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بنية تحتية

Onsite wastewater treatment for semi urban areas:

Abasan case study

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Abstract :

Deterioration of the public health can be caused due to the discharge of untreated wastewater into the aquatic environment. Cesspits systems are the most common treatment units on household level in semi urban areas of Gaza Strip.

The aims of this study are to evaluate the onsite wastewater treatment for semi urban areas in Gaza strip and Abasan area as a case study by monitoring the system for four months. During the monitoring program, samples and tests are for (BOD_5 , COD , TSS , TDS and FC).

Treatment unit consists of four treatment stages that are septic tank followed by trickling filter and sedimentation tank . Sand filter after settling tank is used to remove TSS and FC. The system is designed to treat wastewater from 50 families and reuse it to irrigate farm land in this area.

Results showed that the system works efficiently in terms of the removal of BOD_5 is (86.1%) , COD is (84%) , TSS is (85.34%) and FC is (74.96%). The system has no effects on TDS. The results show quality suitable for restricted agricultural according to Palestinian Draft Standard (PDS) for water reuse.

Previously, the households used to pay 50 NIS (17USD) per month to empty their cesspits. Now they pay 15NIS (4USD) per month for operating the system which encourage them and impacted the socio-economic situation positively.

الخلاصة :

تصريف مياه الصرف الصحي غير المعالجة في البيئة ونظام الحفر الامتصاصية هي النظام الأكثر شيوعا في قطاع غزة وذلك لغياب شبكات الصرف الصحي. يعتبر هذا السلوك من أهم أسباب التدهور في الصحة العامة على مستوى المناطق شبه الحضرية في قطاع غزة.

تهدف هذه الدراسة الى تقييم معالجة مياه الصرف الصحي في الموقع للمناطق شبه الحضرية والتي تتميز بالزراعة الحضرية. تم اخذ منطقة عبسان كدراسة حالة.

خلال فترة المتابعة (مايو - اكتوبر 2013) تم أخذ العينات و فحصها لكلا من: متطلب الأكسجين الحيوي (BOD_5) ومتطلب الأكسجين الكيميائي (COD) و مجموع المواد الصلبة العالقة (TSS) ومجموع الأملاح الذائبة (TDS) والبكتيريا القولونية (FC).

تم تصميم نظام المعالجة ليخدم 50 عائلة وتتكون وحدة المعالجة من أربع مراحل هي خزان لتجميع الصرف الصحي يليها مرشح بيولوجي وخزان الترسيب ومرشح رملي. تم اضافة المرشح الرملي بعد خزان الترسيب لإزالة المواد الصلبة العالقة والبكتيريا القولونية بحيث يمكن استخدام المياه المعالجة الناتجة من وحدة المعالجة المذكورة في ري الأراضي الزراعية المجاورة .

أظهرت النتائج أن النظام يعمل بكفاءة من حيث معالجة المواد العضوية بدلالة BOD_5 وCOD بواقع 84 و 86٪ بالتتابع. بلغت نسبة ازالة المواد الصلبة العالقة 85٪. النظام ليس له آثار على ازالة الأملاح الذائبة بل هناك تأثير واضح على ازالة البكتيريا القولونية حيث بلغت الكفاءة 75٪.

تظهر النتائج أن الجودة مناسبة لري المزروعات وفقا للمواصفات الفلسطينية الموحدة لإعادة استخدام المياه العادمة المعالجة.

تكلفت تفريغ الحفر الامتصاصية تبلغ 50 شيكل (17دولار) شهريا للأسرة. علما بان تكلفت تشغيل نظام المعالجة المقترح في الدراسة (وحدات المعالجة المكانية) 15شيكل (4دولار) شهريا الامر الذي جعل السكان في منطقة الدراسة يفضلوا نظام المعالجة وينعكس ذلك على الحالة الاجتماعية والاقتصادية بالإيجاب.

Dedication:

To my Father and to my Mother, for her kindness

To my wife for her Support and Encouragement

To my Brothers and Sisters

To my Friends, Colleagues

To the Islamic University of Gaza

And to all those who believe in the richness of learning

The Student

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Thanks to Allah the compassionate the merciful for giving me patience and strength to accomplish this research.

All thanks and appreciations go to Allah for His unlimited blessings and for giving me the strength to complete this study.

Mere appreciation and thanks to Dr. Abdelmajid Nassar, who served as the chairman of my thesis committee, is nothing compared to what I actually feel for his unparalleled supervision, help and guidance. This work would not have been accomplished without his support and encouragement to me.

My appreciation is also extended to the IUG for giving me the opportunity to carry out this study. Furthermore, great thanks are also to my colleagues and lecturers in the Engineering Faculty and the Civil Engineering Department in particular for their continual encouragement and support.

Thanks go to PHG, for providing me all the necessary information that was helpful in accomplishing this work.

Finally, my most appreciations are to my parents, wife, brothers and sisters for their full support, encouragement and patience that give me the power all life.

Acronyms and Abbreviations

AF: Anaerobic Filter
APHA: American Public Health Association.
BOD: Biological Oxygen Demand
CFSGAS: Continuous-Flow, Suspended-Growth Aerobic System
CFU: Colony Forming Unit.
COD : Chemical Oxygen Demand
DEWATS: Decentralized Wastewater Treatment Plants
EPA: Environment Protection Agency
EQA: Environmental Quality Authority
HRT: Hydraulic Retention Time
ICRC: The International Committee of the Red Cross
IDRC : International Development Research Centre
IUG: Islamic University - Gaza
m^3/d: Cubic meter per day
MCM: Million Cubic Meters
MEnA: Ministry of the Environmental Affairs
mg/L: Milligrams per Liter
MOA: Ministry of Agriculture
MOH : Ministry of Health
NGO's: Non-Governmental Organizations
OWTS: Onsite wastewater treatment system
PARC: Palestinian Agricultural Relief Committees
PCBS: Palestinian Central Bureau of Statistics
PDS: Palestinian Draft Standard
PHG: Palestinian Hydrology Group
PWA: Palestinian Water Authority
SAT: Soil Aquifer Treatment
SS: Suspended Solids
ST: Septic Tank
SWIS: Subsurface Wastewater Infiltration System
TDS: Total Dissolved Solids
TKN: Total Kjeldahl Nitrogen
TSS: Total suspended solid
UASP: Upflow Anaerobic Sludge Blanket
UPVC : Unplasticised Polyvinyl Chloride
UV: Ultra Violet
WHO: World Health Organization
WWTP: Wastewater Treatment Plant

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CHAPTER ONE

1 Introduction

1.1 Background

Gaza strip suffer from failing sewerage system and on average, it is estimated that about 74 % of the population is connected to a sewerage network(PWA, 2013). Cesspits are the other wastewater disposal system in the semi urban areas. Water consumption for agricultural purposes exceeds all other sectors. Hence, there is an increasing need for water reuse for irrigation of agricultural crops with treated wastewater (TWW) (Hamilton et al., 2007).

There are four treatment plants in Gaza Strip, at Beit Lahia, Gaza City, Khanyouns and Rafh, but none is functioning effectively. Approximately 70-80 % of the domestic wastewater produced in Gaza is discharged into the environment without enough treatment, either directly, after collection in cesspits, or through leakages and overloaded treatment plants. Most wastewater is discharged into the Mediterranean. The wastewater collected from the whole of the Gaza Strip is fed into three main treatment plants; Beitlahya, Gaza and Rafah with total capacity of 20,000, 75,000 and 16,000 m^3/day (total of 40 MCM/year) by the year 2010, respectively, of which 26 million m^3/year passes into sewerage networks and the rest to cesspits or pit latrines (PWA, 2010).It has been reported that the discharge of untreated wastewater into the aquatic environmental is worldwide the main cause of diarrhoeal diseases (Lens et al. (2001)). Developing countries are focusing on this issue where public health is seriously affected by diseases directly related to inadequate wastewater management.

Onsite (or decentralized) wastewater treatment systems (OWTS) are used to treat wastewater from a home or business and return treated wastewater back into the receiving environment. They are typically referred to as septic systems, because most involve a septic tank for partial treatment (EPA, 2008).

The decentralized wastewater management approach on the other hand could be a valuable alternative to conventional, centralized approaches, if low cost processes adapted to the local conditions are applied and properly maintained.

The onsite wastewater management approach includes the collection, the treatment and the disposal or reuse of wastewater from individual homes, clusters of homes, isolated communities, and institutional facilities at or near to the point of waste generation (Crites & Tchobanoglous, 1998).

In most developing countries, including Palestine, the conventional septic tank is the most frequent onsite treatment facility for domestic wastewater in residential areas where no available infrastructure exists. Although septic tanks remove COD, BOD_5, SS, and helminthes eggs to a certain extent, the technology is not able to produce an effluent, which meets national quality standards. One of the main objectives of this study is to evaluate the existing onsite treatment units using many assessment indicators.

Some areas in the Gaza Strip especially eastern areas suffer from the lack of sewerage network so they use cesspits for the disposal of sewage or are flow into the farmland, causing a lot of health and environmental problems.

Abasan area as semi urban area is one of areas where sewerage network not constructed . Yet full of agriculture land where treated wastewater can be used and far from the centralized treatment plant so community use cesspits to collect wastewater. This project aims to collect wastewater from about 50 families and establish a small wastewater treatment plant for about 25 m^3/day. The treatment plant was constructed within the farm land of 15 dunums where effluent will be used by the land owner in irrigating olives and fruits.

1.2 Problem statement

There is in the Gaza Strip semi urban areas far from the centralized treatment plant suffer from a lack of wastewater network and depend on wastewater discharge on cesspits that pollute the environment , costly and ineffective .

Individual trials were done to dispose wastewater as soil aquifer treatment (SAT) and reed bed but these efforts fail so group of people connect together as semi centralized or decentralized wastewater treatment plant.

Connection of semi urban areas with centralized treatment plant is difficult now . The population use individual efforts to dispose of wastewater which are failed . These areas still suffer from wastewater and require effective solution .

1.3 Objectives

Allocate effective treatment and disposal of wastewater in semi urban areas. The study will mainly focus on the specific objectives:

- Study the technical effectiveness of onsite treatment plant in semi urban areas and evaluate the performance of treatment system with respect to the removal efficiency of BOD_5, COD, TSS, TDS, FC .
- Propose any required modifications.

1.4 Scope of study

The data of local onsite treatment unit were collected from the implementing association that adapted the system. The main implementing association were Palestinian Hydrology Group (PHG). They implemented a system of system of septic tank and trickling filter with a sedimentation tank respectively. The evaluation criteria will consider many indictors as treatment efficiency, operation and maintenance, and environmental impacts and need to lands. The system was implemented in the semi urban areas in Gaza strip.

1.5 Methodology

To achieve the objectives of this research, the following methodology will consist of several steps as the following:

1.5.1 Data collection

PHG has implemented treatment unit in semi urban area in Abasan in the southern governorate of Gaza strip in order to reuse the treated wastewater in irrigating fruits and olives trees that are tolerant to the moderate saline water.

Sewerage system was built for the residents of the area to collect wastewater and to see how much wastewater entering the plant. The field visits to residents and consumption bills for residents show the number of individuals in each house to see consumption per house .

1.5.2 Measurements

- Monitoring the system after operating for four months .
- Taking samples every two weeks.
- Testing BOD_5, COD , SS and FC from inlet of the system and outlet of the septic tank , trickling filter , sand filter and the system .

1.5.3 Analysis

- Modification of the system for actual results compare with design for small wastewater treatment units.
- Check if this treated wastewater suitable for reuse in restricted agriculture.

1.5.4 Evaluation Criteria of the System

- Treatment Efficiency

Effluent will be analyzed to measure the quality of the treated wastewater and to measure the efficiency of the system. Technology chosen should produce effluent quality that is up to standard with regard to various quality measurements.

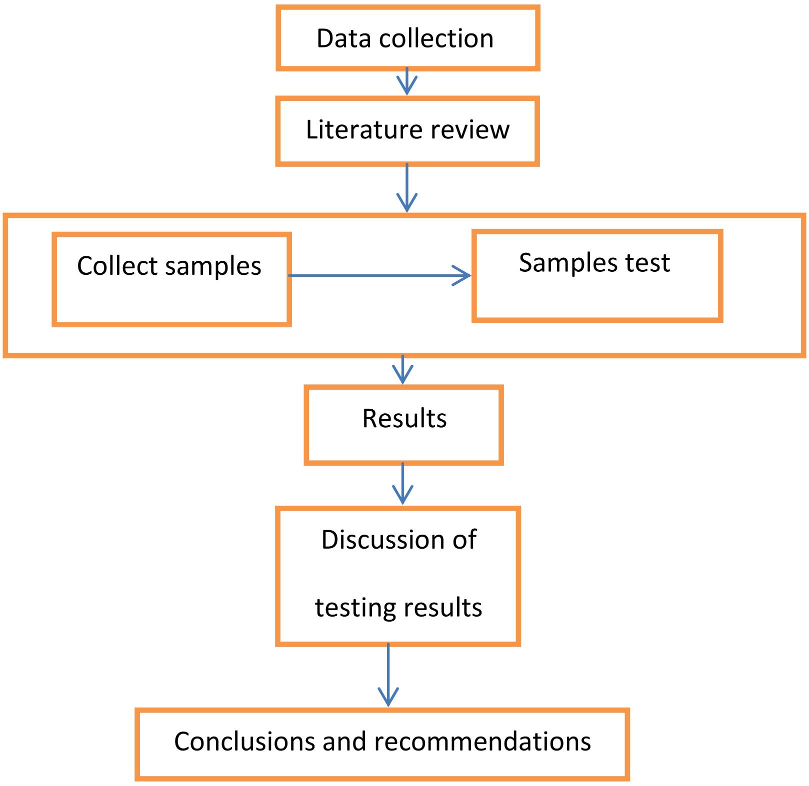


Figure 1-1: Work plan chart

1.6 Thesis outline

Chapter one presents background , problem definition, objectives and thesis structure.

Chapter two provides literature review about onsite treatment technology, its advantages and disadvantages.

Chapter three is the methodology adapted to construct the study.

Chapter four provides the test results and discussion.

Chapter five gives conclusions and recommendations of the study.

CHAPTER TWO

2 Literature review

2.1 Present Situation of Wastewater in Gaza strip

In term of wastewater in Gaza, access to sewerage facilities at present varies from areas where more than 95 % of the households are served by well-functioning sewerage systems, to areas where there is no sewerage system at all. On average, it is estimated that about 74 % of the population is connected to a sewerage network. Cesspits and boreholes are the other wastewater disposal systems in the area. There are four treatment plants in Gaza Strip, at Beit Lahia, Shikh Ejleen , Khan Younis and Rafah, but none is functioning effectively. Approximately 70-80 % of the domestic wastewater produced in Gaza is discharged into the environment without enough treatment, either directly, after collection in cesspits, or through leakages and overloaded treatment plants. Most wastewater is discharged into the Mediterranean. The effluent from Shikh Ejleen and Rafah treatment plants is mostly discharged into the Mediterranean. In the case of the Beit Lahia treatment plant, a substantial quantity of wastewater infiltrates into the ground, contaminating soil and groundwater in the area (MEnA Desk study, 2002). The total annual wastewater production in Gaza strip is estimated to be 40 million m^3, of which 26 million m^3 passes into sewerage networks and the rest to cesspits or pit latrines. The major aim of the plant was to produce effluent of a quality suitable for direct use in irrigation. However, as a result of the poor quality of the treated wastewater, which is far below World Health Organization (WHO) guidelines for use in agriculture, plans for transporting treated wastewater to agricultural areas were never completed. The influent quality wastewater in all plants are shown in Table (2.1).

Table 2-1 :Typical characteristics of wastewater in Gaza strip (PWA, 2003)

parameter	Wastewater Characteristics		
	North Area	**Gaza**	**Rafah**
BOD5(mg/L)	728	667	777
COD(mg/L)	1385	1306	1399
SS(mg/L)	663	617	540
SS/BOD	0.9	0.95	0.69
BOD/COD	0.526	0.51	0.56

2.2 Wastewater Composition in Gaza Strip

Total wastewater for the Gaza strip and West Bank is estimated at 72 million m^3 (PCBS, 2002). Low per-capita water consumption within Palestinian households affects the sewage composition by increasing the organic constituents and influent salinity. The biochemical oxygen demand (BOD_5) level of sewage in Gaza averages 686 mg per liter. This is higher than the common BOD_5 levels of 200-300 mg per liter in many developed countries(Polprasert, 1996).

2.2.1 Wastewater from a household

There are four types of wastewater from the household that varies in their strength and contents. They can be characterized as in Table (2.2) (Winnerberger, 1969; Li et al., 2001):

Table 2-2: Types of wastewater from household.

No.	Type of wastewater	Source of wastewater
1	Gray water	washing water from kitchen, bathrooms, laun-dry, etc. without faeces and urine
2	Black water	water from flush toilets (faeces and urine with flush water)
3	Yellow water	urine from separation toilets and urinals (with or without water for flushing)
4	Brown water	black water without urine or yellow water

The strength of wastewater depends mainly on the degree of water dilution, which can be categorized as strong, medium, or weak, as shown in Table (2.3). These wastewater characteristics can vary widely with local conditions, hour of the day, day of the week, season, and type of sewers (either separate or combined sewers where storm water is included) (Polprasert, 1996).

Table 2-3: Typical characteristics of domestic wastewater(Polprasert, 1996)

Parameter	Concentration (mg/L)		
	Strong	Medium	Weak
BOD5	400	220	110
COD	1,000	500	250
Org-N	35	15	8
NH3-N	50	25	12
Total N	85	40	20
Total P	15	8	4
Total solids	1,200	720	350
Suspended solids	350	220	100

The common wastewater types from domestic uses are gray and black wastewater. Table (2.4) shows the wastewater characteristics from different household sources for both types of domestic wastewater.

Table 2.4: Typical characteristics of domestic wastewater fraction (US EPA, 1980)

Parameter	Concentration (mg/l)	
	Black water	Grey water
BOD5	280	260
SS	450	160
Nitrogen	140	17
Phosphorus	26	13

2.3 Wastewater Treatment

The term "treatment" means separation of solids and stabilization of pollutants. Stabilization means the degradation of organic matter until the point at which chemical or biological reactions stop. Treatment can also mean the removal of toxic or otherwise dangerous substances (for e.g. heavy metals or phosphorous) which are likely to distort sustainable biological cycles, even after stabilization of the organic matter."(Sasse, 1998)

2.3.1 General parameters to measure organic pollution

COD (Chemical Oxygen Demand) is said to be the most general parameter to measure organic pollution. COD describes how much oxygen is required to oxidize all organic and inorganic matter found in the wastewater sample. BOD_5 (Biological Oxygen Demand) describes what can be oxidized biologically, with the help of bacteria and is always a fraction of COD. Usually BOD_5 is measured as BOD_5 meaning that it describes the measured amount of oxygen consumed over a five days measurement period. It is a direct measurement of the amount of oxygen consumed by organisms removing the organic matter in the waste. Suspended Solids (SS) describes how much of the organic or inorganic matter is not dissolved in water and contains settleable solids that sink to the bottom in a short time and non settleable suspended solids. It is an important parameter because SS causes turbidity in the water causing clogging of filters etc(Sasse, 1998). The mentioned parameters are measured in mg/l.

2.4 Centralized Wastewater Treatment Plants

The concept of centralized wastewater treatment plant is to have one system that treats wastewater for the whole area or city. Figure (2.1) illustrates the concept of centralized wastewater treatment plant .In Urban areas, wastewater is carried over by sewers to a large scale centralized treatment plant, which can satisfy the requirements for safe wastewater disposal. Unfortunately, complete sewerage is not possible for small communities and specially communities live in a critical economic situation in developing countries and suffer from limited finance and limited operation and maintenance budget. The number of people without sewers is increasing because of the population growth that exceeds the provision of new sewer connections. The need of such communities to get the same degree of treatment of discharge effluent up to the same standards as the large communities (US.EPA, 1980).

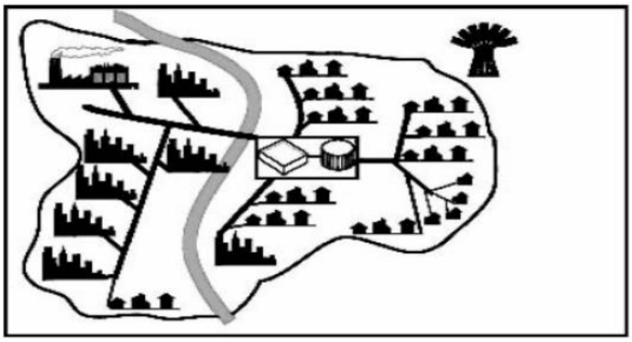


Figure 2-1: A centralised wastewater treatment system (Anaant, 2003).

2.5 Decentralized Wastewater Treatment Plants (DEWATS)

2.5.1 History of onsite(decentralized) wastewater treatment systems

King Minos installed the first known water closet with a flushing device in the Knossos Palace in Crete in 1700 BC. In the intervening 3,700 years, societies and the governments that serve them have sought to improve both the removal of human wastes from indoor areas and the treatment of that waste to reduce threats to public health and ecological resources. The Greeks, Romans, British, and French achieved considerable progress in waste removal during the period from 800 BC to AD 1850. But removal often meant discharge to surface waters; severe contamination of lakes, rivers, streams, and coastal areas; and frequent outbreaks of diseases like cholera and typhoid fever (Curry. 1998). The past century has witnessed an explosion in sewage treatment technology and widespread adoption of centralized wastewater collection and treatment services throughout the world. Although broad uses of these systems have vastly improved public health and water quality in urban areas, homes and businesses without centralized collection and treatment systems often continue to depend on technologies developed more than 100 years ago. Septic tanks for primary treatment of wastewater appeared in the late 1800s, and discharge of tank effluent into gravel lined subsurface drains became common practice during the middle of the 20th century (Curry. 1998). Scientists, engineers, and manufacturers in the wastewater treatment industry have developed a wide range of alternative technologies designed to address increasing hydraulic loads and water contamination by nutrients and pathogens. These technologies can achieve significant pollutant removal rates.

2.5.2 Nature of onsite wastewater treatment system

The concept of onsite wastewater treatment plants (OWTS) is to have a wastewater treated system as close as possible to the fresh wastewater source. A decentralized system employs a combination of onsite and/or cluster systems and is used to treat and dispose of wastewater from houses, public buildings close to the source. Decentralized wastewater systems allow for flexibility in wastewater management, and different parts of the system may be combined into "treatment trains," or a series of processes to meet treatment goals, overcome site conditions, and to address environmental protection requirements. Figure (2.2) illustrates the concept of decentralized wastewater treatment plant . Dewats if properly designed and implemented, it will be distinguished by many properties as it is an approach rather than just a technical hardware. And as a result of many trials in various countries, it provides treatment for wastewater flows from 1-500 m^3/day from both domestic and industrial resources. It is based on a set of treatment principles of which has been determined by their reliability and tolerance towards inflow fluctuation, it also works without technical energy and thus can’t be switched off intentionally and it is the best solution where skilled and responsible operation and maintenance is guaranteed. It doesn't require sophisticated maintenance. It is implemented with low cost and distinguished by long desludging intervals (Anaant, 2003).

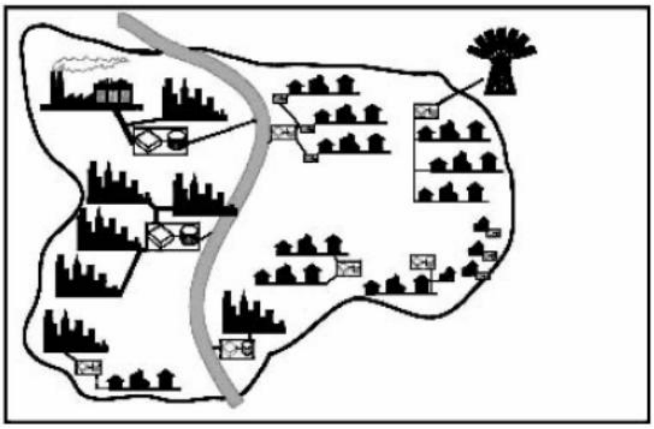


Figure 2-2: Decentralized wastewater treatment system (DEWATS) (Anaant, 2003).

2.5.3 Common systems of Decentralized wastewater treatment system

DEWATS is based on four treatment systems:

- Sedimentation and primary treatment in sedimentation ponds, septic tanks or Imhoff tanks.

- Secondary anaerobic treatment in fixed bed filters (anaerobic filters) or baffled septic tanks.

- Secondary and tertiary aerobic/anaerobic treatment in constructed wetlands (subsurface flow filters).

- Secondary and tertiary aerobic/anaerobic treatment in ponds. These systems are combined in accordance with the wastewater influent and the required effluent quality.

2.5.4 Common types of Decentralized wastewater treatment system .

The common types of Dewats that are used in the world are conventional septic tanks, Imhoff tanks, septic tank with up flow filter, anaerobic ponds, baffled septic tanks, upstream anaerobic sludge blanket (UASB), horizontal gravel filter, aerobic stabilization ponds and anaerobic filter.

a- Conventional septic tank

The most common of decentralized units is Conventional septic tank, it is used to receive wastewater discharged from individual residences, and other non-sewer facilities, for examples; toilet water, water used from cooking or bathing. While relatively simple in construction and operation, the septic tank provides a number of important functions through a complex interaction of physical and biological processes. The essential functions of the septic tank are as follow:

• To separate solids from the wastewater flow.

• To cause reduction and decomposition of accumulated solids.

• To provide storage for the separated solids (sludge and scum).

• To pass the clarified wastewater (effluent) out to a leaching field or pit.

Septic tanks (Figure2.3a and 2.3b) provide a relatively quiescent body of water where the wastewater is retained long enough to let the solids, oils and greases separate by both settling and flotation. This process is often called a primary treatment and results in three products: scum, accumulated sludge (or septage), and effluent. These tanks serve as combined settling and skimming tanks, unheated unmixed anaerobic digesters, and as sludge storage tanks (Crites and Tchobanoglous, 1998). In some countries, the septic tank is followed by a soil absorption system, or another post-treatment unit. The organic material retained in the bottom of the tank undergoes facultative and anaerobic decomposition and is converted to more stable compounds and gases such as carbon dioxide (CO_2), methane (CH_4), and hydrogen sulphide (H_2S). The sludge that accumulates in the septic tank is composed primarily of ligneous material contained in toilet paper. While these materials will be eventually decomposed biologically, the rate is extremely slow, which accounts for the accumulation (USEPA, 1980).

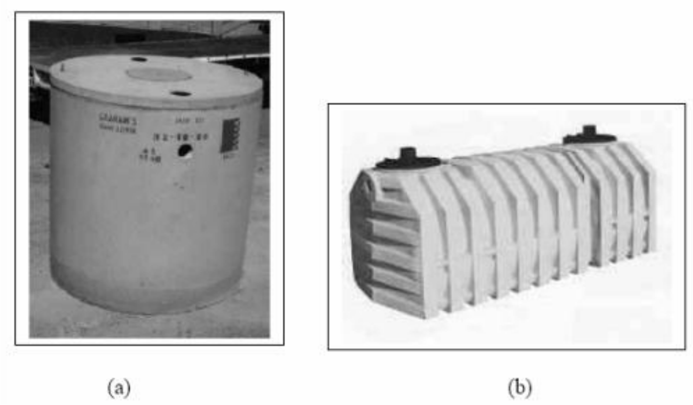


Figure 2-3: Typical conventional septic tanks (a) Concrete type with reinforcing steel (under construction) and (b) fiberglass type (http://www.wieserconcrete.com).

In order to improve the treatment performance, an in-tank baffle is sometimes used to divide the tank, and access ports are provided to permit inspection and cleaning (Figure2.4). Two compartments have been used to limit the discharge of solids in the effluent from the septic tank. Based on measurements made in both single and double compartments, the benefit of a two-compartment tank appears to depend more on the design of the tank. Currently, most houses in several cities of developing countries are equipped with septic tank or other on-site systems. The use of septic tanks can be traced back to the year 1860 in France (Crites and Tchobanoglous, 1998). Septic tanks are made out of concrete, steel, red-wood or polyethylene, but the use of steel and redwood tanks is no longer accepted by most regulatory agencies. Polyethylene tanks are inferior to concrete and fiberglass tanks because they will deform after some years in operation. Today, most of the conventional septic tanks are made out of concrete or fiberglass. Fiberglas septic tanks are rather expensive. They are usually used in areas where concrete septic tanks cannot be installed. Regardless of the material of construction, a septic tank must be watertight and must be able to withhold the wastewater loads if it is to function properly; especially where subsequent treatment units such as intermittent or recirculating packed bed filters or pressure sewers are to be used.

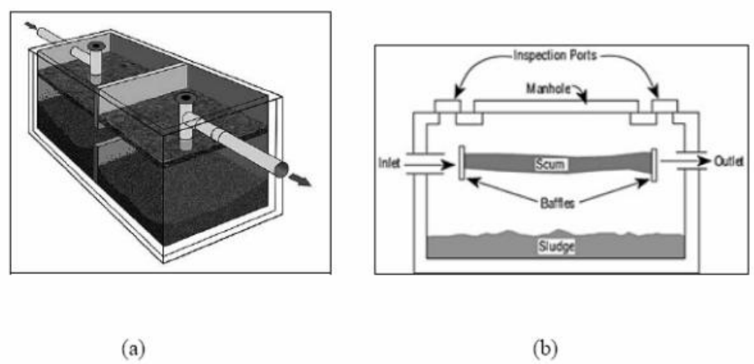


Figure 2-4: Schematic typical septic tanks : (a) two-compartments tank and (b) a single compartment tank (http://www.septic-info-com).

b- Imhoff Tank

Imhoff tanks are used for domestic or mixed wastewater flows where effluent will undergo further treatment on ground surface. The Imhoff tank is divided into an upper settling compartment in which sedimentation of solids occurs as illustrated in Figure (2.5). Sludge then falls through opening at the bottom into the lower tank where it is digested an aerobically. Methane gas is produced in the process and is prevented from disturbing the settling process by being deflected by baffles into the gas vent channels. Effluent is odorless because the suspended and dissolved solids in the effluent do not come into contact with the active sludge causing it to become foul. When sludge is removed, it needs to be further treated in drying beds or such for pathogen control. Treatment efficiency in Imhoff tank is equivalent to primary treatment as it achieves 40% BOD_5 reduction and 65% suspended solids reduction but effluents continue to be contaminated due to the poor pathogen removal. In term of operation and maintenance, the construction of such system requires skilled labors with no need to electrical requirement and high area of land. To be maintained well, removal of scum and sludge has to be carried out at regular intervals. This system has the advantages of low cost, electrical requirements, land space and operational and maintenance requirements. Therefore, it needs skilled contractor for construction and it also doesn't meet the required reuse quality because of the existence of pathogens.

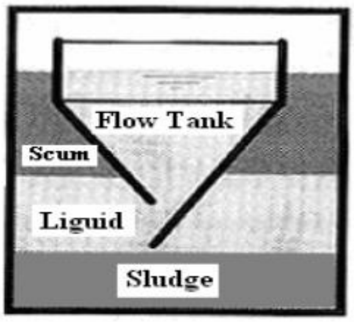


Figure 2-5: Cross section of Imhoff Tank

c- Septic Tank With Up flow Filter

This is essentially a septic tank with an up flow filter that is incorporated directly after the second chamber of the septic tank as shown in Figure (2.6). Effluent after leaving the second chamber of the septic tank is directed upwards through the bottom of the filter before exiting to be disposed of either in leach fields etc. It is also mainly designed for onsite treatment of domestic sewage. In the up flow filter the effluent enters at the base and flows up through the layer of coarse aggregate, which is then discharged over a weir at the top. Anaerobic bacteria grow on the surface of the filter material and oxidize the effluent as it flows past. Disposal of the effluent may be into a stream or into soakage pits etc. Septic Tank With Up flow Filter produce good effluent quality, it can reduce BOD_5 up to 70 % in addition to changing the highly turbid gray water to an odorless clear light yellow effluent. This system is applicable for both gray water and black water that can be flushed through the system. In term of operation and maintenance, the construction of such system requires skilled labors with no need to electrical requirement and high area of land. Filter is expected to operate without maintenance for 18-24 months, then it needs to be washed out be fresh water. Septic tank needs to regular desludging.

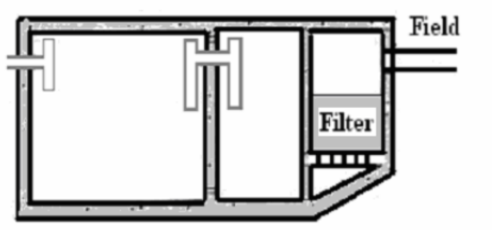


Figure 2-6: Septic Tank with Upflow filter section

d- Anaerobic Ponds

Anaerobic ponds use the same biological process and same basis for loading as septic tanks but on a much larger scale. Anaerobic Ponds as the name implies operates in the absence of air. Therefore deep tanks with small surface areas operate more efficiently then shallower ponds. Before using these ponds, they should be filled with water to prevent foul conditions from occurring. After functioning of these ponds, raw sewage sludge will accumulate on the bottom of the pond and a crust will form on the surface which eliminates all odors. The wastewater type and the method of post treatment outline the role of the anaerobic ponds. Anaerobic ponds are designed for hydraulic retention times of between 1-30 days depending on strength and type of wastewater and also the desired treatment effect. Storm water could cause shock volumetric loads which may affect the performance of ponds and should be taken into account in earlier stages of pond development. The system can achieve 70 % reduction in term of BOD_5 in addition to changing the highly turbid gray water to an odorless clear light yellow effluent. This system is applicable for both gray water and backwater that can be flushed through the system. In term of operation and maintenance, the construction of such system requires skilled labors with no need to electrical requirement and high area of land. It is distinguished by feasibility as it doesn't need to electrical, operation and maintenance requirements and the system produces high effluent quality by low loaded ponds with long HRT. Figure (2.7) illustrates the anaerobic ponds system.

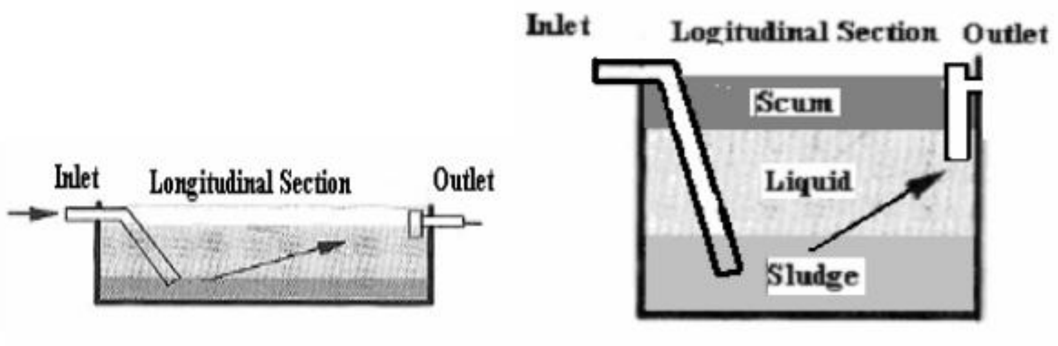


Figure 2-7: Low and high loaded anaerobic ponds sections.

e- Baffled Septic Tanks

This process is suitable for all kinds of wastewater including domestic. The baffled septic tank consists of an initial settler compartment and a second section of a series baffled reactors as shown in Figure (2.8). Sludge settles at the bottom and the active sludge that is washed out of one chamber becomes trapped in the next. The reason for the tanks in series is to assist in the digestion of difficult degradable substances especially towards the end part of the process. For the purpose of quicker digestion influent upon entering the process is mixed with active sludge present in the reactor. Wastewater flows from bottom to top causing sludge particles to settle on the up flow of the liquid wastewater allowing contact between sludge already present with incoming flow. The settler can be used for treatment after effluent has left the tank. Hydraulic and organic shock loads have little effect on treatment efficiency. In term of effluent quality, the system achieve moderate effluent quality as, 70-95% BOD_5 removal and 65-95% COD removal, This system is applicable for both gray water and black water that can be flushed through the system. The system requires skilled labors for construction with no need to electrical power or big area of land. Therefore, it requires moderate operation and maintenance process as the regular removal of sludge. The system is distinguished by low cost, availability of construction materials and low land space requirements.

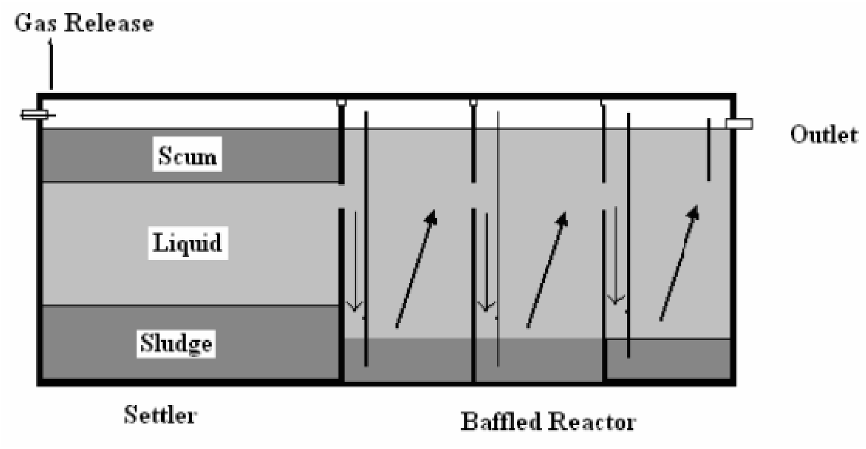


Figure 2-8: Baffled septic tanks sections.

f- Upstream Anaerobic Sludge Blanket (UASB)

This process is suitable for all kinds of wastewater including domestic. The UASB maintains a cushion of active sludge suspended on the lower part of the digester and uses this sludge blanket directly as filter medium. The sludge blanket is kept in place by the equilibrium formed between the upstream velocity and settling speed of the sludge. After weeks of maturation, granular sludge forms that improve the stability and filter capacity of the sludge blanket. The organic load of the system is responsible for the development of new sludge. A fully controlled UASB is used for relatively strong industrial wastewaters where biogas can be utilized, with slanting baffles separating gas bubbles from solids. UASB require several months to mature i.e. to develop sufficient granular sludge for treatment. This system is applicable for both gray water and black water that can be flushed through the system. The system requires low land space and cost. Therefore, it requires moderate operation and maintenance process, time to stabilize process and operator intervention from time to time to control and adjust treatment process. Figure (2.9) illustrates the UASB system.

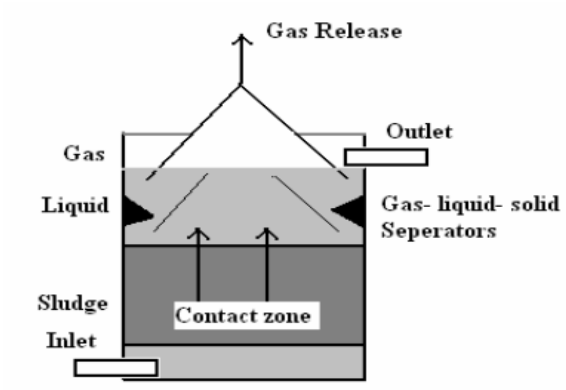


Figure 2-9: Upstream Anaerobic Sludge Blanket (UASP) sections.

g- Ponds/Beds/Lagoons (Reed bed systems, Horizontal Gravel Filter)

Reed bed systems are suitable for domestic and industrial wastewater that has undergone preliminary treatment and that has a COD content not higher than 500mg/l. The reed bed system is one meter deep basin sealed with clay or some other form of lining to prevent percolation into groundwater with the basin itself being filled with soil in which reeds are then planted. Oxygen is transported through the pores of the plant down to the roots whereby the oxygen content increases the biological activity of the soil. When wastewater runs through the root zone soil organic compounds and other impurities are eliminated by microorganisms in the soil. This system achieve good effluent quality as it gives 84% COD removal rate and 86% for BOD_5 that are considered as high effluent quality in addition to the low requirement for operation and maintenance as only trenches are to be maintained regularly from erosion. Moderate requirement for land and costs and no requirement for electrical power.

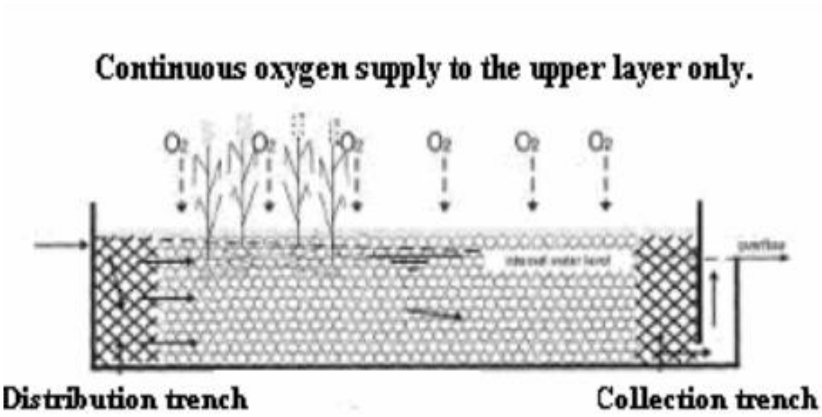


Figure 2-10: Principles of Horizontal Gravel Filter process.

h- Ponds/Beds/Lagoons (Aerobic Stabilization Ponds/Algal Ponds/Oxidation Ponds)

In aerobic stabilization ponds the organic matter causing pollution is consumed by biological organisms that need oxygen in proportion to the amount of organic matter removed. Oxygen is supplied in these ponds by a growth of algae, which is dependent on photosynthesis. If there is not enough oxygen supplied to organisms that consume organic matter then they will not function and anaerobic organisms will become active causing offensive odors and polluted effluent to be produced. Aerobic ponds should be half-filled with water before use to prevent offensive conditions from occurring. The treatment efficiency increases with longer retention times. This system is produces high quality effluent as it achieves 82% BOD_5 removal rate that reaches 97% in multiple pond systems and 78% COD removal rate and 95% pathogen removal . It needs high volume of water for transportation to treatment site, regular desludging in defined intervals and start up needs special arrangements and moderate requirements for land and costs. Therefore, it requires low operation and maintenance and no electrical powers. Figure (2.11) illustrates the aerobic stabilization ponds system.

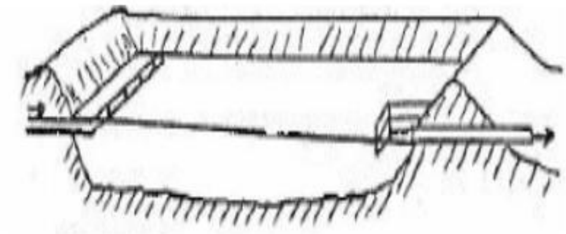


Figure 2-11: Aerobic Stabilization Ponds section.

i- Filters, Anaerobic Filters/Fixed Bed Reactor/Fixed Film reactor

The anaerobic filter is suitable for domestic wastewater and all industrial wastewater that have a lower content of suspended solids. Anaerobic filters allow the treatment of non settleable and dissolved solids by bringing them into close contact with surplus active bacterial mass. The dispersed or dissolved organic matter is digested by bacteria within short retention times. Bacteria fix themselves to filter material like gravel, rocks, and cinder etc. allowing incoming wastewater to come into contact with active bacteria. Preliminary treatment may be required to remove solids of larger size. The system achieves 70-90% BOD_5 removal in a well operated anaerobic filter and moderate effluent quality for other measures. It serves well when only receives liquid waste and not suitable where scarce or unreliable water and it is applicable for gray and black water. It requires high operation and maintenance, desludging regularly, cleaning of filter material, electrical power and high cost. Figure (2.12) illustrate the anaerobic filter system.

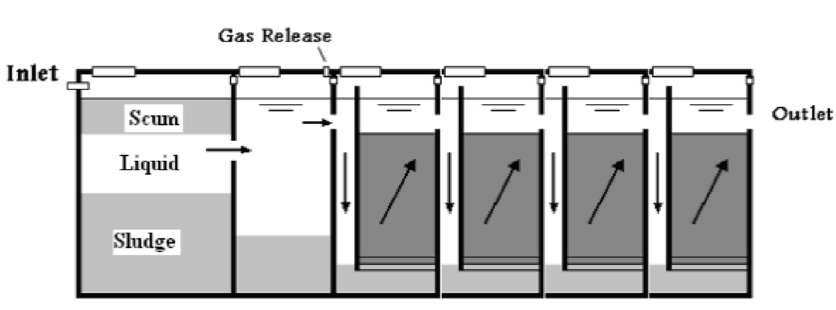


Figure 2-12: Anaerobic Filter section.

2.6 Local Trials in Decentralized Systems.

The decentralized wastewater treatment units in Gaza strip were used for long time existing in rural and camps areas in a conventional form that is a cylindrical shape constructed from concrete bricks for external walls without any lining in the bottom as shown in Figure (2.13). These units consist of unsanitary construction system and depend mainly on infiltration to remove the wastewater that contaminated the soil ground water in Gaza for large extent. Another case of onsite treatment units in Palestine was adding a separation rectangular tank before the septic tank. It is estimated that 40% of the houses in Gaza have such conventional septic tank and more than 80% before 1994 (MEnA, 2002). The idea of decentralized wastewater treatment plants (DEWATS) has been used by the local community as a technology but as a tradition. Unsanitary septic tank system was used for long time as a result of unavailable sewerage. Most of Gaza and West bank people were suffering from unavailable sanitary sewerage system due to the ignorance of refugee camp in addition to many cities and villages from such services as an Israeli policy of deteriorating the Palestinian environment. Their policy had been well implemented as it has deteriorated the groundwater, soil and surface water of Palestinian areas. Unavailable sewerage has forced the people to implement conventional septic tanks beside their dwellings to discharge wastewater from houses and other facilities. The traditional decentralized wastewater treatment plant in Palestine was only a cylindrical septic tank constructed from concrete bricks with holes and without any isolating lining in the bottom of the septic tank. The lack of the lining system normally accelerates the infiltration of wastewater to the soil and percolation to the groundwater. The situation has been improved since 1994 after the coming of the Palestinian Authority that got the fund from many donors to implement many sanitation projects in the Palestinian territories. However, the fund was not enough that lift many areas without sewerage or other infrastructure that encouraged the non-governmental organizations (NGO's) to participate in the mitigation of the stress over environment. The first initiative to develop the decentralized treatment system was adapted by these organizations in the beginning of last decade to treat gray water in the rural areas of Gaza strip because of the deficiency of irrigation water in addition to the bad quality of existing water.

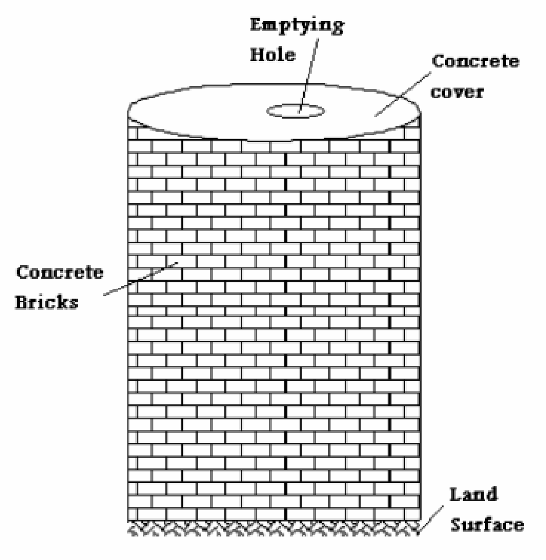


Figure 2-13: Local convential septic tank in Palestine.

Twenty five septic tanks were implemented by the Union of Agricultural Work committees using the same system of the traditional system but with some additional sanitary measures as tank ground lining and totally closed walls of tank that prevented to some extent the infiltration to the ground water but with very small fraction in treatment efficiency. NGO's have tried to develop the idea and implemented more than 150 system in Gaza and West Bank since 1995. The main two NGO's were the Palestinian Hydrology Group (PHG) through their Wastewater treatment and reuse in Agriculture project and Palestinian Agricultural Relief Committees (PARC).

2.6.1 Palestinian Hydrology Group (PHG) treatment system

PHG system was one of the first trials in Gaza strip to treat wastewater in rural areas. The system was designed to treat gray water and to utilize the system as a potential source for treated wastewater reuse. The system was implemented in many parts of Gaza strip specially in the rural areas where treated wastewater can be reused. The aims of the system implementation were to protect the environment and to enhance the nontraditional water resources use and decreasing the use of Cesspools. The system has some basic stages as, wastewater collecting network, wastewater treatment plant and reuse the treated wastewater through the distribution network in the olives trees field. The unit has the capacity to treat 12 cubic meter per day and serving seven families with average 80 members. The treated wastewater used for irrigating five dunum of land farmed with olive trees. Wastewater treatment unit consists of septic tank and trickling filter beside collecting tank. The treatment method depends on the primary Treatment by using the Septic Tank and the secondary treatment by Trickling filter. The used system had many parts as collection part, treatment part and reuse part.

A- Collection Part

It is the local collection networks within the rural areas to serve both the farm and the houses as shown in Figure (2.14). This part involves UPVC pipes with 8 Inch diameter and 305 m in length, UPVC pipes with 8 Inch in diameter and 30 m in 24length, 10 manhole with 80cm diameter and one manhole with 60cm diameter.

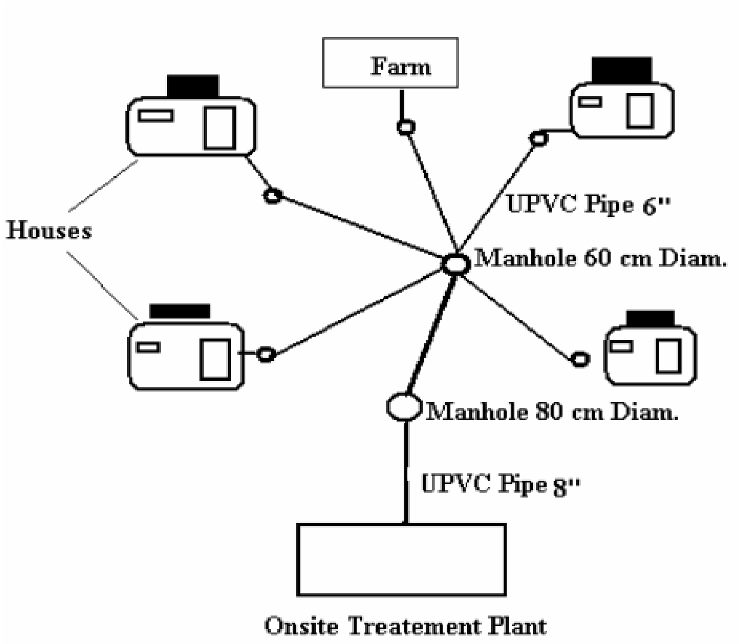


Figure 2-14: Schematic diagram of wastewater collection system.

B- Septic tank

The first tank is a septic tank where separation of solids happens primarily by gravity in addition to flotation to remove fat, grease and oil. It consists of a primary septic tank in addition to a chamber forming half of the first tank volume as shown in Fig (2.15). The outside volume of the septic tank is 13.2 cubic meter with 3.0 m length , 2.0m width and 2.2m height.

C- Trickling filter

It is a cylindrical plastic tank with 1.50 m^3 volume depending on the volume of effluent and involving internal filter of gravel with granular diameter 3-4cm at one layers , height 1.5m and with water distributer to equally distribute water over the filter.

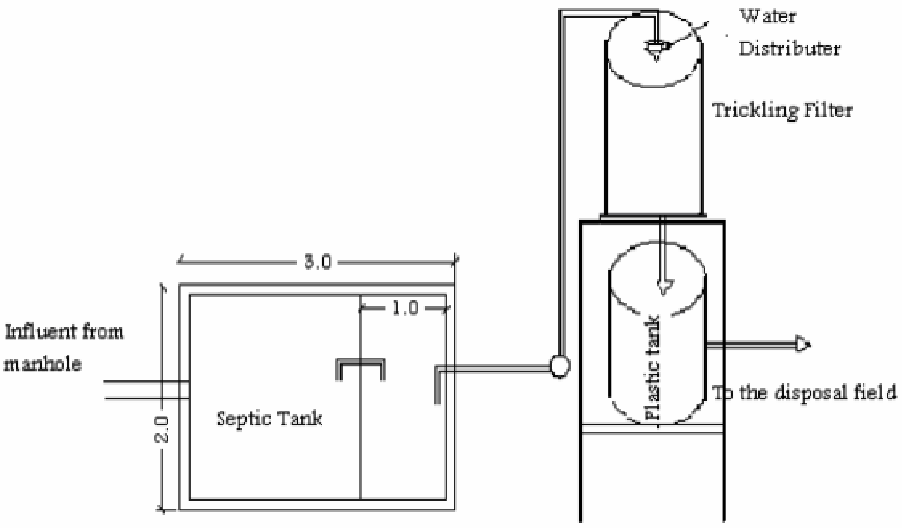


Figure 2-15: PHG on site treatment plant.

D- Treated water collection system

This system includes two cylindrical plastic tank, the upper collection tank and final collection tank with volumes equal 1.5 m^3 and 1.0 m^3 respectively. The first one receives water from the trickling filter and the final one receives water from it to the irrigation network system.

E- Irrigation water collection tank

The disposal field was selected to be Olive farms, the network length was 550 m of 2 to 4 inch in diameter of UPVC pipes conveying treated water to the site to be utilized to irrigate 5dunams.

- Efficiency of the system

Fifteen tests were carried out to measure the extent that the system has reached to achieve its objectives to treat wastewater and reuse it in irrigation of olive farms. The tests included many wastewater parameters as BOD_5, COD, Electrical conductivity (ECw), Total dissolved solids (TDS), Cations and anions, Nutrients and miscellaneous.

2.6.2 Palestinian Agricultural Relief Committees (PARC) treatment system

The system of PARC has been implemented in West Bank and Gaza and was funded by the International Development Research Centre (IDRC) in cooperation with agricultural committees in the rural areas to reuse treated wastewater in irrigating farms. The system was designed to treat 10 m^3 and serving five families with average 70 numbers. The used system consist of many parts as screening manhole, tanks, pump, trickling filter and water collection tank.

A- Screening Manhole

It is a small manhole with 40 cm diameter as shown in Figure (2.16), it is involving an internal screen with holes not greater than one cm^2 to allow the waste water flow easily and to prevent clogging in the pipes

Figure 2-16: Screening manhole in PARC system.

B- Tanks

The first tank is a septic tank where separation of solids happens primarily by gravity in addition to flotation to remove fat, grease and oil. Unwanted flotation occurs in septic tanks and other anaerobic systems where floating layers of scum are easily formed. The second tank is anaerobic gravel filter contains solid stones with diameter 2-3 cm to provide a fixed surface for treatment of bacteria and they form a physical obstacle for the smaller solid particles by creating adhesion of particles to their surfaces. This tank receives wastewater from the first tank by steel pipes in the bottom of the tank with regular holes on their surface for well distribution of water. The third tank constitute the same previous filter media but with diameter 0.5 – 1 cm with also anaerobic filter. The fourth tank is a collection tank that receives water from the third tank through upflow pipe. Electrical pump is placed in this tank to pump water to the trickling filter as shown in Figure (2.17).

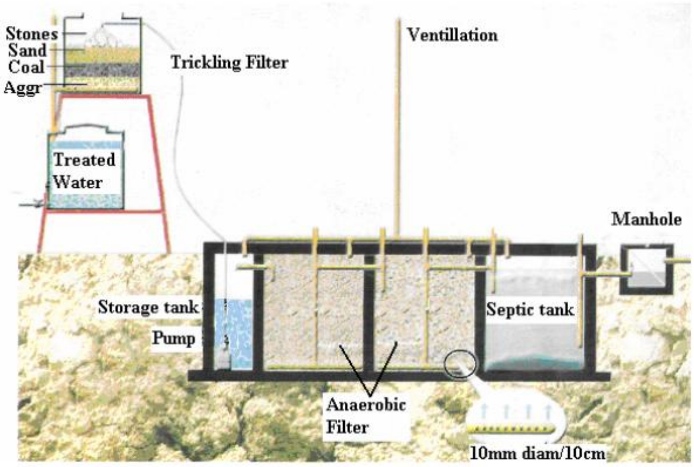


Figure 2-17: PARC decentralized treatment plant tanks.

C- Trickling filter

It is a cylindrical plastic tank with 0.5 – 1 m^3 volume depending on the volume of effluent and involving three layers of 20cm thick of sand, coal and gravel starting up from sand and receiving water from the fourth treatment tank by the pump as shown in Figure(2.18).

D- Irrigation water collection tank

It is a cylindrical plastic tank with a volume 0.5 – 1.0 m^3 used for collection and storing treated water to be utilized in irrigation later.

E-Irrigation system

It involves a small network linking the collection tank with irrigation network transporting water to the farm.

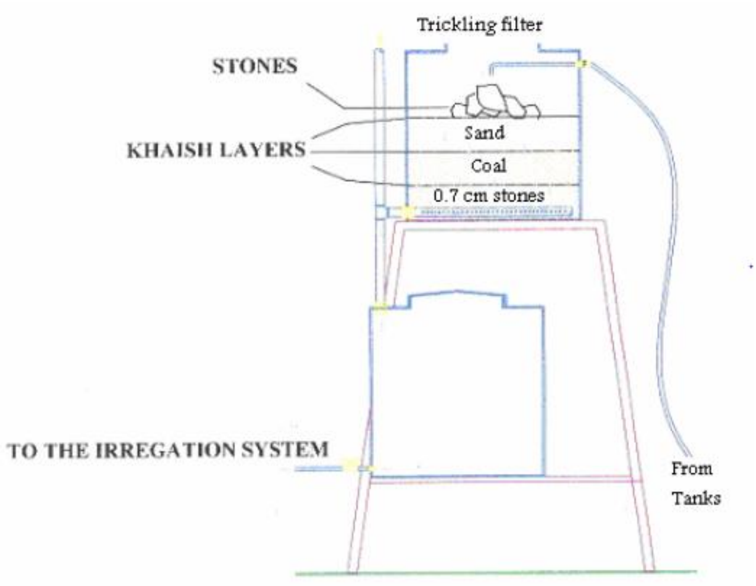


Figure 2-18: PARC decentralized treatment plant trickling filter.

2.7 Current International Developed Decentralized Systems.

2.7.1 USA Decentralized wastewater treatment system

One of the most common systems in the united states is the graywater treatment system. The usage of this system is adapted in the areas where there is a lack of water for irrigation which is existing in California and others (EPA, 2003)

Septic systems consist of two basic parts, a septic tank and a soil absorption system as shown in Figure (2.20). The septic tank provides a small portion of the treatment by creating a large quiet compartment to allow solid material to settle out of the wastewater and collected in the tank. Once the large solid material is settled out, the sewage follows into a deep layer of unsaturated soil where the soil and microorganisms growing in the soil removing the pollutants before the wastewater infiltrates into the ground. Septic systems are simple to operate and when properly designed, constructed, and maintained, they do an excellent job of removing pollutants from wastewater to protect water resources.

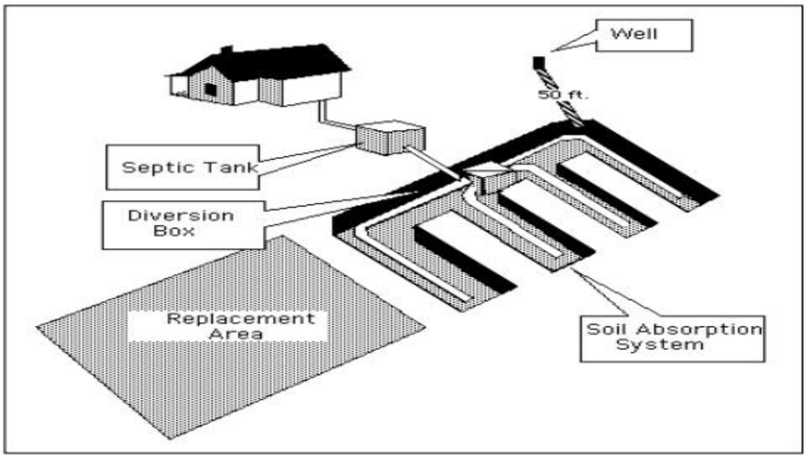


Figure 2-19: Diagram of a septic system.

Another common system is Continuous-Flow, Suspended-Growth Aerobic Systems (CFSGAS). The activated sludge process is an aerobic suspended-growth process that maintains a relatively high population of microorganisms (biomass) by recycling settled biomass back to the treatment process. The biomass converts soluble and colloidal biodegradable organic matter and some inorganic compounds into cell mass and metabolic end products. The biomass is separated from the wastewater through settling in a clarifier for recycling or wasting to sludge handling processes. Preliminary treatment to remove settleable solids and floatable materials is usually provided by a septic tank or other primary treatment device. Most onsite designs are capable of providing significant ammonia oxidation and effective removal of organic matter. The basic system consists of a number of interrelated components as shown in Figure (2.21) as follows:

• An aeration tank or basin.

• An oxygen source and equipment to disperse atmospheric or pressurized air or oxygen into the aeration tank at a rate sufficient to always maintain positive dissolved oxygen.

• A means to appropriately mix the aeration basin and ensure suspension of the biomass (usually accomplished by the aeration system).

• A clarifier to separate the biomass from the treated effluent and collect settled biomass for recycling to the aeration basin.

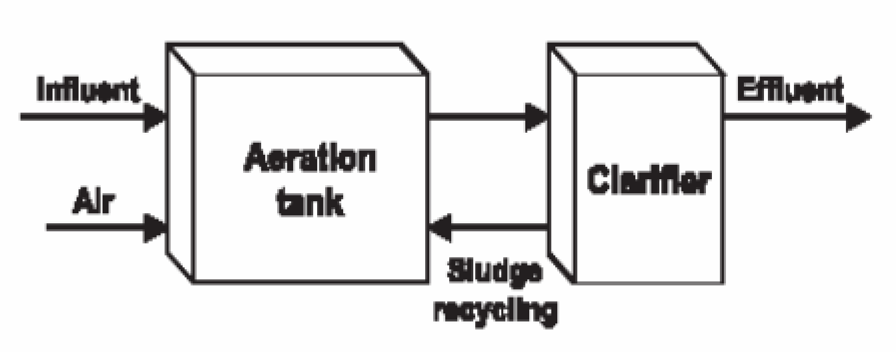


Figure 2-20: A basic CFSGAS configuration.

Several modifications of this basic process are commercially available. These include different aeration devices; different means of sludge collection and recycling to the aerator; the use of coarse membrane filters, or in addition to, the clarifier; and process enhancement through the addition of an inert media area on which biofilms can grow. The addition of surfaces where biota can become attached and grow increases the capacity of the system (increased organic loading possible). This last modification is the most significant enhancement. The combined fixed-film/suspended growth process is sometimes referred to as a class of treatment processes called coupled contact aeration, enhanced, or high biomass systems. To enhance performance and increase the capacity of the aeration tank, an inert support medium is added to the aeration tank. This allows a fixed film of biomass to attach and grow on the medium to augment the suspended microbial population, providing more biomass to feed on wastewater constituents as shown in Figure (2.22). Synthetic trickling filter media, loops of fiber bundles, and a variety of different plastic surface configurations can be suspended in the aeration tank. Advantages include increased active microbial mass per unit volume, enhanced potential for nitrification, reduced suspended solids loading to the clarifier, improved solids separation characteristics, reduced sludge production, and resilience under variable influent conditions.

Onsite package treatment units should be constructed of no corrosive materials, such as coated concrete, plastic, fiberglass, or coated steel. Units may be stand alone or manufactured to drop into a compartmented septic tank. Some units are installed above ground on a concrete slab with proper housing to protect against severe climatic conditions. Units may also be buried underground as long as easy access is provided to all mechanical parts, electrical control systems, and water surfaces (Mason, 1977).

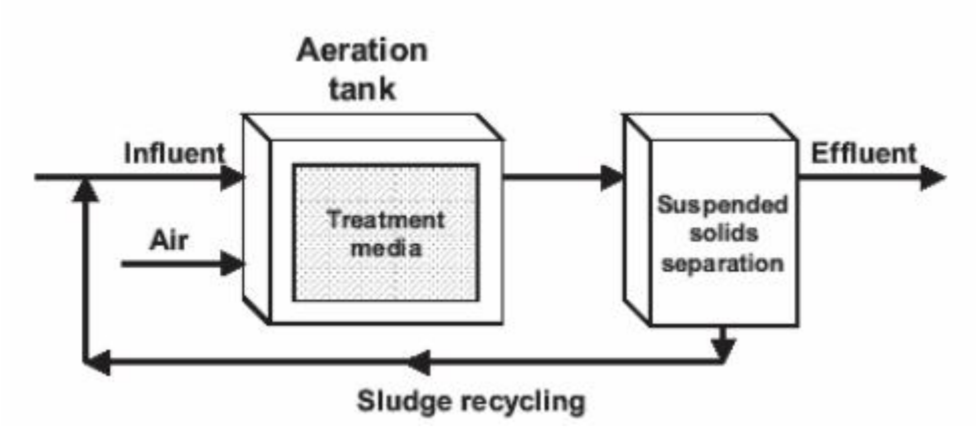


Figure 2-21: An enhanced CFSGAS or" high biomass" system.

These systems are usually preceded by a septic tank and followed by a subsurface wastewater infiltration system (SWIS). Despite some claims of reduced SWIS sizing when compared to the conventional septic tank pretreatment, the designer is cautioned to consider ground water protection. These systems should be applied only where onsite system management services are available. For surface water discharge, the system must be followed by disinfection at a minimum to consistently meet discharge standards. However, some subsurface (non-human-contact) reuse may be implemented without further treatment. High biomass systems can be a low-cost means of upgrading existing overloaded CFSGAS units that currently do not meet BOD_5 or nitrification goals. They can also compete directly with conventional designs because they have greater stability in handling highly variable loadings (Mason, 1977).

Another systems are the Subsurface wastewater infiltration systems (SWISs). SWISs are the most commonly used systems for the treatment and dispersal of onsite wastewater in development countries as shown in Figure (2.23). Infiltrative surfaces are located in permeable, unsaturated natural soil or imported fill material so wastewater can infiltrate and percolate through the underlying soil to the ground water. As the wastewater infiltrates and percolates through the soil, it is treated through a variety of physical, chemical, and biochemical processes and reactions. Many different designs and configurations are used, but all incorporate soil infiltrative surfaces that are located in buried excavations. The primary infiltrative surface is the bottom of the excavation, but the sidewalls also may be used for infiltration. Perforated pipe is installed to distribute the wastewater over the infiltration surface. A porous medium, typically gravel or crushed rock, is placed in the excavation below and around the distribution piping to support the pipe and spread the localized flow from the distribution pipes across the excavation cavity. The porous medium provides storage space for the wastewater within its void fractions (interstitial spaces, typically 30 to 40 percent of the volume) during peak flows with gravity systems. A permeable geotextile fabric or other suitable material is laid over the porous medium before the excavation is backfilled to prevent the introduction of backfill material into the porous medium. Natural soil is typically used for backfilling, and the surface of the backfill is usually slightly mounded and seeded with grass. Subsurface wastewater infiltration systems provide both dispersal and treatment of the applied wastewater. Wastewater is transported from the infiltration system through three zones . Two of these zones, the infiltration zone and vadose zone, act as fixed-film bioreactors. The infiltration zone, which is only a few centimeters thick, is the most biologically active zone and is often referred to as the "biomat." Carbonaceous material in the wastewater is quickly degraded in this zone, and nitrification occurs immediately below this zone if sufficient oxygen is present. Free or combined forms of oxygen in the soil must satisfy the oxygen demand generated by the microorganisms degrading the materials. If sufficient oxygen is not present, the metabolic processes of the microorganisms can be reduced or halted and both treatment and infiltration of the wastewater will be adversely affected (Otis, 1978). The vadose (unsaturated) zone provides a significant pathway for oxygen diffusion to reaerate the infiltration zone (Otis, 1978, Siegrist et al., 1986). Also, it is the zone where most sorption reactions occur because the negative moisture potential in the unsaturated zone causes percolating water to flow into the finer pores of the soil, resulting in greater contact with the soil surfaces. Finally, much of the phosphorus and pathogen removal occurs in this zone (Robertson and Harman, 1999). There are several different designs for SWISs. They include trenches, beds, seepage pits, at-grade systems, and mounds. SWIS applications differ in their geometry and location in the soil profile. Trenches have a large length-to-width ratio, while beds have a wide, rectangular or square geometry. Seepage pits are deep, circular excavations that rely almost completely on sidewall infiltration. Seepage pits are no longer permitted in many jurisdictions because their depth and relatively small horizontal profile create a greater point-source pollutant loading potential to ground water than other geometries. Because of these shortcomings, seepage pits are not recommended in most world states. Infiltration surfaces may be created in natural soil or imported fill material. Most traditional systems are constructed below ground surface in natural soil (Hinson, 1994). Infiltration surfaces may be constructed at the ground surface ("at-grades") or elevated in imported fill material above the natural soil surface ("mounds"). An important difference between infiltration surfaces constructed in natural soil and those constructed in fill material is that a secondary infiltrative surface (which must be considered in design) is created at the fill/natural soil interface. Despite the differences between the types of SWISs, the mechanisms of treatment and dispersal are similar. Results from numerous studies have shown that SWISs achieve high removal rates for most wastewater pollutants of concern with the notable exception of nitrogen. Biochemical oxygen demand, suspended solids, fecal indicators, and surfactants are effectively removed within 2 to 5 feet of unsaturated, aerobic soil. Phosphorus and metals are removed through adsorption, ion exchange, and precipitation reactions. However, the retention capacity of the soil is finite and varies with soil mineralogy, organic content, pH, redox potential, and cation exchange capacity. The fate of viruses and toxic organic compounds has not been well documented (Tomson et al., 1984). Field and laboratory studies suggest that the soil is quite effective in removing viruses, but some types of viruses apparently are able to leach from SWISs to the ground water. Fine-textured soils, low hydraulic loadings, aerobic subsoils, and high temperatures favor destruction of viruses and toxic organics. The most significant documented threats to ground water quality from SWISs are nitrates. Wastewater nitrogen is nearly completely nitrified below properly operating SWISs. Because nitrate is highly soluble and environments favoring denitrification in subsoil are limited, little removal occurs. Chlorides also leach readily to ground water because they, too, are highly soluble and are non-reactive in soil.

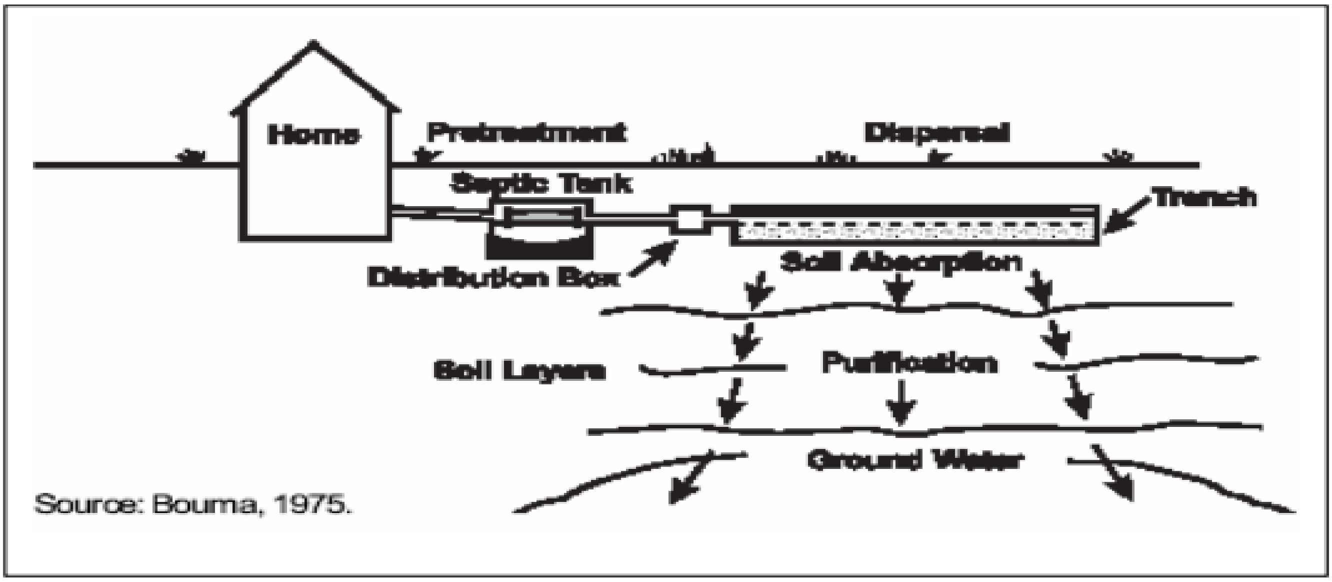


Figure 2-22: Lateral view of conventional SWIS-based system (Bouma, 1975).

Onsite wastewater treatment system designs vary according to the site and wastewater characteristics encountered. However, all designs should strive to incorporate the following features to achieve satisfactory long-term performance:

Shallow placement of the infiltration surface (< 2 feet below final grade) ·Organic loading comparable to that of septic tank effluent at its recommended hydraulic loading rate

Trench orientation parallel to surface contours

Narrow trenches (< 3 feet wide)

Timed dosing with peak flow storage

Uniform application of wastewater over the infiltration surface

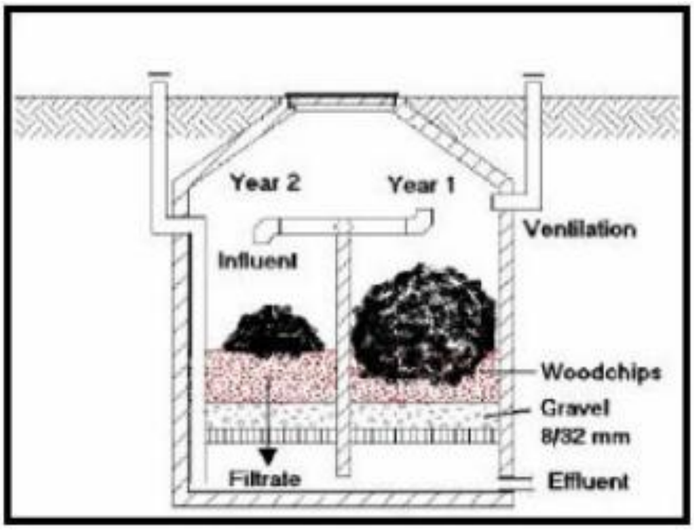
Multiple cells to provide periodic resting, standby capacity, and space for future repairs or replacement

Based on the site characteristics, compromises to ideal system designs are necessary.

However, the designer should attempt to include as many of the above features as possible to ensure optimal long-term performance and minimal impact on public health.

2.7.2 Germany Decentralized wastewater treatment system (Pre-treatment of domestic wastewater with pre-composting tanks)

In Germany some existing pre-composting tanks for decentralized pre-treatment of domestic wastewater were investigated as shown in Figure (2.14). Inside the tanks two filter bags, one that is being used called active filter bag and another that has been already used called inactive filter bag, are hung side by side and used alternately in an interval of 6-12 months. The capacity of the systems varies from 4 to 40 inhabitants. Most of the systems have been in operation for 4-5 years. Pre-composting tank is made up of concrete monolithically and constructed underground outside the building. It is covered with a prefabricated concrete slab and provided with ventilation. A shutter for changing filter bag, adding straw into the pre-composting materials, inspection and cleaning has been provided on the covering of the tank. The filtrate is collected at the bottom of the tank which is (only bottom portion) divided by a partition wall with an overflow and a pumping sump. The filtrate is pumped with the help of a time and level controlled submersed pump in an interval of 2-5 times per day into the adjacent constructed wetlands, where it is treated and then discharged into the watercourses. Due to the appropriate sloping in some systems, an overflow pipe is provided, through which the filtrate flows into the constructed wetland.



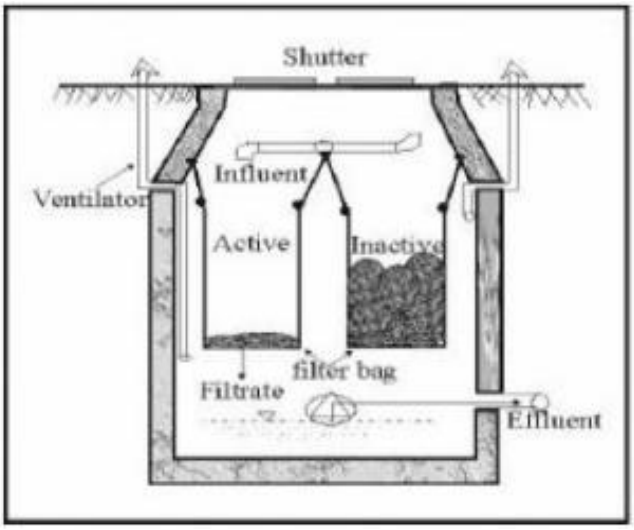


Figure 2-23 : Pre-composting tank (Rottebehaelter) for decentral pre-treatment of domestic wastewater.

2.8 Summary

Many treatment schemes are used for onsite treatment plants in semi urban areas that are not connected to sewerage network such as

- Increase the efficiency for the same treatment process
- Add a new treatment process to increase the treated wastewater quality
- Increase the flow rate by wide the sewer network to irrigate more farmland
- Construct more units in other areas .

CHAPTER THREE

3 Methodology

3.1 Introduction

To achieve the objectives of the research, the local system was studied to measure the effectiveness of the treatment plant, design modification and social and economic effects in achieving their objectives. The selected unit was in Abasan area. The methodology steps are as shown in Figure(3.1).

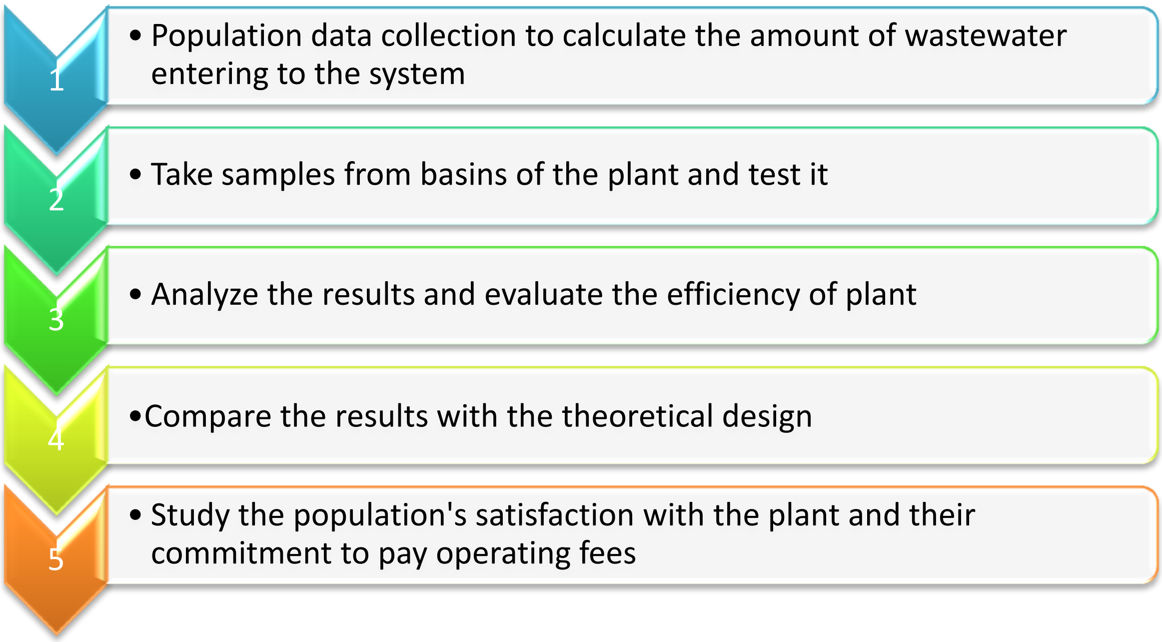


Figure 3-1 : The methodology steps

3.2 Study area

The Gaza Strip is divided geographically into five governorates: Northern; Gaza; Mid Zone; Khan Yunis; and Rafah s shown in Figure (3.2). Khan Yunis is located at the southern part of Gaza Strip.

The population of Khan Yunis reached 270979 inhabitants in 2007 (PCBS, 2009),. Khan Yunis municipality consists of the following zones:karar ; Absan kabera ; Absan jadeeda ; Alfakhari and Khaza'a . Absan jadeeda located in the governorate

Khan Younis, sits the town of New Abasan on flat ground, and the land is easy scalable to grow all kinds of crops.

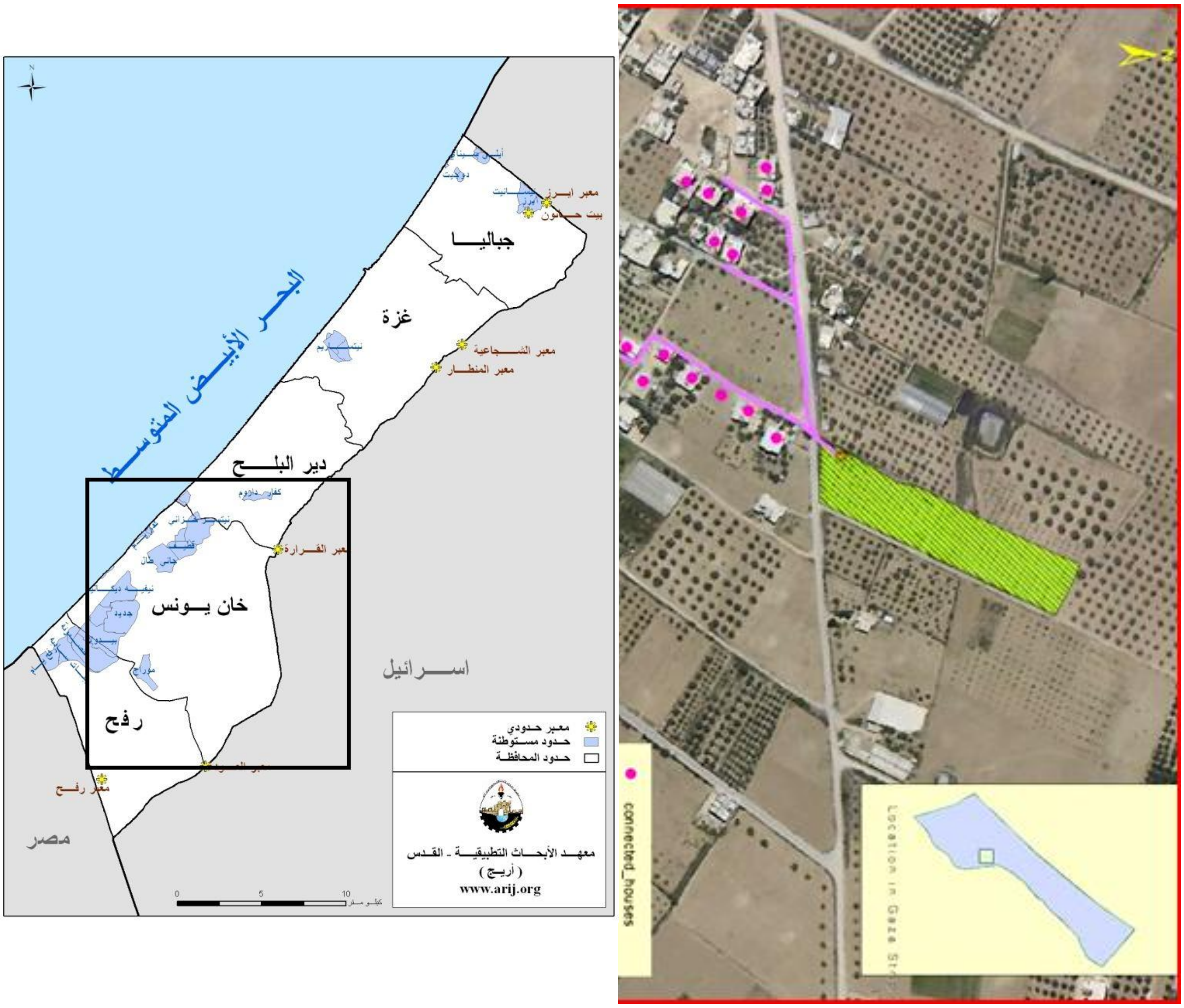


Figure 3-2 : study area

3.3 System description

PHG has implemented treatment unit in semi urban area in Abasan in the southern governorate of Gaza strip in order to reuse the treated wastewater in irrigating fruits and olives trees that are tolerant to the moderate saline water.

The system was designed to treat black wastewater and to utilize the system as a potential source for treated wastewater reuse. The aims of the system implementation were to protect the environment and to enhance the nontraditional water resources use and decreasing the use of Cesspits. The system has some basic stages as, wastewater collecting network, wastewater treatment plant and reuse the treated wastewater through the distribution network in the olives and fruit trees field. The unit has the capacity to treat 24.5 cubic meter per day and serving 50 families with average 350 members but nowadays the system receives 14.5 cubic meter per day from 24 families with average 168 members . The treated wastewater used for irrigating 15 dunum of land farmed with olive and fruit trees. Wastewater treatment unit consists of septic tank , trickling filter sedimentation tank and sand filter beside collecting tank. The treatment method depends on the primary Treatment by using the Septic Tank and the secondary treatment by Trickling filter.

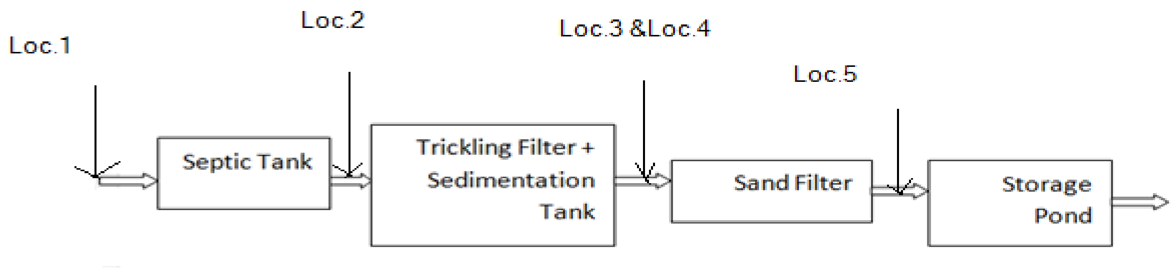


Figure 3-3:treatment unit tanks

Table 3-1: design wastewater quantities

Description	No.	Unit
# of families	50	Family
Inhabitants per family	7	persons
Total Population	350	persons
Wastewater Production	70	L/C/D
Average Wastewater	25 0.28	m3/day L/S
Peak Factor	4	
Peak flow	1.15	L/S

Quality measurements were conducted through CMWU lab in cooperation with PHG, the main parameters are showed in Table(3.2) in 1st July 2012.

Table 3-2:Values of the main parameters influent to the system

BOD_5	220 mg/l
COD	470 mg/l
SS	110 mg/l
TKN	126 mg/l
F.C.	2×10^8

3.3.1 Septic tank

Typically the septic tank volume for a conventional tank and on-site effluent disposal system is estimated at (1.5 – 5) times the average total daily wastewater flow as shown in Figure (3.4). This volume exclude the area for sludge and scum storage as shown in Table(3.3).

Table 3-3: septic tank design

BOD_5 in	300	mg/l
Retention time	4	days
Effective Volume	98	m^3
Scum Volume	49	m^3
Sludge Volume	49	m^3
Total Volume	196	m^3
BOD_5 out	120	mg/l

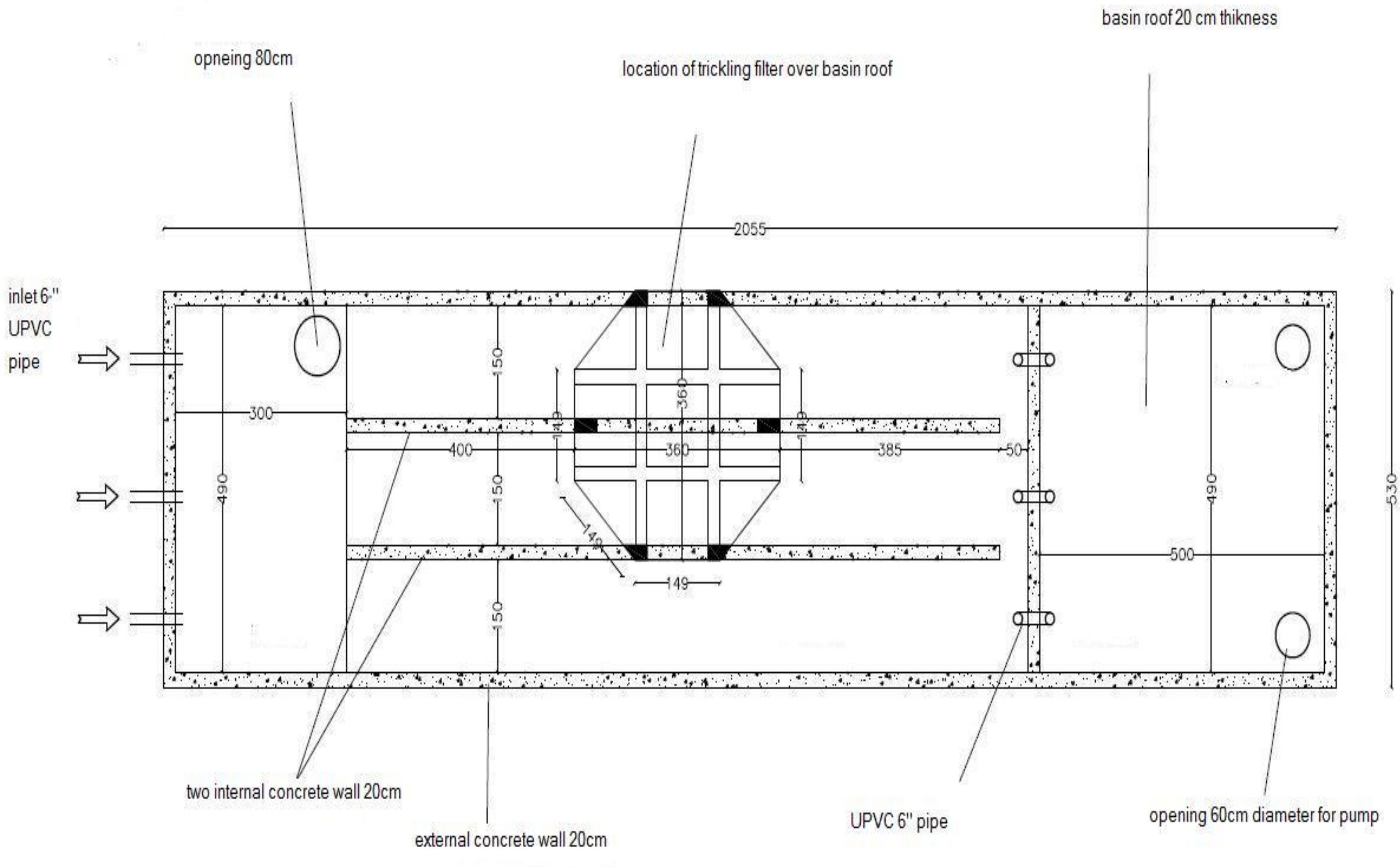


Figure 3-4:layout and dimension of septic tank

3.3.2 Trickling filter

Trickling filter is an attached growth process i.e. process in which microorganisms responsible for treatment are attached to an inert packing material. Packing material used in attached growth processes include rock, gravel, slag, sand, redwood, and a wide range of plastic and other synthetic materials. Trickling filters are classified as high rate or low rate, based on the organic and hydraulic loading applied to the unit.

The material was used in the trickling filter is gravel with granular diameter 3-4cm at one layers and height 1.5m as shown in Table(3.4).

Table 3-4:trickling filter design

BOD_5 in	120	mg/l
Surface Area	4	m^2
Recirculation Ratio	3	
F	2	
BOD_5 Loading	735	g/ m^2/day
Efficiency	63	
BOD_5 out	44	mg/l

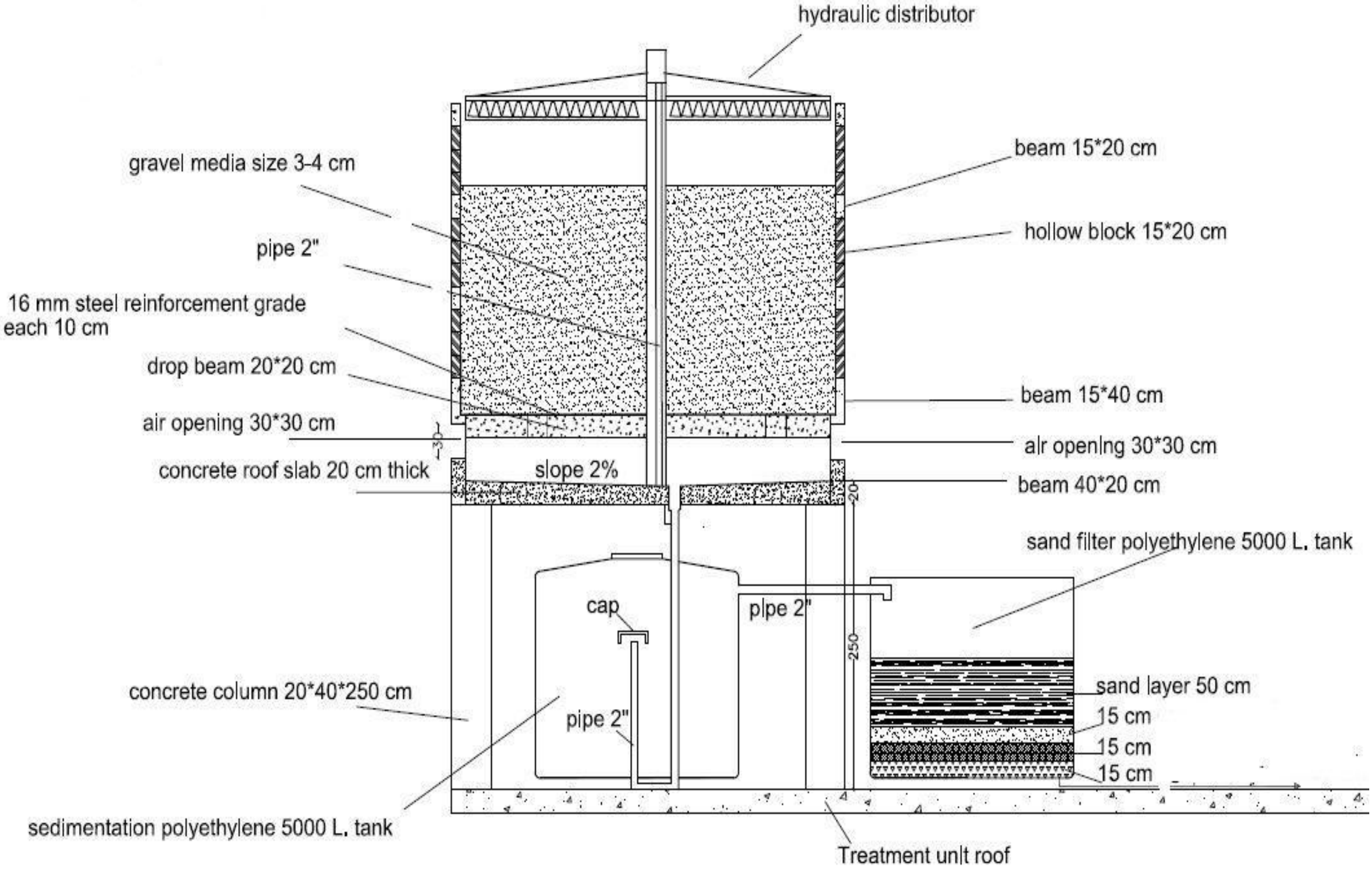


Figure 3-5: layout and dimension of trickling filter

3.3.3 Sedimentation tank

The settling tank design in such cases depends on both surface loading and detention time.

For settling tanks treating municipal or domestic sewage, recommended design values given in table may be used. Knowing the average depth, the detention time is then computed. Excessively high detention time (longer than 2.5 h) must be avoided especially in warm climates where anaerobicity can be quickly induced.

The following design criteria are adapted as shown in Table(3.5)

Table 3-5 : design criteria are adapted

Hydraulic Retention time	3	hrs
Average Hydraulic load	1	m^3/hr
Size	3	m^3
Overall size	5	m^3

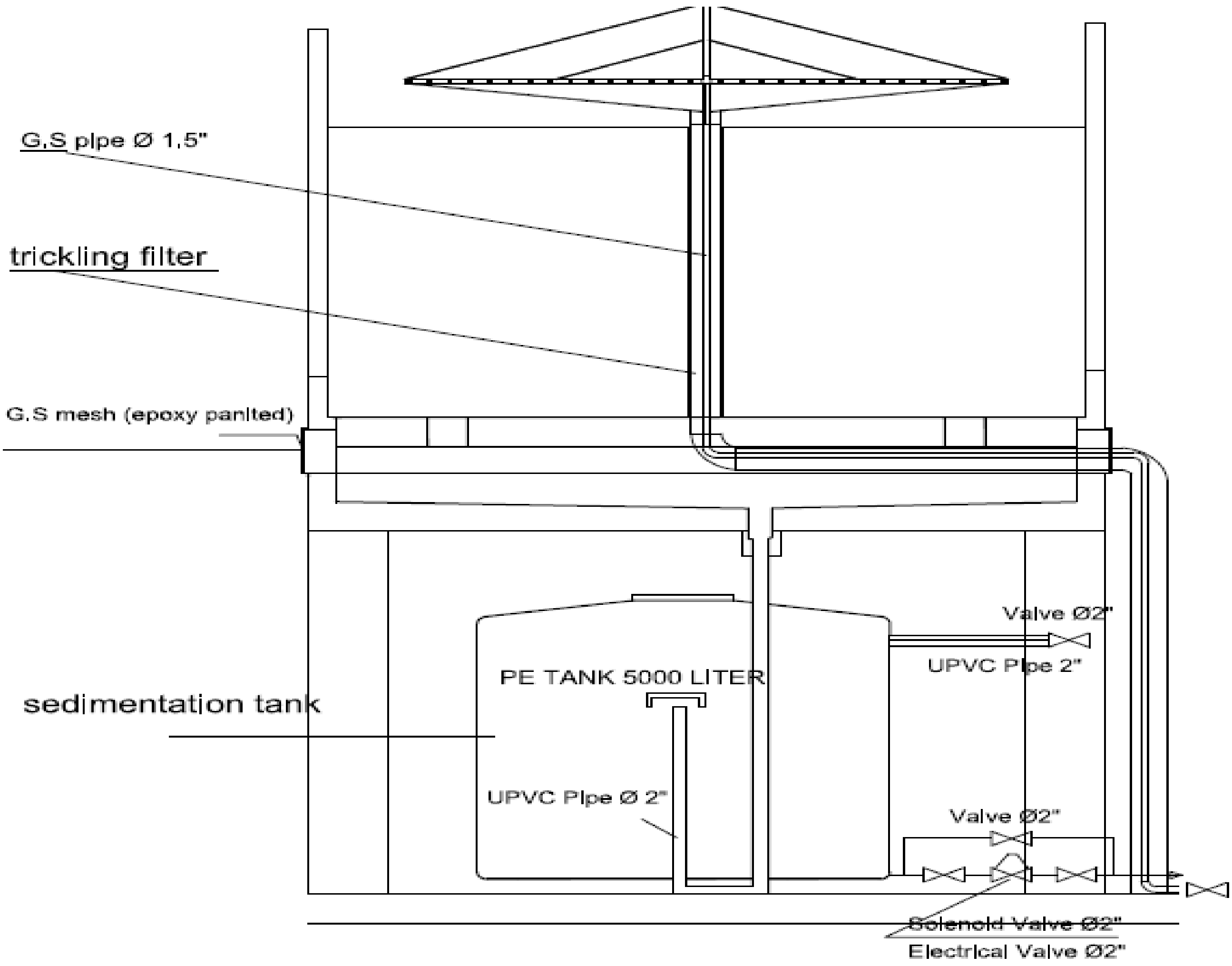


Figure 3-6: layout and dimension of sedimentation tank

3.3.4 Sand filter

Sand is generally used as filter media. The size of the sand is measured and expressed by the effective size. The effective size. The uniformity in size or degree of variations in sizes of particles is measured and expressed by the term called uniformity coefficient. The uniformity coefficient, i.e. (D_{60}/D_{10}) may be defined as the ratio of the sieve size in mm through which 60 percent of the sample of sand will pass, to the effective size of the sand.

In Abasan treatment unit the sand filter has two parts each one has one cubic meter that contains from two layers of gravel between them coal layer.

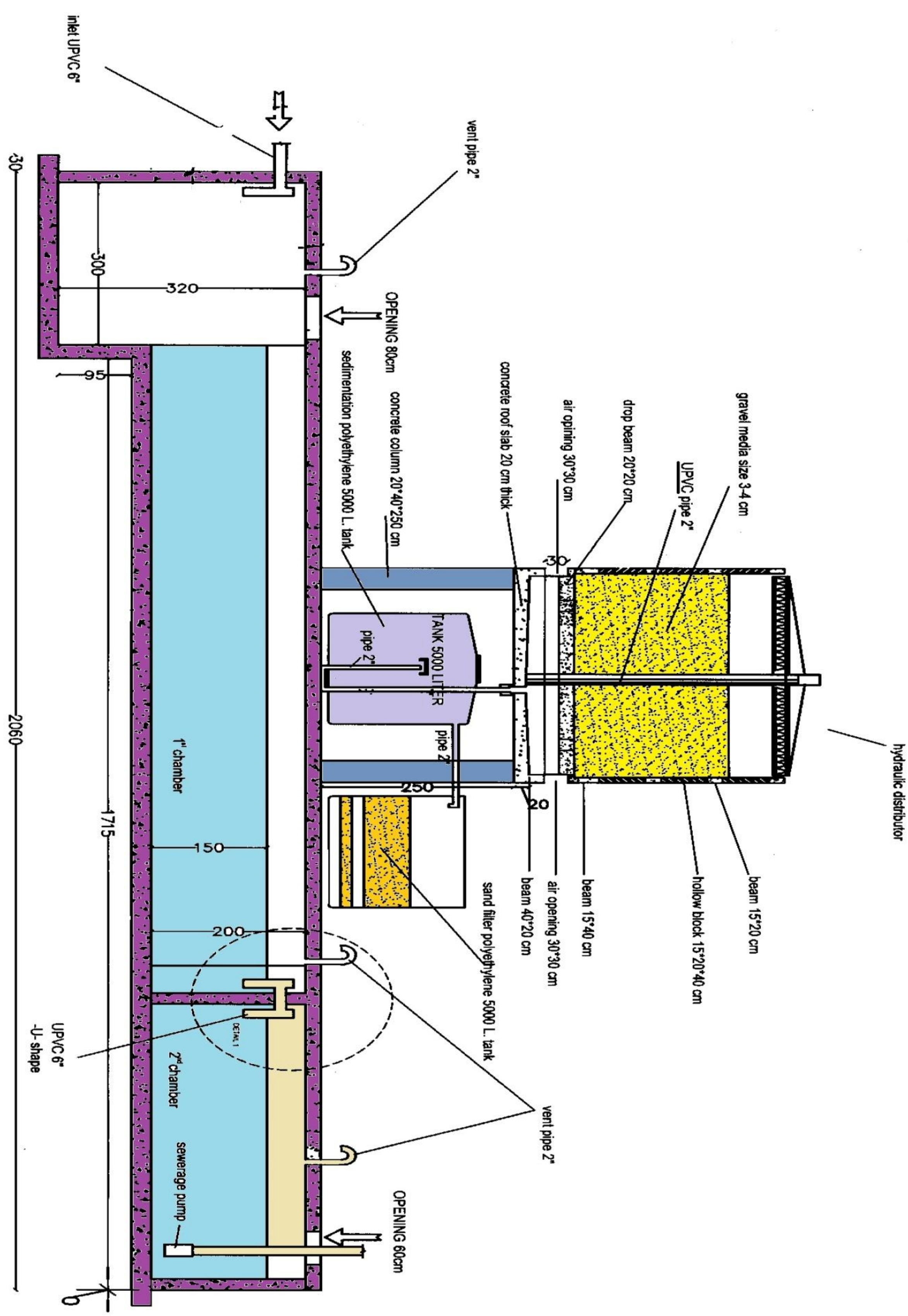


Figure 3-7: treatment unit dimensions

3.4 Data collection

Sewerage system was built for the residents of the semi urban area to collect wastewater and to see how much wastewater entering the plant the visits was doing to households.

3.5 Sampling and analysis

Wastewater sampling is generally performed by one of two methods, grab sampling or composite sampling. Grab sampling is just what it sounds like; all of the test material is collected at one time. As such, a grab sample reflects performance only at the point in time that the sample was collected, and then only if the sample was properly collected. Composite sampling consists of a collection of numerous individual discrete samples taken at regular intervals over a period of time, usually 24 hours. The material being sampled is collected in a common container over the sampling period. The analysis of this material, collected over a period of time, will therefore represent the average performance of a wastewater treatment plant during the collection period.

Numerous industry references list various parameters for wastewater testing and whether samples should be collected using grab sampling or composite sampling methods. For example, grab sampling allows the analysis of specific types of unstable parameters such as pH, dissolved oxygen, chlorine residual, nitrites and temperature. However, the most widely used indicators of treatment plant performance, including BOD_5 (five day carbonaceous biochemical oxygen demand), TSS (total suspended solids) and TN (total nitrogen) require the use of composite sampling techniques.

Composite samples of effluent collected, stored, analyzed, tabulated and averaged over an extended period of time provide the only verifiable indication of treatment plant performance. Collecting and analyzing these composite samples is often an expensive and time-consuming process.

In Abasan wastewater treatment system samples takes as on hour composite sample from the influent manhole to the system , effluent from septic tank , effluent from trickling filter , effluent from sedimentation tank and system effluent that is after sand filter and screen filter therefor six samples are taken from it then the average of tests results is calculated .

Implemented treatment unit consists of septic tank , trickling filter , sedimentation tank and sand filter respectively .System was monitored in the period between May/2013(after two weeks from system operating) to Oct/2013 and samples taken from five locations influent manhole to the system (Loc. 1) , effluent of septic tank (Loc. 2), effluent of trickling filter (Loc. 3), effluent of sedimentation tank (Loc. 4), effluent of sand filter and screen filter (Loc.5).

3.5.1 Biochemical oxygen demand (BOD_5)

BOD_5 was measured with OxiTop measuring system. The quantity of samples was taken after well mixing according to corresponding measuring range recommended in the manufacturer manual . The samples discharged into OxiTop bottles followed by placing a magnetic stirring rod. Rubber quiver inserted in the neck of the bottle. Three sodium hydroxide tablets were placed into the rubber quiver with a tweezers. OxiTop bottle was directly tightly closed and pressed on S and M buttons simultaneously for two second until the display shows 00. The bottles were placed in the stirring tray and incubated for 5 days at 20 ºC. Readings of stored values was registered after 5 days by pressing on M until values displayed for 1 second (Modified from OxiTop Manual) as shown in Figure (3.8).

Figure 3-8: OxiTop device used to measure BOD

3.5.2 chemical oxygen demand (COD)

The chemical oxygen demand (COD) is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. The closed dichromate reflux method (colorimetric method) was used to determine COD as shown in Figure (3.9). Two ml of the sample is refluxed in strongly acid solution vessel . After digestion in COD reactor at 160°C for 2 hrs, oxy gen consumed is measured against standard at 620 nm with a spectrophotometer.

Figure 3-9: Hach spectro- photometer used to measure COD.

3.5.3 Total suspended solids (TSS)

Quantification of solids in wastewater samples is usually done using gravimetric analysis following oven drying and ignition. A well-mixed sample (50 mL) i s evaporated in weighted dish and dried to constant in an oven at 103 to 105°C as shown in Figure (3.10).. The increase in dish weight over that of the empty dish represents the total solids (APHA ,2005).

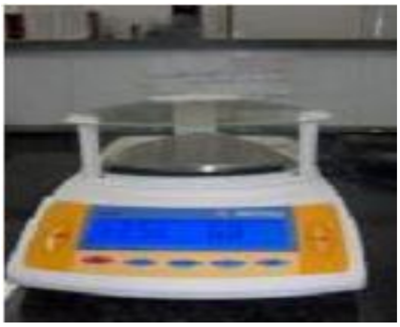


Figure 3-10: Balance used to measure solids

Suspended solids calculated by subtracting dissolved solids from total solids (APHA, 2005).

3.5.4 Total Dissolved Solids (TDS)

A well-mixed sample (50 mL) is filtered through a standard glass fiber filter, and the filtrate is evaporated to dryness in a weighed dish and dried to constant weight at 180 °C. The increase in dish weight represents the total dissolved solids (APHA, 2005).

3.5.5 fecal coliform (FC)

For estimation of FC bacterial populations, The Membrane Filtration (MF) technique is performed. In the initial step, several dilutions of the sample volume are passed through a membrane filter with a pore size small enough (0.45 microns) to retain the bacteria present. The filter is placed on an absorbent pad (in a petri dish) saturated with a culture medium that is selective for coliform growth (mFC). The petri dish containing the filter and pad is incubated, upside down, for 24 hours at the appropriate temperature (44.5 ± 0. 2 oC). After incubation, the colonies that have blue color are identified and counted using a low-power microscope. Few colonies from each plate were picked and biochemical tests were performed to confirm the identity (APHA, 2005).

3.6 Social and economic analysis

Project was built in semi urban area that was surveyed by questioner to know people who agree to connect with the system, standard of living for family, What is the better before or after project operation? and commit to pay fees to operate the system. The operational cost is the price of the batteries that operate the system by solar energy.

3.7 Evaluation Criteria of the System

An evaluation study for the utilized systems of onsite wastewater treatment plants in Abasan was conducted here to explore the efficiency and the problems of the system.

Evaluation criteria will mainly depend on some significant indicators that are related to the efficiency, tolerance and feasibility that should be defined well to measure the effectiveness of the system. The most common needed indicators to assess the systems are in the following .

3.7.1 Treatment Efficiency

Effluent will be analyzed to measure the quality of the treated wastewater and to measure the efficiency of the system. Technology chosen should produce effluent quality that is up to standard with regard to various quality measurements.

$$\text{Efficiency} = \frac{\text{influent quality} - \text{effluent quality}}{\text{influent quality}} \times 100\%$$

3.7.2 Maintenance and Operation

Evaluation will focus on the extent skills needed to operate the system and carry out the maintenance. It is assumed that a certain degree of maintenance is required and also skilled owners to perform maintenance and operational duties when needed to operate and maintain the systems.

3.8 Utilization of Solar System

The plant operated by electricity that generate by solar energy that produced by solar cells .

CHAPTER FOUR

4 Results and Discussion

4.1 System Efficiency

The results focus on analyzing the technical performance aspects of the system that were implemented in Abasan in Gaza strip to treat domestic wastewater from houses in semi urban area.

The system was implemented to reuse wastewater in irrigating olive and fruit farm in southern governorate of Gaza strip .

Implemented treatment unit consists from septic tank , trickling filter , sedimentation tank and sand filter respectively .System was monitored in the period between May/2013(after two weeks from system operating) to Oct/2013 and samples taken from five locations influent manhole to the system (Loc. 1) , effluent of septic tank (Loc. 2), effluent of trickling filter (Loc. 3), effluent of sedimentation tank (Loc. 4), effluent of sand filter and screen filter (Loc.5) as shown in Figure (4.1).

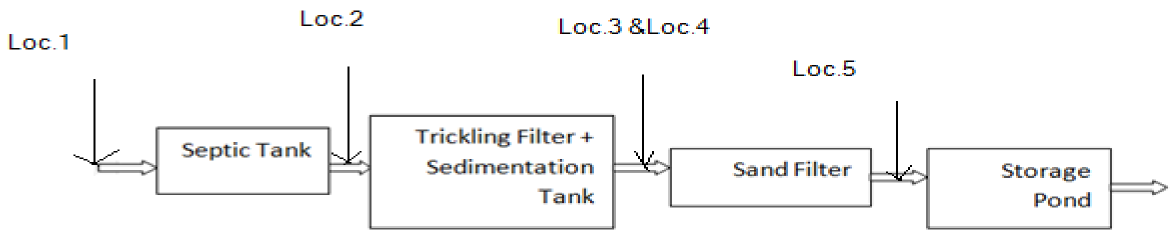


Figure 4-1: Locations to collect samples

4.1.1 System Efficiency in BOD removal

The total flow rate reaching the treatment unit is estimated at 14.5 m3/day with BOD_5 concentration range of 230 – 520 mg/l with an average of 333mg/l. The flow effluent from septic tank with BOD_5 range of 210-480 mg/l with an average of 304 mg/l. The removal rate ranges between 5.7-38% with an average of 14.48% . The removal rate increased with time.

The effluent BOD_5 range from trickling filter is 105-190 mg/l with an average of 133 mg/l . The efficiency range of 47.62-68.18% with an average of 57.45% and it is the highest efficiency for BOD_5 removal. The effluent from the sedimentation tank has a BOD_5 range of 10-70 mg/l with an average of 43mg/l. The efficiency range from 36.36 to 78.95% with an average of 53%.

Sand filter was added in 27/07/2013 to the system to improve the effluent characteristics. It consists of two tanks with one m3 volume filled with gravel. The effluent BOD_5 range is 5-80 mg/l and its efficiency increased with time.

The total BOD_5 removal rate range for the system is 71.43 – 95.65% with an average of 86.1% which also increased with time as shown in Table (4.1).

Table 4-1: : The characteristics of influent and effluent of BOD system.

Date	BOD (mg/l)						Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5	standard	septic tank	trickling filter	sedimentation tank	total Efficiency
26/5/2013	300	280	130	60		45	6.67	53.57	53.85	80.00
03/07/2013	350	330	105	60		45	5.71	68.18	42.86	82.86
15/7/2013	520	480	190	40		45	7.69	60.42	78.95	92.31
27/07/2013	245	210	110	70	80	45	14.29	47.62	36.36	71.43
19/08/2013	355	220		20	21	45	38.03			94.37
05/10/2013	230			10	5	45				95.65
Average	**333.33**	**304.00**	**133.7**	**43.33**	**35.3**	45	**14.48**	**57.45**	**53.00**	**86.10**

Figure (4.2) present the BOD_5 concentration at different sampling points and at different dates of the treatment system. It shows that the removal increases with time due to the formation of bacterial cells that accelerate the process of treatment.

It can be noticed from the figure that there were a variance in the influent BOD_5 values due to the small population connected to the wastewater network, leading to increase the effects of the person on the specifications of influent wastewater as shown in 15/7/2013 readings.

In 27/7/2013 sand filter was added to the system but the reading after sand filter higher than the reading before it because sand filter material was leaching some organic matter.

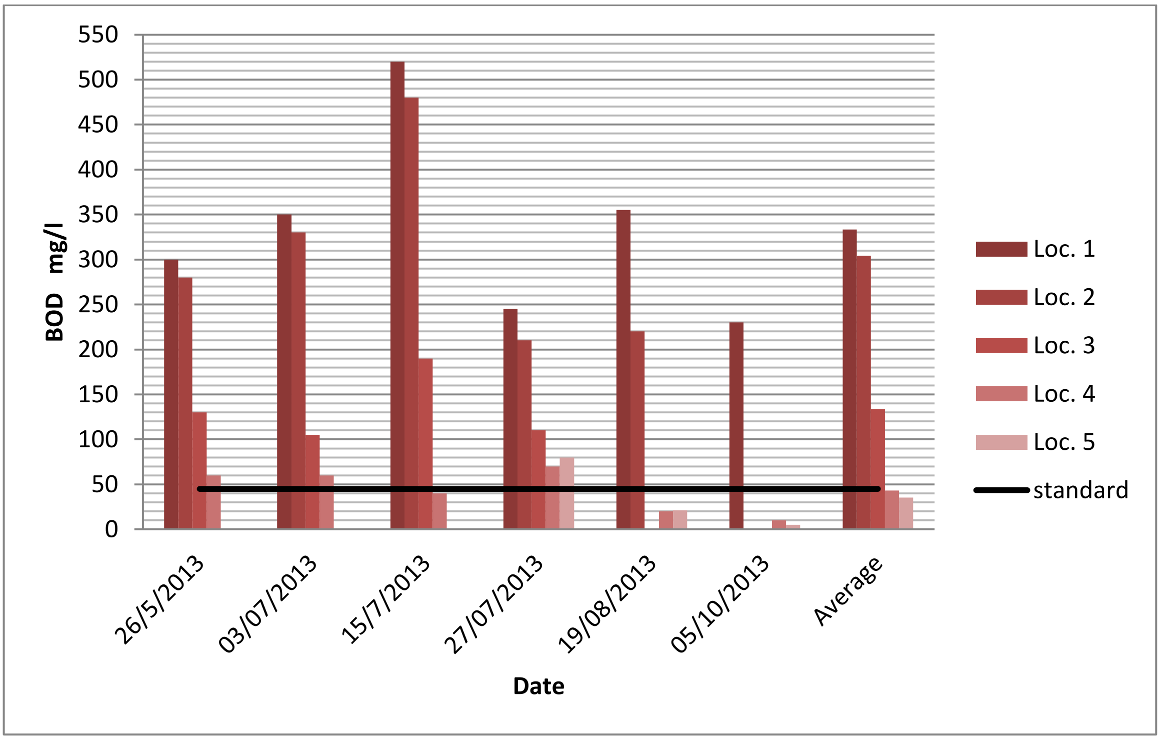


Figure 4-2 : BOD removal for every treatment stages

Most readings about or less than the Palestinian Draft Standard (PDS) as show in appendix 1 for wastewater reuse (45mg/l). As shown in Figure (4.3) the treatment is improved with various component of the system.

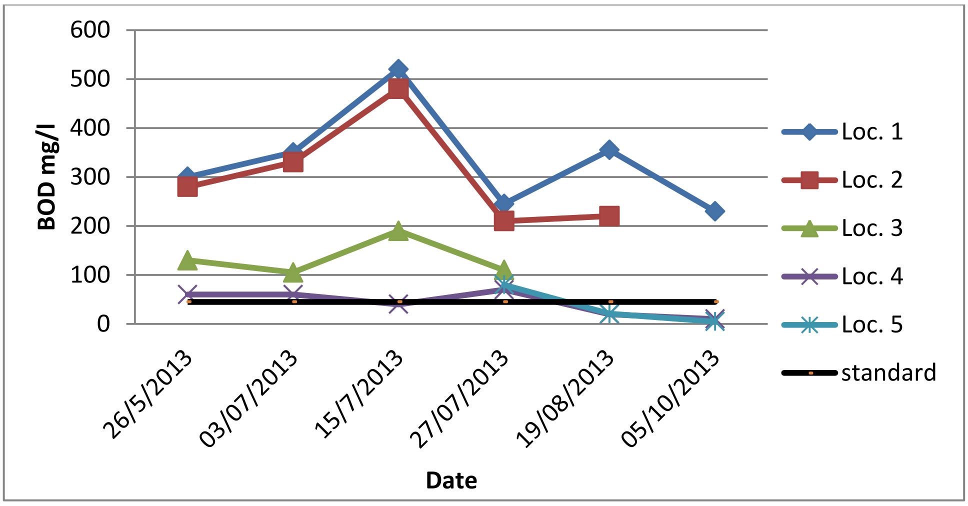


Figure 4-3: : values of BOD in the influent and effluent for each treatment unit

4.1.2 System Efficiency in COD removal

The influent COD concentration range of 695 – 1050 mg/l with an average of 861mg/l. The effluent from septic tank with COD range of 605-1000 mg/l with an average of 801 mg/l. The average removal rate range between 4.76 to 12.95% with an average of 7.41% .

The effluent COD from trickling filter ranges between 290 to 331 mg/l with an average of 307 mg/l (i.e. the efficiency range of 52.07-66.9% with an average of 60.49%). The efficiency increased with time and it is the highest efficiency for COD removal, the effluent from sedimentation tank has COD range of 120-150 mg/l with an average of 131 mg/l. The efficiency ranges from 48.98 to 63.44% with an average of 56.49% .

The total COD removal rate range for the system is 80 – 88.48% with an average of 84.11% which also increased with time as shown in Table (4.2).

Table 4-2: The characteristics of influent and effluent of COD system.

Date	COD (mg/l)					Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	standard	septic tank	trickling filter	sedimentation tank	total Efficiency
26/5/2013	695	605	290	135	150	12.95	52.07	53.45	80.58
03/07/2013	750	700	294	150	150	6.67	58.00	48.98	80.00
15/7/2013	1050	1000	331	121	150	4.76	66.90	63.44	88.48
28/07/2013	950	900	315	120	150	5.26	65.00	61.90	87.37
Average	**861.25**	**801.25**	**307.50**	**131.50**	150	**7.41**	**60.49**	**56.94**	**84.11**

Figure (4.4) illustrated the relationship between COD and time in treatment processes during the monitoring period. It can be noticed from the figure 4.4 that there were a variance in the influent COD readings due to the small population connected to the wastewater network, leading to increase the effects of the person on the specifications of influent wastewater as shown in 15/7/2013 readings that are high.

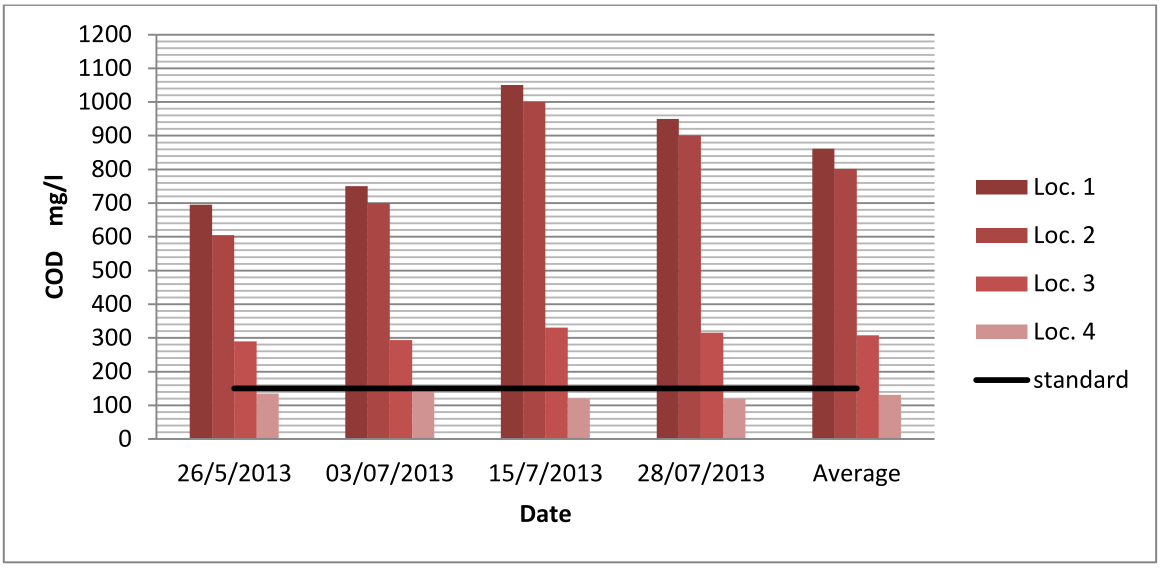


Figure 4-4: : COD removal for every treatment stages

Most readings are within or less than the Palestinian Draft Standard (PDS) for wastewater reuse (150mg/l) as shown in Figure (4.5) and it shows improvement of treatment in various system components.

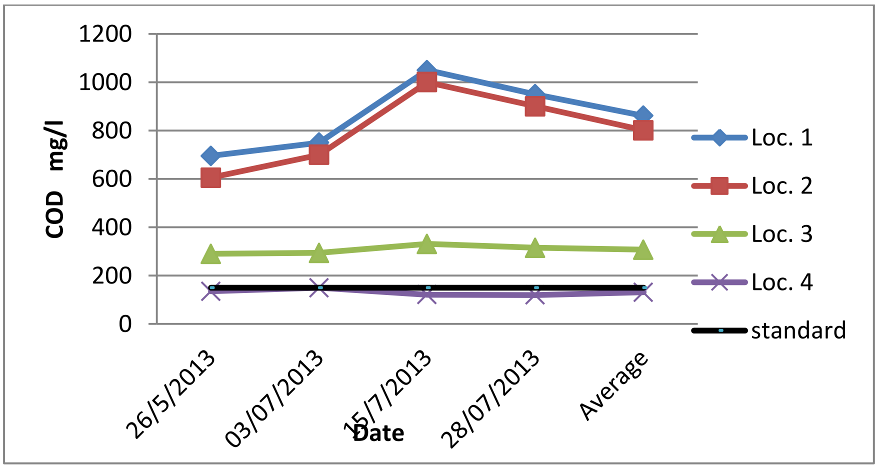


Figure 4-5: : values of COD in the influent and effluent for each treatment unit

Figure (4.6) illustrate that the trend of COD curve is similar to the BOD_5 trends curve which show the effects of bacteria stabilization. Average COD/ BOD_5 intervals between 2.22 and 2.95 with an average of 2.63.

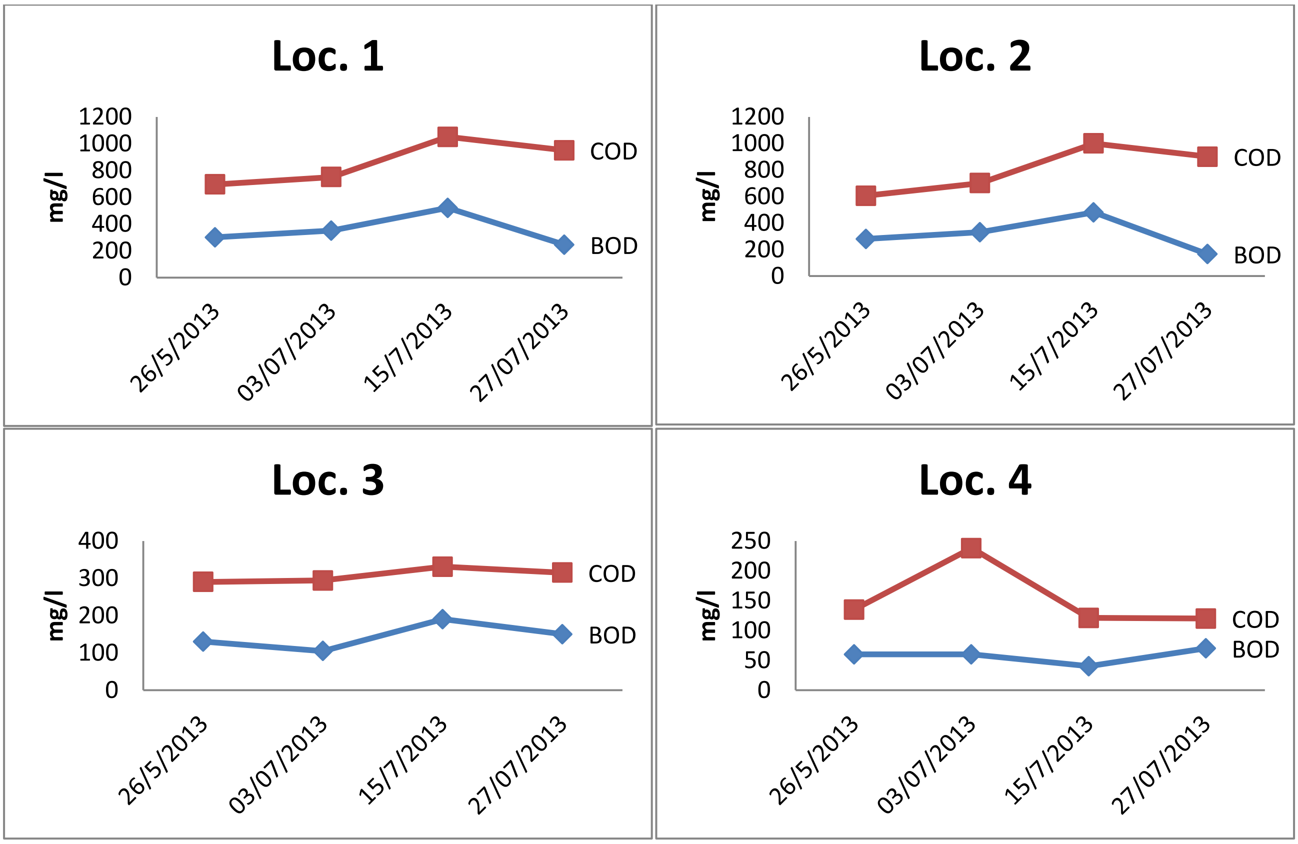


Figure 4-6:values of BOD_5 and COD

4.1.3 System Efficiency in TSS removal

The TSS concentration in the influent ranges between 90 to 1200 mg/l with an average of 389 mg/l. The effluent TSS from septic tank has a range of 70-805 mg/l with an average of 329 mg/l with removal rate range of 5.41-32.92% (average of 16.41%).

The effluent TSS range from trickling filter accounted for 70-140 mg/l with an average of 94.6 mg/l with efficiency range from 42.62 to 88.82% with an average of 51.53%. The effluent from the sedimentation tank has TSS range of 14-65 mg/l with an average of 38mg/l. The efficiency ranges from 27.78 to 85.26% with an average of 57.55%.

The effluent TSS from the sand filter ranges from 12-30 mg/l. The overall TSS efficiency range for the system is 64.44 – 96.76% with an average of 85.7% as shown in Table (4.3).

Table 4-3: The characteristics of influent and effluent of TSS system.

Date	TSS (mg/l)						Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5	standard	septic tank	trickling filter	sedimentation tank	total Efficiency
26/5/2013	320	300	140	50		40	6.25	53.33	64.29	84.38
03/07/2013	90	70	78	32		40	22.22	0.00	58.97	64.44
15/7/2013	1200	805	90	65		40	32.92	88.82	27.78	94.58
27/07/2013	144	122	70	34	17	40	15.28	42.62	51.43	88.19
19/08/2013	370	350	95	14	12	40	5.41	72.86	85.26	96.76
05/10/2013	212			35	30	40				85.85
Average	**389.33**	**329.40**	**94.60**	**38.33**	**19.67**	40	**16.41**	**51.53**	**57.55**	**85.70**

Figure (4.7) illustrated the relationship between TSS and time in treatment processes during the monitoring period.

It can be noticed from the figure that there were a variance in the influent TSS readings due to the Small population connected to the wastewater network, leading to increase the effects of the person on the specifications of influent wastewater as shown in 15/7/2013 readings.

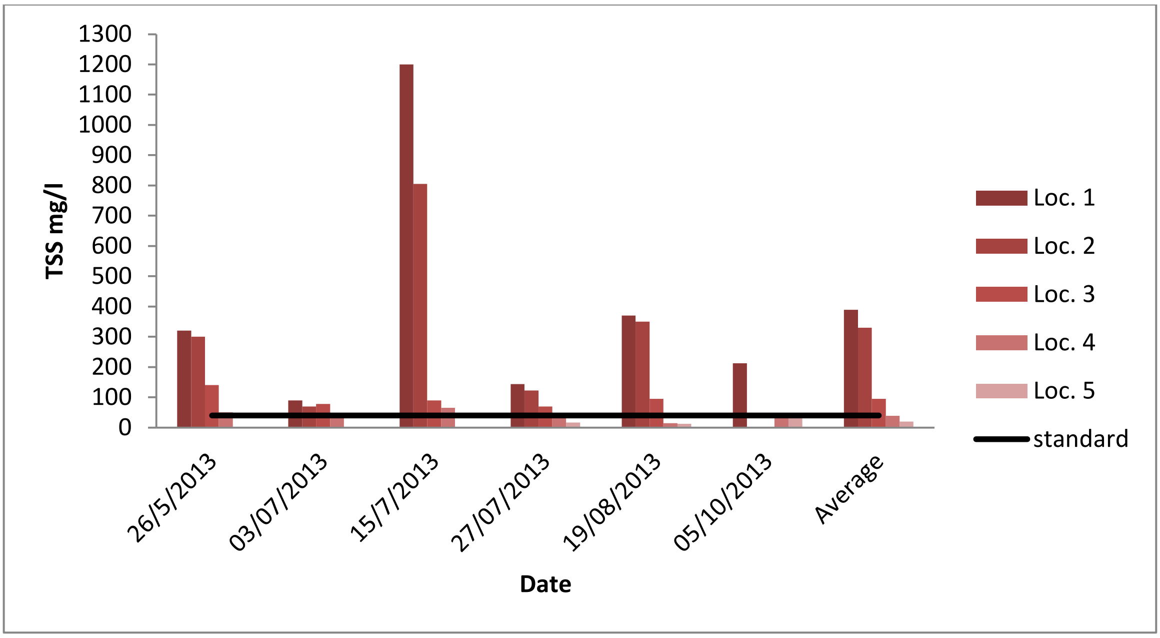


Figure 4-7: TSS removal for every treatment stages

Most readings within or less than the Palestinian Draft Standard (PDS) for water reuse (40mg/l) as shown in Figure (4.8) and it shows improvement treatment with different treatment components.

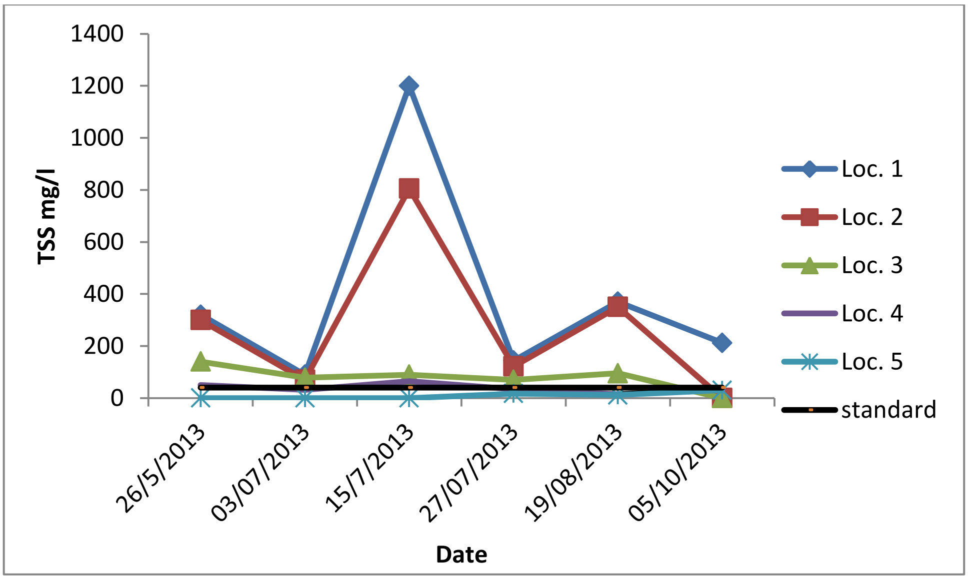


Figure 4-8: : values of TSS in the influent and effluent for each treatment unit

4.1.4 System Efficiency in TDS removal

As shown in Table (4.4) and Figure (4.9 and 4.10) that TDS is not affected by various treatment components, all values less than Palestinian Draft Standard (PDS) for water reuse (1500mg/l).

Table 4-4: The characteristics of influent and effluent of TDS system.

Date	TDS (mg/l)						Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5	standard	septic tank	trickling filter	sedimentation tank	total Efficiency
26/5/2013	1472	1536	1472	1478.4		1500	0	4.17	0.00	0.00
07/03/2013	1330	1330	1330	1250		1500	0	0.00	6.02	6.02
15/7/2013	1190	1270	1060	1160		1500	0	16.54	0.00	2.52
27/07/2013	1170	1170	1180	1160	1100	1500	0	0.00	1.69	0.85
19/08/2013	1290	1350	1260	1200	1200	1500	0	6.67	4.76	6.98
05/10/2013	1180			1180	1140	1500				0.00
Average	**1272**	**1331.2**	**1260.4**	**1238.0**	**1146.6**	1500	**0.0**	**5.47**	**2.49**	**2.73**

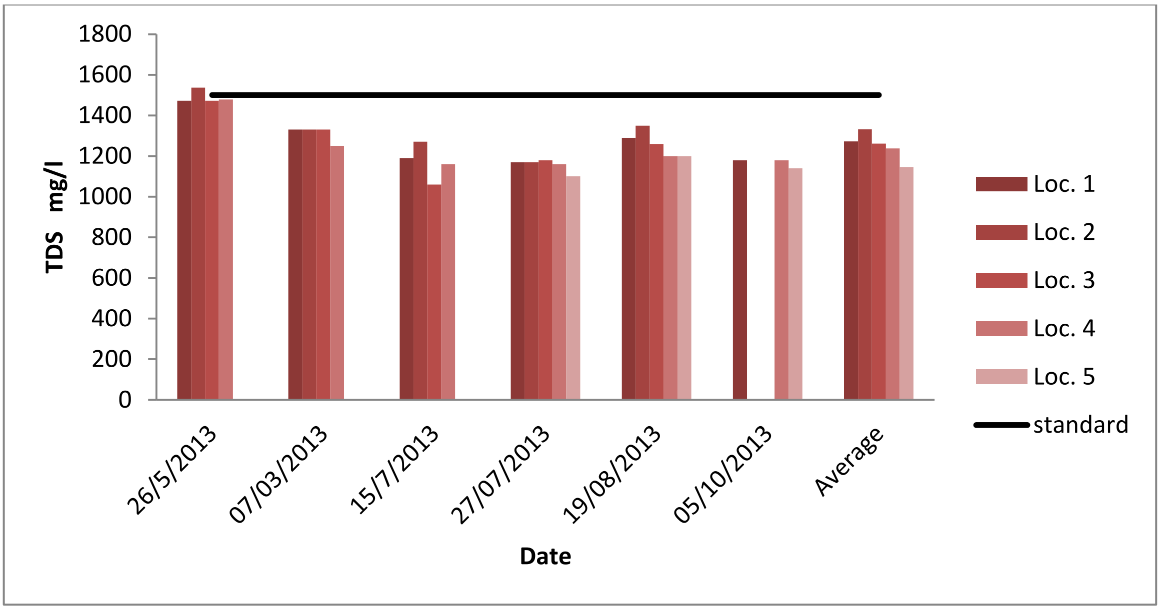


Figure 4-9: TDS removal for every treatment stages

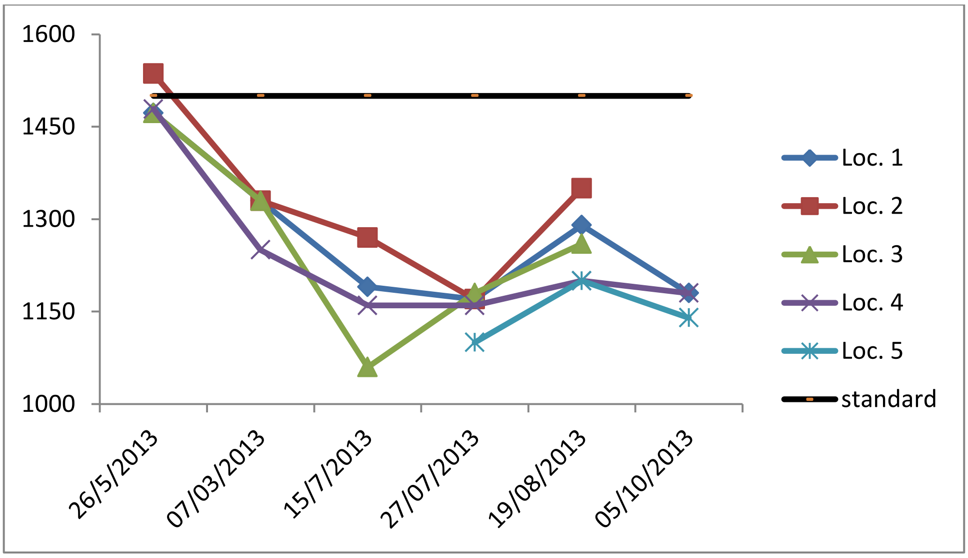


Figure 4-10: values of TDS in the influent and effluent for each treatment unit

4.1.5 System Efficiency in FC removal

The FC influent to the system range is 50×10^3 – 20×10^6 CFU/100ml with an average of 4.04×10^6 CFU/100ml, then the flow effluent from septic tank with FC range of 10×10^3-1.5×10^7 CFU/100ml with an average of 3.8×10^6 CFU/100ml.

The effluent FC from trickling filter is 2.2×10^4 CFU/100ml. The sedimentation tank has FC effluent range of 920-1.1×10^4 CFU/100ml with an average of 1.8×10^4 CFU/100ml. The FC range is 640-1.1×10^4 CFU/100ml with an average of 4247CFU/100ml after the sand filter.

The total FC efficiency range for the system is 38.89 – 99.81% with an average of 74.96% that increased with time as shown in Table (4.5).

The results also shows that the efficiency of the system improves after added the sand filter to go less than Palestinian Draft Standard (PDS) for water reuse (1000 CFU/100ml).

Table 4-5: The characteristics of influent and effluent of FC system.

Date	FC (CFU/100ml)						Efficiency			
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5	standard	septic tank	trickling filter	sedimentation tank	total Efficiency
26/5/2013	20×10^6	1.5×10^7		3.8×10^4		1000	25	100.00		99.81
15/7/2013	1.8×10^4	2.4×10^4	2.2×10^4	1.1×10^4		1000	0	8.33	50.00	38.89
27/07/2013	1.8×10^4	2.4×10^4	2.2×10^4	1.1×10^4	1.1×10^4	1000	0	8.33	50.00	38.89
19/08/2013	50×10^3	10×10^3		920	1.1×10^3	1000				97.80
05/10/2013	1.1×10^5			2.7×10^4	640	1000				99.42
Average	4.04×10^6	3.8×10^6	2.2×10^4	1.8×10^4	4246.67	1000	**8.33**	**38.89**	**50.00**	**74.96**

PHG did some tests on the plant appears in the Appendix (2). All units were designed to produce effluent with a quality compliant with the local and international standard as shown in Appendix (1) that illustrates the Palestinian Draft Standard for reusing treated wastewater in different aspects.

Table 4-6:actual tests result compared with Palestinian standard for wastewater reuse

parameter	Actual	Palestinian Draft Standard
BOD_5	43	45 mg/l
COD	131	150 mg/l
TSS	38	40 mg/l
TDS	1146	1500mg/l
FC	4246	1000CFU/100ml

4.2 : Modification of the system for actual results compared with design

Conceptual design of the treatment unit was based on hypotheses and tests after the operation of the unit samples have been taken to ensure their effectiveness and compatibility with the conceptual design, but were not completely identical so it should be taken into consideration and work necessary modification.

The treatment plant aims to treat wastewater collected from 50 families. The quantity of wastewater is estimated according to Table (4.7) but the actual consumption shown in Figure (4.11).

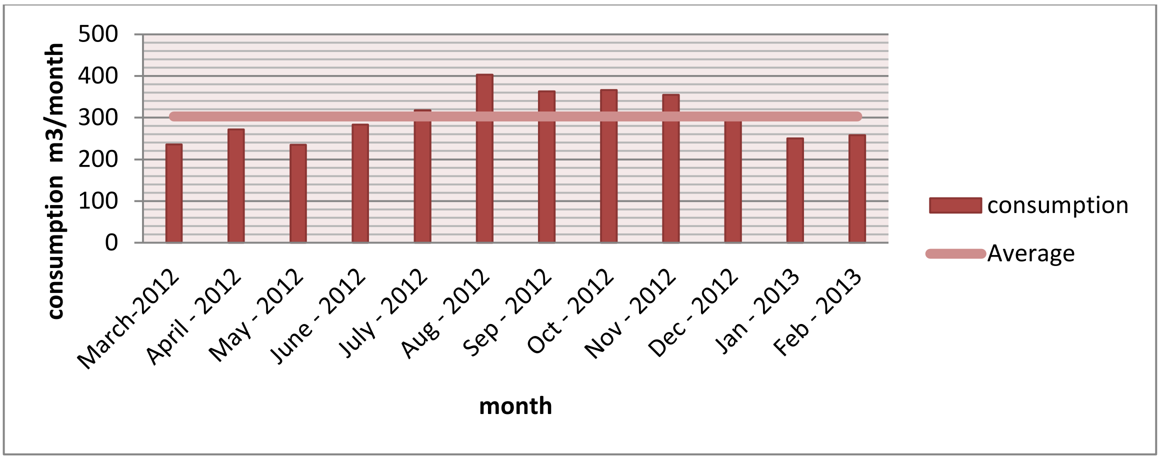


Figure 4-11: Actual consumption for studed area in one year

The actual quantity as shown in Table(4.7).

Table 4-7:actual Wastewater quantities

Description	No.	Unit
# of families	24	Family
Inhabitants per family	7	persons
Total Population	168	persons
Wastewater Production	85	L/C/D
Average Wastewater	14.28 0.16	m3/day L/S

After tests the actual results are shown in Table(4.8).

Table 4-8:the actual results

BOD_5	333mg/l
COD	861mg/l
TSS	389 mg/l
F.C.	4.04×10^6 CFU/100ml

From design the effluent BOD_5 from the system is 44 mg/l but tests show 35mg/l. Removal rate of BOD_5 in the design is 85.3% but the BOD_5 average actual removal rate is 86.1 %.System breakdown and stops working for nearly two weeks and then repair and sand filter was added. Effluent BOD_5, COD, TSS, TDS and FC concentration better than treatment plant design criteria and about or lower than WHO guidelines for non-restrictive irrigation (BOD_5: 25mg/L, FC: 10^3cfu/100ml , SS: 30mg/L). The actual results are better compared with the design.

4.3 Social acceptance

On 1st July 2012 Palestinian Hydrology Group(PHG) and Polish Humanitarian Action (PAH) signed an agreement to implement the project Improvement of household sanitation by using low cost treatment unit and Improve environmental health conditions for houses in the target area supported by solar energy and apply wastewater reuse for agriculture in the semi urban area of Abasan Gaza, 2012 .

a main sewerage network was been building and population pledged by sign a pledge to connect to the network and pay a fee to use in the operation of the plant.

The connection of 24 family to the system in three streets shown in the map in Figure (4.12) number of beneficiaries is 168 capita .

Figure 4-12 : Abasan area map .

The sustainability of the system was depend on community participation , this was ensured through intensive interviews with the community and municipality , and creation of the project management committee which consisted of served people and the operator of the system , to agree about the proper tariff (the project make suggestion for the committee after feasibility study of the operational cost of the system . The cost that each family should pay is 15 NIS / month to operate the system. Community survey depend on the collected data from questioner distributed to the 24 family in the project area at the beginning of the project.

The production wastewater is used to irrigate 15 dunum planted with fruit trees, (citrus , olive , peach , apples , and cactus) that is needs for each dunum 5 m^3 /dunum / day by a farmer . Farmer agreed to Construction the project on his farm , encourage for it and used wastewater production satisfaction after the satisfactory results of the tests without any hesitation.

Compared with what was paid by residents to empty cesspits, the fees paid to operate the treatment unit connectors are they save a lot.

Although population connected to the network pledged to pay the fees due on them, they did not commit the payment to the lack of an official body responsible for collecting fees.

Questioner surveyed all connected families with the plant that shows all surveyed families commitment to connect to wastewater network, all surveyed families satisfied with the project due to it solves a lot of economical and health problems and no one pay the fees because of most of them suffer from bad standard of living.

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Improvement of household sanitation by using low cost treatment unit supported by solar energy and apply wastewater reuse for agriculture in the rural area of Abasan Gaza Strip, 2012

تحسين الاصحاح البيئي في منطقة عبسان الريفية قطاع غزة باستخدام وحدة المعالجة المدعومة بالطاقة الشمسية و تطبيق إعادة استخدام المياه العادمة للزراعة

طلب استفادة للأسرة

Application for family

1-1	الاسم (رباعي) name :			
2-1	رقم الهوية ID:			
3-1	العنوان Address:	المحافظة Gov	البلدية Mun	المنطقة Area:
1-2	عدد أفراد الاسرة family size	ذكور m ______	إناث f ______	
2-2	الطلاب في الاسرة students in the family	مدارس Sch ______	جامعات Univ ______	
1-3	النوع الاجتماعي لمعيل الاسرة Gender for responsible	رجل m ( )	إمرأة f ( )	
2-3	هل تتلقى الاسرة مساعدات كوبونات غذائية food coupons	شؤون اجتماعية MOSA	وكالة الغوث UNRWA	
3-3	متوسط دخل الأسرة بالشهر بالشيكل family monthly income NIS			
4-3	عدد حالات الاعاقة داخل الاسرة disability _____ حالة	نوع الأعاقة disability type		
1-4	حجم خزانات المياه water tanks Volume			
2-4	معدل فاتورة المياه water bill average			
	وسيلة اتصال رقم هاتف CONTACT TEL ______________	رقم جوال MOBILE ______________________		

تنبيه :إن أي معلومة غير صحيحة في هذا الطلب ستؤدي إلى إهماله لذا يرجى قبل التوقيع عليه التحقق من بياناته

يجب ارفاق صورة هوية شخصية كاملة

توقيع مقدم الطلب Signature   التاريخ / / 2012

Figure 4-13 :Application for family to connect with the system

Palestinian Hydrology Group

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Improvement of household sanitation by using low cost treatment unit supported by solar energy and apply wastewater reuse for agriculture in the rural area of Abasan Gaza Strip, 2012

تحسين الاصحاح البيئي في منطقة عبسان الريفية قطاع غزة باستخدام وحدة المعالجة المدعومة بالطاقة الشمسية و تطبيق إعادة استخدام المياه العادمة للزراعة

تعهد Commitment

أتعهد أنا_______________________________ .... رقم هوية...__________..

من منطقة.**عبسان الجديدة – سوق مازن** ...المستفيد من تنفيذ مشروع **تحسين الاصحاح البيئي في منطقة عبسان الريفية قطاع غزة باستخدام وحدة المعالجة المدعومة بالطاقة الشمسية و تطبيق إعادة استخدام المياه العادمة للزراعة** المنفذ من قبل مجموعة الهيدرولوجيين الفلسطينيينPHG– وبتمويل من *المساعدات الانسانية البولندية PAH.*

أتعهد بربط منزلي بشبكة جمع الصرف الصحي المنشأة من خلال المشروع و بالتزام بالعمل المشترك مع جميع المستفيدين و لجنة ادارة المشروع و الالتزام بالتعليمات التي تلقيتها خلال التدريب للمحافظة على نظام جمع المياه العادمة و الالتزام مع لجنة ادارة المشروع بالدفع شهريا للجنة بتكاليف ثابتة يتم تحديدها من قبل لجنة المشروع التي تتكون من ممثلين عن المستفيدين و مشغل النظام لضمان تشغيل مستمر لوحدة المعالجة و لتصريف جيد للصرف الصحي من منزلي .

.

اسم المستفيد ____________________ التوقيع ______________________________

اعتماد PHG بلدية عبسان الجديدة اعتماد لجنة المشروع

Figure 4-14 : Commitment to connect with the system

CHAPTER FIVE

5 Conclusions and Recommendations

5.1 Conclusions

The system has been monitored for four months and BOD_5, COD, TSS, TDS and FC has been analyzed and it is concluded the following:

1. The BOD_5 removal rate in the septic tank reached14.5 %, in the trickling filter reached 57.5%, in the sedimentation tank reached 53%and in the sand filter reached18.46%.The overall BOD_5 removal is 86% .

2. The COD removal rate in the septic tank reached 7.5%, in the trickling filter reached 60.5%, in the sedimentation tank reached 57% .The overall COD removal is 84% .

3. The TSS removal rate in the septic tank reached 16.5 %, in the trickling filter reached 51.5%, in the sedimentation tank reached 57.5%and in the sand filter reached 48.6%. The overall TSS removal is 85.7%.

4. No significant removal for TDS .

5. The FC removal rate in the septic tank reached 8%, in the trickling filter reached 39%, in the sedimentation tank reached 50%and in the sand filter reached 75.85%. The overall FC removal is 75%.

6. The treated wastewater quality compared with Palestine standard is suitable the for direct irrigation of olives and fruits .The last two tests after adding sand filter for FC less than Palestine standard but the average higher than it .

7. Operation cost was estimated 15NIS per household compared with 50NIS for empty cesspits.

8. Socially, the system is accepted by resident as no disposal of raw sewage in starts .

9. The land owner operate the system properly and interests to increase the home-connection units.

10. In Gaza strip many trials were used to disposal wastewater such as cesspits , SAT and reed bed systems . None of the this trailed system sustained so it is still needed to investigate more sustainable system for treatment and disposal wastewater in semi urban areas .

5.2 Recommendations

1. The system seems suitable for semi urban areas although longer monitoring program is required to study the long term impact.

2. It is recommended to construct other units on other areas.

3. Public awareness program are required to aware resident and encourage them to cover the operation cost.

4. The ministries and authorities as MOA , MOH and EQA has to establish monitoring program to monitor the effluent quality , crop quality and health impact.

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Useful Web Pages

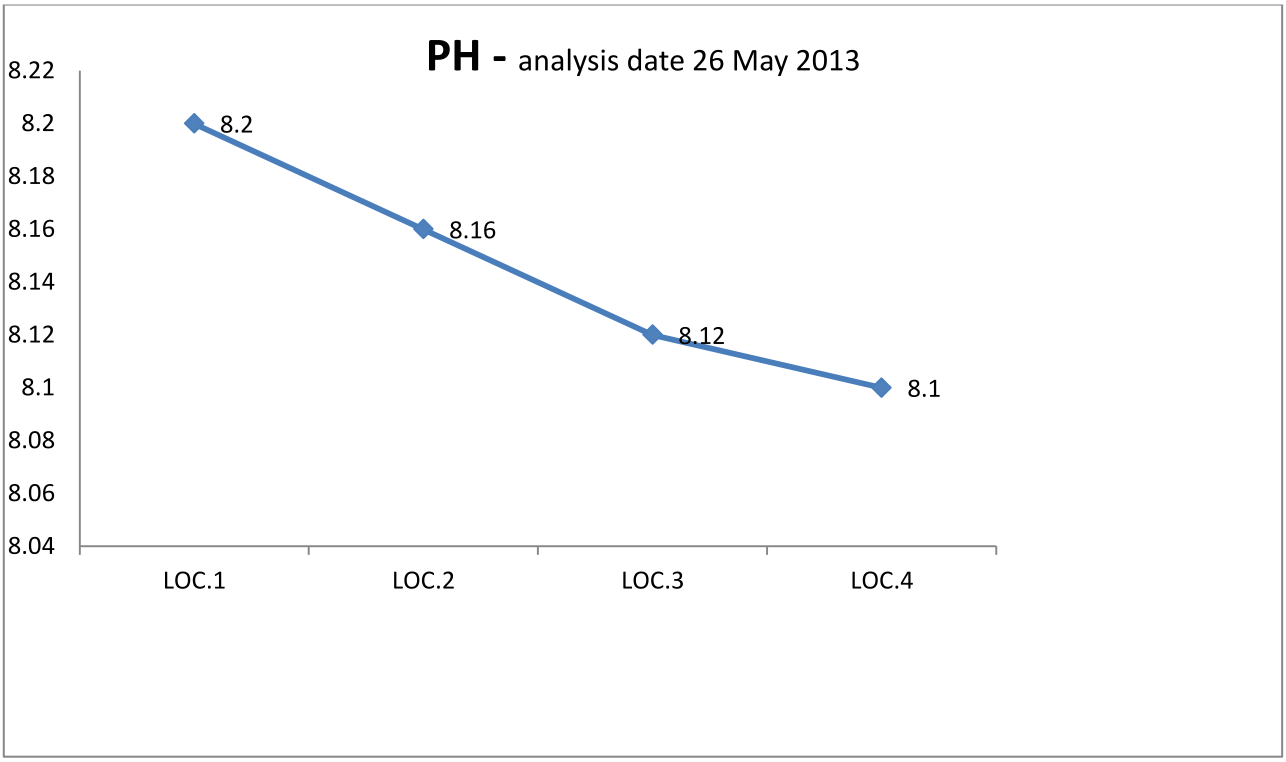
- http://ossf.tamu.edu/onsite-wastewater-treatment-systems-owts/
- http://www.info.com/search?qkw=onsite+wastewater+treatment+system&qcat=web
- http://www2.epa.gov/science-and-technology/water-science

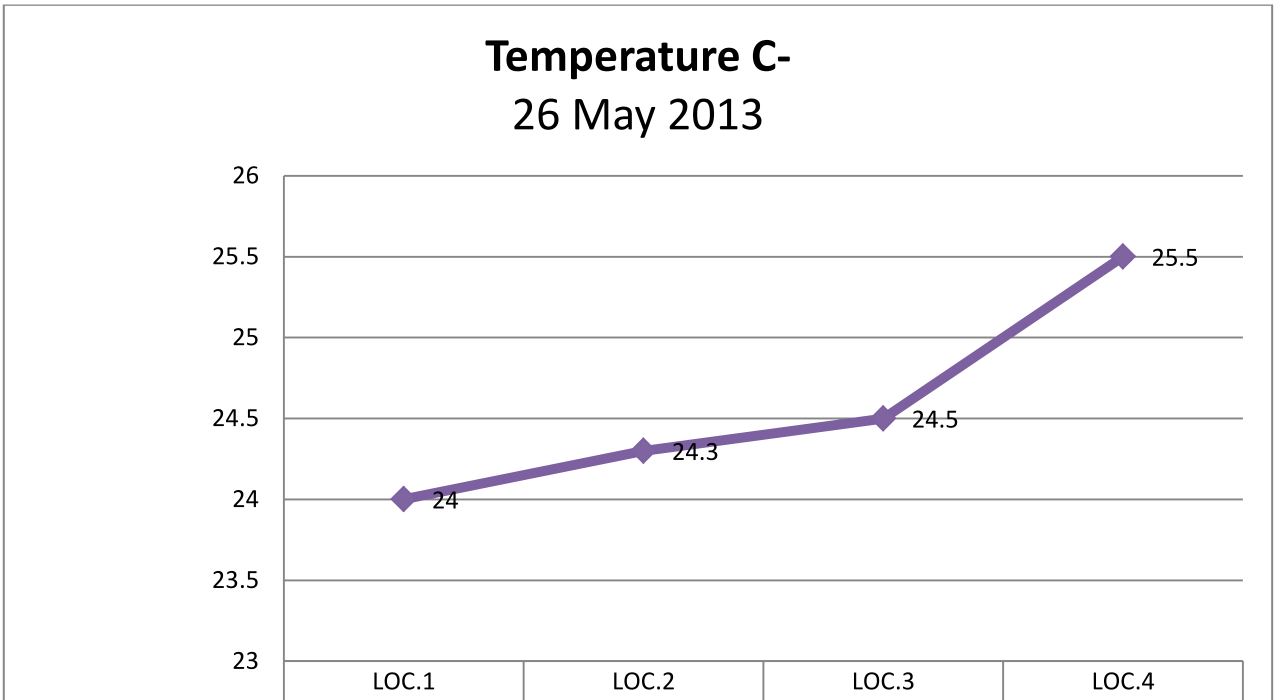
Appendices

Appendix 1 : Palestinian Draft Standard (PDS) for water reuse.

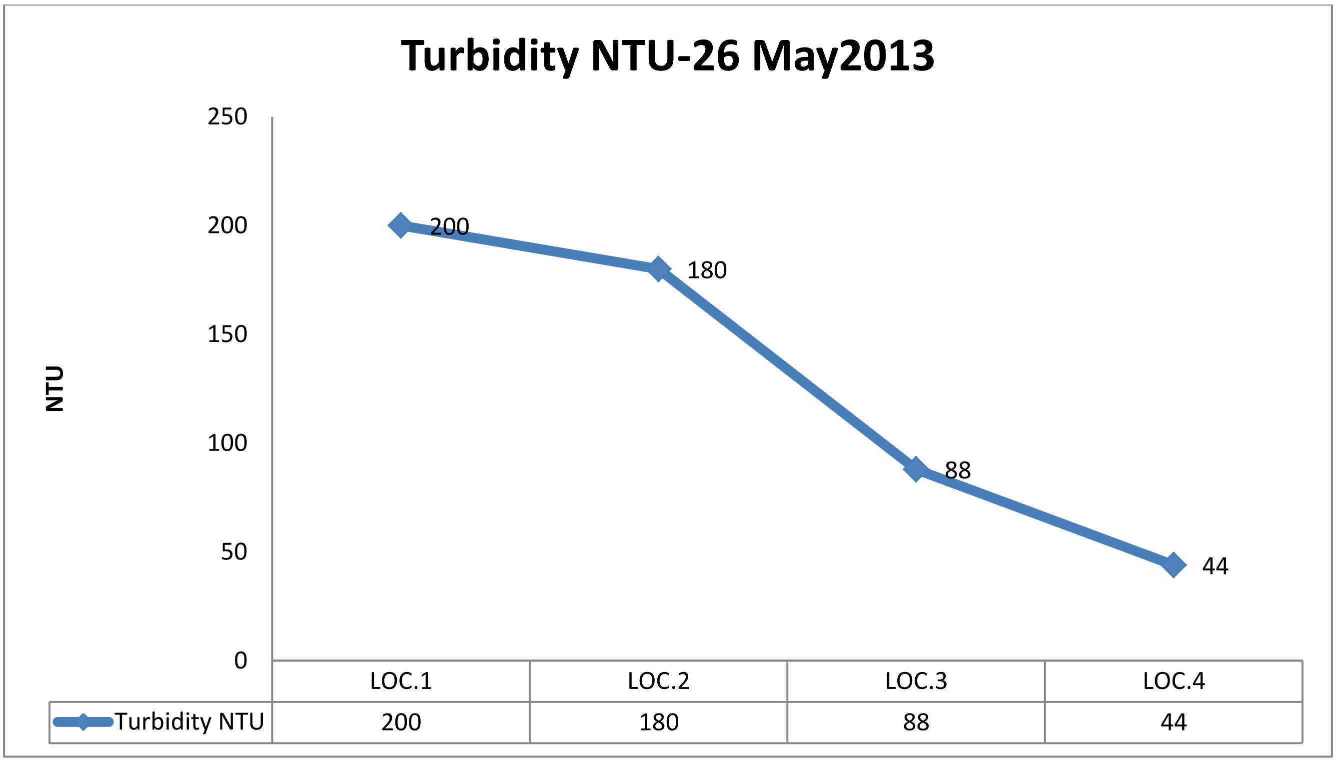
Quality Parameters mg/l except otherwise indicated	Animals Feed		Parks, playgrounds	Seeds as corn	Aquifer Recharge	To the see 500m inside	Forests not used as parks	Productive trees		
BOD	60	45	40	60	40	60	60	45	45	45
COD	200	150	150	200	150	200	200	150	150	150
DO	>0.5	>0.5	>0.5	>0.5	>1	>1	>0.5	>0.5	>0.5	>0.5
TDS	1500	1500	1200	1500	1500	-	1500	1500	1500	1500
TSS	50	40	30	50	50	60	50	40	40	40
PH	6-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9	6-9
Color (PCU)	Free	Free	Free	Free	Free	Free	Free	Free	Free	Free
FOG	5	5	5	5	0	10	5	5	5	5
Phenol	0.002	0.002	0.002	0.002	0.002	1	0.002	0.002	0.002	0.002
MBAS	15	15	15	15	5	25	15	15	15	15
NO3-N	50	50	50	50	15	25	50	50	50	50
NH4-N	-	-	50	-	10	5	-	-	-	-
O.Kj-N	50	50	50	50	10	10	50	50	50	50
PO4-P	30	30	30	30	15	5	30	30	30	30
CL	500	500	350	500	600	-	500	400	600	400
SO4	500	500	500	500	1000	1000	500	500	500	500
Na	200	200	200	200	230	-	200	200	200	200
Mg	60	60	60	60	150	-	60	60	60	60
Ca	400	400	400	400	400	-	400	400	400	400
SAR	9	9	10	9	9	-	9	9	9	9
Residual C12	-	-	-	-	-	-	-	-	-	-
B	0.7	0.7	0.7	0.7	1	2	0.7	0.7	0.7	0.7
FC (CFU/100ml)	1000	1000	200	1000	1000	1000	1000	1000	1000	1000
Pathogens	Free	Free	Free	Free	Free	Free	Free	Free	Free	Free

Appendix 2 : wastewater tests/PHG

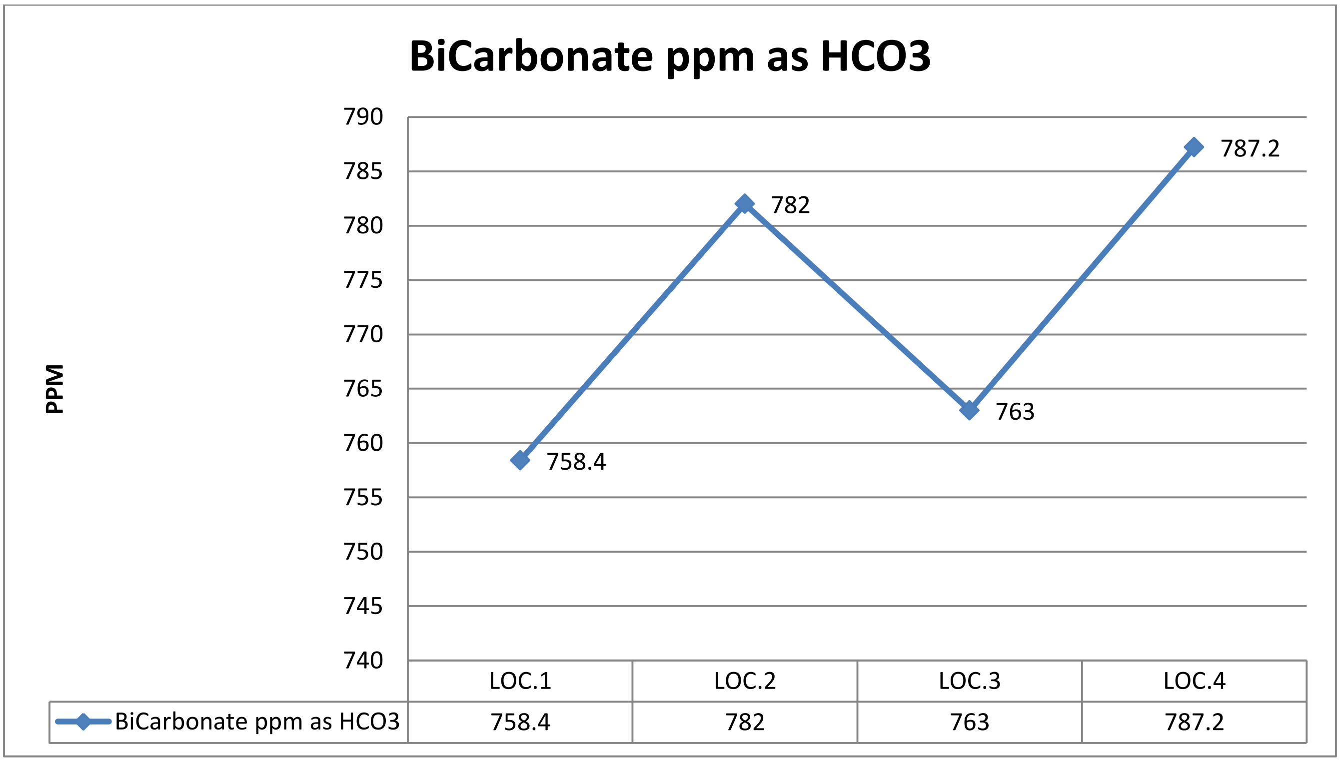




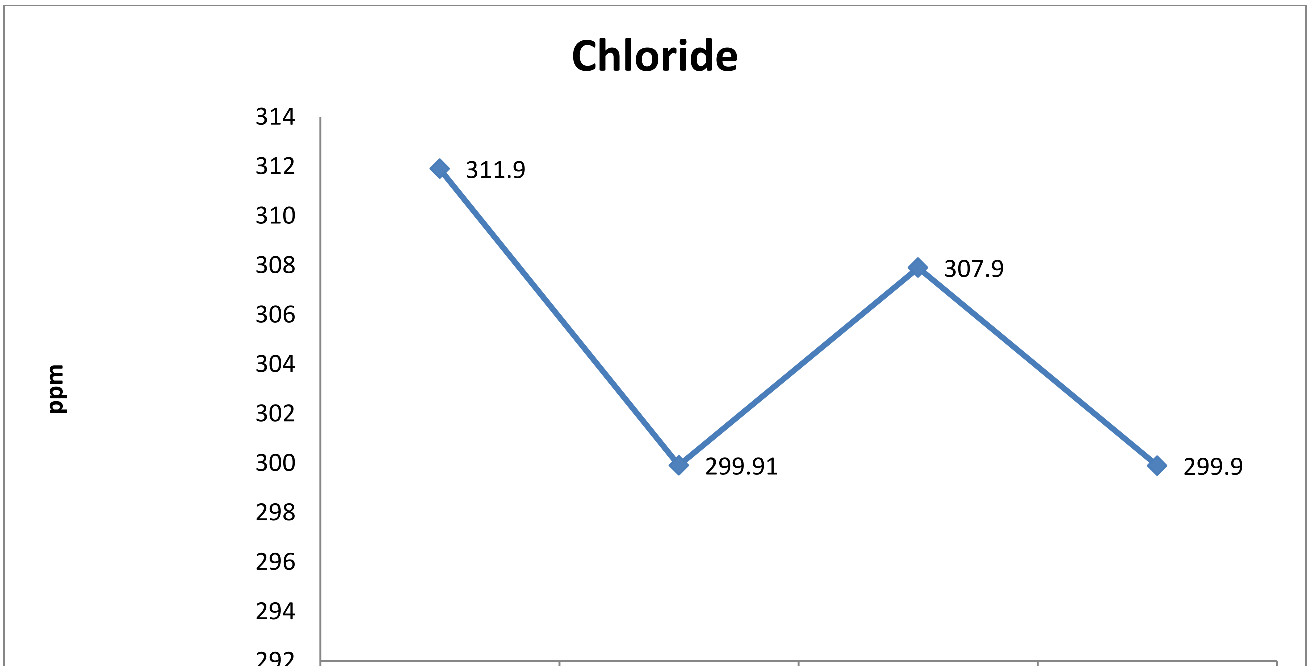
	LOC.1	LOC.2	LOC.3	LOC.4
Temperature C	24	24.3	24.5	25.5



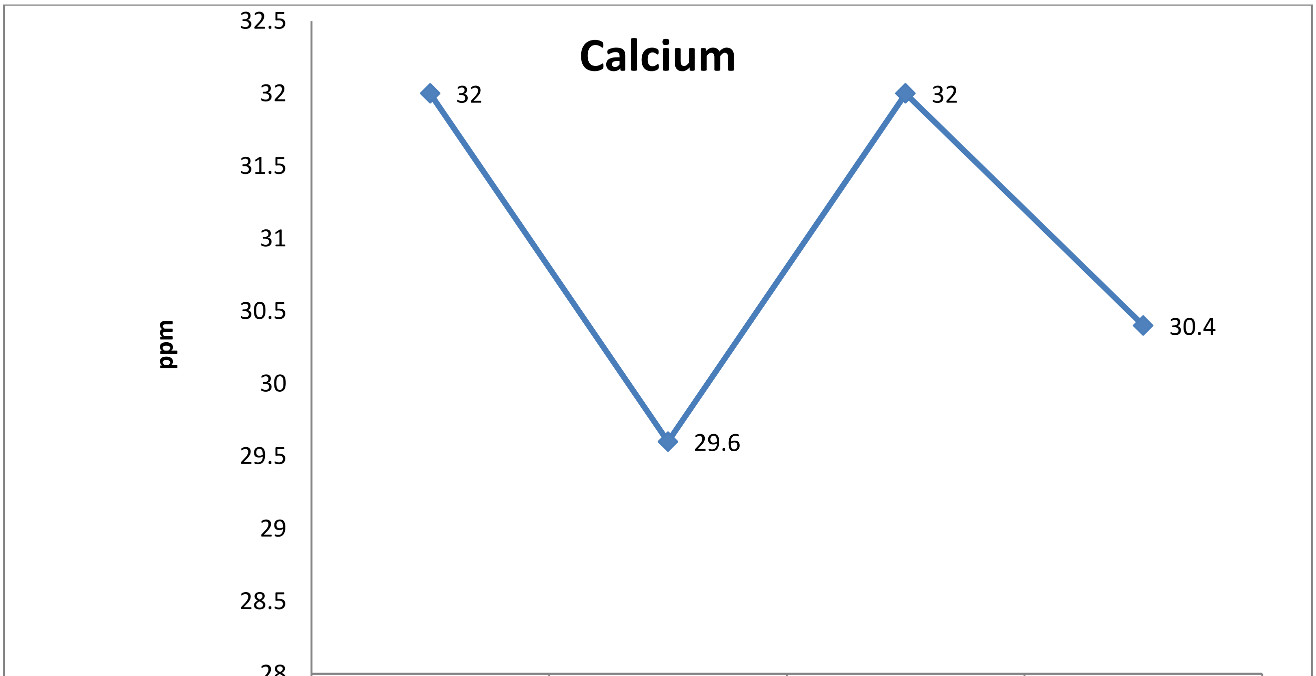
	LOC.1	LOC.2	LOC.3	LOC.4
Turbidity NTU	200	180	88	44



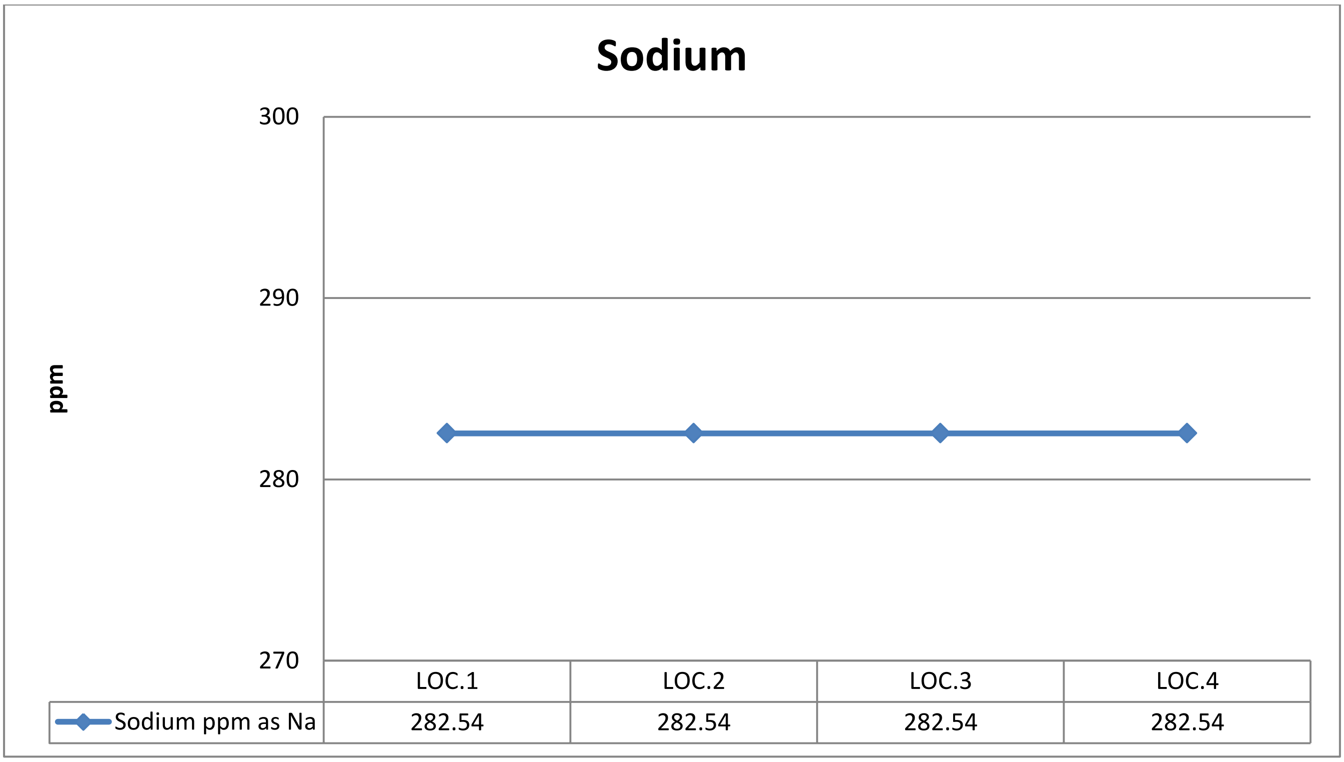
	LOC.1	LOC.2	LOC.3	LOC.4
BiCarbonate ppm as HCO3	758.4	782	763	787.2

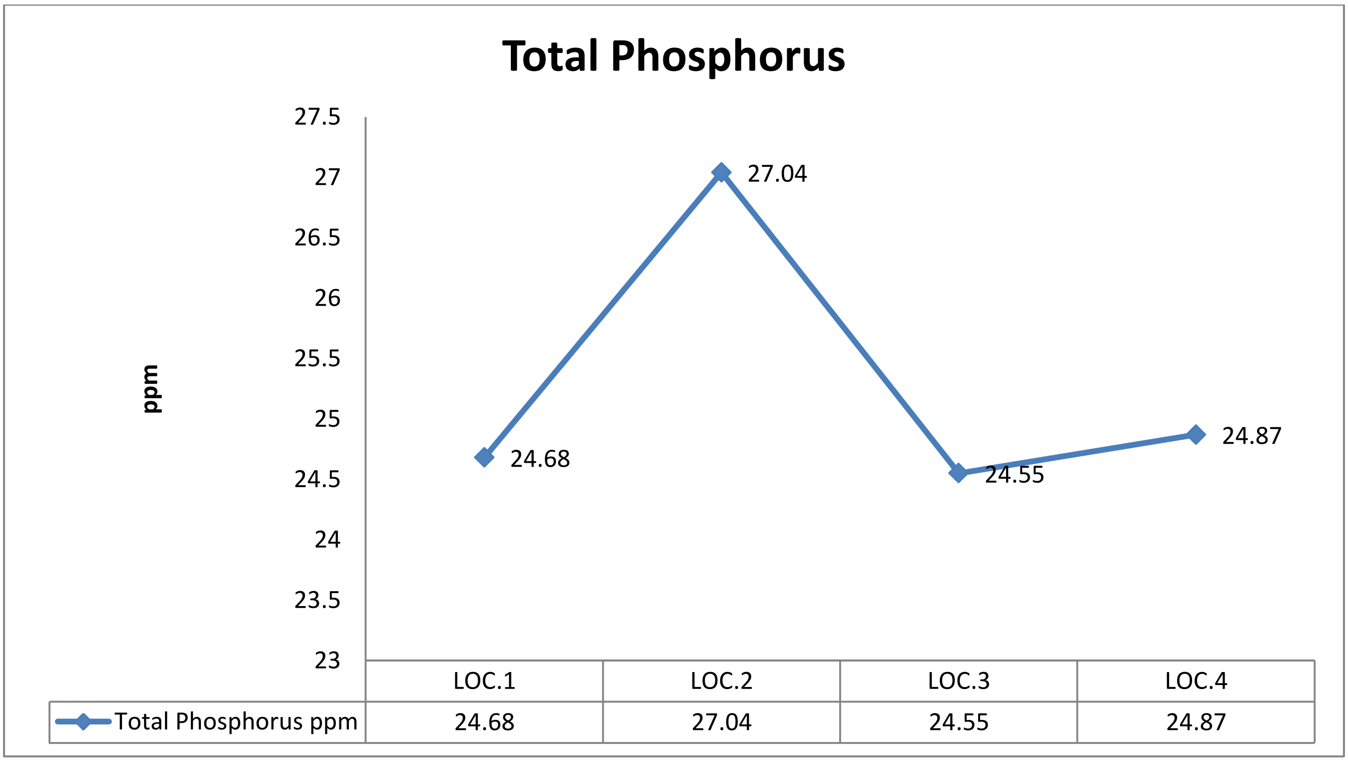


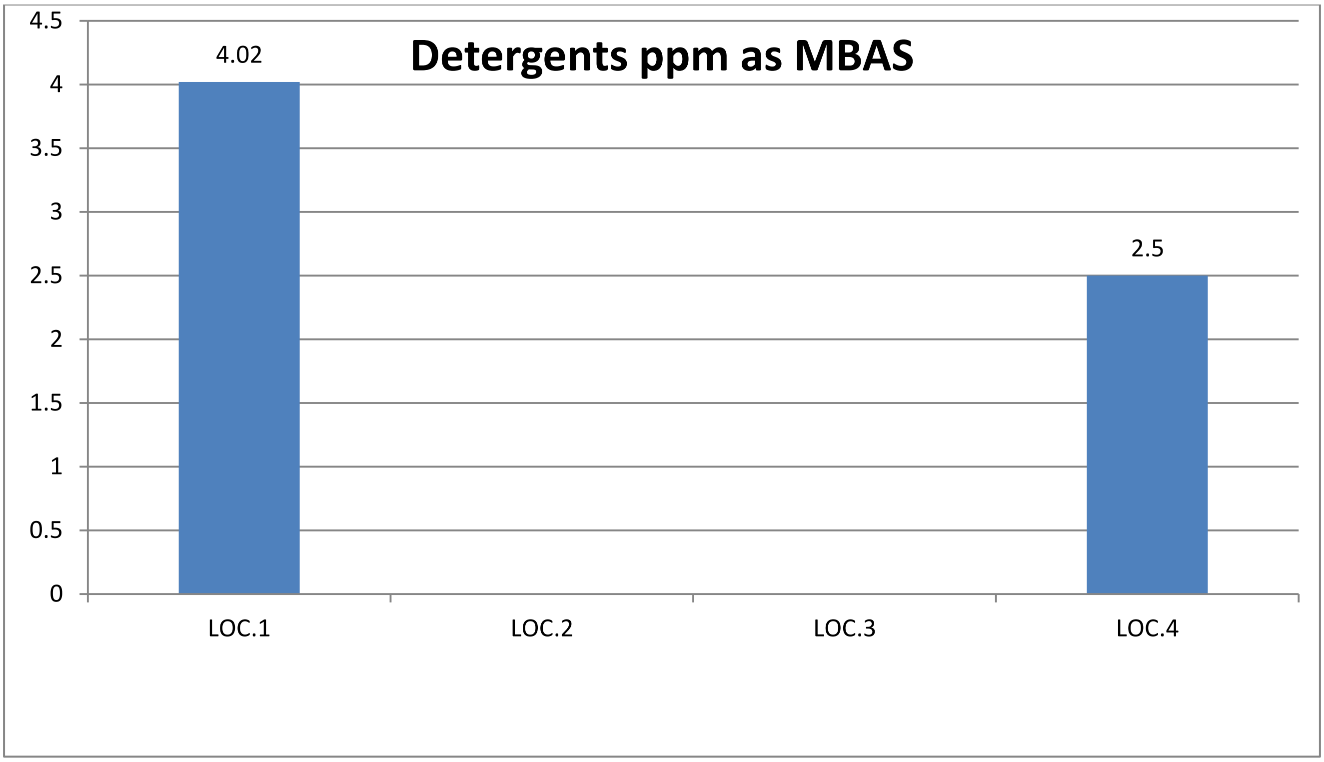
	LOC.1	LOC.2	LOC.3	LOC.4
Chloride ppm as cl	311.9	299.91	307.9	299.9

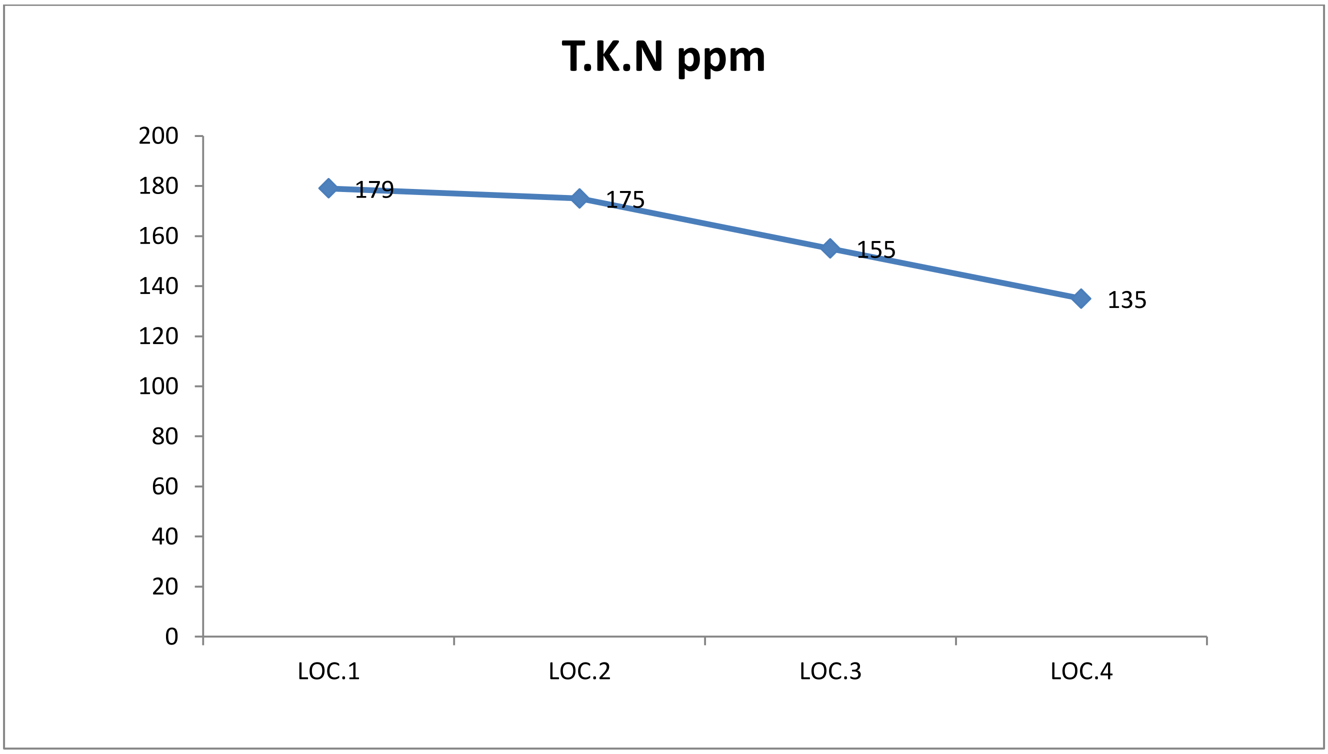


	LOC.1	LOC.2	LOC.3	LOC.4
Calcium ppm as Ca	32	29.6	32	30.4


Sodium
ppm
300
290
280
270
LOC.1
LOC.2
LOC.3
LOC.4
Sodium ppm as Na
282.54
282.54
282.54
282.54


Total Phosphorus
ppm
27.5
27
26.5
26
25.5
25
24.5
24
23.5
23
27.04
24.68
24.55
24.87
LOC.1
LOC.2
LOC.3
LOC.4
Total Phosphorus ppm
24.68
27.04
24.55
24.87


Detergents ppm as MBAS
4.02
2.5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
LOC.1
LOC.2
LOC.3
LOC.4


T.K.N ppm
200
180
160
140
120
100
80
60
40
20
0
179
175
155
135
LOC.1
LOC.2
LOC.3
LOC.4

Appendix 3:households data

حجم الخزان لتر	معدل الدخل شيقل	الاعاقة	اناث female	ذكور male	Family member عدد الافراد	St #-1 3-2	الاسم name	الرقم
1500	2000	0	2	1	3	1	فوزي حمد أحمد رضوان	1
1500	400	0	3	2	5	1	نائل فوزي حمد رضوان	2
1500	600	0	1	2	3	1	محمد فوزي حمد رضوان	3
1500	1000	0	1	3	4	1	أحمد فوزي حمد رضوان	4
2000	1000	0	5	4	9	1	أمل فايز حمد أبو رضوان	5
2000	1200	0	2	2	4	1	اشرف فايز حمد أبو رضوان	6
2000	500	0	3	3	6	3	توحيد رضوان منصور رضوان	7
2000	1000	0	2	2	4	3	شادي توحيد منصور رضوان	8
1500	3000	0	2	5	7	3	جمال رضوان منصور رضوان	9
1000	500	2	4	5	9	3	جمعة رضوان منصور رضوان	10
500	750	1	2	4	6	3	محمد رضوان منصور رضوان	11
500	2000	1	1	5	6	3	مازن محمد رضوان رضوان	12
500	3000	0	6	2	8	3	فتحي رضوان منصور رضوان	13
500	2000	0	2	3	5	3	رياض محمد رضوان رضوان	14
500	1500	0	6	2	8	3	ماجد محمد رضوان رضوان	15
1500	400	1	2	7	9	1	عدنان حسني عطية رضوان	16
1500	1500	0	3	5	8	1	علاء حسني عطية رضوان	17
2000	300	0	1	3	4	1	محمد حمد أحمد أبو رضوان	18
2000	700	0	2	5	7	1	شريف محمد حمد أبو رضوان	19
1000	600	0	1	5	6	1	فايز محمد حمد أبو رضوان	20
1000	600	0	3	4	7	1	ياسر محمد حمد أبو رضوان	21
2000	600	0	1	1	2	1	إسماعيل محمد حمد أبو رضوان	22
1500		0	5	4	9	2	زياد محمد سالم رضوان	23
1500	3000	0	6	4	10	2	رأفت علي حماد أبو رضوان	24