**Al-Azhar University-Gaza**
**Deanship of Postgraduate Studies**
**Institute of Water and Environment**
**Master of Water and Environmental Science**

# Evaluation of Selected Local Media for Water Treatment by Columns Filtration

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**A Thesis submitted in partial fulfillment of the requirements for the degree of Master in Water and Environmental Science**

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## تقييم الوسائط المحلية في معالجة المياه

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# *Dedication*

***I would like to dedicate this thesis to the soul of my Aunt Majeda, to my great parents, My beloved husband Mr. Ramadan* Mansur, *to my sons Ghalia, Eman, Asia, Salah EL- Deen, and Muhammad, in addition to my brothers and sisters.***

**Reena Hamouda**

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# Abstract

This study is divided to two parts, the first part was collection of samples sand from twelve locations distributed on the five governorates of the Gaza Strip, then testing the samples of sand for Particle size, the Effective size (ES) (d10 value) and Uniformity Coefficient (UC) (d60 value). The results were shown the samples number 2, 6, and 7 that collected from the locations of North Gaza N: 31º32'59.0" E: 34º31'31.7", Middle Gaza N: 31º24'57.1" E: 34º24'02.3 ", and Middle Gaza N: 31º25'46.3" E: 34º20'49.4" respectively are adapted sand which has the recommended properties regarding the effective size and uniformity coefficient that needed for drinking water treatment, due to the recommended UC range = 1.5 to 2.5 and the recommended ES range = 0.15 mm to 0.20 mm (likely to achieve 0.4 L/minute flow rate, also recommended for community slow sand filters), therefore during the coming research investigations for water treatment, the site number 7 which located in Al- Wusta was chosen to represent the investigated local media during this research study, where it has 0.164 ES and 2.2 UC.

The second part of this study was designing six columns to investigate the proficiency of different types of modified sand filter media for water treatment, where basically local sand from the Gaza Strip was used as a control filter column in parallel to modified sand filters with Kaolin, Crushed glass, Sawdust, dried Guava, and Fig leaves. The height of each filter will be around 120 cm, diameter 4 inch of PVC pipe. The Guava and Fig leaves were collected and dried for two weeks, then crushed and washed for several times by distilled water then dried again using the oven at 70 C° for 10 hours then used as modifiers for the sand filters, The glass was collected , washed , dried , and crushed, Which the effective size was 4mm, and the sawdust was provided by El Horany carpentry. Both crushed glass and sawdust were washed by distilled water and dried using the oven at 90 C° for 24 hours then used as modifiers for the sand filters. Also the kaolin was used as new modifiers with sand filter for water treatment.

The investigations of the columns efficiency for contaminants removal were tested for Nitrate $(NO_3)^-$, Detergent, TDS, and Water Hardness based on the retention time of the polluted water into the column. where the tap water was used and adjusted the nitrate concentration to be 146.4 ppm, the detergent concentration of about 5 ppm, the water hardness 1100 ppm, and TDS 1883 ppm. Pre and post analysis of each water sample for

nitrate and detergent was conducted directly and the results were registered in addition to measure the TDS, water Hardness, and pH too.

The maximum removal efficiency for Nitrate was 100% in columns no. (4, 5, 6 ) which contain ( Sawdust, Guava, Fig leaves respectively ) and they were found to be the most effective in removing nitrate from water. The main mechanism for nitrate removal by columns no. (4, 5, 6 ) is most probably adsorption and biological denitrification process.

Column no. ( 1, 2, 3 ) which contain (Sand without any additives, Kaolin, Crushed glass gave high removal of Nitrate about (84%, 97%, 88%). The main mechanism for nitrate removal from water by column no. (1, 2, 3) basically by adsorption, rather than biological denitrification, so that the removal of nitrate lower than column no (4, 5, 6). The maximum removal efficiency for detergents was in columns no.(1, 3, 4, 5, 6) which gave high removal about (88%, 92%, 100%, 99%, 95% respectively ), while the removal rate of detergent in column no. 2 was 40%. The removal of detergents by columns no.(1, 2, 3 ) caused by adsorption process. The mechanism of detergents removal by columns no. (4, 5, 6) were attributed to the physicochemical characteristics of (Sawdust, Guava, Fig ), where the adsorption extent increases with contact time till reaching saturation level where the uptake percentage attains a constant value (86, 86, 82% respectively) at 456 hours. The removal of hardness was about (56%, 61%, 56% ) in columns no.(1, 3, 4 respectively). In column no.2, the removal of hardness was about 54%, the removal of hardness may be to interaction between the negative charges on silicate and positive charge on $Ca^{2+}$ and $Mg^{2+}$ ions. In columns no. (5, 6 ) the hardness was increased, this issue could be related to the component of the added media. The TDS values was less efficiency through all columns, where all columns had a similar behaviors for TDS decreasing except column no. 6, which had a remarkable increment of TDS value by time, where the column control was 3%, column no. 2 which had removal percentage of about 55%, Column no. 3, 4, and 5 the highest rate of removal was between 10 to 15 %.

# ملخص الدراسة

هذه الدراسة تنقسم الى جزئين ، الجزء الأول تم فيه جمع عينات من الرمال من ثلاثة عشر موقعا موزعة على خمس محافظات في قطاع غزة ، تم تحليل حجم الجسيمات، وتحديد الحجم الفعال (القيمة D10) ، معامل التوحيد (القيمة D60 ) لعينات الرمل التي جمعت ، أظهرت النتائج ان العينات رقم 2 و 6 و 7 التي تم جمعها من المواقع في شمال قطاع غزة N: º32'59.031 "E: º31'31.734 "، الوسطى N: º24'57.131" E: º2434 02.3"، N: º25'46.331 "E: º20'49.434 " على التوالي لديها الخصائص الموصى بها فيما يتعلق بالحجم الفعال ومعامل التوحيد التي تحتاج لمعالجة المياه لذلك تم اختيار المنطقة الوسطى لتمثيل الرمال المحلية لتحقيق هذه الدراسة البحثية حيث أن الحجم الفعال لديها 0.164 و معامل التوحيد لديها 2.2.

الجزء الثاني من هذه الدراسة هو تصميم ستة أعمدة للتحقق من الرمال المعدلة مع الأنواع المختلفة من الوسائط لتنقية المياه حيث تم استخدام الرمل المحلي من قطاع غزة كمرشح السيطرة بالمقارنة مع مرشحات الرمل المعدلة مع الكاولين والزجاج المسحوق نشارة الخشب وأوراق الجوافة و التين المجفف. العمود او المرشح عبارة عن انبوب PVC ارتفاعه حوالي 120 سم، وقطره 4 بوصة.

أوراق الجوافة والتين تم جمعها وتجفيفها لمدة أسبوعين، ثم طحنت وغسلت عدة مرات بالماء المقطر ثم تجفيفها مرة أخرى باستخدام الفرن على درجة حرارة °70درجة مئوية لمدة 10 ساعات ثم استخدمت كمعدلات للمرشحات الرملية، ايضا تم جمع الزجاج المسحوق وغسله وتجفيفه ، اما نشارة الخشب فكانت من منجرة الحوراني.

تم غسلها بالماء المقطر وتجفيفها باستخدام الفرن على حرارة 90 درجة مئوية لمدة 24 ساعة ثم تستخدم كمعدلات للمرشحات الرملية .كما يتم استخدام الكاولين كمعدلات جديدة مع مرشح الرمل لمعالجة المياه.

تم التحقق من اختبار كفاءة الأعمدة لإزالة النترات المنظفات، الاملاح الذائبة، عسر المياه من المياه على أساس وقت الاحتفاظ بالمياه الملوثة في الاعمدة. حيث تم استخدام ماء الصنبور وتعديل تركيز النترات ليكون 146 جزء في المليون ، وتركيز المنظفات حوالي 5 جزء في المليون ، عسر الماء (1100 جزء في المليون) ، وTDS (1883 جزء في المليون) ، التحاليل اجريت مباشرة لعينات الماء قبل وبعد المعالجة وسجلت النتائج.

حيث ان أقصى كفاءة لإزالة النترات 100% في الاعمدة (4, 5, 6 ) التي احتوت على (، نشارة الخشب ، وأوراق الجوافة و التين المجفف على التوالي), الآلية الرئيسية لإزالة النترات في الأعمدة على الارجح هي الامتزاز وعملية نزع النتروجين البيولوجية. في الاعمدة (1, 2, 3 ) ازالة النترات كانت كالتالي (84%, 97%, 88% على التوالي) من الممكن من خلال الامتزاز بدون عملية نزع النتروجين البيولوجية.

في حين ان إزالة المنظفات في الاعمدة (1, 3, 4, 5, 6 ) فكانت كالتالي (88%, 92%, 100%, 99%, 95% ) حيث ان الازالة في الاعمدة كانت عن طريق عمليات الامتزاز و الخصائص الفيزيائية .

اما اقصى ازالة للعسر فكانت (56%, 61%, 56% ) في الاعمدة (1, 3, 4 على التوالي ), في عمود 2 المحتوي على الكاولين فكانت الازالة 54%, حيث ان الازالة تمت من خلال التفاعل بين الشحنات السالبة على السيلكا والشحنات الموجبة على $Mg^{2+}$, $Ca^{2+}$ . الاعمدة ( 5, 6 ) ارتفعت فيها املاح الكالسيوم و المغنيسيوم بسبب مكونات اوراق الجوافة والتين المجففة المحتوية على الاملاح العضوية.

بالنسبة لقيم الاملاح الذائبة فكانت متشابه في جميع الاعمدة ما عدا عمود رقم 6 الذي ازدادت به نسبة الاملاح الذائبة في الماء, حيث ان قيمة الازالة للأملاح الذائبة في عمود السيطرة كانت 3%, اما عمود رقم 2 المحتوي على الكاولين فكانت قيمة الاملاح الذائبة 55%, وفي الاعمدة (3, 4, 5 ) فكانت ما بين 10% الى 15%.

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## Abbreviations

| | |
|---|---|
| A R | Analytical reagent |
| BSF | Biosand filter |
| BSFZ | Biosand filter with zeolites |
| CAWST | Centre for Affordable Water and Sanitation Technology |
| Cfu | Colony Forming Units |
| CWC | Clean Washington Centre |
| DO | Dissolved Oxygen |
| EDTA | Ethylene diamine tetra acetate acid |
| E. coli | Escherichia coli |
| EPA | Environmental Protection Agency |
| ES | Effective size |
| EU | European Community |
| GN | Granite |
| GV | Gravel |
| HDR | Heterotrophic denitrification reactor |
| HRT | Hydraulic retention time |
| IOCs | Inorganic oxyanion contaminants |
| kg | Kilogram |
| $km^2$ | Square kilometer |
| LAS | Linear Alkyl benzene Sulfonate |
| LPD | Local Plastic Design |
| L/h | Liter/hour |
| $m^3$ | Cubic Meter |
| m/h | Meter/hour |
| ml | Mililiter |
| mg | Miligram |
| mm | Millimeter |
| Nm | Nanometer |
| NOCs | Nonionic Organic Contaminants |
| NTU | Nephelometric Turbidity Units |
| OPS | Oil Palm Shell |
| PCBS | Palestinian Central Bureau of Statistics |
| pH | Acidity or Alkalinity of an aqueous solution |
| ppm | Part Per million |
| PVC | Polyvinylchloride |

| | |
|---|---|
| QAC | Quaternary Ammonium Compounds |
| RH | Rice Husk |
| SMZ | Surfactant Modified Zeolite |
| SSF | Slow Sand Filtration |
| TDS | Total Dissolved Solids |
| TOC | Total Organic Carbon |
| TSF | Trickling Sand Filter |
| TU | Turbidity Units |
| UC | Uniformity Coefficient |
| UN | United Nations |
| UNEP | United Nations Environment Programme |
| UNICEF | United Nations International Children's Emergency Fund |
| UV | Ultraviolet |
| WHO | World Health Organization |

# CHAPTER ONE

# INTRODUCTION

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background

The huge changes in the human life style in addition to the increased requirements of the modern civilizations affect directly and indirectly the global water status. The augmenting global freshwater demand and the deteriorate water quality are the basic issues for many health and environmental crisis. The demand for water is rapidly increasing at a rate of three times faster than the world's population growth. Alarming statistics, such as 780 million people lack access to an improved water source; approximately one out of nine people (WHO/UNICEF, 2010), where more than 3.4 million people die each year from water, sanitation, and hygiene-related causes. Nearly all deaths, 99 percent, occur in the developing world (WHO.2008), furthermore, the UN report said that over half the world's hospital beds are occupied with people suffering from illnesses linked to contaminated water (UN,2012).

Water in the Middle East has always been a scarce resource. Consequently, the development and management of water has assumed a strategic and political importance. Per capita availability is the lowest, rates of withdrawal already the highest, and more water storage has already been installed than in any other region of the world (Report to Seminar on Water and Energy Linkages in the Middle East, August 2009). In the Gaza Strip – Palestine nearly 1.6 million inhabitants are living in around 365 km$^2$ (PCBS, 2011 and UNEP, 2009) . This region is considered as one of the most populated areas in the Middle East in which groundwater is the main water source (Kenneth M Persson, and Mohammad Aljaradin,2010). The political and economic instability contribute in appearing several environmental problems, one of the urgent problems facing the inhabitants of the Gaza strip is water problem. The Gaza Strip is suffering of both of water shortage and deteriorated quality of drinking water, many researches show the continuous degradation of water quality and the increased demand (Husam Baalousha , 2006). The existing water problems in the Gaza Strip are becoming a real augmenting crisis which should consider as a critical dangerous threatened the life and environment in the region. Serious efforts should take place from different levels to face the existing deterioration of the water sector in the Gaza Strip. This thesis is focus on the improvement of the water quality in the Gaza Strip by studying the enhancement of water treatment using modified slow sand filters (Bio Sand Filter) constructed by local media from the Gaza Strip.

## 1.2 Problem Statement

The reports of UN declared the alarms of water crisis in 2016 and complete damage of groundwater in the Gaza Strip by 2020, as well as the Palestinian Water Authority published report in December 2014 that 96.2% of the groundwater in the Gaza Strip is above WHO standards with respect to salinity and nitrate concentrations. Furthermore the poor economic situation in addition to the closure of the Gaza Strip represents challenges facing the water treatment process. Therefore, the unavailability of applicable local solutions for water treatment is a real problem facing the sustainability of the life in the Gaza Strip.

This study is designed to fill the gap of information regarding efficiency of new local filters in water treatment.

## 1.3 Main Goal and Objectives

### 1.3.1 Main Goal

Investigating the efficiency of proposed new filters prepared from local media for water treatment in the Gaza Strip.

### 1.3.2 Objectives

- Studying the efficiency of local sands from the Gaza Strip to be used for removal of Nitrate , Detergent, water Hardness, TDS from water.
- Improvement of local sand filters efficiency by addition of Kaolin, Crushed glass, Sawdust, Guava and fig leaves.
- Studying the filtration conditions (type of media and retention time) for new constructed filters.

### 1.4 Study Significance

- ➢ To provide research contribution in solving water problems in the Gaza Strip.

- To study the local resources for enhancing water quality as slow sand, Kaolin, Crushed glass, Sawdust, Guava and fig leaves.

## 1.5 Justification of the study

There is limited studies about waters treatments in the Gaza Strip using local media, so this study will add to the accumulating literature on sand filter and water treatment.

- Lack of studies related to the investigation of water treatments using local materials.
- The needs to find out a significant, effective, available, and inexpensive method for waters treatments.

## 1.6 Thesis structure

This thesis consists of four chapters as follows:

**Chapter One (Introduction):** Chapter one includes general background about water problems in the Gaza Strip, problem identification and objectives of the study.

**Chapter Two (Literature review):** Chapter two covers a general literature review on water treatment and the types of filter media.

**Chapter Three (Materials and methods):** Chapter three discusses the methodology of study including the media preparation, investigations of filters efficiency for water treatment, analysis.

**Chapter Four (Results and Discussion of the study):** Chapter four presents the results and findings of this study including figures show the relation between parameters of water sample and Retention time before and after addition of media and removal efficiency.

**Chapter Five (Conclusion and Recommendations):** Chapter five presents the main conclusion and recommendations of the study.

# Chapter Two

# Literature Review

# Chapter Two

# Literature Review

## 2.1 Introduction

Groundwater refers to all the water occupying the voids, pores and fissures within geological formations, which originated from atmospheric precipitation either directly by rainfall infiltration or indirectly from rivers, lakes or canals. Groundwater are potentially unsafe for human consumption because they are constantly exposed to contamination from human, animal, industrial wastes, and from natural sources such as soil, vegetation. The chemical, physical and bacterial characteristics of groundwater determine its usefulness for various purposes. The ground water analysis reviewed includes taste , odor, pH, nitrates, chlorine content, total dissolved solids (TDS), turbidity, dissolved oxygen and hardness others include alkalinity, chloride, toxic chemicals as lead, iron and the presence of coliform organisms. (Olumuyiwa I. Ojo et al, 2012).

## 2.2 Water treatment

Water treatment is the process of converting raw water from surface or sub-surface source into a potable form that is suitable for drinking and other domestic uses (Hofkes, 1981). It also entails the removal of pathogenic organisms and toxic substances listed earlier, but does not necessarily make the drinking water pure or sterile in the analytical sense (Oluwand, 1983).

The conventional methods by which water is made potable are namely aeration, coagulation, flocculation, sedimentation filtration and other means of disinfection which make use of physical processes to achieve their objectives (Olumuyiwa I. Ojo et al, 2012).

## 2.3 Treatment processes

The water treatment process may vary slightly at different locations, depending on the technology of the plant and the water it needs to process, but the basic principles are largely the same. This section describes standard water treatment processes.

### *2.3.1 The pretreatment*

Pre-treatment processes may be used to modify the water chemistry and possibly the contaminants themselves, to improve their removal by later treatment processes. One of the functions of pre-treatment processes is to provide a buffer against changes in source water quality, so that quality changes and the rate of change are reduced. Where treatment plants experience biological growths in parts of their system, such as the clarifier tanks, pre-treatment may also be used to control these growths. The pretreatment can be achieved by the following methods (Chris Nokes 2008).

#### *2.3.1.1 Sedimentation basins*

Sedimentation basins reduce the load of sediment in the water reaching the main treatment processes, and they reduce the magnitude of water quality changes. This is done by providing a large impounded area in which the water flow is reduced, which gives time for particles to settle out under gravity. Insoluble chemical contaminants may also be partially removed by the settling process.

#### *2.3.1.2 Infiltration galleries:*

Levels of turbidity and natural organic matter, and to some extent microbiological contamination in water can be reduced by abstracting the water in directly from the source through an infiltration gallery. This form of pretreatment achieves little removal of Cryptosporidium.

#### *2.3.1.3 Pre-oxidation*

Pre-oxidation may be carried out using oxidising chemicals such as chlorine, ozone or potassium permanganate. It is typically used to modify natural organic matter NOM (the substances that give some waters a yellow-brown color) to improve its removal during the coagulation/flocculation step. It may also be used to oxidise soluble iron or manganese usually in ground waters) and sometimes arsenic, to precipitate them for removal by particle removal processes. Pre-oxidation can destroy some cyanotoxins (toxins produced by cyanobacteria: blue green Algae).

#### *2.3.1.4 Aeration*

In Aeration, water is brought into intimate contact with air in order to increase their oxygen content to facilitate precipitation and result in the removal of iron and manganese in their ferric and manganese forms, and organic compounds. Aeration reduces the carbon dioxide content of water and thus decreasing the solubilization tendencies of water, which causes corrosion and leaching of plumbing materials into water. Ground high is iron and manganese benefit from aeration (Sangodoyin, 1987).

### 2.3.2 Particle removal

By weight, clay, silt and sand particles are the main contaminants removed by this group of processes, but particle removal processes also improve the microbiological quality of the water by physically removing the micro-organisms. The most important task of particle removal, from a public health view point, is the removal of protozoa – some of which are not easily inactivated by chlorine. Particle removal processes can also contribute to the removal of bacteria (Chris Nokes 2008). Particle removal can be achieved by the following methods:

#### *2.3.2.1Coagulation/flocculation:*

Coagulant, usually an aluminum (eg, alum) (($Al_2$ $(SO_4)_3$.) or iron salt, is added to the water. This encourages small particles in the water to stick together to form larger particles, which are more readily removed from the water by the processes that follow. The addition of the coagulant also results in the formation of ‘flocs’ (particles) of insoluble metal hydroxides. The flocs further assist in contaminant removal by providing surfaces for adsorbing contaminants, and trapping contaminants as floc formation occurs, Coagulation reduces load on filters, thereby reducing costs through the extension of the life of the filter (Sangodoyin, 1987).

#### *2.3.2.2 Filtration*

This is a process designed to remove bacteria, debris and organic matter. It is often considered as the final polishing operation in water treatment. When sand is used as a medium, it is called slow sand filtration, which is often employed in developing nations. It does not work for high turbidity water since it can get clogged easily. In sand filtration there is complete physical, chemical and biological treatment in one unit (Sangodoyin, 1987).

### *2.3.2.3 Disinfection processes*

Disinfection is simply the killing of potentially harmful organisms. Its objective is to obtain microbiologically clean water, which contains no pathogenic organism sand is free from biological forms that may be harmful to human health or aesthetically objectionable (Kootapepet al., 1980). Chemical disinfections employ the use of chemical called disinfecting agents, for example chlorine, ozone, potassium permanganate and chlorine dioxide.

## 2.3.3 Additional treatments

### *2.3.3.1 Mechanisms and definitions of adsorption*

Adsorption is a mass transfer process which involves the accumulation of substances at the interface of two phases, such as, liquid–liquid, gas–liquid, gas–solid, or liquid -solid interface. The properties of adsorbates and adsorbents are quite specific and depend upon their constituents. The constituents of adsorbents are mainly responsible for the removal of any particular pollutants from wastewater (Khattri SD and Singh MK 2009). If the interaction between the solid surface and the adsorbed molecules has a physical nature, the process is called physisorption. In this case, the attraction interactions are van der Waals forces and, as they are weak the process results are reversible. On the other hand, if the attraction forces between adsorbed molecules and the solid surface are due to chemical bonding, the adsorption process is called chemisorption. Contrary to physisorption, chemisorption occurs only as a monolayer and, furthermore, factors affecting the adsorption process are: (1) surface area, (2) nature and initial concentration of adsorbate, (3) solution pH, (4) temperature, (5) interfering substances, and (6) nature and dose of adsorbent. Substances chemisorbed on solid surface are hardly removed because of stronger forces at stake .

The overall idea is to reduce the use of activated carbon because of high costs. Therefore, scientific world is looking for low-cost adsorbents for water pollution. In addition to cost problem, another important factor pushing toward low-cost adsorbents is the use of agricultural and industrial waste products in order to extend the life of waste materials without introducing into the environment new materials as adsorbents and to reduce costs for waste disposal therefore contributing to environmental protection.

Anyway a suitable non-conventional low-cost adsorbent should:

(1) be efficient to remove many and different contaminants,

(2) have high adsorption capacity and rate of adsorption, and

(3) have high selectivity for different concentrations ( Mariangela Grassi, et al 2012)

## *2.4 Commercial Adsorbents*

### *2.4.1 Activated Carbon*

Activated carbon contains a very high surface area per unit weight that can adsorb contaminants. Activated carbon adsorption can remove a wide range of contaminants from water, particularly trace organic contaminants including industry solvents and pesticides (Chris Nokes 2008).

Activated carbon prepared from different source materials (e.g. coal, coconut shells, lignite, wood, etc.) is the most popular and widely used adsorbent in wastewater treatment throughout the world (Gupta VK, et al 2009). Activated carbon is produced by a process consisting of pyrolysis of raw material followed by activation with oxidizing gases. The product obtained is known as activated carbon and generally has a very porous structure with a large surface area ranging from 600 to 2,000 $m^2/g$. Although, activated carbon is undoubtedly considered as universal adsorbent for the removal of diverse kinds of pollutants from water, its widespread use is sometimes restricted due to the high costs (Bhatnagar A and Jain AK 2005 ).

### *2.4.2 Clays*

Natural clay minerals are well known from the earliest day of civilization. Because of their low cost, high surface area, high porosity, and abundance in most continents, clays are good candidates as adsorbents. There are many kinds of clay: smectites (montmorillonite, saponite), mica (illite), kaolinite, serpentine, pylophyllite (talc), vermiculite, sepiolite, bentonite, kaolinite, diatomite, and Fuller’s earth (attapulgite and montmorillonite varieties) The adsorption capacities depend on negative charge on the surface, which gives clay the capability to adsorb positively charged species (Gupta VK, et al 2009 ). The natural clay and its composites are capable of removing contaminants ranging from metals to priority pollutants from contaminated drinking water and its sources. The recent advances in using natural clay and its modified composites show the flexible nature of the clay and its ecofriendly nature. They are capable of removing organic and inorganic contaminants from drinking water with very high removal ratios of toxic trace metals, nutrients, and organic matter. In most of the cases, they proved to be better or comparable with the existing commercial filter materials, adsorbents, and conventional methods used for decontamination of drinking water. Being natural and their abundance presence makes them a low-cost green, nontoxic adsorbent which can be used for removal of different contaminants from water and making clean and pure drinking water available for developed and developing nations (Rajani Srinivasan2011).

### *2.4.3 Minerals*

Another class of adsorbents includes natural minerals. Among these zeolite and goethite have been investigated in the adsorption of pharmaceuticals. Zeolite is typically used for the removal of dyes and heavy metals. Like clay minerals, adsorption capacity is linked to negative charge on the structure (Mariangela Grassi, et al 2012).

### *2.4.4 Low Cost Adsorbents*

Attempts have been made to develop low-cost alternative adsorbents which may be classified in two ways (1) on basis of their availability, i.e., (a) natural materials (wood, peat, coal, lignite etc.), (b) industrial/agricultural/domestic wastes or by-products (slag, sludge, bagasse flyash, red mud etc.), and (c) synthesized products; or (2) depending on their nature, i.e., (a) inorganic and (b) organic material (Gupta VK, et al 2009) .

### *2.4.5 Agricultural Waste*

Agricultural materials containing cellulose show a potential sorption capacity for various pollutants. If these wastes could be used as low-cost adsorbents, it will provide a two-fold advantage to environmental pollution. Firstly, the volume of waste materials could be partly reduced and secondly the low-cost adsorbent, if developed, can reduce the treatment of wastewater at a reasonable cost (Bhatnagar A, Jain AK 2005, Jain AK, et al 2003) . The agricultural solid wastes from cheap and readily available resources such as almond shell, hazelnut shell, poplar, walnut sawdust (Aydin AH, et al 2004), orange peel (Arami M, et al 2005), sawdust (Shukla A, et al 2002) , rice husk (Vadivelan V, Kumar KV2005), and papaya seed (Hameed BH 2009) have been investigated for the removal of pollutants from aqueous solutions.

### 2.4.6 Industrial Waste

Widespread industrial activities generate huge amount of solid waste materials as by-products. Industrial wastes such as sludge, fly ash, and red mud are classified as low-cost materials, locally available and can be used as adsorbents for removal of pollutant from aqueous solution (Gulnaz O, et al, 2004).

### 2.4.7 Ion-exchange adsorption

Synthetic organic resins that can attract and adsorb positively or negatively charged ions (depending on the design of the resin) in the water are used in the ion-exchange adsorption treatment process. The most widely used ion-exchange systems are those used for removing positively charged ions. These are used to soften water, by removing calcium and magnesium, and for removing soluble iron and manganese (these metals in their insoluble form will foul the resins and inhibit their operation). Other contaminant metals in their soluble forms can also be removed by ion-exchange systems with varying degrees of efficacy (Chris Nokes 2008).

## 2.5 Filtration

Filtration is an ancient and widely used technology that removes particles and at least some microbes from water. The practicality, ease of use, availability, accessibility and affordability of these filtration media and methods vary widely and often depend on local factors. The effectiveness of these filtration methods in reducing microbes also varies widely, depending on the type of microbe and quality of the filtration medium or system. Granular media used for water filtration include sand, anthracite, crushed sandstone or other soft rock and charcoal. In recent years, efforts have been made to improve the performance of granular filter media for removing microbial contaminants by coating or co-mingling sand, coal and other common negatively charged granular media with metal oxides and hydroxides of iron, aluminum, calcium or magnesium. Such modified media are positively charged and therefore, more effective for removing and retaining the negatively charged viruses and bacteria by electrostatic adsorption (Mark D. Sobsey 2002).

### *2.5.1 Media types*

There are a number of different types of filter media that are used for water treatment. These include sand, coated sand, gravel, crushed glass, perlite, peat,leaf compost, mulch, zeolite, granular activated carbon and other media (Moller et al. 2002, Datryet al. 2003, Liu et al. 2004, Liu et al. 2005, Baltrenas and Brannval, 2006, Ray et al. 2006). Research on alternate filtration media, particularly recycled materials, has expanded the options available for improving effluent quality. The Factsheet published by EPA in 2000 summarizes the research on several alternate media materials, including crushed glass, recycled textiles, synthetic foam, and peat (EPA, 2000).

Media Filters may be classified based on the type of media used

1- Sand or gravel
2- Expanded shale
3- Cinders
4- Limestone
5- Activated carbon
6- Peat or Peat fiber

Manufactured products

7- Textile fabric
8- Open cell foam cubes
9- Crushed glass (Ted Loudon, Lead. 2003).

Alternate media filters are moderately inexpensive, have low energy requirements and do not require highly skilled personnel. They generally produce high quality effluent. The process is stable and requires limited intervention by operating personnel.

The media may be able to withstand higher loading rates than traditional sand filters due to increased surface area (EPA, 2000).

#### *2.5.1.1 Glass filter*

Glass is a product of the super-cooling of a melted liquid mixture consisting primarily of sand (silicon dioxide and sodium carbonate) to a rigid condition. This material does not crystallize; and when the glass is crushed to a size similar to natural sand, it exhibits properties of an aggregate material. Coarse angular material is effective in trapping dirt and impurities in the filters for water treatment and offers a greater filtration power than sand. Glass grains are less porous and do not saturate itself compared to traditional sand (do not form a cake in the filter) (Opta Minerals Inc., 2008). Much researches have been conducted to identify low-cost and low-technology systems for wastewater treatment. Crushed glass is an amorphous (non-crystalline), angular surfaced material and has no grain boundaries, which gives glass more resistance to breakdown through filtration backwashing cycles (Source: www.wrap.org.uk). (Echosmarte.com 2012) have produced a universal crushed glass media that is used for pool, industrial, and environmental filtration. The Echosmarte glass provides a direct replacement for sand or zeolite in both freshwater and saltwater pools (Source:www.ecosmarte.com). In the present study crushed recycled glass has been used to investigate the applicability of waste glass filtration in the removal of arsenic from contaminated water. Three colors of glass and two different sizes of crushed glass (2-4 mm, and 0.5-1 mm) were examined. Batch experiments were performed using glass which had been prepared by two different processes - imploding and grinding. Clean Washington Center (CWC) has also investigated crushed glass as a filter medium for wastewater treatment (Source: **www.wrap.org.uk 2**005). Other studies of crushed glass filtration media for slow sand or rapid sand filters have included by Richard Huebner, Ph.D, (1994), and DR. Guna Selvaduray, (1994). These studies have indicated that crushed glass media filters function as well as conventional sand filters and may remove small turbid particles more efficiently than conventional sand media.

Clean Washington centre CWC,1998 prepared another report in which recycled crushed glass and sand were evaluated for high-rate filtration. In conclusion it was reported that, when using crushed glass as a medium, the advantages over conventional sand were that better turbidity results were achieved, less backwash water was required to clean the filter medium (approx. 20%) and less medium by weight was required (approx 20%). Again, the report did not present any information about the removal of metals.

(Horan, N.J and Lowe, M, 2007) used the recycled glass as a tertiary filtration medium for wastewater treatment. The results indicated that Crushed and graded recycled glass is able to remove suspended solids from the effluent of a domestic wastewater treatment plant, when used as a medium for tertiary filtration. The glass filter medium was able to treat 10% more flow than the sand medium. The performance of glass media was at least as good, and generally better, than the sand medium traditionally used in tertiary filters. For an influent that has a suspended solids concentration of 70 mg/l or less, then up to 70% removal of suspended solids can be achieved and a consent of less 20 mg/l is possible.

Yulia Zakharova and Andrew Wheatley (2008) were studied the filtration medium chosen for an initial evaluation of the possibility of metal removal from urban runoff. The removal efficiency of some common metals, namely copper, iron and zinc both in their total and dissolved forms, were studied using a filter unit filled with crushed glass. The results indicate that glass can be effectively used for the removal of a metal such as iron in its total form, whereas this medium is likely to be less effective for metals like copper and zinc which are predominantly found in the dissolved form.

(Sultana Kudrati Khoda et al 2012) were collected the recycled glass bottles from local outlets and imploded using a Krystaline GP1 Imploder or ground using a Glen Creston Cross Beater Mill, Model 16-151. The glass granules were sieved using sieves of 4 mm, 2 mm, 1mm and 0.5mm mesh size. The sieved glasses were then separated for subsequent experiments. Arsenic solution was prepared by dissolving $As_2O_3$ (Arsenic Trioxide) in distilled water and diluted to the necessary test concentration. Batch experiments showed that glass granules have some potential for arsenic removal, at a smaller particle size of 0.5-1 mm (possibly due to greater surface area of these particles).

By EPA (2000) a pilot project was conducted for the City of Roslyn, Washington, to evaluate the feasibility of using crushed recycled glass as a filtration medium in slow sand filters. The study used a 38 centimeter (15 inch) PVC pipe as the media container and three types of sand and crushed glass. Wastewater was added to the filter at a loading rate of 0.002 cubic meters /minute/square meter ( 0.06 gallon/minute/square foot). The removal of bacteriological contaminants demonstrated that the glass filter media obtained an activity level typical of slow rate sand filtration. The results suggest that slow rate filtration may be an effective treatment process for Roslyn’s raw water source with the addition of a roughing filter. All three filters had similar removal efficiencies, although it was hard to draw conclusions for other geographical areas .

#### *2.5.1.2 Sawdust filter*

Sawdust is one of the most appealing materials among agricultural waste materials, used for removing pollutants, such as, dyes, salts, and heavy metals from water and wastewater. The material consists of lignin, cellulose, and hemicellulose, with polyphenolic groups playing important role for binding dyes through different mechanisms, which are active ion exchange compounds (A. Shukla, Y. Zhang 2002).

All researchers were mixing sawdust with other green sorption media. Xuan et al 2010 were studied a mix of selected media consisted of 68% fine sand, 25% tire crumbs, and 7% of sawdust. They used less than 10% of sawdust in their adsorption media for supporting denitrification. If part of the medium becomes anaerobic, in that case, sawdust acts as an electron donor. They investigated that 96 % of nitrates were removed during 24 hours of shaking time which followed by 24 hours of anaerobic period .

Hossain et al, (2009) mixed 50% sand, 20% limestone, 15% sawdust, and 15% tire crumb in their experiments. They concluded that the filter media mixture was efficient and effective for the removal of nitrate and nitrite at lower concentration. The highest removal efficiency was reached at 95.36% with 0.5 mg/L influent of nitrate after 5 hours of hydraulic retention time.

There is a very limited literature explaining the mechanism of adsorption on sawdust solely in storm water. Since sawdust is abundant, inexpensive and unused resources from agricultural byproduct, the use of this material would be beneficial for both the environment and wood agriculture: polluted streams would be cleaned and a new market would be opened for the sawdust.

Harmayani and A. H. M. F. Anwar (2012) studied investigates the adsorption characteristics of sawdust for removing nutrients (e.g., $NH_3^-$-N, $NO_3^-$-N, and $NO_2$-N) from storm water. Results revealed that the maximum removal was obtained at lower initial concentration. An increase of adsorbent dosage increased the percent removal of $NH_{3-}$N, $NO_3^-$-N, and $NO_2$N. The maximum removal of $NO_3^-$-N, and $NO_2$-N was found 100%, while $NH_3$N removal was found 55%, These studies revealed that nitrate and nitrite as nitrogen are well adsorbed onto sawdust at lower concentrations. Schipper et al, (2005) did an experiment by using sawdust denitrification wall to remove nitrate in shallow groundwater with hydraulic retention time (HRT) of 5 days. They dug a trench (about 35.00 m long, 1.500 m deep and 1.500 m wide) and used 30.00% Monterey pine sawdust (Pinus Radiata D. Don) by volume mixed with the excavated soil to place in the trench. The research group suggested that the nitrate concentration was a limiting factor rather than carbon for denitrification because when they added additional nitrate in soil, it increased the denitrification rate. No nitrate accumulation was observed in organic matter in soil or nitrate transformed into ammonia. They found a nitrate N removal rate of 1.400 g N $m^{-3}$ of wall $d^{-1}$that is about 97.20% of nitrate removal . Richman (1997) found that compost had good removal for 90.00% solids, 85.00% oil and greases and 90.00% heavy metals.

Volokita et al, (1996) used shredded newspaper for denitrification in drinking water by column study. Newspaper is a good source of carbon and support for microbial population. They found that the system could remove about 77.78% of nitrate after 30 days and 38.90% of nitrate after 120 days. This longer time was taken due to the growth of denitrifying bacteria in the system. The group suggested that temperature and retention time has a marked effect on the cellulose based denitrification. The detention time can be increased by decreasing the flow or by increasing the length of the system. The ink on paper also effected the growth on microbial in the system but not a limiting factor for the system. The research group observed that the temperature should be 25.00-32.00C° and unprinted newspaper was better to achieve higher denitrification rate. Kim et al, (2000) used different kinds of sorption media, such as alfalfa, mulch compost, newspaper, sawdust, wheat straw, wood chips for nitrate removal from storm water runoff. They found that alfalfa and newspaper had 100% nitrate removal efficiency but mulch compost had 60% nitrate removal efficiency. They also found that sawdust, wheat straw and wood chips had good removal efficiency (>95%), but wood chips showed consistently better performance in nitrate removal over sawdust. From their experiment, it could be concluded that all of these were electron donors and good carbon sources for promoting denitrification. They suggested that increasing the retention time may gain better removal efficiency. and also found that soil could only remove 7% to 10% of nitrate due to its anionic form.

Hsieh and Davis, (2003) found that mulch was very effective in removing nitrate, unlike sand. But they had not gained good ammonia removal efficiency by using mulch. Savage and Tyrrel, (2005) used wood mulch, compost, soil, broken brick and polystyrene packaging for removal of $NH_3^-N$ from compost leachate. They reached in a conclusion that wood mulch (75%) and compost (55%) had better removal efficiency for $NH_3^-N$ than other media and polystyrene was the least capable one to remove $NH_3\ ^-N$. Soil and broken brick could remove 38% and 35% of $NH_3^-N$, respectively.

### *2. 5. 1. 3 Agriculture waste*

Dried plants are natural materials widely available and studied as an alternative adsorbent for different heavy metals. plant leaves are natural wastes that are found to be efficient in removing considerable amounts of metals like lead, cadmium, nickel, and aluminum from aqueous metal solutions (Sayrafi ,et al, 1996). Abu-El-Halawa et al., (2003) reported the removal of zinc from aqueous solutions by 15 species of plant leaves. They found that the removal efficiency of zinc dependent on the plant species used. Dry plant leaves of thyme, sage, banana, mint, anise and oleander plants have also been suggested as natural, simple and cheap adsorbent for efficient removal of several metal ions from polluted water. Benhima et al., (2008), Abdel-Halim et al., (2003); and Chiban et al., (2005, 2009, 2011) studied the use of dried plants in the wastewaters treatment. The results of the laboratory investigations showed that dried plants are good adsorbents for the removal of arsenate, nitrate, phosphate, cadmium and lead ions from synthetic wastewaters. Claudio Della Rocca et al, (2005) presented the results obtained from a pilot-scale cotton-supported heterotrophic denitrification reactor (HDR) where cotton acts as both organic carbon source and supporting material for the growth of a denitrifier biofilm. A trickling sand filter (TSF) was inserted as post-treatment to remove TOC released by the HDR and to re-oxygenate the treated water. The system is evaluated for drinking water treatment. Nitrate removal efficiency of the HDR was over 90% for 85 mg/ℓ of inlet nitrate concentration which is a mean groundwater value in many EU countries.

R. Salim, et al, (2008) studied the removal of cadmium from aqueous solutions using 20 types of plant leaves. The results showed that the efficiency for the studied plant leaves to remove cadmium from aqueous solutions can be arranged in the decreasing order: styrax > plum > pomegranate > walnut > medlar > cypress > mulberry > carob > olive > eucal Yptus > pistachio > almond > vine > fig > apricot > oak > Pine > apple > orange > lemon
leaves. The styrax leaves are the most efficient and the lemon leaves are the least efficient types of plant leaves.

L. Shao et al, (2009) rice husk were chosen as a carbon source and the only physical support for microorganisms. The focus of the study was to determine whether rice husk can serve as the sole carbon for the denitrification of wastewater and the sole physical support for bacterial attaching. Natural rice husk with a length of 4-7mm and width of 2-3mm was collected from a local village of Chongming county in Shanghai, Rice husk was washed by tap water prior to oven drying (30ºC). The inoculated reactor was allowed to stand for 3 days before flow was initiated. Medium solution was prepared daily by tap water supplemented with $KNO_3$ as N source and $K_2PO_4$ (A. R., Shanghai Chemicals Plant, China) as P source. To establish different Dissolved Oxygen (DO) conditions in the feed vessel, the media was swept by nitrogen gas. The results suggest that rice husk is effective in wastewater treatment as the sole chemical and physical substrate for the denitrifying microorganism. Moreover, it is safer to use rice husk as substrate in wastewater denitrification when compared with traditional liquid carbon sources.

Wanielista and Chang, (2008) examined the material property, sorption Capacity and reaction kinetics of selected mixes of sorption media for nutrient removal using batch and column tests. Pollutants of concern mainly include ammonia, nitrate, nitrite, and orthophosphate. Sorption media of interest include but are not limited to tire crumb, sawdust, activated carbon, iron amended resins, orange peel, peat, leaf compost, naturally occurring sands, zeolites, coconut husks, polymers, soy bean hulls, etc. The results was indicated that the functionalized media mix has the potential to effectively and efficiently remove most of the nutrient species within an appropriate detention time via the sorption processes. The life expectancy of the proposed sorption media is reasonably long in terms of orthophosphate removal.

Chang et al, (2010) designed the column tests to determine the nutrient removal performance of the selected green sorption media in saturated and unsaturated conditions that mimic the field condition of stormwater dry ponds. The columns were 182.88 cm (6 ft) long, with an inner diameter of 14.73 cm (5.8 in) and a wall thickness of 0.51 cm (0.2 in). Each column had three sampling ports. The first port was 39.37 cm (15.50 in) from the bottom of the column, the second port was 44.45 cm (17.5 in) above the first, and the third port was 38.10 cm (15.00 in) above the second. A plastic mesh filter with gravel was placed at the bottom of each column to prevent the outward flow of finer particles from the columns during sample collection. All the columns were filled with sand or sorption media to a height of 121.92 cm (48 in). The fill line was slightly below the first port and 38.10 cm (15 in) above the second port. The first pair of columns was filled with natural soil collected at the Hunter's Trace pond as a control case. In the second pair, the first column was filled with natural soil, and the second column was filled with the sorption media mixture.

The natural soil was sun dried, and impurities were removed with a number 10 sieve. The control case natural soil was compacted to a density of 516.00 kg/m3(106.00

lb/ft3), and the media mixture was compacted to a density of 204.45 kg/m3(42.00 lb/ft3). In each pair, the first column was considered to be the unsaturated (vadose) zone, and the second column was considered to be the saturated zone. water was pumped from the unsaturated column using a peristaltic pump. In particular, the media mixture with an initial concentration of 2.53 mg/L removed approximately 99.20% of the $NO_3^-$-N compared to the natural soil that removed only 39.50% of the $NO_3^-$-N with an HRT of 4.00 hours. the OP removal efficiency was about 55.20% by the soil and 91.40% by the sorption media.

### *2.5.1.4 Kaolin:*

Kaolin is one of the clay materials widely used for a large number of applications such as in ceramics, paper coating, paper filling, paint extender, rubber filler, cracking catalyst or cements, oil refinery and water treatment, Kaolinite has the chemical formula $Al_2Si_2O_2(OH)_{4}$- (Eze k. A et al 2012).

Many researchers began to use cationic surfactant to modify natural soil to enhance the sorption capacity of inorganic oxyanion contaminants (IOCs) such as nitrate, sulphate, arsenate, selenate and chromate and nonionic organic contaminants (NOCs) such as benzene, toluene, ethylbenzene and xylene.

Surfactant modified clays can provide selectivity, and are produced from inexpensive base material and are chemically regenerable. The adsorption capacities of clay mineral have been shown to improve significantly due to the modification with quaternary ammonium compounds (QAC) . The molecular structure of the modifying cations was also shown to play an important role in controlling the preference adsorption. Therefore, modification of a specific clay mineral with a quaternary ammonium salt can produce a sorbent that is capable of sorbing inorganic from aqueous solutions (Aroke, et al 2014) .

There are large reserves of natural resources like zeolites in South Africa yet there is limited research on zeolite application in water and wastewater treatment in South Africa. Surfactant modified zeolite with a positive charge will attract anionic contaminants like nitrates by electrostatic interactions.

Li et al, (2007) arsenic were removed from water using surfactant modified zeolite. Perchlorate can also be removed by surfactant modified zeolite. (Majdan et al, 2006) concluded that surfactant modified chabazite is an efficient adsorbent for the removal of chromates from aqueous solutions. Masukume, et al (2010) evaluated surfactant modified zeolite (SMZ) for nitrate removal in batch equilibrium and fixed bed column experiments.

The project was aimed at exploring the application of surfactant modified natural zeolite in removing nitrates from South African groundwater.

The effects of surfactant loading, adsorbent dosage and temperature on the adsorption process were investigated. Modification of the zeolite resulted in a significant increase in the adsorption capacity of the adsorbent. An increase in adsorbent dosage resulted in a corresponding increase in the percentage removal of nitrate from water.

Natural zeolites are environmentally and economically acceptable hydrated aluminosilicate materials with exceptional ion-exchange and sorption properties. Because of the excess of the negative charge on the surface of zeolite, which results from isomorphic replacement of silicon by aluminumin the primary structural units, natural zeolites belong to the group of cationic exchangers. Numerous studies so far have confirmed their excellent performance on the removal of metal cations from wastewaters. The applicability of natural zeolites for the simultaneous removal of ammonia and humic acid, two of the most encountered current contaminants, from the surface waters was also investigated. Their removal depends on pH value, initial concentrations of humic acid and ammonia, temperature and contact time (Karmen Margeta, et al 2013).

Krishna et al , (2014) studied two-dimensional filter simulation test apparatus which was constructed to examine the effectiveness of mixed media for the removal of multiple contaminants from synthetic stormwater. The mixed media consisted of a mixture of calcite, zeolite, sand, and iron filings. The mixed media was tested for removal of coexisting nitrate, phosphate, Ni, Cu, Cd, Cr, Pb, and Zn at concentrations and conditions relevant for typical urban storm water. Results showed that the mixed-media filter was able to maintain high flow rates without any clogging issues, with an average hydraulic conductivity around 30 cm  min. No significant initial release or final desorption of the contaminants was observed.

The filter system proved effective for the simultaneous removal of nutrients and heavy metals from the stormwater, except for Ni, which had significantly lower removal efficiency than the other metals. Overall, the study indicated that a mixed-media filter can be designed with high contaminants removal capacity, but additional studies are recommended for evaluating long-term performance of the mixed-media filter under variable storm water field conditions.

### *2.5.1.5 Sand filter*

There are two types of sand filters

#### *2.5.1.5.1 Rapid sand filters*

These filters use coarser sand than slow sand filters and the effective size of the filtermedia is usually greater than 0.55 mm. The flow rates are normally between 4 and $21m^3/h$ equating to 400 to 2100 l/h per $m^2$ of filter. These filters do not remove disease causing entities as efficiently as slow sand filters and usually need a post filtration chlorination process (WWW.ITACANET.ORG, 2005).

#### *2.5.1.5.2 Slow sand filters*

Slow sand filters use sand with effective sizes of 0.15 - 0.35 mm to remove a large percentage of coliforms, cryptospridum and Giardia cysts. They operate most effectively at a flow rate of 0.1 – 0.3 m/h (or $m^3/h/m^2$), which equates to 100 – 300 l/h per $m^2$ of filter area.

These filters use physical processes such as sedimentation, adsorption and straining to remove fine particles as well as microbiological processes to remove organic material and bacteria. Because of the slow filter rates the raw water sits above the sand for several hours before passing through it, various oxidation reactions break down organic material during this time. Algae, that grows on the sand surface, consumes this oxidised organic material and releases oxygen back into the water (WWW.ITACANET.ORG, 2005).

Slow sand filtration is a long established technique for reducing turbidity and bacteria in water; it has been in large-scale use for 100 years. Slow sand filtration as a system of water purification has been in continuous use since the beginning of the twentieth century and has proved effective under widely differing circumstances. It is simple, inexpensive and reliable, and is still the chosen method of purifying water supplies for some of the major cities of the world (Tebbutt, T.H.Y., 1999).

The slow sand filter system is a highly biologically active unit, therefore, the filter has to be operated for several days to develop a biological film (schmutzdecke) on the grain of the filter until the purifying bacteria become well established and plays an important part in the treatment process (Ellis and Kov, 1985).

A. E. Adeniran ,and J. O. Akanmu (2010) evaluated the slow sand filtration as advanced treatment of secondary effluent from a water hyacinth based domestic treatment plant using effective graded size of sand 0.35mm that was conducted at the University of

Lagos, Nigeria. The secondary effluent from the water hyacinth sewage pond was applied at a flow rate of $90m^3/h$ to the slow sand filter. The filter was operated at sand depths of 100 cm. It was found that the removals of colour, turbidity, BOD, TDS, nitrate and e-coli were 88%, 100%, 91.67%, 94.35%, 74.07%.and 100%, respectively, at the end of 28 days of operation.

## 2.6 Media characteristics

The primary sand media characteristics affecting filtration performance are the effective grain size and uniformity coefficient (Crites and Tchobanoglous, 1998). These characteristics tend to affect the retention time of liquid passing through the media and the potential for clogging.

### *2.6.1 Effective particle size (d10)*

The effective size (ES) is defined by the size of screen opening where 90 percent of a sample of granular media is retained on the screen and 10 percent passes through the screen, and is referred to as D10 (John Eliasson 2002). (Read this value from the graph where the line crosses the Passing Through the Sieve line at 10%).

d10 = the size of grain such that 10 percent by weight of the total sample is smaller [mm].

Recommended ES range = 0.15 mm to 0.20 mm (likely to achieve 0.4 L/minute flow rate in the biosand filter, also recommended for community slow sand filters) (CAWST 2009). The effective size is important because (1) the grain size determines the surface area and void space within the bed, (2) the smaller grains would occupy the void space created by the larger grains, and the water would be forced between the smaller particles.

### *2.6.2 Uniformity coefficient (UC)*

This is defined as a ratio and calculated as the size opening that will just pass 60% of the sand (d60 value) divided by the size opening that will just pass 10% of the sand sample (the d10 value) (Ted Loudon, Lead. 2003). UC = the ratio of the size of grain that has 60 percent of the sample finer than itself to the size that has 10 percent finer than itself, that is, d60/d10.

Recommended UC range = 1.5 to 2.5 (likely to achieve 0.4 L/minute flow rate,also recommended for community slow sand filters) (CAWST 2009). The uniformity coefficient provides the ratio between larger grains and smaller grains, and determines the size of pore openings and surface area.

## *2.7 Advantages of slow sand filter*

- It is a low energy consuming process
- It has great adaptability in components and applications maintenance is minimal
- Systems can be built and installed by laymen
- Costs of building and running significantly lower than other disinfestations methods(http://oasisdesign.net/water/treatment/slowsandfilter.htm).

## *2. 8 Filtration mechanism in slow sand filters*

There are several mechanisms for the removal of contaminants from water as follows:

### *2. 8. 1 Physical and mechanical processes*

The sand in sand filter bed acts in mechanical way to strain out solid particles in the raw water. These mechanisms are:

#### *2. 8. 1.1Transport*

The processes that occur within the sand bed can be summarised as followed:

1- Interception – the water flows so that particles move close enough to a sand grain to become attached.

2- Diffusion – random Brownian motion brings particles close to grains.

3- Sedimentation – gravitational forces move particles downwards onto the top surfaces of grains.

4- Hydrodynamic – particles in a velocity gradient (i.e. where water is flowing around a grain) often develop a rotation which provides lateral forces that move particles out of the water stream and into contact with sand grains.

#### *2. 8. 1. 2 Attachment*

These processes involve electrostatic and molecular (Van der Waals) forces that are similar to those that occur in coagulation. These attractions are sensitive to the surface charges on the sand grains. The electrostatic force creates attraction between particles of opposite charges, and repels particles with the same charge. Clean quartz sand has a negative charge, and thus attracts particles with positive charge such as, crystals of carbonates, and metal ions (iron, manganese, aluminum, etc.). Colloidal particles of organic origin and bacteria normally have negative charges.

### *2. 8. 2 Biological action*

Biological action occurs in slow sand filter beds. Because of the low hydraulic loading and smaller sand size found in slow sand filters , most of the solid particles are removed within the top 0.5- 2 cm of sand, as opposed to rapid filters where the penetration is much deeper. This top layer of sand develops into a biologically active area known as the *schmutzdecke* (which translates roughly from German as ‘dirty layer’). While most of the biological activity occurs in this region. The Schmutzdecke is perhaps the single most important feature of the slow sand filter and is a sticky reddish brown layer consisting of decomposing organic matter, iron, manganese and silica. It acts as a fine filter to remove fine colloidal particles from the raw water and is also the initial layer of bioactivity.

The schmutzdecke takes a while to form and ripen, this may take 2 – 3 weeks depending on the temperature and the biological content (bacteria and organic material) of the raw water (WWW.ITACANET.ORG, 2005).

Safira Astari dan Rofiq Iqbal, (2007) studied the efficiency of sand filter for water treatment using different four sand filter systems as shown in table 2.1.

**Table (2.1) : Different four sand filter systems (Safira Astari dan Rofiq Iqbal ,2007)**

| Sand filter diameter | sand Depth | High of water | Flow rate |
|---|---|---|---|
| 115 cm | 50 cm | 50 cm | 0.045 $m^3$/hr |
| 95 cm | 57 cm | 38 cm | 0.48 $m^3$/hr |
| 60 cm | 40 cm | 52 cm | 0.085 $m^3$/hr |
| 29 cm | 60 cm | - | 1 L/min |

The results showed better treatment efficiency for the system number one for the treatment of Iron, Manganese, Organic matter as well as the decrease of turbidity, where the system in general have the following removal efficiency for turbidity, iron, manganese, nitrite, nitrate, organic matter, total hardness, dissolved solid were 92.6%, 91,5%, 93%, 80%, 69%,23.5%, 4.7%, and 7.7% respectively.

Themba. et al (2011) studied the design , the construction and evaluation a cost-effective biosand filter and evaluate the chemical contaminant removal efficiency. They have used modified biosand filter with zeolites (BSFZ) , the filter consisted from four layers, where the zeolites represents the second layer between the fine sand and coarse sand. In this study a natural zeolite (clinoptilolite) with a particle size of between 1 mm and 3 mm was used without any modification. They used this filter to study the treatment of drinking water. The results showed the removal of up to 80% calcium, 89% magnesium, 99% iron, 56% arsenic, 54% fluorides, 96% turbidity, 37% nitrates and 41% total organic carbon. The study recommend that BSFZ users should avoid filtration of highly turbid water as this result in quick clogging of the filter media.

WF DUKE et al (2006) conducted a study to evaluate the use and performance of the Manz Biosand filter in the Artibonite Valley of Haiti. The objective of the study collect data about the filters efficiency in removing bacteria and reducing turbidity under typical working conditions, and track the levels of Escherichia coli in household water from source to point –of use. The container was made of concrete , stands 95 cm in height and 36 cm in width. It weight approximately 150 kg empty, and 225 kg filled with the sand and water and ready to use. The flow rate is 30-40 L/h with a maximum of 60 L/h. The filter was cleaned by stirring the top 5-10 cm of sand. Different sources of waters were used shallow, hand-dug wells, water piped and deep wells, shallow, hand-dug wells provided the only source of water for 61% of the households ,with 26% using water piped from springs or deep wells and 13% having access to both. The overall bacterial removal efficiency for the filters was calculated to be 98.5%. Turbidity decreased from an average of 6.2 NTU in source water samples to 0.9 NTU in the filtered water. None of the households treated the water after filtering, 91% used the filtered water only for drinking. No problems related to filter construction were observed, 13% of the samples from the filters spouts containing >10E. coli cfu/100ml and 22% of the stored filtered water samples at point-of-use containing >10 cfu/100 ml.

Izumi Kikkawa (2007) studied local BSFs which were constructed in Northern Region, Ghana, He used four local plastic design (LPD) to test and evaluate an experimental modification of the LPD BSF for treatment of highly turbid water. Modifications of the LPD BSFs were made in order to provide an additional, biolayer 5 - 10cm of fine sand of diameter of <1mm where the used main sand filter media consists of 17.8 cm of fine sand of diameter of <1mm, the core layer of a BSF where most removal and degradation of pathogens occured. This adjustment was carried out by providing an additional diffuser basin, the flow rate decreased by increasing the depth of the additional sand layer 32. l/h, 21.8 l/h and 21.1 l/h for standars BSF, additional 5 cm and additional 10 cm of fine sand respectively. All LPD BSFs removed turbidity by an average of 92-95 %

after Day 13, with average effluents of 10- 16 TU (14 . 22 NTU), The average total coliform removal after 11 days was 87 % with an average effluent concentration of 430 cfu/100 ml from an influent concentration of 15,000 cfu/100 ml.

**Table (2.2) : Different sand filter systems without modification and additional 5 to 10cm sand layer(Izumi Kikkawa (2007).**

| **BSF** | **flow rate** | **Volume of the plastic bucket** | **Gravel** (6-15 mm) | **Coarse Sand** (1-6 mm) | **Fine sand** (<1.0 mm) | **Standing Water Depth** | **Average turbidity removal after day 13** |
|---|---|---|---|---|---|---|---|
| **without modification** | 0.14 - 0.18 $m^3/m^2/h$ | 50 L | 5 cm | 3.5cm | 17.8 cm | 4 cm | 93 % |
| **additional 5 cm sand layer** | 0.14 - 0.18 $m^3/m^2/h$ | 50 L | 5 cm | 3.5cm | 17.8 cm | 4 cm | 95 % |
| **additional 10 cm sand layer** | 0.14 - 0.18 $m^3/m^2/h$ | 50 L | 5 cm | 3.5cm | 17.8 cm | 4 cm | 95 % |

# Chapter Three

# Material and methods

# Chapter Three

# Material and methods

## 3.1 Materials:

The raw materials as sand, gravels, waste glass, kaolin, sawdust, guava and fig leaves and PVC columns are provided from local market.

### *3.1.1 sand:*

Sand consists of small grains or particles of minerals and rock fragments. Although these grains may be of any mineral composition, the dominant component of sand is the mineral quartz, which is composed of silica (silicon dioxide) its chemical structure as shown in Fig (3.1). Other components may include aluminum, feldspar and iron-bearing minerals. Sand with particularly high silica levels that is used for purposes other than construction is referred to as silica sand or industrial sand (Dr. Kamar Shah Ariffin, 2004).

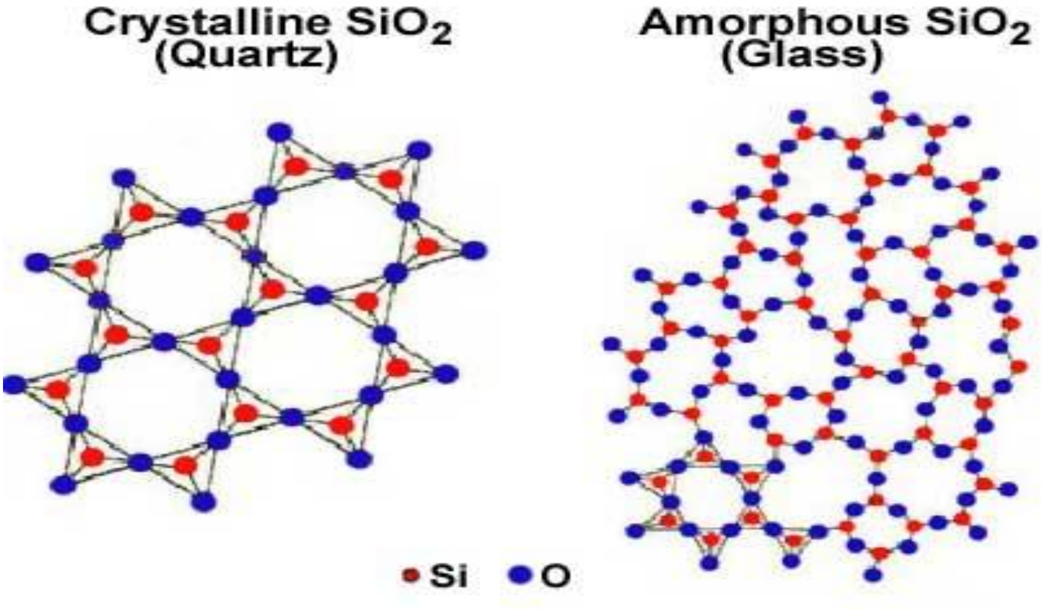


**Figure (3.1) : Chemical structure of sand(Dr. Kamar Shah Ariffin, 2004).**

### *3.1.2 Glass :*

Glass consist of silica dioxide ($SiO_2$) and other metal oxide as sodium, potassium, calcium, boron, which reacted with ($SiO_2$) to form silicate network as shown in fig (3.2 and 3.3).

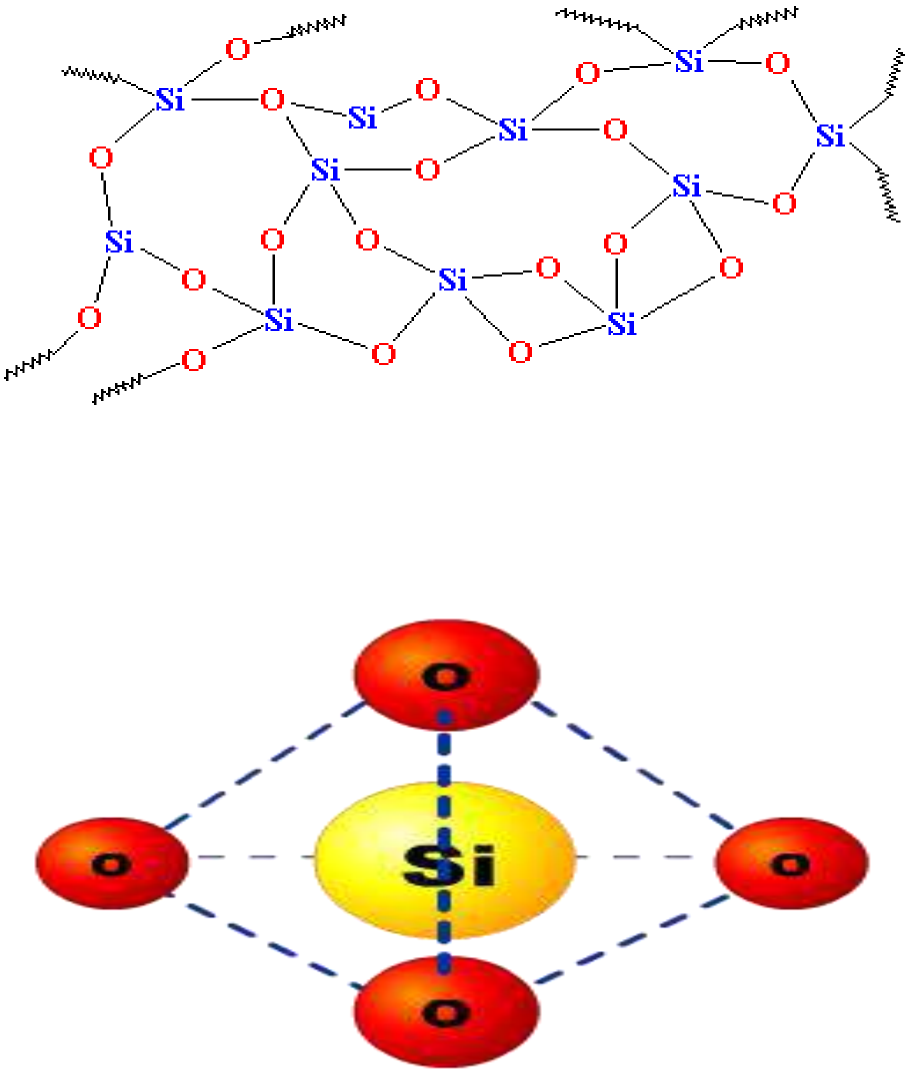


**Figure (3.2) : Chemical structure of glass**

### *3.1.3 Kaolin:*

Kaolin is any of a group of fine clay minerals with the chemical composition of $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, Kaolinite is the major mineral component of kaolin, which Kaolinite is a clay mineral with chemical composition $Al_2Si_2O_5(OH)_4$. It is a layered silicate mineral as show in fig(3.4) (Deer .W.A. et al, 1992).

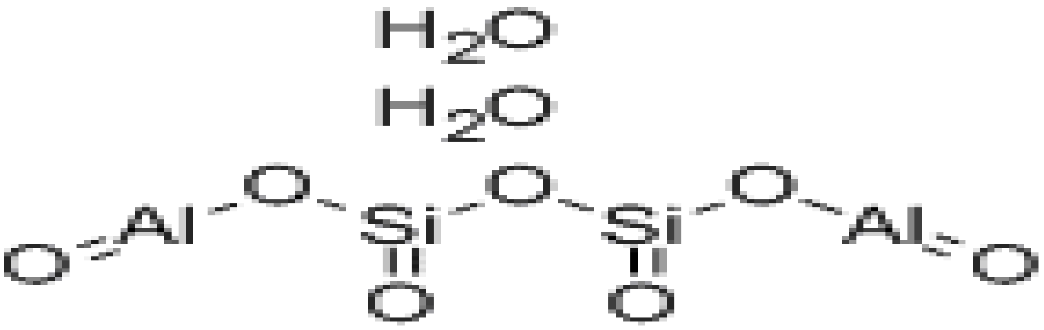


**Figure (3.3) : Chemical structure of kaolin(Deer W.A. et al, 1992).**

### *3.1.4 Wood:*

All wood contains cellulose, lignin, and tannins or other phenolic compounds which are active ion exchange compounds (Shukla. A, Zhang. Y 2002) as shown in figure(3.5).

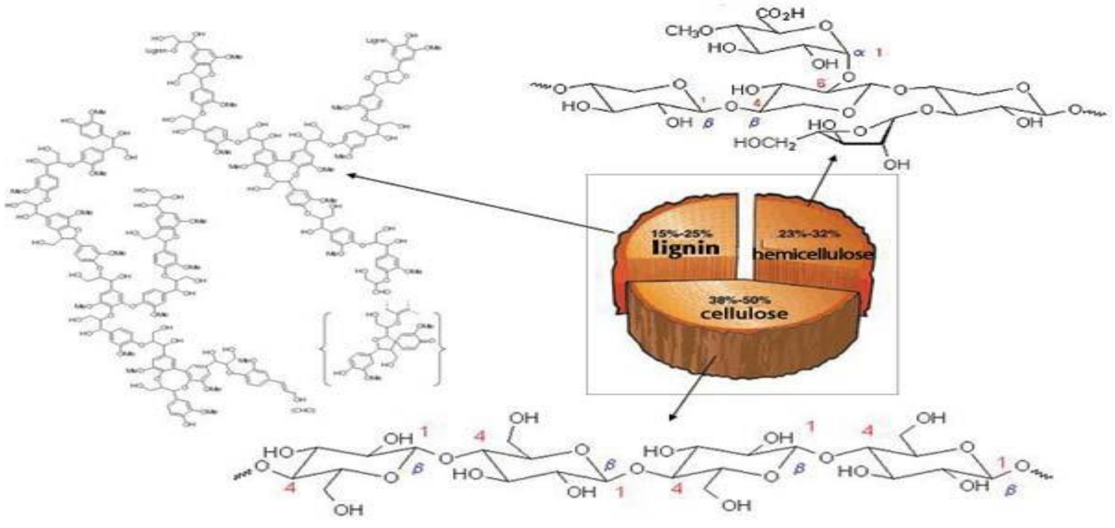


**Figure (3.4) : Chemical structure of sawdust(Shukla. A, Zhang. Y 2002)**

### *3.1.5 Guava leaves:*

The main constituents of guava leaves are phenolic compounds, isoflavonoids, gallic acid, catechin, epicathechin, rutin, naringenin, kaempferol (**Sandra M. Barbalho** et al, 2012).

The composition of guava leaves was investigation by (Kim et al, 2011) The main compounds present in guava leaves are ascorbic acid, citric acid, acetic acid, epicatechin, xanthine, protocatechuic acid, glutamic acid, asparagine, malonic acid, trans-aconitic acid, maleic acid and cis-aconitic acid. The chemical composition of Guava leaves (Psidium guajava Linn.) is described in table (3.1) (Mini priyar, 2011).

**Table (3.1) : Chemical composition of leaves Guava (Psidium guajava Linn.) (Mini priyar, 2011)**

| Parts | Constituents | Reference |
|---|---|---|
| **Leaves** | α-pinene, β-pinene, limonene, menthol, terpenyl acetate, isopropyl alcohol, longicyclene, caryophyllene, β-bisabolene, caryophyllene oxide, β-copanene, farnesene, humulene, selinene, cardinene and curcumene, mallic acids, nerolidiol, β-sitosterol, ursolic, crategolic, and guayavolic acids, cineol, quercetin, 3-L-4-4-arabinofuranoside (avicularin) and its 3-L-4-pyranoside (Essential oil), resin, tannin, eugenol, caryophyllene (1a α-, 4a α-, 7 α-, 7a β-, 7b α-)]-decahydro-1H-cycloprop[e azulene, Guajavolide (2α-,3 β-,6 β-,23- tetrahydroxyurs-12-en-28,20 β-olide; 1) and guavenoic acid (2 α-,3 β-,6 β-,23-tetrahydroxyurs- 12,20(30)-dien-28-oic acid, triterpene oleanolic acid, triterpenoids, flavinone-2 2’-ene, prenol, dihydrobenzophenanthridine and cryptonine. | Zakaria *et al.,* 1994, Iwu1993, Nadkarni and Nadkarni, 1999; Oliver- Bever, 1986; Begum *et al.,*2002; Wyk *et al.,* 1997, Joseph *et al.,* 2010 |

### *3.1.6 Fig leaves*

The main constituents of fig leaves are moisture, 67.6%; protein, 4.3%; fat, 1.7%; crude fiber 4.7%; ash 5.3%; N-free extract 16.4%; pentosans 3.6%; carotene, bergaptene, stigmasterol, sitosterol, and tyrosine. Ficusin, taraxasterol, betasitosterol, rutin , sapogenin, calotropenyl acetate, lepeolacetate and oleanolic (Baby Joseph, S.Justin Raj, 2011).

### *3.2 Media preparation*

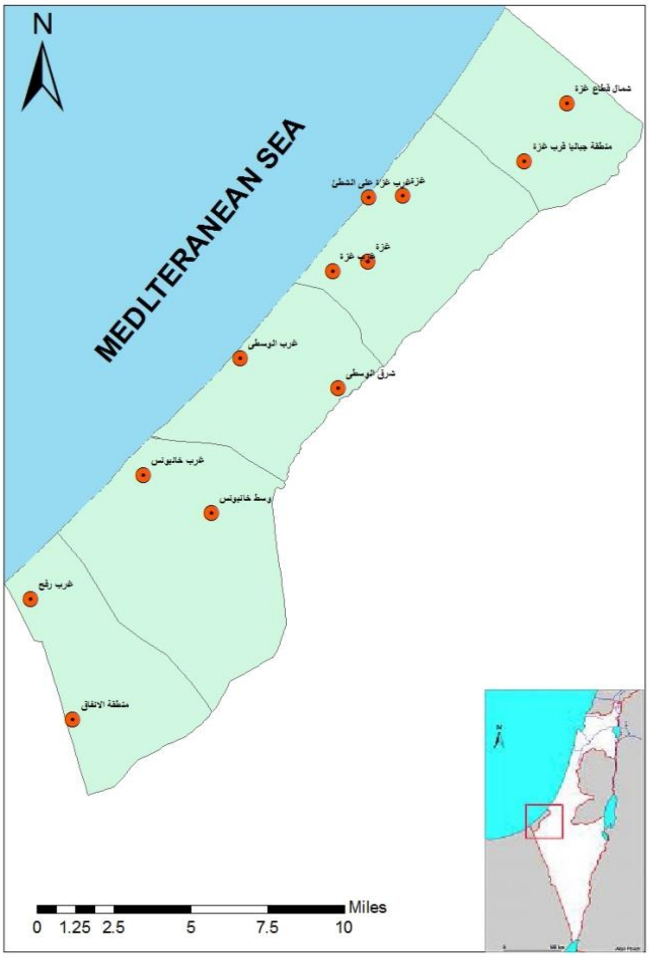
The selection of the media was based on the following considerations:

1) consistent in composition, 2) easily or commercially available, 3) low in cost, (4) environmentally benign, 5) permeable.

The Guava and Fig leaves were be collected and dried for two weeks, then crushed and washed for several times by distilled water then dried again using the oven at 70 C° for 10 hours then used as modifiers for the sand filter, The crushed glass was collected , washed , dried and crushed in El Ghefari crusher, and the sawdust was provided by El Horany carpentry. Both crushed glass and sawdust were washed by distilled water and dried using the oven at 90 C for 24 hours then used as filtration media modifiers. Also the kaolin is used as new modifiers with sand filter for water treatment.

## *3.3 Local sand selection*

The selection of the local sand were depend on the analysis of the effective size range (ES) and the uniformity coefficient (UC) for the proposed sand samples which collected from 12 locations distributing on the five governorates of the Gaza Strip as shown in the figure 3.6:



**Figure( 3.5) : Soil sampling locations from different areas of the Gaza Governorates**

After sampling each sand sample was labeled and treated separately where ES and UC were calculated based on the sieve analysis.

### *3.3.1 Sieve analysis*

For each sample the collected sand was washed by the running tap water to remove excessively fine grains , dirt's and dust , then dried using the oven ( MOV-212, Japan ) at 105 °C for 24 hours before, The sieve analysis was performed by shaking machine for 15 minutes where the samples of about 900 g of sand passed through a series of seven screens with a catch pan at the bottom, the mish number and the diameter of the used sieve were tabulated in table 3.2.

**Table (3.2) : Mish and Diameter**

| **Mish** | **Diameter(mm)** |
|---|---|
| 16 | **1.18** |
| 30 | **0.6** |
| 40 | **0.425** |
| 50 | **0.3** |
| 70 | **0.212** |
| 100 | **0.15** |
| 200 | **0.063 mm** |

At the end of shaking, the samples retained from each sieve was weighted and registered. The produced data from shaking process were used for the calculation for both of ES and UC.

### *3. 3. 2 Effective size calculation*

The determination of the Effective Size (ES) for all the sand samples were done using Win Sieve software after the entry of the retained mass in gram in each sieve after 15 minutes of the sample shaking.

### *3.3. 3 Uniformity coefficient calculation*

The determination of the Uniformity Coefficient based on the given data by Win Sieve Software which represented by $d_{10}$ and $d_{60}$ where the uniformity coefficient is defined as the ratio of $d_{60} / d_{10}$ that given directly from the software. Where $d_{10}$ is the size opening that will just pass 10% of the sand , and $d_{60}$ is the size opening that will just pass 60% of the sand for each sample.

## *3.4 Modified sand filter*

Preparation of modified sand filter was prepared by adding new additives, The selected additives which used with sand filter were Kaolin, Crushed Glass, Sawdust, Guava and Fig leaves. The columns used in preparation of filters manufacture from PVC at constant height length 120 cm and 4 inch diameter was shown in Fig(3.6). The preparation of modified columns was shown in table 3.3.

**Table (3.3) : Column of contents**

| Columns | Column contents |
|---|---|
| Column no.1 | Gravels 10cm, Sand 70cm (Blank column). |
| Column no. 2 | Gravels 10cm, Sand 40cm , Kaolin 10cm, Sand 20cm. |
| Column no.3 | Gravels 10cm, Sand 40cm , Crushed Glass 10cm, Sand 20cm. |
| Column no.4 | Gravels 10cm, Sand 40cm , Sawdust10vm, Sand 20cm. |
| Column no. 5 | Gravels 10cm, Sand 40cm , Guava Leaves 10cm, Sand 20cm. |
| Column no. 6 | Gravels 10cm, Sand 40cm , Figs Leaves 10cm, Sand 20cm. |

Figure( 3.6) : **Designed and constructed the columns**

## 3. 5 Investigation of filters efficiency for water treatment.

After the selection of suitable local sand based on ES and UC measurements and calculations, the described filters tabulated in table (3.3) where column number one is representing the control column. The investigations of the columns efficiency for water decontamination were been tested for nitrate ($NO_3^-$), Detergents, TDS, and water Hardness based on the retention time of the polluted water into the column. Contaminated water was prepared at the laboratory of Chemistry in Al-Azhar University, where the tap water was used and adjusted for the nitrate concentration to be 146,4 ppm, the detergents concentration of about 5 ppm, the water hardness ( 1100 ppm ), and TDS (1883 ppm), Pre and post analysis of each water sample for nitrate and detergents was been conducted directly and the results were registered in addition to measure the TDS, water hardness and pH Measurement. All data were treated using Microsoft Office Excel then analyzed and discussed.

## *3.6 Instruments and chemicals*

### 3.6.1 Instrumental

For the measurements of PH-values, TDS, nitrate and detergent concentration, the following instruments were used as described in the table (3.4).

**Table (3.4) : Instruments used in analysis**

| | Instrument | Company |
|---|---|---|
| 1 | pH-meter | HI-3220, Hanna company, Japan. |
| 2 | TDS-meter | HI-4321, Hanna company, Japan. |
| 3 | UV/Vis Spectrophotometer | UV-1601, Shimadzu, Japan. |

### *3.6.2 Chemicals and reagents*

The chemicals, reagents, formulas and sources were tabulated in table (3.5). The water used in preparation of reagents was demoralized for spectroscopy , and distilled water used for all other preparation.

**Table (3.5): Chemicals used in analyses**

| | Compound | Formula | Company |
|---|---|---|---|
| 1 | EDTA Sodium salt | $(CH_2 N (CH_2COOH) CH_2 COONa)_2 .2H_2O$ | Merck, Darmstadt, Germany. |
| 2 | Eriochrome Black T | $C_{20} H_{12} N_3 NaO_7 S$ | Merck, Darmstadt, Germany. |
| 3 | Magnesium Sulphate 7hydrate | $Mg SO_4.7H_2O$ | Merck, Darmstadt, Germany. |
| 4 | Ammonium Chloride | $NH_4Cl$ | Haifa, 26110, Israel. |
| 5 | Ammonium Hydroxide | $NH_4OH$ | Haifa, 26110, Israel. |
| 6 | Calcium Carbonate Anhydrous | $CaCO_3$ | Haifa, 26110, Israel. |
| 7 | Hydrochloric Acid | HCL | Merck, Darmstadt, Germany. |
| 8 | Sodium Hydroxide | NaOH | Pune, 411011, India. |
| 9 | Linear Alkyl benzene Sulfonate(LAS) | $C_{18} H_{30}SO_3$ | |
| 10 | Chloroform | $CHCl_3$ | Haifa, 26110, Israel. |
| 11 | Sodium Dihydrogen Phosphate | $NaH_2PO_4$ | Merck, Darmstadt, Germany. |
| 12 | Sulfuric Acid | $H_2SO_4$ | Haifa, 26110, Israel. |

## 3.7 Methods of Analysis:

### *3.7.1 Nitrate Determination*

The method used for nitrate determination in water samples using UV Spectrophotometers , at wave length 220 nm and 275 nm with matched silica cells of 1-cm using UV - Spectrophotometers -1601, JAPAN, shimadzu (Standard methods for examination of water and wastewater 19thed 1995).

### Reagents

The chemicals and reagents used in the analysis of nitrate were free nitrate water (redistillated water was used for preparation and dilution.

1. Preparation of stock nitrate solution:

Dry potassium nitrate ($KNO_3$) in an oven at 105°C for 24 h. Dissolve 0.153g of $KNO_3$ in water and dilute to1000 mL,(1.00 mL= 0.1ppm $NO_3^-N$) and Preserve with 2 mL$CHCl_3$/L to stable for 6 months.

2. The different concentrations of $NO_3^-N$ in ppm were prepared as seen in table 3.6.

3. Hydrochloric acid solution, HCl, 1N.

### Procedure:

Add 0.5 mL HCl solution to 25 mL clear sample, (filtration if necessary) and mix thoroughly.

Preparation of standard curve: From stock nitrate solution different diluted solutions were prepared (10 to 1.63 mg $NO_3^-$\N) as shown in table (3.6).

**Table (3.6) : Absorbance $NO_3^-$ N concentration**

| **Absorbance** | 0.266 | 0.565 | 0.682 | 0.908 | 1.127 | 1.353 |
|---|---|---|---|---|---|---|
| **$NO_3^{--}$N,mg/L** | 1.63 | 3.35 | 5 | 6.60 | 8.34 | 10 |

## Spectrophotometric measurement

Measurement absorbance against redistilled water set at zero absorbance. By using wavelength at 220 nm to obtain $NO_3^-$ reading and a wavelength of 275 nm to determine interference due to dissolved organic matter.

## Calculations

For samples and standards, subtract two times the absorbance reading at 275 nm from the reading at 220 nm to obtain absorbance due to $NO_3^{--}$. Prepare a standard curve by plotting absorbance due to $NO_3^-$ against $NO_3^-$ N concentration of standard. Obtain sample concentrations directly from standard curve, by using corrected absorbance as shown in figure (3.7) (Standard methods for examination of water and wastewater 19th ed 1995).

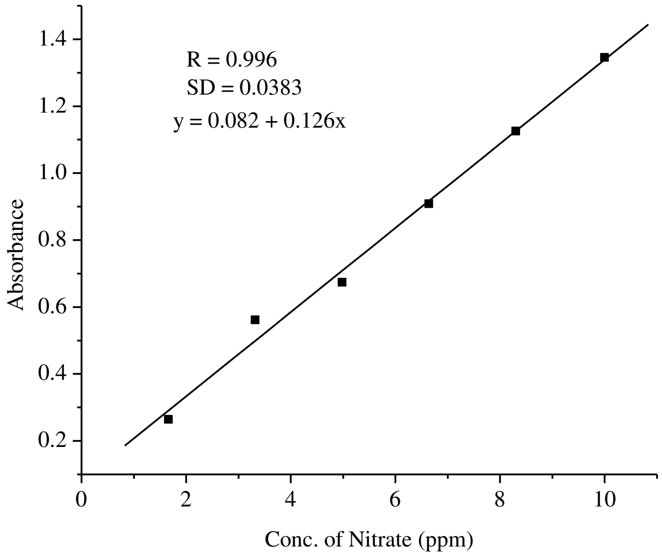


**Figure (3.7) : Calibration curve of nitrate**

### *3.7.2 Detergent determination*

The method used for detergents determination in water samples, UV Spectrophotometers at wave length 652 nm with matched silica cells of 1-cm using UV - Spectrophotometers -1601, JAPAN, shimadzu (Standard methods for examination of water and wastewater 19th ed 1995).

## Reagents:

1. Stock Linear Alkyl benzene Sulfonate (LAS) solution: Weigh an amount of the reference material equal to 1.00 g LAS on a 100% active basis.

Dissolve in water and dilute to 1000 mL;( 1.00 mL = 1.00 mg LAS). Store in a refrigerator to minimize biodegradation.

2. Standard LAS solution: Dilute 10.00 mL stock LAS solution to 1000 mL with water; (1.00mL = 10.0 µg LAS).

3. Phenolphthalein indicator (1gm of Phenolphthalein dissolved in 100 ml ethanol) as indicator solution.

4. Sodium hydroxide solution, NaOH, 1N.

5. Sulfuric acid, $H_2SO_4$, 1N and 6N.

6. Chloroform,$CHCl_3$.

7. Methylene blue reagent:( Dissolve 100 mg methylene blue in 100 mL water). Transfer 30 mL to a 1000-mL flask. Add 500 mL water, 41 mL 6N $H_2SO_4$, and 50 g mono sodium dihydrogen phosphate, ($NaH_2PO_4 \cdot H_2O$). Shake until dissolved. Dilute to 1000 mL.

8. Wash solution: Add 41 mL 6N $H_2SO_4$ to 500 mL water in a 1000-mL flask. Add 50 g$NaH_2PO_4H_2O$ and shake until dissolved. Dilute to 1000 mL.

9. Methanol,$CH_3OH$.

## Spectrophotometric measurement

a. Preparation of calibration curve: Prepare an initial calibration curve consisting of at least five standards covering the referenced or desired concentration range as shown in table 3.7. Provided that linearity is demonstrated over the range of interest (r= 0.995 or better) run daily check standards at the reporting limit and a concentration above the expected samples' concentration.

**Table (3.7) : Detergent concentration and absorbance**

| **Concentration mg/L** | 0.05 | 0.25 | 0.5 | 1.0 |
|---|---|---|---|---|
| **Absorbance** | 0.72 | 0.166 | 0.248 | 0.425 |

## Procedure

1) Add100 mL of sample to a separatory funnel. Make alkaline by drop wise addition of 1N NaOH,.
2) Add 10 mL $CHCl_3$ and 25 mL methylene blue reagent, Rock funnel vigorously for 30 second and let the two layer to separate,
3) Draw off $CHCl_3$ layer into a second separatory funnel, Rinse delivery tube of first separatory funnel with a small amount of $CHCl_3$. Repeat extraction two additional times, using10 mL $CHCl_3$ each time, If blue color in water phase becomes faint or disappears, discard and repeat, using a smaller sample.
4) Combine all $CHCl_3$ extracts in the second separatory funnel. Add 50 mL wash solution,10 mL $CHCl_3$ and shake vigorously for 30 second. Extract wash solution twice with 10 mL $CHCl_3$ each and add to flask. Collect washings in volumetric flask, dilute to mark with $CHCl_3$, and mix well. Then complete the volume of emulsion to 100 mL $CHCl_3$ (A.D.Eaton, et al. 1995).

## Measurement:

Determination of absorbance at wave length( 652 nm) against a blank of $CHCl_3$, and then the absorption of all extracted samples were determined at the wave length.

## Calculation:

From the calibration curve reading mg/l of apparent LAS corresponding to

the measured absorbance as shown in figure(3.8).

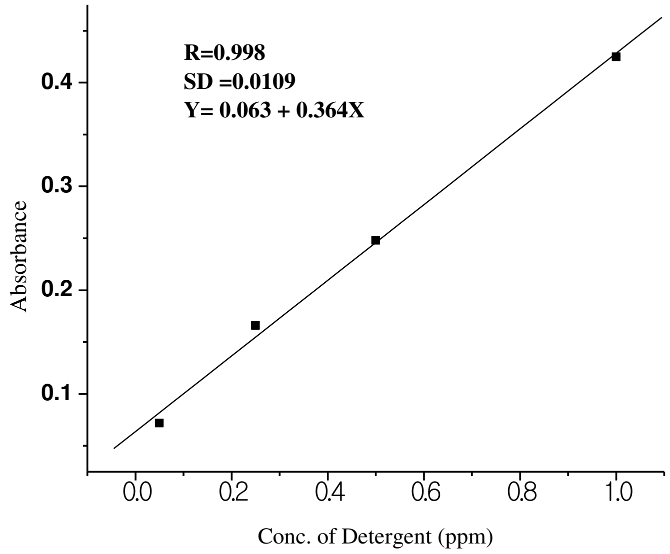


**Figure (3.8) : calibration curve of detergent**

### *3.7.3 Water Hardness determination*

The hardness of water samples were determined by compleximetry method using EDTA reagents in presence of Eriochrome Black T.

## Reagents

## 1.Standard EDTA Titrant (0.005M)

Weigh 3.723g analytical reagent-grade disodium ethylenediaminetetraacetate dihydrate, also called sodium salt (EDTA), dissolve in distilled water, and dilute to 2000 mL and store in plastic bottles .

## 2. Standard calcium solution

Weigh 1.000 g anhydrous $CaCO_3$ powder (annular grade ) into a 500-mL erleneyer flask. Place a funnel in the flask neck and add, a little at a time,1:1 HCl until all $CaCO_3$ was dissolved. Add 200 mL distilled water and boil for a few minutes to expel $CO_2$. Cool, add a few drops of methyl red indicator, and adjust to the intermediate orange color by adding 3N$NH_4OH$ or 1:1 HCl, as required. Transfer quantitatively and dilute to 1000 mL with distilled water; (1 mL= 1.00 mg $CaCO_3$).

## 3. Sodium hydroxide, NaOH, 0.1N.

## 4. Eriochrome Black T

Preparation of reagent prepared by dissolving of 0.5 g of Eriochrome Black T in 100 g Sodium salt of triethanolamine).

## 5. Buffer solution

1) Dissolve 16.9 g ammonium chloride ($NH_4Cl$) in 143 mL conc ammonium hydroxide($NH_4OH$).

2) Dissolve 1.179 g disodium salt of ethylenediaminetetraacetic acid dihydrate (analytical reagent grade) and 780 mg magnesium sulfate ($MgSO_47H_2O$). Add this solution to ammonium buffer, and dilute to 250 mL with distilled water.

Adjust the buffer solution at pH 10 and Store the twoSolutions 1and 2 in glass bottles for no longer than 1 month.

## Procedure

## 1. Titration of sample

Add (1 - 2 drops) of indicator solution and 1ml of buffer solution to 25ml of the sample.

Add standard EDTA titrant slowly, with continuous stirring, until the last reddish tinge disappears. At the end point the solution normally is blue (A.D.Eaton, et al. 1995) .

## Calculation:

Hardness (EDTA) as mg $CaCO_3$/L =(M*M.W*1000)/V1

Where:

V1= mL of sample

M= mL titration for sample and

M.W= mg $CaCO_3$ equivalent to 1.00 mL EDTA titrant.

$F = M*M.W*1000/V1$

PPm $CaCO_3$=F*V2

V2=mL of (EDTA)

### *3.7.4 Measuring pH*

Standardization of the pH instrument using initial buffer solution of pH 4.00 (Potassium hydrogen phthalate) and the second buffer solution of 7.00(potassium dihydrogen phosphate) then the pH of the sample solution was measured by using pH meter .

### 3.7.5 Measuring of Total dissolved solid (TDS)

The total dissolved solid (TDS) of sample solutions was determined by TDS meter.

# Chapter Four

# Results and Discussion

# Chapter Four

# Results and Discussion

## 4.1 Local Sand Specifications

The specifications of sand samples which collected from twelve locations distributed on the five governorates of Gaza Strip figure (3.1), where the specifications of the sand based on the measurement and calculations of both of the effective size (ES) and the uniformity coefficient (UC) as described on the pervious chapter, the obtained results of ES and UC are shown in the table 4.1.

**Table 4.1 Effective size and uniformity coefficient for sand sample**

| **Site No.** | Governorate | **Location** | **ES** | **UC** |
|---|---|---|---|---|
| 1 | **North Gaza** | **N: 31°31'21.4 "<br>E: 34°30'08.4 "** | 0.22 | 1.9 |
| 2 | **North Gaza** | **N: 31°32'59.0"<br>E: 34°31'31.7 "** | 0.159 | 1.9 |
| 3 | **Gaza** | **N: 31°28'14.5"<br>E: 34°23'50.1"** | 0.218 | 1.66 |
| 4 | **Gaza** | **N: 31°30'19.2"<br>E: 34°25'00.5 "** | 0.223 | 2 |
| 5 | **Gaza** | **N: 31°30'21.6"<br>E: 34°26'08.1 "** | 0.218 | 1.66 |
| 6 | **Al- Wosta** | **N: 31°24'57.1"<br>E: 34°24'02.3 "** | 0.189 | 2.1 |
| 7 | **Al- Wosta** | **N: 31°25'46.3"<br>E: 34°20'49.4 "** | 0.164 | 2.2 |
| 8 | **Al-Wosta** | **N: 31°28'30.8"<br>E: 34°24'58.9 "** | 0.115 | 2.8 |
| 9 | **Khanyonis** | **N: 31°21'24.3"<br>E: 34°19'54.7 "** | 0.212 | 1.7 |
| 10 | **Khanyonis** | **N: 31°22'26.8"<br>E: 34°17'38.2 "** | 0.132 | 2.7 |
| 11 | **Rafah** | **N: 31°18'56.2"<br>E: 34°13'58.8 "** | 0.216 | 1.6 |
| 12 | **Rafah** | **N:31°15'17.9""<br>E: 34°16'535"** | 0.080 | 2.8 |
| 13 | **Rafah** | **N: 31°15'34.5"<br>E: 34°15'23.6 "** | 0.087 | 3.3 |

The appeared results show the samples number 2, 6, and 7 that collected from the locations of North Gaza N: 31º32'59.0" E: 34º31'31.7", Middle of the Gaza N: 31º24'57.1" E: 34º24'02.3 ", and Middle of the Gaza N: 31º25'46.3" E: 34º20'49.4" respectively are adapted sand which has the recommended properties regarding the effective size and uniformity coefficient that needed for drinking water treatment (CAWST 2009) ,therefore during the coming research investigations for the water treatment the site number which located in Middle of the Gaza was been chosen to represent the investigated local media where it has values 0.164 ES and 2.2 UC (CAWST 2009.

## 4.2- Nitrate Removal

The series composed from six sand filter columns that have similar high of each layer of the column with a specific modification for each one as described in table (3.1)

The results show different percentages of nitrate concentrations REMOVAL depending on the contents of the columns and the applied medias. The column no. 5 had the highest removal percentage of nitrate of about 100 % after 168 hours of retention time then its removal efficiency gave a stable status as shown in figure(4.4). Column number 2 had a stable high removal percentage between 97.6% to 98.1% after a time period of 264 to 360 hours as shown in figure(4.1). Column number 6 gave 100% of removal of nitrate at time 96 hours then decreased to 94% at time 144 hours, then increase to constant value 98.0% after 432 hours as shown in figure(4.5). Column number 4 gave high removal percentage of about 95.8% at 120 hours then the reduction of nitrate concentration had decreased till 192 hours of the retention time of contaminated water which reached 84% then restarted to increase its removal capacity and gave a very high removal of about 100% at 456 of the retention time as shown in figure(4.3).

Column number 3 gave high removal percentage of about 88% until 168 hours then the removal capacity of nitrate concentration decreased and showed a stable percent around 40% as shown in figure(4.2). The control column which contains the local sand without modifications showed removal percentage between 81% to 84% during the first 120 hours then its removal capacity was decreased and seems stable between 37.9% and 22.5% after a retention time between168 – 456 hours, This result is also supported by Adeniran A. E. and Akanmu J. O. (2010) study which were evaluated slow sand filtration as advanced treatment of secondary effluent from a water hyacinth based domestic treatment plant using effective graded size of sand 0.35 mm that was conducted at the University of Lagos, Nigeria. The secondary effluent was applied at a flow rate of 90 $m^3$/h to the slow sand filter. The filter was operated at sand depths of 100 cm. It was found that the removals of nitrate was, 74.07%. at the end of 28 days of operation.

These results show that the good nitrate removal efficiency by all five media in both conditions comparatively with control column.

The main mechanism for nitrate removal by all columns may be according to adsorption phenomena. The obtained results at different columns indicates that adsorption increases with increasing retention time. The heighest nitrate removal was in column no. 4, 5, 6, which have media (Sawdust, Guava, Fig leaves respectively) as shown in figure (3.6), Which were found to be the most effective in removing nitrate from water. the highest removal percentage of nitrate was about 100 % . These results found that nitrate can be removed by adsorption and biological denitrification process. which the biological denitrification is the conversion of nitrate into nitrogen gas by microorganisms.

Denitrifying microorganisms use nitrate dissimilative, as a terminal electron acceptor for respiration. denitrifying bacteria decrease inorganic nitrogen such as nitrate and nitrite into innocuous fundamental nitrogen gas (M. Prosnansky, et al 2002). This process is shown in the following equation (Horan N. J., 1991 ) .

$NO_3- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

The capability to carry out this process is widely distributed among soil and sediment bacteria, the requirements for denitrification are (1) a carbon source and (2) oxygen-deficient conditions (Tom C. Kaspar, 2003). Sawdust, Guava, and Fig leaves were found to be the most effective in removing nitrate from water. Where the media of Sawdust, leaves of guava and Figs as an organic carbon source.

This results agreement with various researchers as studies by Richman (1997), Kim et al. (2000), Clark et al. (2001), Hsieh and Davis (2003), Ray et al. (2006), and Seelsaen et al. (2006) demonstrated successful uses of sorption media to remove nutrients. These tests found that nutrients can be removed by adsorption and biological nitrification/denitrification processes. The sorption materials involved included compost, peat, sand, wollastonite, limerock, alfalfa, sawdust, newspaper, wheat straw, wood chips, lignocelluloses materials, aspen wood fibers, mulch, hardwood mulch, fine and coarse glass, and clinoptilolite. In addition to nutrients, sorption media can also remove significant amounts of solids, BOD material, and heavy metals from storm water runoff.

In control column, column no. 2, and 3, the removal of nitrate from water basically by adsorption, rather than biological denitrification, so that the removal of nitrate lower than column no 4, 5, 6.

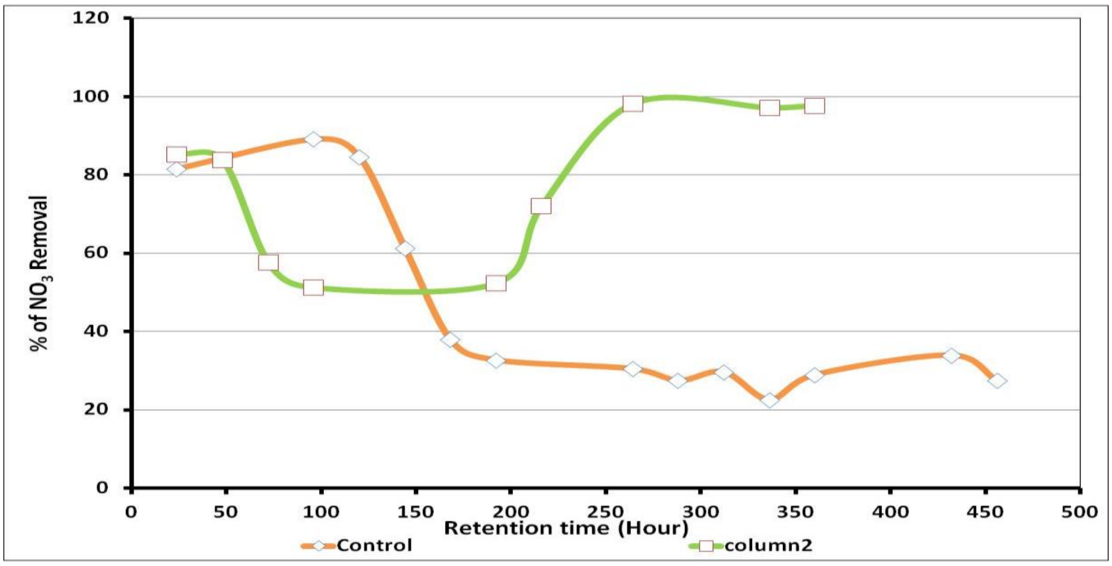


**Figure (4.1) :Nitrate removal % vs. time with and without addition of Kaolin.**

**◊ Control Column ☐ Kaolin Column**

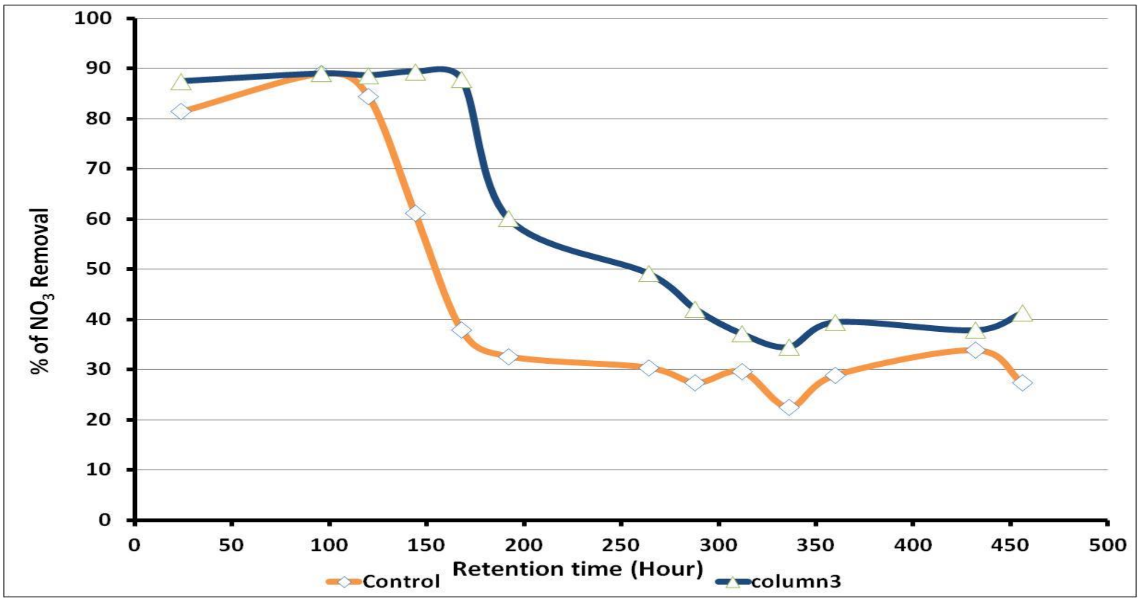


**Figure (4.2) : Nitrate removal % vs. time with and without addition of Glass.**

**◊ Control Column Δ Glass Column**

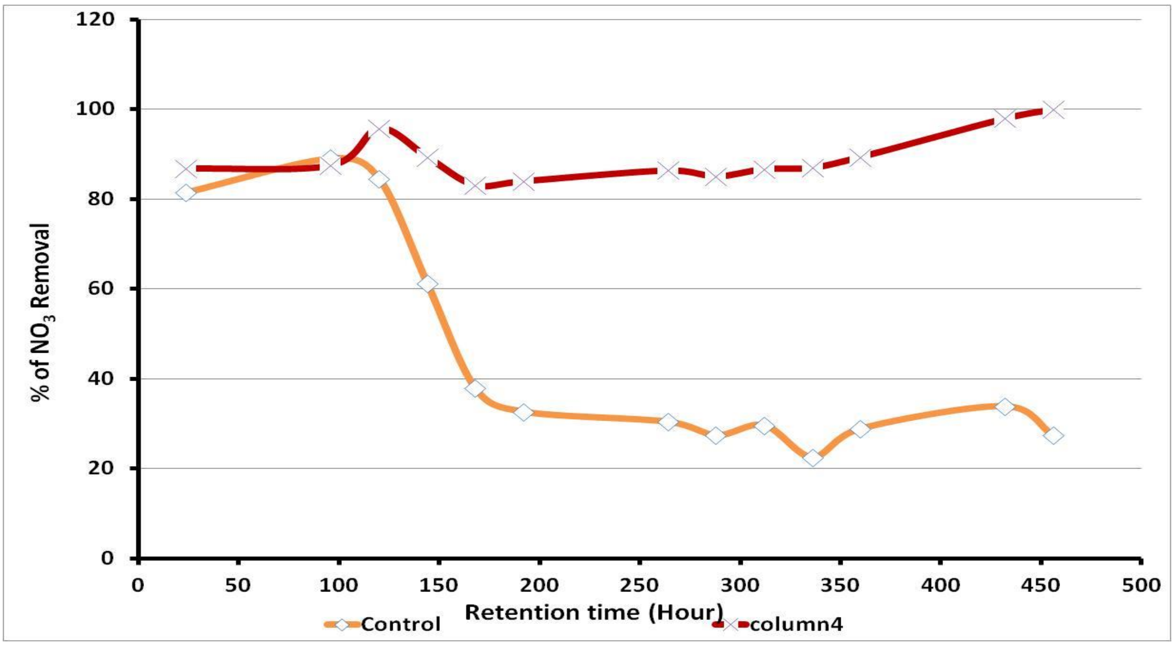


**Figure (4.3): Nitrate removal % vs. time with and without addition of Sawdust.**

**◊ Control Column × Sawdust Column**

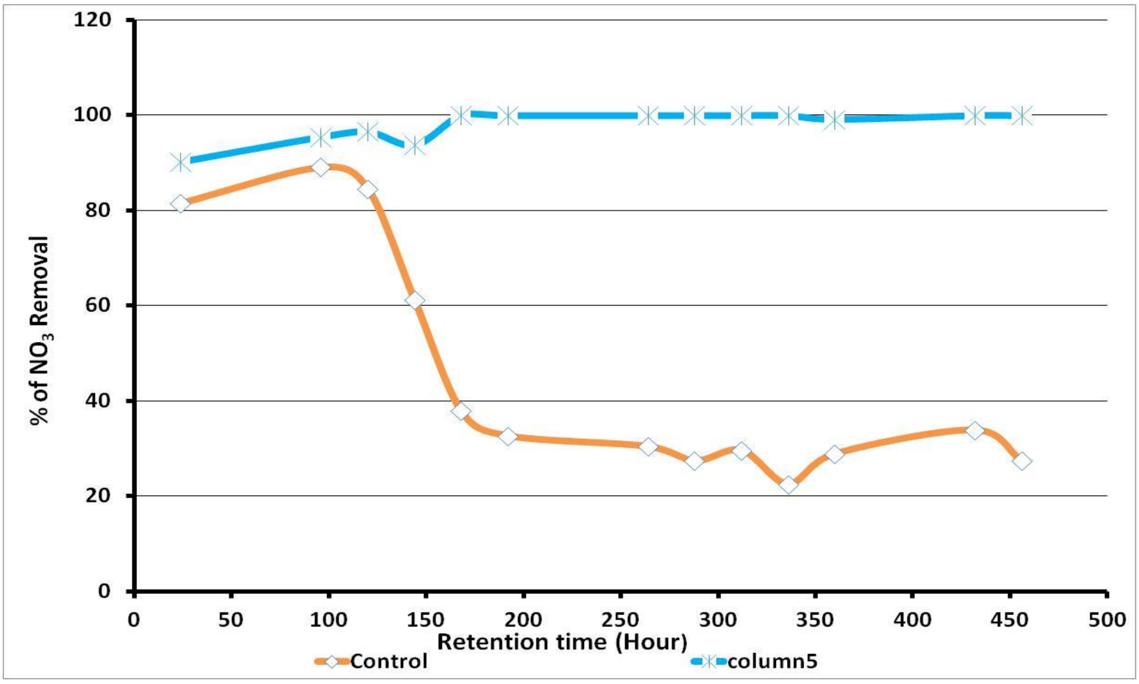


**Figure (4.4) : Nitrate removal % vs. time with and without addition of Guava leaves.**

**◊ Control Column ∗ Guava leaves Column**

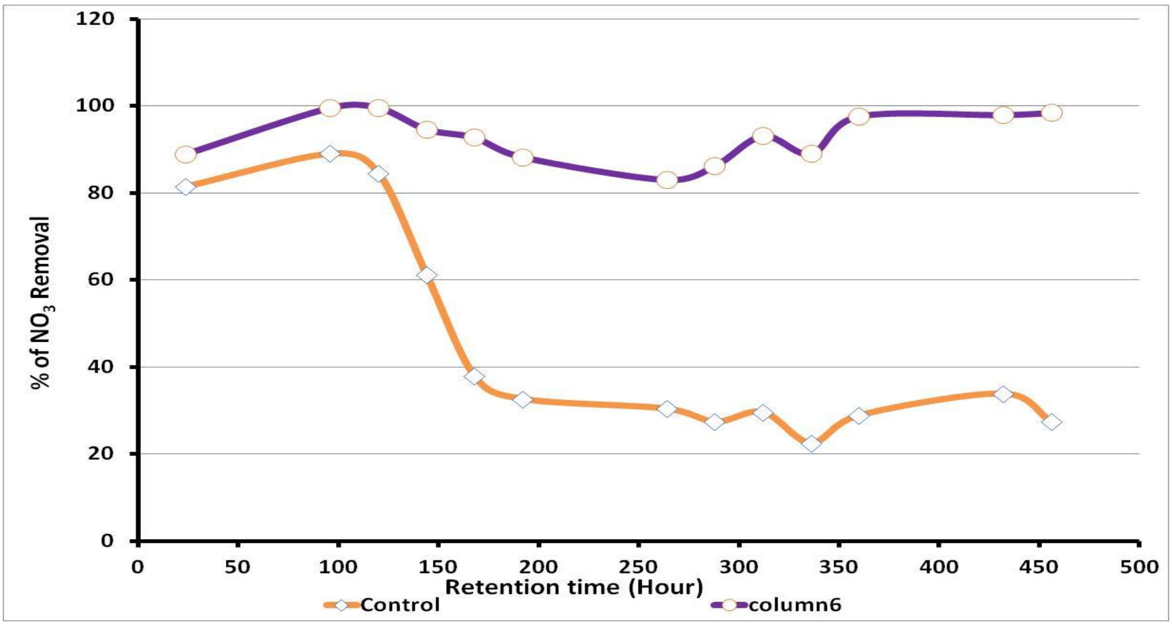


**Figure (4.5) : Nitrate removal % vs. time with and without addition of Fig leaves.**

**◊ Control Column o Fig leaves Column**

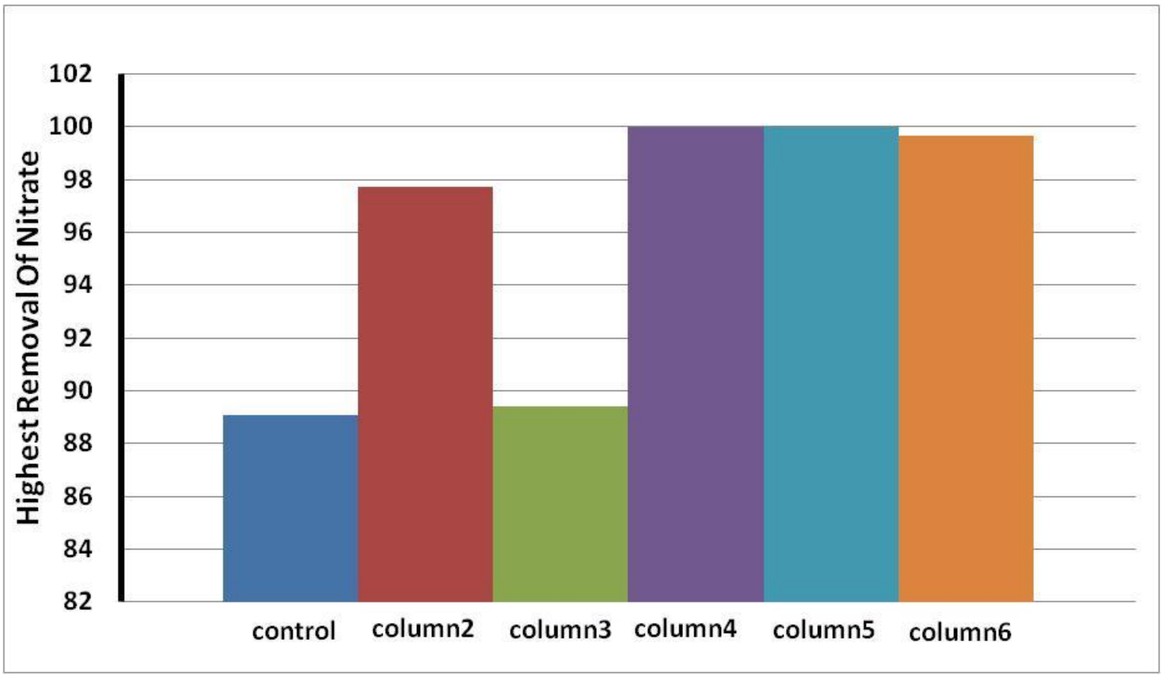


**Figure (4.6) : Relation between average percentage % of $NO_3$ removal by different columns.**

## 4.3- Detergent Removal

The results show different percentages of detergent concentration decrease depending on the contents of the column and the applied medias. The highest percentage removal of the detergent appeared in column no. 4 where it reached 100% at 312 hours then decreased until 86% after 456 hours as shown in figure (4.9). The column no. 5 had the highest rate of removal of about 99% at 336 hours then decreased to 86% after 456 as shown in figure (4.10). Column no.3 had the highest rate of removal of about 92% at 336 hours then decreased to 89% after 456 hours as shown in figure (4.8). Column no.6 had the highest removal of about 95.4% at 312 hours where column no. 2 had the highest rate of removal was of about 40% at 336 hours as shown in figures (4.11, 4.7 respectively). The results show that the removal rates of detergent in column no. 3, 4, 5, 6 were higher than the control, while the removal rate of detergent in column no. 2 was less than the rest of the columns as shown in figure (4.12). The control column had the highest removal of about 88% at 360 then decreased until 80% at 456 hours. The removal of detergents by columns no. of (1, 2, 3) caused by adsorption process the Linear Alkyl Benzene Sulphonate (LABS) contents sulphonate group ($-SO_3^-$ ) which attached with positive center in the filter media (Sand, Glass, Kaolin ) attached with electrostatic attractive. Removal of detergent from column no.(3, 4, 5, 6) using of crushed glass, Sawdust, leaves of Guava, and Fig were the maximum detergent removal efficiency, which that contains 5mg/L sodium linear alkyl benzene sulphonate. The mechanism of detergents removal by columns no. (4, 5, 6) were attributed to the physicochemical characteristics of (Sawdust, Guava, Fig ), where the adsorption extent increases with contact time till reaching saturation level where the uptake percentage attains a constant value (86, 86, 82% respectively) at 456 hours. The amount of adsorbate properties, such as molecular weight and size, and aqueous solubility. Which these structure were founding in(3, 4, 5, 6). The nature of the adsorbent, such as surface area, pore size and distribution, surface distribution, and surface characteristics also affected on the removal on the detergents.

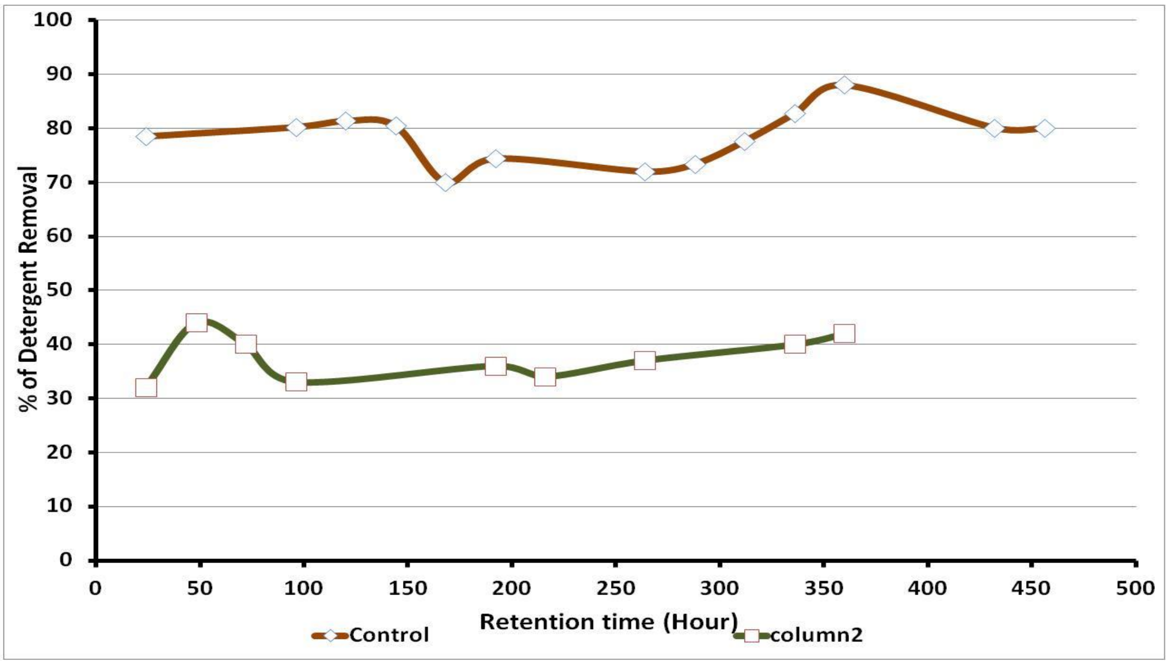


Figure (4.7) : Detergent removal % vs. time with and without addition of Kaolin.

◊ Control Column □ Kaolin Column

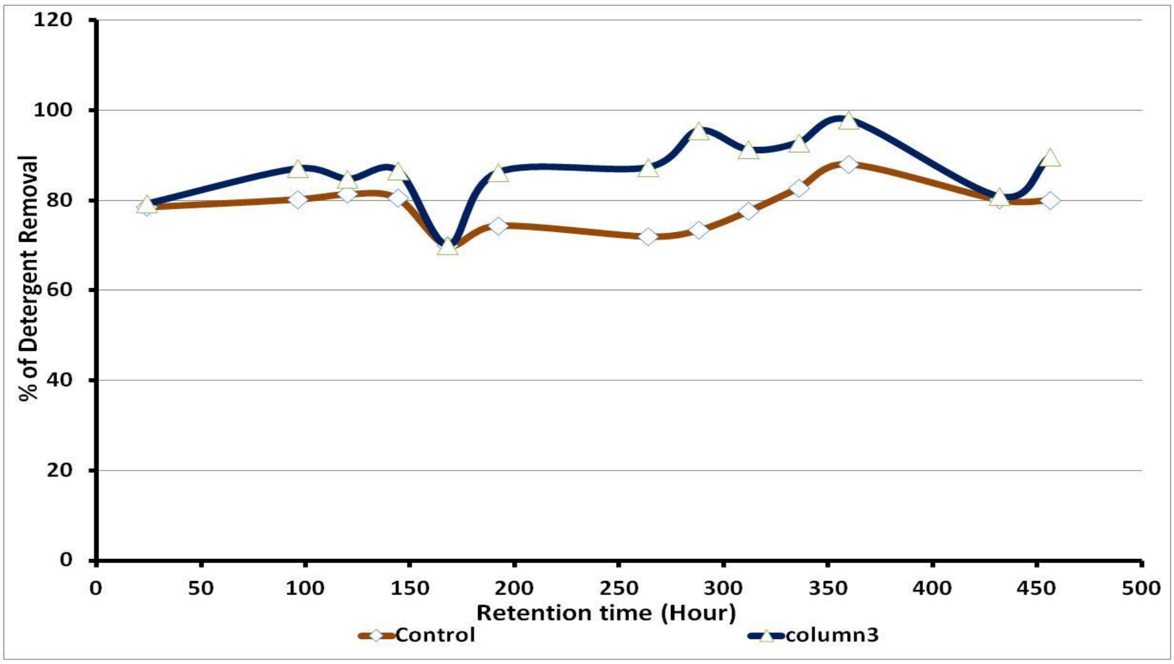


Figure (4.8) : Detergent removal % vs. time with and without addition of Glass.

◊ Control Column , Δ Glass Column

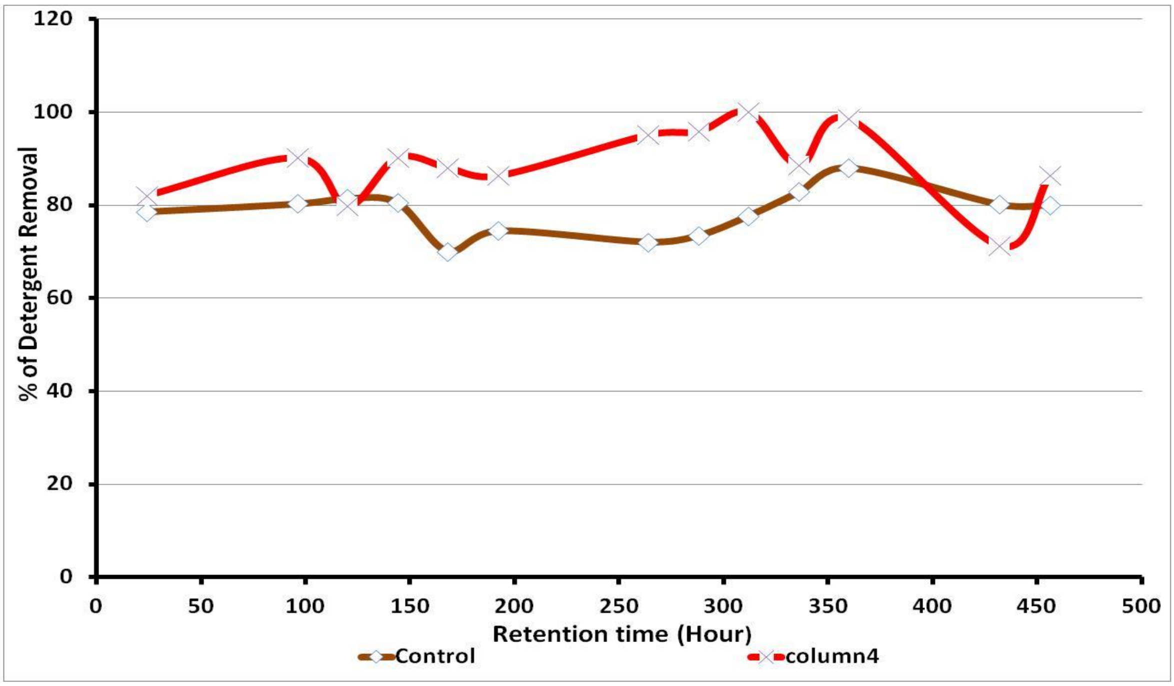


Figure (4.9) : Detergent removal % vs. time with and without addition of Sawdust.

◊ Control Column × Sawdust Column

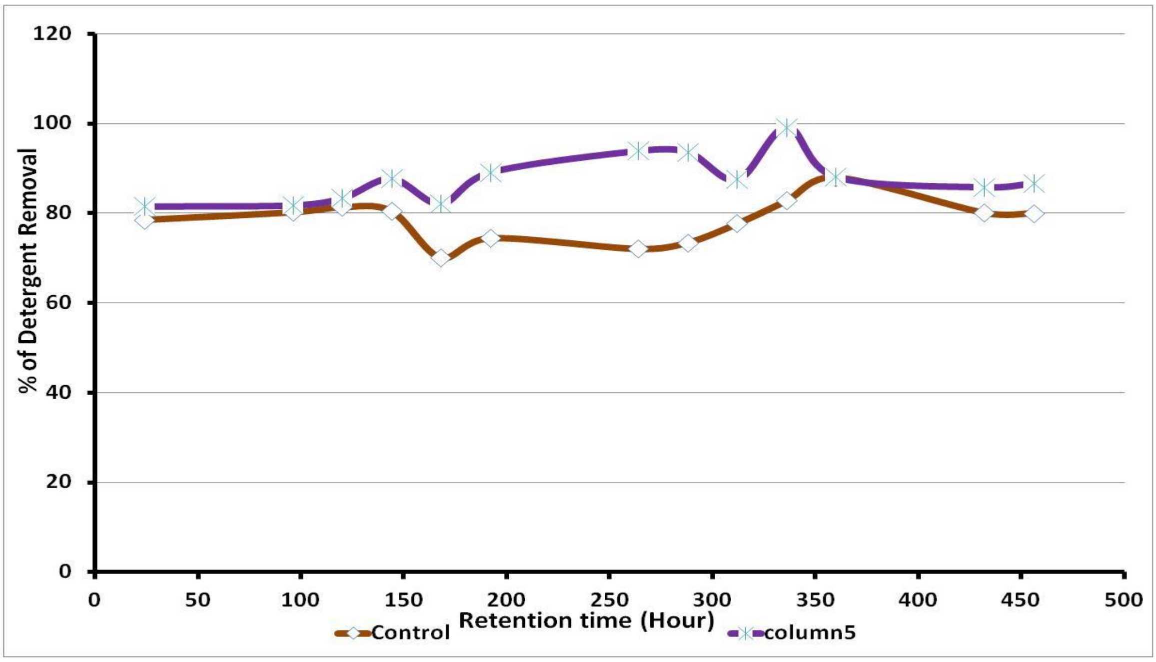


Figure (4.10) : Detergent removal % vs. time with and without addition of Guava leaves.

◊ Control Column * Guava leaves Column

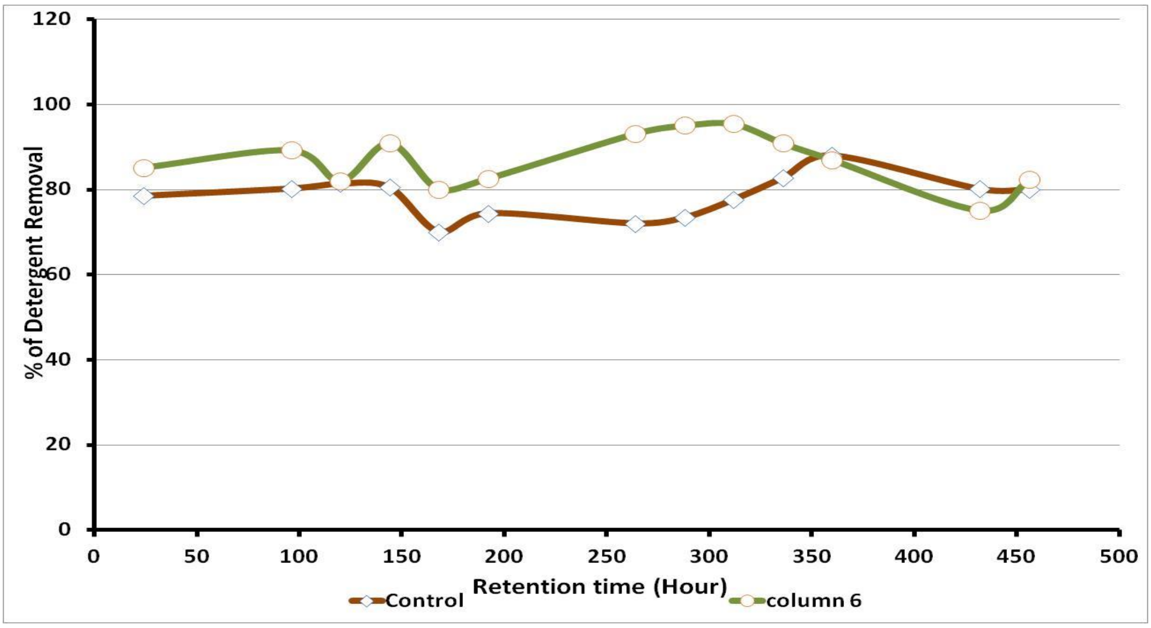


**Figure (4.11) : Detergent removal % vs. time with and without addition of Fig leaves.**

**◊ Control Column o Fig leaves Column**

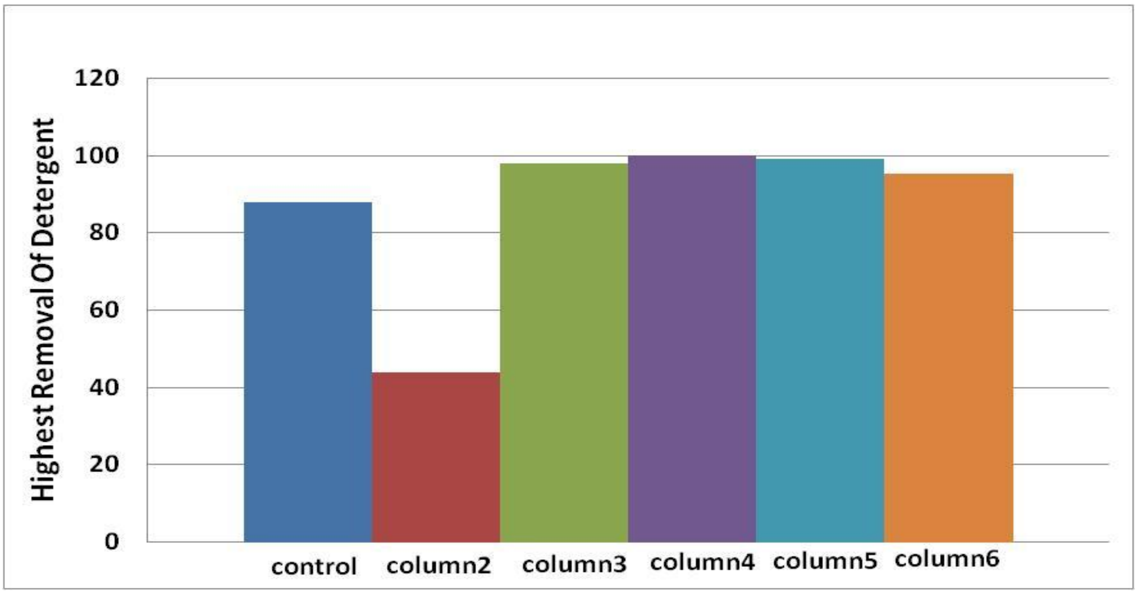


**Figure (4.12) : Relation between average percentage % of Detergent removal by different columns.**

## 4.4- Hardness Removal

The results show different percentages of hardness concentrations decrease, where the behaviors of columns no. 3 and 4 show the similar values with a comparative results to the control column. The removal of hardness was about (56%, 61%, 56% ) at 336 hours in control column, column no. 3, column no.4 respectively as shown in figure (4.14, 4.15). This similarity are due to the same removal mechanism of these columns, where the column control and columns no. 3 have the same chemical composition, which is composed of silica (silicon dioxide). Glass particles have a slight negative charge on their surface, which tends to hold onto fine particles during the filtration cycle (Rafa H.Alsuhaili et al (2012). The removal of hardness may be to interaction between the negative charges on silicate and positive charge on $Ca^{2+}$ and $Mg^{2+}$ ions. This result agreed with various researchers finding as (Horan, N.J and Lowe, M. 2006 and Dryden Aqua 2003). Their findings have shown that recycled crushed glass is equally good as sand or in some cases, a much more effective and more environmentally friendly alternative to sand. The column no.4, which media was Sawdust, contains cellulose, lignin, and tannins or other phenolic compounds are active ion exchange compounds (A. Shukla, Y. Zhang 2002).

At time 24 hours in column no.2 the removal of hardness was about 54%, after 48 hours the removal decreased to 38%, then increased by time gradually increased at the first time the decreasing of hardness may be to interaction between the negative charges on kaolin silicate and positive charges on $Ca^{2+}$ and $Mg^{2+}$ ions. These interaction is very weak, so by increasing the time these ions were dissociated removed and leaching in the water as shown in figure(4.13). If the interaction between the solid surface and the adsorbed molecules has a physical nature, the process is called physisorption. In this case, the interactions were Van der Waals forces and, as they are weak the process results are reversible. This result is supported by the study (Prapat Pentamwa, et al 2011) which was to investigate the use of waste polystyrene foam and plastics such as foam packaging for food and air bubble plastics as synthetic resins with a combination of packed sand-gravel filters in columns system to remove hardness in groundwater. The results revealed that the hardness removal efficiency of control column (no packed resin) was averaged of 386.7 mg $CaCO_3$/L (12%). while added made resins in the system was in the range of 248-250 mg $CaCO_3$/L. In column no. 5, and 6 the hardness was increased , this issue could be related to the component of the added media, this indicates a possibility dissolved solids from the media of guava, and fig leaves entered into the water, which guide us to requesting a special pretreatment of the added media by More washing as shown in figures (4.16 and 4.17).

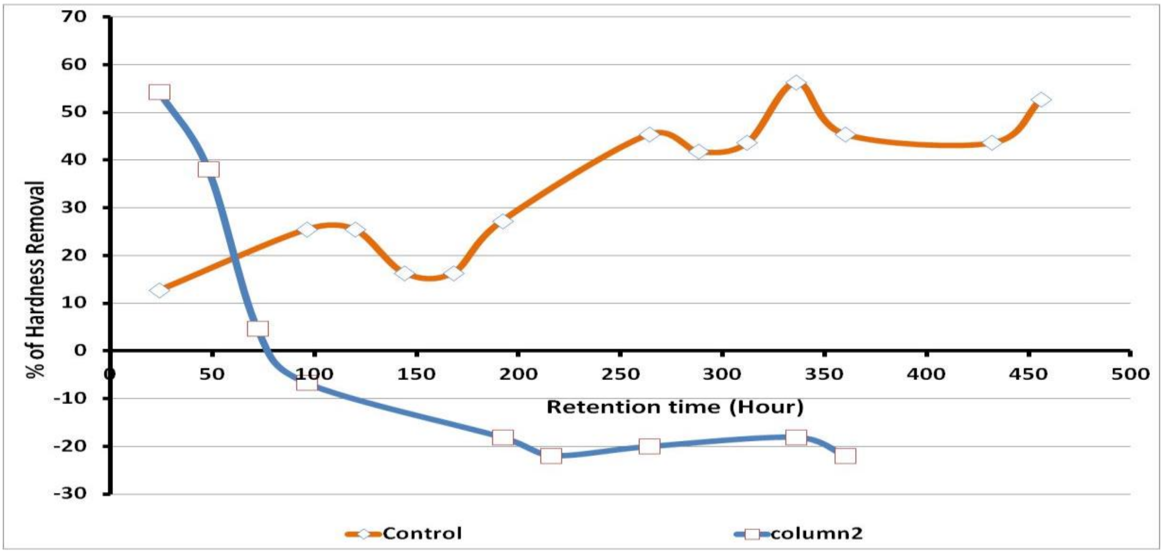


**Figure (4.13) : Hardness removal % vs. time with and without addition of Kaolin.**

**◊ Control Column □ Kaolin Column**

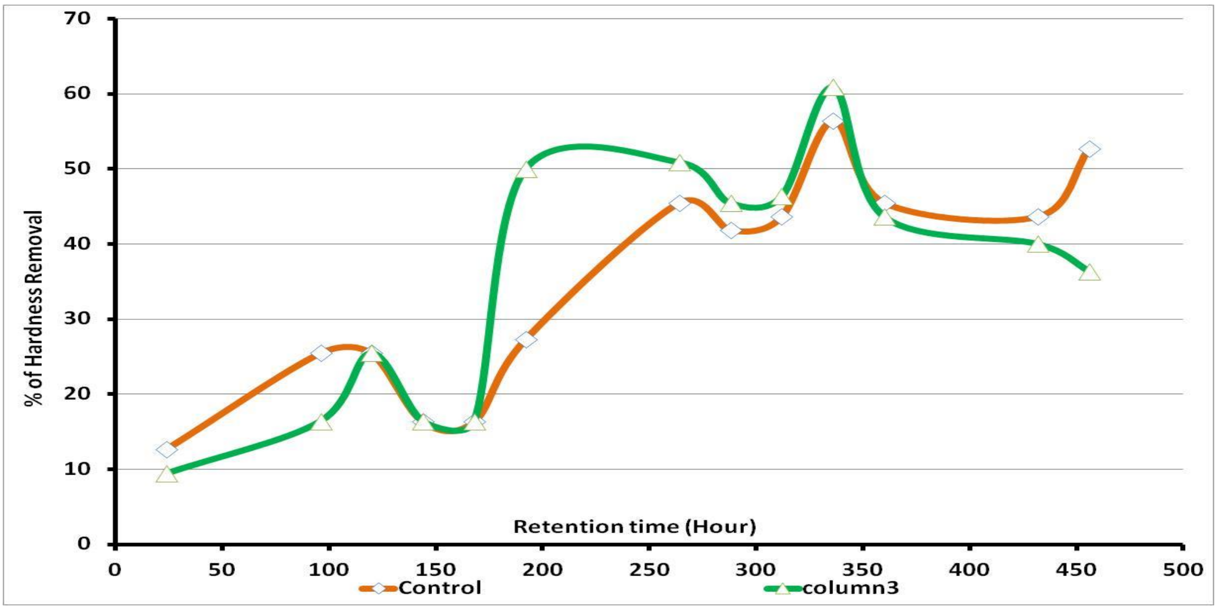


**Figure (4.14) : Hardness removal % vs. time with and without addition of Glass.**

**◊ Control Column Δ Glass Column**

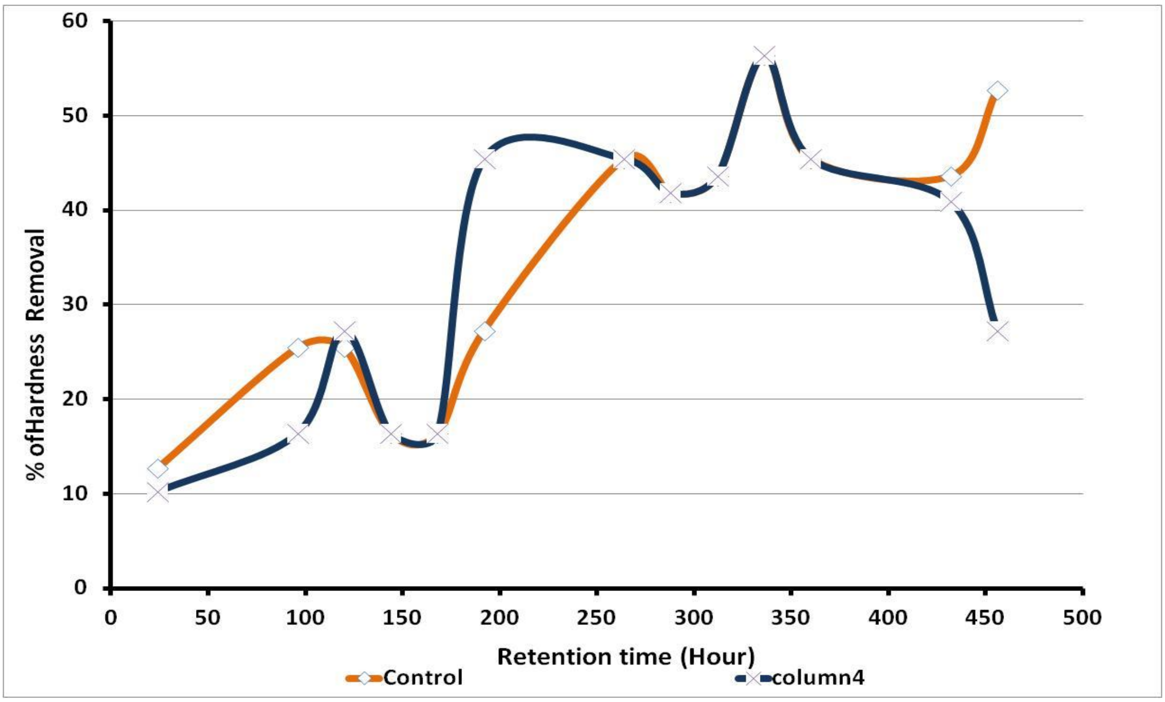


Figure (4.15) : Hardness removal % vs. time with and without addition of Sawdust.

◊ Control Column × Sawdust Column

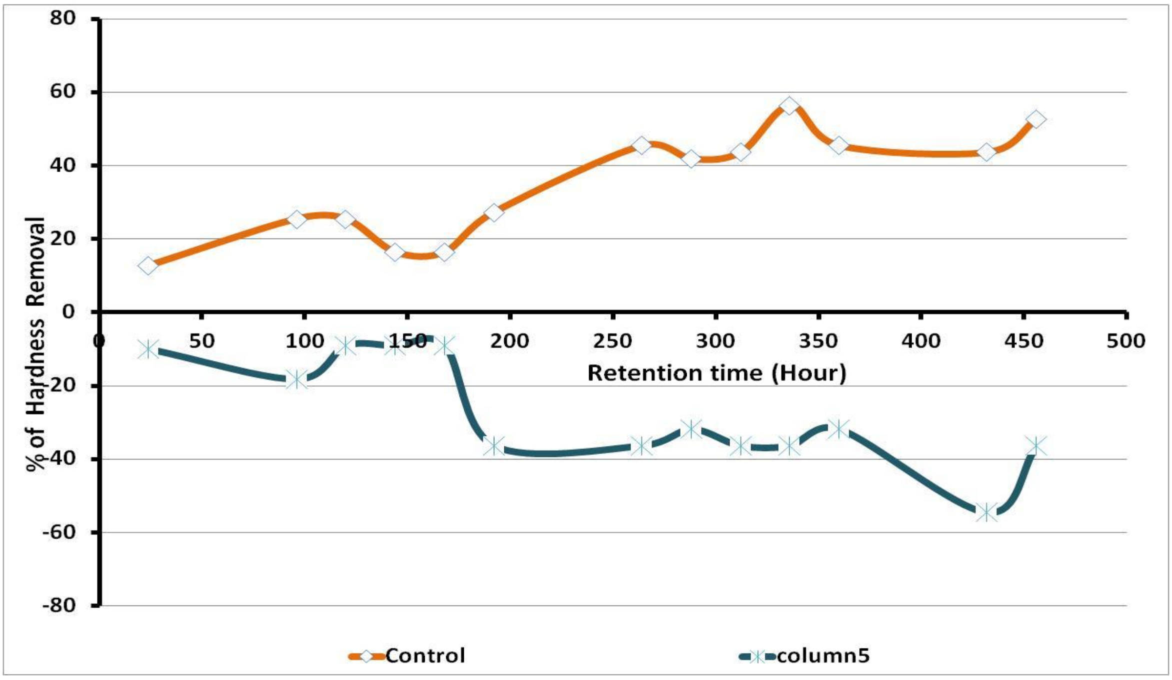


Figure (4.16) : Hardness removal % vs. time with and without addition of Guava leaves.

◊ Control Column * Guava leaves Column

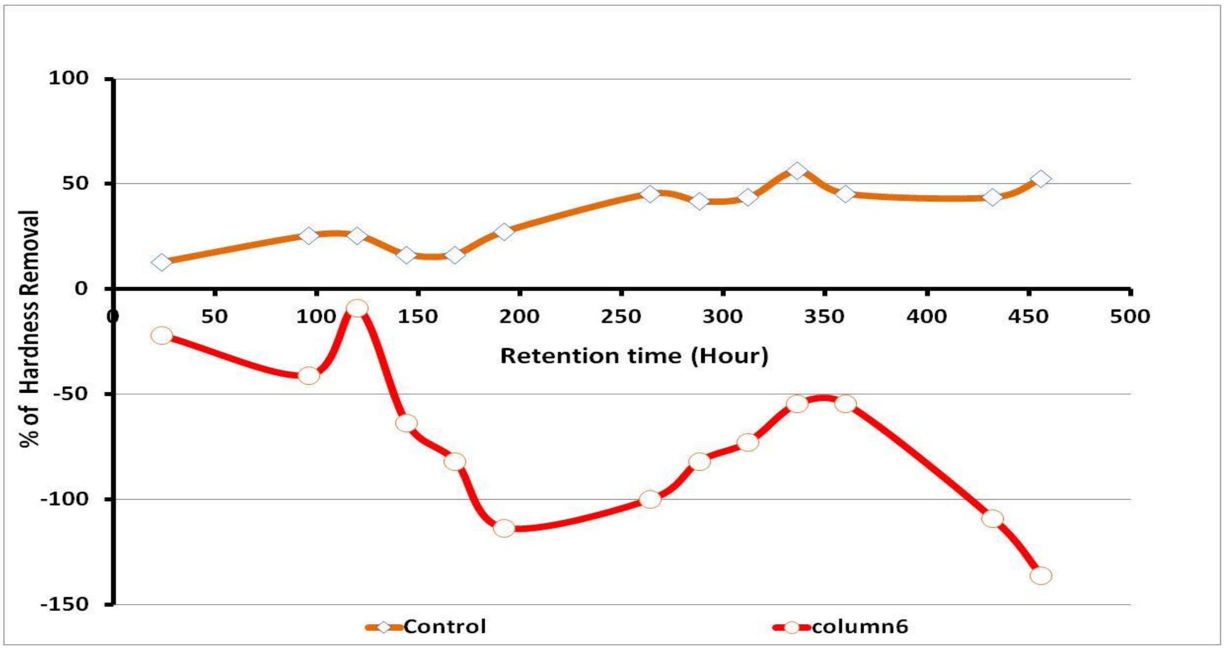


**Figure (4.17) : Hardness removal % vs. time with and without addition of Fig leaves.**

**◊ Control Column o Fig leaves Column**

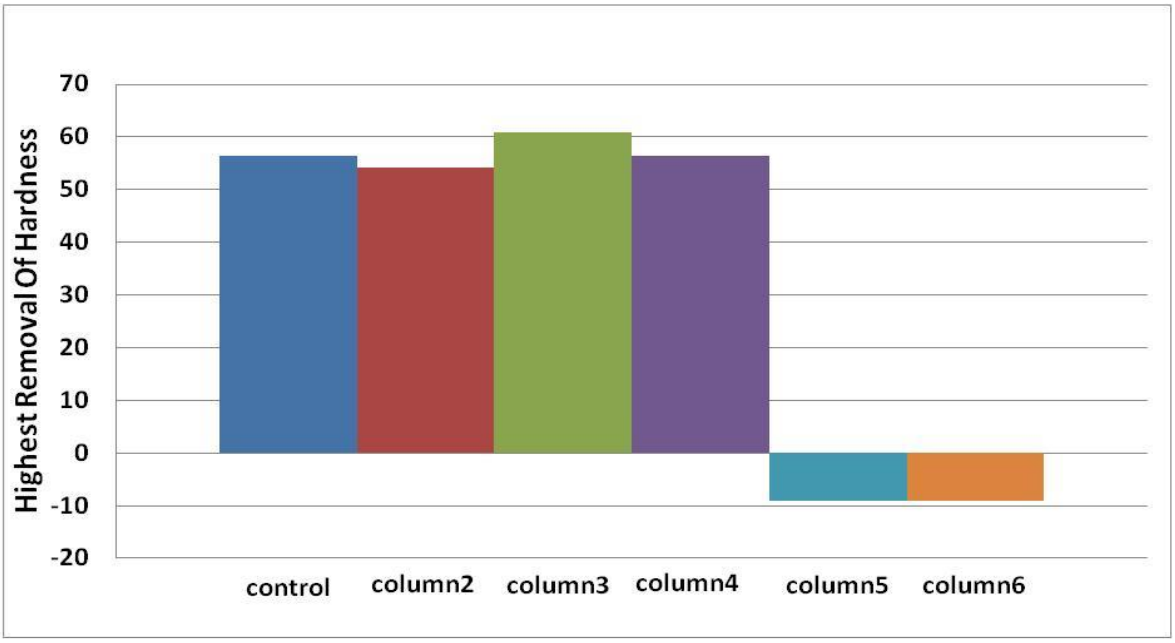


**Figure (4.18) : Relation between average percentage % of Hardness removal by different columns.**

## 4.5- TDS Removal:

The results showed very small efficiency for TDS removal through all columns. All columns had a similar behaviors for TDS decreasing except column no. 6, which had a remarkable increment of TDS value by time as shown in figure(3.23). This indicates a possibility of releasing of dissolved solids from media of fig leaves entered into the water. Figure (4.24) shows the column control which is composed of sand(silicon dioxide), the TDS after 24 hours was 3%. Column no. 2, had removal percentage of about 55% after 24 hours then decreased to about 9% after 360 hours of retention time as shown in figure (4.19). From the achieved result it was observed that in general column no. 2 which had media of kaolin performed better than all columns for reduction of TDS as shown in figure (4.24) . Column no. 3, 4, and 5 the highest rate of removal was between 10 to 15 % at 120 hours, then it decreased gradually to achieve 0% o removal then the TDS is increased about the origin concentrate as shown in figure (4.20, 4.21, and 4.22). This similarity is due to the same behavior of these columns. The percentages of TDS removal in all columns were higher than the control column.

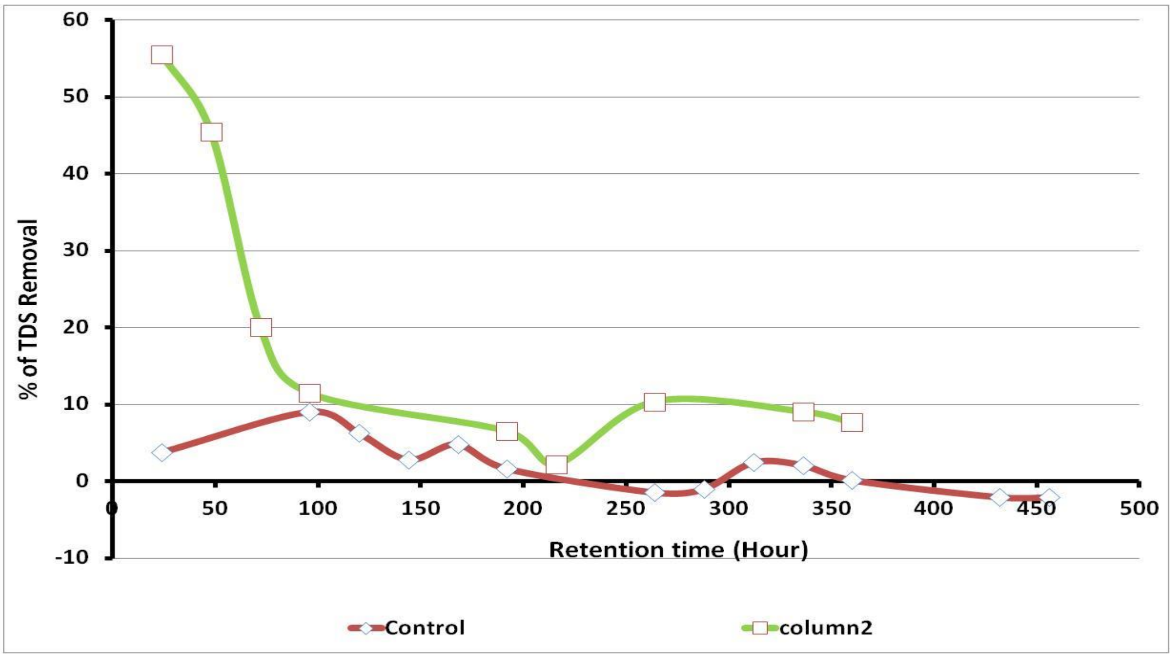


**Figure (4.19) : TDS removal % vs. time with and without addition of Kaolin.**

**◊ Control Column □ Kaolin Column**

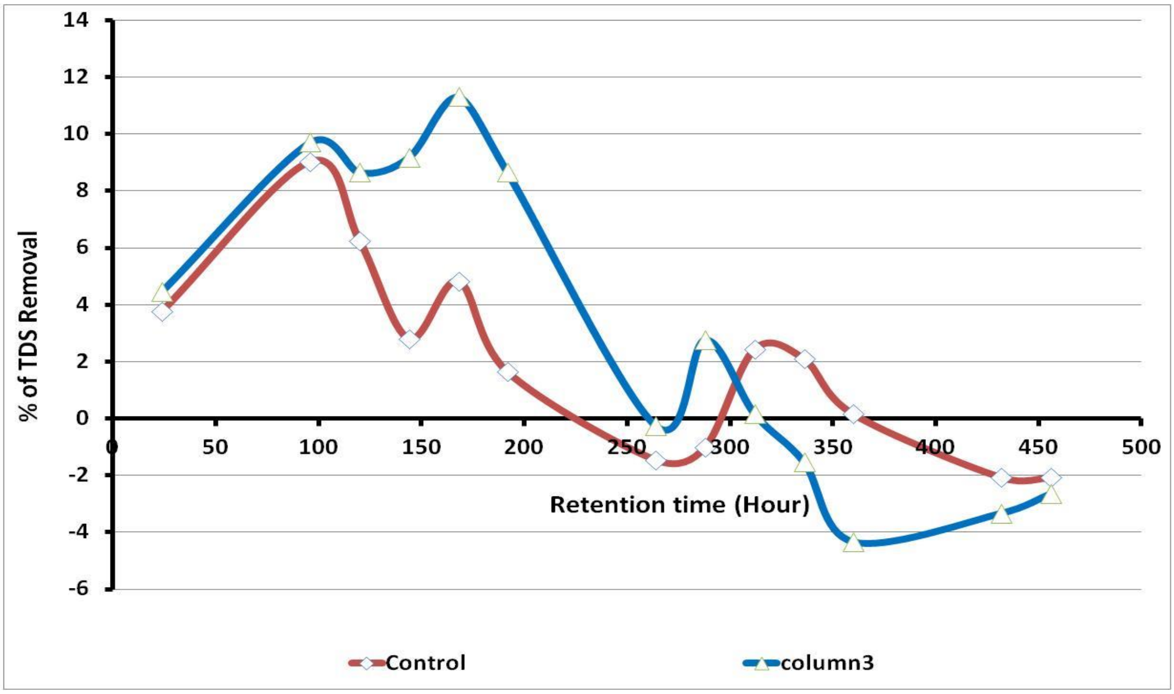


Figure (4.20) : TDS removal % vs. time with and without addition of Glass.

◊ **Control Column** Δ **Glass Column**

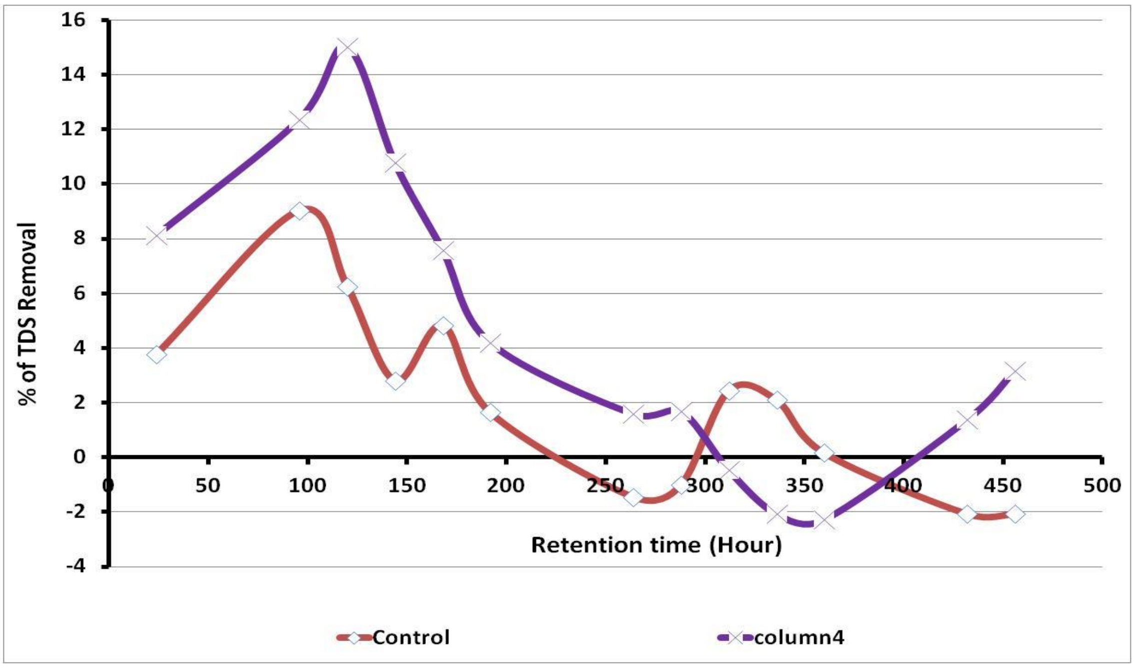


Figure (4.21) : TDS removal % vs. time with and without addition of Sawdust.

◊ **Control Column** × **Sawdust Column**

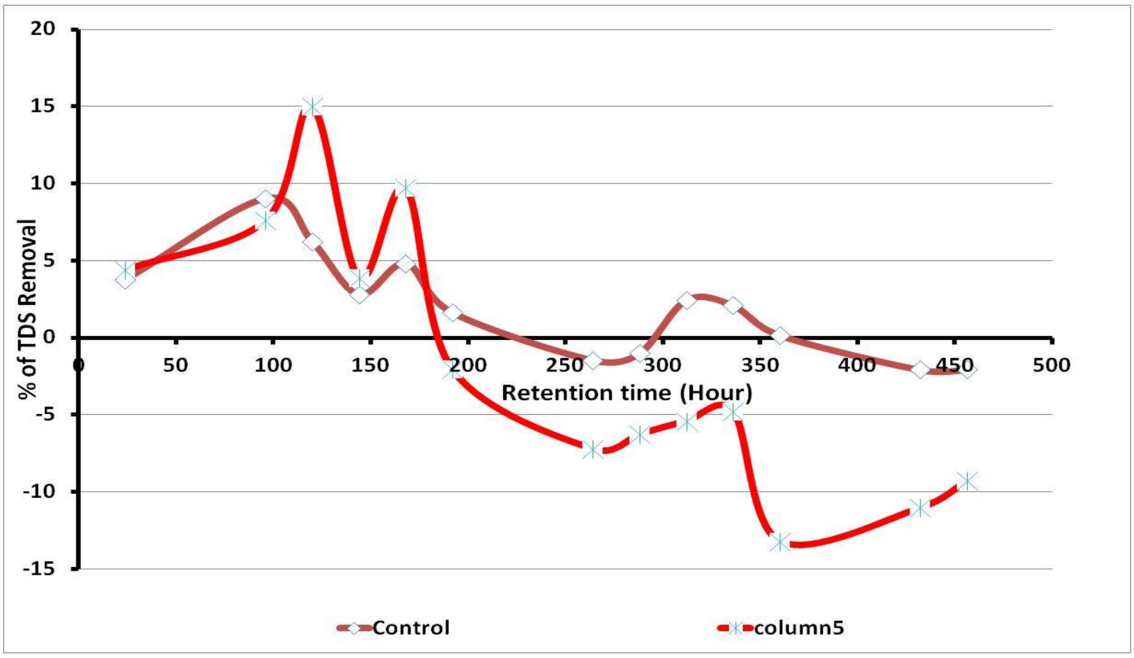


Figure (4.22) : TDS removal % vs. time with and without addition of Guava leaves.

◊ Control Column ∗ Guava leaves Column

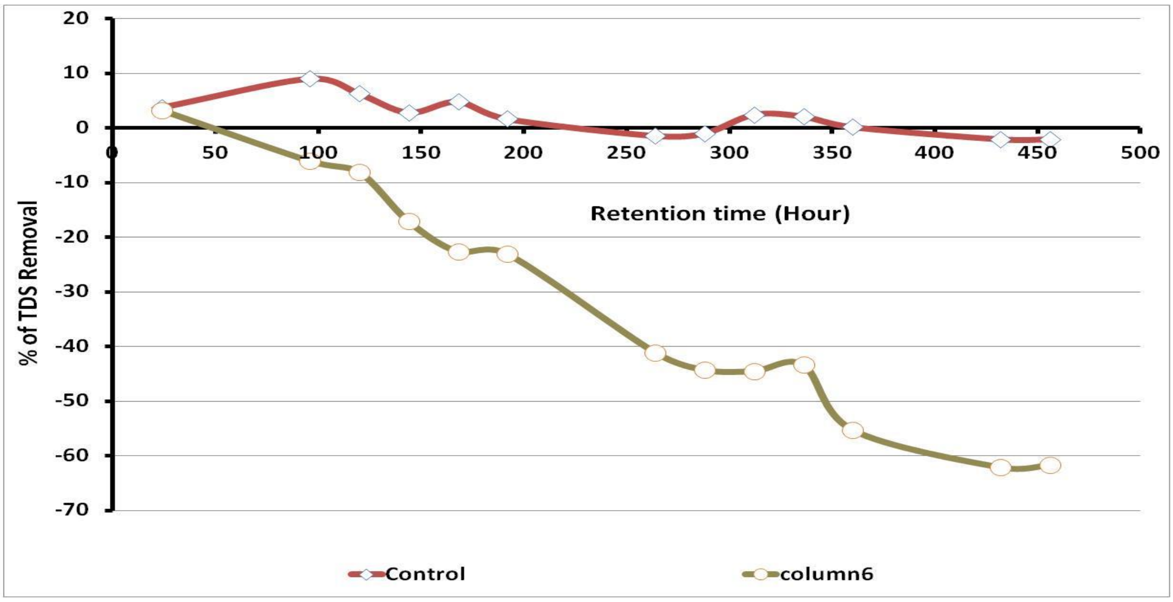


Figure (4.23) : TDS removal % vs. time with and without addition of Fig leaves.

◊ Control Column o Fig leaves Column

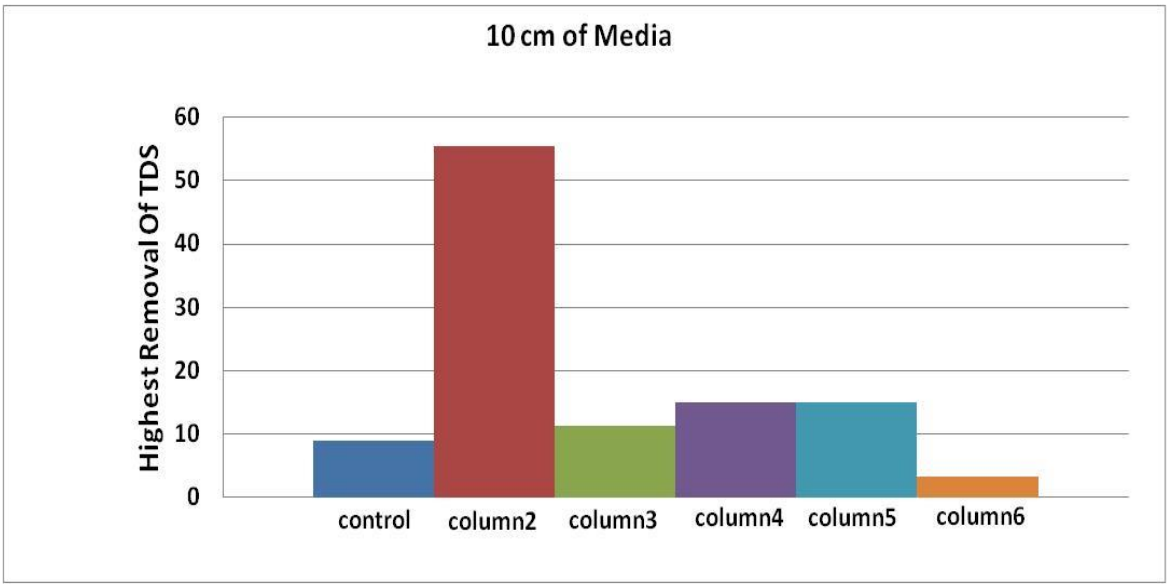


**Figure (4.24) : Relation between average percentage % of TDS removal by different columns.**

## 4.6 - Behavior of Control column

Through the analysis conducted in the laboratory it was noted that the results showed different percentages concentration reduction of nitrate, detergent, TDS, and Hardness. The removal of detergent was the highest where it was 80% at 456 hours, followed by nitrate, which was initially 81.5% at 24 hours then it decreased gradually until reached 27% at 456 hours , then followed by reduction of hardness where initially it was 25% at 96 hours and raised to where it reached 56.7% at 456 hours, then followed by the reduction of TDS which was 9% at 96 hours and then decreased to reach 0% removal then it increased to be more than the original concentration, this increment of TDS concentration could be explained by the released of the solid attached to the media or by dissolving of some ions in the media used as shown in figure (4.25). The mechanisms for detergent, Hardness, TDS removal may be according to adsorption process. But the mechanisms for nitrate removal may be according to adsorption and denitrification process.

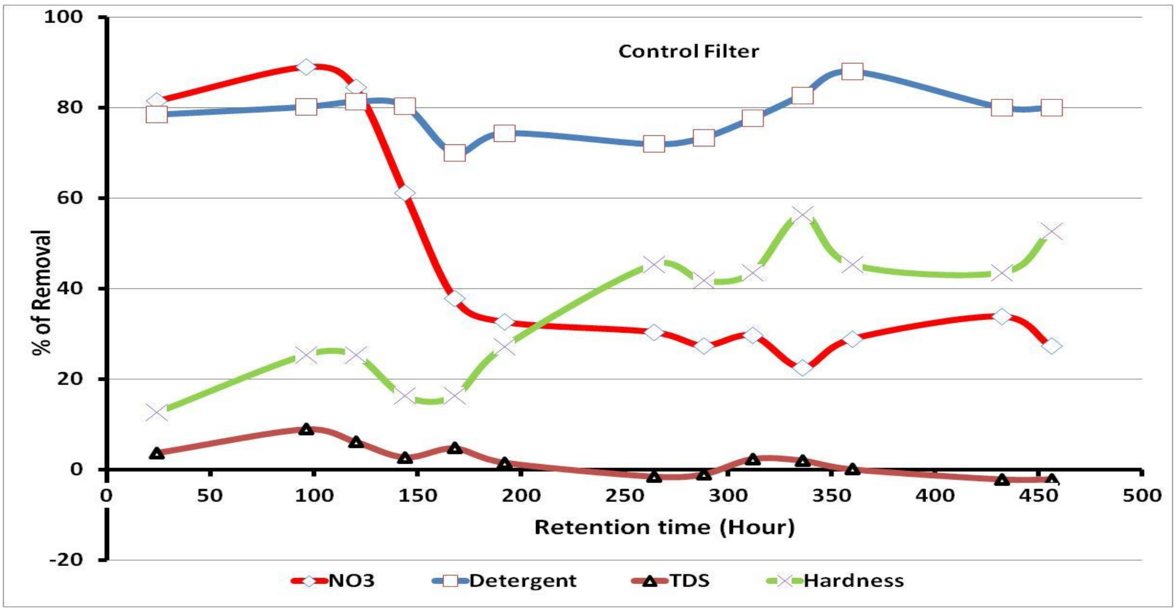


**Figure (4.25) : Relation between the different parameters and retention time of control column:**
**◊ Nitrate □ Detergents Δ TDS × Hardness**

## 4.7 - Behavior of column no.2 (10cm of Kaolin)

Figure (4.26) shows the removal efficiency of the detergent , nitrate, hardness, and TDS in column no. 2. The removal percentage of nitrate was the highest one where it reached 97.7% at 360 hours, followed by detergent, where the percentage decreased gradually until reached 42% at 360 hours, then TDS reduction where it reached 55.5% at 24 hours and then decreased to that reach 7.6% at 360 hours, followed by reduction of hardness, which reached 52% at 24 hours and then decreased to the increased proportion of hardness in the water as shown in figure (4.26). The removal of contaminants may be according to adsorption and ion exchange process.

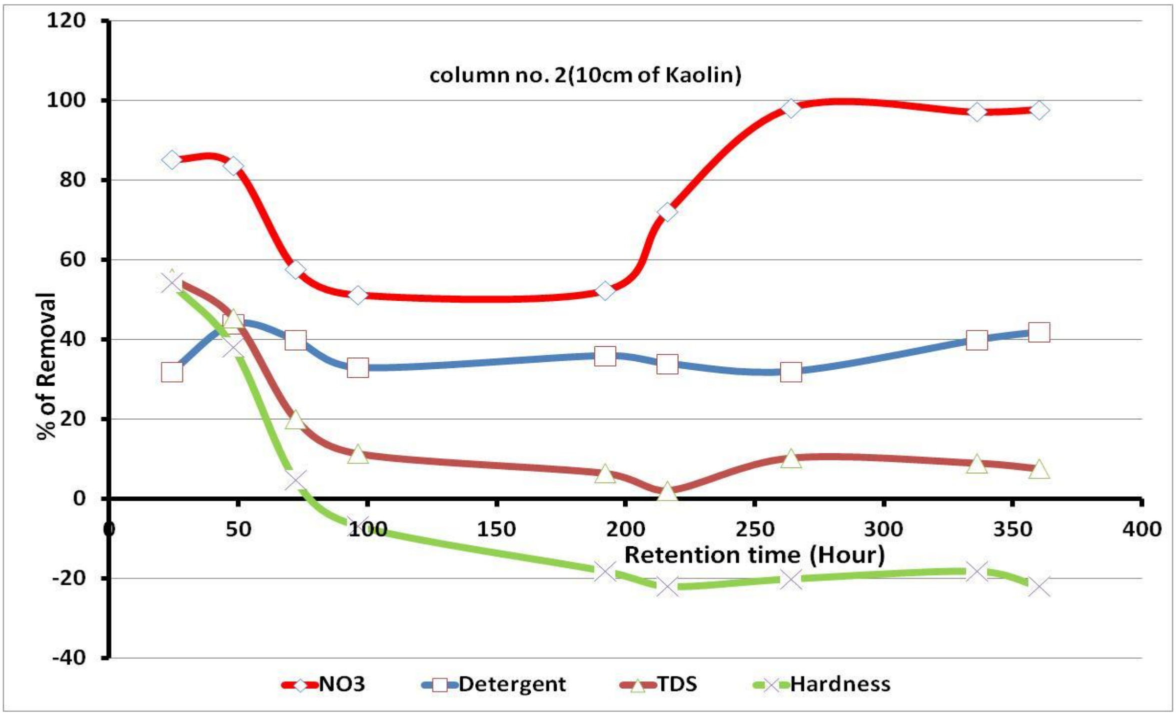


**Figure (4.26) : Relation between the different parameters and retention time of column no. 2:**
**◊ Nitrate □ Detergents Δ TDS × Hardness**

## 4.8 - Behavior of column no.3 (10cm of Crushed Glass)

The results show in the column no. 3 that the efficiency reduction of nitrate was the highest where it reached 87.5% and then decreased gradually with the time until reached 41% at 456 hours, followed by reduction of detergent, which was initially 79% and then increased gradually until reached 89.7% at 456 hours, followed by reduction of hardness, which was initially 16% were increasing and decreasing until it reached 36% at 456 hours, where reaching 61% at 336 hours, then followed reduction of TDS where reached 4% at 24 hours and then increased until it reached 11% at 168 hours, and then decreased gradually to be increased percentage of TDS in water as shown in figure (4.27). The removal of contaminants by Glass may be according to adsorption.

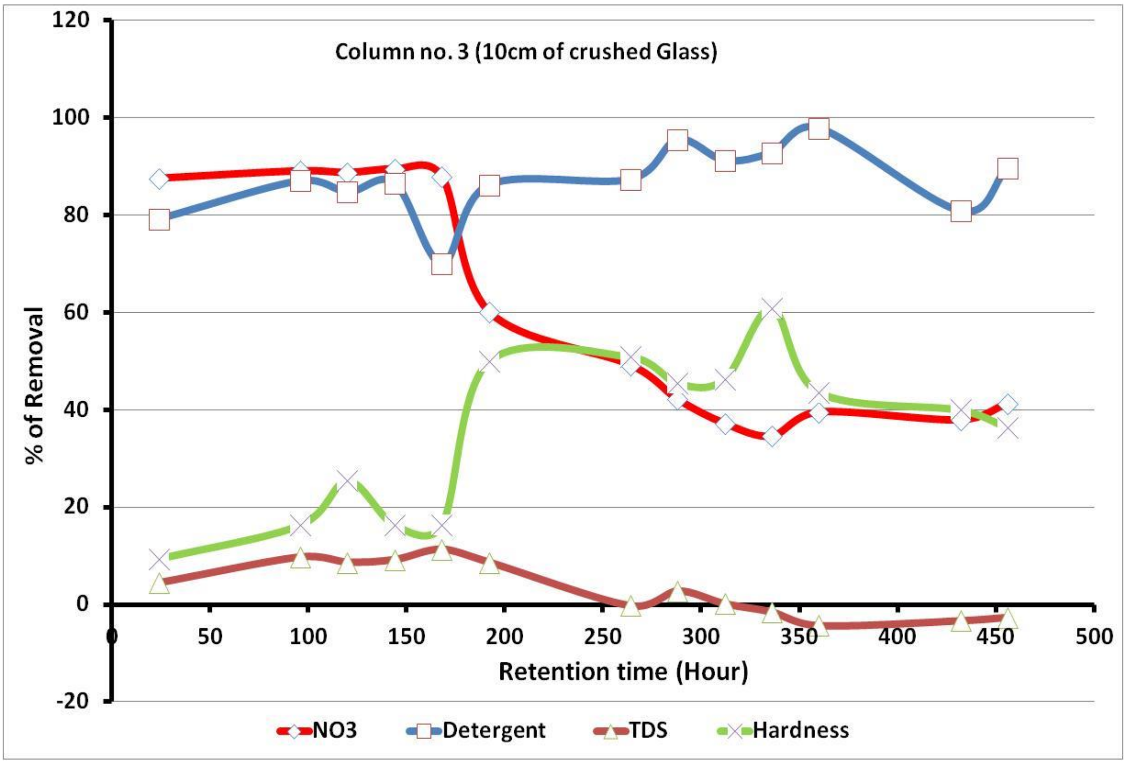


**Figure (4.27) : Relation between the different parameters and retention time of column no. 3:**
**◊ Nitrate □ Detergents ∆ TDS × Hardness**

## 4.9 - Behavior of column no.4 (10cm of Sawdust)

Through results in column no.4 it was noted that the highest reduction of detergent, where it reached 100% at 312 hours and then decreased to 86% at 456 hours, followed by reduction of nitrate where it reached 100% at 456 hours, followed by reduction of hardness where it reached 16% and then increased until it reached 56 % at 336 hours. and finally reduction of TDS ,where it initially was reached 8% at 24 hours and then increased until it reached 15% at 120 hours and then decreased gradually to reach 0% and then it increased to be more than the origin concentration of water sample because the composition sawdust contain of organic acid which leaches in the output water as shown in figure (4.28). The removal of contaminants by Sawdust according to adsorption different cations by hydrogen bonds because sawdust contain multi oxygen atom attached as glycosidic linkage or adsorbed by van der waals forces.

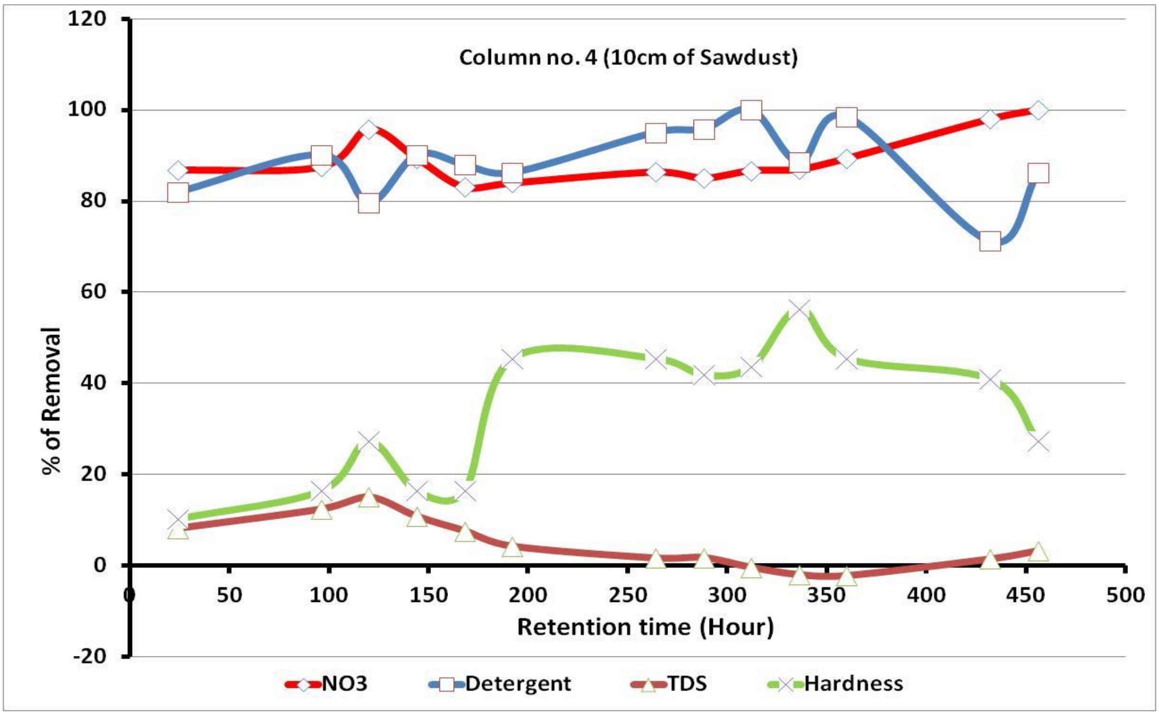


**Figure (4.28) : Relation between the different parameters and retention time of column no. 4:**
**◊ Nitrate □ Detergents Δ TDS × Hardness**

### 4.10 - Behavior of column no.5 (10cm of Guava leaves)

The results show in column no. 5 that initially the reduction of nitrate is the highest where it was reached 90% at 24 hours, then reached 100% at 168 hours, and then stabilized reduction of nitrate even 456 hours, followed by reduction of detergent where initially it was reached 79 % at 24 hours and then increased gradually and reached 99% at 336 hours, followed by reduction of TDS where initially it was reached 4% at 24 hours , then increased until it reached 15% at 120 hours and then decreased gradually until increased proportion of TDS in the water. while the reduction of hardness not there was reduction or removal, but increased hardness in the water as shown in figure (4.29). The mechanisms for nitrate removal by Guava leaves may be according to adsorption and denitrification process.

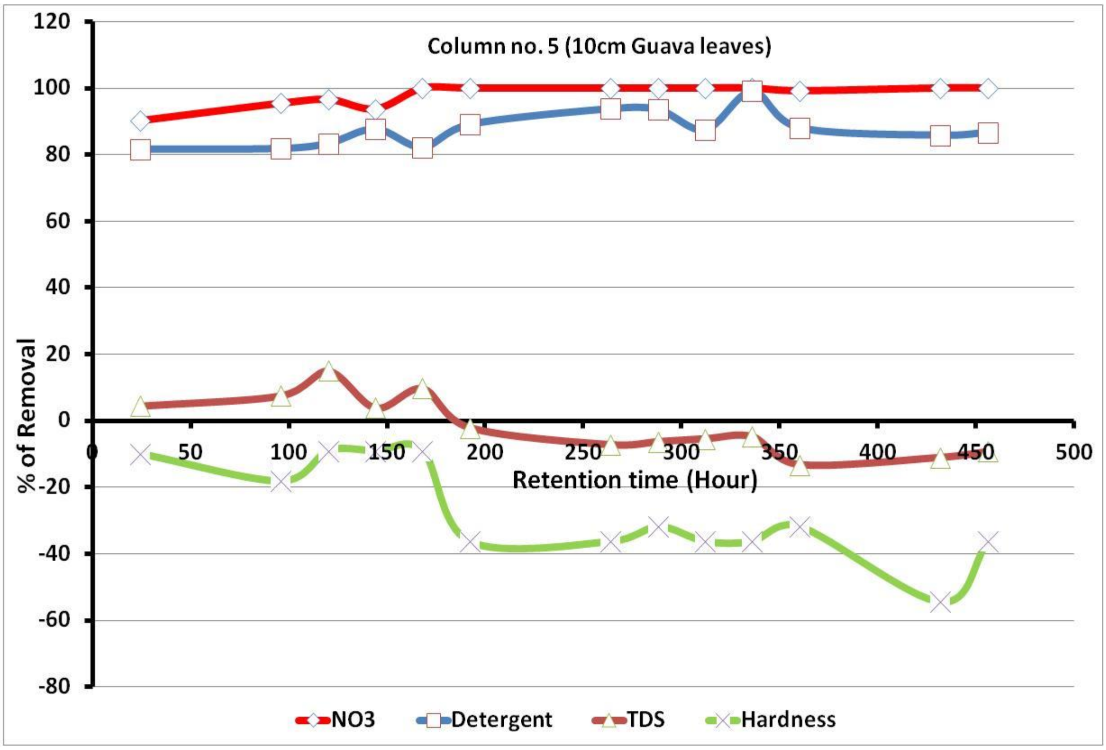


**Figure (4.29) : Relation between the different parameters and retention time of column no. 5:**

**◊ Nitrate □ Detergents Δ TDS × Hardness**

## 4.11 - Behavior of column no.6 (10cm of Fig leaves)

The results show in column no. 6 that initially the reduction of nitrate was the highest where it was 89% at 24 hours until reached 95.8% at 120 hours, and then increased gradually until reaching 100% at 456 hours, followed by reduction of detergent where initially it was 85% at 24 hours then increased gradually and reached 95% at 312 hours and then decreased to that reached 82% at 456 hours, while there was no removal of TDS and hardness, but increased the proportion of each of the TDS, hardness in water as shown in figure (4.30). The mechanisms for nitrate removal by Figs leaves may be according to adsorption and denitrification process.

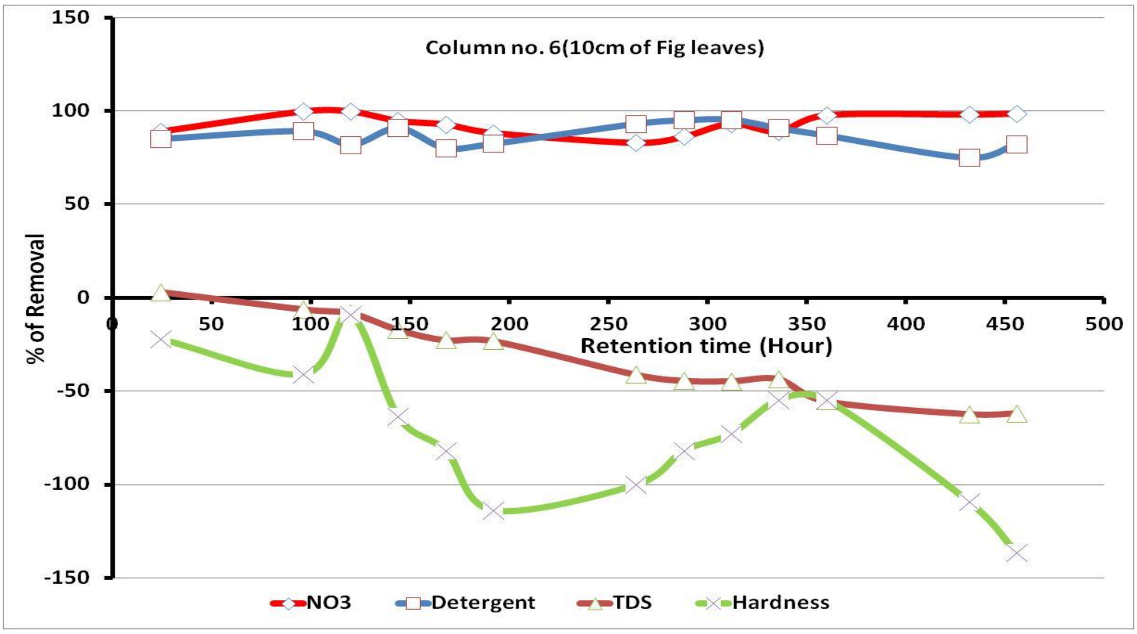


**Figure (4.30) : Relation between the different parameters and retention time of column no. 6:**
**◊ Nitrate □ Detergents Δ TDS × Hardness**

## 4.12 Result reuse experimental:

After washed the contents of the columns with distilled water and drying the columns, we were reused twice, after determination of all parameters as nitrate, detergents, TDS, water hardness, we found nearly unchanged. This was indicated that the reusing of columns many times are a good efficient for removed of the contaminants from polluted water. This confirmed and supported our work in the removal of the pollutants by using sand filters with different additives. The table (4.2) shows the mean and standard deviation of the three experiments at 24 hours for reducing nitrate, detergents, TDS, water hardness.

**The table (4.2) The mean and standard deviation of nitrate, detergent, TDS and water hardness removal.**

| Parameters | Control column | Column no. 2 | Column no. 3 | Column no. 4 | Column no. 5 | Column no. 6 |
|---|---|---|---|---|---|---|
| Nitrate reduction at 24 hours(mean) | 48.20 | 80.67 | 78.97 | 86.13 | 88.53 | 87.27 |
| Nitrate reduction at 24 hours (st.d) | 29.09 | 4.51 | 7.98 | 0.98 | 1.62 | 1.80 |
| Detergents reduction at 24 hours (mean) | 55.50 | 19.33 | 57.67 | 71.33 | 75.00 | 77.33 |
| Detergents reduction at 24 hours (st.d) | 20.02 | 11.02 | 18.50 | 9.45 | 5.68 | 7.09 |
| Hardness reduction at 24 hours (mean) | 12.20 | 54.47 | 12.00 | 10.73 | -8.33 | -34.90 |
| Hardness reduction at 24 hours (st.d) | 0.56 | 1.36 | 2.60 | 1.02 | 4.73 | 11.25 |
| TDS reduction at 24 hours (mean) | 4.32 | 54.97 | 11.05 | 5.07 | 11.13 | 13.67 |
| TDS reduction at 24 hours (st.d) | 0.50 | 2.25 | 5.75 | 3.00 | 6.02 | 9.29 |

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATIONS

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATIONS

## 5.1 CONCLUSION

The results of this study have indicated a good potential for nitrate, detergents removal from water through the six sand filter columns with their additives. But TDS and water Hardness were removed partially from water samples. The significant observations of this research were as following:

1) This study showed the possibility to use the media of Kaolin, Crushed Glass, Sawdust, Guava leaves, and Fig leaves as modified sand filter to reducing nitrate, detergent from polluted water.
2) The techniques used in this study were efficient, simple, cost-effective and easy to extrapolate for a practical applications of the reduction of water contaminants .
3) The applied water treatment by filtration were conducted without any pre chemical treatment.
4) Nitrate were removed by filter media of sand filter with Sawdust, dried Guava leaves, and Fig leaves from water basically by adsorption, precipitation and denitrification. Adsorption is taking place due to high surface area and good active sites of filters.
5) Media of sand filter with sawdust, dried Guava, and Fig leaves can act as electron donor and can help the denitrification process as excellent source of carbon. So filter media can save the cost of chemicals used as carbon source in traditional biological process.
6) The contact time of the water has a great importance through the experiments, because it's the flotation water condition. The best adsorption and denitrification capacity for nitrate, and detergents were increased with increasing contact time which depended of the type of additives.
7) Most of this work has shown that the sand filter and the new additives were good and generally better, than the sand medium alone traditionally used in filters.
8) The study showed that the water hardness and TDS by using sand filter with dried Guava, and Fig leaves were increased. This issue could be related to the component of the added media, this indicates a possibility of dissolving of these

($Ca^{2+}$ and $Mg^{2+}$ ions) solids from guava, and fig leaves media and diffuse into the water.

## 5.2 Recommendations:

According to the results of this study, the following recommendations are made:

1) This aspect needs to more investigated further in order to promote large-scale of utilization of natural resource for water treatment through filtration.
2) Using of natural media for water treatment applications are strongly recommended due to their local availability, an environmental friendly, and cost effectiveness.
3) Investigation the effects of longer retention time for the efficiency of the treatment process is highly recommended.
4) Investigation of using afferent different forms of filter modifications by using another forms of media toward the enhancing of the water treatment efficiency.
5) Investigating the efficiency of the filter columns using low polluted water of nitrate ,detergent, water hardness and TDS concentration.

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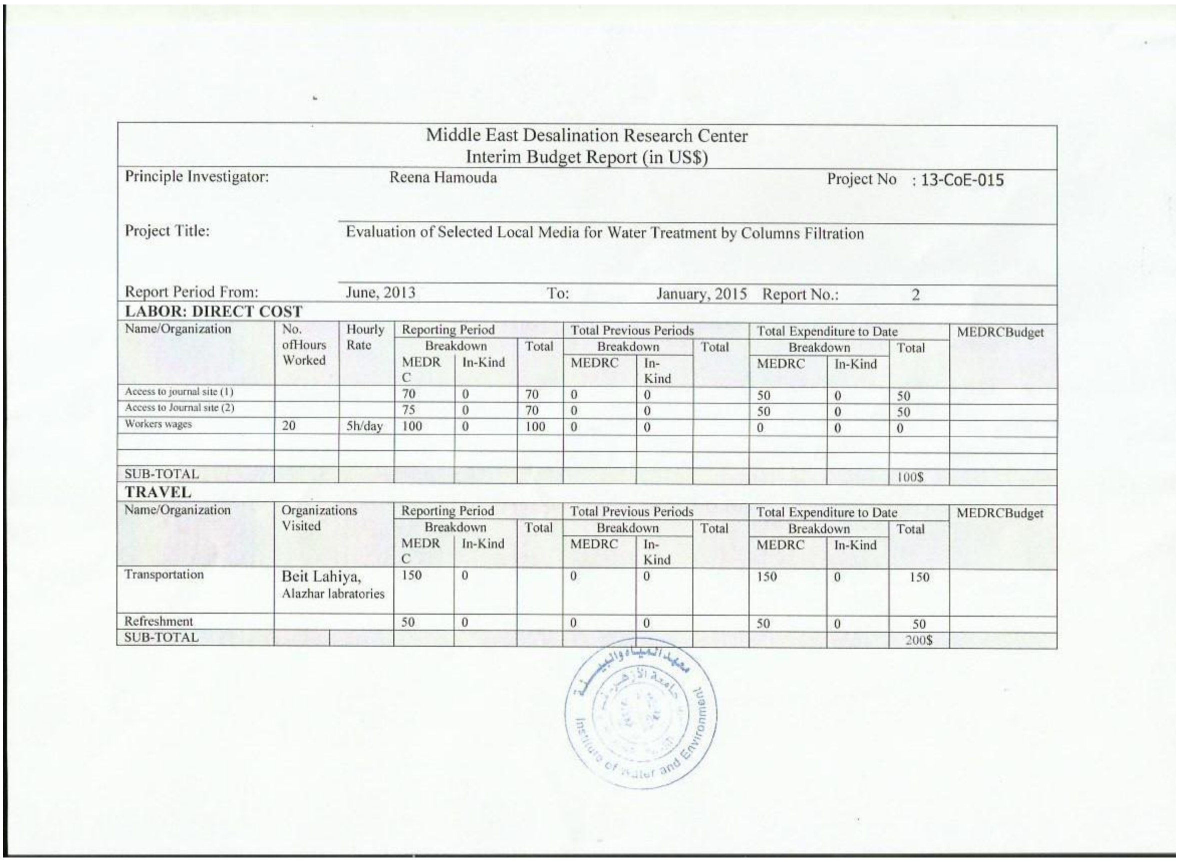

Middle East Desalination Research Center
Interim Budget Report (in US$)

Principle Investigator: Reena Hamouda Project No : 13-CoE-015

Project Title: Evaluation of Selected Local Media for Water Treatment by Columns Filtration

Report Period From: June, 2013 To: January, 2015 Report No.: 2

**LABOR: DIRECT COST**

| Name/Organization | No. ofHours Worked | Hourly Rate | Reporting Period | | | Total Previous Periods | | | Total Expenditure to Date | | | MEDRCBudget |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breakdown | | Total | Breakdown | | Total | Breakdown | | Total | |
| | | | MEDRC | In-Kind | | MEDRC | In-Kind | | MEDRC | In-Kind | | |
| Access to journal site (1) | | | 70 | 0 | 70 | 0 | 0 | | 50 | 0 | 50 | |
| Access to Journal site (2) | | | 75 | 0 | 70 | 0 | 0 | | 50 | 0 | 50 | |
| Workers wages | 20 | 5h/day | 100 | 0 | 100 | 0 | 0 | | 0 | 0 | 0 | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| SUB-TOTAL | | | | | | | | | | | 100$ | |

**TRAVEL**

| Name/Organization | Organizations Visited | Reporting Period | | | Total Previous Periods | | | Total Expenditure to Date | | | MEDRCBudget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Breakdown | | Total | Breakdown | | Total | Breakdown | | Total | |
| | | MEDRC | In-Kind | | MEDRC | In-Kind | | MEDRC | In-Kind | | |
| Transportation | Beit Lahiya, Alazhar labratories | 150 | 0 | | 0 | 0 | | 150 | 0 | 150 | |
| Refreshment | | 50 | 0 | | 0 | 0 | | 50 | 0 | 50 | |
| SUB-TOTAL | | | | | | | | | | 200$ | |

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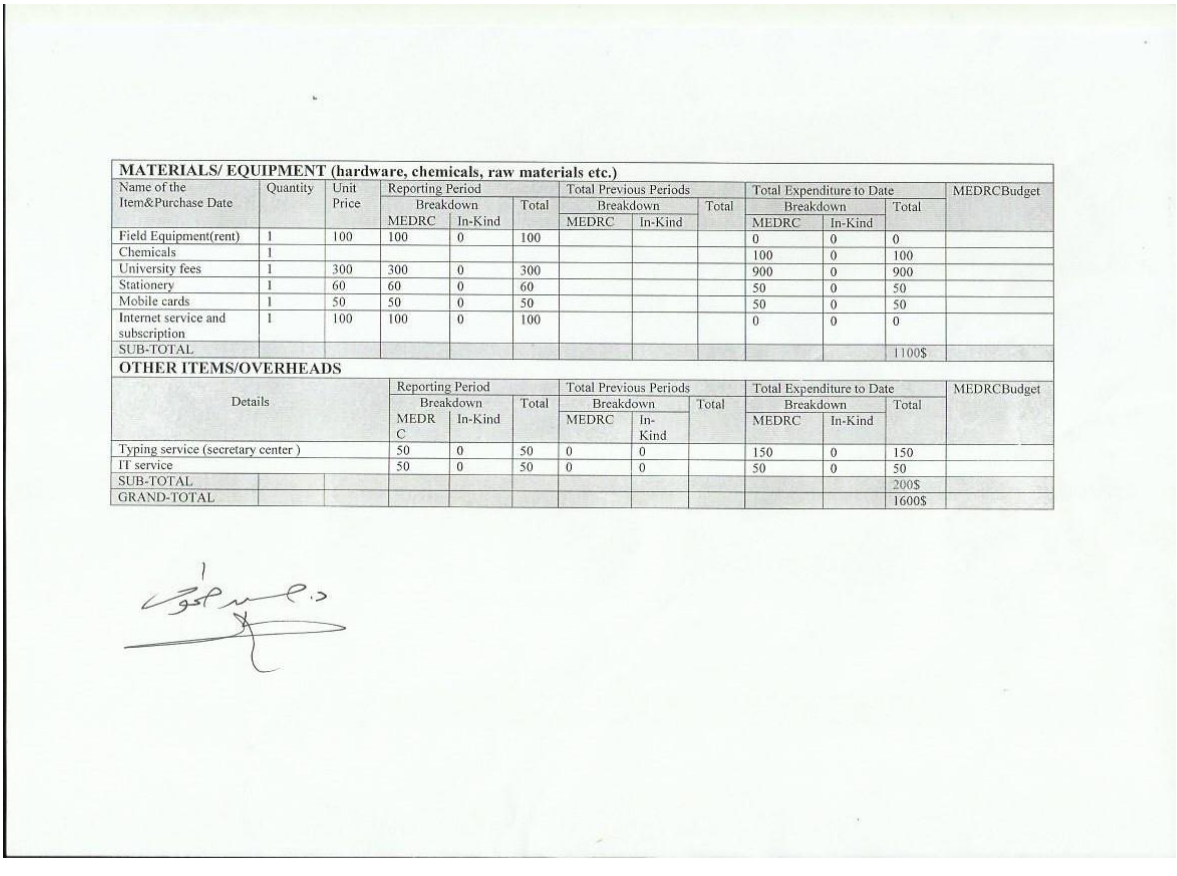
جامعة الأزهر
Institute of Water and Environment



**MATERIALS/ EQUIPMENT (hardware, chemicals, raw materials etc.)**

| Name of the Item&Purchase Date | Quantity | Unit Price | Reporting Period | | | Total Previous Periods | | | Total Expenditure to Date | | | MEDRCBudget |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breakdown | | Total | Breakdown | | Total | Breakdown | | Total | |
| | | | MEDRC | In-Kind | | MEDRC | In-Kind | | MEDRC | In-Kind | | |
| Field Equipment(rent) | 1 | 100 | 100 | 0 | 100 | | | | 0 | 0 | 0 | |
| Chemicals | 1 | | | | | | | | 100 | 0 | 100 | |
| University fees | 1 | 300 | 300 | 0 | 300 | | | | 900 | 0 | 900 | |
| Stationery | 1 | 60 | 60 | 0 | 60 | | | | 50 | 0 | 50 | |
| Mobile cards | 1 | 50 | 50 | 0 | 50 | | | | 50 | 0 | 50 | |
| Internet service and subscription | 1 | 100 | 100 | 0 | 100 | | | | 0 | 0 | 0 | |
| SUB-TOTAL | | | | | | | | | | | 1100$ | |

**OTHER ITEMS/OVERHEADS**

| Details | Reporting Period | | | Total Previous Periods | | | Total Expenditure to Date | | | MEDRCBudget |
|---|---|---|---|---|---|---|---|---|---|---|
| | Breakdown | | Total | Breakdown | | Total | Breakdown | | Total | |
| | MEDRC | In-Kind | | MEDRC | In-Kind | | MEDRC | In-Kind | | |
| Typing service (secretary center ) | 50 | 0 | 50 | 0 | 0 | | 150 | 0 | 150 | |
| IT service | 50 | 0 | 50 | 0 | 0 | | 50 | 0 | 50 | |
| SUB-TOTAL | | | | | | | | | 200$ | |
| GRAND-TOTAL | | | | | | | | | 1600$ | |

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غزة - الرمال - شارع خليل الوزير
تلفون: ٠٨-٢٨٧٠٠٢٨ تلفاكس: ٠٨-٢٨٧٠٠٢٩

التاريخ: 2/ 4/ ٢٠١4م

| | | |
|---|---|---|
| دينار JD | — | |
| دولار $ | — | |
| شيكل NIS | 200 | |

سند قبض رقم № 003709 **Receipt Voucher**

وصلني من السيد / رينا حمودة

مبلغاً وقدره / مائتان شيكل فقط لا غير

وذلك مقابل / فاتورة رقم 57568

| الرقم | المبلغ | رقم الشيك | البنك | تاريخ الاستحقاق | رقم الفاتورة |
|---|---|---|---|---|---|
| | 200 | / | / | / | 57568 |

| | |
|---|---|
| مجموع الشيكات | |
| نقداً | 200 |
| خصم المصدر | — |
| المجموع | 200 |

Z.M.S

التوقيع

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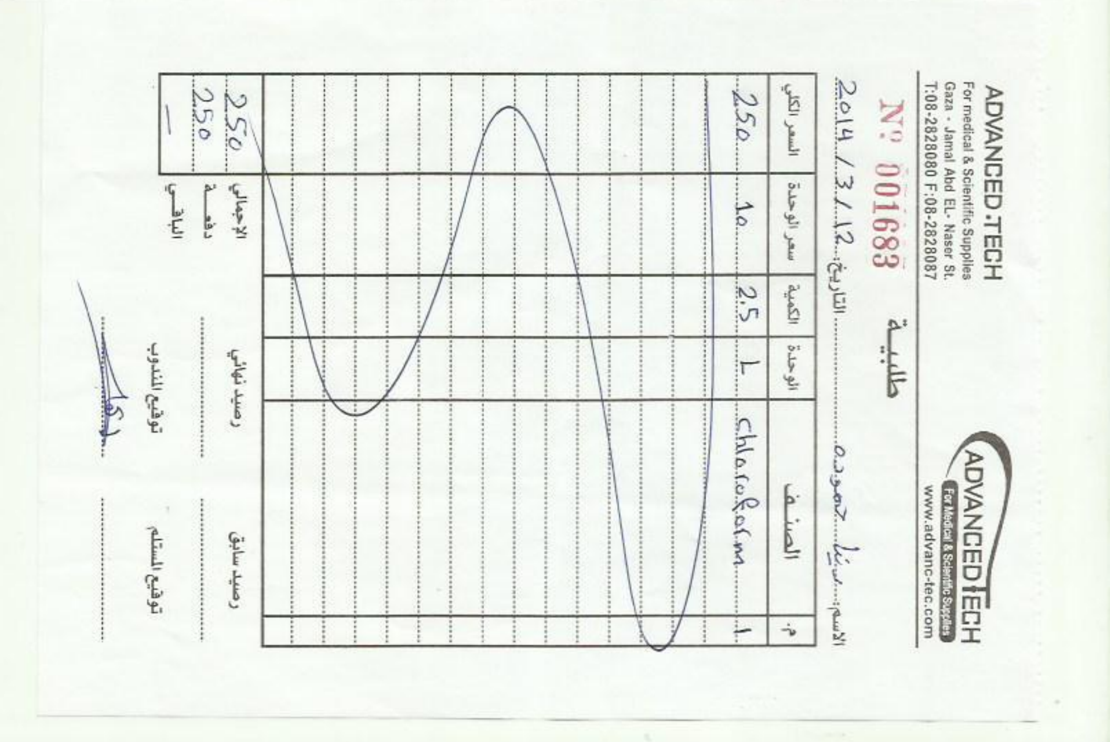

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№ 001683

الاسم: رينا حموده التاريخ: 2014/3/12

| م | الصنف | الوحدة | الكمية | سعر الوحدة | السعر الكلي |
|---|---|---|---|---|---|
| 1 | Chloroform | L | 2.5 | 10 | 250 |

| | |
|---|---|
| الإجمالي | 250 |
| دفعة | 250 |
| الباقي | — |

رصيد سابق ..........

رصيد نهائي ..........

توقيع المستلم ..........

توقيع المندوب ..........