Greywater Treatment using Integrated Sand filtration and Ultrafiltration for Reuse

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The global response to climate change has been getting stronger in the recent years with more countries joining the efforts of climate change mitigation by including climate-related targets in their policies and strategies. Egypt is one of those countries. In 2022 Egypt released its updated Nationally Developed Contributions (NDCs) showing a serious direction towards sustainability in the water sector with a focus on non-conventional water resources and water reuse, energy efficiency, green building, and low carbon strategies. Utilizing greywater is mentioned explicitly in Egypt's plans to build climate resilience in the water sector.

The goal of this study is to investigate the potential of domestic greywater treatment by sand filtration followed by gravity-driven ultrafiltration. The goal of treatment is to reuse the effluent in landscape irrigation, toilet flushing, and other non-potable water uses.

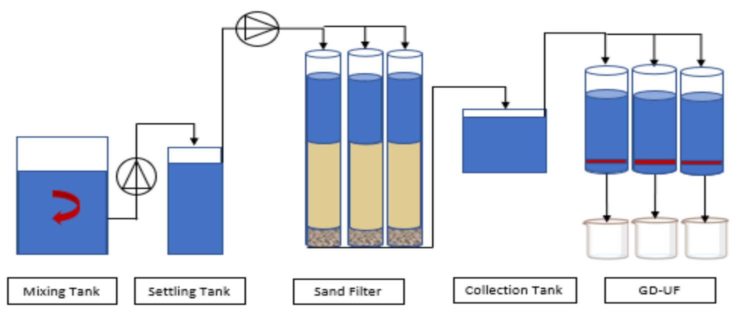

Figure 1 System Diagram

The study consisted of three phases. The first phase focused on optimization of the sand filter parameters using synthetic greywater mimicking real greywater characteristics. The optimum sand media size (D10) was found to be in the range of 0.8-1.2 mm and the optimum rate of filtration equal to $4m^3/m^2/day$.

The second phase of the study focused on gravity-driven ultrafiltration. Membrane flux was observed, and the two membrane sizes that achieved stable flux were chosen to be used in the later stages of the study. The chosen membranes were of 300 kdA and 400 kDa Molecular Weight Cutoff (MWCO).

The third phase of the study involved running the full system on synthetic greywater then on real greywater. The parameters investigated were COD, TSS, Turbidity and BOD_5. Total COD removal after sand filtration, 300kDa UF and 400 kDa UF was 65, 66 and 73.4% respectively. Total TSS removal after sand filtration, 300kDa UF and 400 kDa UF was 93.1, 98 and 98.1% respectively. Total turbidity removal after sand filtration, 300kDa UF and 400 kDa UF was 82.1, 85.8 and 83.8% respectively. And total BOD5 removal after sand filtration, 300kDa UF and 400 kDa UF was 59.1, 90.8 and 96.5% respectively.

The results obtained show that the 400 kDa membrane gave better results in COD and BOD_5 removal (73.4% and 96.5%). The 300kDa UF membrane gave better turbidity removal (85.8%). While TSS removal was the same for both 300 and 400 kDa membranes (98%). Overall, the system showed resilience to TSS shock loads, and all effluents from sand filter and ultrafiltration membranes complied with the Egyptian Code of Wastewater Reuse Category A (TSS less than or equal 15 mg/l). Membrane effluent BOD_5 concentrations also complied with the limits for Category A in the Egyptian code (BOD5 less than or equal 15 mg/l). All membrane effluents satisfied category A limit in the Egyptian Code for Wastewater Reuse in Agriculture for BOD5 (15 mg/l).

It can be concluded that the system has very good potential to be scaled up and implemented especially in new urban development areas. Further studies should be carried out to investigate the system performance relative to other pollutants. The initial cost of the system will be drastically decreased if UF membranes are manufactured locally. Finally, it is recommended to have a set of guidelines and a code of reuse for greywater specifically.