Sudan University of Science and Technology

College of Graduate Studies

Treatment of Wastewater Produced from Tri-Nitro-Toluene (TNT) Factory using Moringa Leaves

معالجـة المياه الملوثـة الناتجــة من مصـنع ثلاثي نايتروتولوين باستخدام أوراق المورينقا

A Thesis

Submitted in Full Fillment for the Degree of Doctor of Philosophy in Chemical Engineering

By

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September 2020

الآية

بسم الله الرحمن الرحيم

قال تعالي (أو لم ير الذين كفروا أن السموات والأرض كانتا رتقا ففتقناهما وجعلنا من الماء كل شي حي أفلا يؤمنون)

صدق الله العظيم

الآية رقم (30)سورةالانبياء

Dedication

To my father, my mother, my wife and sons, my brother and sisters, my teachers.

Acknowledgment

My full thanks to my honorable supervisor Prof. Babiker Karama Abdulla for his best efforts that he was offering during research period , full guidance, encouragement and helpful in solving many problems that faced the research. In fact I learned a lot from him.

Thanks to my honorable co-supervisor Dr. Yousif Ali Yousif who supplied me with more information, besides helping in solving any problems that faced the research.

Thanks to staff of Omdurman military Medical center –laboratories, Abdelmoneim massad who permitted me to use Tana wastewater treatment station.

Thanks to my mother, my wife, my children, my brothers and my sister and all my colleagues in chemical and civil engineering departments of Karary University for their supports.

Abstract

Moringa Oleifera is a tropical plant, which has been reported to exist in Sudan since 1887. It is used mainly as fences and for water purification .Its roots, leaves, pods; seeds are used as fodder, and as a natural coagulant of turbid water as well as a source of physiomedical compounds. Moringa is a multipurpose tree whose seeds contain a high content of edible oil (up to 40% by weight) and water soluble proteins that act effective in water and wastewater treatment.Tana factory is one of the Sudanese Military factories that make different types of chemicals such as (TNT, DNT, and MNT). The design flow rate of acidic wastewater is $288m^3$/day. The pH of the acidic wastewater is 1.20, COD is 72.00, TDS is 7.46 and S^{-2} is 12.00 mg/l respectively. The acidic wastewater was mixed with 10 w% sodium hydroxide lye and neutralized with agitation in a neutralizing tank. After neutralization the pH of water was raised to six. When the crushed Moringa Oleifera leaves are added to the raw acidic wastewater the results showed a significant rise in pH from 1.20 to 6.80 in 3 hours. This is within the SSMO; NO137 2008.These data included reduction in BOD from 30.00 to 5.00 mg/l which is also within the range of SSMO NO137, 2008. The COD value of the acidic wastewater which is 72.00 mg/l which is also within the range of SSMO, NO137, 2008. The reduction of COD from 72.00 to 10.12 mg/l in 3 hours is satisfactory and less than the SSMO, NO137 2008 range. While the TDS was increased from 7.46 to 12.56 mg/l in 3 hours which matched the SSMO NO137, 2008 range. The sulphide content was significantly reduced within the first 2 hours from 12.00 to 00.001 mg/l satisfying the SSMO; NO137, 2008 requirements.However when wastewater is treated with sodium hydroxide in the first and second stages (HCL and $NaNo_2$) were added for 30 minutes in order to check the existence of (TNT,

MNT, and DNT). The color changed to yellow indicating the end of the reaction and complement of the treatment process, in the third stage H_2SO_4 is added within 30 minutes in order to check the existence of (TNT, MNT and DNT) the color changed to orange indicating the end of the reaction and treatment process. In the addition to the crushed leaves of Moringa to the acidic wastewater in the first and second stages (HCL and $NaNo_2$) were added within 30 minutes in order to check the existence of (TNT , MNT, and DNT).The color changed to yellow showing the end of the reaction and treatment process. In the third stage H_2SO_4 is added during 30 minutes to check the existence of (TNT, MNT and DNT), the color changed to brown indicating the end of the reaction and treatment process. The Moringa leaves contain various types of salts and earth metal such as CO. Ca, K, Mg, Na, and Fe. Moringa Oleifera also contains proteins, Ash, Fiber, CHO, and fats. This study has shown that Moringa Oleifera leaves are highly effective in the treatment of industrial acidic wastewater that contains (TNT, MNT, and DNT). It is recommended that a feasibility study has to be carried out for manufacturing tablets of Moringa for acidic wastewater treatment.

ألمستخلص

تعتبر شجرة ألمورينقا نبات مداري ،أفادت التقارير بوجودها في السودان منذ عام 1887وكانت في الغالب تستخدم كأسوار للمنازل والمزارع وتستخدم في تنقية المياه.تستخدم جذورها وأوراقها ولحائها وبذورها كعلف وكمصدر طبيعي لتخثر المياه العكرة وكمصدر لمركبات بعض الأدوية. ،كما أنها شجره متعددة الاستخدامات فالحبوب تحتوي علي 40% من وزنها زيت ومن فوائدها أيضا أن الماء يقوم بتذويب البروتين والذي يعتبر أكثر عنصر فعال في معالجة المياه والمخلفات السائلة. يعتبر مصنع تانا أحد المصانع العسكرية السودانية التي تصنع أنواعا مختلفة من الكيماويات مثل(TNT, MNT, DNT) السعة التصميمية لمعدل التدفق للمصنع من المياه الحمضية الملوثة حوالي m^3/day 288 برقم هيدروجيني 1.20، BOD 30.00 mg/l ، COD 72.00 mg/l ، TDS 7.46 mg/l، S^{-2} 12.00 mg/l، المياه الحمضية الملوثة حاليا تتم معالجتها بخلطها مع 10%من هيدروكسيد الصوديوم في خزان الموازنة وبعد عمليه النترته يصل الرقم الهيدروجيني pH إلي 6 .عند إضافة أوراق ألمورينقا المسحونة للمياه الحمضية الملوثة أظهرت النتائج ارتفاعا ملحوظا في قيمة pH من 1.20 إلي 6.80 في خلال ثلاث ساعات، مما يتطابق مع قانون الهيئة السودانية للمواصفات والمقاييس رقم 137 لعام 2008، شملت هذه البيانات انخفاض في قيمة BOD من30.00 mg/l إلي 5.00 mg/l وهو مطابق لقانون الهيئة السودانية للمواصفات والمقاييس رقم 137لعام 2008، قيمة COD في المياه الحمضية الملوثة هي 72.00 mg/l وهذه مطابقة لقانون الهيئة السودانية للمواصفات والمقاييس رقم 137 لعام 2008، انخفضت قيمة COD من72.00 mg/l إلي 10.12 mg/l في خلال ثلاث ساعات اقل من قيمة الهيئة السودانية للمواصفات والمقاييس رقم 137لعام 2008 بينما زادت قيمة TDS من 7.46 mg/l إلي 12.56 mg/l في خلال ثلاث ساعات وطابقت قيمة الهيئة السودانية للمواصفات والمقاييس رقم 137 لعام 2008، محتوي الكبريتيد مخفض جدا خلال ساعتين فقط ووصل إلي 0.001 mg/l من 12.00 mg/l وأيضا طابقت قيمة الهيئة السودانية للمواصفات والمقاييس رقم 137 لعام 2008. علي أي حال عندما تتم معالجة المياه الحمضية الملوثة بواسطة هيدروكسيد الصوديوم في المراحل الأولي والثانية تتم إضافة (HCL and $NaNO_2$) في النهاية لمدة 30 دقيقة لاختبار وجود (TNT, DNT MNT

) ويتحول عندها اللون إلي اللون الأصفر مما يدل علي نهاية التفاعل واكتمال عمليه المعالجة، في المرحلة الثالثة تتم إضافة (H_2SO_4) في النهاية لمدة 30دقيقة لاختبار وجود TNT, DNT and MNT) ويتحول عندها اللون إلي اللون البرتقالي مما يدل علي نهاية التفاعل وعملية المعالجة .في إضافة أوراق ألمورينقا المسحونة للمياه الحمضية الملوثة في المراحل الأولي والثانية تم إضافة (HCL and $NaNO_2$) في النهاية لمدة 30دقيقة لاختبار وجود TNT, DNT) MNT) وتحول عندها اللون إلي اللون الأصفر مما يدل علي نهاية التفاعل وعملية المعالجة، في المرحلة الثالثة تم إضافة (H_2SO_4) في النهاية لمده 30دقيقة لاختبار وجود TNT, DNT (MNT) وتحول عندها اللون إلي اللون البني مما يدل علي نهاية التفاعل وعملية المعالجة. تحتوي أوراق ألمورينقا علي مختلف الأنواع من الأملاح والمعادن مثل CO, Ca, K, Mg, Na, Fe.أيضا تحتوي علي proteins, Ash, Fiber, CHO, Fat, . أوضحت هذه الدراسة أن أوراق ألمورينقا ذات تأثير عالي وفعال في معالجه المياه الحمضية الصناعية التي تحتوي علي TNT, DNT MNT)) .توصي الدراسة بشدة أن يتم عمل دراسة مجديه لتصنيع أقراص ألمورينقا لمعالجة المياه الحمضية الملوثة .

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Abbreviations:

BOD: Biochemical Oxygen Demand.

COD: Chemical Oxygen Demand.

BNR: Biological Nutrient Removal.

CETP: A common Effluent Treatment Plant.

EIA: Environmental Impact Assessment.

SSMO: Sudanese Standards and Metrology Organization.

USB: Up flow Anaerobic Sludge Blanket.

IAWW: Industrial Acidic Wastewater.

APHA: American Public Health Association

Chapter one

Introduction

1.1 General back ground:

The modern industry needs a lot of water for manufacturing products. The wastewater after treatment will be used in two ways as drinking water and for irrigation of any kinds of plants that can be used for food for human beings and animals, and for trees used to as protect the factory site from desertification. The technology of nitration processes is unavoidably associated with the problem of wastewater disposal. The water which comes from washing the nitration product contains acid components from the nitrating mixture and nitro compounds. Both the acid and the nitro compounds in solution, or suspended, or in both states are highly noxious for the flora and fauna of rivers and lakes. Thus nitro compounds in a concentration as low as a few milligrams per liter are lethal to fish .For this reason the removal of these compounds from the waste water prior to its discharge is of primary importance. As a rule acids are removed from wastewater by discharging it into pits filled with limestone, where they are neutralized.

Clearly nitro compounds suspended in water are easily removed by passage through settling tanks or filters. Nitro compounds dissolved in water are most difficult to remove .Various methods are possible, which make use of various physical and chemical properties of the nitro compounds. for example, physical methods which have been suggested and applied include adsorption of nitro compounds on absorptive ((e.g.

carbon)) and extraction with solvents of low volatility ((e.g. ophthalmic esters)).More chemical methods, the destruction of nitro compounds by oxidation with hypo chlorus acid is possible. Since nitro compounds are often resistant to oxidation, more complex process are sometimes more efficient, consisting first of the reduction of the nitro compound then its oxidation. Chemical methods are generally expensive and are rarely used; in particular oxidation by hypo chlorous acid consumes considerable quantities of chlorine up to 3gm for 1 liter of solution.

The pollution of fresh water by human action was hardly known before two events of the most far reaching significance took place in quick succession. One was industrial Revolution in Europe; the other was the invention of the modern waterborne sewage system and in particular, of the water closet. Out of the first grew the problem of water fouling by industrial waste, from the second erupted the menace of bacteriological pollution.

Before waterborne sewage systems became general, it was the land that was fouled, and once fouled it usually remained fouled. The system of water borne sewage had the theoretical advantage that waste matter was carried physically away and became innocuous, partly by dilution and partly, in the case of vegetable matter, by bacteriological action. The ancient Romans sewage system worked on this principal and was entirely successful because the water flowed continuously through the city drains and was thousands of times in excess of the waste matter had to carry .The effluent was therefore diluted to extent of being harmless even before it ran into the river Tiber .The rabid and uncontrolled growth of trade effluents that followed the Industrial Revolution in Europe soon resulted in chemical pollution overtaking dilution in stretches of river directly below large industrial centers. Agriculture pollution by fertilizers, insecticides, and pesticides also increased, and pollution by human sewage overtook bacteriological action in the growing urban areas of high population density. Many rivers in industrial areas thus became chemically poisoned, while in non industrial centers of population they became carries of waterborne disease. Since rivers were the primary source of water for human consumption almost everywhere, pollution suddenly became a vital public problem. In England a Royal Commission on sewage disposal was set up in 1968, and eight years later the British Parliament passed the River Pollution Prevention Act, which became the model for similar legislation the world over.

Industrial pollution by directly toxic substances such as phenols, cyanides, and salts of chromium and lead, is now rare, legislation has seen to that. Pollution by the bacteria of disease, caused chiefly by waterborne domestic sewage, is controlled by water treatment. In addition there is pollution by two categories of nontoxic substances –those that can subsequently become harmful as a result of chemical or biological decomposition , and those that render the water aesthetically unpleasant or otherwise unacceptable for domestic use , or chemically and or physically unsuitable for certain specific industries . Domestic considerations include color, taste, smell, turbidity, the presence of minerals causing digestive disorders, and the concentration of substances, such as fluorine and iodide, necessary for general health. Nontoxic industrial waste is exemplified by the effluents of coal-washing and china-clay plants, and by distillery waste .Sometimes, heat passed into water at power stations also has to be considered. In recent years two new forms of water pollution have arisen. One is fouling by detergents, the other is radioactive pollution.

Neither is wholly removed by established water treatment processes, and both constitute a growing problem .Some public water supplies, after treatment, have been known to have a detergent content as high as 0.0001 per cent .And while nontoxic detergents do not appear to affect health, this is not a proven fact. Perhaps the most worrying aspects of pollution control in the modern world are the rate of growth in the volume of waterborne sewage of which authorities have to dispose.

One recent problem has been the influx of nitrate into rivers and lakes. This chemical produced by bacterial action in sewage effluent or washed directly from fields treated with nitrate fertilizer, encourages the rapid growth of algae (waterborne plants seen as green scum on ponds), which decay and cause more pollution. The problem is particularly serious in American, where Lake Erie one of the Great Lakes has been described as being on the brink of a biological catastrophe owing to an accumulation of rotting algae and organic wastes. Possible solutions to this problem, which has also affected several lakes in Switzerland, are massive effluent treatment schemes and restrictions in the use of nitrate fertilizer.

1.2 The Moringa Oleifera tree

Moringa Oleifera Lam (Photo 1.1 and 1.2) is a perennial plant that grows very fast, with flowers and fruits appearing within 12 months of planting. They grow up to a height of 5-12 meters and pods 30-120 cm long (Lilliehöök, 2005) and are harvested up to two times a year in India (WELL, 1999). The tree prefers lowlands in hot semiarid conditions with sandy or loamy soils (Schwarz, 2000) but is known to adapt to new conditions quickly. It tolerates light frost, a soil pH of 9 and can live in areas with annual rainfall of up to 3000 mm. Today it can be found on elevations up to 2000m in Zimbabwe (Lilliehöök, 2005).

Photo 1.1: Open fruit with seeds of M. Oleifera (Lilliehöök, 2005).

Photo 1.2 Seed of M. Oleifera (Lilliehöök, 2005).

With its origin in India and Pakistan M. Oleifera was brought to the Africa continent and Sudan in particular for ornamental purposes during the colonial era. The women of Sudan soon discovered the abilities of the tree and have used the seeds for water treatment since the beginning of the 20th century (Schwartz, 2000). The natural coagulant found in Moringa Oleifera is present in 6 of the 14 species of Moringa growing in Africa, Madagascar, India and Arabia. Moringa Oleifera is the only one of the species in the botanic family that is present in tropical and subtropical regions around the world, and is therefore the most famous (Schwartz, 2000).

The different purposes of the tree are many as all parts of the tree are used. Oil extracted from the seeds is used for working machinery, cosmetics, cooking and soap. The press cakes, what is left after the oil extraction, is used as soil fertilizer. Pods and leaves are used for eating both by humans and animals, as they contain a lot of vitamins. Using the tree as a vegetable is the main reason that it has been cultivated in large scale in India, but this is yet the only commercialized part of the tree (Sutherland.et. al., 2001). Different parts of the tree are used in traditional medicine for treating diarrhea and epilepsy among others (Trees for life, 2006), and some even claim to be treating tumors (Lilliehöök, 2005). The wood pulp can be used for papermaking and the tree itself can be used as a fence, natural windbreaks or fuel (Trees for life, 2006).

1.3 Problem Statement

The Sudanese military factory manufacturing Tri Nitro Toloune (TNT), Di Nitro Toloune (DNT), Mono Nitro Toloune (MNT), produced acidic wastewater of pH value 1.2.Tana is one of the Sudanese military factory with design capacity of acidic wastewater 288 m^3/day, treatment ability 12 m^3/hr. Acidic wastewater is mixed together with 10% sodium hydroxide and neutralized under agitation in the neutralizing tank. The pH value of water after neutralization reaction should be around 6.

Solid powder material contained acidic wastewater to be treated in wastewater treatment building(4), mainly comes from nitration and purification building (1), drying acid treatment building (2) and spent acid treatment building (3), table(1.1) state that. The process of wastewater, process of equipment flushing wastewater and floor flushing wastewater .Main pollutants in wastewater include nitro-base organic compounds such as TNT,DNT and MNT, sulfuric acid and small amount of nitric acid .This made environmental pollution and made explosion if the main pollutants accumulation large amount, beside that high cost of treatment wastewater by sodium hydroxide.

Table 1.1: Wastewater volumetric rate:

Serial number	Sources	m^3/day	m^3/hr
1	Building 1 TNT nitration and purification building	11.4	0.48
2	Building 2 Drying and packing building	1.6	0.07
3	Building 3 Spent acid treatment building	218.8	9.12
4	Unforeseen volume rate	34.8	1.45
Total		266.7	11.1

1.4 Justification:

Wastewater treatment process mainly consists of three units such as lye preparation primary treatment and activated carbon adsorption. Acidic wastewater shall be treated until it meets the requirement of discharge, then it can be discharged to plant drainage system. The wastewater treatment unit is mainly controlled automatically and also is operated manually.

The most widely applied water treatment technology, a combination of some or all of coagulation, flocculation and sedimentation, plus filtration have been used routinely for water treatment since the early part of the twentieth century. Coagulation is a simple and inexpensive way to improve the quality of water and reduced levels of organic compounds, dissolved phosphorus, color, iron, and suspended particles. Up to 70% of Chemical Oxygen Demand (COD) in municipal wastewater is attributable.

To particulate matter larger than 0.45mm (Nieuwen huijzen et al., 2001). Several pollutants are also incorporated into, or adsorbed onto, the particulate material. Thus, it is of interest to explore the development of a treatment strategy for the enhanced removal of suspended and colloidal solids from wastewater.

Moringa Oleifera contains a natural organic polymer ,which is non – toxic and usually presumed safe for human consumption(Grabow et al.,1998;Raghuwanshi et al.,2002), softening hard waters (Muyibi and Evison,1995) and acting as an effective adsorbed of cadmium (Sharma et al.,2006).The seeds have shown a high coagulation activity for high turbid water (Muyibi et al.,2001;Muyibi et al .,2002).

Current studies reported that Moringa Oleifera seed is effective sorbents for removal of heavy metals and volatile organic compounds in the aqueous system (Akhtar et al .,2006,Sharma et al .,2006).Many studies have also been done on the performance of Moringa Oleifera seeds as primary coagulants .The seed as a coagulant could be used for wastewater treatment (Fodil et al .,2001) .Moringa Oleifera has antibacterial properties and studies show that an average of 1.1-4.0 log reduction of several microorganism including E. Coli can be achieved (Ghebremichael,2004).Biological materials such as Moringa Oleifera have been recognized as cheap substitutes for wastewater treatment and are safe for human health(Hsu et al .,2006) .

1.5 Objectives

1.5.1 General objective:

- To investigate the acidic wastewater treatment using Moringa, and its suitability for reuse in irrigation.

1.5.2 Specific objectives:

(i) To investigate the suitability of treated wastewater for irrigation of vegetables or trees.

(ii) To assess the environmental impact of the process unit.

(iii) To investigate the Feasibility and Economical Cost Evaluation

Chapter Two

Literature Review

2.1 Previous Studies:

The discharge of effluents rich in sulphate and nitrate is of increasing concern. Discharging industrial effluents containing high sulphate concentrations into surface waters contributes directly to mineralization and corrosion potential of the receiving waters , while nitrate contributes to eutrophication and is toxic to infants and toddlers .Sulphate originates from the use of sulphuric acid in manufacturing , chemical and metallurgical processes, or from the oxidation of pyretic material in our bodies under natural conditions .Nitrate originates from domestic wastewater, on from fertilizer and explosive manufacturing. Unacceptably high concentrations of sulphate and nitrate may occur in cooling water due to evaporation.

Generally, sulphate level less than 200 to 500 mg/L are acceptable for discharge into public streams. Nitrate is acceptable at levels of less than 10 mg/l .The municipality of Johannesburg and water authorities in this region allow the discharge of water containing high sulphate concentrations 2000 mg/L into sewer systems or rivers. The main reason for this is that the ratio of sulphate rich water produced by industrial activities from industries (e.g. mining, chemical and power station) to surface water, is high in that region. It is expected that as soon as proven technologies are available for the removal of sulphate at an acceptable cost, legislation will be forced to prevent the discharge of high sulphate concentrations into the receiving waters.

Sulphate and nitrate can be removed from water by desalination processes such as reverse osmosis and ion exchange, but these are costly. Hence, increasing attention has been given to biological sulphate removal (e.g. Maree and Strydom 1985; Maree et. al., 1986) and biological nitrate removal (Matais et. al., 1983). Sulphate can be removed biologically provided that a suitable energy source is available , e.g. Lactic acid (Middleton and Lawrence, 1977), wood dust and sewage sludge (Butlin et.al.,1949,1960;Conardie and Grutz ,1973 ;Knivett ,1960; Sandana and Morey,1962.Tuttle et. al. ,1969) .Good sulphate removal was obtained for all the carbon sources, but a long retention time of 5-10 days was required for the latter two .

Up flow packed bed reactors were used by (Maree and Strydom ,1985) to establish well developed microbial bio films for sulphate removal from mine water with sugar, pulp mill effluent or sewage as energy sources. They concluded that 1.6 gm sugar, 16.7 ml of spent sulphide liquor or 172 ml raw sewage sludge were necessary to remove 1800mg sulphate. (Maree et.al., 1986) showed that three stages process (anaerobic-aerobic) employing up flow packed bed reactor for anaerobic treatment, and an activated sludge system for aerobic treatment, could be used for producing reusable water from mining effluents. Sulphate was reduced from 2.5gm/L to less than 0.5gm/l with concomitant removal of H_2S, carbonates, complexes cyanides, phenol and heavy metals. Molasses was used as the energy source.(Olthof e t. al.,1985) described the "Bio sulfix" process in which H_2S gas produced during sulphate reduction is absorbed in sodium hydroxide and converted to sodium bisulphate .The latter product can be reused in pulp manufacturing.

(Cork ,1982) proposed that H_2S and Co_2 removal from waste gases could be achieved through the use of Chlorobium thiosulfatophilum a green photosynthetic sulphur bacterium. He suggested that such a biological process has much potential and that sulphur would be a by-product. Buisiman (1989) showed that H_2S produced during biological sulphate reduction can oxidized only to elemental sulphur (and not to sluphate) provided that the oxygen level is kept low .A major disadvantage when sulphate is removed biologically from an effluent with an organic carbon source as substrate , is the high residual organic carbon content , which requires downstream treatment after the anaerobic reactor .This disadvantage was overcome by replacing organic carbon sources with producer gas mixture of H_2 ,CO and CO_2(du Preez et. al.,1991). Another benefit of using producer gas over organic carbon sources is that it can be produced in sufficient quantities for the treatment of large flows, as coal is the raw material.

2.2Wastewater characteristics:

Prior to about 1940, most municipal wastewater was generated from domestic sources. After 1940 as industrial development in the United States grew significantly, increasing amounts of industrial wastewater have been and continue to be discharged to municipal collection systems .The amounts of heavy metals and synthesized organic compounds generated by industrial activities have increased, and some 10000 new organic compounds are added each year .Many of these compounds are now found in the wastewater from most municipalities and communities.

As technological change take place in manufacturing, changes also occur in the compounds discharged and the resulting wastewater characteristic. Numerous compound generated from industrial processes are difficult and costly to treat by conventional wastewater treatment processes. Therefore effective industrial pretreatment becomes an essential part of an overall water quality management program enforcement of an industrial pretreatment program is a daunting task, and some of the regulated pollutants still escape to the municipal wastewater collection system and must be treated in the future with the objective of pollution prevention, every effort should be made by industrial dischargers to assess the environmental impacts of any new compounds that may enter the wastewater stream before being approved for use if

a compound cannot be treated effectively with existing technology it should not be used.

2.2.1 Chemical characteristics:

The most important chemical characteristics of wastewater its chlorides, dissolved gases, hardness, hydrogen-ion concentration (pH value), acidity, metals and other chemical substances, nitrogen and its compound, total solids, BOD, COD.

2.2.2 Physical characteristics:

The most important physical characteristic of wastewater is its total solids content, which is composed of floating matter, settle able matter, colloidal matter, and matter in solution, other important physical characteristics include particle size distribution, turbidity, color, temperature, odor, conductivity and density specific gravity, specific weight, sometimes considered a physical factor.

2.3 Water Pollution Control:

The water available in the various sources of water may or may not contain impurities .The water which contains impurities, is known as polluted water. The word pollution is derived from the Latin word pollutes (pol means before and lutes means wash).There is difference between words pollution and contamination. Pollution is the general term, which means impure water or water containing various types of impurities, in the presence of whom the water may be safe or unsafe for use by the people. The word contamination is the specific term used to denote the polluted water which is unsafe and unreliable for use. The colored water, foul smelling water, water containing oil, grease floating bodies, saline water etc, are the examples of the polluted water. The water containing high percentage of harmful disease causing and pathogenic bacteria etc, are the example of the contaminated water.

The pollution causes undesirable changes and it affects the land, water and air, or the environment as a whole. For healthy living the environment must be clean, scenic, refreshing and ecologically well – balanced. In the modern living the heavy industrialization and increase of population increased the rate of water pollution. There for, the need of water pollution control has drawn the attention of the concerned departments. To use the water available in various best possible ways has given the birth to the new subject known as water management. The topic of water management is practiced by the developing nations.

2.4 Water Pollution Sources:

The main water pollution sources are as under:

(i) Industrial sewage.

(ii) Domestic sewage.

(iii) Miscellaneous pollution sources

2.4.1 Industrial sewage:

The industrial wastes coming from the industrial areas and big industries contain grease, oil chemical, highly odorous substances, explosives, etc .The main industries which contribute to the Indian rivers pollution are oil and soap, pulp paper, sugar and distilleries, chemical, textile, steel mills, pharmaceuticals, tanneries, oil refineries and various other miscellaneous industries. When the sewage wastes of these industries are allowed to dispose off in river it causes water pollution. Even if these industrial wastes are disposed of by land treatment these may pollute the underground water sources. Therefore the industrial sewage should be allowed to dispose off on land or water after its proper treatment, so that it may not pollute the water sources or water.

2.4.2 Domestic sewage:

The domestic sewage also contains oils, human excreta, decomposed kitchen wastes, soapy water, pathogenic bacteria from the sick people sewage, hospital sewage etc. If the domestic sewage is disposed off in the water sources, it will pollute them. On the other hand if the domestic sewage is not properly handled after its production or even if the effluent received at the end of the sewage treatment plant is not of adequate standard, these may pollute the water sources. If the sewage or partly treated sewage is directly disposed off into the surface water sources, they may get contaminated and become unsafe for direct human use.

2.4.3 Miscellaneous pollution sources:

Following are the various water pollution sources:

(i) Faulty joints and cracks. If the pipes carrying treated water for distribution have some faulty joints or cracks, the following water will get contaminated from the surrounding substances.

(ii) Navigation ships. The oily waste and sewage from the navigation ships, tankers and boats moving in the rivers will pollute their water and beaches.

(iii) Radioactive wastes. The wastes from the industries dealing with the radio- active substances may seriously pollute the waters. The radio-active pollution can only be measured by special precise instruments.

(iv) Run off. During rains the surface runoff water collects large number of impurities from the earth surfaces which reach the surface sources. These impurities may be of organic or mineral material and bacteria and may highly contaminate the surface sources water. The use of fertilizers and insecticides in the fields is also a source of contamination of runoff water.

(v) Storage Reservoir. When the water after treatment is stored in the reservoirs open to atmosphere, its water may get polluted from dust, dirt falling from the atmosphere. When such reservoirs are near railway stations or power houses, then fine coal particles discharges along with smoke may also reach the reservoir through air and pollute it. To protect the treated water it should be stored in covered water reservoirs.

(vi) Travel of water. Depending upon the presence of minerals and organic impurities in the ground. When the ground water travels through it, these are dissolved in the water and pollute it.

2.5 Treatment of industrial wastewaters:

2.5.1 Water pollution:

Natural water is rarely chemically. When it rains, organic and inorganic suspended particulate matter, gases, vapors, mists, etc. in the air get dissolved in water, through which it reaches the earth's surface. In addition, water carries surface pollutants and contaminants during its flow over the ground. Water which percolates into the ground dissolves various salts and becomes rich in total dissolved solids. Thus it acquires a

number of impurities while in its natural states. This necessitates adequate treatment of naturally occurring water before it can be used for domestic, industrial, commercial, agricultural or recreational purposes.
The extent of treatment will depend on the end use of the treated water. Use of the treated water even once adds considerably to the amount and variety of pollutants.

This necessitates further treatment of the water before it can be reused, although it is not strictly necessary to have water of uniformly high quality for each of the above uses. In view of the limited availability of water for meeting our growing demands, and in the interest of protecting the environment, it is essential to think and act in terms of reducing water consumption, reusing and recycling once used water and minimizing the pollution effects of wastewater resulting from variety of uses.

Domestic and industrial uses of water add a number of contaminants and pollutants to it. Contaminants are capable of causing diseases and rendering water unfit for human consumption, while pollutants are substances which impair the usefulness of water, or render it offensive to the senses of sight, taste and smell. Contamination may accompany pollution. Domestic wastewater contains contaminants, while industrial waste water may contain both contaminants and pollutants.

Industries use water for a variety of purposes, such as for manufacturing goods, heating, cooling, as carrier of raw material, as solvent, for firefighting, for lawn sprinkling and gardening, and for use in the canteens and toilets. While only a small fraction of the supplied water is present in the end product, or is lost by evaporation, the rest is converted into industrial wastewater. Indiscriminate discharge of these waste water streams into the environment can render soils sick, pollute the receiving bodies of water and cause air pollution by generating obnoxious gases, Treatment of these wastewaters within the factory premises ,or preferably their elimination at source, should be the aim of every industry ,if total elimination of the wastewater streams is not feasible, the least that can be done is to reduce their volume and strength, by taking one or more of the in-plant measures such as reducing fresh water consumption, reusing waste water(either with or without treatment), substituting process chemicals for those which contribute to pollution, changing or modifying the manufacturing process, and following good housekeeping practices. Of course due care must be taken to see that these steps do not adversely affect the quality of the finished product or damage the manufacturing machinery .In addition proper disposal of residues arising out of recycling and reuse must be provided for, along with the treatment of the wastewater streams ,which are not to be recycled or reused.

2.5.2 Categories of pollutants:

Industrial wastes contain a large variety of pollutants which are categorized as follows:

(i) Inorganic pollutants.

This include alkalis, mineral acids, inorganic salts, free chlorine, ammonia Hydrogen sulphide salts of chromium of nickel, zinc, and cadmium, copper, silver, etc, anions such as phosphates, sulphates, chlorides, nitrates and nitrites, cyanides, cautions such as calcium, Magnesium, sodium, potassium, iron, manganese, etc. .

(ii) Organic pollutants. These include high molecular weight compounds such as sugars, oils and fats, proteins, hydrocarbons, phenols, detergents, and organic acids. Some of these pollutants are resistant to biodegradation and or others are toxic to aquatic life in the receiving water. Their removal, or at least reduction to allow concentration, becomes necessary in order to be able to treat such waste water by biological means.

In addition, industrial wastes may contain radioactive materials, which need very careful handling, treatment and disposal. The characteristics of industrial wastes, which are combined with domestic sewage generated within the factory premises, are somewhat different from those of the industrial wastes alone, on account of dilution offered by the sewage. Further, such mixtures are easier to treat biologically because of the presence of microorganisms in the sewage. If the industrial waste is deficient in nutrients such as nitrogen and phosphorus, these elements are supplied to some extent by sewage, leading to economy in the consumption of chemicals, e.g. .urea and DAP, which are commonly used for nutrient supplementation. An added benefit in such a case is that a common treatment plant can be designed for treating both, industrial wastes and sewage. (Awadelseed, 2011).

The aim of the treatment is to remove pollutants from the wastewater and render it fit for safe discharge to the environment. In view of the increasing demand for water, and its decreasing availability, mere end of pipe treatment is not the answer to pollution control. Reuse, recycling and where feasible, by product recovery must become an integral part of the treatment scheme. Experience shows that it is possible to achieve this goal without incurring heavy expenditure. In many cases, the practice of reuse, recycling and by product recovery has resulted in not only meeting the operating costs, but also offering an attractive payback period to the industry. Some examples of successful reuse and recovery are given.

2.6 Wastewater Treatment Methods (WTM):

WWT methods can be classified as follows:

(i) Physical methods:

These include screening, sedimentation, floatation, filtration mixing, drying, incineration, freezing, adsorption, gas transfer, elutriation, etc.

(ii) Chemical methods:

These include pH correction, coagulation, softening, ion exchange, oxidation, reduction, disinfection.

(iii) Biological methods:

These employ aerobic, facultative and anaerobic microorganisms to destroy organic matter and reduce the oxygen demand of the wastewater.

(iv) A combination of the above three methods is also used to treat wastewater.

Adequate treatment can also be obtained by selecting one or more of the physical, chemical and biological units and arranging them in a logical sequence, so that the effluent of one unit is suitable as influent to the next unit. Selection and sizing of the proper units is done by:

(i) Flow measurement, sample collection and characterization of the wastewater flows.

(ii) Subjecting the wastewater samples to treatment ability studies by employing laboratory scale models, which may run on a batch feed basis, semi continuous feed basis, or continuous basis.

(iii) Deciding which combination of unit operations and unit processes will be appropriate for the wastewater under study.

(iv) If necessary, running pilot plant, this will simulate the working conditions in awful scale plant.

The size of the pilot plant may be chosen such that it can be conveniently incorporated into the full scale plant. Industries manufacturing a variety of end products can benefit from maintaining a pilot plant, even after the full scale plant is commissioned, in order to ensure adequate treatment of influents of varying quality. These variations in quality may occur due to change of product, raw materials, or method of production. Pilot plants can play a very important role in the case of industrial states, in which many different industries are located together and produce wastewaters of divergent quality.

A common effluent treatment plant (CETP) may be the right technical solution for pollution control in such cases. Pilot plant studies help in arriving at rational design criteria for such estates, choosing the most appropriate treatment train, and avoiding costly modifications to the CETP once it goes on stream.

Disposal of treated wastes is an important step and industry has to follow in order to ensure that the delicate ecological balance of the environment is not disturbed. Disposal may be done in a receiving body of water such as a river, lake, or sea. Disposal on land is also practiced, taking care to see that the soil is not adversely affected by the residual pollutants in the effluent .Where underground sewerage is available, the treated effluents may be discharged into municipal sewers, provided they meet the quality standards laid down for this mode of disposal .In addition, the quality of the industrial effluents must be such that:

(i) They will not endanger the lives of the drainage maintenance crew, who may be required to enter the sewers for maintenance and repairs.

(ii) The material of the sewers will not be damaged.

If one is provided at the end of the drainage system, will be capable of taking the hydraulic and organic loads imposed by the industrial effluents. Industries wishing to follow this mode of disposal will almost always be required to give some pretreatment to the wastewater. Its extent depends on the volume and strength of the waste water and the degree of dilution offered by the sewage flowing in the drainage system.

A result of treating wastewater by one or more of the above discussed means is the generation of sludge, which may be organic or inorganic in nature. Sludge constitutes a peculiar problem on account of their properties such as viscosity, presence of pollutants in a concentrated form, some of which can be toxic and or hazardous or difficult to dewater and dispose off .This fact needs careful consideration while designing the wastewater treatment plant The treatment is said to be complete when the soil residues, liquid effluents and gaseous emissions are adequately treated and safety disposed of.

The effect of discharge of wastewater in to natural water bodies should be considered from the following two interrelated standpoints:

(i) The effect of wastewater on the water environment.

(ii) The effect of the receiving water on the wastewater.

The first effect considered is pollution effect while the second effect is self –purification .These two factors are discussed in the following:

The effect of wastewater on the water environment may be physical, chemical and biological.

Physical effects includes increase in turbidity and suspended solids, addition of color, taste and odor producing substances, and formation of sludge banks on the beds and sides of the water bodies. Industrial wastes such as cooling waters from power stations, dyeing and printing wastes from textile industry, spent wash from alcohol distilleries, etc. Raise the temperature of water in the receiving body and reduce the dissolved Oxygen content in it. These conditions impart an aesthetically unacceptable appearance to the water, create an environment unsuitable for aquatic creatures such as fish, render it difficult to treat, and initiate the chain of chemical and biological effects.

Chemical effects include a drastic change in the pH value of the receiving water due to the discharge of acidic wastes such as mine drainages or alkaline wastes such as textile wastes. High chlorides render the water unacceptable as a source of drinking water, high sulphates, under favorable circumstance tend to form hydrogen sulphide and produce malodorous condition , nitrates and phosphates encourage algal and other aquatic growths, toxic and inhibitory substances either wipe out the aquatic life or severely limits its growth, and most importantly, reduce the available dissolved oxygen in the water .The dissolved oxygen may even become zero in the presence of a slug of oxygen demanding wastewater .

It takes considerable time for the receiving water to regain its original quality and re-establish the beneficial aquatic life in it .Thus one polluter, located upstream, can create serious problems for downstream users. Biological effects due to industrial wastes alone are not very serious because many of them do not contain pathogenic organisms that are present in domestic sewage .An exception to this is the tannery waste which contains anthrax bacilli. When industrial waste are discharged in combination with domestic sewage, biological effects become significant although a large number of microorganisms in the sewage are killed by unfavorable environmental conditions in the industrial wastes. The physical and chemical effects mentioned above have an adverse effect on the aquatic biological life, e.g. turbidity and suspended solids, along with color, cut off penetration of sun light into the water and reduce photosynthetic activity. Suspended solids can choke the gills of fish and kill them.

Organic suspended solids settle to the bottom of the receiving body of water and in the presence of microorganisms, decompose an aerobically. The products of anaerobic decomposition gradually diffuse to the upper layers of water and add to the total oxygen demand. Anions such as chlorides, subparts add to the total dissolved solids contents of the water and interfere with metabolic process of microorganisms

Nitrates and phosphates encourage enormous algal growth in the water. Dead algal masses settle to the bottom and add to anaerobic condition. Toxic and inhibitory captions such as mercury, chromium, cadmium, copper, etc, reduce the growth of microorganisms or even wipe out the microbial population, if present in high concentrations. Dissolved oxygen in the water, which is so essential to the survival of micro and microorganisms, is reduced and may even become zero under heavy polluting conditions. This leads to either the migration of fish populations or large scale fish kills, which in turn add to the dead organic matter already present in the water. Toxic heavy metals and radioactive pollutants enter the biological food chain and ultimately reach the human and animal consumers .The net result of all the above effects is a drastic reduction in the usefulness of the receiving body of water.

2.7 Treatment Methods:

Methods of treatment in which the application of physical forces predominate are known as unit operations. Methods of treatment in which the removal of contaminants is brought about by chemical or biological reactions are known as unit processes. At the present time, unit operations and processes are grouped together to provide various levels of treatment known as preliminary, primary, advanced primary, secondary without or with nutrient removal, and advanced or tertiary treatment. In preliminary treatment, gross solids such as large objects, rags, and grit are removed that may damage equipment. In primary treatment physical operation usually sedimentation is used to remove the floating and settle able materials found in wastewater. For advanced primary treatment chemicals are added to enhance the removal of suspended solids and to a lesser extent dissolved solids. In secondary treatment biological and chemical processes are used to remove most of the organic matter. In advanced treatment additional combinations of unit operations and processes are used to remove residual suspended solids and other constituents that are not reduced significantly by conventional secondary treatment .A listing of unit operations and processes used for the removal of major constituents found in wastewater.

About 20 years ago biological nutrient removal (BNR) for the removal of nitrogen and phosphorus was viewed as an innovative process for advanced wastewater treatment. Because of the extensive research into the mechanisms of BNR the advantage of its use and the number of BNR systems that have been placed into operation nutrient removal for all practical purposes has become a part of conventional wastewater treatment. When compared to chemical treatment methods BNR uses less chemical reduces the production of waste solids and has lower energy consumption. Because of the importance of BNR in wastewater treatment BNR is integrated into the discussion of theory, application, and design of biological treatment systems. Land treatment processes commonly termed natural systems, combine physical, chemical, and biological treatment mechanisms and produce water with quality similar to or better than that from advanced wastewater treatment. Natural systems are not covered in this text as they are used mainly with small treatment systems. The treatment processes (Jahn, S.A., 1981) can be classified as shown on table (2.1).

Table 2.1: Treatment level in each treatment process (Jahn, S.A., 1981).

Treatment level	**Description**
Preliminary	Removal of wastewater constituents such as rags, sticks, floatable, grit, and grease that may cause maintenance, or operational problems with the treatment operations, processes, and ancillary systems.
Primary	Removal of apportion of the suspended solids and organic matter from the wastewater.
Advanced primary	Enhanced removal of suspended solids and organic matter from the wastewater. Typically accomplished by chemical addition or filtration.
Secondary	Removal of biodegradable organic matter in solution or suspension and suspended solids. Secondary with Removal of biodegradable organics, suspended solids.
Nutrient removal	Nutrients (nitrogen, phosphorus, or both nitrogen and phosphorus).
Tertiary	Removal of residual suspended solids after secondary treatment, usually by granular medium filtration or micro screens. Nutrient removal is often included in this definition.
Advanced	Removal of dissolved and suspended materials remaining after normal biological treatment when required for various water reuse applications.

2.8 The Moringa Oleifera tree:

2.8.1 Natural coagulants:

A number of effective coagulants have been identified of plant origin. Some of the common ones include normally (Tripathi et al., 1976), M. Oleifera (Olsen, 1987; Jahn, 1988), okra (Al-Samawi and Shokrala, 1996), Cactus latifaira and Prosopis juliflora (Diaz et al., 1999), tannin from valonia (Özacar and Sengil, 2000), apricot, peach.Kernel and beans (Jahn, 2001), and maize (Raghuwanshi et al., 2002). (Bhole, 1995) compared 10 natural coagulants from plant seeds. The study indicated that maize and rice had good coagulation effects when used as primary coagulants or coagulant aid.

Chitosan, a natural coagulant from animal origin is also an effective coagulant (Pan et.al., 1999; Davikaran and Pillai, 2001; Guibal et al., 2006). It has unique properties among biopolymers, especially due to the presence of primary amino groups. It is a high molecular weight polyelectrolyte derived from deactivated chitin and it has characteristics of coagulants and flocculants high cationic charge density, long polymer chains, bridging of aggregates, and precipitation (in neutral or alkaline pH conditions). It has also been used for the chelating of metal ions in near neutral solution and the complication of anions in acidic solution (cationic properties due to amine protonation). Its coagulation and flocculation properties can be used to treat particulate suspensions (organic or inorganic) and also to treat dissolved organic materials. It has also been reported that chitosan possesses antimicrobial properties (Liu et al., 2000; Chung et al., 2003).

By using natural coagulants, considerable savings in chemicals and sludge handling cost may be achieved. (Al-Samawi and Shokrala ,1996) reported that 50 – 90% of alum requirement could be saved when okra was used as a primary coagulant or coagulant aid. Apart from being less expensive, natural coagulants produce readily biodegradable and less voluminous sludge. For example, sludge produced from M. Oleifera coagulated turbid water is only 20 – 30% of that of alum treated water (Ndabigengesere et al., 1995; Narasiah et al., 2002). The coagulation process in water treatment is complimented by filtration. The successfulness of coagulation in most cases determines the performance of the filtration system, which may be of a mono medium or dual media type.

2.8.2 Mechanism of water purification using Moringa Oleifera:

The mechanism of coagulation was suggested to be adsorption and neutralization of charges, or adsorption and bridging of destabilized particles, the two assumed to take place simultaneously. (Jahn, 1981) (Gassenschmidt et al., 1994) and Ndabigengesereet al., 1995) reported the isolation from M. Oleifera of a flocculating protein of 60 residues with molecular mass of about 6.5 kDa, is electronic point above pH 10, high levels of glutamine, arginine and proline with the amino terminus blocked by pyroglutamate, and flocculent capacity comparable to a synthetic poly a crylamide cationic polymer. However, a non-protein coagulant has also been reported but not characterized (Okuda et al., 2001).

2.8.3. Treating water with Moringa Oleifera seeds:

The knowledge that seeds from the Moringa Oleifera tree can purify water is not new; the seeds have been used for generations in countries like India and Sudan (Lilliehöök, 2005).Photo (2.4) shown Moringa seeds.

Women of Sudan have used the technique of swirling seeds in cloth bags with water for a few minutes and letting it settle for an hour. This procedure is today recommended by different agencies (PACE and

ECHO etc.) for people with limited access to clean water.

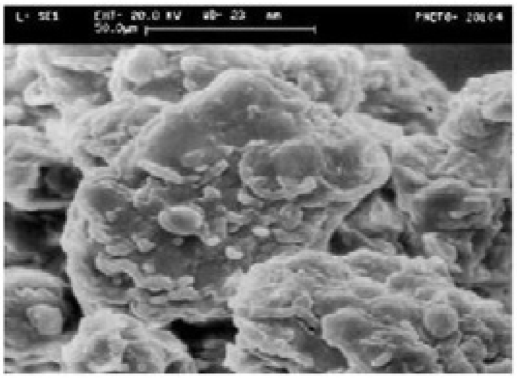
The required area for cultivation of Moringa when used for drinking water treatment is dependent on the raw water and dosage. With a production of 3 kg seed kernels per tree and year and a dosage of 100mg/l, 30 000 liters of water can be treated from one tree. By assuming tree spacing of 3m, an area of 1ha can treat 30000m annually (Lilliehöök, 2005).

Photo 2.1 Shelled Moringa Oleifera seeds (Lilliehöök, 2005).

After oil extraction from M. Oleifera seeds, the residue pressed cake contains water soluble proteins that act as effective coagulants for water purification. One to two seeds per liter are required for water purification. Seed powders are mixed with water, after hours, the water is filtered to get purified water. The charged protein molecules can serve as nontoxic natural polypeptide to settle mineral particles and organics in the purification of drinking water, vegetable oil, depositing juice (sugarcane) and beer (Foidl et al., 2001).

In recent times, there has been an increasing trend to find some indigenous cheaper material for wastewater treatment. Since the conventional procedure of wastewater treatment has some disadvantages, such as incomplete metal removal, high cost and high energy requirements, biological materials have been recognized as cheap substitutes for wastewater treatment. Current studies report that Moringa seeds and pods are effective sorbents for removal of heavy metal and volatile organic compounds in the aqueous system (Akhtar et al., 2006, Sharma et al., 2006). It can be added in oxidation lagoons of wastewater treatment units to coagulate algae as well.

The algae are removed by sedimentation, dried and pulverized, and then used as protein supplement for livestock (Foidl et al., 2001). The unique characteristic of Moringa seeds could be a possible solution for the developing countries which are suffering from lack of clean water for irrigation.



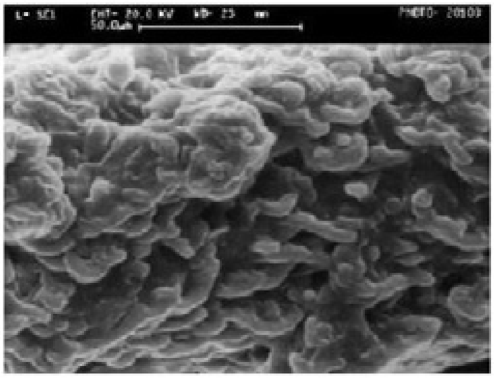


Photo 2.2(a) Photo 2.3(b)

Photo 2.2 (a): Scanning electron micrograph (SEM) of untreated Moringa seeds showing large spherical clusters type morphology.

Photo 2.3 (b): SEM of treated Moringa seeds showing dense agglomerated, etched dendrite type morphology (Kumari et al., 2006).

2.8.4 Characteristics of the active agents:

The coagulant in the seeds was first confirmed by the German scientist Samia Alazharia Jahn (Schwartz, 2000), from 3 to 60 kDa, all possessing coagulating ability, which means that the Moringa seeds probably contain several different proteins that may The active agent is believed to be a protein, but the exact form of the protein is not yet known. Recent researchers have identified proteins of sizes ranging act as coagulants.

The protein(s) act as cationic polyelectrolyte's (Sutherland et al 1994), which attach themselves to the soluble particles and create bindings between them, leading to large flocks in the water. Stirring and mixing accelerates the electrostatic flocculation, and the flocks condense (Göttsch, 1992).

2.8.5 Extraction of the active agents:

Extraction of the coagulants can be done in several ways. Most of them, including recommendations for domestic use, follow the pattern: dried seeds are ground, with or without shells, using either a kitchen blender or a mortar. The powder is mixed with a small amount of water and the solution is stirred and filtered (Ndabigengesere and Narasiah, 1998, Muyibi and Alfugara, 2003, Ghebremichael et al., 2005). The filtered solution is called a crude extract‖ or stock solution‖ and could be used for treating water without further preparation.

Several studies show that salt water and/or tap water is more efficient as solvent for the active agents as compared to distilled water. The study from (Okuda et al., 1999) showed that the coagulation capacity with Nacl was up to 7.4 times higher with Moringa extract than with distilled water. This is based on the assumption that the coagulating protein is more soluble in water with high concentration of ions (Okuda et al, 2001). Other studies have focused on purifying the active agent as much as possible and producing a stable protein powder without excessive organic matter.

Two separate studies show that the active agents could be purified from the extract using a cation exchanger, leading to reduced levels of

COD in the treated water (Ghebremichael, 2005; Ndabigengesere and Narasiah, 1998). A more low-tech way of reducing the organic content is to extract the oil from the seeds with an organic Solvent (Ghebremichael 2005).

2.8.6 Coagulation efficiency and influence on water quality:

The coagulation and flocculation ability of the seeds has been investigated in several different projects around the world (Ndabigengesere and Narasiah 1998, Bengtsson 2003, Muyibi and Alfugara 2003). These previous studies have shown that neither pH nor alkalinity or conductivity was affected during the treatment, but an increase in COD, nitrate and orthophosphate has been observed (Bengtsson, 2003, Ndabigengesere and Narasiah 1998). Some studies indicate that treatment with Moringa is dependent on the pH of the raw water, optimum treatment is achieved above neutral pH (Okuda et al., 2001a), whereas others showed that, it is independent of raw water pH (Schwartz, 2000). The treatment efficiency is dependent on the turbidity of the raw water as revealed in previous studies from (Katayon et al.2004).It was shown that Moringa is more efficient if the water has high initial turbidity (Katayon et al, 2004).

Moringa has also been proven to produce significantly less sludge than aluminum sulphate, which is an advantage especially if the sludge is to be dewatered or treated in some other way before it is disposed of (Ndabigengesere et al., 1994) The Moringa coagulant can also be used in combination with other flocculating salts, such as aluminum sulphate (Ndabigengesere and Narasiah 1998). The use of Moringa Oleifera on a large scale has been tested in a drinking water treatment plant in Malawi with good results (Sutherland et al., 1994).

2.8.7 Storage of seeds and extract:

Previous studies indicated that storage of the crude extract is not possible in order to remain good coagulation. Storage of the crude extract will lead to a decrease of treatment efficiency with an increase in duration of storage (Katayon et al., 2006).

The study does not discuss the reason for this but it could be assumed that it is due to microbial degradation of the proteins. Differences in temperature and container did not have any effect on the properties. Duration of storage should not be above 24 hours as degradation of active agents is believed to occur beyond this time. A study from(Katayon et al.,2004), shows that stock solution stored for three days has between 73.6 % and 92.3% lower turbidity removal depending on the turbidity of the raw water. The study also observed that the highest removal efficiency was performed by solutions stored maximum one day (Katayon et al., 2004).

Storage of seeds and its influence on coagulation properties has been investigated by (Katayon et al., 2006). Seeds were dried, crushed and stored in different containers at different temperatures. The study concluded that the temperature and container did not have any significant effect on treatment efficiency but that the duration of storage did. The seeds stored for one month showed better treatment efficiency than the seeds stored for three and five months.

2.8.8 Previous studies:

For treatment applications, the seed pods are allowed to dry naturally on the tree prior to harvesting. The mature seeds are readily removed from the pods, easily shelled and then crushed and sieved using traditional techniques such as those employed for the production of maize flour. The crushed seed powder, when mixed with water yields. (Boating, 2009). Water soluble proteins that possess a net positive charge (molecular weight 13 kDa and is electric pH 10-11). Dosing solutions are generally prepared as 1-3% solutions and are filtered prior to application to the untreated water (Sutherland et al., 1990). M. Oleifera seeds in diverse extracted and purified forms have proved to be effective at removing suspended material (Ndabigengesere and Narasiah 1998; Raghuwanshi et al., 2002). The seeds have shown a high coagulation activity for highly-turbid water (Muyibi et al., 2001; Muyibi et al., 2002).

Bench scale testing at Leicester confirmed that the press cake (solids residue remaining after oil extraction) still contains the active, water-soluble proteins. Significantly, two potentially valuable products may be derived from the seed. Moringa derived coagulants offer several advantages over conventional coagulants such as a aluminum sulphate:

- Activity is maintained over a wide range of influent pH values no pH correction is required.
- Natural alkalinity of the raw water is unchanged following coagulation no addition of alkalinity is required.
- Sludge production is greatly reduced (by a factor of up to 5) and is essentially organic in nature with no aluminum residuals (Ndabigengesere and Narasiah 1998).

Experiment on purification of the coagulant protein from Moringa Oleifera seed, showed both flocculating and antibacterial effects of 1.1– 4 log reduction (Kebreab et al., 2005). Moringa Oleifera acts as an effective absorber of cadmium (Sharma et al., 2006).Earlier studies have shown that M. Oleifera seed powder is effective in heavy metal remediation of water (Sajidu et al., 2005). Ongoing studies by (Mataka, et al ,2006) on low cost effective heavy metal remediation using Moringa stenopetala and Moringa Oleifera seed powder techniques in developing countries has already demonstrated that Moringa Oleifera, the well known source of natural water clarifiers, is effective in heavy metal detoxification of water. Recent studies by (Akhtar et al., 2006, Sharma et al., 2006) reported that Moringa seeds are effective sorbents for removal of heavy metal and volatile organic compounds in the aqueous system.

It is now regarded as axiomatic that both water and wastewater technology for developing countries must be no more complex than strictly necessary and be robust and inexpensive to install and maintained. A prototype treatment works was designed based on this philosophy. The pilot plant was constructed within the grounds of the theology Water Treatment Works controlled by the Malawi Government. The pilot plant, with a design flow rate of 1 m/ h, consisted of; a header tank, where M. Oleifera seed solutions were introduced into the turbulent jet of incoming water and mixed hydraulically; an 18 minute flocculation period provided within gravel bed flocculates; plain horizontal sedimentation and rapid gravity filtration. All the units were locally fabricated in sheet steel.

The system was successfully commissioned during the rainy season with the source river exhibiting turbidity levels in excess of 400 NTU throughout the study period. In general solids removal within the plant was consistently above 90% following the gravel bed flocculation stage and plain horizontal flow sedimentation. Subsequent rapid gravity s and filtration gave final, treated water turbidity generally well below 5 NTU with M. Oleifera seed dose ranging from 75-250 mg/L depending on the initial raw water turbidity (Folkard et al., 1993).

During the following wet season the main theology works was operated using M. Oleifera solution as coagulant. The works comprised up flow contact clarifiers followed by rapid gravity filters and chlorination. The clarifiers were in a state of some disrepair with the impeller drives and chemical feed pumps inoperative. Under normal operation, alum solution is introduced into the incoming flow of 60m h by simple gravity feed at a declining rate. Comparable treatment performance with alum was achieved. During a 7.5 hour test run with the main works flow at 60 m, the inlet turbidity of 325 NTU was reduced to below 2 NTU following filtration with a seed dose of 75 mg/L. This was the first time that M. Oleifera had been successfully used as a primary coagulant at such a scale with the treated water entering supply (Sutherland et al., 1994). M. Oleifera seed for the full-scale trials was purchased from enthusiastic, local villagers. This was viewed as a temporary yet very welcome new source of cash income in what is a poor rural community of Southern Malawi. The tree is widely cultivated in this area, being highly prized as a source of fresh, green vegetable.

(Ndabigengasere and Narasiah 1996) investigated the effects of ambient temperature on turbidity removal. The authors reported lower residual turbidity (from 21 to 8 NTU residual turbidity for 105 NTU initial turbidity) at the optimum coagulant doses at temperature increased (from 2 to 25^{o}c) for set physical conditions.

A comprehensive study was also undertaken, to evaluate the potential of using M. Oleifera coagulant within a contact flocculation-filtration (CFF) pilot plant rig. CFF is defined as the high rate filtration process for relatively low turbidity raw waters (< 50 NTU) wherein the coagulant is dosed immediately prior to entry to the sand bed.

Flocculation and subsequent deposition occurs entirely within the filter bed. A wide range of operating conditions was evaluated in order to establish the useful working envelope of operational parameters for this single stage process. Previous studies had shown that at the low turbidities of the River Swazi experienced in the dry season, the effectiveness of M. Oleifera coagulant is reduced. Flocks that formed were small, compact and light giving reduced settling velocities. This is considered to be a result of the fundamental nature of the coagulation and flocculation involved. The relatively low molecular weight of the active proteins indicates that charge neutralization and flock formation are brought about by the patch mechanism as opposed to the bridging Mechanism (Gregory, 1991).

The field installation of the pilot CFF rig and full experimental details are given elsewhere (Mc Connachie et al., 1999), however, for prevailing raw water turbidities of < 50 NTU the single stage treatment of CFF gives consistent filtrate turbidity < 1 NTU for filtration rates up to 10 mh^{-1}. Moreover, the M. Oleifera seed dose required to achieve this is relatively low (< 25 mgL) and the filter run times are appropriate for effective plant operation.

As a coagulant within chemically enhanced primary sedimentation (CEPS) of a mixed domestic industrial wastewater, M. Oleifera dosed at 150mgl/l gave additional removals (compared to a plain sedimentation control) of 40% for biochemical oxygen demand (BOD) and chemical oxygen demand (COD) and in excess of 80% for suspended solids (SS) (Folkard et al., 1999). Subsequent laboratory work at the University of Ghent coupled an up flow anaerobic sludge blanket reactor (UASB) to CEPS (Kalogo et al., 2000). The UASB process relies on the propensity of anaerobic biomass to aggregate into dense flocks or granules over time. Mixing is achieved by pumping influent wastewater from an entry at the base upwards through the sludge blanket. Above the blanket, finer particles flocculate

In the upper settlement zones and settle back as sludge in the blanket thus preventing washout of biomass. The biogas, which has poor solubility in water, is separated at the top of the reactor. Domestic wastewater treatment in UASB reactors has proved particularly effective in tropical regions of the world.

Effective removal of organic matter and suspended solids is evident at reduced excess sludge volume compared to aerobic treatment. The system is compact, requires minimal energy inputs and does not require support media normally associated with anaerobic systems (De Sousa et al., 1996). UASB is characterized by a very high mean cell retention time (MCRT) and a relatively low hydraulic retention time (HRT). M. Oleifera coagulant in the CEPS pre- treatment unit beneficially increased the ratio of soluble COD to volatile SS by a factor of 10 compared to plain sedimentation and 3 when dosing ferric chloride as coagulant. The UASB yielded more biogas and gave 71% removal of total COD at 2 hours HRT. This compared with 54% removal of total COD at the same retention time when ferric chloride was used.

The loading capacity of an anaerobic wastewater treatment system is essentially determined by the amount of active biomass retained in the reactor. In UASB reactors, the microbial aggregates must combine two important characteristics, namely a high biodegradation activity and excellent settling properties, favored by the formation of granular sludge particles. One of the main problems in the application of this treatment process so far has been the extensively long start-up periods needed for the development of granules (up to six months).

In a subsequent study, a water extract of M. Oleifera seeds was used to enhance the start-up of a self-inoculated UASB reactor treating raw domestic wastewater (Kalogo et al, 2001). Two reactors labeled control and test were started without special inoculums. Both reactors were fed continuously for 22 weeks with domestic wastewater with an average total COD of 320 mg L/l and SS of 165mgL. The reactors operated during the entire experimental period at 29°C and at a HRT of 4 hours. The test reactor received 2 mg L of a 2.5% (w/v) M. Oleifera seed stock solution per liter of influent wastewater. The test reactor gives the following enhanced performance advantages over the control:

1. Shortened the biological start-up period by 20%.
2. Increased the cidogenic and methanogenic activity by factors of 2.4 and 2.2respectively.
3. Increased the specific biogas production by a factor of 1.6.
4. Favored fast growth of the sludge bed.
5. Allowed the aggregation of coccid bacteria and growth of microbial nuclei - the precursors of anaerobic granulation.

There are a number of food production processes where solid/liquid separation is an essential stage to achieve the final product quality. One such example is the production of sugar from sugar cane. In the production of organic sugar, the use of synthetic polyelectrolyte to remove extraneous solids suspended in the cane juice is not permitted. Coagulant derived from natural plant materials are used e.g. the bark of atrium feta lap pula and gum from Lanai co roman delica. A laboratory study was conducted at the Mauritius Sugar Research Institute to evaluate the efficacy of applying M. Oleifera seed coagulant to clarify limed cane juice (Wong Sack Hoi et al, 1999). In one test series, M. Oleifera dosed at 0.48% gave a 37% increase in turbidity removal compared to a proprietary coagulant (Super floc, A, 2013). Other tests were conducted with the addition of betonies in small quantities as a weighting agent to the M. Oleifera flocks. The authors conclude that the quantities of M.

Oleifera seed that would be required for the daily production of cane juice are favorable compared to alternative natural coagulants in use.

Treating water with water extracts of M. Oleifera seeds has one identified disadvantage. The coagulant-inactive seed material that is also water-soluble leads to elevated dissolved organic materials in the treated water (nitrates, orthophosphates etc.). If chlorination is adopted for final disinfection of the clarified water then the potential for the formation of disinfection by-products (DBP) is increased. DBPs such as chloroform are suspected carcinogens and are strictly regulated in Europe and the United States. Residual organic matter may also exert a chlorine demand at the treatment works and be utilized by microorganisms as substrate for re-growth in the distribution system. Therefore there has been much recent research work on the extraction and purification of only the coagulant-active proteins from within the seed kernel. Protein extraction and purification from M. Oleifera seed has been reported at laboratory scale only.

Studies were carried on by securing a few milligrams of pure protein for the characterization of coagulant activity and structure. Extraction of the proteins using 1 mg sodium chloride solution gave enhanced coagulation at significantly reduced dosage compared to water extracted material 95% turbidity reduction at 4 ml / L compared to 78% reduction at 32 ml/ L for a prepared test water comprising kaolin in water of initial turbidity 50 NTU (the dosage being expressed as volume of 1% stock seed solution, (Okuda et al., 1999). The improvement in extraction is attributed to the salting in mechanism whereby increased ionic strength gives increased protein solubility. The extraction of seed proteins in other salts gave similar improvements. (Okuda et al., 2001);

The purified material was deemed to be an organic polyelectrolyte of molecular weight around 3 kDa - but not to be a protein, polysaccharide or lipid. The authors claim that the specific coagulation efficiency‘ of this active material is up to 34 times more than that of a water extract of seed, that it is effective for low turbidity waters and that no increase in residual organic carbon is evident following application. Bhuptawat1 et al., (2007), achieved overall COD removals of 50% at both 50mg/l and 100 mg/l M. Oleifera doses. When 50 and 100 mg/l seed doses were applied in combination with 10 mg/l of alum, COD removal increased to 58and 64% respectively.

Studies by (Eilert et al, 1981) identified the presence of an active microbial agent in M. Oleifera seeds. The active agent isolated was found to be 4 α-L-r harmnosyloxy- benzyl isothio cyanate, at present the only known glycoside mustard oil. (Madsen et al., 1987) carried out coagulation and bacterial reduction studies on turbid Nile water in the Sudan using Moringa Oleifera seed and observed turbidity reduction of 80- 99.5% paralleled by bacterial reduction of (90-99.99%) within the first one to two hours of treatment, the bacteria being concentrated in the coagulated sediment. Also a study has shown that Moringa Oleifera as a coagulant is non-toxic and biodegradable and usually presumed safe for human consumption (Grabow et al., 1985).

(Muyibi and Evision, 1995), investigated into the possible use of Moringa Oleifera seed suspension for the softening of hard water. Four water sources: synthetic water (distilled water spiked with calcium chloride), naturally hard surface water and groundwater from two tube wells at different locations were used for the study.

Modified laboratory jar test procedures for coagulation studies were used for the experimental runs. Water hardness from the sources varied from 300 up to 1000 mg/l as Ca CO. The mechanism for softening was found to be due to adsorption with the adsorption isotherm approximating to the Langmuir type, and conversion of soluble hardness-causing ions to insoluble products by precipitation reactions. Removal efficiency was found to increase with increasing dosage of Moringa Oleifera. Higher dosages were required to achieve equivalent residual hardness for water samples with the same initial hardness but higher number of hardness-causing species in the water.

Hardness removal was found to be independent of pH of the raw water. (Al-Khalili et al, 1997) found low doses of Moringa Oleifera extract to be effective in contact flocculation filters for low turbidity waters. Experiments were performed with laboratory sand contact flocculation filters at filtration rates of 10 and 20 m/hr and at raw water turbidities from 10 to 75 NTU. Experiments showed that the natural coagulant was effective on low turbidity water at filtration rates at or below 10m/hr.
Moringa Oleifera seeds, an environmental friendly and natural coagulant are reported for the pretreatment of palm oil mill effluent (POME). In coagulation–flocculation process, the M. Oleifera seeds after oil extraction (MOAE) are an effective coagulant with the removal of 95% suspended solids and 52.2% reduction in the chemical oxygen demand (COD). The combination of MOAE with flocculants (NALCO 7751), the suspended solids removal increased to 99.3% and COD reduction was 52.5%. The coagulation–flocculation process at the temperature of 30°C resulted in better suspended solids removal and COD reduction compared to the temperature of 40, 55 and 70°C. The MOAE combined with flocculants (NALCO 7751) reduced the sludge

Volume index (SVI) to 210 mL/g with higher recovery of dry mass of sludge (87.25%) and water (50.3%) (Bhatia et al, 2007). (Ndabigengesere and Narasiah , 1998) experimented with using Moringa Oleifera seeds as a primary coagulant for the treatment of industrial and municipal wastewater. Extracts from pulverized Moringa seeds efficiently reduced the chemical oxygen demand, nitrogen and phosphorus concentrations of the wastewaters.

The coagulant of seeds could be used for wastewater treatment (Foidl et al., 2001). Although many studies have been carried out on Moringa Oleifera’s efficiency as a coagulant (Muyibi and Okufu, 1995; Muyibi and Evison, 1996), studies on the effects of its coagulation performance on wastewater for vegetable irrigated farms have not been established yet.

Chapter Three

Materials and Methods

3.1 Study area

Tana is one of the Sudanese military factory manufacturing (TNT, DNT and MNT) lying in the north of Sudan near Shandy town. Design capacity of industrial acidic wastewater is 288 m^3 /day with pH value 1.2. Treatment ability 12m^3/hr. Quality index of acidic wastewater and water discharge according to the data from process design concentration of nitro compound in acidic wastewater<210 mg/l, concentration of acid (as H_2SO_4) <1%, quality data of water to be discharged after treatment nitro compound <5mg/ l , pH value 6-9.

Wastewater treatment station consists of wastewater regulation pond, wastewater treatment building and sludge drying bed. The wastewater treatment building covers about 432m^2 areas. With 36m length and 12m width, which includes the following rooms, (treatment room, on-duty control room and analysis room).With three shifts working time, persons required for each shift are 6, with the total number of 18 persons.

Source and volume of wastewater, powder contained acidic wastewater to be treated in wastewater treatment building (A_1) mainly comes from nitration and purification building (A_2), drying building (A_3) and spent acid treatment building (A_4). Table (3.1) explains factory wastewater volume. It is process wastewater, process equipment flushing wastewater and floor flushing wastewater. Main pollutants in wastewater include nitro-base organic compounds such as TNT, DNT and MNT, sulfuric acid and small amount of nitric acid.

Table (3.1): Factory wastewater volumetric rate:

Serial Number	Sources	m^3/day	m^3/hour
1	A_1 TNT nitration and purification building	11.4	0.48
2	A_2 Drying and packing building	1.6	0.07
3	A_3 Spent acid treatment building	218.8	9.12
4	Unforeseen volume	34.8	1.45
Total		266.7	11.1

3.2 Chemicals and equipment:

3.2.1 Chemicals:

The materials used in the project are listed as follows:

1. CaCl by APHA standard method for the analysis of water and wastewater, 20th Edition.
2. FeCl by APHA standard method for the analysis of water and wastewater, 20th Edition.
3. $MnSO_4$ by APHA standard method for the analysis of water and wastewater, 20th Edition.
4. H_2SO_4 by APHA standard method for the analysis of water and wastewater, 20th Edition.
5. $MgSO_4$ by APHA standard method for the analysis of water and wastewater, 20th Edition.
6. $Na_2S_2O_3$ by APHA standard method for the analysis of water and wastewater, 20th Edition.
7. Azed by APHA standard method for the analysis of water and wastewater, 20th Edition.

8. Baffer by APHA standard method for the analysis of water and wastewater, 20th Edition.
9. $K_2Cr_2O_7$ by APHA standard method for the analysis of water and wastewater, 20th Edition.
10. K_2SO_4 by APHA standard method for the analysis of water and wastewater, 20th Edition.

3.2.2 Equipment and tools:

The equipment used in the project is listed as follows, plates (1to 6) show the need of each:

1. Tubes different size.
2. Pipettes.
3. Beakers (100-250-500) ml.
4. Oven.
5. Filter paper (what man).
6. Glass bottle.
7. Digital balance 0.01gm.
8. pH meter AR15-Fisher Scientific.
9. Glass rod.
10. Burette.
11. Spoon and vacuum pump.
12. A magnetic stirrer.

3.3 Experimental Procedures:

3.3.1 Introduction:

At first, quantities of industrial wastewater with pH value 1.2 were collected. Leaves of Moringa trees were also collected, dried, and grinded and kept in two glass bottles. The weight approximately 500gm.In the initial experiments, we chose weights from (1to5 gm) of the weight of the

Moringa leaves, and found that the value of (pH,BOD,COD,TDS,S^{-2}) began to increase and in light of these good results ,we decided to take the lowest weight 5 gm and the highest weight of 12.5 gm, so we got excellent results for each of the (pH,BOD,COD,TDS,S^{-2}).And when we chose weight of 15 gm we found there were difficulties in dissolving. The procedures that were use in the project are given below.

3-3-2 pH:

1. Diagram of lab scale that consists of beakers, digital balance, glass rode, spoon, pH meter, filter paper, burette, spoon and vacuum pump.
2. Two Liters of industrial wastewater from Tana factory with pH 1.2 were purchased.
3. Two Bottles (500 mg) of dried and grinded Moringa were prepared.
4. The experiments were carried out in Omdurman Military Medical Center Laboratories (BOD, COD, pH, TDS, S^{-2}).
5. (5, 7.5, 10, and 12.5) gm of Moringa leaves were weighted and dissolved in 100 ml of industrial wastewater.
6. Four testes at different times were done, at temperature 25^{o}c .Each test gave four results, which were read and tabulated.
7. Recycle leaves were dried and used tow times and pH was measured.
8. The flow sheet of the lab scale showed that small scale facilities could be scaled up to make a pilot plant.

3.3.3 Biological Oxygen Demand (B O D):

1. (5, 7.5, 10and12.5) gm of Moringa powder were taken and dissolved in 100 ml industrial wastewater.
2. Four samples were filtered with Moringa powder by filtration paper and were taken 100 ml by pipette and vaccumate in 500ml beaker.
3. In 1000 volumetric flask sample were completed by distil water to

mark on flask.

4. Samples were distributed on 3 BOD bottle 300 ml.
5. In first day DO_1 were accounted in one bottle and two other BOD bottle in biochemical incubator were saved for five days under 20^oc.
6. Feeding water (food for bacteria) were prepared by add 2ml from ($MgSO_4$-Cacl-Fec-Baffer) for every litter from distil water.
7. In 1000 ml volumetric flask Sample were diluted by feeding water to the mark.
8. On 3 BOD bottle samples were distributed.

9.To calculate DO_1 (300ml) of BOD bottle were taken and 2ml a zaid were added immediately configuration brown precipitate then 2ml H_2SO_4 were added precipitate is dissolved and 2was be free .

10. 200 ml were taken from solution, and titrated against Na_2SO_3 by using starch as indicator.

11. Readings were taken from purate and were recorded this process every hour for 4 times.

12. Same steps were done after 5 days to calculate DO_2 for BOD bottle.

13. Law of BOD=

$$BOD=\frac{DO_1-DO_2\times 1000}{V} \tag{3.1}$$

3.3.4 Chemical Oxygen Demand (COD):

1. (5, 7.5, 10, and 12.5) gm of Moringa leaves were taken and dissolved in 100ml of industrial wastewater.
2. (Blank) 2.5ml distil water were taken and 1.5 $K_2Cr_2O_7$ and 3.5H_2SO_4 conc. were added.
3. Two concentrate (2ml, 1ml) or (0.5ml, 1 ml) were taken (depending to the turbidity).

4. 1.5 $K_2Cr_2O_7$and 3.5H_2SO_4 were added.
5. 0.5 distil water were added to 2 ml to complete volume to 2.5 ml.
6. For volume 1ml, 1.5 distill water were added to complete volume to 2.5 ml also.
7. Samples and (Blank) were put in oven under 150^{o}C for two hours.
8. After time complete samples and (Blank) were taken to titrate by F.A.S (Fe $(NH_4)2(SO_4)26H_2O$) were added to solution 1drop of indicator ferr.
9. End point of titrate were taken when the color change to dark brown
10. Reading for (Blank) and sample were recorded.
11. Use the low:

$$\frac{(B\text{-}A)\times 800}{V \text{ of sample}} \tag{3.2}$$

B = reading of Blank.

A = reading of sample.

3.3.5 Total Dissolved Solid (TDS):

1. (5, 7.5, 10, and 12.5) gm of Moringa leaves were weighted and dissolved in 100ml of industrial wastewater.
2. Four testes at different times were done in pH meter.

3.3.6 Sulfide (S^{-2}):

1. Blank as sample (KI (10ml+1mlHCL1:1) were titrated.
2. (5, 7.5, 10and 12.5) gm of Moringa leaves were weighted and dissolved in 100ml of industrial wastewater.
3. 100 ml from sample were taken by cylinder and vaccumate in beaker.
4. 1 ml HCL1:1 and 10 ml KI were added.
5. Samples were titrated and addition by Na_2SO_3 until color translates to yellow.

6. After that 3 drop from starch as indicator were added until sample be colorless then reading were taken.
7. Results in low were applied:

$$S^{-2} = \frac{B - A \times 16000 \times 0.025}{100ml} \quad (3.3)$$

B: Blank.

A: Sample.

0.025: Molarity of KI.

16000: Const.

3.3.7 Determination of nitro component Di-nitro-toluene (DNT):

1. The experiments were carried out in Tana Military Factory Center Laboratories.
2. 500ml of industrial wastewater before treatment were prepared.
3. (5, 7.5, 10 and12.5) gm of Moringa were weighted and dissolved in 100ml of industrial wastewater.

4. 5 tubes in same size were taken, in tube (1) 3ml distil water were added, tube (2and 3) 3ml of industrial wastewater before treatment were added, tube (4and5) 3ml wastewater after treatment were added.

5. 3ml of HCL in 5 tubes were added and reduction by 1gm of Zink powder.

6. Five tubes were filtrated by filter paper (what man).

7. Two ml of sodium nitrate ($NaNo_2$) were added in 5 tubes.

8. Two ml of ammonia sulfide ($NH_4SO_3.2H_2O$) were added.

9. Distill water were added until volume 25ml in 5 tubes.

10. After 30 minutes result were taken.

11. All process at 23^oc.

3.3.8 Determination of nitro component Tri-nitro-Toloune (TNT):

1. The experiments were carried out in Tana Military Factory Center Laboratories.
2. 500ml of industrial acidic wastewater before treatment were prepared.
3. (5, 7.5, 10and12.5) gm of Moringa were weighted and dissolved in 100ml of industrial acidic wastewater.

4. Five tubes in same size were taken, in tube (1) 10ml distil water were added, tube (2and3) 10ml of industrial acidic wastewater before treatment were added, tube (4and5) 10ml wastewater after treatment were added.

5. two ml of HCL in 5 tubes were added and reduction by 1gm of Zink powder.
6. Five tubes were filtrated by filter paper (whatman).
7. Two ml of (H_2SO_4) in 5 tubes were added and shacked.
8. Two ml of (Na_2SO_4) in 5 tubes were added and shacked.
9. Distil water were added until volume 25ml in 5 tubes.
10. After 20 mints result were taken.
11. All process at 23^{o}C.

3. 4 Moringa Plantation:

Field experiments were conducted for two consecutive seasons (2011\2012- 2012\2013) in the Demonstration Farm at Shambat (latitude 15º40´ N, longitude 32º32´ E and altitude 386m above sea level) at the Sudan University of Science & Technology, College of Agricultural Studies, to study two Moringa species. The Moringa seeds that were used in this study were obtained from the Seed Research Centre (Soba) Khartoum Sudan.

Complete randomized block design with four replications were used to execute this experiment using three irrigation intervals (control irrigated every 10 days [irrigation 1]; the other watering intervals extended every 20 days [irrigation 2] and 30 days [irrigation 3]. The spacing between ridges was 70 cm. The plot size was 3 x 3 m ridge. Seed rate was two seeds shown per hole spaced at 15 cm along the ridge. Nitrogen (urea) was applied four weeks after sowing at a rate of 112g N/ plot. The experiment was irrigated firstly every seven days, and after the seed germinated, irrigation intervals of the treatments were every 10 days, 20 and 30 days. The fertilizer was applied after 2 months.

The Harvesting was carried out after four to five months .Five tagged plants from each plot were chosen randomly for each plot treatment to monitor the growth characteristics every week .Plant height was measured from the soil surface to the upper plant recorded as the average plant height expressed in centimeters .Also all the leaves in the five tagged plants and the average number of leaves per plant was determined. The thickness of the stalk at the middle of internodes from the plant base was measured using digital vernier caliper.

The fresh weight of the total number of plants (five plants/plots), was taken per square meter, by cutting plants from each plot and weighting using a balance. The fresh forage yield was left to dry in the air and then weighed again to give the dry weight by using sensitive balance. The same plants which were harvested to take fresh weight were taken to estimate root dry weight, the roots were separated from fresh plant stems and dried by air, and dry weight was measured by using sensitive balance.

3.5 Treatment Method of Moringa leaves:

Moringa trees are planted around the factory in three rows with three meters space between the rows. Harvesting of leaves is to be carried out after four to five month; starting from the first row .Then the second, then the third and vice versa. The leaves are to be dried on concrete made of cement platform and it has to be grounded in mills; then to be weighted using sensitive balance weighting machine. The seeds are to be squeezed for extraction of oil used for as nutrition food, and the wood is used for burning.

These leaves should be added to the industrial acidic wastewater in tank through a pipe, the amount of wastewater is about ($288m^3$/day) Moringa leaves are about (36 tons/day), after three hours samples should be taken for (pH, BOD, COD, TDS, and S^{-2}) and analysis.

The treated water should be filtered by three different size filters, and then the leaves contained in filter should be dried and used as an isolator in the ceiling roof of the house made of metal or as an isolator in factory bakeries .Finally the water after treatment is used for irrigation of Moringa trees around the factory. Figure (3.1) shows the schematic diagram of the experiment setup and figure (3.2) shows the process flow sheet of Moringa.

Plate 3.1: Beakers and stop watch and conical flasks

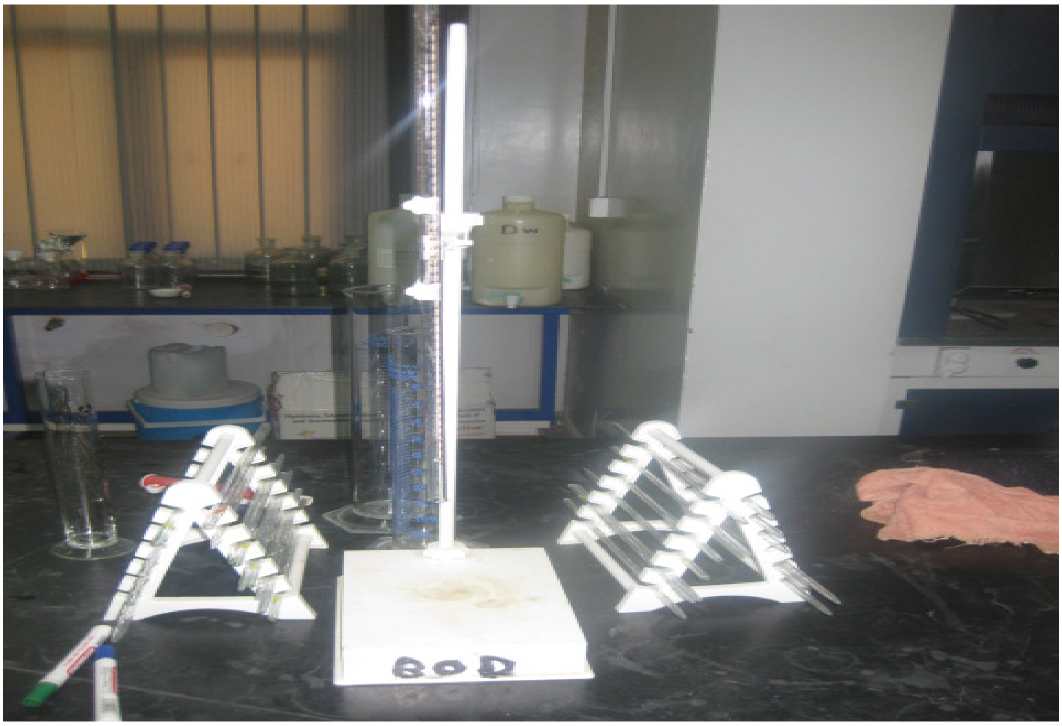


Plate 3.2: BOD Bottle and COD tubes.

Plate 3.3: Automatic Pipette.

Plate 3.4: pH meter.

Plate 3.5: COD reactor

Plate: 3.6: Incubator

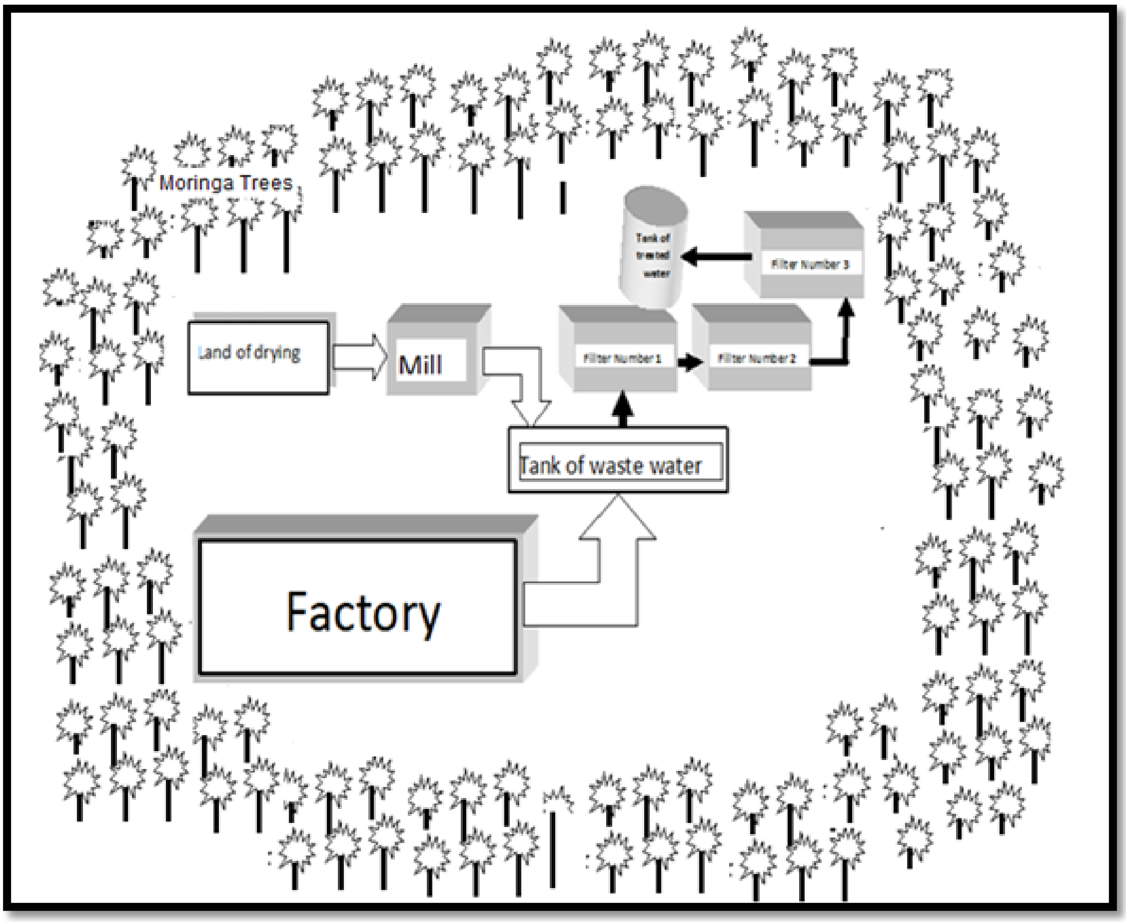


Figure (3.1): Schematic diagram of the experiment setup

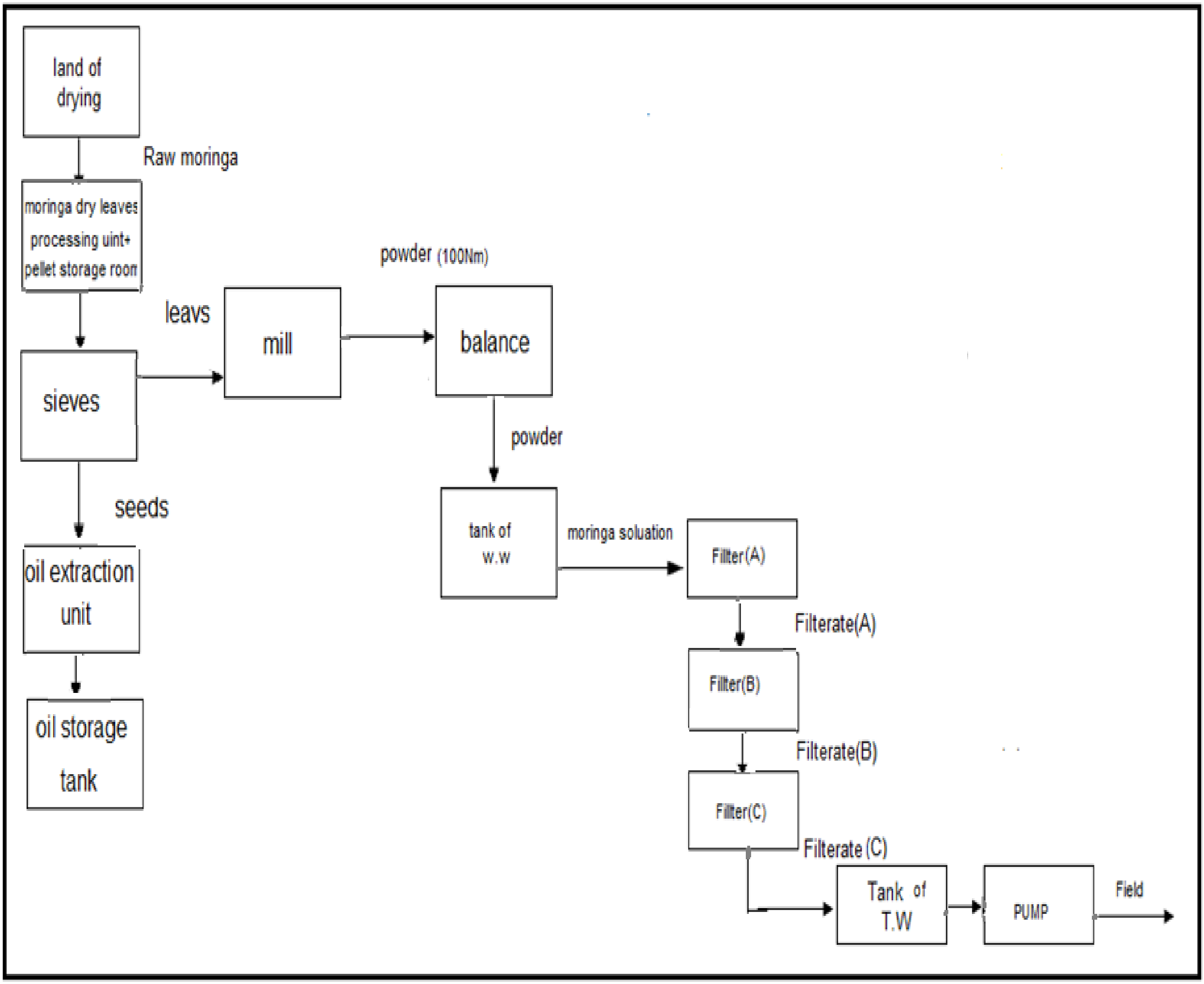


Figure (3.2): Process Flow Sheet of Moringa 1

Chapter four

Results and Discussion

4.1 Introduction:

This part contains the results obtained through the procedure shown in (3.5).

4.2pH measurement:

pH meter was used and industrial acidic wastewater(IAWW) of pH value 1.2 mixed with Moringa , each test consists of four results ,which were read and tabulated Four readings were obtained for different weights and times. Flow charts were plotted from the obtained data, tabulated in tables (1, 2, 3, 4 and 5) and plotted in figures (1, 2, 3, 4 and 5).

4.2.1 Experimental work:

Table (4.1) Effect of Moringa in the treatment process (pH):
Weight 5 gm:

Time(hr)	pH
1	6.50
2	6.52
3	6.54
4	6.55

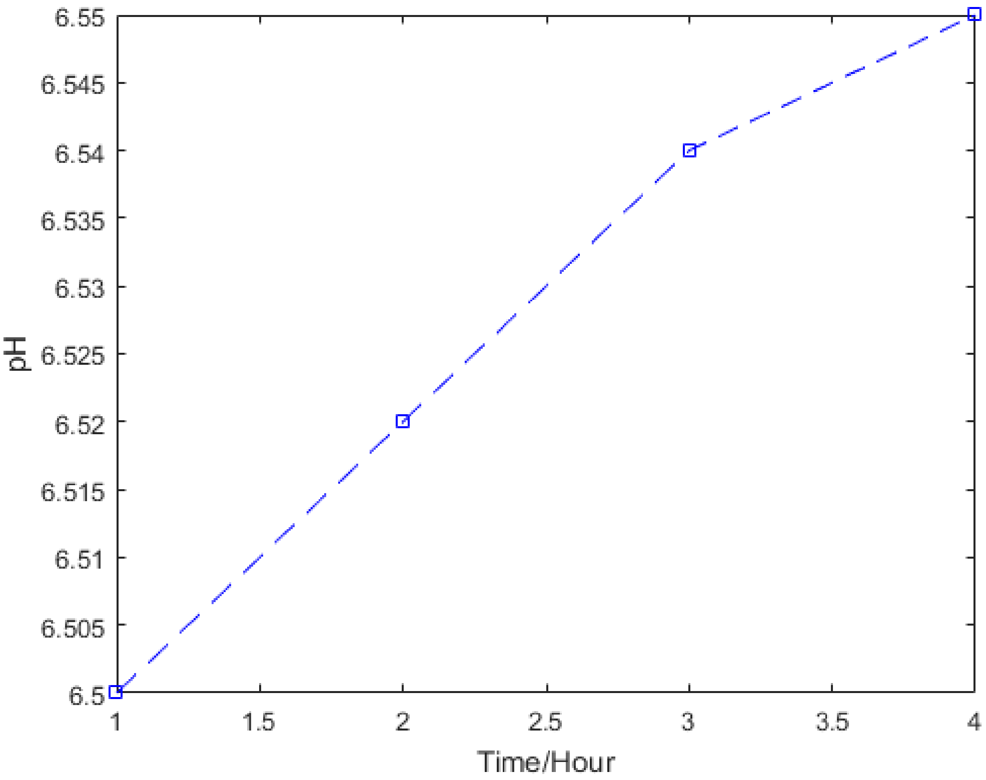


Figure (4.1): Effect of Moringa in the treatment process (pH).

Table (4.2) Effect of Moringa in the treatment process (pH):
Weight 7.5 gm:

Time(hr)	pH
1	6.60
2	6.63
3	6.66
4	6.67

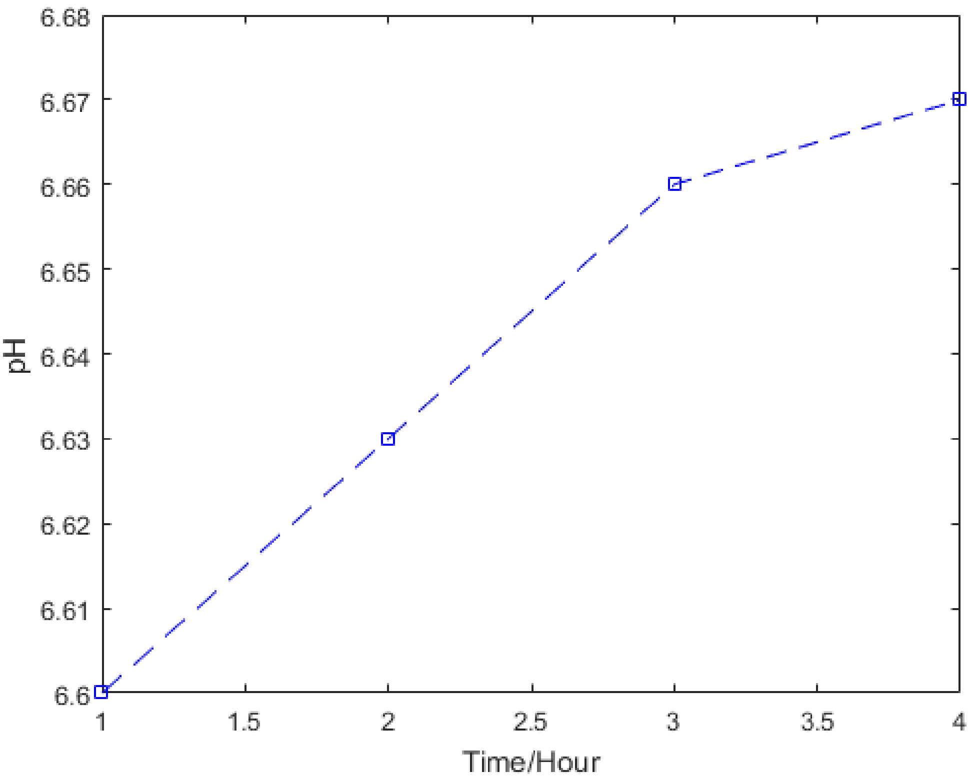


Figure (4.2): Effect of Moringa in the treatment process (pH).

Table (4.3) Effect of Moringa in the treatment process (pH):
Weight 10 gm:

Time(hr)	pH
1	6.75
2	6.76
3	6.77
4	6.77

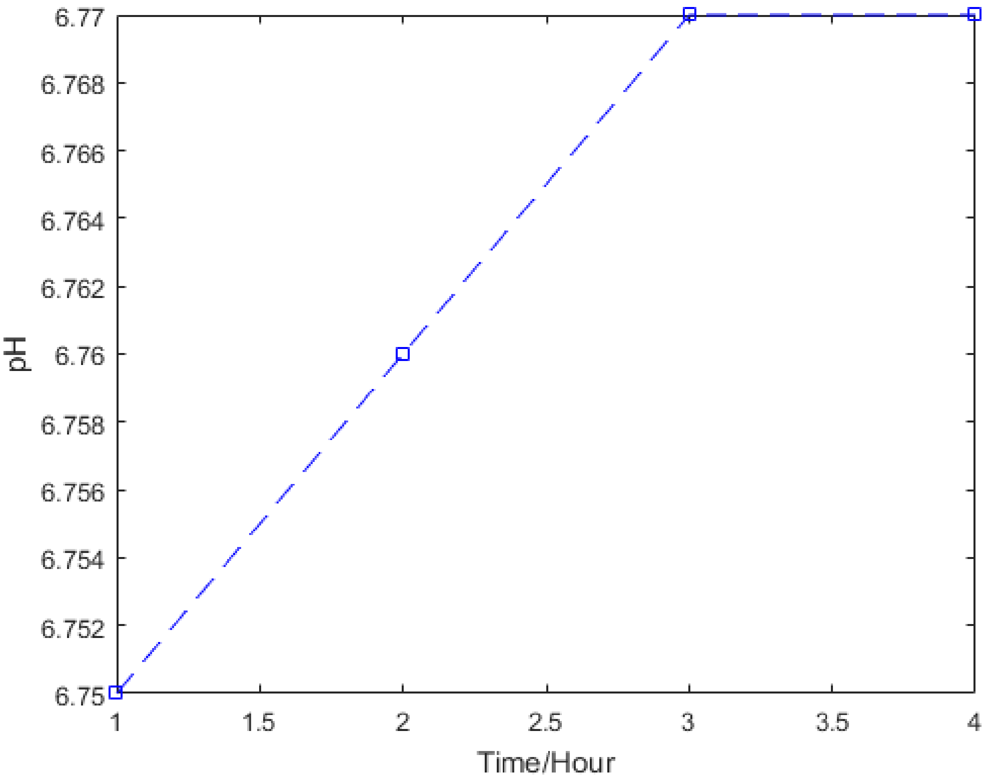


Figure (4.3): Effect of Moringa in the treatment process (pH).

Table (4.4) Effect of Moringa in the treatment process (pH):
Weight 12.5 gm:

Time(hr)	pH
1	6.80
2	6.79
3	6.81
4	6.81

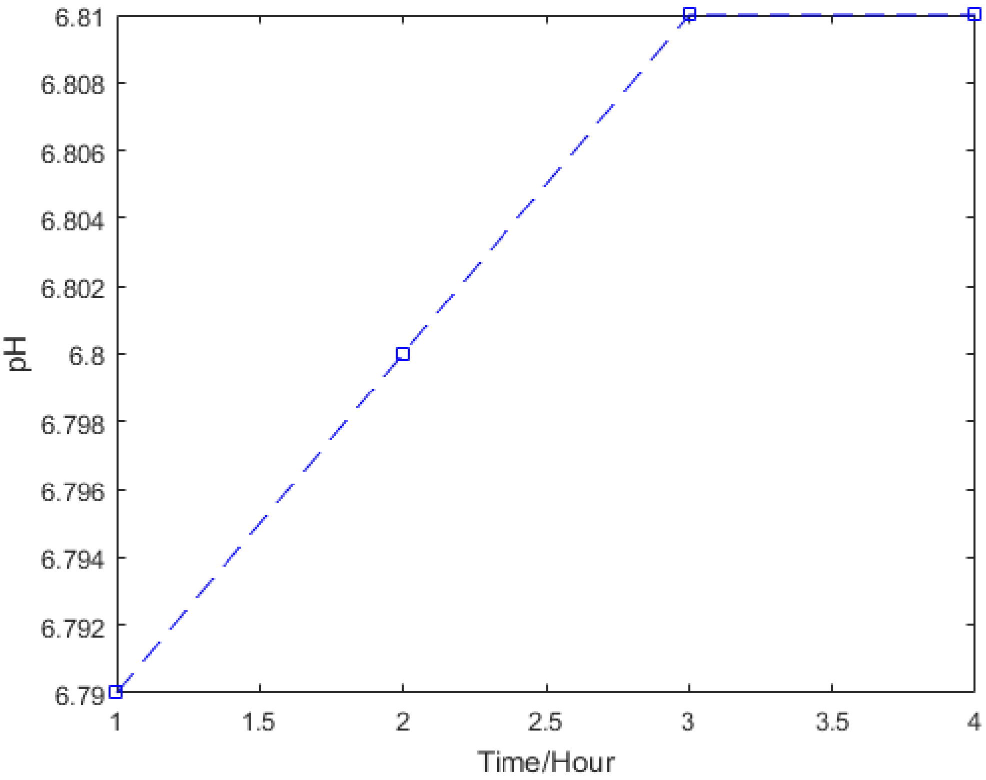


Figure (4.4): Effect of Moringa in the treatment process (pH).

Table (4.5) Effect of Moring in treatment process (pH removal):

Weight(gm)	pH/1 hr	pH/2 hr	pH/3hr	pH/4hr
5	6.5	6.52	6.54	6.55
7.5	6.6	6.63	6.66	6.67
10	6.75	6.76	6.77	6.77
12.5	6.8	6.79	6.81	6.81

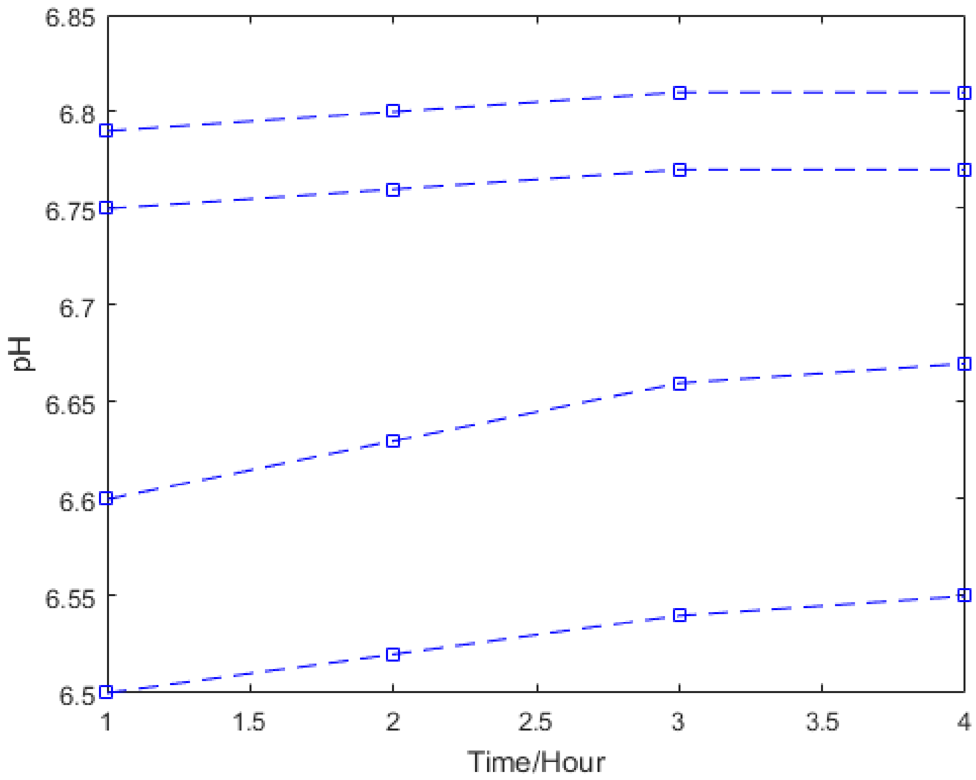


Figure (4.5): Effect of Moringa in the treatment process (pH).

Table (4.5) and figure (4.5) show the effect of Moringa on pH at temperature 25^{o}C under atmospheric pressure, for the first reading. Four readings were obtained for different weights and time. The test results showed that there was increase from (the first hour to the fourth hour) in pH value until it reached 6.81. Industrial Acidic wastewater with pH value 1.2 mixed together with a (10%)sodium hydroxide lye until the pH value 6was reached , now pH value 6.8 without addition of sodium hydroxide was obtained. The pH value after 3 hours 6.8 which was an ideal value that matches the Sudanese Specification Corporation (SSMO, NO 137, 2008). The 3 hours time was found to be the optimum time for (AWW) to be treated with Moringa.

4.3 Biochemical Oxygen Demand (BOD):

Industrial acidic wastewater of (BOD) value 30 mg/l mixed with Moringa in different weights and time. Four tests were done, each test consists of four results, which were read and tabulated. Flow charts were plotted from the obtained data, tabulated in tables (1, 2, 3, 4 and 5) and plotted in figures (1, 2, 3, 4 and 5).

Table (4 6) Effect of Moringa in the treatment process (BOD):

Weight 5 gm:

Time(hr)	BOD
1	9.60
2	8.90
3	8.60
4	8.60

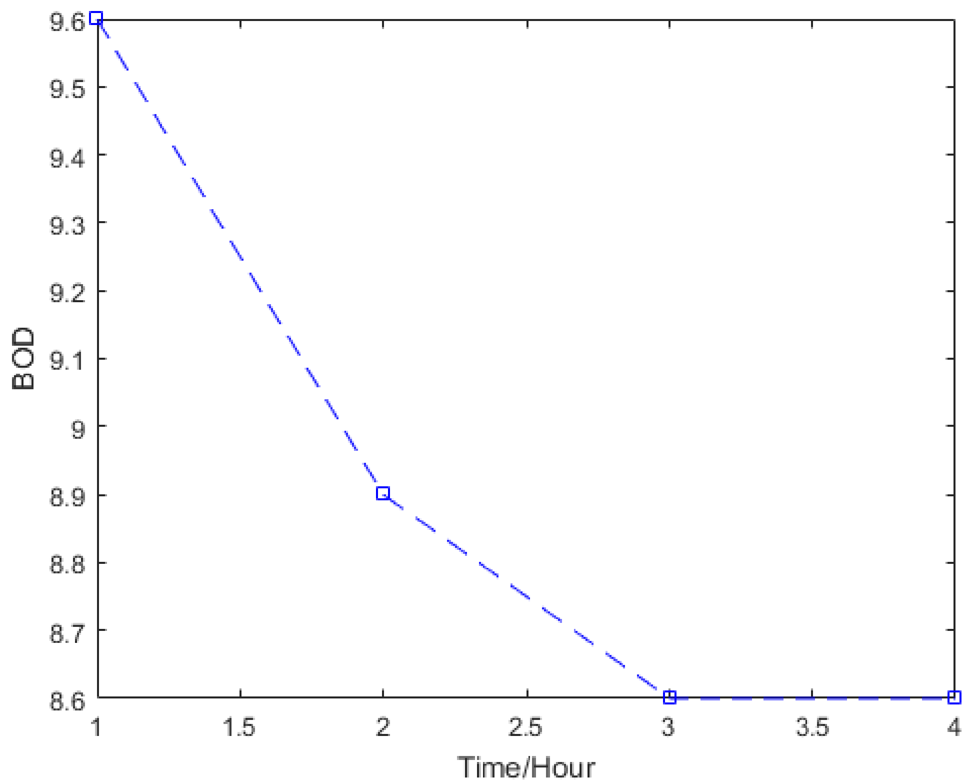


Figure (4.6): Effect of Moringa in the treatment process (BOD).

Table (4 7) Effect of Moringa in the treatment process (BOD):
Weight 7.5 gm:

Time (hr)	BOD
1	7.80
2	7.20
3	7.10
4	7.00

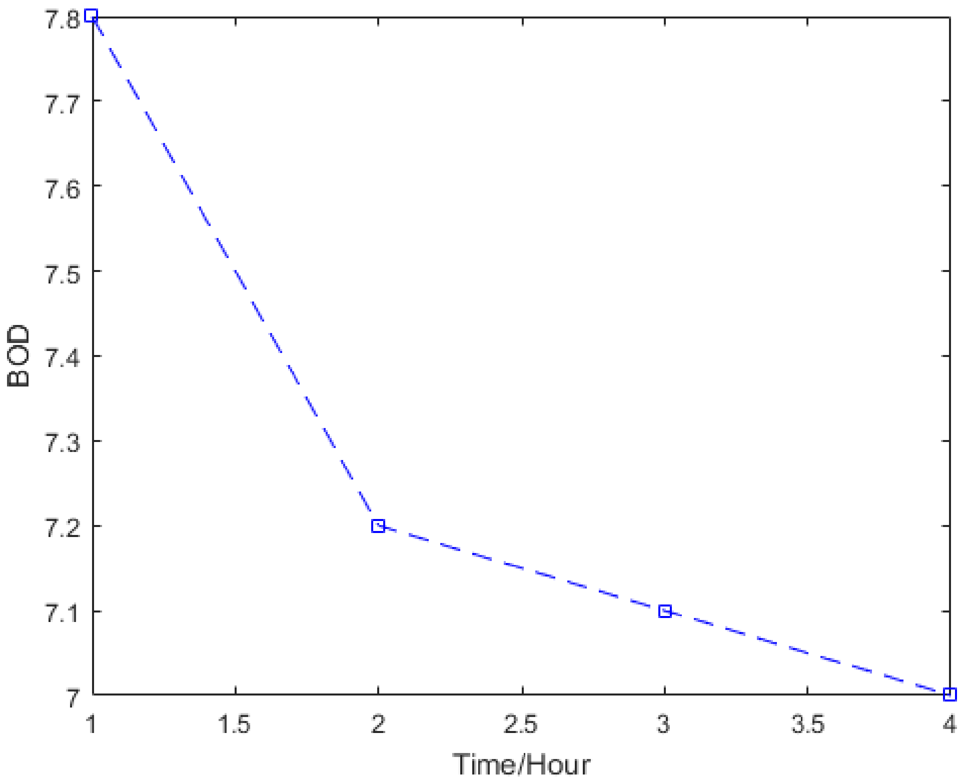


Figure (4.7): Effect of Moringa in the treatment process (BOD).

Table (4.8) Effect of Moringa in the treatment process (BOD):
Weight 10 gm:

Time(hr)	BOD
1	6.90
2	6.40
3	6.20
4	6.00

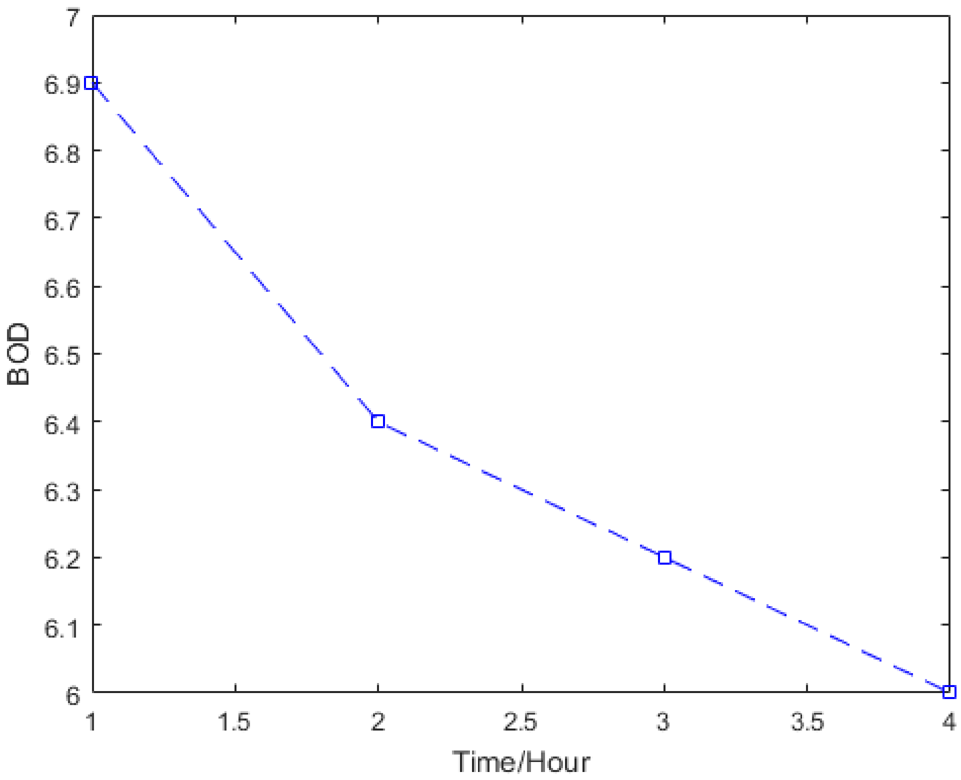


Figure (4.8): Effect of Moringa in the treatment process (BOD).

Table (4.9) Effect of Moringa in the treatment process (BOD):
Weight 12.5 gm:

Time(hr)	BOD
1	5.90
2	5.20
3	5.00
4	5.00

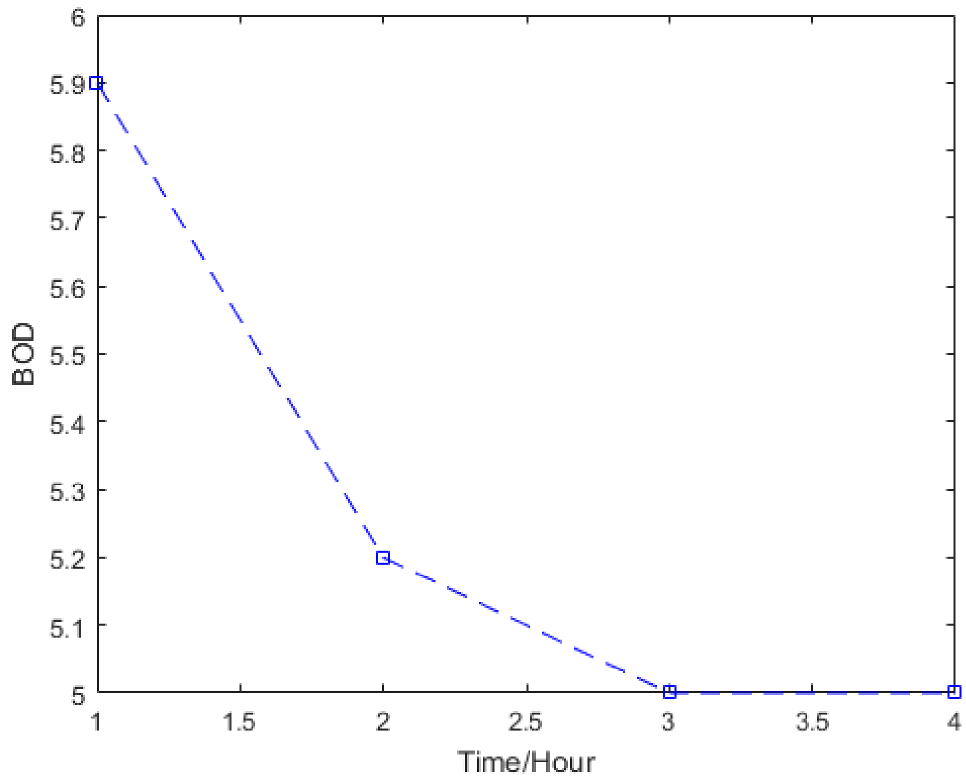


Figure (4.9): Effect of Moringa in the treatment process (BOD).

Table (4.10) Effect of Moring in treatment process (BOD removal):

Weight (gm)	BOD/1hr mg/l	BOD/2hr mg/l	BOD/3hr mg/l	BOD/4hr mg/l
5	9.6	8.9	8.6	8.6
7.5	7.8	7.2	7.1	7
10	6.9	6.4	6.2	6
12.5	5.9	5.2	5	5

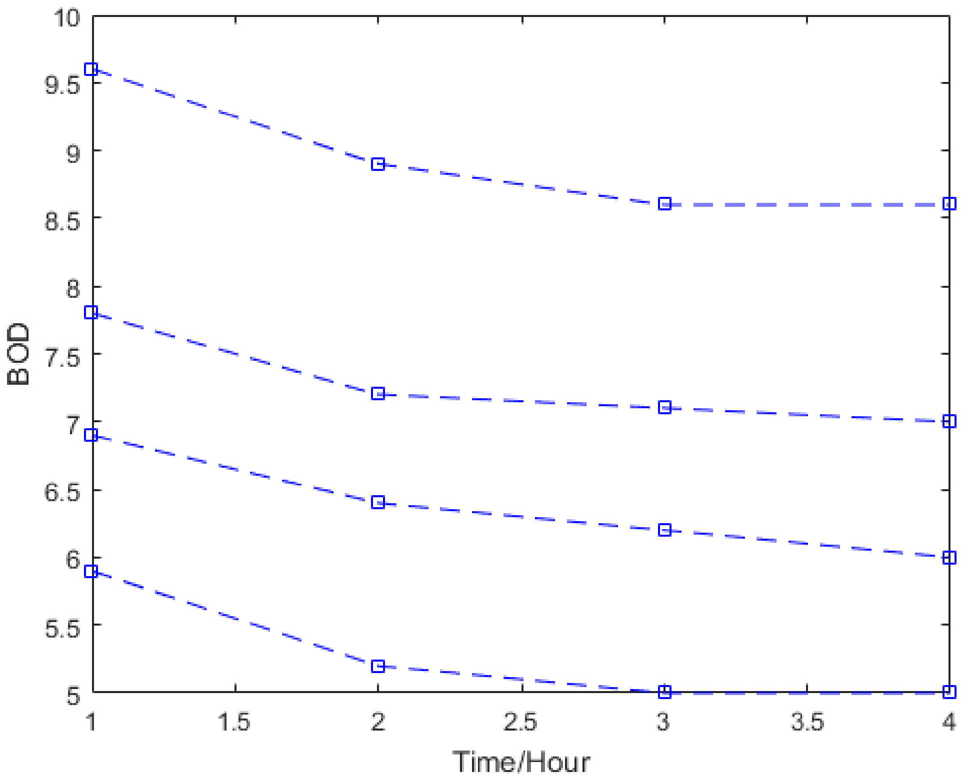


Figure (4.10): Effect of Moringa in the treatment process (BOD).

Table (4.10) and figure (4.10) show the effect of Moringa on (BOD) at temperature 25^{o}C under atmospheric pressure, for the first reading. Four readings were obtained for different weights of the Moringa. The test results showed that there was decrease in the (BOD) value throw the four hours in the range of 30 values to 5 when Moringa is used. It can be notice that the value of (BOD) depends on the weight of Moringa; increasing the weight of Moringa decreasing the value of (BOD) of the treated industrial acidic wastewater. The (BOD) value after 3 hours 5mg/l which is an ideal value that matches the Sudanese Specification Corporation SSMO, NO137, 2008, the value of (BOD) in treatment by Moringa it is magnificent value. The 3 hours time was found to be the optimum time for (BOD) decrease in acidic wastewater treated with

Moringa.

4.4 Chemical Oxygen Demand (COD):

The (COD) of the acidic wastewater is 72.00mg/l which is mixed with Moringa in different weights and time, four tests were done each test consists of four results, which were read and tabulated. Flow charts were plotted from the obtained data, tabulated in tables (1, 2, 3, 4 and 5) and plotted in figures (1, 2, 3, 4 and 5).

Table (4.11) Effect of Moringa in the treatment process (COD):
Weight 5 gm:

Time(hr)	COD
1	18.40
2	16.82
3	16.12
4	16.09

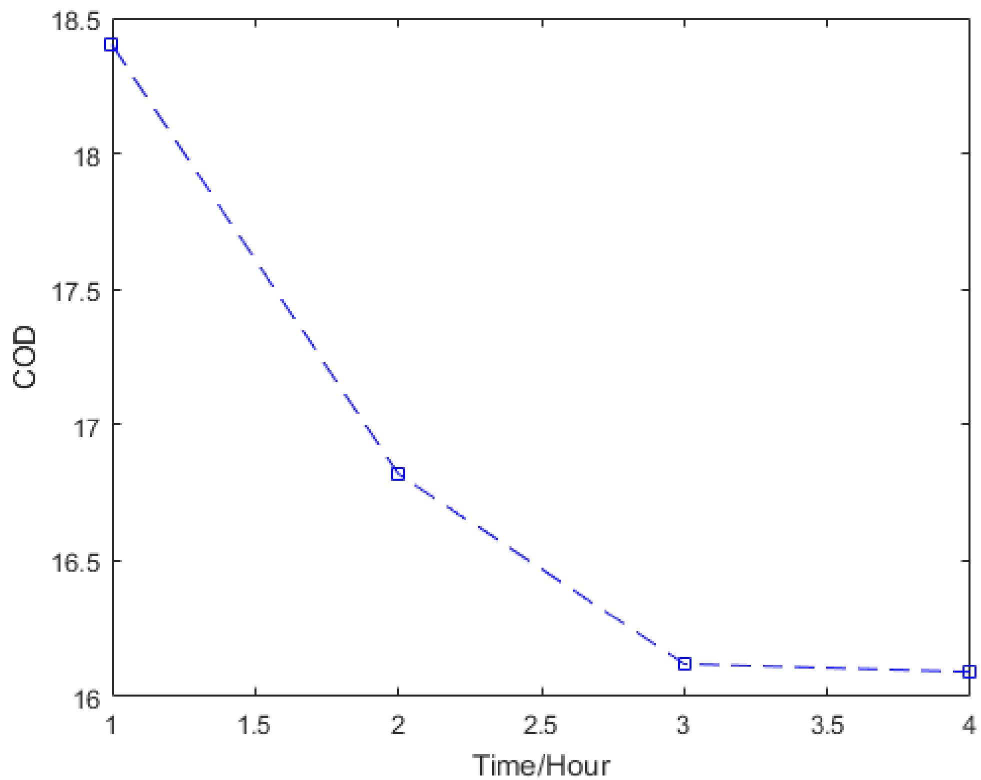


Figure (4.11): Effect of Moringa in the treatment process (COD removal).

Table (4.12) Effect of Moringa in the treatment process (COD):
Weight 7.5 gm:

Time(hr)	COD
1	14.18
2	14.08
3	14.06
4	14.00

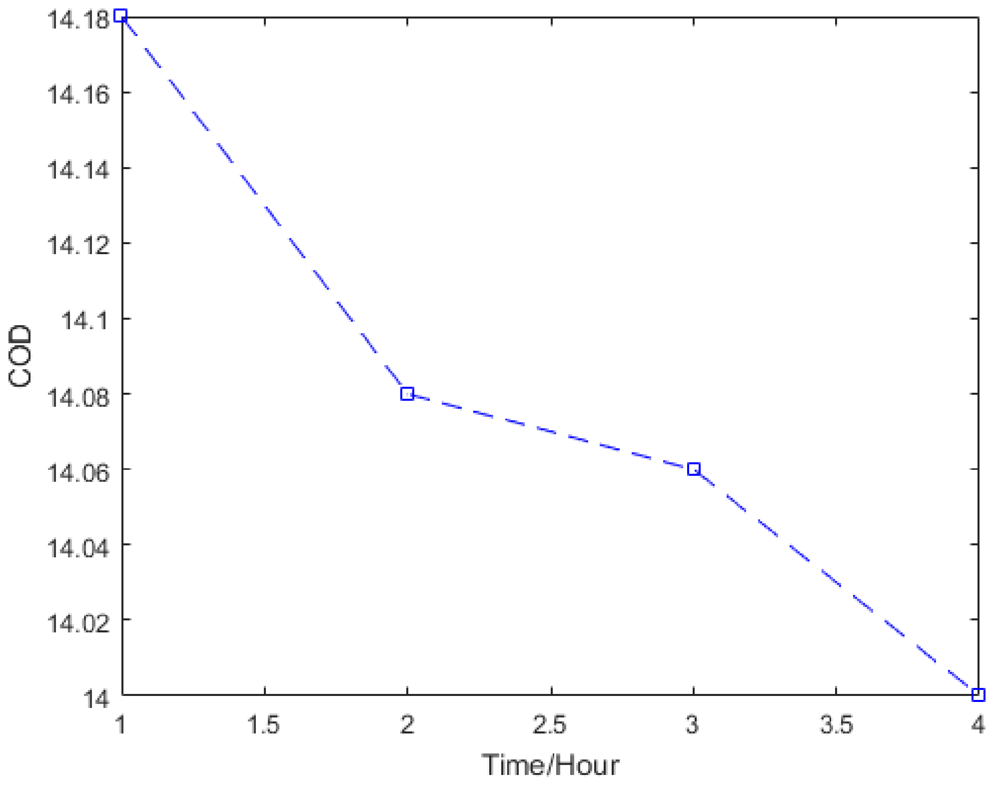


Figure (4.12): Effect of Moringa in the treatment process (COD removal).

Table (4.13) Effect of Moringa in the treatment process (COD):
Weight 10 gm:

Time (hr)	COD
1	12.52
2	11.44
3	10.12
4	10.06

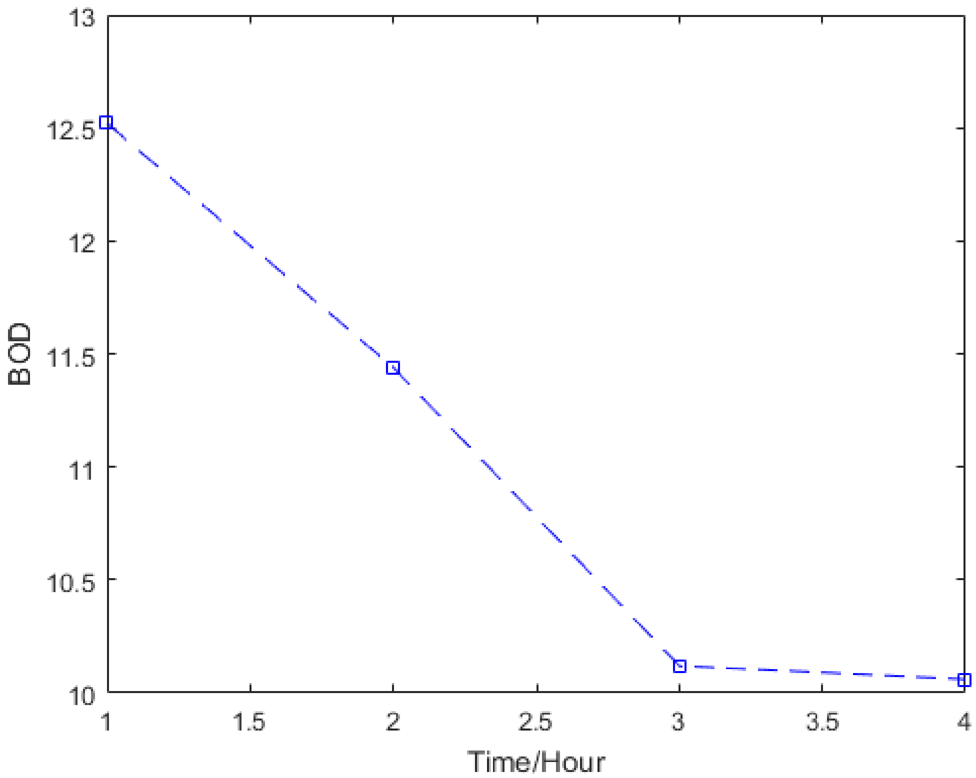


Figure (4.13): Effect of Moringa in the treatment process (COD removal).

Table (4.14) Effect of Moringa in the treatment process (COD):
Weight 12.5 gm:

Time(hr)	COD
1	10.21
2	10.18
3	10.08
4	10.02

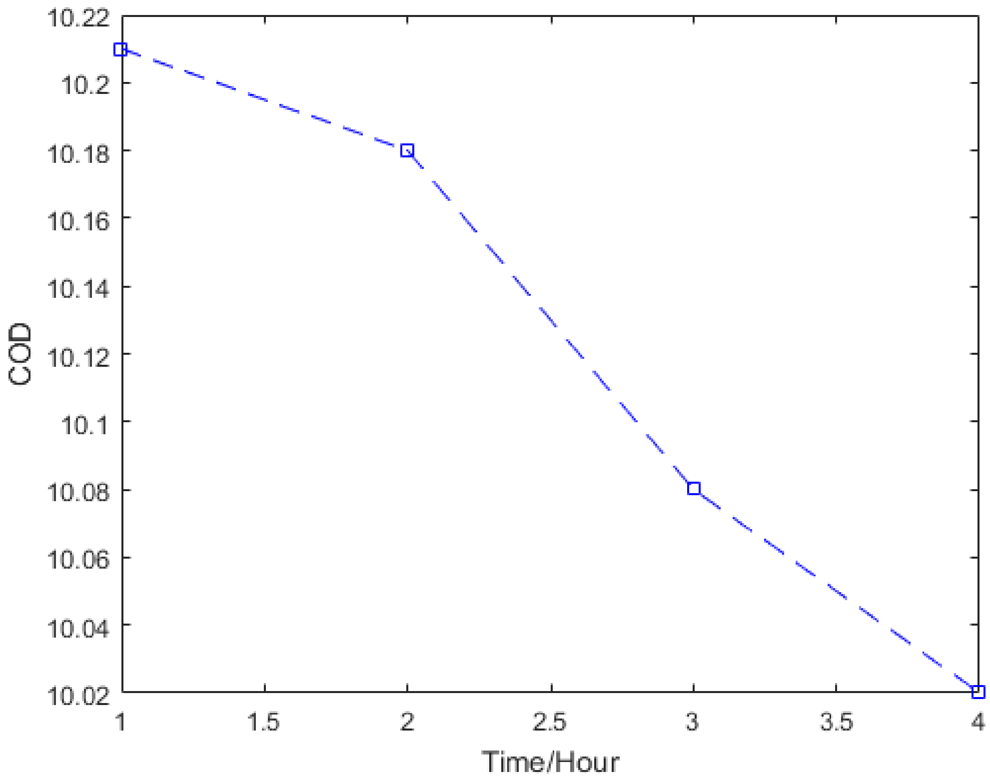


Figure (4.14): Effect of Moringa in the treatment process (COD removal).

Table (4.15) Effect of Moring in treatment process (COD removal):

Weight (gm)	COD/1hr mg/l	COD/2hr mg/l	COD/3hr mg/l	COD/4hr mg/l
5	18.4	16.82	16.12	16.09
7.5	14.18	14.08	14.06	14
10	12.52	11.44	10.12	10.06
12.5	10.21	10.18	10.08	10.02

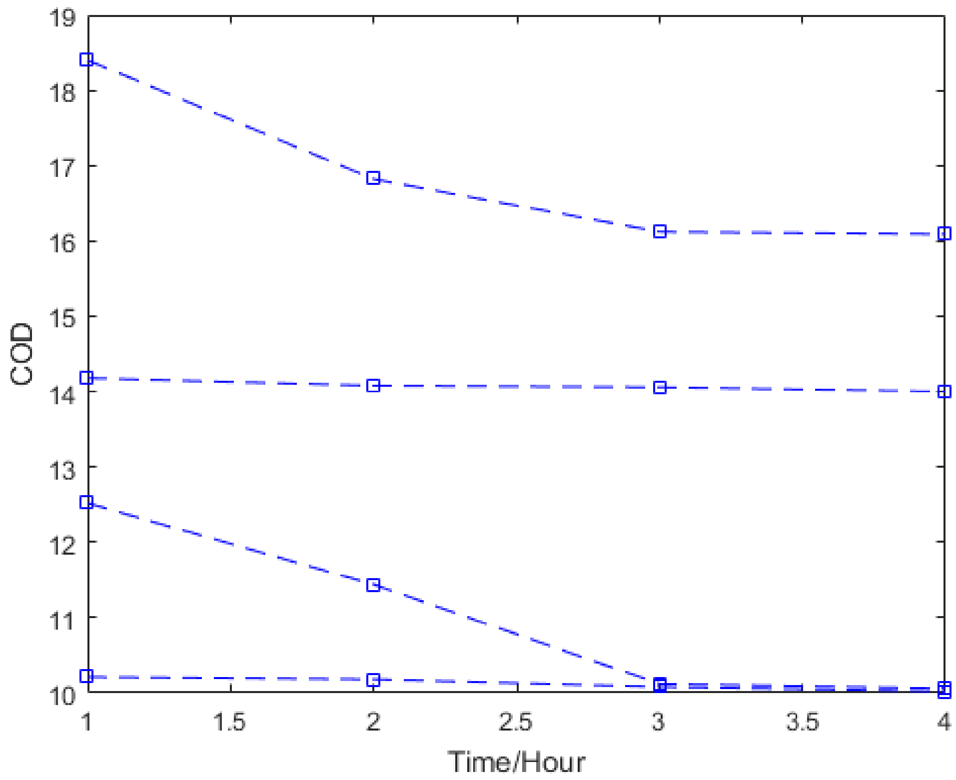


Figure (4.15): Effect of Moringa in the treatment process (COD removal).

Table (4.15) and figure (4.15) show the effect of Moringa on (COD) at temperature 25^{o}C under atmospheric pressure, for the first reading. Four readings were obtained for different weights. Although the (COD) value of the (IAWW) was within the range of the (SSMO, NO, 137, 2008) but when adding Moringa the obtained results of (COD) were very excellent. The (COD) value was reduced from (72.00 to 10.02) mg/l which is below (SSMO, NO 137, 2008) range.

4.5 Total Dissolved Solids (TDS):

The (TDS) of the acidic wastewater of value 7.46 mg/l which mixed with Moringa in different weights and time. Four tests were done. Each test gives four results. Flow charts were plotted from the obtained data, tabulated in tables (1, 2, 3, 4, and 5) and plotted in figures (1, 2, 3, 4, 5).

Table (4.16) Effect of Moringa in the treatment process (TDS): Weight.5 gm:

Time(hr)	TDS
1	5.03
2	4.72
3	4.65
4	4.58

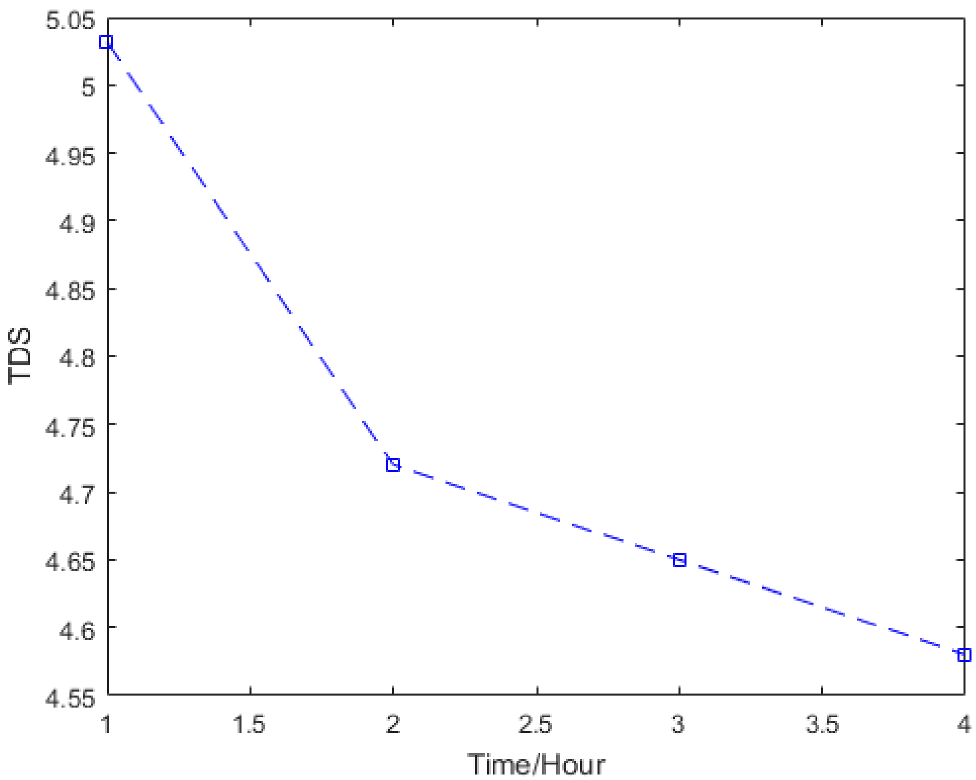


Figure (4.16): Effect of Moringa in the treatment process (TDS removal).

Table (4.17) Effect of Moringa in the treatment process (TDS): Weight7.5 gm:

Time (hr)	TDS
1	13.36
2	13.12
3	13.80
4	13.10

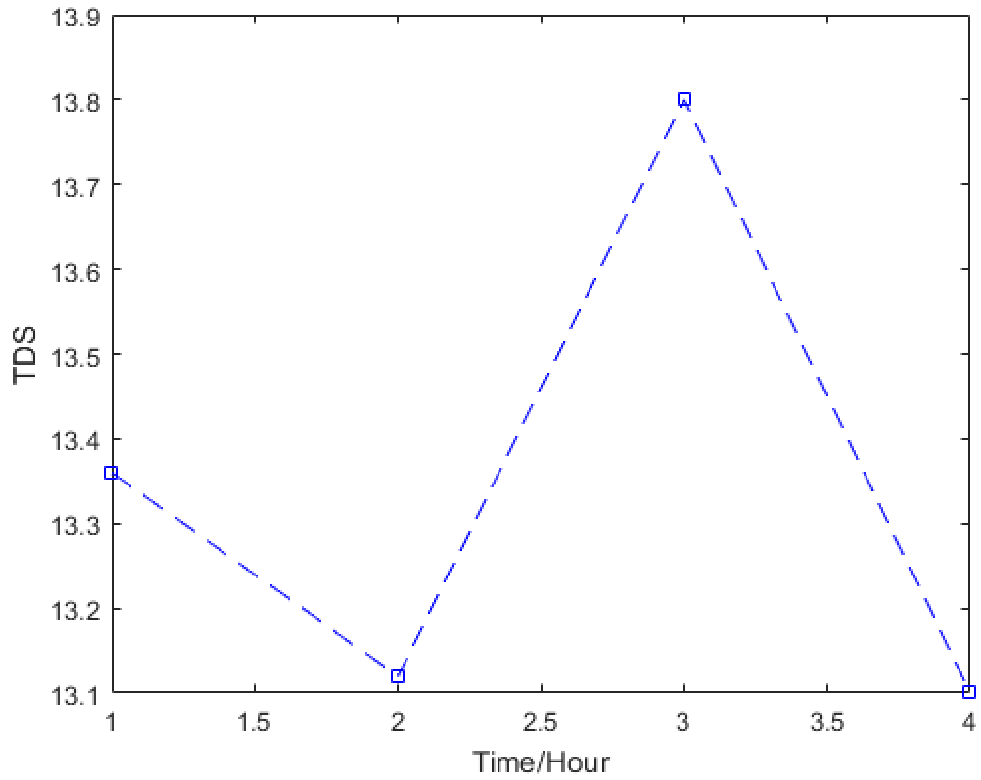


Figure (4.17): Effect of Moringa in the treatment process (TDS removal).

Table (4.18) Effect of Moringa in the treatment process (TDS):
Weight 10 gm:

Time (hr)	TDS
1	14.64
2	13.32
3	13.19
4	12.04

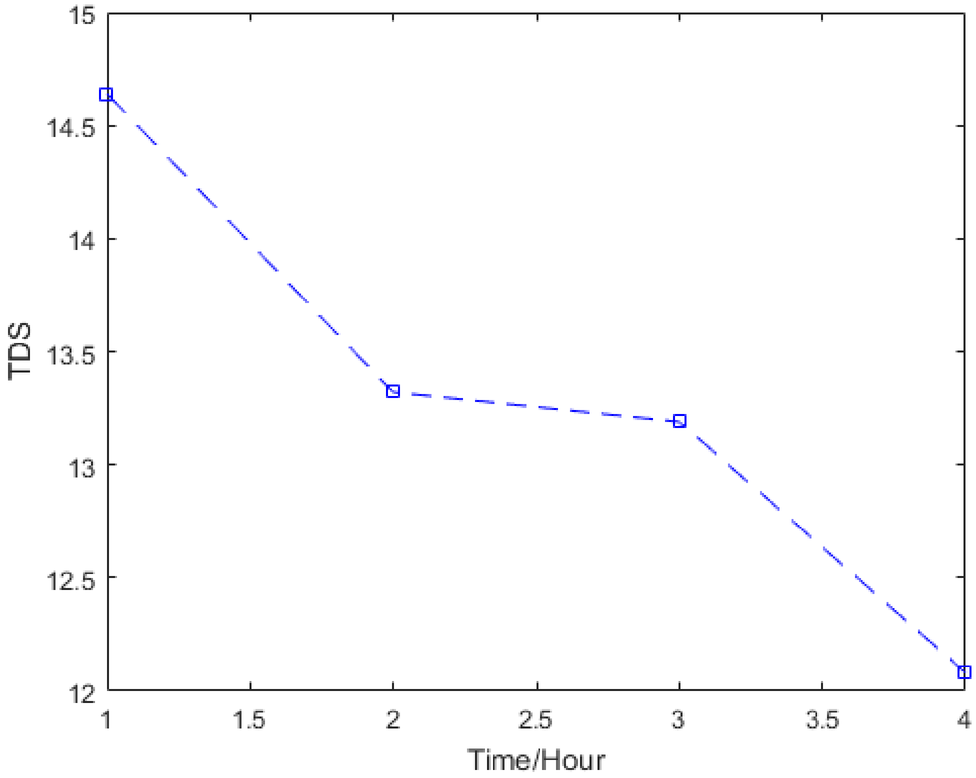


Figure (4.18): Effect of Moringa in the treatment process (TDS removal).

Table (4.19) Effect of Moringa in the treatment process (TDS):
Weight 12.5 gm:

Time (hr)	TDS
1	16.64
2	15.80
3	14.12
4	14.04

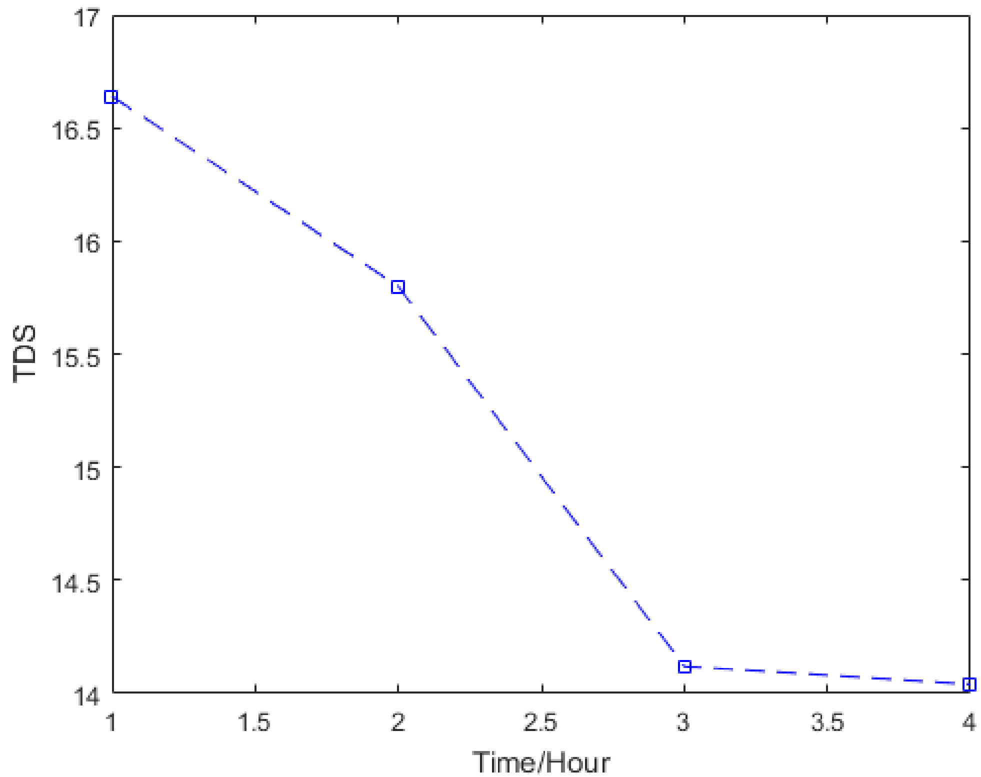


Figure (4.19): Effect of Moringa in the treatment process (TDS removal).

Table (4.20) Effect of Moring in treatment process (TDS removal):

Weight (gm)	TDS/1hr mg/l	TDS/2hr mg/l	TDS/3hr mg/l	TDS/4hr mg/l
5	5.032	4.72	4.65	4.58
7.5	13.36	13.12	13.8	13.1
10	14.64	13.32	13.19	12.08
12.5	16.64	15.8	14.12	14.04

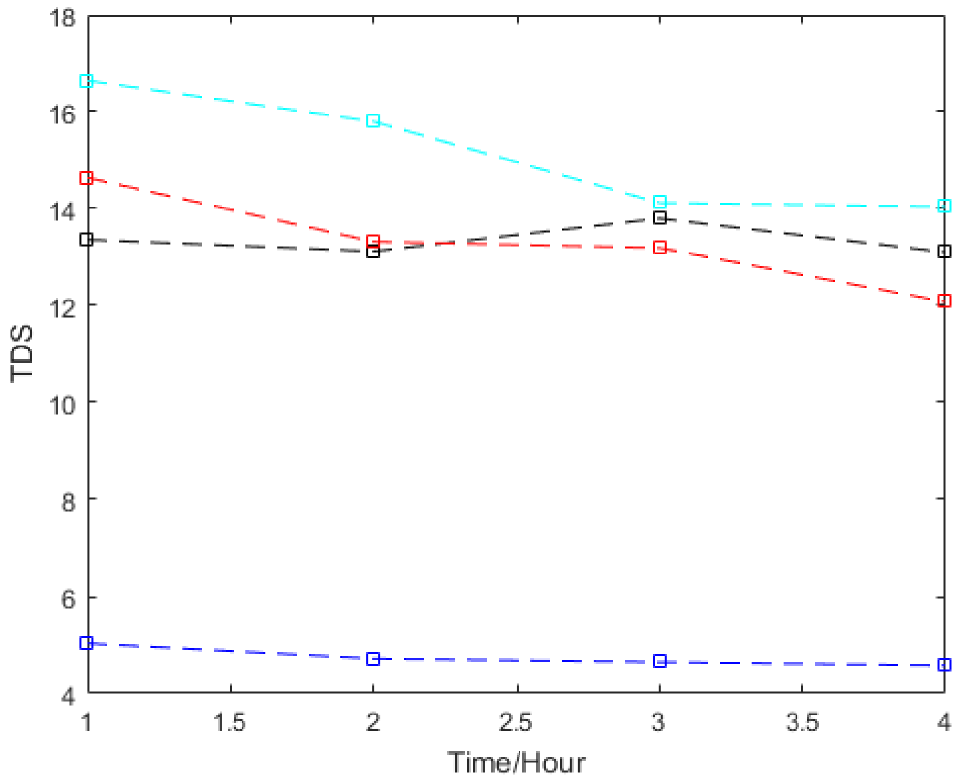


Figure (4.20): Effect of Moringa in the treatment process (TDS removal).

Table (4.20) and figure (4.20) show the effect of Moringa on TDS at temperature 25°C under atmospheric pressure, for the first reading .Four readings were obtained at different weights of the Moringa. Although the TDS value of the (AWW) was within the range of the (SSMO, NO137, 2008) but when adding Moringa and measuring TDS the results obtained were very high. The TDS value was increased from (7.46 to 14.12) mg/l which is matching below the (SSMO, NO 137, 2008) range. The test results showed that there was increase in TDS value through the 3 hours in the range of 7.40 values to 14.12. The value of TDS depends on the weight of Moringa used. Increasing the weight of Moringa leads to high value of (TDS). The TDS value after 3 hours 14.12 mg/l which is an ideal value that matches the Sudanese Specification Corporation (SSMO, NO 137, 2008). The 3 hours time was found to be the optimum time for industrial acidic wastewater to be treated with Moringa.

4.6 Sulphide(S^{-2}):

The sulphide(S^{-2}) of the acidic wastewater (AWW) of value 12mg/l which is mixed with Moringa in different weights and time. Four tests were done, each test consists of four results Flow charts were plotted from the obtained data, tabulated in tables (1, 2, 3, 4 and 5) and plotted in figures (1, 2, 3, 4 and 5).

Table (4.21) Effect of Moringa in the treatment process (S^{-2}):
Weight.5 gm:

Time (hr)	S^{-2}
1	0.16
2	0.032
3	0.001
4	0.001

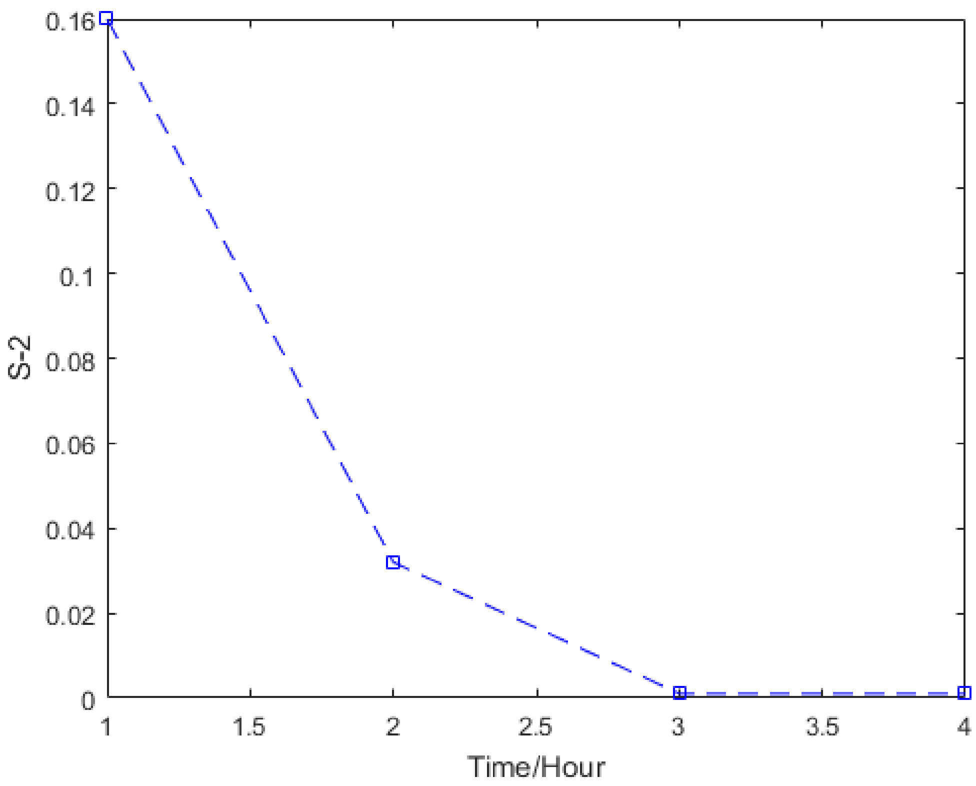


Figure (4.21): Effect of Moringa in the treatment process(S^{-2})

Table (4.22) Effect of Moringa in the treatment process (S^{-2}): Weight7.5 gm:

Time (hr)	S^{-2}
1	0.15
2	0.002
3	0.001
4	0.0001

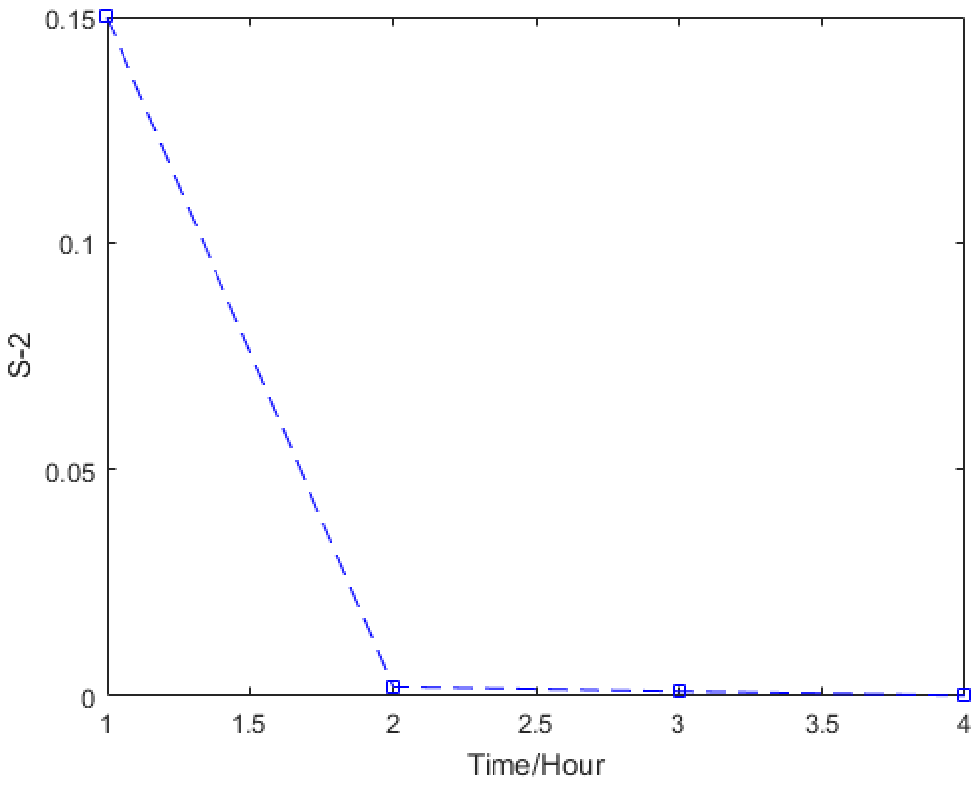


Figure (4.22): Effect of Moringa in the treatment process(S^{-2})

Table (4.23) Effect of Moringa in the treatment process (S^{-2}): Weight 10 gm:

Time(hr)	S^{-2}
1	0.09
2	0.001
3	0.001
4	0.0001

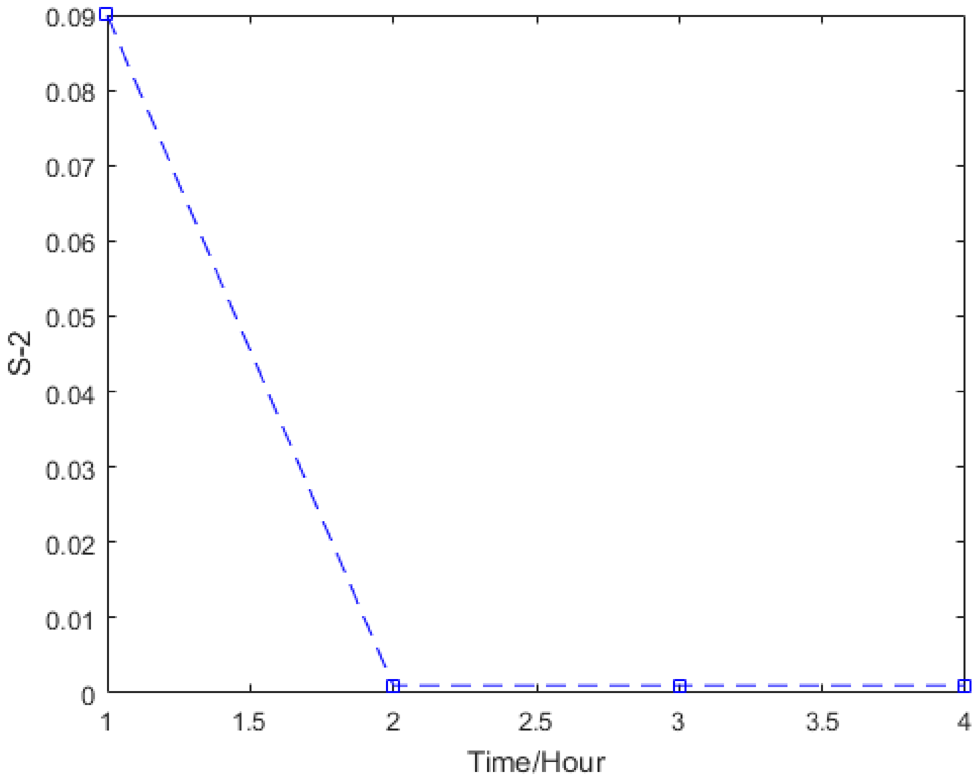


Figure (4.23): Effect of Moringa in the treatment process(S^{-2})

Table (4.24) Effect of Moringa in the treatment process (S^{-2}):
Weight 12.5 gm:

Time (hr)	S^{-2}
1	0.01
2	0.001
3	0.001
4	0.001

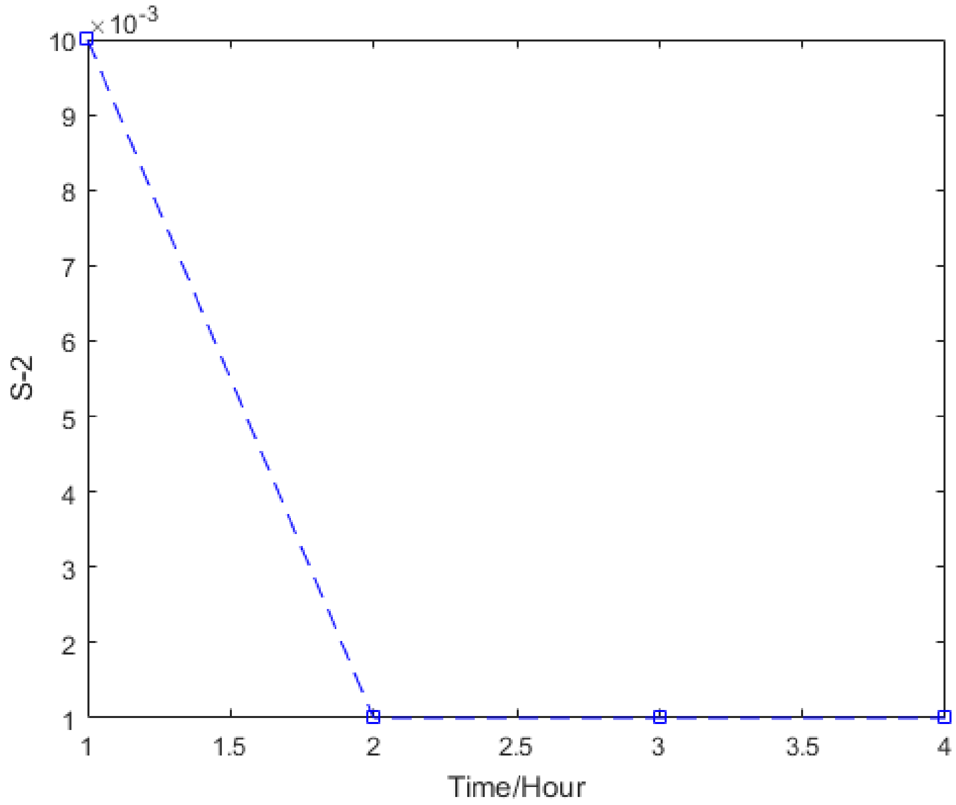


Figure (4.24): Effect of Moringa in the treatment process(S^{-2})

Table (4.25) Effect of Moring in treatment process(S^{-2} removal):

Weight (gm)	S^{-2}/1hr mg/l	S^{-2}/2hr mg/l	S^{-2}/3hr mg/l	S^{-2}/4hr mg/l
5	0.16	0.032	0.001	0.001
7.5	0.15	0.002	0.000	0.000
10	0.09	0.001	0.001	0.000
12.5	0.01	0.001	0.001	0.001

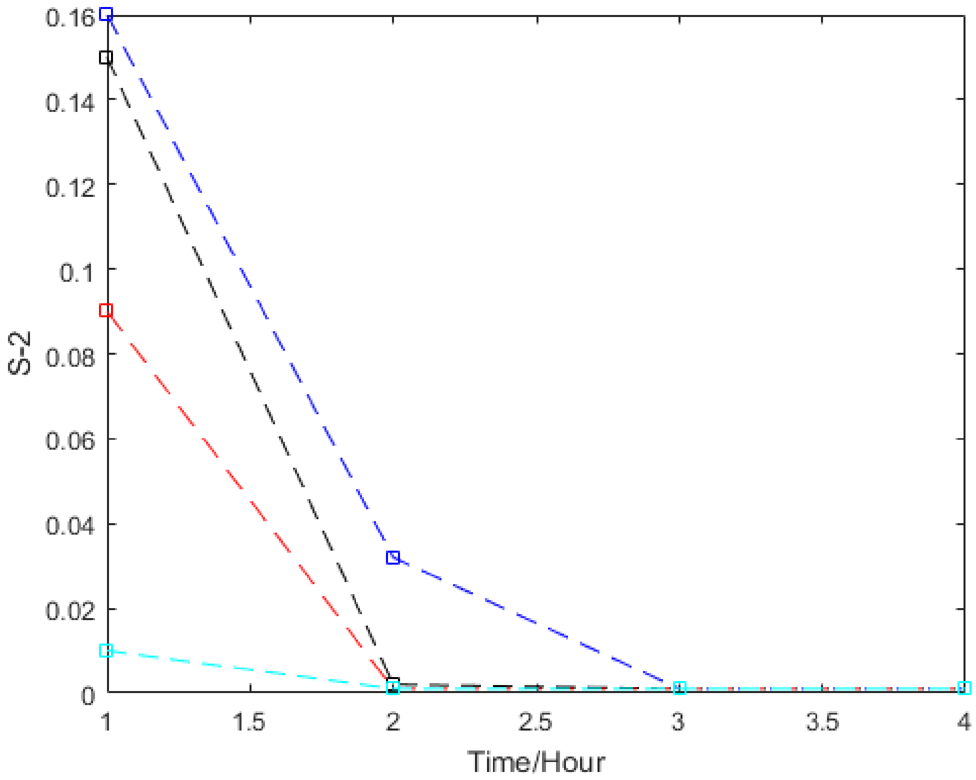


Figure (4.25): Effect of Moringa in the treatment process(S^{-2})

Table(4.25) and figure (4.25) show the effect of Moringa on sulphide .For the first reading at temperature 25°C under atmospheric pressure .Four readings were obtained for different weights .The test results showed that there was decrease through the four hours in (S^{-2}) value until it reached 0.001.From the results obtained it is clear that Moringa reduced the sulphide content sharply .The amount of 5 gm of Moringa reduced the sulphide content in the first 2 hours .The value of (S^{-2}) decreases with the increase of Moringa. The (S^{-2}) value after 3 hours (0.001) mg/l which is an ideal value that matches the Sudanese Specification Corporation (SSMO, NO137, 2008). The value of (S^{-2}) in treatment by Moringa is excellent. The 3 hours time was found to be the optimum time for

Moringa to treatment of acidic wastewater.

4.7 Determination of nitro component Di-Nitro-Toloune (DNT):

The industrial acidic wastewater containing (DNT) of value 60 to 55(mg/l) was mixed with Moringa in different weights and the same time 30 mints. Four tests were done; each test consists of one result as tabulated in table (4.26).

Table (4.26): Effect of Moringa in DNT after 30 min.

Weight gm	DNT mg /l
5	70
7.5	77
10	90
12.5	108

Table (4.26) shows the results, at first 30 mints which was chosen for each reading at temperature 23^{o}C under atmospheric pressure (ƛ=540). One reading was obtained for different weights. The test results showed that there was an increase through the 30 mints in (DNT) value until it reached 108mg/l. From the obtained results it is clear that Moringa increased the (DNT) content in industrial acidic wastewater after treatment. In step one and two when (HCL and $NaNO_2$) were added to the treated water .Treated water color transferred to yellow color that matches the stander methods of treatment of industrial acidic wastewater in Laboratories. When $H_2SO_4$was added in step three the treated water color was transferred to brown color it indicated the end of reaction. In step three the color must be transferred to orange color to indicate the end of reaction .But the color transferred to brown color that leads to relation between Moringa leaves and H_2SO_4.

4.8 Determination of nitro component Tri-Nitro-Toloune (TNT):

The Tri-Nitro-Toloune (TNT) of the Industrial Acidic Wastewater of value (73 to 78)mg/l which is mixed with Moringa in different weights and the same time 30 mints. Four tests were done each test consists of one result as shown in table (4.27).

Table (4.27): Effect of Moringa on TNT after 30 min.

Weight gm	TNT mg/l
5	72
7.5	96
10	102
12.5	116

Table (4.27) shows the results, at first 30 mints which was chosen for any reading, at temperature 23^oC under atmospheric pressure (λ=465). One reading was obtained for different weights. The test results showed that there was an increase through the 30 mints in (TNT) value until it reached 116 mg /l. From the obtained results it is clear that Moringa increased the (TNT) content in industrial acidic wastewater after treatment. In step one and two when (HCL and $NaNO_2$) were added to the treated water .Treated water color transferred to yellow color that matches the stander methods of treatment of industrial acidic wastewater in Laboratories. When $H_2SO_4$was added in step three the treated water color was transferred to brown color it indicated the end of reaction. In step three the color must be transferred to orange color to indicated the end of reaction .But the color transferred to brown color that leads to relation between Moringa and H_2SO_4

4.9 Proximate analysis and minerals contents of Moringa Oleifera:

Tables (4.28) and (4.29) show the proximate analysis and minerals composition of the Moringa used in the treatment. The proximate analyses were carried out in the laboratories of the Sudan University of Science & Technology, University of Khartoum, and Food and Technology Research Centre at SHAMBAT - Sudan.

Table (4.28): proximate analysis of leaves and roots of Moringa Oleifera

Element	Protein (%)	Ash (%)	Fiber (%)	CHO (%)	Fat (%)
Moringa Oleifera- leaves	23.5	9.7	17.6	14.6	7.7
Moringa Oleifera - roots	-	11.2	18.6	-	-

Table (4.28) shows the proximate analysis of leaves and roots of Moringa. The results showed that Moringa leaves are rich in protein and amino acid composition which is suitable for human and animal nutrition. Moisture percent is about 26.9%. Results illustrated that Moringa leaves can be considered as good fodder as they contain essential nutrients that can improve growth performance of animals. Moringa being extremely rich in nutrients is an excellent source of minerals for feeding human and animals. These results indicated that the Moringa Oleifera was slightly high. These results indicated that the Moringa Oleifera roots showed higher fiber content. The roots contain only ash-fiber; therefore leaves were used more than the roots.

Table (4.29): Minerals composition of leaves and roots of Moringa Oleifera

Element	Ca (%)	Mg (%)	Na (%)	K (%)	Fe (%)
Moringa Oleifera leaves	3.5	0.10	1.06	3.80	2.38
Moringa Oleifera roots	0.15	0.20	0.75	0.75	0.13

Table (4.29) shows the minerals composition of leaves and roots of Moringa Oleifera. Moringa Oleifera leaves gave higher percentage of Ca, K, Fe, and Na. Moringa Oleifera roots gave lower percentage of Ca, K, Fe, and Mn. Chemical constitutes are distributed through the leaves and roots with small difference .

Chapter Five

Conclusions and Recommendations

5.1 Conclusions:

From the experimental work carried out and the results obtained from the analysis it be concluded that:

- The Moringa Oleifera leaves good treatment properties especially when used for acidic wastewater of pH value (1.2).
- Treatment of (IAWW) with Moringa leaves increase TDS, but the obtained TDS values are still within SSMO range.
- Moringa Oleifera leaves can raise pH value to (6.8) in three hours according to the (SSMO) value.
- High concentration of BOD can be reduced to (4 mg/l) within three hours according to the (SSMO).
- COD was reduced within three hours to (10.08 mg/l) which is below the (SSMO) value
- Good treatment with (S^{-2}) results obtained. It is clear that Moringa Oleifera reduced sharply the sulphide content within two hours (0.001mg/l).
- TDS increased from (7.46 to14.12mg/l) also within 3 hours according to the (SSMO).
- Moringa is found to be a sustainable, cheap solution for acidic wastewater treatment. Also the Moringa Oleifera leaves can be produced locally at low cost.

- Cheap and sustainable treatments of acidic wastewater for explosive manufacture since the plantations are established and can supply seeds and leaves
- The use of Moringa Oleifera (leaves and seeds) have several technical benefits, especially in tropical developing countries and rural communities, in addition to helping in treating water for small scale tree farming.
- Treatment of (IAWW) with Moringa is a method that can certainly be considered as a good sustainable and cheap solution for military explosive wastewater, if the supply of Moringa Oleifera seeds can be guaranteed.

5.2 Recommendations:

Based on the work done and the results obtained, it can be recommended that:

- Moringa Oleifera is now widely grown in Sudan, while the other plant parts like leaves, parks and roots may be used for medicinal purpose, the pressed cake which is obtained after oil extraction is equally efficient for coagulation, therefore more people should be encouraged to engage in the plantation and oil extraction of Moringa Oleifera business so that farmers can obtain the press-cake at very cheap cost or at no cost for wastewater treatment. Therefore this treatment must be accounted for.
- It is highly recommended that realistic visibility study must be carried out to design and apply the manufacture of the tablets of Moringa.
- An Economical evaluation needs to be carried out beside health and hygiene and analysis.

- It is recommended to do further studies and experimental work for longer period.
- It is recommended that to reduce the particles sizes of the powder to nano-size, to enhance the mass transfer rate.
- Since the Moringa grows in different sites in the country it is recommended to study tree grown in different places i.e. South Kordofanian, South Darfur and Blue Nile.
- Due to the success achieved by using the Moringa plant in sharply reducing the BOD of the wastewater, it is also recommended to study the use of Moringa in domestic water processing for microbial reducing instead of traditionally used chlorine (Cl_2) because Moringa is anti bacteria.

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Appendices

Sudanese Standards and Metrology Organization (SSMO), 2008 Liquid Waste (effluents) after final Treatment

1. Domain:

This Sudanese Standards Specification is concerned with the maximum limits allowed for the concentration of pollutants in liquid waste after treatment in preparation for final disposal and re-used for other purposes.

2. Definitions:

2.1 Liquid waste: It is fluid and water-borne pollutants and effluents, which include household, industrial, service and commercial operations that are discharged into the sewage network and treated in final treatment plant before using it or disposal.

2.2 Pollutants Effluents: are the elements of physical, chemical or biological found in liquid wastes and can adversely affect the rights and the environment and allegedly shown in table No. (1)

2.3 The maximum permitted limit: is the maximum amount allowed concentration of pollutants in the water treated completely, and which will be re-used or discharged into the environment.

2.4 The final treatment: means the operations which take place in the plants for treatment of liquid at the final stage before being discharged or reused.

2.5 Reuse: use of effluent after treatment in the final treatment plant for specific purposes.

2.6 The final Treatment Station: unit of units designed for treating the waste liquid and its purification to reduce the concentration of pollutants.

2.7Irrigation: The process of spraying or flooding the land in part or in whole by using waste liquid.

2.8Aquifer: Any geological unit capable of producing large quantities of ground water to support wells and (Foundation).spring

3. Requirements and Conditions

3.1The concentration of pollutants must not exceed the maximum limits allowed included in Table (1).

4. The Values of the maximum rate permitted

4.1(Table 1) shows the maximum limits of draining and re-using of effluent after the final treatment (a) and (b).

4.2areas of application of criteria (a) and (b) in Table (1) as follows:

4.3Criteria (a):specifications of effluent after treatment by:

- draining into rivers, which water is used for different purposes

4.4re-used for irrigation of vegetables and fruits that can be eaten fresh

4.5used to irrigate entertainment venues and public parks

4.6used to feed the groundwater basins

5. Criteria (b): specifications of effluent after treatment by:

5.1Used to irrigate vegetables and to cook or can be manufactured.

5.2Used to irrigate fodder and grain.

5.3Used to irrigate pastures and forests.

6. Laws and regulation of waste water in Sudan:

(I) Bind of using drainage services

It is not permitted to any person or cooperates to remove, collect, treat or get rid of wastewater except through the net of drainage in the same area according to verdicts of this law and its issued regulations.

(II) Authority of closing or removing drainage:

In the case of the existence of drainage and omission of any person or cooperate to use drainage services in question to verdicts of article (1) above, it is allowed to the cooperation to instruct closing or removing any means or equipments are using or used by any person or cooperate to transport or gathering or treated or removing the drainage water out the net according to conditions specified by the cooperation in the issued instruction of removing or closures.

(III) Establishing or modification the internal nets or other on structions:

It is not permitted to any person or cooperates to establish or modify any drainage net inside the building or establishing any constructions to drainage or removing the waste water unless they obtain the written etherification from the cooperation according to its conditions and maps and charts which are approved by it.

(IV) Rights of cooperation in inspection:

It is permitted to any official in the corporation to conduct during suitable period according to the procedures and conditions which mentioned in the regulations to enter any building to inspect and examine the drainage net inside the building or for any other purposes concerning the services of drainage or its net.

7. **Penalties**:

(I) Any person causes in destruction or decreasing the values of stations of drainage or lifting or treatment, or the lines of drainage nets commits a crime and should penalize after can demand by a chail for periodontal less of three years or affine not less than the value of the damage and he should pay all the costs of damage repairs in addition to any other penalties in any other law

(II) Every person who exposes through carelessness the stations or lines of drainage to risk or may causing damage to the stations or lines of drainage net or abstains to take the necessary procedures to protect the station or drainage nets from danger caused by any human or animal or machine or material under his supervision or administration or in his possession should penalties by a chail period not less of one year or fine equal to the value of caused damage or with the two penalties.

(III) With the consideration to the verdicts of articles (1) and(2)above ,should penalties every person who violated any other verdicts in this law by the fine not than fifty thousand pound or by chail for a period not than one month in addition to repay the identified price.

Table No (1) max limit concentration of liquid in industrial waste					
Limit of permission		Unite	Symbol	Elements	No.
Standard(A)	Standard(B)				
9-6	9-6	mg/l	PH	Hydrogen number	1
15	50	mg/l	BOD	Biological oxygen Demand	2
75	150	mg/l	COD	Chemical oxygen Demand	3
30	50	mg/l	TSS	Total Suspended Solid	4
350	500	mg/l	CL	Chlorides	5
40	60	mg/l	N-NO3	Nitrogen as Nitrate	6
1500	1500	mg/l	TDS	Total Dissolved Solid	7
300	350	mg/l	SO4	Sulphate	8
0.1	0.1	mg/l	S	Sulphide	9
3	5	mg/l	G&O	Oil& Grease	10
2	4	mg/l	P	Phosphorous	11
0.05	0.05	mg/l	Cr	Chromium	12
0.05	0.1	mg/l	Cn	Cyanide	13
5	5	mg/l	Fe	Ferrous	14
5	5	mg/l	Zn	TIN	15
0.5	1	mg/l	Cu	Copper	16
0.1	0. 5	mg/l	Mn	Manganese	17
5	10	mg/l	N-NH4	Ammonia of Nitrogen	18
0.1	0.3	mg/l	As	Arsenic	19
1	2	mg/l	Ba	Barium	20
0.5	1	mg/l	Bo	Boron	21
0.5	0.5	mg/l	Co	Cobalt	22
0.1	0.2	mg/l	Pb	Lead	23
100	100	mg/l	Mg	Magnesium	24
5	5	mg/l	Al	Aluminum	25
0.002	0.2	mg/l	Hg	Mercury	26
0.2	0.2	mg/l	Ni	Nickel	27
20	20	mg/l	Se	Selenium	28
0.01	0.05	mg/l	Ag	Silver	29
200	300	mg/l	Na	Sodium	30
5	10	mg/l	N- organic	N-organic	31
0.05	0.1	mg/l	CN	Cyanide	32
0	0	(counts/ 100ml)	Feacal Coli form	Number of colon Bacteria	33
500	1000	(counts/ 100ml)	Aerobic Plate Count	Total Number of Bacteria	34

Table No (2) Methods of Analysis and Investigation

Test Method	Parameter	Pollutant	Number
PH-meter	PH	Hydrogen Number	1
Incubation &titration method	BOD	Biological Oxygen Demand	2
Digestion method (Dichromate)	COD	Chemical Oxygen Demand	3
Gravimetric method	TSS	Total Suspended Solid TSS	4
Titration	CL	Chlorides	5
Spectra photometric method	(N-NO3)	Nitrogen as Nitrate	6
Evaporation method	TDS	Total Dissolved Solid	7
Electrical conductivity method	S	Sulphide	8
Distillation followed by titri metric or colorimetric	CN	Cyanide	9
Liquid –Liquid extraction GC or photometric method	C6H5OH	Phenol	10
Ion chromatographic method	NH3	Ammonia	11
Atomic absorption spectrometric method		Metals	12
Extraction method (Organic solvent)	(O&G)	Oil &Grease	13
Membrane filter techniques	E .Coli	Colic El Bacteria	14
Gas chromatographic method	VOC	Dissolved volatile material	15