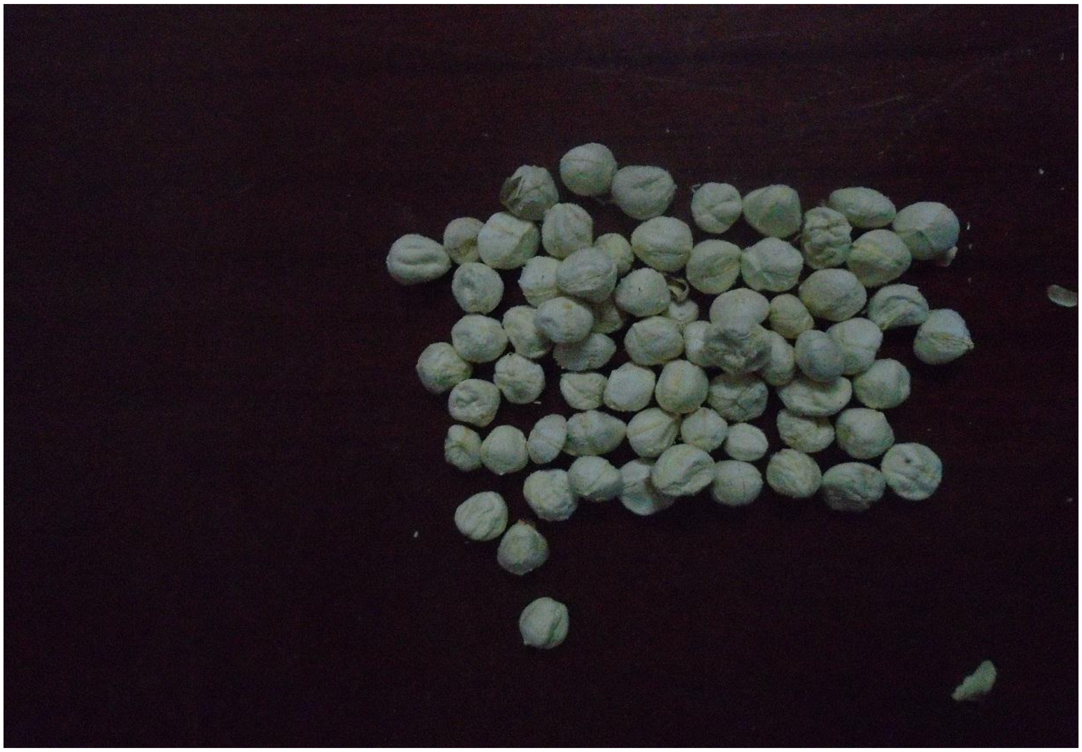
Dose
Turbidity



	RAW	Moringa	PAC
🟩 Dose	0	8	1
🟦 Temp	25.2	28.4	32.3
🟨 PH	7.7	7.4	7.5
🟦 Hardness	92	94	90
🟫 coliform	110	4.3	0.7
🟩 E.coli	110	1.5	0.7
🟦 TDS	135	137	134
🟨 EC	208	210	207

Moringa seeds

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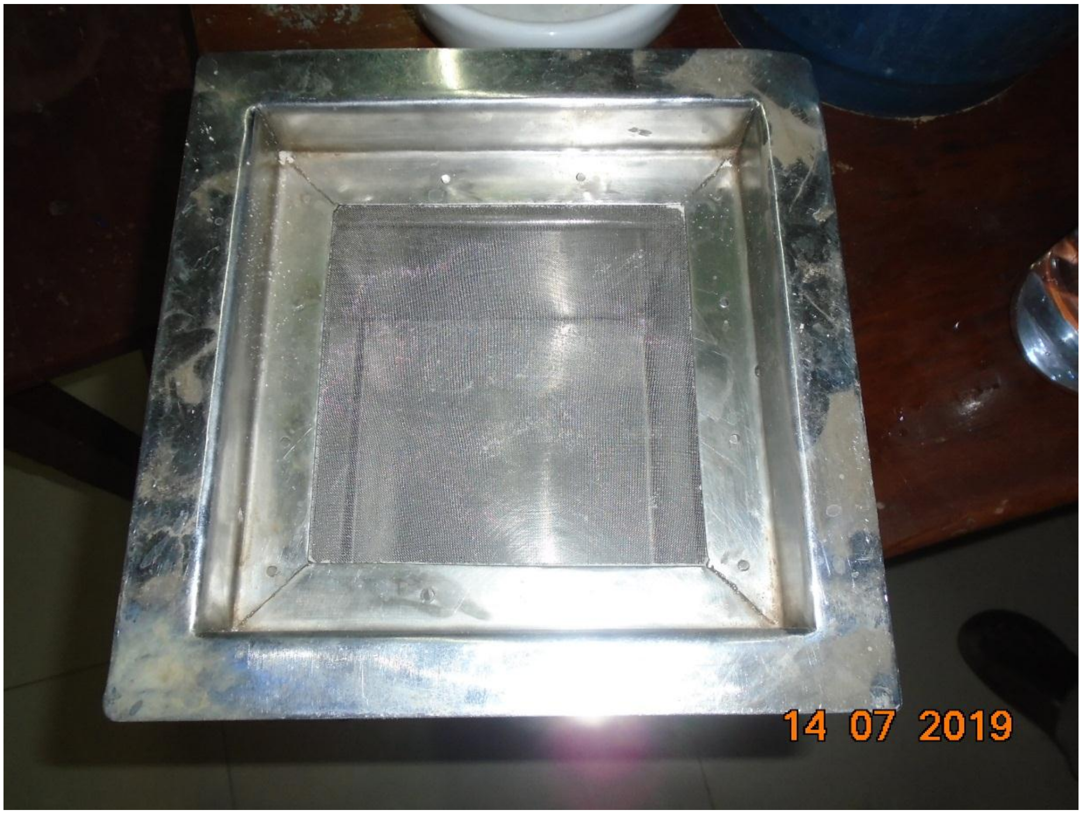
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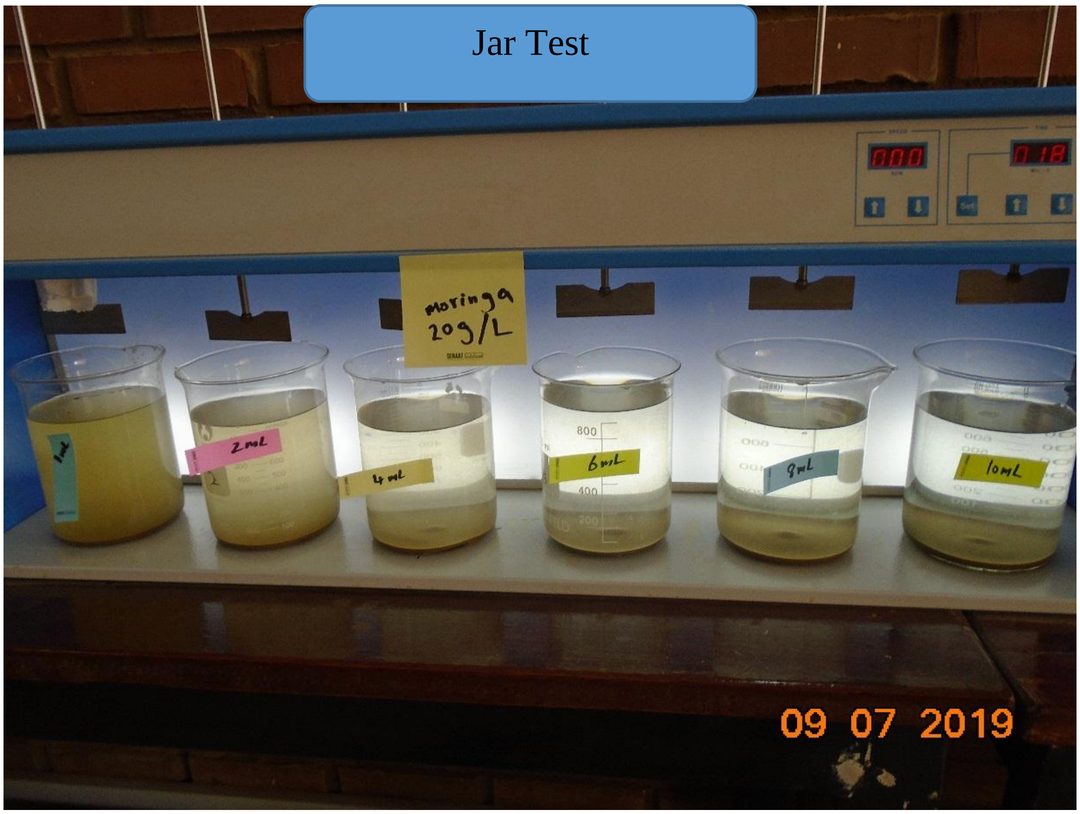
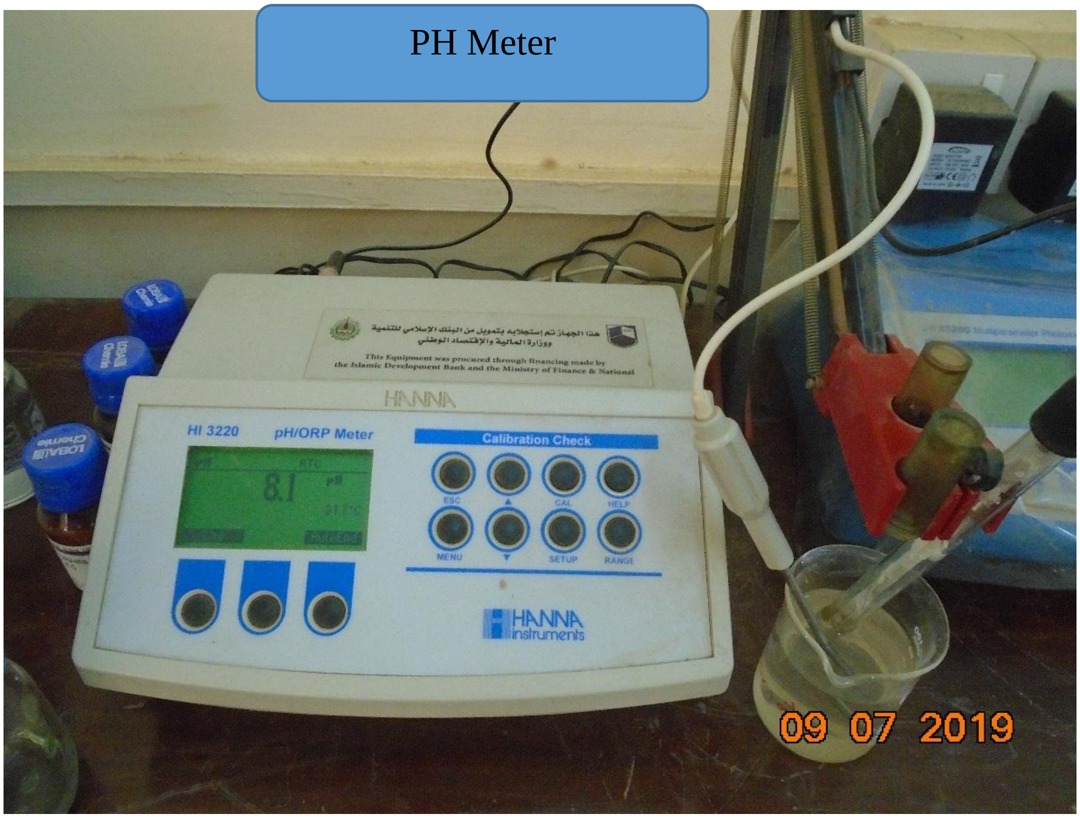
Jar Test


Moringa
20g/L
2mL
4 mL
6mL
8mL
10mL
09 07 2019


1 PPm
2 PPm
4 PPm
6 PPm
8 PPm
10 PPm
09 07 2019

PH Meter



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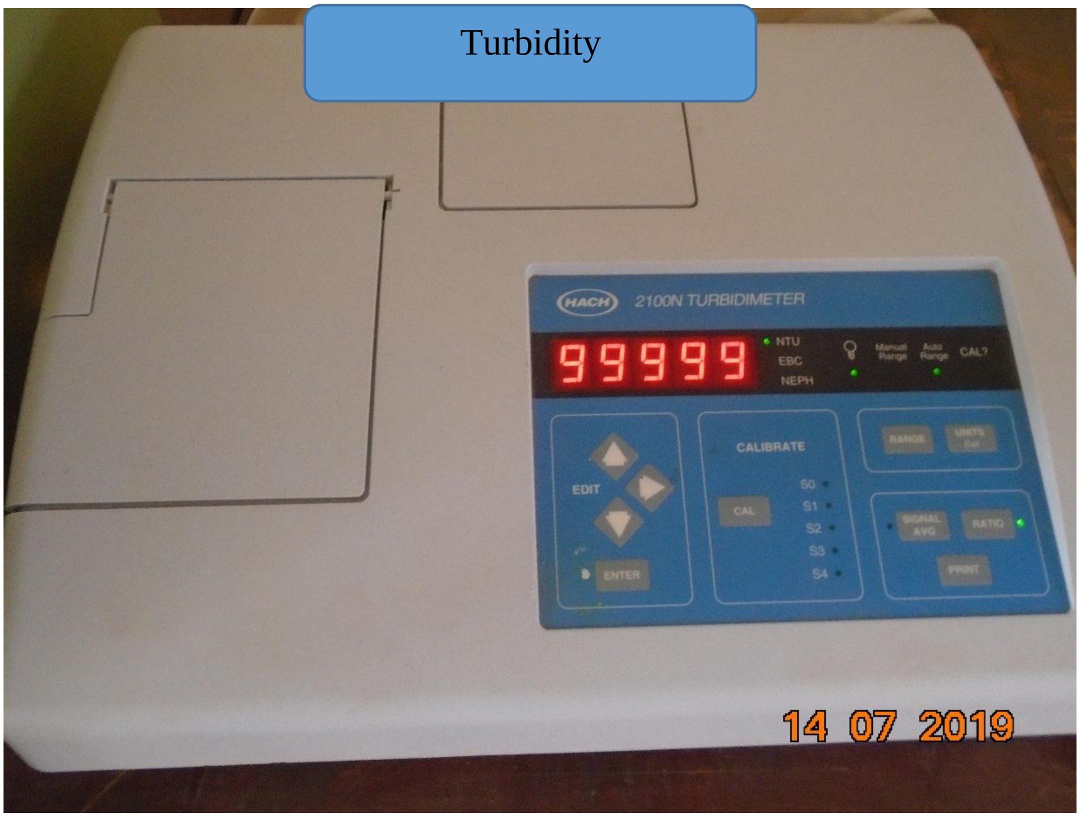
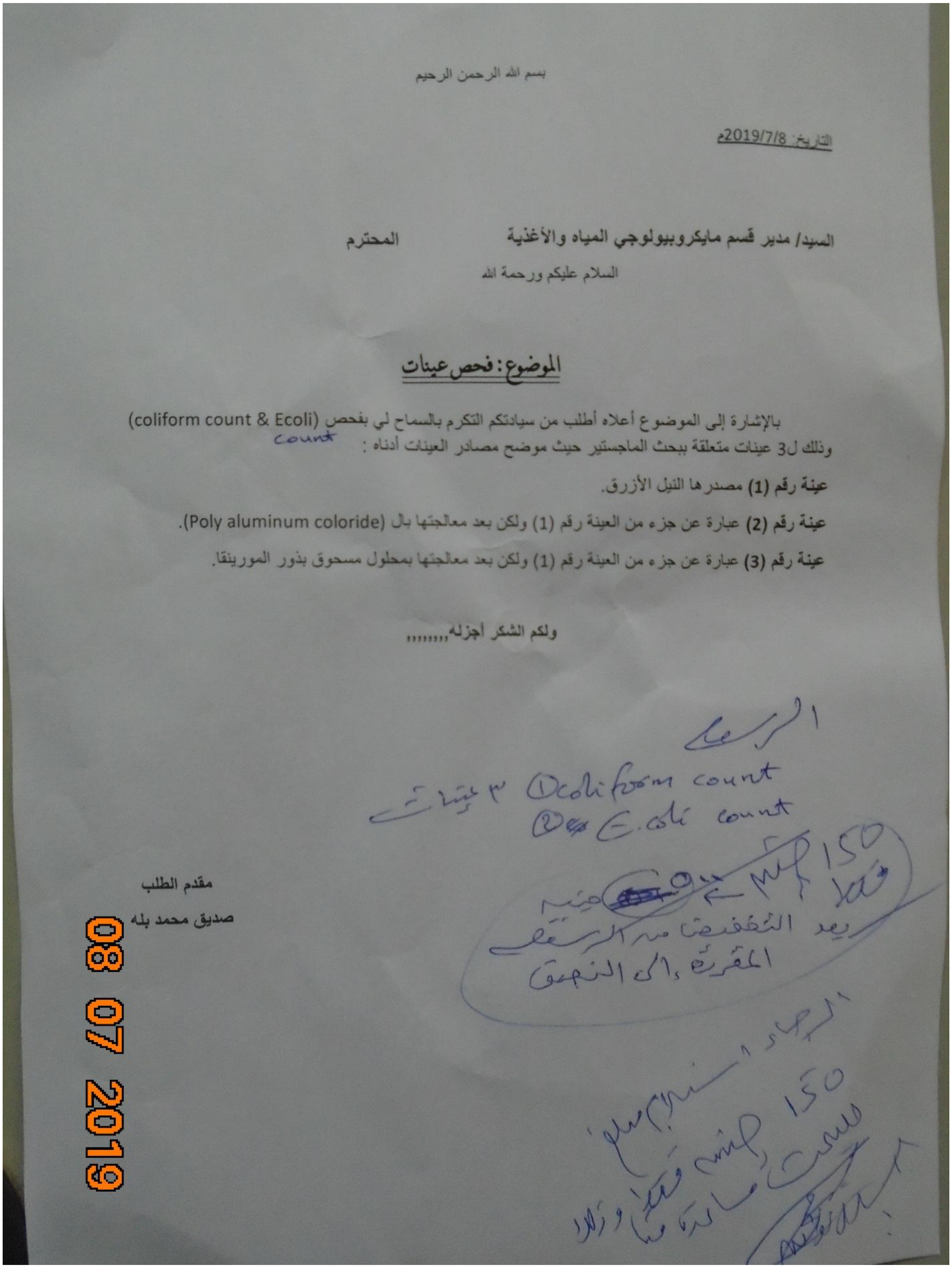
Turbidity



14 07 2019


PAC
2
Moringa
14 07 2019


①Raw
Blue Nile
10:25
②PAC
Blue Nile
11:15
③Moringa
Blue Nile
11:18
14 07 2019



بسم الله الرحمن الرحيم

التاريخ: 2019/7/8م

السيد/ مدير قسم مايكروبيولوجي المياه والأغذية المحترم

السلام عليكم ورحمة الله

الموضوع: فحص عينات

بالإشارة إلى الموضوع أعلاه أطلب من سيادتكم التكرم بالسماح لي بفحص (coliform count & Ecoli count) وذلك لـ3 عينات متعلقة ببحث الماجستير حيث موضح مصادر العينات أدناه :

عينة رقم (1) مصدرها النيل الأزرق.

عينة رقم (2) عبارة عن جزء من العينة رقم (1) ولكن بعد معالجتها بال (Poly aluminum coloride).

عينة رقم (3) عبارة عن جزء من العينة رقم (1) ولكن بعد معالجتها بمحلول مسحوق بذور المورينقا.

ولكم الشكر أجزله,,,,,,,,

الرسوم

٣ عينات ① coliform count

② E.coli count

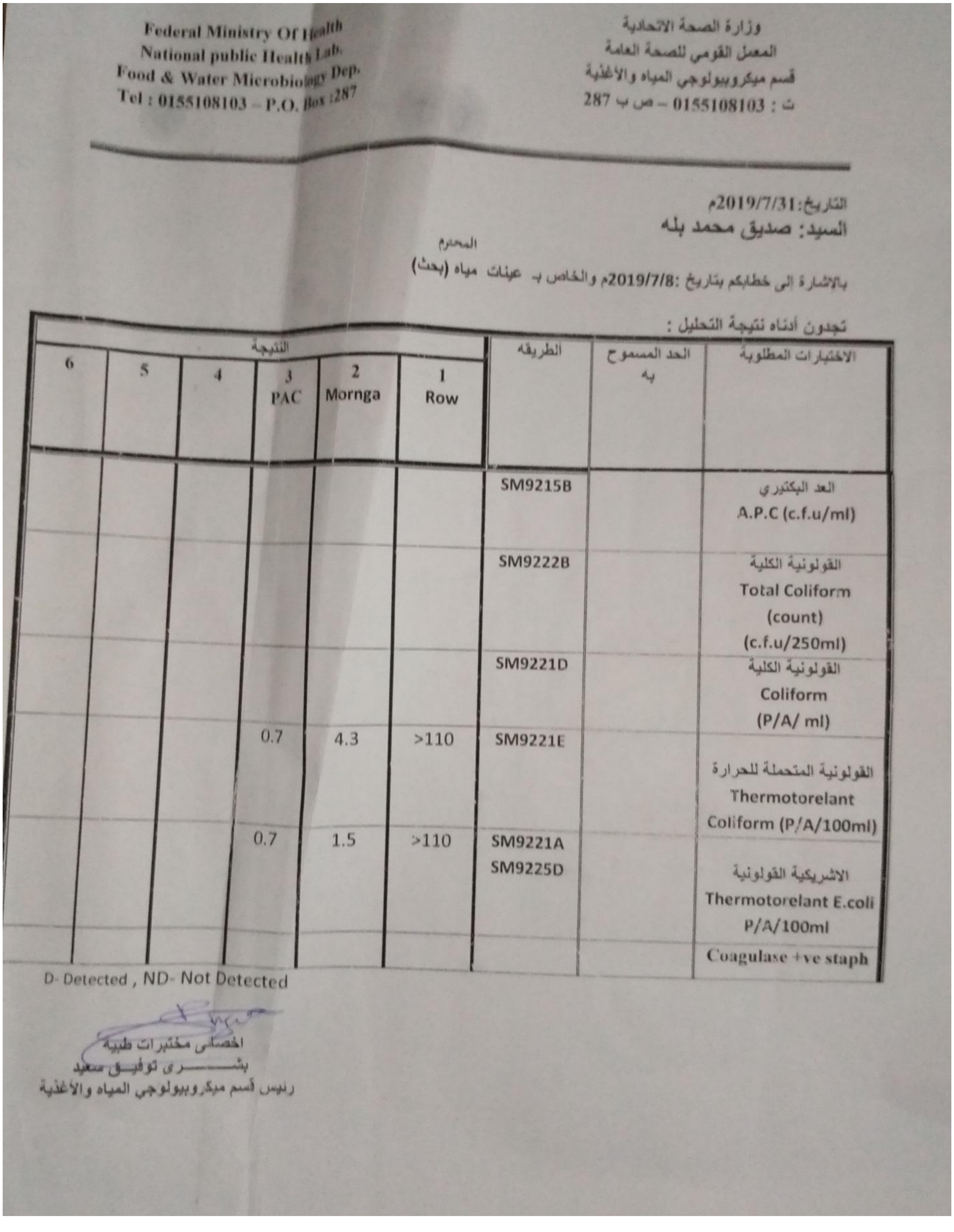
150 ج للعينة ← ~~[illegible]~~ جنيه فقط

بعد التخفيض من الرسوم المقررة الى النصف

الرجاء استلام مبلغ 150 جنيه فقط مائة وخمسون [illegible]

مقدم الطلب

صديق محمد بله



Federal Ministry Of Health
National public Health Lab.
Food & Water Microbiology Dep.
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وزارة الصحة الاتحادية
المعمل القومي للصحة العامة
قسم ميكروبيولوجي المياه والأغذية
ت : 0155108103 – ص ب 287

التاريخ:2019/7/31م

السيد: صديق محمد بله

المحترم

بالاشارة إلى خطابكم بتاريخ :2019/7/8م والخاص بـ عينات مياه (بحث)

تجدون أدناه نتيجة التحليل :

الاختبارات المطلوبة	الحد المسموح به	الطريقه	النتيجة 1 Row	2 Mornga	3 PAC	4	5	6
العد البكتيري A.P.C (c.f.u/ml)		SM9215B						
القولونية الكلية Total Coliform (count) (c.f.u/250ml)		SM9222B						
القولونية الكلية Coliform (P/A/ ml)		SM9221D						
القولونية المتحملة للحرارة Thermotorelant Coliform (P/A/100ml)		SM9221E	>110	4.3	0.7			
الاشريكية القولونية Thermotorelant E.coli P/A/100ml		SM9221A SM9225D	>110	1.5	0.7			
Coagulase +ve staph								

D- Detected , ND- Not Detected

اخصائي مختبرات طبية
بشـــــــرى توفيـــق سعيد
رئيس قسم ميكروبيولوجي المياه والأغذية