GREYWATER TREATMENT AND REUSE VIA DIFFERENT SIMPLE AND ADVANCED TECHNIQUES

By
Ahmed Makki Jabbar Al-Sulaiman

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of The
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
In
PUBLIC WORKS ENGINEERING
(SANITARY & ENVIROMENTAL ENGINEERING)

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Title of Thesis:

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Key Words: Greywater, Reuse, Effective microorganisms, Membrane bioreactor, Sequencing bioreactor, Up-flow anaerobic sludge blanket, Constructed wetland

Summary:

The present study deals with real GW that was collected from five flats and connected to a pilot plant, which was setup in NCR, Egypt, included sump tank, ST, AE, and CW. Three treatment systems were installed in this pilot plant namely, MBR, SBR, and UASB. Raw Greywater was subjected to two successive settling tanks. The effluent was divided into four streams. The first one was directed to the AE, the second one was directed to the CW, the third was directed to the MBR, and while the fourth was directed to the SBR. A pilot-scale of UASB followed by MBR unit was installed and operated in the NRC. Real raw greywater was subjected to UASB and the effluent was further treated with MBR. The objective of this study was to investigate different hybrid treatment processes for handling the GW for unrestricted water reuse. The viability and efficiency of sedimentation process at different times was examined. The viability and efficiency of sedimentation process followed by AE system, and CW system were also examined. Raw GW treatment was further evaluated employing chemical and biological coagulation followed by sedimentation processes. The chemical coagulation includes lime (CaO_2) and lime aided with ferric chloride ($FeCl_3$) as well as advanced oxidation as Fenton's reaction (Fe_2 $(SO_4)_3.H_2O_2$), serves as possible pre-treatment to ensure a successful sedimentation process. The experimental method involves monitoring of specific water quality constituents, under varying operating conditions, at different sedimentation periods and different chemicals doses to reach the sustainable approach. GW treatment was examined first in batch experiments to determine the optimum operating conditions. The obtained optimum conditions were implemented throughout the pilot plant investigation. Additionally, EM was added to the sedimentation process to enhance the efficiency of treatment was also investigated. The effluent was further subjected to CW. The final effluent could cope with the Egyptian code for water reuse. Further study was carried out to investigate the efficiency of MBR and SBR separately for the treatment of raw GWr. The treated effluent exhibited efficient quality for unrestricted water reuse.

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ وَأَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ﴾

سورة النمل(19)

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Ahmed Makki Al-Sulaiman

Dedication

I dedicate this thesis to my wife ***Rafel,*** *the exceptional people who have given me their unequivocal support throughout, as always, for which my mere expression of thanks likewise does not suffice.*

I am heavily indebted to my loving ***parents*** *for inundating me with their infinite love and care, raising me on the value of insistence and determination, educating me the sense of appreciation of learning, motivating me to chase my dreams, sacrificing their comfort to provide the perfect atmosphere for me to complete this work and praying for me to be a successful person.*

To whom I am deeply grateful for their extreme support & their indefinite patience.

I dedicate this work to my lovely kids

(Taha & Aya)

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