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Assessing the Feasibility of Wastewater Finishing Treatment by Modified Sand Filters

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Abstract:

The purpose of this study was to investigate the performance of the modified biosand filter in lab. scale. In order to achieve this purpose it had been decided to change (modify) the traditional biosand filter. The modification attempt included the invention of other stage to the tradition one. Since at the tradition one was including only one stage of that target wastewater to be sequentially flown down through different filtration material layers those including fine sand ,small gravel and large gravel.

Target wastewater in the modified biosand filter be passing up flow in a second stage or part (modified part) through other three filtration material layers those including small gravel at the bottom, fine sand and small gravel.

Along with the experiment period of 90 days, daily results been collected, analysed and yet tabled at the laboratories of the Publicly Owned Water Treatment Station – Palermo that being operated by AMAP. Those analysis been conducted were included the bacteriological and chemical different parameters within the standard measures.

The E. coli and Total Coliform was carrying out by MF membrane filtration, and the other chemical parameters as standard methods, the study found that filtrated water or effluent has very low turbidity, total suspended solid, BOD and COD, and very high removal. The removal efficiency of the Total nitrogen and Total phosphorus was 40 to 60%. The pH was around 7-7.8. From 92 to 95 as a removal average of the Total Coliform and E. Coli.

According to the obtained results this study highly recommend the use of the modified biosand filter technology and yet to be adapted on a large scale especially in my home country (Libya) and developing countries as well. It would be necessary to insure the correct construction, operation and maintains procedures be in a parallel with monitoring plane.

Acknowledgment

In preparing this thesis, I was in contact with many people including academicians and practitioners. They contributed toward my understanding and thought in particular I wish to express my sincere appreciation to my main thesis supervisor prof. Salvatore Nicosia and Dr eng. Torregrossa Michele for their advices, guidance and motivation. Without their continued support and interest this work would not have been as presented here. From the depth of my heart, I am grateful to you sirs.

I am also indebted to Laboratory Team in study site at the Publicly Owned Water Treatment Station - Palermo, operated by *AMAP – Azienda Municipal Acquedotto Palermo* for training and their help, and also for all the staff in my department I deserve special thanks for their assistance for everything, it is not possible to list all of them in this limited space. I am grateful to my family particularly my father who guides me in all my life stages.

To my mother's spirit I dedicate my work.

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By the name of ALLAH

Chapter 1

Introduction

1-1 Overview

More than a billion people in development countries lack access to safe and reliable source of drinking water. Half humanity lives without clean water or basic sanitation kill more people every year, and every year 1.8 million child dies from water related diseases (UNDP, 2006), than AIDS, Malaria and Tuberculosis combined are effected the most Diarrhoeal diseases from water related illness affect the ability of children to absorbed nutrients, thus effecting the growth of both their brain and their body. Generally poor health conditions and many hours/day spent just to bring water for their families (Nth et al. 2006) are the overall picture.

Among the affordable, cheap techniques of water sanitation we will deal with biosand filters (BSFs). The BSF is an excellent choice due to the low cost, good performance, limited requirements, and provide natural appearance and other more benefits. For large wastewater flows, BSF has the possibility to be used in small scale for family or large scale community where area of land is available.

This work is aimed at improving the efficiency of biosand filter (BSF) by changing the filtration layers in BSF functional design approach. The work also attempts to put proper perspective on the appropriate design of BSF for improving its performance.

The BSF which we used in our work, as tertiary treatment step or after secondary treated, produce water free of coloration, odour and bacterial load, so that it can be used in food preparation, person hygiene sanitation, or agriculture in case of large scale design models.

1-2 Fundamentals

All the natural treatment methods of wastewater utilize the same mechanism with non significant different, all of them based on biological and environmental factors. BSFs is a starting point in a long way to improve wastewater treatment technology, which grows up in Nicaragua in early 1990s by Dr. David Manz, University of Calgary, Alberta, Canada.

The methodology on which the BSF detects the pathogenic factors and epidemics, has been focusing on most traditional common techniques such as membrane filtration, presence/absence, most probable number etc., with the authorities agreement in mind time and cost factors.

Today, BSF are used in over 65 countries, many technical reports have been published confirming that under optimal conditions of operation, BSF is able to remove 97% of fecal coli form, 100% giardia cysts, 99.98% oocysts , 100% worms parasites up to 90% organic and inorganic toxicant from wastewater.

Water is scarce and recycling domestic wastewater for private and public landscape irrigation can reduce potable water use by up to 50% (DHWA, 2002). The appropriateness of any treatment methods for use everywhere depend on many factors includes the following:

- type of raw water related;
- affordable cost;
- education level and local customs;
- probable water - related diseases
- and other environmental and demographic factors (Nath et al., 2006).

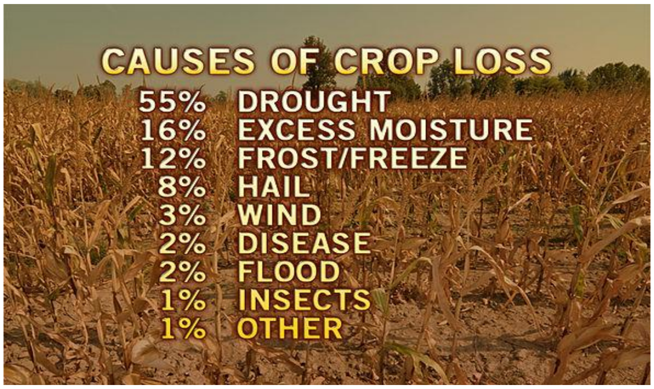


Figure 1.1 Losses in cropo production caused by drought and other adverse factors

1-3 Short history

Sand filtration as earliest technology to water treatment started its development by John Gibb in Scotland 1804, to obtain clear water. Its design was improved by Robert Tom in 1829. After John Snow linked the outbreak of disease such as cholera and typhoid fever to waterborne contamination, sand filter become mandatory for potable water drawn from River Thames.

From 1852 (Huisman and Wood, 1974). Further convincing proof of the effectiveness of SSF at controlling waterborne disease, was provided in 1892 by the expertise of two cities, Hamburg and Altona, which both abstracted water from the River Elbe. The former deliverer drink water from the River untreated, while the later filtered the supplied water.

When river water become infected with the cholera, Hamburg suffered from cholera epidemic, while Altona escaped the epidemic. SSF was the sole method of water treatment until the development of RSF rapid at the end of 19^{th} century (Ellis 1985), which flowed by another chemical and coagulation techniques in water treatment, this new technology led to decline in the use of slow sand filters. (Bowles et al., 1983).

Despite the wide spread of SSF as a water treatment method, operational strategies and of filtration mechanisms remain limited. Indeed there is comparatively little scientific literature on SSF, compared with the volume of material published on rapid sand filter (Luiza, 200).

- damage in ecosystem along Elbe river due to flood protection

a-  b- 

Figure 1.2 a- Damage along Elbe river due to flood protection. b- Health problem by arsenic and fluoride in ground water in India.

The main goal of this study:

- The first aim of this invented literature reviewed and evaluated biological, physical, processes within Biosand filter in small lab scale,
- The major purpose of the case study is to improve the design operation,
- To assess the impact of environmental condition such as variation of salt concentration, PH, temperature,
- Attempt to reduce pathogenic to zero level in base of in/output concentration (removal capacity),
- To find an acceptable treatment solution before its safe disposal in environment and/or reuse,
- To reduce organic matter, solid nutrients, diseases causing organisms,
- The improvement of the knowledge about the problem.

Frequently asked question in wastewater treatment

- What are sand filters? Sand filters refers to technology designed to employ ecological processes found in nature, utilize sand gravels and associated microorganisms to remove contaminated from wastewater.
- What are sand treatment systems? Mainly there are three types: Surface flow, subsurface flow, and vertical subsurface flow.
- Are sand filters reliable? The ability of the sand filters made the WHO to recommend this technique for water treatment in the developing countries, where clean drink water is unavailable.
- What do they effectively treat? Most of the researches in sand water treatment, showed that it has good potential to remove most of the pathogens up to 90%, regarding turbidity , it also manages to filter more than 90%, and the total suspended solid above 18%.
- How does sand filtration works? There are three mechanisms classifications: physical, biological, and chemical processes, can be illustrated into:
  - a- Physical straining
  - b- mechanically trapped by the pore spaces in the sand depend on bacteria cell size or cell shape and also large particular
  - c- Adsorption / attachment – sticking to the sides of the sand grains .
  - d- Predation – where is diversity in life form at any ecosystem there is predation which is one of relations ,as parasite commensalism between bray and predator an ecological system sustained by nutrients and oxygen.
  - e- Natural death -The end product of metabolism are in reverse transferred in to the liquid phase where any essential nutrients to microorganisms is not supplied ,biological reaction will be effected. There for if any one of these nutrients is exhausted at certain depth of biofilm, biological reaction will not occur in the deeper layers, which lead the death of pathogenic factors (Natural death) ref- (IWAI. Kitao 1994).
- What is the adverse effects that may be expected during the operational period of the filter?
  - clogging by high inlet turbidity, microorganisms, and/or organic matter content.
  - anaerobic condition by high organic matter.
  - gaseous bubbles and possibly obnoxious odors.
  - The filter box does not have cracks and is not leaking cracks lead to water leaking out of filter, and adverse effects.

1-4 Water state and life forms

Foreword

Water is made up of two hydrogen atoms and one oxygen atom. Water is unique, it has an unusually high boiling point and absorbs enormous amounts of heat for such a simple compound, its solid phase is less dense than its liquid phase, and it is considered a universal solvent dissolving almost anything by time.

Water is essential for life forms, no life without water. There are many things known about water, yet, we are increasingly aware of what we don't know about our intricate and intimate relationships with water. Approximately 2.5% of the Earth's water is freshwater; 30% of freshwater is in the form of groundwater (WHO) and only 0.3% is available as surface water which is used by water policy decisions.

The United Nations (UN) estimates that the Earth's human population will increase from 7 billion in 2011 to 8 billion in 2025, and then to 9 billion by 2043. It is also estimated that by 2025, 1.8 billion people will be living in areas with absolute water scarcity (the UN estimates the abandon amount will be less than 500 m^3/person annually) and 2/3 of the world's population will be living under water stressed conditions (less than 1700 m^3/person annually). The Food Agricultural Organization and the UN concluded that world water use has been growing twice of the rate of population increase in the past century. Increasing populations and water consumption, combined with uncertainties (FWO) due to climate change, result in enormous challenges for us in the future.

We must address these challenges and improve our water resources now to ensure that future generations have the ability, knowledge, and resources to maintain clean and abundant water resources for their posterity. The challenges we currently face are daunting, but not insurmountable. We are starting to approach water resource management in a more holistic manner, by recognizing that the natural and engineered worlds are interwoven – impacts from wastewater (treated or not) affect water sources which affect the way drinking water is managed and treated. As the title suggests, this study including this comprehensive approach, the method for secondary wastewater treatment as supporting teamwork and enhancement researchers in this important issue, and always the first aim is to safe people's life everywhere.

Earth or blue planet and water

Water arrive to us by two ways: from the sky as rain, or coming out from the earth as springs. In both cases, it appears purest and potable throughout human history on the planet. Our planet contains 1400.000.000 km water, all of this huge water body is in continuous movement, the life form will be finished on the earth without movement factors, these movements in form of water cycle, water currents in the oceans, and seas etc., using great energy which we cannot imagine, such as sun temperature, winds, volcano, earthquake, tides, season change, all these factors give us pure water, without it, all the planet water become contaminated because billions of billions of pathogenic microorganism live in water.

Some facts about water

- The amount of evaporated water from total earth surface/year is 380.000 km^3 (atmosphere holding capacity).
- 320.000 km^3 evaporated from water surface and comeback as rain to the same surface just 284.000 km^3 (-36 km^3) !
- 60.000 km^3, evaporated from land surface !
- and comeback to land in rain form 96.000 km^3 (+36.000 km^3) !
- the oldest life forms began in the water before 3800 million years !
- The oldest life forms began in terrestrial before 400 million years (after 3400 million year water)
- There aren't any biological reaction occur except in water media.

The amount of rain is the same every year the different is where it rain some region after 6-7 year like in Nevada desert (Zaghloul,)

Figure 1.3: A water drop

Table(1:1): Human body and water

Baby body contain	90% water
Adult man body contain	65 -70 % water
Adult women body	60-65%

1-5 Sustainable investment in treated wastewater

Sustainable is defined as ‘it meets the needs of the present without compromising the ability of future generations to meet their own needs’ (WCED, 1987). The ‘Bruntland Report’ for water

resources, Feitelson and Chenoweth (2002*) interpret this as ‘water resources left for future generations should be of similar quantity and quality as those available to current generations’.
Especially in developing countries, it is predicted that over half the world’s people will face water shortages during the next 30 years (Postel, 1997. UNEP, 2002. Hunt, 2003).

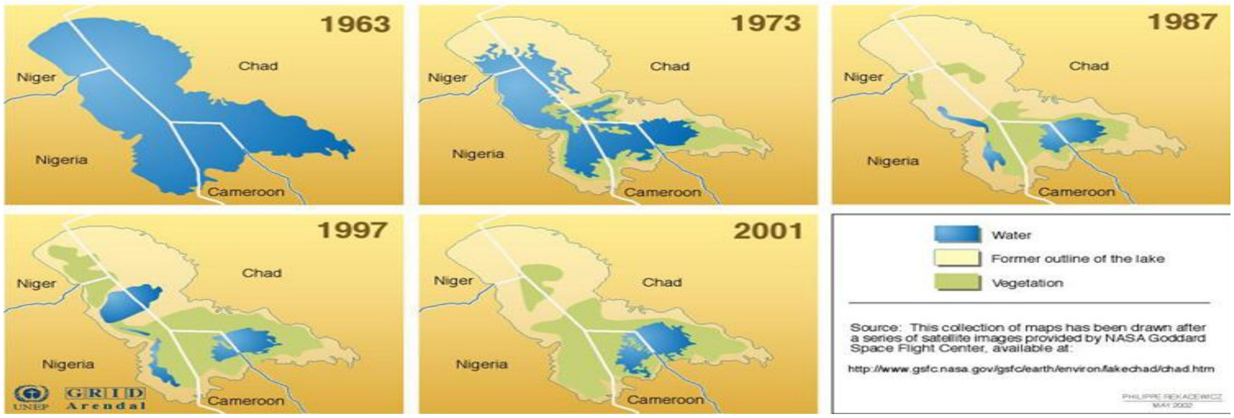


Figure 1.4: The progressive disappearance of Lake Chad in Africa.

Agriculture consumes vast quantities of water (~70 percent of global extracted water), in addition to industries, and there is an enormous currently unfulfilled, domestic demand for water. The development and exploitation of water resources, to meet these needs, must be sustainable (as defined above), and part of the solution leads towards sustainability, concerning domestic wastewater treatment. This includes:

- Direct re-use of treated wastewater in agriculture and aquaculture
- Indirect re-use which is discharge into inland surface, used by downstream communities for agricultural and industrial use, as well as for domestic supply.

Developing countries authorities (which may be city or town councils, or specific wastewater treatment authorities, need to understand that domestic and other wastewaters require treatment before discharge or preferably, re-use in agriculture and/or aquaculture. They also need to act, but first they need to decide where, when and how much to invest in wastewater treatment.
The Example below shows the economical benefit of treated water re-use.

As an example, a city with a population of 500,000 and water consumption of 200 l/d per person would produce approximately 85,000 m^3/d (30 Mm^3/year) of wastewater, assuming 85% inflow to the public sewerage system. If treated wastewater effluent is used in carefully controlled irrigation at an application rate of 5000 m^3/ha.year, an area of some 6000 ha could be irrigated.
In addition to the economic benefit of the water, the fertilizer value of the effluent is of importance.

With typical concentrations of nutrients in treated wastewater effluent from conventional sewage treatment processes as follows: (Nitrogen (N): 50 mg/l), (Phosphorus (P): 10 mg/l), (Potassium (K): 30 mg/l);
assuming an application rate of 5000 m3/ha.year;
the fertilizer contribution of the effluent would be:- N: 250 kg/ha.year, P: 50 kg/ha.year and K: 150 kg/ha. year.

Thus, all of the nitrogen and much of the phosphorus and potassium normally required for agricultural crop production would be supplied by the effluent. In addition, other valuable micronutrients and the organic matter contained in the effluent will provide additional benefits.

Many developing countries have a warm or hot climate, and often they have sufficient land for land-intensive wastewater treatment technologies (WSP, for example). They should take maximal advantage of their climate and their land availability for wastewater treatment. Generally these two 'natural' processes are used in series, treating the wastewater first anaerobically and then photosynthetically.

The following issues are considered in relation to wastewater treatment investment:

- Engineering feasibility,
- Economic feasibility,
- Financial feasibility,
- Development of a construction financing plan and revenue program.
- Institutional feasibility,
- Formal discussion with suppliers, wholesalers, retailers, and users of reclaimed water,
- Environmental and Social impact and public acceptance
  - distance from irrigated land (economic criteria).
  - distance from protection zones and surface water bodies.

with the goal to reach an agreement on legal and operational responsibilities with clear future visions.

Table (1.2): Capital expenditure in smart water system for leaking management in selected countries during 2011-2018

Country / $m	2011	2012	2013	2014	2015	2016	2017	2018
USA	128.5	141.1	157	174.7	194.9	217.6	243.1	271.7
UK	82.6	90.8	99	107	116.3	132.7	149.8	173.8
AUSTRAL	67	75.1	86.3	101	102.9	109	112.4	118

Source: GWI

Table (1.3): Comparison factors in wastewater treatment in industrialized and developing countries

Factor Industrialized		Developing countries
Efficiency	C•••••	••••
Reliability	C•••••	C•••••
Sludge production	•••	C•••••
Land requirements	C•••••	••
Environmental impact	••••	••
Operational costs	•••	C•••••
Construction costs	••	C•••••
Sustainability	•••	C•••••
Simplicity	•	C•••••

Notes: C: critical; •••••: extremely important , •: no impact.

Source: adapted from von Sperling (1996a*)

Secondary influent characters in study site and in other semiarid zone in the Middle East

Table (1.4): Major Constituents of typical domestic wastewater

	Concentration, mg/l		
Constituent	Strong	Medium	Weak
Total solids	1200	700	350
Dissolved solids(TDS)[1]	850	500	250
Suspended solids	350	200	100
Nitrogen (as N)	85	40	20
Phosphorus (as P)	20	10	6
Chloride[1]	100	50	30
Alkalinity (as $CaCO_3$)	200	100	50
Grease	150	100	50
BOD_5[2]	300	200	100

Source: UN Department of Technical Cooperation for Development (1985) FWO book published 1992, Wastewater treatment and use in agriculture, URL http://www.fao.org/docrep/T0551E/T0551E00.htm

Table 1.5: Average composition of wastewater in Amman, Jordan

Constituent	Concentration, mg/l	Constituent	Concentration mg/l
Dissolved solids (TDS)	1170	Alkalinity (as $CaCO_3$)	850
Suspended solids	900	Sulphate (as SO_4)	90
Nitrogen (as N)	150	BOD_5	770
Phosphorus (as P)	25	COD[1]	1830
		TOC[1]	220

FWO book published 1992, Wastewater treatment and use in agriculture URL http://www.fao.org/docrep/T0551E/T0551E00.htm

Table 1 6: Chemical Composition of wastewaters in Alexandria and Giza, Egypt.

Constituent	**Alexandria**		**Giza**	
	Unit	**Concentration**	**Unit**	**Concentration**
EC	**dS/m**	**3.1**	**dS/m**	**1.7**
pH		**7.8**		**7.1**
SAR		**9.3**		**2.8**
Na^+	**meq/l (mg/l)**	**24.6 (565.8)**	**mg/l**	**205**
Ca^{2+}	**meq/l (mg/l)**	**1.5 (30)**	**mg/l**	**128**
Mg^{2+}	**meq/l (mg/l)**	**3.2 (38.4)**	**mg/l**	**96**
K^+	**meq/l (mg/l)**	**1.8 (70.2)**	**mg/l**	**35**
Cl^-	**meq/l (mg/l)**	**62 (2200)**	**mg/l**	**320**
SO_4^{2-}	**meq/l (mg/l)**	**35 (2800)**	**mg/l**	**138**
CO_3	**meq/l (mg/l)**	**1.1 (66)**		
HCO_3^-	**meq/l**	**6.6(402.6)**		
NH_4^+	**mg/l**	**2.5**		

Constituent	Alexandria		Giza	
NO_3	mg/l	10.1		
P	mg/l	8.5		
Mn	mg/l	0.2	mg/l	0.7
Cu	mg/l	1.1	mg/l	0.4
Zn	mg/l	0.8	mg/l	1.4

FWO book published 1992 Wastewater treatment and use in agriculture URL http://www.fao.org/docrep/T0551E/T0551E00.htm

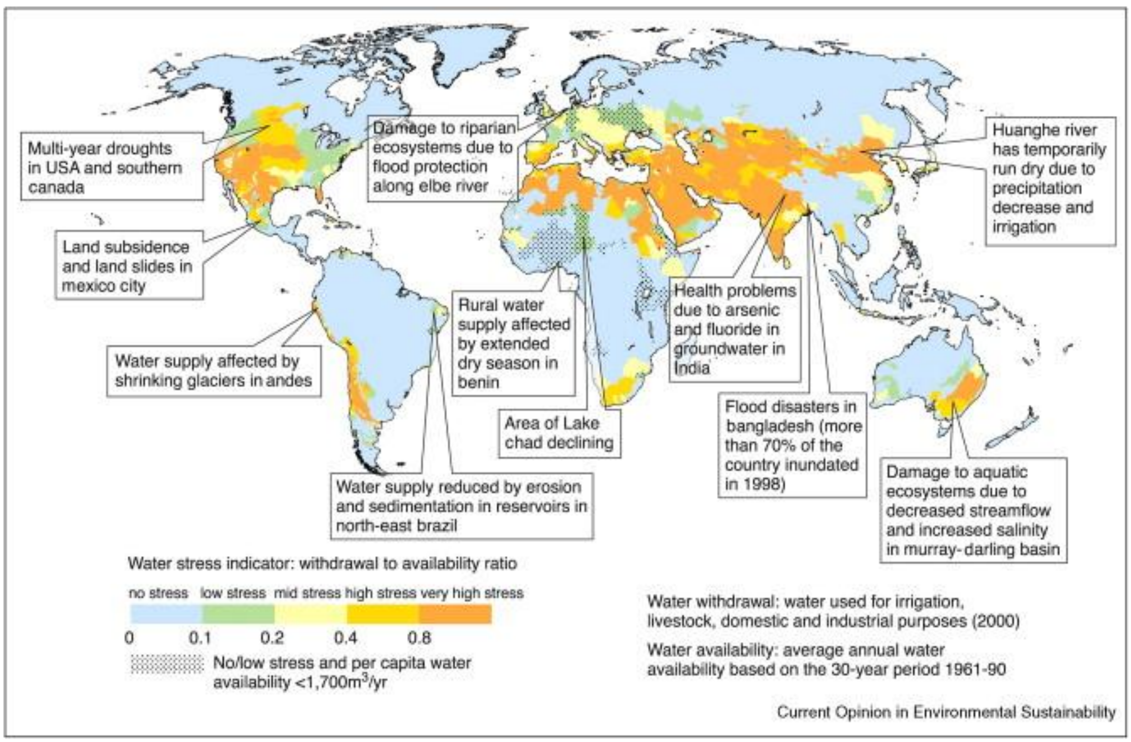


Figure 1.5 Global water problems

Chapter 2

Wastewater Treatment Mechanisms

2-1 Introduction

Wastewater treatment and re-use needs high engineering understanding of wastewater microbiology for two reasons: first, because wastewater contain micro-organisms that cause human disease, and secondly, because most wastewater treatment processes are biological processes. We generally use the term 'biological wastewater treatment' to reflect this.

Wastewater treatment must be done for a specified purpose – for example, to produce an effluent water suitable for agricultural or aquacultural reuse (or both), moreover, to produce an effluent that can be safely discharged into inland or coastal waters. Wastewater treatment plant designers have to know what is going to happen to the effluent: re-use or discharge, before they design the plant as the effluent quality requirements will vary. Regulatory agencies have to be responsible to define the governing legislation of water treat and re-use. Unfortunately, in many developing countries not all such regulations are as sensible as they should be.

Mono-disperse suspensions of colloids and water-saturated micro models employed: Different particle sizes, grain surface roughness, solution ionic strength, and flow rates. Straining and attachment were observed and measured by tracking the trajectory and fate of individual colloids using optical microscopy. Classical filtration theory proved to be appropriate for throat to colloid ratios (T/C) larger than 2.5mm, but did not take into account the possibility of straining that becomes an important capture mechanism for smaller colloidal particles (Maria, vol 42).

2-2 Mechanism Affecting Retention of Pathogenic Bacteria

2-2-1 Straining

The straining is defined as particles too large to pass, through the interstices between sand grain (Hoarhoff and Cleasby ,1991). Another definition by Huisman and Wood for the strain is: Tightly packed bed of spherical grain could capture particles about 15% of grain diameter (Huisman and Wood 1974). A clean sand of 200μm effective size, is expected to capture particles of about 30 μm in size by straining, this is substantially large than man bacteria particles to be removed from surface water as shown in table(2.1). Strain mechanism consider as purely physical phenomenon

Table (2.1) Dimensions of Variable pollutants

1- Cyst	**(1-20 mm)**
2- Bacteria	0.1 to 10 µm
3- Viruses	0.01 to 0.1 µm
4- Colloid particles	0.001 to 1µm

(Haaroff and Cleasby, 1991)

2-2-2 Porous Media(Filter media) In Pollutants Removal

Variability in dimension, surface texture and charge of porous media, influences the adhesion process (M.F. DeFlaun and L.M.). Fine sand particle sizes expose a larger surface area compared to large particles, hence providing good ability to adhesion D.E. Fontes, A.L. Mills, G.M. large cation exchange capacity, and the occurrence of a large surface area per unit volume. large cation exchange capacity and the occurrence of a large surface area per unit volume, the surface roughness of a medium may increase the adsorption as a result of reduced shear forces thereby lowering adsorption rates and increased substratum area.

In the media with macro-pores, adhesion will be reduced, due to decreased contact time and increased distance, between bacteria and the media. Solid surfaces in natural environments often carry negative electrostatic charges, T.C. Loder and P.S. Liss. This surface charge will depend on the ionization of surface groups, or adsorption of ions from the aqueous phase.

The ionization of surface groups is determined by the pH of the solution J.T. Gannon, Y. Tan, P. Baveye and M. Alexander,. Media having the greatest difference in surface charge from the bacteria would be expected to have the greatest bacterial adhesion M.A. Scholl, A.L. Mills, J.S. Herman and G.M. Hornberger.

2-2-3 Pathogenic shape and size

Cell size and shape play an important role in retention the pathogenic from wastewater according to the classical filtration theory as described in straining above . The classification of organisms according to their shape

2-2-3-1 Viruses

Virus size is very small compared with sand grain diameter, and virus removal mechanism are not fully understand , but it is believed that they are remomed mainly by sedimentation and we theoretically and practically trying in our work and modifying concerning to employment gravity factor to enhancement the sedimentation mechanism to improve performance and removal efficiency. Sedimentation of virus following adsorption to bacteria , and algae as hosts (which settle out when they die).more researches studies is required in this field.

2-2-3-2 Bacteria

Bacteria are the most important microorganisms in water and wastewater treatment process. Because it is source of disease infection caused million of death, bacteria have many shape and size as Rods, staphylococcus, streptococcus, spiral.

Bacteria shape influence their transport through a porous media: large bacteria cells are assumed to removal with more effectively in filtration, in starvation at decrease of bacterial cell size become more effectively in penetrate into the pores.

2-2-3-3 Role of protozoa in wastewater treatment

1 - add weight to flux particles and improve their settling.
2 - consume dispersed cells and cleanse waste stream.
3 - recycle nutrients in water systems especially (N-P).
4 - produce and release secretion that coat and remove fine solid.

2-2-4 Clogging

The flow pattern change during the filter run, due to biomass in the porous media Schwager and Boller, found a significant increase in wastewater retention time, with the filter media by the time of run, this was explained by changes in the hydraulic properties of upper part of the filter. Clogging may be caused by the accumulation of stable solid materials between, or on the surface of the porous (Siegrist et al ., 1987).

Clogging may be due to an improper balance of the intricate microorganism within the filter, and accumulation of biomass from the growth of the microorganisms, and execration of substance by some bacteria ,4 filtration of wastewater involves the development of pore clogging mainly at the infiltration surface, and deeper layer in filter media. building up of biofilm may restrict pore size, and thus enhances the effect of straining.

There is much experimental evidence that removal of bacteria is more efficient in clogged filtration system compared with unclogged system [44, 45, 46] Kristainsen 48 found highest concentration of *fecal coli forms* in outlet water, of sand filters that were least biofilm maturation. Clogged can cause hydraulic dysfunction, anoxic condition and diminished wastewater purification 49 50. The suggested remedies for head loss and clogging problem, which is associated with the filtration cycle, can be reduced by implementing the flowing:-

- judiciously select the type of filter media multimedia provide efficient utilization of filter depth, better response to high solid and longer filter run,
- design filter system with option to operate either parallel or in series mode in case high load SS, series operation could help to meet the requirement of effluent quality to minimize the problem of backwash,

- incorporation modification of upstream clarification process e.g. polymer addition to decrease SS loading,
- add ballast tank to stabilize the influent flow and solid concentration
- provide automatic control to ensure even flow distribution among filter
- provide formal training on filtration technology and filter operation to all operators who work with filtration system

2-2-5 Adsorption

The word "adsorption" was coined in 1881 by German physicist Heinrich Kayser (1853-1940), Adsorption is the binding of molecules or particles to a surface. Must be distinguished from absorption, the filling of pores in a solid, Molecular sieves are used as adsorbent for gases and liquids. Molecules small enough to pass through the pores are adsorbed while larger molecules are not. It is different from a common filter in that it operates on a molecular level and traps the adsorbed substance.

For instance, a water molecule may be small enough to pass through the pores while larger molecules are not, so water is forced into the pores which act as a trap for the penetrating water molecules, which are retained within the pores. Because of this, they often function as a desiccant. A molecular sieve can absorb water up to 22% of its own weight.[7]

The principle of adsorption to molecular sieve particles is somewhat similar to that of size exclusion chromatography, except that without a changing solution composition, the adsorbed product remains trapped because, in the absence of other molecules able to penetrate the pore and fill the space, a vacuum would be created by desorption.

2-2-6 Porous media

Transport of suspended participate matter is widely recognized to occur in subsurface environments. Field data indicate that viruses, bacteria, and clay minerals can migrate considerable distances, and that small particles and macromolecules, are implicated in the transport of organic contaminants and radionuclides.

Furthermore, media permeability can be significantly altered by changes in aqueous chemistry, through particle release and capture. Quantitative models for predicting particle transport are available, within the water filtration literature, that account for the mechanisms of particle-media collisions and the conditions for attachment. Predictions from the filtration models are used to analyze particle migration through porous media, at typical groundwater flow velocities. As particles accumulate within media pores, available models become less predictive because of the coupling between particle retention and permeability reduction.

An examination of filtration data reveals that retention of a relatively small solid volume within media pores can reduce media permeability by orders of magnitude. The fact that contaminants adsorbed to particles are mobile has important implications in understanding and predicting contaminant transport

- Removal of pathogenic in slow sand filter of secondary clarifier effluent, mainly depend on the sand surface area, grain size, and *Schmutzdecke* (Langendbach et al., 2009).
- Within SSF Transport mechanisms and active movement bring bacteria in contact with the *Schmutzdeck*, with the sand grains and the biofilm on sand grain. Retention of this bacteria in filter system is due to adsorption and straining (Huisman and Wood, 1974).
- The concentration of bacteria retained, or immobilized is a function of the concentration of bacteria in water, reflect the factors below:
    - Sand grain size
    - Sand bed depth
    - Sand surface area
- Kinds of bacteria mobile or immobile (bio diversity) Ellis,K.,1995 ,1987 SSFas techn

2-2-7 Bio film

Ripening time can be defined in many ways but a filter could be considered ripened when the *E. coli* bacteria removal reaches 90% . some previous study showed that:

a- Biofilm Maturation time
• Slow Sand Filters: 2 to 4 weeks running continuously
• Nepal (Dipina study of 4 filters): 3 weeks

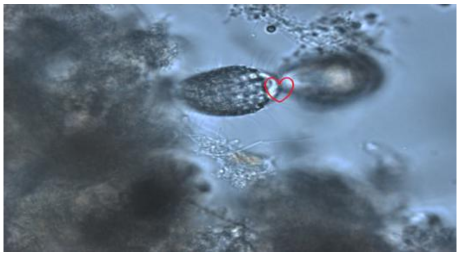


Figure 2.1 A biofilm from our BSF

• Haiti (Duke, 2006 5 filters): within 3 to 4 weeks
• Lab study of BSF at UNC (Stauber, 2006): Ripening time varies, probably due to influent water quality"
• Evidence of 'deep bed maturation' over longer period (i.e. a year) will significantly improve virus removal (Elliot, 2011 and Bradley, 2011)
Incidentally: our BSF result show good performance after 2-3 weeks (see Chapter 5).

b- Process of substrate utilization by biofilm is three steps

I. Substrate transport from the bulk liquid to external biofilm
II. Diffusion of substrate within biofilm surface

III. The substrate consumption by microorganisms within the biofilm.

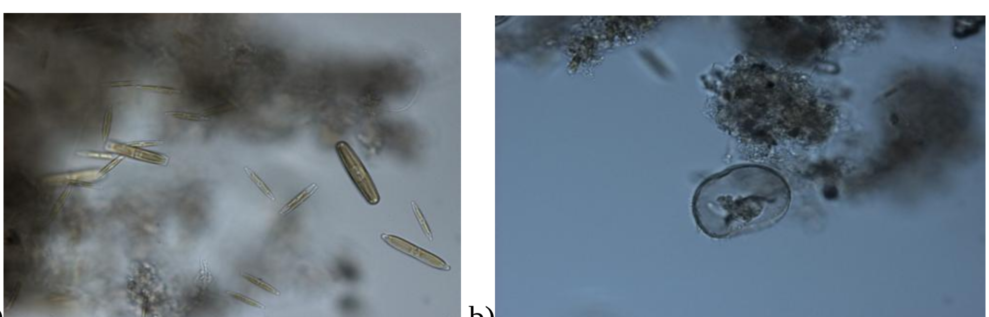
The first step is the most important, although it is a purely physical phenomenon because, under the steady state condition , the rate of overall reaction , resulting from step 2 and 3, always equal to the rate of the first step, colloid and suspended organic matter, cannot diffusion in to biofilm directly, these must be hydrolysis to low molecular mass, before diffusion process take place in biofilm. (Iwai. Kitao 1994).

Biofilms in aquatic environments and especially in drinking water distribution systems are places for the long-term persistence of potential pathogens such as *E. coli*, *Legionella*, *Klebsiella* and/or *Pseudomonas*. However, real biofilms hardly occur in oligotrophic, energy-limited aquifers, numbers of *Legionella* spp. detected in groundwater were always lower than those detected in man-made environments. Legionella species might survive also protected in protozoa amoeba. The human pathogenic *L. pneumophila* proliferates in various amoebal hosts.

Fortunately, so far high numbers of infected amoeba have been found only in cooling towers but not in natural environments. Therefore, this association between bacteria and amoeba might be favored only under special environmental conditions.

Together with a multitude of natural non-pathogenic bacteria some faecal pathogens developed a unique strategy to survive in oligotrophic, energy-limited conditions. These bacteria, including the species *E. coli*, *E. faecalis*, *V. cholerae*, *Shigella spp.*, and *Campylobacter* spp. may change their physiological stage and enter low-active or dormant, viable but not cultivable state. This state, characterized by a very low content of nucleic acids and significantly smaller cell size, allow the organisms to resist unfavorable conditions.

Although still alive, partially still infectious or at least able to return to an infectious stage they are no longer detectable by traditional enrichment assays (Oliver 2005). One of the most persistent bacterial states of dormancy is the survival in spores. The production of spores, as known for species of the genus *Bacillus* and *Clostridium*, allows surviving hostile conditions such as the physical and chemical treatments used in drinking water production. Fortunately, efficient adsorption of *Cl. perfringens* spores to sand particles was shown, however the attachment was reversible for most of the spores dependent on their total concentration.



a) b)

Figure 2.2 Different microorganisms in the BSF biofilms, a- *Diatoms* b- *Amoeba*

2.3- Mechanisms affecting contaminants elimination

2-3-1 A Biotic Factors

2-3-1-1 Temperature as an Environmental constraint:-

Enzymes are biological catalysts whose function is affected by a variety of factors including temperature, which, at different ranges, may improve or hamper enzymatic mediated reactions. This will have an effect over the optimal cellular growth and metabolism. Which permits classification of microorganisms according to the range of temperatures, at which they can survive and reproductive.

For instance: psychrophiles (<25°C), mesophiles (25-45°C), thermophiles (45-60°C) and hyper-thermophiles (60-121 °C). Although such cells optimally grow in these temperature ranges there may not be a direct relationship with the production of specific metabolites. In most wastewater treatment methods, psychrophiles (<25 °C) that range of temperature is preferred in most treated pond. See table (5)

Table 2.2: Survival of excreted pathogens (at 20-30°C)

Type of pathogen		Survival times in days			
		In faeces, nightsoil and sludge	**In freshwater and sewage**	**In the soil**	**On crops**
Viruses					
1	*Enteroviruses*	<100 (<20)	<120 (<50)	<100 (<20)	<60 (<15)*
Bacteria					
1	*Faecal Coli forms*	<90 (<50)	<60 (<30)	<70 (<20)	<30 (<15)
2	*Salmonella* spp.	<60 (<30)	<60 (<30)	<70 (<20)	<30 (<15)
3	*Shigella* spp.	<30 (<10)	<30 (<10)	-	<10 (<5)
4	*Vibrio cholerae*	<30 (<5)	<30 (<10)	<20 (<10)	< 5 (<2)
Protozoa		<30 (<15)	<30 (<15)	<20 (<10)	<10 (< 2)
1	*Entamoeba histolytica cysts*	<30 (<15)	<30 (<15)	<20 (<10)	<10 (< 2)
Helminths		Many	Many	Many	<60 (<30)
1	*Ascaris lunbricoides eggs*	Months	Months	Months	

* Figures in brackets show the usual survival time. Source: Feachem *et al.* (1983)

2-3-1-2 Organic matter content

Most organic compounds of human, animal or plant origin in sewage effluent are rapidly decomposed in the environment. Under aerobic conditions, breakdown is generally faster and more complete (to carbon dioxide, minerals and water) than under anaerobic conditions. The latter prevail in the soil profile during continuous or long-term flooding. Stable, non-toxic organic compounds such as humic and fulvic acids can be formed as products of reactions between proteins and carbohydrates (cellulose or lignin).Table (1) major constituents of typical domestic wastewater

Table 2.3 wastewater strength in term of BOD_5 and COD

Concentration, mg/l

Strong	BOD_5	COD
Weak	<200	400
Medium	350	700
Strong	500	1000
Very strong	>750	> 1500

Source: UN Department of Technical Cooperation for Development (1985) FWO book published 1992 Wastewater treatment and use in agriculture

The BOD_5 of sewage varies from several hundred to about 1000 mg/l for raw sewage, and from about 10 to 20 mg/l for good quality secondary effluent. systems can handle high BOD-loadings, probably hundreds of kg/ha day (Bouwer and Chaney, 1974). BOD, TSS, COD, turbidity and ORP levels are generally reduced to zero after treated by our BSF through sand. However, the final product water from BSF systems free or with minimum organic matter contents according to the obtained results.

2-3-1-3 pH

pH is an indicator of the acidity or basicity of water but it is seldomly a problem by itself. The normal pH range for water quality is from 6.5 to 8.4; pH values outside this range are a good warning that the water is abnormal in quality. Normally, pH is a routine measurement in irrigation water quality assessment. Moreover, pH in liquid phase may affect the extent of adsorption of bacteria to solid surface which depend on the nature of bacterial surface and ionic strength.

In solutions, the importance of pH in determining the surface charge increases at low ionic strength. Increasing retention of bacteria has been found to occur when pH was decreased from 9.3 to 3.9 (Tor Kristaian Stevk el al., 2003). The pH in our BSF effluent ranged between 7 to 8 during run time which were three months. In an experiment with *S.typhi* and *E.coli*, Cohen found that survival was optimal at pH between 5-6.4. This range is present in influent source which feed the BSF. **Cohen B. disinfication studies. J bacteria 1922:7:183-230**

2-4 Biotic factors

2-4-1 Bacteria species

As we see in table (2) the variation of organisms in size, bacteria, Virus as smallest pathogenic and the most dangerous with dimension between o.o2 to 0,2, fortunately virus cannot live as free organism, but only in other plants or animal cells as host to be able reproduce itself by combine the DNA of host cells

Table 2.4: Average size ranges of selected microorganisms and viruses.

Class	Microorganism	Size
virus	Bacteriophage -	0.02-0.2 µm diame
Poliovirus		0.03 µm diameter
Bacteria	Bacterial spores- (Bacillus, Clostridia)	1 µm
E. coli -		0.5 µm x 1.0 µm x 2.0 µm
Salmonella typh		0.6 µm x 0.7 µm x 2.5 µm
Shigella spp		0.4 µm x 0.6 µm x 2.5 µm
Protozoa	Cryptosporidium oocysts	4.0-6.0 µm diameter
Giardia		7.0-14.0 µm diameter
Enteroamoeba histolitica		20-25 µm diameter

Resource: Steffen Krauss, Christian Griebler: Pathogenic Microorganisms and Viruses in Groundwater, acatech Materialien Nr. 6, München 2011.

2-4-2 Other microorganisms

Viruses

The smaller a particle, the easier it may pass filters such as soil and sediments. Hence, the penetration of pathogenic viruses to aquifers seems much more likely than for pathogenic bacteria and protozoa . The risk of viral contamination of water is further increased because of the extremely high numbers by which enteric viruses are shed into the environment. Their numbers in infected individuals range from105 up to 1011 per gram of stool (Fong and Lipp 2005). Moreover, viral pathogens from human and animal faeces have much longer survival times in water than most intestinal bacteria, are generally more infectious than bacteria and protozoa and are remarkable resistant to common disinfection treatments. These features make pathogenic viruses the most important, candidates for faecal contamination of groundwater.

Protozoa

Most common species of human pathogenic protozoa include the zoonotic *Cryptosporidium parvum*, *Giardia lamblia*, and *Toxoplasma gondii* as well as *Entamoeba histolytica* which potentially cause severe diarrhea, encephalitis or even dysentery in the infected individuals (Smith and Smith 1990; Exner and Gornik 2004). Generally infections with the four mentioned protozoan pathogens are self-limited in healthy individuals. However, they can cause life threatening diseases in elderly, immunocompromised hosts or unborn children. Within parasites *E. histolytica* infections are third in terms of lethality, right behind malariacausing plasmodia and schistosomes (Marshall *et al.* 1997). While giardiasis and amoebiasis can effectively be cured with drugs, at present no efficient drug treatment exists for cryptosporidiosis (Smith and Smith 1990; Chakrabarti and Chakrabarti2009)

At present, several symbiotic and pathogenic interactions between bacteria and free-living protozoa or even higher organisms (e.g. copepods).For example, increased numbers of the protozoan parasites Naegleria spp. generally go along with a contamination of the water with coli forms. Some species of protozoa were shown to interact with *Legionella* spp., and might play a role in its distribution and removal. For more information see table (4)

Table 4: Factors that influence the survival of pathogens in the subsurface

Factor	Influence
Temperature	Long survival at low temperatures, rapid die-off at high temperatures. For some faecally-derived bacteria high temperatures might give rise to growth.
Moisture content	Desiccation is detrimental to most microorganisms (spores excepted). An increased rate of reduction will occur in drying soils. This is of most relevance in the unsaturated zone.
Sunlight	More rapid die-off at the soil surface due to UV irradiation.
pH	Bacteria die-off more rapidly in acid soils (pH 3-5) than in alkaline soils. The pH influences the adsorption of microorganisms and viruses to the soil matrix and indirectly influences survival.
Organic carbon content	The presence of organic carbon increases survival and may give rise to the regrowth of bacteria
Cations	Certain cations have a thermal stabilising effect on viruses and increase virus survival. Cations also enhance virus adsorption to soil and this indirectly increases survival, as viruses appear to survive better in the adsorbed state.
Micro flora	Soil bacteria and fungi may produce exo-enzymes that damage the structure of faecal microorganisms, while amoebae and other protozoa may feed on them. Bacterial survival is shorter in natural soils than in sterilised soils, but for viruses no clear trend is observed.

Resource: Steffen Krauss, Christian Griebler: Pathogenic Microorganisms and Viruses in Groundwater, acatech Materialien Nr. 6, München 2011

Chapter 3

Traditional Biosand Filters in the Globe

3-1 Biosand overview

Biofiltration encompasses all forms of water filtration that include a biologically mediated treatment component, and this includes a wide variety of applications, designs, media, filtration rates, and water treatment capabilities. This review focuses particularly upon intermittent slow sand filtration (SSF) or bio-sand filtration (BSF), a ―low technology‖ water treatment process that has a long history of successful international application (Figure 1).

The performance of BSF is controlled by an ecosystem of living organisms (biolayer or *schmudzdecke*) whose activities are affected by the raw water quality, and in particular, by the temperature. The quality of the treated water and the maintenance requirements for the system depend on selected variables like sand size, flow rate, and sand bed depth.

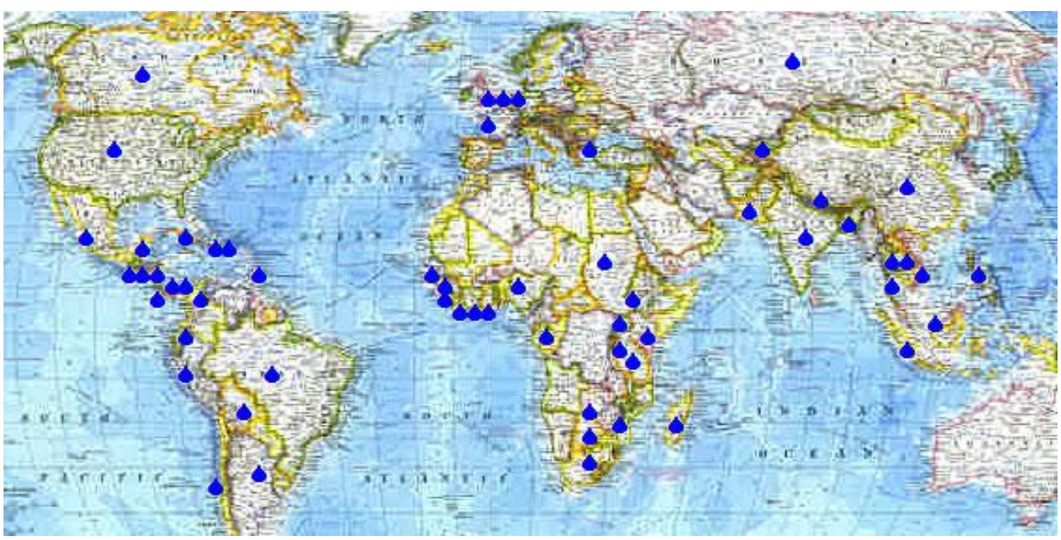


Figure 3.1, shows more than 300,000 Household BioSand Water Filters in more than 100 countries (source: Google Maps)

The sand used is characterized by its effective size (ES or d10) and uniformity coefficient (UC or d60/d10). The recommendations for ES vary between 0.15 mm and 0.40 mm (Hagedorn C, et al.

1981). The UC should be between 1.7 and 3.0, but preferably not greater than 2.7 (Ziebell WA, et al. 19741). The sand bed depth can be up to 1.4 m and a minimum depth of 40 cm.

The conventional flow rate is 0.1 m/h or 0.6 L/m (Hagedorn C, et al. 1981). However, it is possible to increase the flow rate considerably if effective pre-treatment is given, and if an effective disinfection stage follows the filtration (Ziebell WA, et al. 19741). The National Environmental Engineering Research Institute (Stewart LW, et al. 1981). in India used flow rates of 0.1, 0.2 and 0.3 m/h and found no significant difference in fecal coli form reduction. Huisman and Wood (Viraraghavan T, 1978) reported the use of higher filtration rates (0.25 and 0.45 m/h) without any marked difference in effluent quality.

Additionally, BSF, due to its relative simplicity of design, basic maintenance procedures, and low labour costs, has often been considered suitable for smaller, less developed communities or those with less knowledge, skills, or access to higher technologies. However, SSF has also been applied for the treatment of water at large-scale process plants in highly developed countries. SSF, as with other water treatment technologies (individually or in treatment trains as operational systems), has distinguishable capacities for the improvement of water quality.

These capacities have been well described and are detailed in numerous published papers, reviews, manuals, and texts. In fact, Huisman and Wood (Viraraghavan T, 1978) state ―No other single water treatment process can improve the physical, chemical, and bacteriological quality of surface water better than bio-sand filtration.‖ Nonetheless, two drawbacks to the household BSF can be noted:

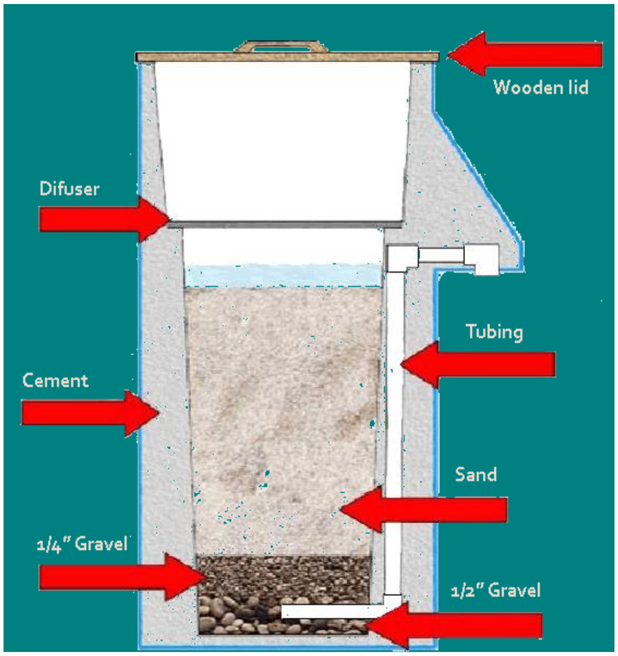


Figure 3.2 show BSF components

3-2 The BSE components

Filter body according to the available raw material and cost it might be plastic, concrete, or ceramic Lid (cove), diffuser, pipes for collect treated water and discharge tube, sand and gravel selected and prepared carefully, Figure (3.2)

3-3 Biosand Filter can treat the following water different sources

- Water from ponds, lakes, cisterns, reservoirs, rivers, streams,
- Water from shallow and deep wells,
- Rainwater,
- Spring water,
- Unsafe water from piped systems,
- Unsafe delivered water,
- Grey water.

3-4 Biosand Filter can remove the following pathogenics

- Helminthes (eggs and worms) 100%

- Parasites (Giardia, Amoeba, Schistosomiasis, and Cryptospordia) 100%
- Bacteria 100% (with disinfection)
- Viruses 100% (with disinfection)
- Spores 100%
- Sand, silt and other suspended solids including algae (turbidity less than 0.3 NTU if used with roughing filter and coagulants)
- Oxidized iron, manganese and hydrogen sulfide 100% (may use oxidants such as chlorine or potassium permanganate)
- Fluoride (Nalgonda technique)
- Organic and inorganic toxins including
- Colour, taste and odour (with GAC) 100%

Biosand filters have been shown to remove 90-99% of pathogens found in water. The filter has been tested by various government, research, and health institutions, as well as by non governmental agencies in both laboratory and field settings.

- Overall, these studies have shown that the biosand filter removes:
- • > 97% of *E. coli* - an indicator of fecal contamination (Duke, 2006; Stauber, 2006)
- • > 99% of protozoa and helminths (Palmateer, 1999)
- • 80-90% of viruses (Stauber, 2005)
- • 50-90% of organic and inorganic toxicants (Palmateer, 1999)
- • 90-95% of iron (Ngai, 2007)
- • Most suspended sediments

Based on slow sand filter research, the biosand filter may also remove some heavy metals (Muhammad, 1997; Collins, 1998). There is also a design modification known as the KanchanTM Arsenic Filter that is effective in removing both pathogens and 85-90% of arsenic from source water (Ngai, 2007).

- Preliminary health impact studies estimate a 30-40% reduction in diarrhea among all age groups, including children under the age of five, an especially vulnerable population (Liang, 2007; Sobsey, 2007).

3-5 Filter material descriptions

This report summarizes the literature on the topic of specifications for media of sand-based on-site wastewater treatment systems. The granular media must be coarse enough to permit a sufficient flow rate yet fine enough to provide adequate treatment. Media that is too coarse lowers the wastewater retention time to a point where treatment becomes inadequate.

Media with small grain size slow the water movement and increase the chance of clogging. The effective size (D10) and uniformity coefficient (Uc) are the principal characteristics of granular media treatment systems. The ideal sand media for intermittent sand filters is a coarse sand with an effective size between 0.3 mm and 0.5 mm. The media sand grains should be relatively uniform in size having a low Uc value (less than 4.0) to promote movement of water and prevent clogging.

A goal of a granular media specification is to balance the desired wastewater treatment performance with the preferred hydraulic performance. Granular media should be neither too coarse nor too fine. Coarse media may allow wastewater to pass too quickly through the filter without receiving adequate treatment, while very fine media can slow the water movement too much, reduce aeration within the media, and increase the chance of clogging. Washed graded coarse sand is the most common because of its availability and relatively low cost.

3-5-1 Effective Particle Size

The effective size (ES) is defined by the size of screen opening where 90 percent of a sample of granular media is retained on the screen and 10 percent passes through the screen, and is referred to as D10. The larger the grain size, the faster the wastewater moves through the sand and the more wastewater that can be filtered.

However, if the grain size is too large, treatment efficiency will be reduced. Boller et al. (1994) observed larger breakthroughs of unoxidized matter due to short retention times and instantaneous lack of oxygen when applying relatively large hydraulic loads to filter media with coarse grain size, especially above 1 mm. The ideal sand for intermittent sand filters receiving domestic wastewater is coarse sand with an effective size between 0.3 mm and 0.5 mm (Crites and Tchobanoglous, 1998; Ohio State University, 1999). Clogging becomes a major concern when using sand with an effective size less than 0.3 mm.

3-5-2 Uniformity Coefficient

The uniformity coefficient (Uc) is a numeric estimate of how sand is graded, and is a dimensionless number or in other words it has no units. The term ìgradedî relates to where the concentrations of sand particles are located by size. Sand with all the particles in two size ranges would be defined as narrowly graded sand and would have a low Uc. Sand with near equal proportions in all the fractions would be defined as widely graded sand and would have a high Uc value. The Uc is calculated by dividing D60 (the size of screen opening where 60% of a sample passes and 40% is retained) by D10 Washington State Department of Health Wastewater Management Program(the effective particle size- that size of screen opening where 10% of a sample passes and 90% is retained). The larger the Uc the less uniform the sand.

It is important that the sand grains all be about the same size; i.e. relatively uniform. A uniformity coefficient of 4 or less is recommended for all filter media (National Small Flows Clearinghouse, 1997)

(Crites and Tchobanoglous, 1998; EPA, 2002). This recommendation is intended to avoid clogging at higher loading rates (Darby et al., 1996). Sands from most natural sources are widely graded containing a variety of grain sizes, which results in a high Uc. If the grain sizes vary greatly, the smaller ones will fill the spaces between the larger particles, making it easier for the filter to clog An ideal sand media has both large surface area to permit wastewater to have maximum contact with the zoogleal film on the particles where most of the treatment is accomplished, and sufficient pore space to allow aeration and unsaturated flow (Ball, 1997). Because sand media treatment is aerobic in nature, the exclusion of fines from the filter media is extremely important to maintain open.

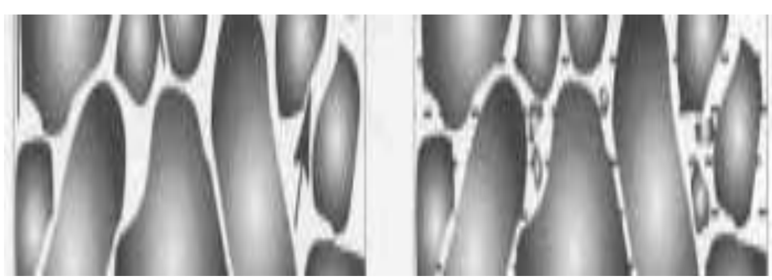


Figure 3.3 shows high UC, widely graded sand (left) and low UC, narrowly graded sand (right)

Table 2 shows how the physical performance of the granular media changes in response to different values in the Uc. Sands with higher Uc values have a more tortuous path (smaller and more convoluted pores spaces) for wastewater to move through and will have lower infiltration rates or permeabilities.

Table 2.1. Physical Performance Data for the Various Uc Values, taken from (Dixon, 1994)

Physical Properties	Sand Uc = 1.5	Sand Uc = 2.3	Sand Uc = 4.6
Infiltration Rate (in/hr)	41.1	34.9	12.7
Bulk Density (g/cc)	1.5	1.6	1.8
Total Pore Space (%)	42.4	39.5	32.3
CapillaryPoreSpace (%)	5.0	4.6	14.4
Saturation (%)	11.8	11.6	14.4

Usually the water retention is also greater with sands that have a higher Uc due to smaller pore volumes and higher bulk densities. These conditions run counter to the objective for a good filter media, which should have sufficiently large pore spaces to allow ample oxygenation and unsaturated flow around the sand particles (Ball, 1997).

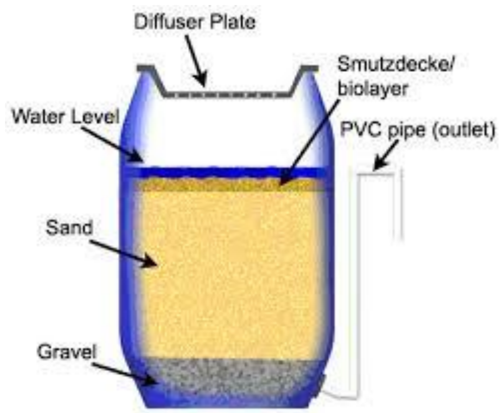
At a hydraulic loading rate of 4 gpd/ft2 and high dosing frequencies (24 times/day), media uniformity does not appear to have as much effect on treatment performance as the media effective size does (Nor, 1991, Darby et al., 1996). The lower per-dose application rate supports thin-flow flow conditions and allows good treatment regardless of media uniformity.

At a high dosing frequency of 24 times/day, (Nor 1991) observed that a sand with high uniformity (D10=0.42 mm, Uc = 1.42) produced worse, but still good (3.9 log) total Coliform removal compared to washed concrete sand (D10=0.29 mm, Uc= 4.52), which produced a 4.7 log Coliform removal. However, as the per-dose application rate increases (less frequent dosing), media uniformity becomes more significant because it affects pore geometry and conditions under which thin-film flow occur (Darby, 1996).

- **General considerations:** when selecting wastewater treatment solution should take in account the following questioners:

- how much wastewater would we like to treat?
- which contaminate are actually in wastewater?
- the cost of methods and raw material
- the environment impacts?
- ground water depth?
- treated water reuse?

4-3-**Bio-sand filter components:**

a 

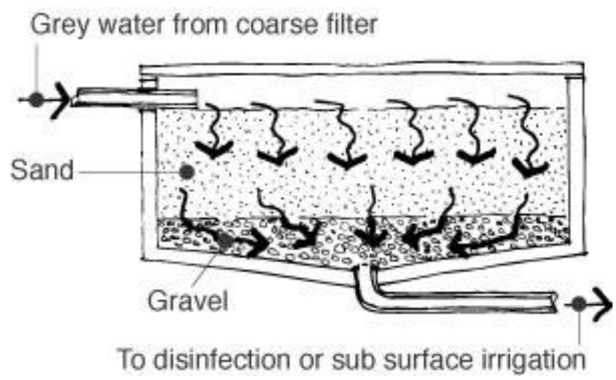
b 

Figure 3.4 a- Traditional biosand filter b- Illustrative diagram of biosand filter showing the composite of sand, gravel and container

- **Specification**

3-Methods and material

The performance of sand filters is influenced by numerous factors, which includes bio augmentation, media, depth, grain size distribution, mineral composition of media, treatment, wastewater composition, nutrient concentration, hydraulic and organic loading rates, temperature, and dosing techniques (Crites and Tchobanoglous, 1998) all these factors are very essentials in any of the wastewater methods

Biosand filter and contaminates removal mechanisms

a-**Biological:**

As all natural processes physical , chemical and biological treatment ,micro-organism consume organic and inorganic substance in autotrophic or heterotrophic feeding methods this process occur in surface sand layer. and other species interaction like predation , parasitic et.tjis mechanism consider as most important removal and or elimination mechanism occurance in upper sand layer of sand filter.

By the time biofilm growth, or increase in maturation, the flow rate through the sand decreases with usage, and this limit of water availability, may lead to the application of excessive flow or use of other untreated water sources.

A- Mechanical:

Another treatment mechanism is mechanical trapping in which organisms and other small particle captured by fine sand and gravel layer this occurred through al biosand layers

B- Adsorption:

Is adhesion of atomic or molecular from liquid dissolved solid to the surface of adsorbent, adsorption may be physic-sorption or chemisorptions in water purification ion exchange between matters molecules

C- Natural or ecological death:

Naturally death in biology normal result in any ecosystem when limiting factor for survival decrease to the minimum or the ecosystem lose one of limiting factors organisms leading to immigration, adaptation or and last choice natural death.

Chapter 4

The Modified Sand Filter in our Study

The Design and construction

The Biosand filter is defined or described as a set of processes whereby wastewater organic and inorganic material is removed by biological, chemical, and physical operations.

4-1 Foreword

There are two ways to build a house; one might study the construction of many houses. Perhaps a large subdivision or even hundred of thousand of houses, or one might study the construction of particular house, the first approach is across-case method.

The second is a within sample study method, while both are concerned with the same general subject *building house* they flow different bath to the same goal.

In our field, just few cases give better idea about the performance, but there are usually trade-off in my choice and it is able to improve continuously, all the naturally treatment methods of wastewater are the same mechanism with non significant different all of them based on biological and environment factors.

The starting point of the bio-sand filter is a long way to improve wastewater treatment technology which growing of working in Nicaragua in early 1990’s by Dr David Manz University of Calgary . alberta .Canada.

As for the ways in which will detect the pathogenic factors and epidemics, has been focusing on most common technique and traditional such as membrane filtration, presence/absence, most probable number etc.. With the authorities agrees in mind time and cost factors.

Today, Bios and filter are used in over 65 countries. Many technical reports have been published confirm that under optimal condition of operation BSF is able to remove 97% of focal coli form, 100% giardle cysts, 99.98 oocysts, 100% worms parasites up to 90% organic and inorganic toxicant from wastewater.

Water is scare and recycling domestic wastewater for private and public landscape irrigation which can reduce potable water use by up to 50% (DHWA, 2002). The appropriateness of any treatment methods for use everywhere depend on many factors includes the flowing :-

Type of water related, cost, education level such as local customs, water related diseases and environmental demographic factor (Nath et al., 2006).

4-2 Modified Biosand Filter (MBSF) design:

This purpose of the study was to investigate the effectiveness and the performance of the modified Bio-Sand filter in removal of wastewater contaminants. To achieve this goal we added another stage to the common bio-sand filter to become bi-biosand filter.

To investigate the effectiveness and the performance of the bio-sand filter, where wastewater passing in two directions, down flow in first part and up flow in the second part of the filter. As we believe that the process of removing contamination will be more successful.

When water movement is adverse of the gravity, which is evidence of nature, it is find that the purest types of water are springs come out from the earth. From this natural observation we simulated our idea in lab scale filter, the question is how the bio-sand filter works? The mechanism by which filter remove contaminate is biological, physical and chemical removal processes.

Figure 4.1.Spring water in nature

In our attempt, we kept designs which were previously successfully entered into application and usage, and spread widely worldwide and supported by the World Health Organization. In our case, we added to those who have gone before us, the complementary part; which composite of three different layers of different sand texture fine, small and large.

The treated wastewater by first part of bio-sand passing to the second part of as up-flow starting from the bottom of the second part to top in this trip all the processes occurred in first part will continue. In addition to employment of a very important factor gravity, plays an active role in the slower and retain contaminate in the bottom as supported to filter layers already mentioned.

The other factor relying on the speed of the water flow in biosand filter controlled the different water level between first and second part of biosand without any energy required and pause period time decrease and increase. Which has direct relation with retention time to inducement microorganism to consume organic and inorganic material and thus reduce pollutants to minimum.

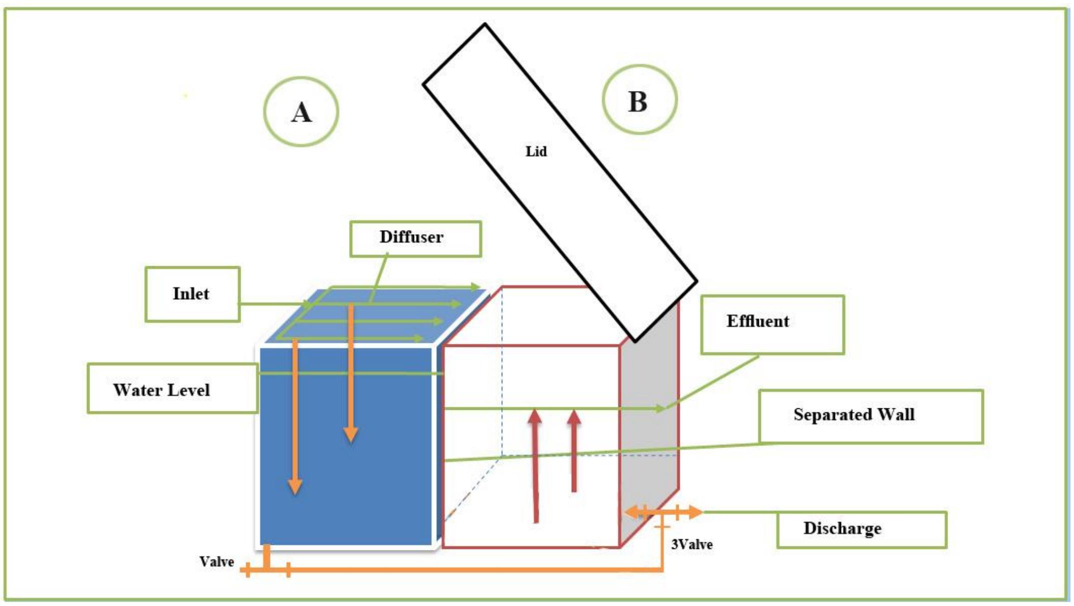


Figure 4.2 Design of BSF shown the BSF parts and the arrows indicate water direction.

To achieve this goal we add another part to the traditional bio-sand filter to become bi-biosand filter, to investigate the effectiveness and the performance of the bio-sand filter in which the secondary treated water passing in two directions:

- Down flow in first part (Figure (4.3)) and
- Up flow in the second part of sand filter (Figure (4.4))

Part A and B of the bio-sand (down flow)

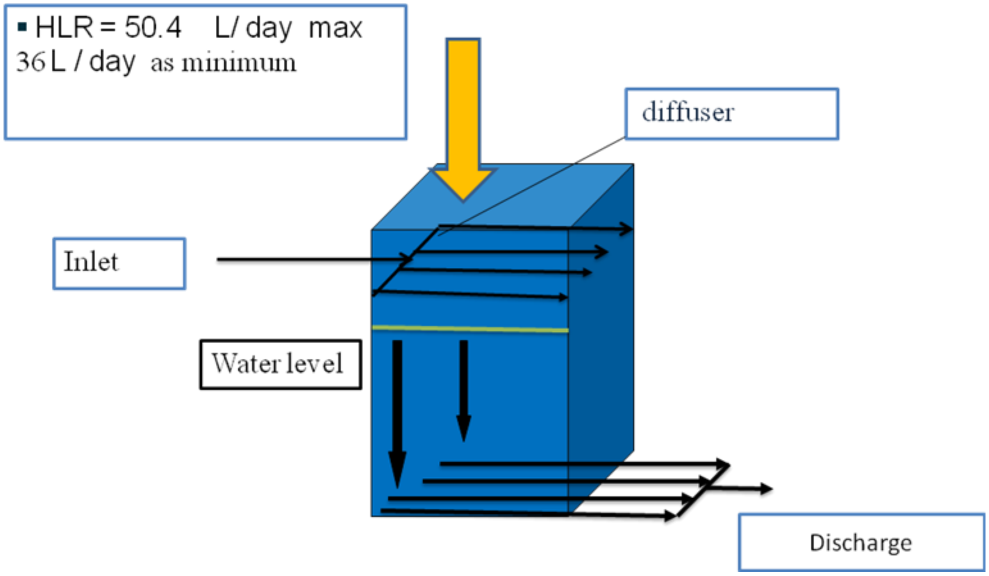


Figure 4.3 Part A of bio-sand filter (down flow)

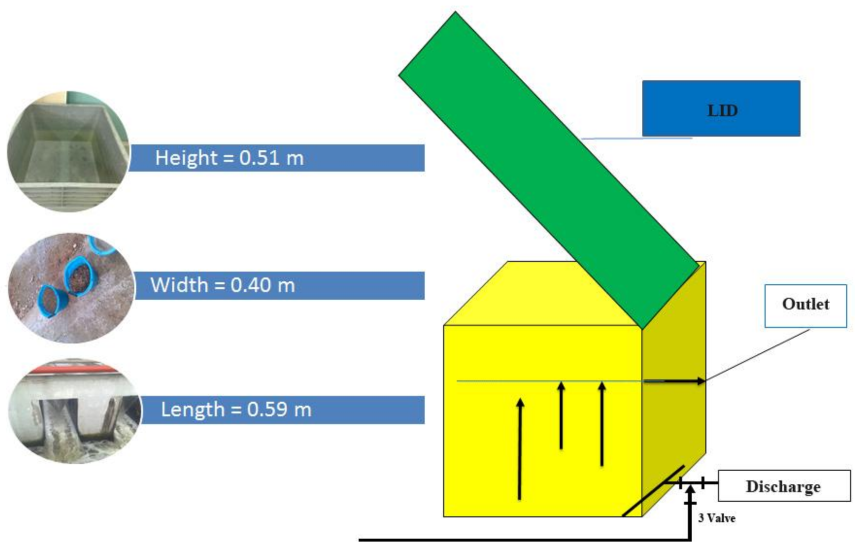


Figure 4.4 Part B of BSF with dimensions and water direction.

BSF detailed description:-

The mean water flow rate is 1.78 L/h or 42 L/d .

The Hydraulic Loading Rate (HLR) of … $q = \frac{Q_0}{A_W} = 141.9$ L/d.

The max water level in part A is 43 cm and min 40 cm

The max water level in part B is 40 cm and min 40 cm
The head loss in the BSF 3 cm

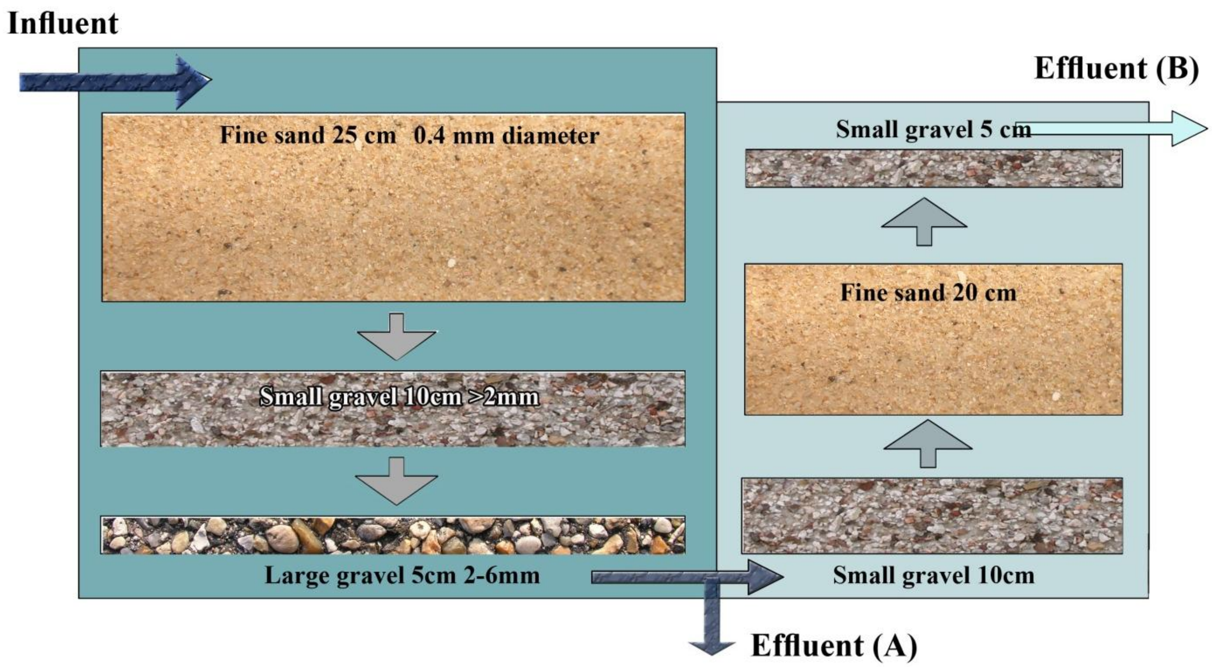


Figure 4.2. shows the Arrangement of filter layers, layer thickness, and water level in real BSF during run

Table 4.1 The BSF dimensions

Dimension	part A (down flow)	part b up-flow
Length	0,593cm	0.59cm
Width	0.52cm	0.40 cm
high	0.51cm	o.51 cm
Area m2	0.3016	0.232
Volume m3	0.1564	0.1203
Volume L	156.4	120.3

Standard water level in BSF

Water level ranges approximately 5 cm above the sand during pause period, this can be explained as follows:

- More than 5cm causing the flowing:
-Lower oxygen diffusion
-blocked the out let tube.
- Less than 5cm causing:
-may evaporate quickly specially in hot climate thin caused drying of biological layer which is the (the most important area in the system)   (Haarhoff and Cleasby, 1991)

Table:4.2 Differences between BSF and slow sand filter

	BioSand Filtera	*Slow Filtersb*
Filtration rate	0.6m/h	0.1m/h
Rest water above top sand	0.05m	1.5m
Sand depth	0.46m	0.8
Size	Higth 0.9m width 0.3m	Hight 3.5m width4-15m
Raw water quality	>100 NTU	<20 NTU

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Biosand filter rate (loading)

Flow rate per square meter of sand surface area which have been proved to be effective in lab and field test to provide an initial flow rate after prepared filter with material (sand ,different gravel size) during loading .the empirical pore –volume of initial flow rate was measured by filling the upper filter chamber full and measure the time it took to filter 500 ml

Hydraulic loading rate

Hydraulic loading rate (HLR) is the volumetric flow rate divided by the surface area and represented the depth of water distribution to wetland surface over specific time interval the hydraulic loading time can be $q = \frac{Q_0}{A_w}\ L/T$.and the used HLR are [3 (L/h) /0.3 (m^2)] = 141.9L/d.

Water depth

Water depth from approximately 0.1 to over 2.0 m, (NADB, 1993. Kadlecik, 1996).

The typical water depth is between 0.15 to 0.60 meter (Kadlecik, 1996).

In our experiment the water depth was ranged between 0.50 to 0.58 meter.

Volume (V_w)

Volume can be determined by multiplying average water depth (h) by area (A_w)

$$V_w = A_w \times h$$

Hydraulic retention time (HRT)

Is the ratio of the useable wetland water volume to the average flow rate Qavg

$$T = V_w \times \frac{E}{Q_{avg}}$$

Preparing filter materials

- Locating source of gravel and sand

Manufactured sand and gravel are required because it is clean, pure and relatively uniform in size and shape, in the absence of manufactured source, if there is other choices, one could use riverbed sand. This is not highly recommended because riverbed sand could be contaminated from animal wastes. More rounded and smooth as (opposed to angular) which decrease the effectiveness in trapping contaminates.

4-3 Tools and Materials:

Grading sieves use for separating of gravel, sand, silt and clay are as follows:-

- 12 mm (½")
- 6 mm (¼”)
- 1 mm (0.04”)
- 0.7 mm (0.03”)

Table 4.3. shown USA department of agriculture (USDA) diameter limit

Name of soil separate	
Clay	less than 0.002
Silt	0.002–0.05
Very fine sand	0.05–0.10
Fine sand	0.10–0.25
Medium sand	0.25–0.50
Coarse sand	0.50–1.00
Very coarse sand	1.00–2.00

Within this table, our filtering media ...as shown in table 10.4

Table 4.4. shown bed matrial used and location

Name of soil separate	Diameter limits (mm) (USDA classification)	Place in BSF
Medium sand	0.25–0.50	Upper layer part A
coarse sand	0.50–1.00	Second layer part B
Very coarse sand	1.00 – 2.00	Second layer part A
Gravel	2.00 – 6.00	1^{st}, 3^{rd} part B 3^{rd} part A
Large gravel	> 6	Bottom layer in both A & B

Selecting biosand filter media, the most important issue in the sand filtration, therefore the media must be selected carefully, taking under consideration the location and also:-

- Hard, durable, angular grains, free of loam, clay, organic matter and angular grains.

- The effective size d_{10} with range 0.15 – 0.35 mm.
- River bed or beach sand is more suitable required characteristic
- Decrease porosity and increased resistance to flow water.
- Free of organic matter.
- Must be washed and dried before introduce sand in plant

Figure 4.3 Sand washing, 25/10/2012

Steps of preparation

1. The sand must be passed through the 12 mm (½”) sieve, the 6 mm (¼“) sieve, the 1mm (0.04”) sieve, and the 0.7 mm (0.03”) sieve, in that order.

2. Discard the material that does not pass through the 12 mm (½”) sieve.

3. Store the material that is captured by the 6 mm (¼”) sieve – this is used for your drainage gravel layer. (used in the bottom to protect drainage pipe)

4. Store the material that is captured by the 1 mm (0.04”) sieve – this is used for your separating gravel layer.

5. Store the material that is captured by the 0.7 mm (0.03”) sieve – used as filtration sand.

6. The material that passes through the 0.5 mm (0.03”) sieve is the filtration sand that goes into our filter yet this sand should not be mixed.

Figure 4.4. Fine sand and large gravel used in the BSF

The direction of water through different biosand layers as flowing see Figure (4.2)

1-The secondary treatment water passing first 250 mm of fine sand 0.45mm

2- Layer of 100 mm of small gravel 1mm

3- Layer of 50 mm of large gravel more than 6 mm see figure 4.4

The water then moves into another part of the filter with reverse direction which is up-flow, this direction water passing another three layers to the top direction with the same texture but different arrangement from the bottom to top as the flowing:-

- Small gravel 100 mm the bottom layer in part (B)
- 200mm fine sand med layer in part (B)
- 100mm large gravel upper layer part (B) see figure 5.4

Used materials and their function in the BSF

• The plastic container: to contain the sand media and water

• Lid: to prevent contaminants from entering the system.

• Diffuser plate: to minimise and protect disturbance of the biofilm *schmutzdecke* during the filling cycle the diffuser design has holes of 3mm diameter, spaced 2.5 cm apart, for a total of about 90-100 holes. The (CAWST 2012), recommendation in the 2012 Biosand Filter Manual (3mm, 2.5 cm apart, 80-100 holes

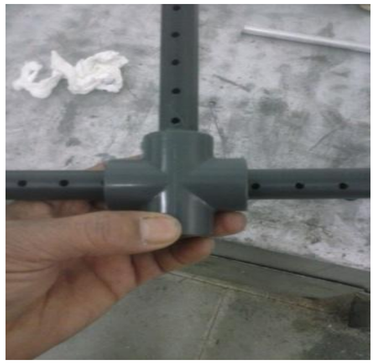


Figure 4.5 The used inlet water diffuser

• Outlet pipe: to drain water from the bottom of the filter and hydraulically control the top water level of the supernatant, and effluent sample collect tape.

Figure 4.6 The used drainage led

• Gravel layer: to support the sand. The CAWST (2008) design specifies 12 mm diameter. Gravel; the Kanchan™ 6 to 15 mm diameter gravel; the International Aid Hydr Aid™ BSF gravel diameter is unknown.

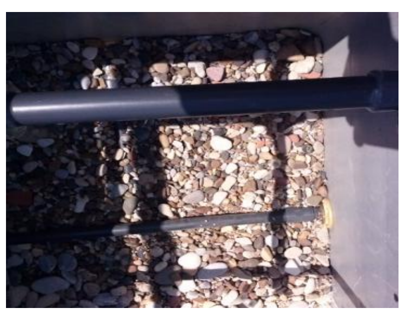


Figure 4.7.The used drainage led

• Coarse sand or small gravel layer: to prevent the fine sand from dropping in to the gravel and either leaving the system with the filtered water or clogging the outlet pipe.

• Fine sand layer: which supports the mechanical filtration and provides a surface for the biofilm formation and where most of biological treatment processes in this layer.

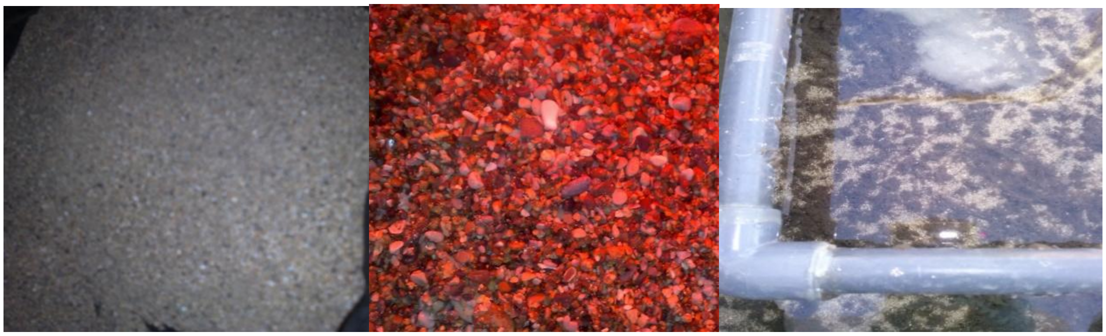


Figure 4.8 a- Fine sand, b- small gravel , c- biofilms

• Supernatant: to prevent drying out of and to facilitate oxygen diffusion to the biologically active layers.

4-4 - Biosand filter maintenance

The intra sand space (space between sand grains) will become plugged by time with suspension solid, as a result in the filtration process the flow rate will slow down, yet it is not an issue in the term of water quality. In our system, there were no need for any maintenance during the three months of experiment, since the maintenance is directly related to the influent waste water quality in addition to the amounts of organic and inorganic components.

When outflow became very slow, sand filter must be cleaned by removing very carefully about (10-15) mm of top layer of sand which includes most *schmutzdecke* maintenance are as follows:

- removal of any accumulated solids in the inlets and outlets;
- repairing any damage caused by rodents, or other animals; and
- repairing any damage to the external fences and gates.(safety procedure)

To prevent algae growth B,S. the system should be protected from direct sun light. To protect system from dust and other contaminates keep the B.S.F closed tightly. And also pause period is very important ,it make the B.S.F more active and efficiency when operates intermittently and consistently, the pause period should be a minimum one hour up to 48 h, the benefits of pause period is:-

-   Allow time for micro-organises in bio layer to consume the pathogenic in wastewater (biological treatment processes)

- Allow pathogenic to consume organic and inorganic nutrients in water and also pathogenic then Notes ; if pause period time is extended to long the nutrients cause decrees of nutrients treatment efficiency of the system decline.

- May also be required to take samples for laboratory routine analysis for screening and control.

The maintenance requirements of BSF are very simple, but they must be carried out regularly. Otherwise, there may be nuisance. Maintenance requirements and responsibilities must therefore be clearly defined at the design stage so as to avoid problems later. Routine.

Procedures to reduce maintenance

- To prevent algae growth system should be protected from direct sun light
- To protect system from dust and other contaminate keep the BSF closed tightly
- Pause period is very important, it increase BSF efficiency when operates intermittently and consistently, the pause period should be a minimum one hour up to 48 h
- Pause allow the time for micro-organisms in bio layer to grow and consume the pathogenic

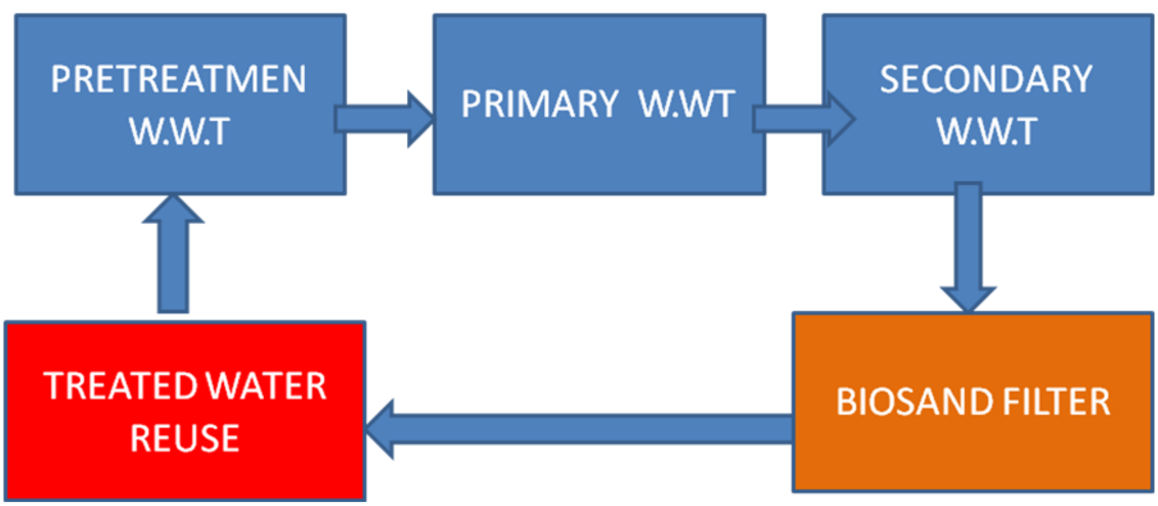


Figure 4.9 Shown position of BSF between wastewater treatment processes which appear after secondary treatment

Chapter 5

Measurements and Results

5.1- Preface

- **General Preparation**

1) Important technique, good laboratory technique is essential when accuracy is important, particularly in microbiological laboratory procedures. Care in sample collection and preservation, a clean laboratory or work surface, proper sterilization and inoculation practices, and close temperature control help assure reliable result.

2) Preparing the Work Area, to save time, start the incubator before preparing the other materials. Set the incubator for the temperature required in the procedure usually 35 ±0.5 °C (95 ±0.5 °F).or any adjustment needed, disinfect the work bench with a germicidal cloth dilute, bactericidal spray, or dilute iodine solution. Mark each pour plate, or other sample container with the sample number, dilution sample, date, and any other necessary information.

3) Preparing Sample Containers: take care to prevent contamination when conducting bacterial tests. All materials used for containing or transferring samples must be sterile. To collect samples, use any of the following: sterilized plastic bags, sterilized disposable bottles, autoclavable glass bottles, or autoclavable plastic bottles. steam sterilize glass and autoclavable plastic containers at 121 °C (250 °F) for 15 minutes. Glass sample containers may be sterilized by hot air at 170 °C (338° F) for one hour.

4) Preparing equipment required for test: use high-quality laboratory equipment and use ready media to save time and minimized error. To simplify technique and minimize the possibility of contamination, use pre. Sterilized equipment and media.

5) Collecting and Preserving Samples: volume of sample (usually 100 ml) for the guidelines to be met. The World Health Organization guidelines (WHOG). Prescribe 200 ml per sample, while Standard Methods for the Examination of Water and Wastewater prescribes 100 ml per sample. Maintain at least 2.5 cm (approximately 1 inch) of air space to allow adequate space for mixing the sample prior to analysis. Avoid sample contamination during collection. Carefully open each sample container just prior to collection, and close immediately following collection.

Do not lay the lid or cap down and avoid touching the mouth or the inside of the container. Do not rinse the container. Analyze as soon as possible after collection. Allow no more than 6 hours to elapse between collection and examination for non-potable water samples and 30 hours for potable water samples. For best results maintain the sample at or below 10 °C, but do not freeze.

6) Diluting sample: very small sample volumes may be required for samples with large coli form populations or for very turbid samples. These volumes are obtained by making serial dilutions of the sample as the flowing steps:

   i. If a 10-ml sample is required: Transfer 11 ml of sample into 99 ml of sterile, buffered dilution water. Filter 100 ml of this dilution to obtain the 10-ml sample.

   ii. If a 1-ml sample is required: Transfer 11 ml of the 10-ml dilution from step A into 99 ml of sterile dilution water. Filter 100 ml of this dilution to obtain the 1-ml sample.

   iii. If a 0.1-ml sample is required: Transfer 11 ml of the 1-ml dilution from step B into 99 ml of sterile dilution water. Filter 100 ml of this dilution to obtain the 0.1-ml sample.

   iv. If a 0.01-ml sample is required: Transfer 11 ml of the 0.1-ml dilution from step C into 99 ml of sterile dilution water. Filter 100 ml of this dilution to obtain the 0.01-ml sample.

   v. If a 0.001-ml sample is required: Transfer 11 ml of the 0.01-ml dilution from step D into 99 ml of sterile dilution water. Filter 100 ml of this dilution to obtain the 0.001-ml sample.

vi. If a 0.0001-ml sample is required: Transfer 11 ml of the 0.001-ml dilution from step E into 99 ml of sterile dilution water. Filter 100 ml of this dilution to obtain the 0.0001-ml sample.

Table 5.1. Recommended Sample Volumes

Water source	100	50	10	1	0.1	0.01	0.001	0.0001
Drink water	x							
Swimming pools	x							
Lakes reservoirs	x	x	x					
Water Supply intake			x	x	x			
Raw sewage					x	x	x	x

- The most common indicators of waterborne pathogens

a) *Fecal coli form* bacteria are a sub-group of the total *coli form* group. They are found in great quantities in the feces of people and animals. The presence of *fecal coli form* in a drinking water sample often indicates recent fecal contamination -- meaning that there is a greater risk that pathogens are present than if only *total coli form* bacteria are detected.

b) *E. coli* is a sub-group of the *fecal coli form* group. Most E. coli are harmless and are also found in great quantities in the feces of people and warm-blooded animals. Some strains, however, may cause illness. Some of these common waterborne illness symptoms include diarrhoea, vomiting , headache, and cramps (acute gastrointestinal illness).

Populations at highest risk to this ailment are: the very young, the very old, and persons with compromised immune systems.

The presence of *E. coli* in a drinking water sample almost always indicates fecal contamination of the water supply, and so *E. coli* outbreaks usually receive a lot of media attention. Many food borne outbreaks have been caused by an especially virulent strain of E. coli known as E. coli 0157: H7 which can cause serious illness or death. For drinking water (same as current EPA standard); zero positive *E. coli* samples from a finished bottled water product or its source water (a zero tolerance FDA Standard of Quality).

If any Coli form bacteria are found, the lab does a second test to look for the special sub-group of Coli form that live in the guts of mammals and birds. This test is for E.coli or fecalcoli form these bacteria indicate that your water source has come into contact with animal waste a very high risk for transmitting diseases.

c) Enterococci:- The *enterococcus* group is a subgroup of the fecal streptococci. The enterococci portion of the streptococcus group is a valuable bacterial indicator for determining the extent of fecal contamination of recreational surface waters. Studies in marine and fresh waters indicate that enterococci are one of the best bacterial indicators of water quality. Enterococcus is a bacteria found in the human intestine and therefore a good indicator of human waste.

The European Water Directive defines reference methods for the enumeration of microbiological parameters in water. Page (53). Defined substrate technology, according to the manufacturer recommendations. The reference method uses membrane filters (47 µm diameter and 0.45 1im pore-size) cultured on Slanetz & Bartley agar (Biokar Diagnostics, Pantin, France) incubated at 36 ± 1°C for 44 ± 4h. Red, brown or rose colonies were considered as typical colonies of presumptive enterococci.

The confirmation was performed by transferring the filters to Bile Esculin Azide agar (Biokar Diagnostics) according to Figueras et al. (1996) previously preheated at 44°C. Membrane filters were incubated at 44 ± 1°C for 2h, and all the colonies with brown or black colour were considered as enterococci.

5.2- Pathogenic indicators

To determine the microbiological quality of wastewater treatment effluents, faecal contamination indicators such as coli forms and enterococci are usually employed. The choice of these micro-organisms is based on two main reasons: first, it is simple and economical to determine their presence and quantify them, and secondly, this determination provides information related to the presence and behaviour of the principal human pathogens present in wastewaters (Vera et al., 2006. Steylr et al., 2007). And the principal indicator micro-organisms of faecal pollution are the faecal coli forms, *Escherichia coli,* enterococci Coli forms are part of the intestinal flora of mammals and other animals.

The quantity of coli forms that an average human excretes daily in faeces varies between 10×106 and 40×106 (CFU/100ml). All the coli forms may exist as saprophytic organisms, with the exception of those belonging to the genus Escherichia, the origin of which is exclusively intestinal. The great quantity of *E. coli* present in the human digestive tract, together with the fact that it is not usually found in other environments, cause this bacterium to be considered one of the best available faecal contamination indicators.

Thus, the presence of this bacterium in water proves a recent faecal contamination and the possible existence of pathogens. The use of the indicator bacterial group enterococci is frequently suggested as an alternative to coli forms. Their advantage over E. coli lies in their greater resistance short life cycle ability to adapt to grow in any environment, such as soil, water, and others (Vera et al., 2006).

Table 5.2. The important methods and features and or characteristic

method / Feature	Membrane Filtration	Most propablr number (MPN)	Presence /absence	Pour plate	Enrichment Technology
Suitable media	Solidified agar	Lauryl tryptose	Solid agare	Solid agare	LTbroth
Economic Cost	inexpensive	expensive	Very cheap	Inexpensive	inexpensive
Time require	Several hour	1 to 2 days	2 days	2 days	2 days
Incubation c°	No need	35+.05 c°	37+0.5 c°	35+0.5 c°	35+0.5 c°
Suitable for	Coli form group	Coli form group	Coli form group	Coli form group	Coli form group
Potabl water	yes	yes	Yes	Yes	No
Nonpotable water	yes	yes	Yes	Yes	Yes
Dilution need	no	Yes 0.1,0.01 0.001	Yes yes	Yes	yes

Routine examination for pathogens organisms is not recommended because of cost and the law number of specific pathogens present at any giving time indicator. The most common indicator of waterborne pathogens contaminated in water are:-

- presence /absence, MF (membrane filtration, entichement method FIGURE xx.. Determined removal capacity of biological pollutants from wastewater on the bases of input and output concentration.

The European Water Directive defines reference methods for the enumeration of microbiological parameters in water. One of the standard methods for *coli forms* and *E. coli* is the membrane filtration technique on Tergitol-flC agar confirmed with the oxidase and indole tests (EU 2006).

However, several technical drawbacks of the procedure, as well as limitations regarding the taxonomy of these microorganisms, require the evaluation of alternative methods (Bernasconi et al. 2006). The Colilert® test is referred to in the Standard Methods for the Examination of Water and Wastewater (1998) as a method for the enumeration of *E. coli* with application to surface water.

5.3- Membrane Filtration Method (MF)

Membrane filtration (MF) (Standards Australia 1995. AS 4276.8 1995) First a sample is filtered through a membrane with a pore size small enough (0.45 microns) to retain any bacteria present. Then filter is placed in a Petri dish either on solidified agar or on an absorbent pad saturated with a culture medium selective for coli form growth. The Petri dish is incubated, upside down, for 24 hours. After incubation, the resulting colonies are identified and counted using a low-power microscope, where the advantages for this methods are shown below.

5.3.1- (M F) Method Observation and reporting results

In this step, after incubation period has been completed, by use microscope

1) Remove the lid from Petri dish and count the colonies found in dish with distinguished between species of organisms according to the media we are use in test.

2) Calculate the coli form density in the filter by using the flowing equation Coli forms /l00ml = (number of colonies counted) 100 /sample size.

3) Determine the average coli form density from summation of all samples, fill the result in table.

5.3.2- (MF) Advantages

- Simple methods no need high experience technique.
- Fast method just few hour to get the result.
- Most the results which done by (MF) an encouraging to use the method.
- We can repeat the test more than one time a day and save time.
- MF test method suitable for both non potable and potable water.
- colonies with a greenish-gold metallic sheen.

Table 5.3. The average coli form density from summation of all samples

	Waters source	Sample size ml	No. coli form Colonies	Coli form/I00 ml
Sample 1				
Sample 2				
Sample 3				

5.4- The Results

Water Analysis: Along with the experiment period of 90 days, daily results been collected, analysed and yet tabled at the laboratories of the Publicly Owned Water Treatment Station – Palermo that being operated by AMAP. Those analysis been conducted were included the bacteriological and chemical different parameters within the standard measures.

Physical Analysis: There are several observations that can be made regarding different aspects of the filter, these observation are important in detecting possible operating problems with the filters. The different aspects of the filter are spouts attachment, diffuser plates , sand layers and cracks in attachment BSF body.

Chemical Analysis: PH, turbidity and dissolved oxygen measurement by use PH /oxi meter, BOD and suspended solids measures as standard protocols (APHA, 1998).

- **Experimental Results**

5.4.1- Physical observation

Spouts attachment:

By the run time normally some attachment happen as normal result of any filtration process especially at outlet taps and diffuser and must be cleaning as routine as we recommended in Biosand filter section,

Diffuser plate:

The diffuser plate must be kept in good condition to keep the force of pouring water from distribution the layer. which lead to decrease efficiency of the filter. filter will be compromised and more significant number of harmful organisms may pass through the filter upper sand layer represented the base for living organisms growth. If this layer disturbed or damaged, the BSF effectiveness and more number of harmful organisms may bas through the filter.

Figure 5.1. Clogging in diffuser

The filter has to be checked below the water the resting water, this cracks if found, the filter could be leaking and flow rate would decrease. this because the cracks create path of the water of less resistance for the water correspondingly, there will be less filtration.

1 **-Sedimentation**

Through the sedimentation test done many times. The result shown no any sedimentation occur at all, which mean effluent water samples free of particles as shown in TSS and turbidity analysis (figure 5.2)

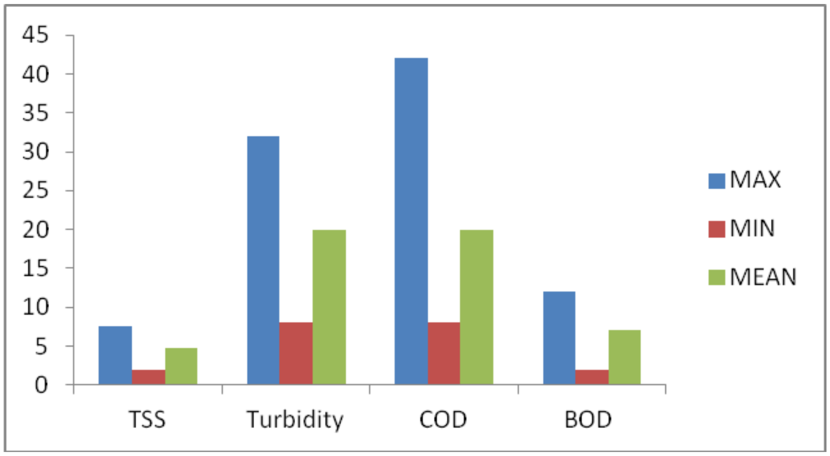


Figure 5.2. The chemical results of the TSS, Turbidity, COD and BOD parameters in effluent (12 operation weeks)

2 **Odours**

No odour release from BSF through 3 months of system running, without odour test needs.

3 **Cracks**

In first three month of system run, some leak in BSF body, caused in construction stage errors when were fixed the outlet pipes, but it were not significant about 300 ml/d, and it decrease by the time, and stopped after about three weeks. all cracks closed by clogged.

4 **Biofilm development**

Biofilm developed increases by time, which refers to microorganisms an organic compound presented in either source or feeded water. (Figure 5.3)

Figure 5.3. A biofilm maturation in the BSF

5 **Colour**

Effluent water samples where very clear (colourless), this result was supported by turbidity and TSS results that we obtained (Figure 5.4)

Figure 5.4. A colourless collected effluent

Chemical analysis:

- **(TSS) Total Suspended Solid** :

The suspended solid removal efficiency was very high, apparently limited both the mean inlet and outlet concentration being 10mg/l which could consistently meet the guideline (EPA 2003) all time the effluent TSS level were even less than those of the influent which mean that the BSF working with high efficiency during 3 month of run. Our results are also consistent with previous findings that the removal of TSS was mainly because of physical, sedimentation, , filtration and biological process.TSS result supported by turbidity figure 7.5

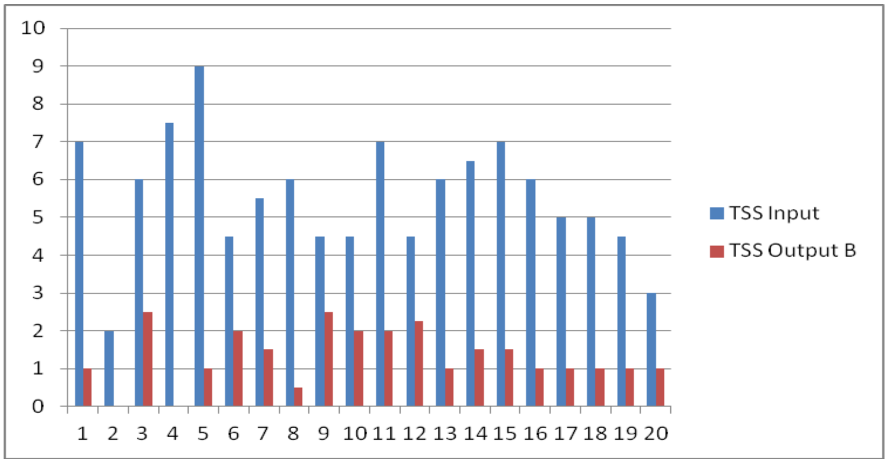


Figure 5-5 Comparison between the input and output of the TSS, mg/l

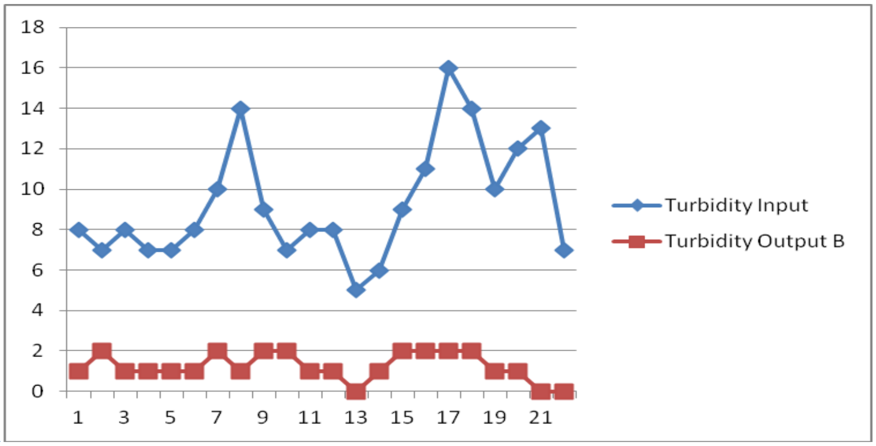
Figure 1

Figure 5-6 Comparison between the input and output of the BOD, mg/l

- **Phosphorus:**

Phosphorus removal in modified BSF occurs mainly, through consume by bacteria as energy cell require ATP, the removal percent by compared between in and output, was 50 to 70% . it consider as good efficiency removal, where the effluent concentrations usually1 mg /l. If lower concentrations are required by the regulator, in-pond dosing with aluminum sulphate or ferric chloride, can be effective in reducing P levels from up to 15 mg/l to ~1 mg/l, without causing significant accumulation (Surampalli et al, 1995*).

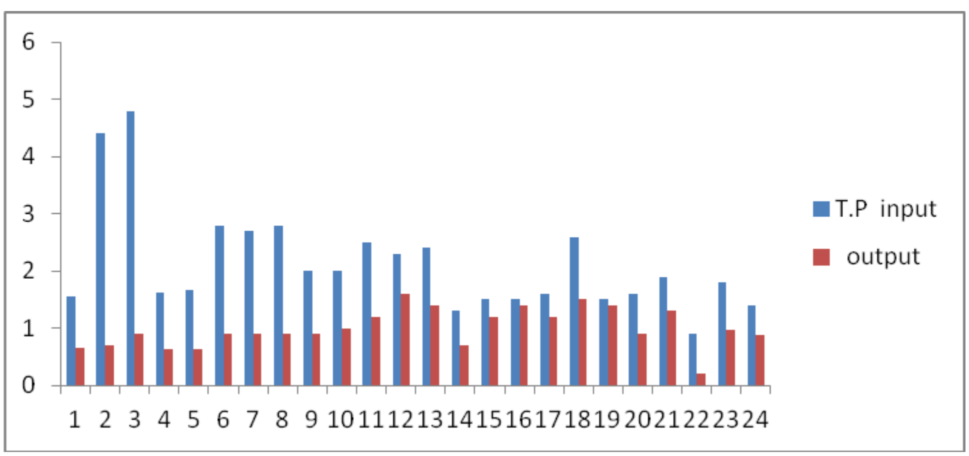


Figure 5-7 Comparison between the input and output of the Phosphorus mg/l

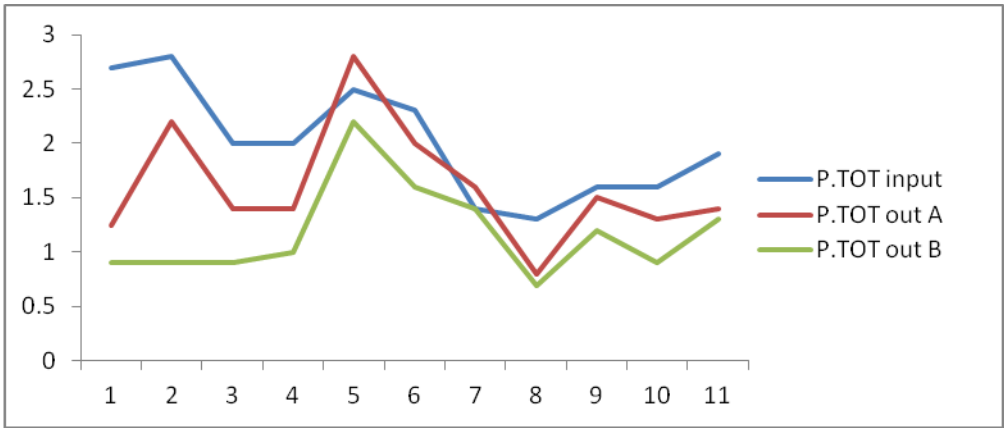


Figure 5-8 Comparison between the input and output of the Total Phosphorus mg/l

- **Total Nitrogen, Nitrate, Nitrite, and Ammonia Concentration:**

Ammonium concentration were low in the influent during (3 months)of continuously run, and the removal rate was fluctuant, sometime the nitrate concentration in the effluent was even higher than that in the influent (figure x) suggesting that ammonium was oxidized to nitrate via nitrification process.

The removal efficiencies of NO3-N and TN were low. Many previous reports have warned that nitrogen removal in the CW system is complicated. For example, nitrogen may be removed through sedimentation, inorganic nitrogen may be reduced by algae uptake. While soluble organic nitrogen m absorbed by biofilm, and ammonium nitrogen removed by volatilization, adsorption algae and nitrification (Vymazal, 2005:Christina et al., 2007; Wn et al., 2008a,b; Li et al., 2009).

In our experiment during run period, the pH of influent sample is ranged between 6.5 -7.3 and effluent range between 7-8, hence, the volatilization of ammonium nitrogen in our systems, likely to be negligible as generally requires a pH of >9.3 (Jing & Lin 2004). Therefore, the main reason for ammonium removal, in BSF is thought to be the nitrification, which could account for the high effluent nitrate observed in some sample as shown in fig NO_3X. In addition, the low nitrogen removal rate may be attributable, to biofilm maturations we observed in no 3 curve the improvement of removal efficiency over time.

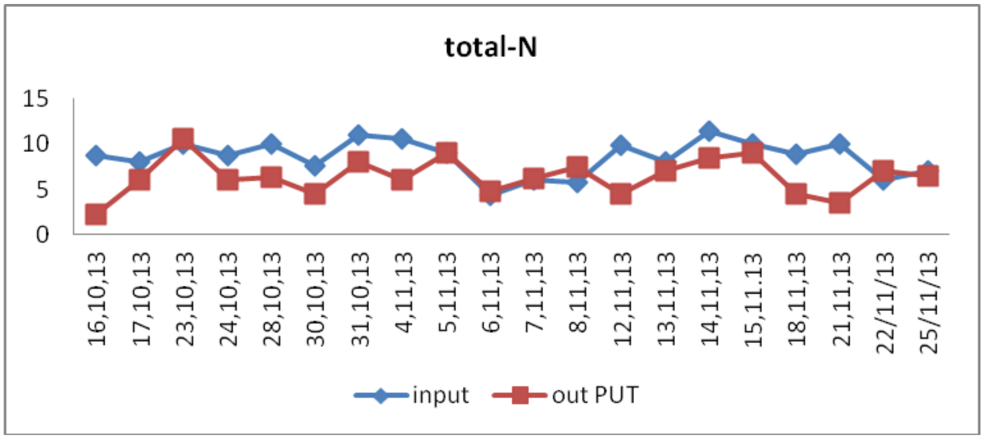


Figure 5-9 the Total Nitrogen, Ammonia mg/l

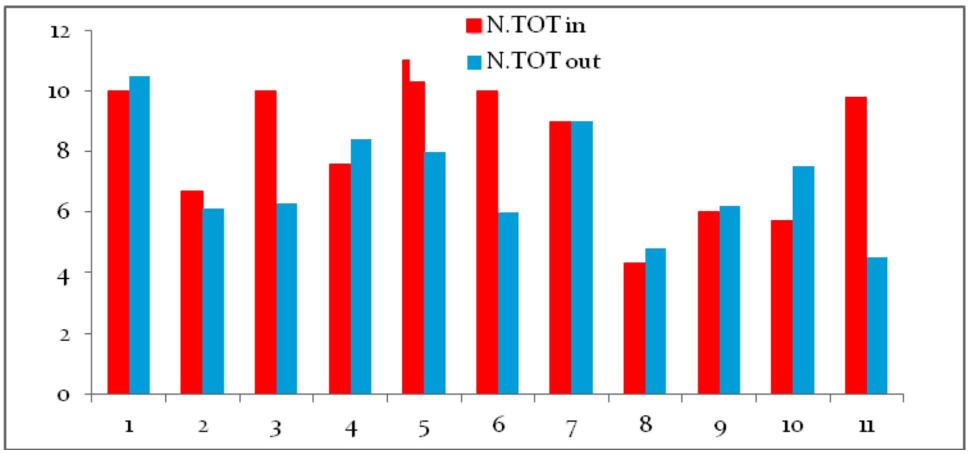


Figure 5-10 the Total Nitrogen in put and output A, B, mg/l

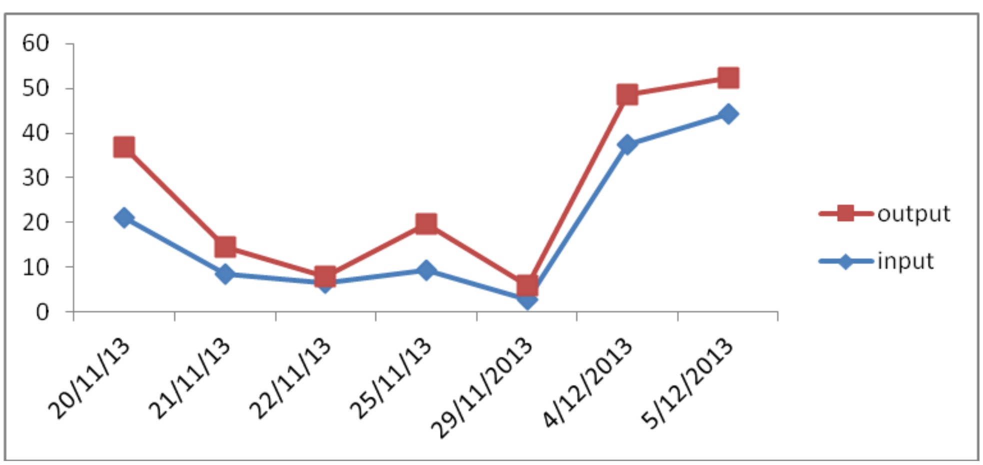


Figure 5-11 the Nitrite NO_3 mg/l

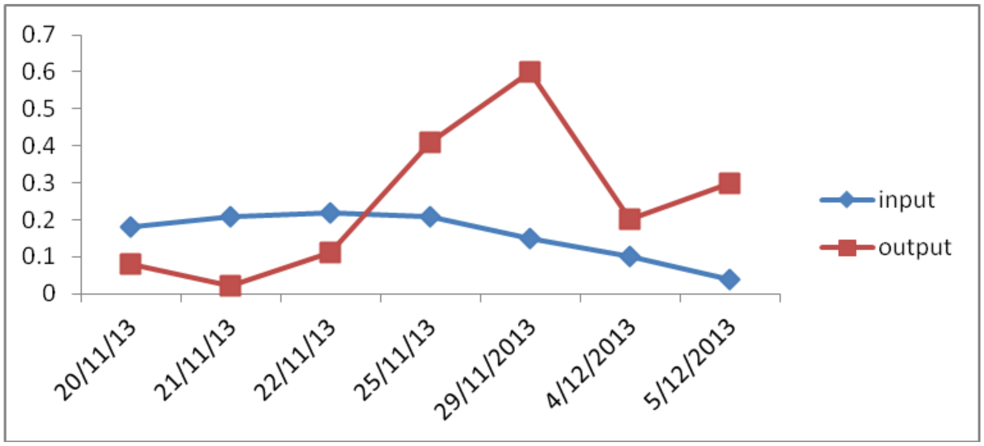


Figure 5-12 the Nitrite NO_2 mg/l

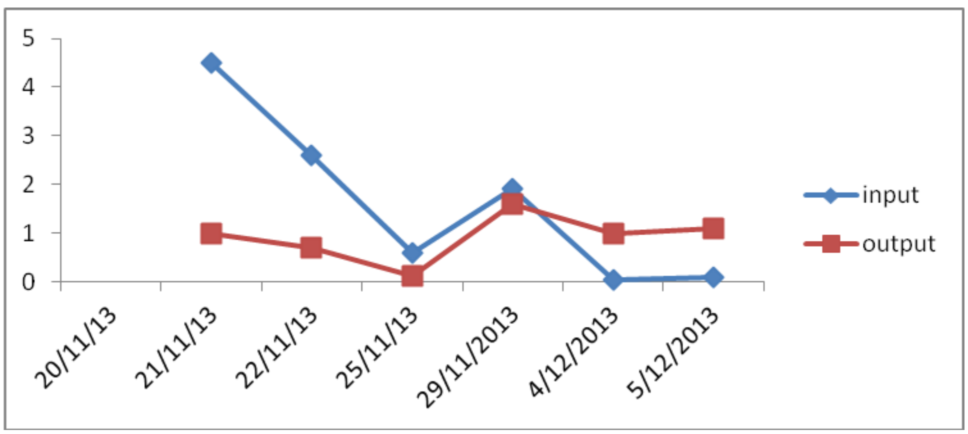


Figure 5-13 the Ammonia NH4 mg/l

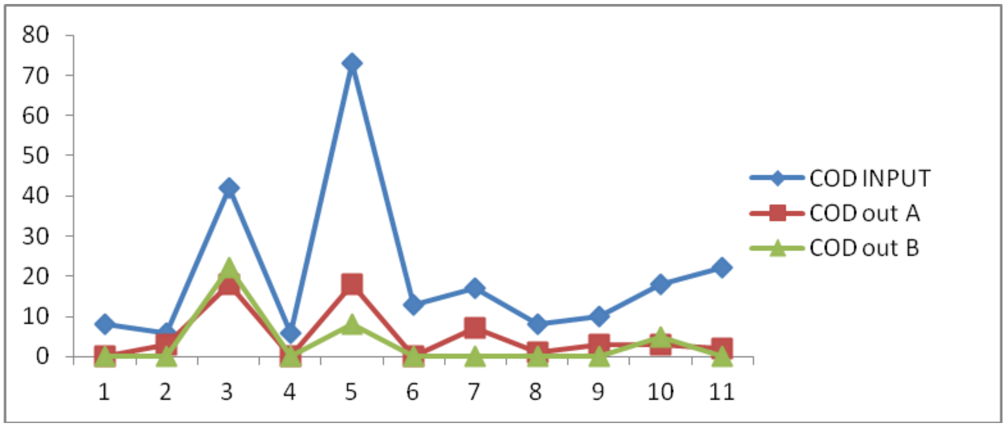


Figure 5-14 the Chemical Oxygen Demand mg/l

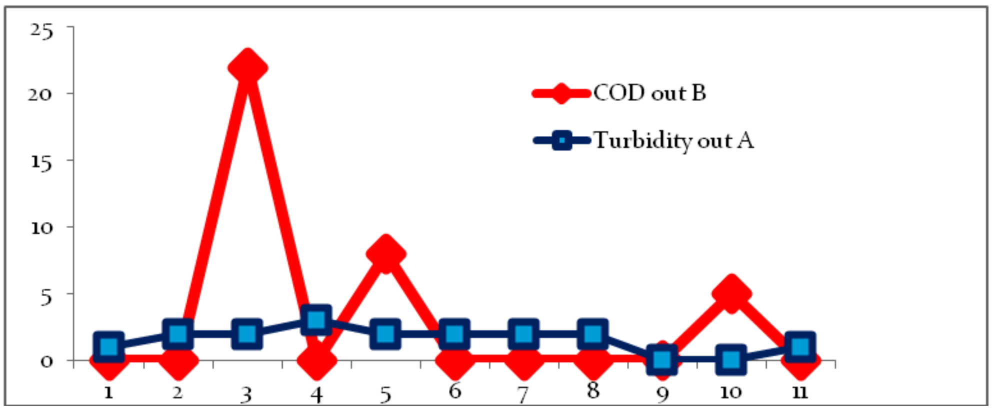


Figure 5-15 the Total Chemical Oxygen Demand and Turbidity(NTU)mg/l

- **Turbidity (NTU) mg/l**

The BSF influent and effluent turbidity was recorded and the test results are provided in Figure (5.16). All of the filter results showed, reduced the turbidity of the feed water. Effluent turbidity up to 95% decreases in influent turbidity were often reflected by an increase or decrease in the effluent frequency turbidity test, it was expected that fluctuations in effluent turbidity reflecting influent turbidity would be seen. but there is no significant change, through study period shows the average turbidity removal efficiency of modified filter, during the control testing period.

Overall BSF achieved the highest turbidity removal efficiency, which is likely a result of passing through a longer (though narrower) body of fine sand which enables a greater extent of mechanical filtration to occur.

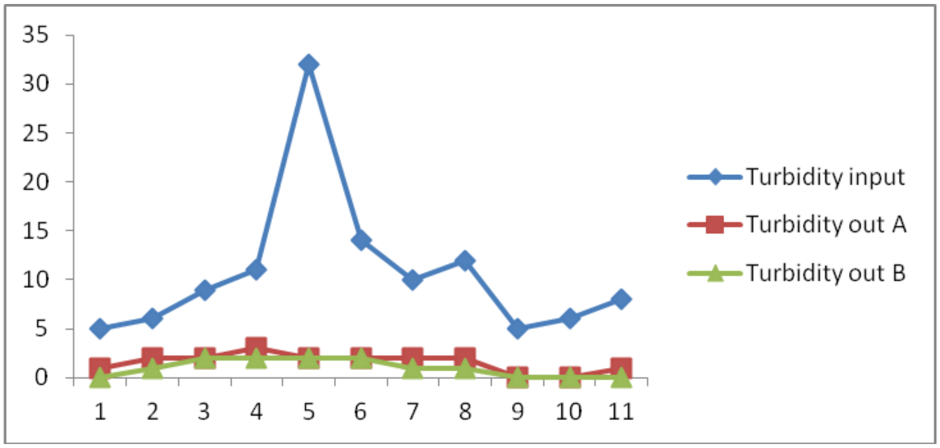


Figure 5-16 the Total Turbidity(NTU)mg/l

Turbidities of 10 NTU or less represent very clear waters. The average turbidity removal efficiencies ranging, from 71% to 90% significantly higher than values documented for BSF use with low turbidity water, which tend to be greater than 80% (Duke et al., 2006; Lee, 2000; Buzunis, 1995). They are also equal than those found by (Kikkawa 2008) which were greater than 90%. It is not known why the efficiencies in this research differed to such an extent from Kikkawa's; however, it may be due to the use of a different source water dugout, biofilm maturation and/or sand grain texture used.

Comparisons

MODIFIED FILTER DESIGN AND SAFE FILTRATE STORAGE by Clair Collin B.E. (Chemical) University of Sydney June 2009

50 NTU is cloudy; and 100-500 or greater is very cloudy to muddy. Some fish species may become stressed at prolonged exposures of 25 NTUs or greater. Furthermore, Barnes (1998) recommended, that to maintain native fish populations in Georgia Piedmont Rivers and streams, that random monthly values should never exceed 100 NTU; that no more than 5 percent of the samples should exceed 50 NTU; and no more than 20% should exceed 25 NTU.

Northeast Georgia Regional Development Center. Watershed Protection Plan Development Guidebook

Turbidity considering indirect measure of microbial count (Reynolds and Richarda,1996)the increase turbidity reduction achieved by our BSF suggested that increased *E.coli* removal could have occurred and further testing of these system should be conducted.

- **Chemical Oxygen Demands COD mg/l:**

Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia_and nitrite. Because this chemical oxidant is not specific to oxygen-consuming chemicals that are organic or inorganic, both of these sources of oxygen demand are measured in COD.

Chemical oxygen demand is related to Biochemical Oxygen Demand (BOD), another standard test for assaying the oxygen-demanding strength of waste waters. However, biochemical oxygen demand only measures the amount of oxygen consumed by microbial oxidation and is most relevant to waters rich in organic matter. It is important to understand that COD and BOD do not necessarily measure the same types of oxygen consumption. And COD allows greater than BOD BOD/COD = 0.5 this equation very closely to the result we find in the results we obtained and supported with the results of other parameters as TSS, Turbidity, and TDS.

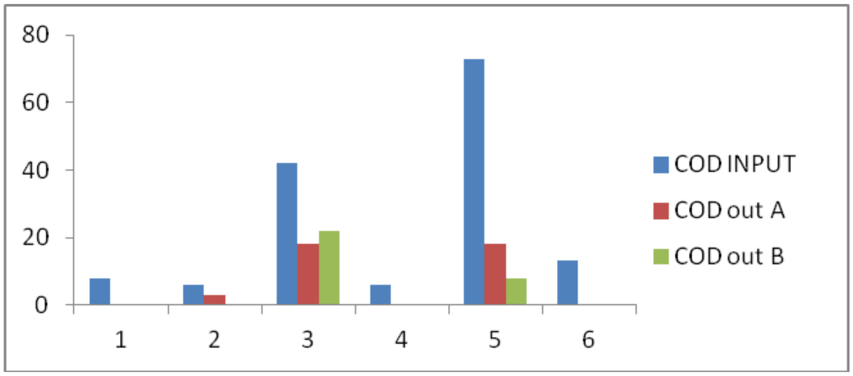


Figure 5-17 the Chemical Oxygen Demands COD mg/l

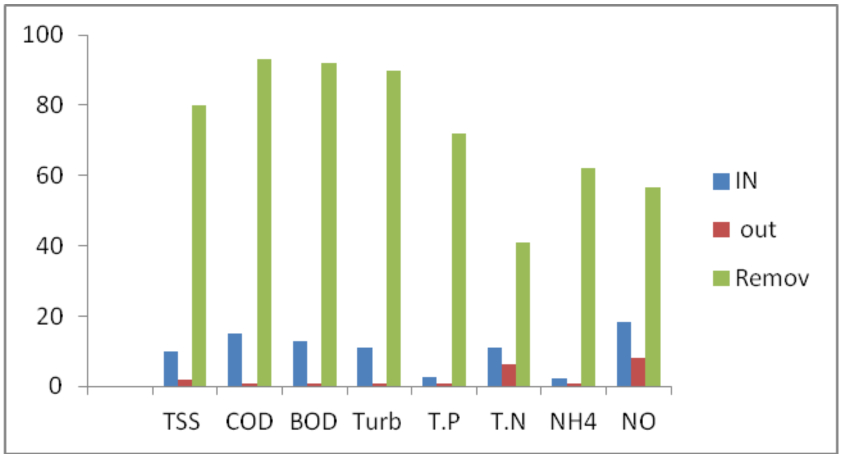


Figure 5-18 the Chemical Oxygen Demands COD mg/l among other parametrs

- **Biological Oxygen Demands BOD mg/l:**

The main focus of wastewater treatment plants is to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste.

BSF remove about 80% which make treated water safe to discharge in natural or reuse.

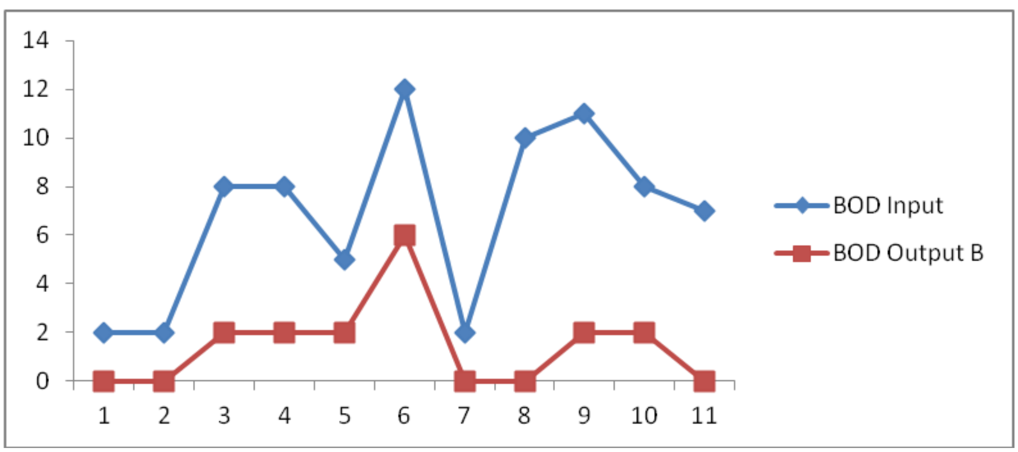


Figure 5-19 Biological Oxygen Demands BOD mg/l themg/l

- **Oxygen Reduction Potential**

In wastewater ORP measurement of the ability of wastewater to permit the occurrence of specific biological oxidation-reduction reaction. which had important in wastewater treatment systems include nitrification, denitrification, and phosphorus removal. The presence of an oxidizing agents such as O2 increase ORP ,while presence of a reducing agent such as substrate or cBOD decrease ORP value by observe the ORP in fig x. we find that there is clearly decrease in value of ORP value, throughout period of system run, which mean there is reaction reduction occurrence in deep layers.

Table 5.4, show Biochemical reaction and corresponding ORP value biochemical reaction

biochemical reaction	.ORP mV
Nitrification	+100 to +350
cBOD degrad with free O2	+50 to +250
biological P removal	50 to +250
denitrification	25 to - 50
sulfideH2S formation	-50 to - 250
bio phosphorus release	-100 to -250
acid formation(fermentation)	-100 to -250
methan production	-175 to -400

source Y S I environmental 2008 www.ysi.com/wastewater

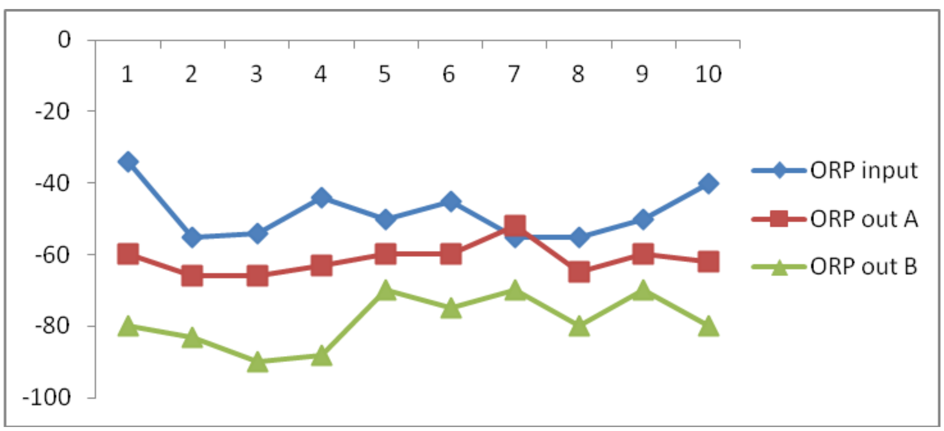


Figure 5-20 the Oxygen Reduction Potential mg/l

- **Total Dissolved Solids (TDS) ppm:**

Total Salt Concentration or (TDS) ppm or mg/l Total salt concentration (for all practical purposes, the total dissolved solids) is one of the most important in agricultural water quality parameters. Because the salinity of the soil and water is related to each other, and often determined by the salinity of the irrigation water.

Accordingly, plant growth, crop yield and quality of produce are affected by the total dissolved salts in the irrigation water. Equally, the rate of accumulation of salts in the soil, is also directly affected by the salinity of the irrigation water. The salinity removal in sand filter as we observed, non significant and fluctuate, through the run period as shown in the following table in the base of input /output.

Table 5.5, show, Total dissolved solid (TDS ppm) values

	Total dissolved solid TDS ppm	
Test number	**Input**	**Output**
1	**526**	**390**
2	**450**	**414**
3	**874**	**760**
4	**1129**	**380**
5	**1130**	**667**

Temperature:

The temperature is one of the limiting factors for all life forms in the planet especially in aquatic ecosystem, and water temperature varies with season, elevation, geographic location, climatic, day and night, the change in water temperature, affect in the values of DO, pH, reproductive activity, metabolic and catabolism rates, rise in temperature can also provide conditions for the growth of disease-causing organisms.

In this study temperature were fixed during BSF run time, temperature was ranged between minimum 18.5 to maximum 224°C that mean temperature is stable and no significant variation between inlet and outlet water.

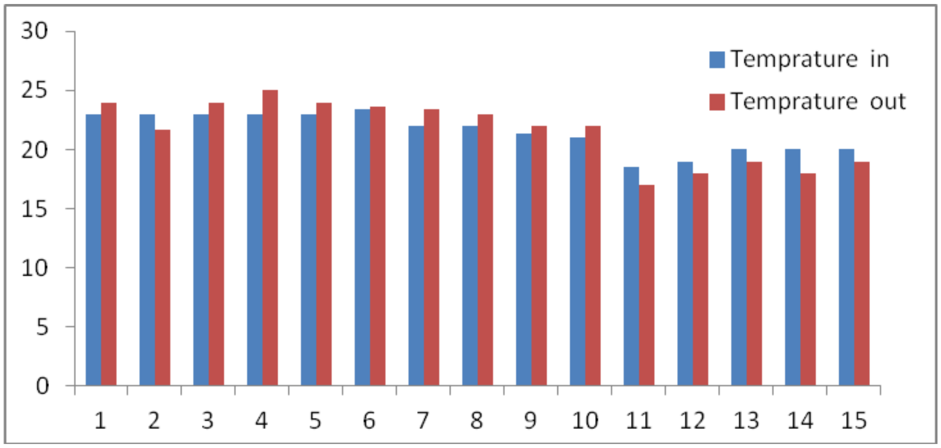


Figure 5.21 showed temperature variation

- **pH:**

Hydrogen ion concentration is an important factor especially in aquatic environment. The pH/ in the liquid phase may affect the extent of same mechanism such as adsorption substance to solid surface(K.Klanova 1994). The influent of pH on bacteria adsorption depend on the bacteria surface charge and ionic strength(R. W.Harvey 1991).

Increased retention of bacteria has been found to occur when pH was decreased from 9.3 to 3.9 (J. Goldschmidt, D. Zohar et al 1973).pH average in this study ranged between 7 to 8 in MBSF effluent and 7 to 7.5 in influent which mean that this parameter hadn't any significant effect and it isn't considered a limiting factor, to be focused on

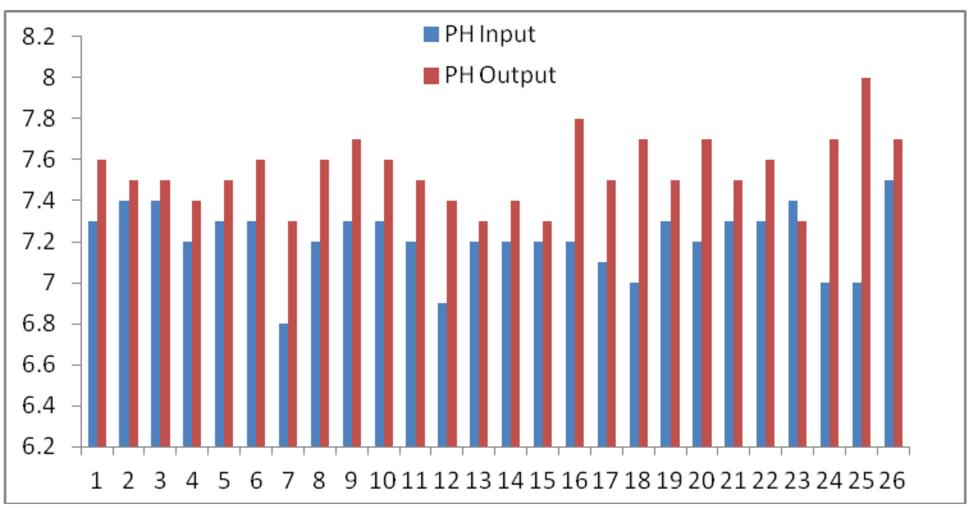


Figure 5-22 the pH parameter as in and output

- **Conductivity:**

Electrical conductivity (EC) is widely used to indicate the total ionized constituents of solution. EC is directly related to the sum of the cations (or anions), as determined chemically and is closely correlated, in general, with the total salt concentration. Electrical conductivity is a rapid and reasonably precise determination and values are always expressed at a standard temperature of 25°C to enable comparison of readings taken under varying climatic conditions. It should be noted that the electrical conductivity of solutions increases approximately 2 percent per 1°C increase in temperature.

The EC, is used to represent the electrical conductivity of irrigation water and to designate the electrical conductivity of the aquaculture. In our BSF, the results show very little decrease in total ionized at effluent, compared with influent value at similar temperature condition.

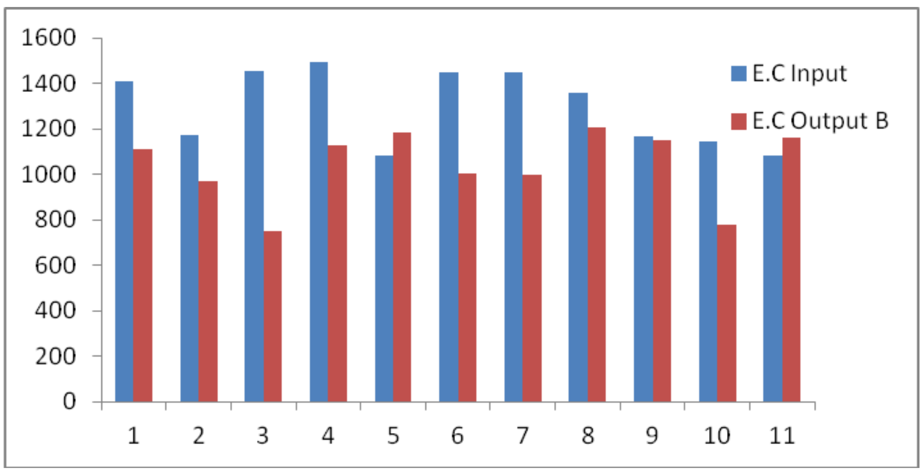


Figure 5-23 The E. Conductivity

- **Wastewater strength:**

Wastewater strength is often judged by its BOD5 or COD, The strength of the wastewater from a community, is governed to a very large degree by its water consumption. BOD (= amount of organic waste), other factor determining the strength of domestic wastewater, produced per person per day. This varies from country to country, and the differences are largely due to differences in the quantity and quality of sullage rather than of body wastes, although variations in food habits are important.

A good value to use in developing countries is 40 g BOD5 per person per day. In Brazil the BOD contribution per person per day was found to vary with income – poor people produce less BOD than richer people, effluent of treated water considered very low strength, according to the BOD and COD analysis results through 3 month of continuous BSF run, moreover the influent or secondary inlet wastewater also weak see fig

Table 5.6 shows, Wastewater Strength in Terms of BOD5 and COD

Strength	BOD_5 (mg/l)	COD (mg/l)
Weak	<200	<400
Medium	350	700
Strong	500	1000
Very strong	>750	>1500

Source : Domestic Wastewater Treatment in Developing Countries(Duncan Mara.2004)

- **Pathogenic Analysis result:**

In addition to the concern with pathogenic; bio colloids there are also questions regarding the transport of beneficial bio colloids for bioremediation, as well as other colloids that may be transporting contaminants, or catalysts to perform a desired reaction. The fate and transport of pathogenic microorganisms in the subsurface are controlled by several processes, including:

- advection,
- dispersion,
- physicochemical filtration,
- training, inactivation,
- dilution, and
- possibly grazing by higher trophic levels.

Among the mechanisms of colloid transport, straining and physicochemical filtration play a significant role in the removal of microbes from the pore fluid.

The most common indicator methods of waterborne pathogens are MF (membrane filtration) to determine pathogenic removal efficiency of BSF on the bases of input and output concentration as cell/100 ml. Quantitative microbiological analysis was performed in an on-site testing lab. The general procedure for obtaining and processing samples is described previously.

- ***Total Coliform*** characteristic:

  - ✓ Easily cultured organisms used to indicate water quality.
  - ✓ Total coli form bacteria consist of environmental and fecal types.
  - ✓ Coli forms are easy to isolate, present in larger numbers.
  - ✓ Usually survive longer in an aquatic environment than viruses, parasites and more serious types of bacteria.
  - ✓ Most of the total coli forms are not considered pathogens under normal conditions.

- ***Total Coliform*** test result:

  - Long Term Users: -

- Filters in use 2 months
- Media: fine sand, small gravel and large
- Flow rate: avg 3.5 L/h
- Effectiveness: avg. 99.5% Effectiveness

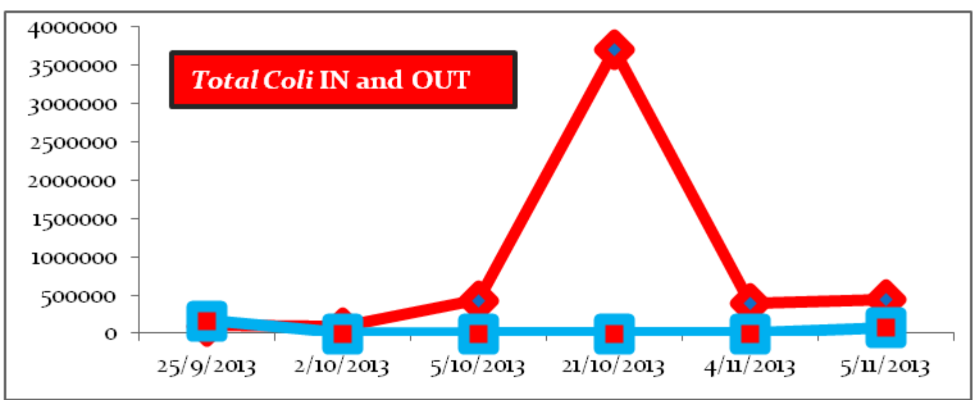


Figure 5-24 The*Total coliform*in- and output

- ***Escherichia. Coli:***

E. coli is a species of coli form bacteria that is directly linked to fecal contamination by the wastes of warm-blooded animals, including humans. Some strains are pathogens in humans.

• Filters in use 2 months

• Flow rate: 3.5 l/h

• Effectiveness: avg. = 99,2%

• Media: fine sand, small gravel and large

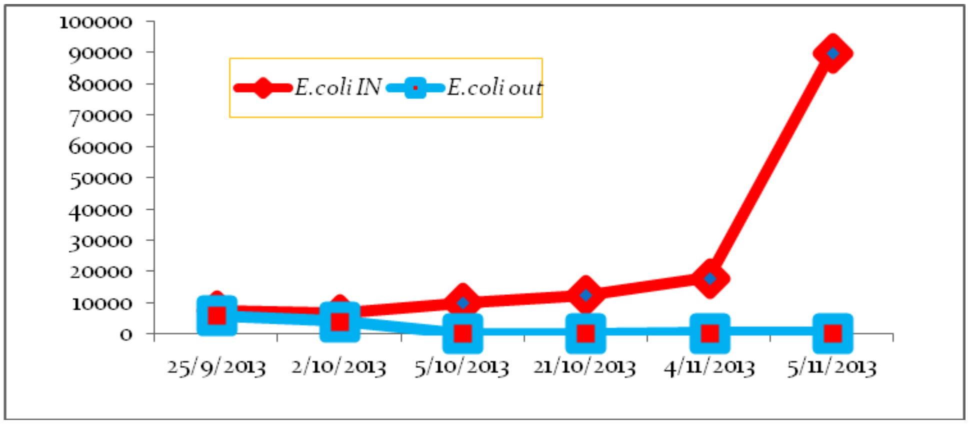


Figure 5-25 The *E. Coli* in and out put

- **Biofilm**

Biofilm maturation time

Initial attachment- irreversible attachment- Maturation- Dispersion

By using microscope we prepare fresh sample, from the biofilm formed on upper sand surface. We find as shown in the picture A matured biofilm with high biodiversity which play important role in removal of contaminates especially pathogenic in complex processes (chapter two) while it is clear in the results obtained. In the other side picture in (fig. 1 part B) there is no any organism found in effluent part of the BSF.

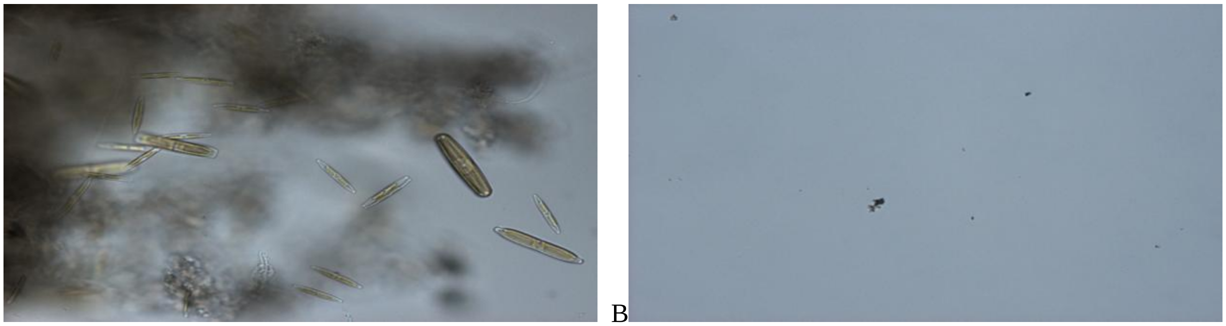
A  B

Figure 5-26 the *Biofilm at A, B surface*

Table 5.7 shows the contaminants removal in percentage at BSF

Parameter	Secondary W.W.T	BSF output	Removal %
TSS mg/l	10	2	80
COD mg/l	15	1	93
BOD mg/l	13	1	92
Turb NTU	11	1	90
E. Coli cell/100ml	24083	263	99.2
Totcolif cell/100ml	60,350,00	257,200	99.5
T.P	2.5	0.7	72
T.N	11	6.4	41
NH4	2.27	0.86	62
NO2	18.5	8	56.7

Modified Biosand Filter (MBSF) results:

Effect of the modification in BSF efficiency

In this chapter evaluation been achieved related to the results been obtained from the 3 months of the system running, different analysis those included chemical, physical and biological, in order to figure out the performance efficiency of the modification been conducted on BSF. Those results been investigated and yet tabled to each single parameter along to the compression among the inputs (secondary waste water) and the out puts (1; effluent of part A, 2; effluent of part B) as in figure 4-2.

The study showed significant results in contaminants removal as clearly demonstrated by the tables x1, x2, x3, x4 and x5

Table 5.8 show; the removal efficiency of the parameter TSS

	TSS					
	Input	Out A	Out B	TSS D. P. (A)	TSS D. P. (B)	Imp. Per.
	4.9	2	0.9	59.2	81.6	22.4
	5	2.5	0.9	50.0	82.0	32.0
	4.5	2	0.5	55.6	88.9	33.3
	3	1	0.6	66.7	80.0	13.3
	24	1.5	0.5	93.8	97.9	4.2
	6.5	1.5	0.5	76.9	92.3	15.4
	16.5	1	0.5	93.9	97.0	3.0
	11	3.5	2	68.2	81.8	13.6
	6.5	1	0	84.6	100.0	15.4
	13	2	1	84.6	92.3	7.7
	4.5	1	0	77.8	100.0	22.2
MAX	24.0	3.5	2.0	93.9	100.0	33.3
MIN	3.0	1.0	0.0	50.0	80.0	3.0
AVR	9.0	1.7	0.7	73.7	90.3	16.6
STD	6.5	0.8	0.5	15.0	7.9	10.1

Input(secondary waste water), Out A (effluent part B), Out A (effluent part B), TSS D. P. A (percentage part A), TSS D. P. B (percentage part B), and Imp. Per. (improvements percentages).

Table 5.9show; the removal efficiency of the parameter COD

	COD					
	Input	Out A	Out B	COD D. P. (A)	COD D. P. (B)	Imp. Per.
	8	0	0	100.0	100.0	0.0
	6	3	0	50.0	100.0	50.0
	42	18	22	57.1	47.6	-9.5
	6	0	0	100.0	100.0	0.0
	73	18	8	75.3	89.0	13.7
	13	0	0	100.0	100.0	0.0
	17	7	0	58.8	100.0	41.2
	8	1	0	87.5	100.0	12.5
	10	3	0	70.0	100.0	30.0
	18	3	5	83.3	72.2	-11.1
	22	2	0	90.9	100.0	9.1
	20	0	0	100.0	100.0	0.0
MAX	73.0	18.0	22.0	100.0	100.0	50.0
MIN	6.0	0.0	0.0	50.0	47.6	-11.1
AVR	20.3	4.6	2.9	81.1	92.4	11.3
STD	19.4	6.6	6.5	18.5	16.4	19.5

Table 5.10 show the removal efficiency of the parameter Turbidity

	Turbidity					
	Input	Out A	Out B	Tur D. P. (A)	Tur D. P. (B)	Imp. Per.
	5	1	0	80.0	100.0	20.0
	6	2	1	66.7	83.3	16.7
	9	2	2	77.8	77.8	0.0
	11	3	2	72.7	81.8	9.1
	32	2	2	93.8	93.8	0.0
	14	2	2	85.7	85.7	0.0
	10	2	1	80.0	90.0	10.0
	12	2	1	83.3	91.7	8.3
	5	0	0	100.0	100.0	0.0
	6	0	0	100.0	100.0	0.0
	8	1	0	87.5	100.0	12.5
	10	1	0	90.0	100.0	10.0
MAX	32.0	3.0	2.0	100.0	100.0	20.0
MIN	5.0	0.0	0.0	66.7	77.8	0.0
AVR	10.7	1.5	0.9	84.8	92.0	7.2
STD	7.3	0.9	0.9	10.2	8.2	7.1

Table 5.11 show the removal efficiency of the parameter Phosphour Total

	P.TOT					
	Input	Out A	Out B	P. TOT D. P. (A)	P. TOT D. P. (B)	Imp. Per.
	2.7	1.25	0.9	53.7	66.7	13.0
	2.8	2.2	0.9	21.4	67.9	46.4
	2	1.4	0.9	30.0	55.0	25.0
	2	1.4	1	30.0	50.0	20.0
	2.5	2.8	2.2	-12.0	12.0	24.0
	2.3	2	1.6	13.0	30.4	17.4
	1.4	1.6	1.4	-14.3	0.0	14.3
	1.3	0.8	0.69	38.5	46.9	8.5
	1.6	1.5	1.2	6.3	25.0	18.8
	1.6	1.3	0.9	18.8	43.8	25.0
	1.9	1.4	1.3	26.3	31.6	5.3
MAX	2.8	2.8	2.2	53.7	67.9	46.4
MIN	1.3	0.8	0.7	-14.3	0.0	5.3
AVR	2.0	1.6	1.2	19.2	39.0	19.8
STD	0.5	0.5	0.4	20.4	21.5	11.0

Table 5.12 show the removal efficiency of the parameter Nitrogen Total

	N.TOT					
	Input	Out A	Out B	N. TOT D. P. (A)	N. TOT D. P. (B)	Imp. Per.
	10	8	10.5	20.0	-5	-25.0
	6.7	6.4	6.1	4.5	8.955223881	4.5
	10	8	6.3	20.0	37	17.0
	7.6	7	8.4	7.9	-10.52631579	-18.4
	11	8	3.1	27.3	71.81818182	44.5
	10.5	8.6	6	18.1	42.85714286	24.8
	8.8	11	9	-25.0	-2.272727273	22.7
	3.4	4.4	4.8	-29.4	-41.17647059	-11.8
	9.8	9	4.5	8.2	54.08163265	45.9
	10	10.5	9	-5.0	10	15.0
	8	6	4.5	25.0	43.75	18.8
MAX	11.0	11.0	10.5	27.3	71.8	45.9
MIN	3.4	4.4	3.1	-29.4	-41.2	-25.0
AVR	8.7	7.9	6.6	6.5	19.0	12.5

Table 5.13 show; the removal efficiency of the parameter Oxygen Reduction Potential

	ORP					
	Input	Out A	Out B	ORP D. P. (A)	ORP D. P. (B)	Imp. Per.
	-34	-60	-80	76.5	135.3	58.8
	-55	-66	-83	20.0	50.9	30.9
	-54	-66	-90	22.2	66.7	44.4
	-44	-63	-88	43.2	100.0	56.8
	-50	-60	-70	20.0	40.0	20.0
	-45	-60	-75	33.3	66.7	33.3
	-55	-52	-70	5.5	27.3	21.8
	-55	-65	-80	18.2	45.5	27.3
	-50	-60	-70	20.0	40.0	20.0
	-40	-62	-80	55.0	100.0	45.0
	-33	-60	-90	81.8	172.7	90.9
	-52	-80	-90	53.8	73.1	19.2
MAX	-33.0	-52.0	-70.0	81.8	172.7	90.9
MIN	-55.0	-80.0	-90.0	5.5	27.3	19.2
AVR	-47.3	-62.8	-80.5	37.5	76.5	39.0
STD	8.0	6.6	7.9	24.6	43.4	21.6

Table 5.14 show; Min, Max, and Avrg. Values of the modified BSF different parameters

parameter	Values		
	minimum	maximum	average
pH	7	8	7'5
TURBIDITY	0	2	1
COD	0	4	2
p-total	2.1	0.69	1.8
BOD	0	6	3
E.Col CFU/100mg	350	0	175
N-total	10	9	9.5
NH4	1.6	0.13	0,86
TSS	6	0	3
ORP	-95	-50	-72.5
conductivity	1600	780	1190
NaCl ATC%	3.9	1.6	2,75
NO2	0.64	0,08	0,36
NO3	1.2	18	9.6

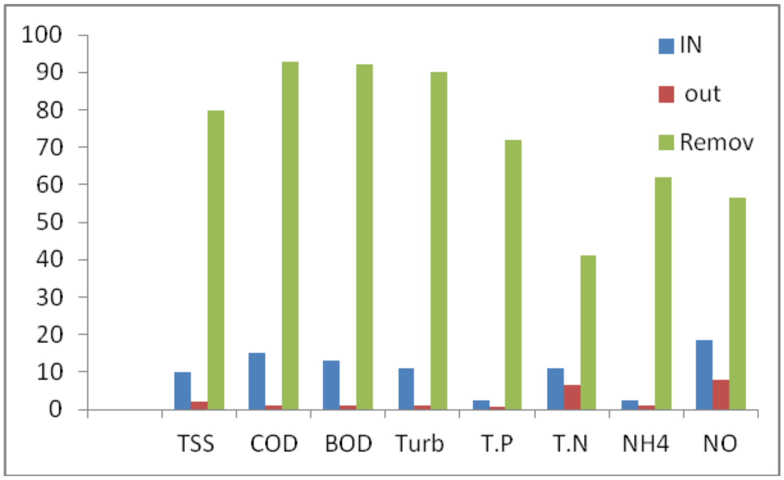


Figure 5.26, show the removal efficiency averages of the different parameters

Chapter 6

Discussion and Conclusions

6-1 Introduction

Proper wastewater management, modern sanitation and groundwater protection strategies efficiently contribute to a reduction of pathogen entry into the subsurface. This is often not implemented in developing countries. Consequences of poverty and overpopulation, are becoming more noticeable in problems related to hygiene and sanitation. Sanitation standards are often outdated and insufficient and most of the sewage is discharged to the environment without any treatment (UNESCO 1999)

Groundwater and/or drinking water in these regions, differ fundamentally in its quality from what is generally served in developed countries (Schwarzenbach et al. 2010). More than half of the world's population, will still not be connected to public sewerage systems in the next 20 years (UNESCO 2009). All above reasons, make me interested to introduce the urgently required research as assessment public, in wastewater treatment research field as step in long way fo future generations.

Since the main results of this study had clearly demonstrated the successful of the modification attempt been adopted by the researcher himself (chapter 5) through a simple revision to the chapter 4 of that all the modifications been described in details. The successful been reached the highest level of removal of the most pathogenic important indicator bacteria that effect badly and negatively to the human being and their existence since the results were(92.5 and 99.5%) of *E. coli* and *Total Coliform* respectively, (chapter 5).

Along and with regards to the modification attempt efficiency of the chemicals removal percentages, removal results reached up to (93, 92, 90, 80, 72, 62, 56, and 41)% of COD, POD, Turbidity, TSS, T.P, NH_4, Nitrite and Total Nitrogen respectively. Those results considerably significant than what had been achieved recently and worldwide.

Physically what had been observed and tested also come to be non objectionable level according to that water outlet odors, tastes, hardness and its colors. Nevertheless, those physical findings been supported by other parameters those included Turbidity, TSS and PH.

The water outlet from the modified biosand filters being accepted to be used within the agricultural and industrial different uses framework. Moreover, that system provide the opportunity to be commercially produced and to be available for so many people whom need it urgently.

Sustainability challenges us to reflect on wastewater treatment differently. Instead of focusing on end-of-pipe-treatment for emission prevention, attention shifts towards optimal resource utilization, favoring the development of decentralized systems. But are these systems more sustainable than centralized wastewater treatment systems? What aspects determine sustainability?

In an extensive literature review we find an overview of sustainability assessment methods and currently used indicators based on this we propose a general assessment methodology that builds on multi-objective optimization and a complete set of sustainability indicators.

For a great extent this study will positively contribute to the extension of wastewater reuse in agriculture, aquaculture and yet to effectively improves the wastewater use practices. The study is dedicated to the all researchers and consumers of wastewater treatment who will benefit wherever wastewater might be used with greater control in the future.

After the Comprehensive assessment for this investigation. We find that our idea for modifying such a system have a wastewater treatment system with a low cost, easily for operating and maintaining, and to be potentially applicable in developing countries, in particular by remote rural communities. According to the results we had obtained which are encouraging us to keep on toward that goal/goals, and with full self confidence.

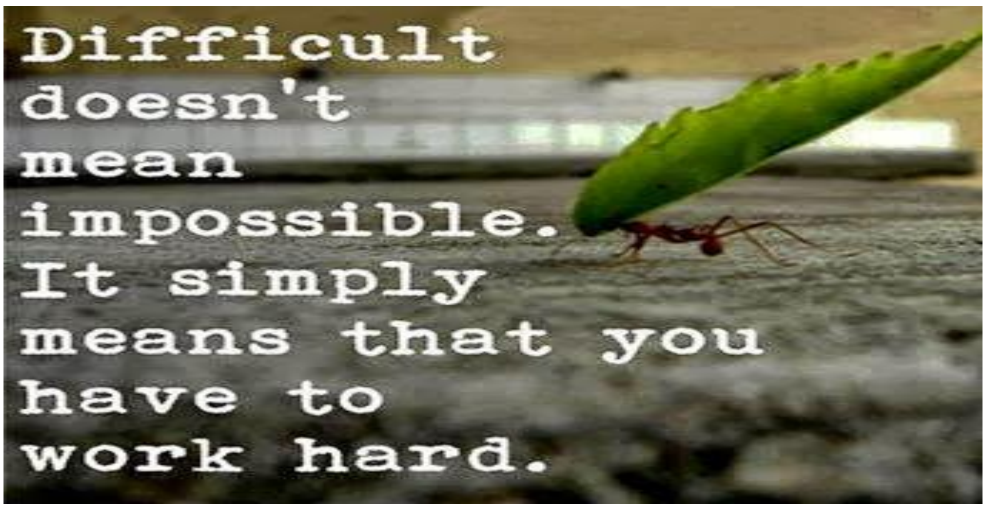
6-2 Recommendations

The modified BSF Effluent water outlet proposed areas to be reuse that supposedly cleared of any of the environmental negative impacts were included household and/or community different scales. It was possible to conclude the main modified BSF Effluent water outlet advantages with the following hints since it effects on:-

1. The cost of potable water supply possibly decreased to 50%.
2. The quality of the water being provided to the plants since it is positively effecting in its growing with regards to its contents of the N and P.
3. The potential cost reductions for regional sewage treatment facilities.
4. The availability of water could supply most, if not all, of the domestic irrigation and landscaped needs that covered with vegetation especially in a semi arid regions.
5. the availability of toilet flushing and washing different purposes water.

6-3 Recommendations arising from this experimental work for technical purposes

1. The water quality source to be filtrated should be chosen based on the local weather and environment, and yet the filtration method set accordingly,
2. In case of BSF been chosen (study case); the technical suitable sand and gravels be selected as filter media should be selected according to the international standards criteria and based on the water quality source,
3. With regards to the filter media texture, the sand and gravels layers should not be mixed,
4. The upper sand layer where biofilm is formed should be carefully selected, and to be flatten for great extent,
5. The diffuser presence is so important in order to protect biofilm, sand surface and to slow the water poured flow,
6. The water quality source preferred to be secondary treated water with low dirtiness,
7. The water quality source preferred to be in continuing flowing status,
8. The outlet valves must be fixed in each single filter media layer within the upper flow part,
9. The water surface level must be at least 5cm above the biofilm when the BSF system is not running,
10. The BSF box design must be completely preserved from any cracks or leaking might caused by the media and water different pressures,
11. Examine the feasibility and evaluate the performance of large scale implementation of the plastic modified biosand filter..


Difficult
doesn't
mean
impossible.
It simply
means that you
have to
work hard.

ABBREVIATIONS

Symbols	Meaning
µm	Micrometer
APHA	American Public Health Association
BOD	Biochemical Oxygen Demand
BSF	Biosand Filter
CFU	Colony Forming UNIT(s)
Cm	Centimeter
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
E.coli	Escherichia col
E.U.	European Union
EC	Electrical conductivity
EPA	Environment Protection of Agriculture
FDA	Food and Drug Administration
HRL	Hydraulic Retention Load
HRT	Hydraulic Retention Time
MF	Membrane Filtration
Mg	milligram
ml	Milliliter
NGO	Non Government Organization
ORP	oxygen Reduction Potential
Pa	Part A
PB	Part B
pH	Hydrogen Potential
SS	Suspension Solid

TDS	Total Dissolved Solid
Total Coli	Total Coli form
TSS	Total Suspension Solid
TU	Turbidity Unit
UNDP	United Nation Development Program
UNESCO	United Nation Education Scientific and Culture Organization
UNICEF	United Nation Children's Fund
WHO	World Health Organization
SSF	Slow Sand Filter
RSF	Rapid Sand Filter
WSP	Water Stabilizing Pond
GWI	Global Water Intelligence

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