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Development of Low Cost Solid-Liquid Separation Prototype Used for Recovering Nutrients from Wastewater in the Gaza strip

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Abstract

The solid-liquid separation (SLS) is a key process for a nutrient recovery from domestic wastewater, besides lowering the requirements of secondary treatment. This study presents the development of a new SLS prototype, which is an interesting alternative to conventional pre-treatment equipment e.g. septic tank, and Imhoff tanks. The SLS was designed, developed, and realized for the first time in the Gaza Strip for a decentralized separation of wastewater solids from liquid at household level in order to facilitate a nutrient recovery. One of the key advantages of this SLS over other conventional pre-treatment equipment is the implementation at shallow depths with less construction and maintenance requirements and costs. The investigation and actual implementation of the prototype showed promising results in recovering nutrients from wastewater, which can be converted into a hygienically safe and nutrient-rich soil conditioner. The SLS prototype was designed to allow the infiltrated liquid to be drained to the next treatment equipment before reuse in irrigation.

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Keywords: Prototype; Low-cost; Pre-treatment, Solid-liquid separation; Wastewater.

1. Introduction

Wastewater contains valuable resources including water, nutrients and energy. The conventional centralized and decentralized approaches for wastewater management, mainly “flush and discharge”, and “drop and store” are globally dominant. However, their long-term sustainability remains questionable [1]. Simply because these

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conventional approaches are not mainly designed for resource recovery [2]. This means, unfortunately, that drinking water, nutrients, and potential energy are wasted [3], even with high investment and costly high technologies for treatment more than 20% of nitrogen, more than 5% of phosphorus and more than 90% of potassium are still emitted into the aquatic environment from treatment wastewater [4]. Therefore, these conventional approaches result in making nutrients to flow in a one-way path from farmlands to bodies of water [5], which causing depletion of soil fertility in many parts of the world [6]. This one-way path of nutrients results in high demands on industrial chemical fertilizers to compensate for the reduction in plant nutrients. Although industrial fertilizers are effective to cope with soil degradation, they cannot be a reliable and sustainable solution as they depend significantly on non-renewable resources and high energy. Therefore, these nutrients should be recovered and reused through treatment of black water and greywater separately [7]. Blackwater, including feces and urine, contains high amount of nutrients compared to greywater that includes water from kitchen, washbasins, showers, and laundry.

Considering the high amount of nutrients contained in the blackwater, the separation of solids form liquid of blackwater is still needed to facilitate recovering these nutrients. Separation of solids form liquid is carried out in a pre-treatment process, called primary treatment or solid-liquid separation [8] process, by which wastewater solids, e.g., oil, grease, sand, fibers, and trash, as well as some organic matter, e.g., feces and toilet papers, are preliminary removed [9]. pre-treatment is necessary for most biological treatment modules [10], e.g., soil filtration beds and constructed wetlands [11]. Pre-treatment can remove the solids, postpone their accumulation, and minimize subsequent blockages in the secondary treatment equipment [12,13].

The pre-treatment equipment uses physical removal mechanisms e.g. screening, flotation, settling, and filtration. Several types of equipment is used for separation of solid from liquid, including screening chambers, grease traps, grit chambers, and sedimentation tanks [9,12]. For household or small-scale applications, conventional pre-treatment equipment include Imhoff tanks, septic tanks [14], and grinder pumps [13], and nonconventional pre-treatment equipment, e.g., compost filter or “Rottebehälter” as called in German [7]. In most conventional equipment, e.g., Imhoff tanks, and septic tanks, anaerobic conditions are common, and cause stabilization of organic matter and reduction in sludge quantities. This gives the possibilities for subsequent recovery of biogas, while the stabilized sludge can be used as manure [15]. Moreover, aerobic conditions in a variety of pre-treatment equipment have been used in recent years [13], with compost filters [11] as one example.

After separation of settleable solids, liquid effluent has a lower load of organics [15] and can be treated in constructed wetlands [16] as well as in other conventional and nonconventional biological modules, via soil filtration beds [17], biofilm modules, e.g., trickling filters, and activated sludge with filtration, e.g., membrane bioreactors or biological filters [18,19]. For further details about different types of SLS equipment, the reader may refer to [20] and [9], and for the basic design equations of septic tank, baffled tanks, and Imhoff tanks, refer to [21].

2. Concept and functions of solid-liquid separation prototype

This paper presents a prototype for pre-treatment equipment, which was designed, developed and realized for the first time in the Gaza Strip for on-site separation of blackwater solids from liquid at a household level. The design, development, and realization of solid-liquid separation (SLS) prototype was accomplished depending upon the locally available resources and materials, and in accordance to less requirements for energy, e.g., electricity. These considerations were key issues for making the SLS be low-cost. Other main features of the prototype are that it is low-tech; and easy to implement, operate, and maintain; as well as culturally adoptable for communities in semi-urban and rural areas in emerging countries, particularly in the Gaza Strip.

2.1. Basic concept

The fundamental concept of the SLS prototype was inspired by development of “Rottebehälter” compost filters. In the compost filters, blackwater solids are stored in a safe and hygienic manner until the favorable time for further processing and the production of soil conditioners. Other advantages of compost filters [22] include:

- No pleasant odor in the effluent compared to that from anaerobic pre-treatment equipment, e.g., septic tanks.