AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Public Works

Optimization of Sand Filtration Characteristics for Waste Water Treatment

A Thesis submitted in partial fulfilment of the requirements of the degree of
Master of Science in Civil Engineering
(Public Works)

by

Mazen Mohamed Nagib Ahmed Kamal Tawfik
Bachelor of Science in Civil Engineering
(Public Works)
Faculty of Engineering, Ain Shams University, 2019

Supervised By

Prof. Tarek Ismail Sabry,
Professor of Public Works, Faculty of Engineering, Ain Shams University.

Dr. Ahmed Shafik El Gendy,
Assistant Professor of Construction and Architectural Engineering, School of Sciences and Engineering, The American University in Cairo.

Dr. Sayed Ismail Ahmed,
Assistant Professor of Public Works, Faculty of Engineering, Ain Shams University.

Cairo - (2019)

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Public Works

Optimization of Sand Filtration Characteristics for Waste Water Treatment

by

Mazen Mohamed Nagib Ahmed Kamal Tawfik
Bachelor of Science in Civil Engineering
(Public Works)
Faculty of Engineering, Ain Shams University, 2019.

Examiners' Committee

Name and Affiliation	**Signature**
Prof. Osama Fathy Mahmoud Professor of Public Works, Al Azhar University.	……………….
Prof. Mohamed El Hussieny Abdel Rahman Professor of Public Works, Faculty of Engineering, Ain Shams University.	……………….
Prof. Tarek Ismail Sabry Professor of Public Works, Faculty of Engineering, Ain Shams University.	……………….

Date: 17 January 2019

Statement

This thesis is submitted as a partial fulfilment of Master of Science Degree in Civil Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Mazen Mohamed Nagib Ahmed Kamal Tawfik

Signature

…………..……….

Date: 17 January 2019

Researcher Data

Name	:	Mazen Mohamed Nagib Ahmed Kamal Tawfik
Date of birth	:	22-02-1992
Place of birth	:	Saudi Arabia
Last academic degree	:	Bachelor of Science
Field of specialization	:	Civil Engineering
University issued the degree	:	Ain Shams University
Date of issued degree	:	2013
Current job	:	Civil Engineer

Thesis Summary

Improving sanitation systems and treatment technologies that allow for safe discharge into agricultural drains and unrestricted irrigation, must be through solutions that requires reduced environmental impact, lower capital cost and simplified operational procedures for wide application in secluded and rural communities with small populations.

This research work is primarily an investigation of the optimum slow sand filter design configurations, for refining the produced effluent quality of the partially treated wastewater to allow for the reuse in the unrestricted irrigation and decrease the load on the surrounding water bodies. Experimental work has been carried on by the variation of design parameters, and correlating with the effluent quality in terms of pollutants removal efficiencies and effluent passage, locating the optimum variables thereafter.

The work has been done on two phases, the first is aimed to locate the optimum design variables for the slow sand filter, in terms of effective size of the sand media, infiltration rate and filtration depth. Where the second phase is aimed to test two low-cost locally-available filter packing material to be mixed with the previously chosen sand media, to serve as an indicator for future studies and research.

It has been observed that the optimum design parameters for the slow sand filtration (SSF) unit that follows the decentralized wastewater treatment compact units, is utilizing sand media with effective size (D10) = 0.8~1.2 mm, Infiltration rate of 2.68 $m^3/m^2/d$ & filtration depth of 90 cm, will result in pollutants removal efficiency of 63%, 59% & 76% for CODtot, CODsol & TSS concentrations respectively. It has also noticed that when mixing the sand media with a sponge packing material from polyurethane foam, will yield a removal efficiency more than the one resulted from the sand media alone.

Key words: Wastewater treatment, decentralized systems, compact units, rural communities, slow sand filter, packing material.

Acknowledgment

I would like to express my sincere gratitude to my research advisors Prof. Tarek Ismail Sabry, Dr. Ahmed El Gendy and Dr. Sayed Ismail Ahmed for their patience and forbearance. Without their continuous support, this research would not have been progressed above various obstacles and setbacks.

Thank you.

March 2019

Table of Contents

List of Figures

List of Tables

CHAPTER 1
INTRODUCTION

1.1 GENERAL

In the current state of social expansion, many developing countries are facing a challenge in providing adequate & reliable sanitation systems to cope with the increasing load on the treatment facilities, not to mention the need for more economically reliable solutions to increase the probability of installation in small communities & dispersed geographical locations.

The centralized waste water treatment systems are not essentially feasible to construct on small scale communities. Meanwhile, the construction of extensive water networks to connect the dispersed locations to such centralized systems is no longer an option. It has become crucial to invest in the development of decentralized systems that is both feasible to construct & easy to operate. Utilizing such approach will allow for flexible installation & simple operation, in contrast to the centralized systems.

1.2 SANITATION SYSTEM IN EGYPT

The government of Egypt has been witnessing a change in approaching the subject of rural sanitation in the past decade, due to the observed decrease of water quality in the Nile river & branched raw water bodies.

The water supply sector is prioritized higher than the supply sector in most of the previous investment plans, though the investment plans has been increasing to be relocated to the sanitation sector in addition to the supply sector. (1) (2) Nonetheless, it is more important to collect all the water supplied through the various networks & construct the required treatment systems for such supply with each intended use. (3)

Currently, 85% of rural Egypt does not have sanitation systems (4), and households devise informal solutions to treat & dispose waste water in relation to its current financial capabilities. Septic tanks are commonly utilized as a simple & cheap solution for sanitation. However, smaller communities will simply dispose waste water away from their premises, in other cases service providers & collection facilities for those communities, will tend to take the same approach for disposal where supervision is not existed, thus disposing in waterways & irrigation networks.

Add to that the ground infiltration to the surrounding soil structure, not only from the direct discharge but from the simple limitations of treatment solutions; leakages from septic tanks & collection facilities, all that adds to the degradation of the water quality of the ground water bodies and posing environmental hazard on the surrounding areas.

1.3 PROBLEM DEFINITION

Major part of rural Egypt lack adequate sanitation systems for treating waste water emerging from the areas geographically away from the centralized systems, also continuously discharging raw waste water to water bodies is impacting the water quality & posing an environmental hazard at the raw water sources.

Conventional centralized waste water treatment systems require high cost of construction & complicated operational requirements, making it less adequate to be used for small dispersed communities.

The above has increased the need for low cost & easy to operate decentralized systems for treating waste water, that allow for reuse in unrestricted irrigation, to cope with the expanding social development in such communities.

1.1 RESEARCH OBJECTIVES

The research main objective is focusing on improving the partially treated water quality, either resulting from a low cost compact unit installed in an existing waste water treatment plant, or directly from the plant itself, by improving existing technology and optimizing system performance. The treatment of the waste water will aim for producing an effluent in compliance with the Egyptian law 48/1982 limits for discharge in agricultural drains with low cost sustainable solutions.