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Evaluation of wastewater post-treatment options for reuse purposes in the agricultural sector under rural development conditions

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ABSTRACT

Reuse of wastewater is a sustainable and renewable source of water, mainly used in the agricultural sector and can contribute to rural development. Agriculture is the second highest sector for water consumption in the Gaza Strip, using more than 50% of water abstractions from the stressed polluted Gaza's coastal aquifer. This paper aims to present and evaluate two available wastewater post-treatment options which could be employed to reuse wastewater for agriculture in Gaza: sand filtration using a textured geo-membrane sand filter and the Soil Aquifer Treatment (SAT) system. This evaluation is based on applying hierarchy grey relational analysis and the comparison matrix through an environmental assessment for each option using a semi-empirical methodology that combines results from field tests and computer hydrological simulations. In addition, it is based on a social and economic and the operational aspects for the Gaza City Wastewater Treatment Plant (WWTP) and its infiltration basin. The evaluation factors for the two options are juxtaposed in a Comparison Matrix with associated weighted scores and pre-defined scales to quantify the evaluation process before using the hierarchy grey relational analysis. The results show that the operational costs and the environmental aspects are the main factors that affect the evaluation process for wastewater post-treatment options. The sand filtration (with textured geo-membrane) option is ranked higher than the SAT system for this particular case study with an overall integrated grey relational grade equal to 0.3276, compared to 0.2596 for the SAT system.

1. Introduction

Wastewater reuse is one of the main options to develop non-conventional water resources because it can be considered as a renewable and sustainable source of water [24]. This water resource can be used for agricultural purposes or for groundwater recharge. The reuse of reclaimed wastewater reduces the gap between the water demand and the supply. It can also improve the environment by reducing the load of environmental contaminations [22], as well as providing economic and health advantages such as reducing the cost of wastewater disposal as well as the cost for irrigation water [18,29]. In addition to that, long term investment in the management system for agricultural water is a challenge, especially in the concern of rural development [11].

Water scarcity is one of the key difficulties and challenges facing human society across the world. The Gaza Strip suffers from water scarcity due to the continuously over-pumping and the huge gap between water demand and water supply, which has caused both water quantity and quality problems [5,32]. The situation is further deteriorated and exacerbated by climate change impacts [14,13] and the continuous substantial increases in population leading increased water demand. As such, the need of finding new unconventional water resources for the agricultural sector becomes of paramount importance for the Gaza Strip. Using treated wastewater for irrigation purposes is one of the most environmental friendly available options [16] and according to the Palestinian Water Authority (PWA) strategic plan, this option will be feasible for the future.

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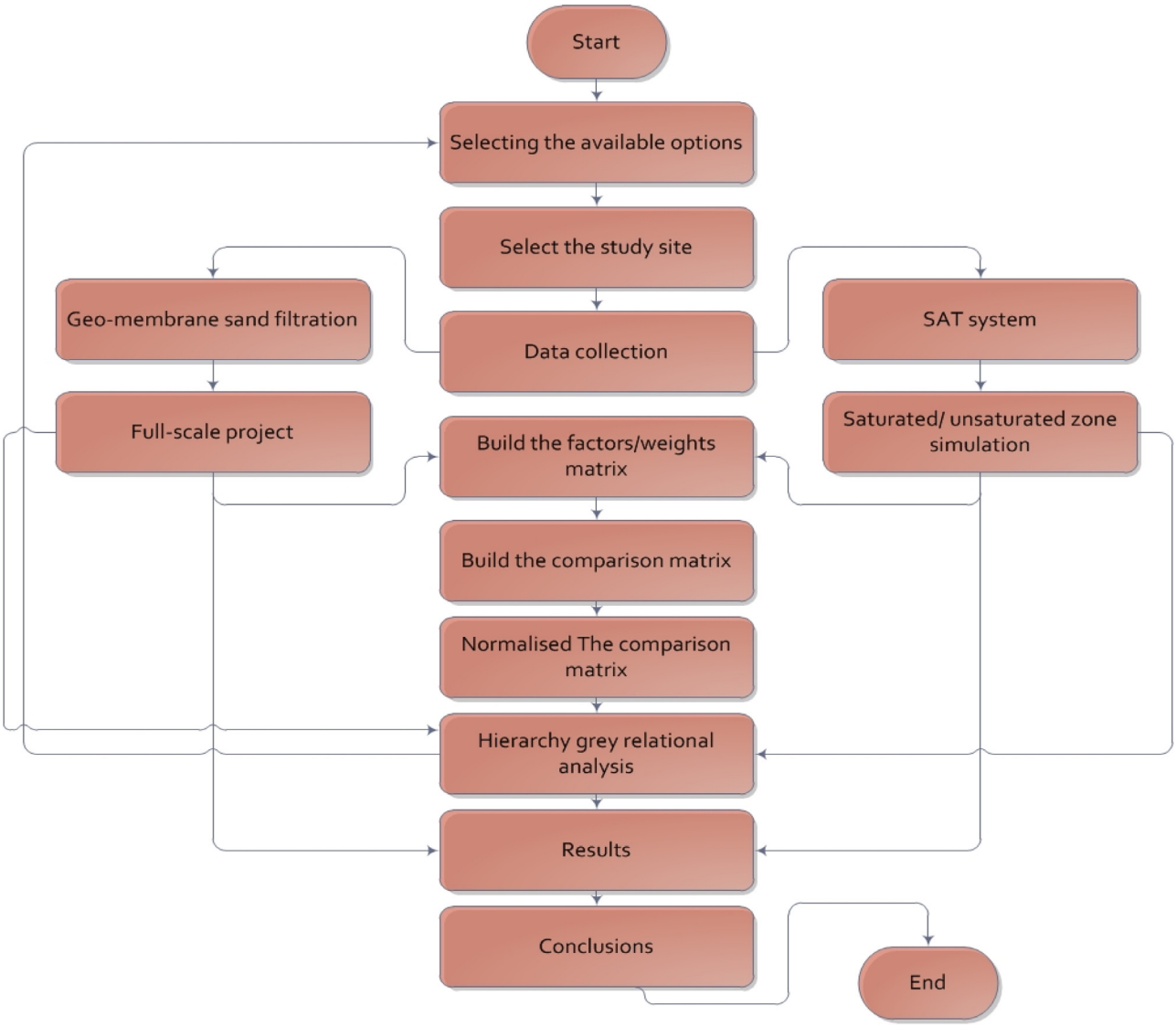

Fig. 1. Methodology flow chart.

In the Gaza Strip there are 5 Wastewater Treatment Plants (WWTPs), but the treated effluent quality does not meet the minimum regulations for irrigation purposes or even for discharge to water bodies. The main reason for this bad efficiency is the overloaded situation for these WWTPs, hydraulically and biologically [15]. In order to overcome this obstacle, a post treatment process is needed to provide a higher level of treated wastewater that meets the reuse regulations [33,12], with minimum direct and indirect costs and impacts [6].

This paper provides a semi-empirical methodology that combines results from field tests and computer hydrological simulations, to evaluate two suitable wastewater post-treatment options: sand filtration using a textured geo-membrane and Soil Aquifer Treatment (SAT) based on social, economic and environmental aspects.

Sand filtration using a textured geo-membrane is an open slow sand filter with multiple layers consisting of coarse gravel, sand, fine sand and textured geo-membrane. The filter is fed by wastewater effluent [17].

SAT can provide post treatment to WWTP effluents by land-based managed aquifer recharge technology. SAT provides physical, chemical and biological treatment processes in order to improve the quality of wastewater effluent by its infiltration through soil layers to yield water of acceptable quality for reuse purposes [1,2,36]. In this paper the environmental sub-assessment process for SAT has been carried out through groundwater simulations for flow and tracer pollutant transport.

The methodology in this paper is based on identifying the optimized solution by applying a hierarchy grey relational analysis [35] followed by a comparison matrix [19,9] which compares environmental and socioeconomic aspects [27] for each option using practical field full scale experimental results and hydrological simulations. In addition it is based on a social and economic survey as well as the operational aspects for the Gaza City WWTP and its infiltration basin, as a case study in a region with stressed water situation.

2. Materials and methods

The comparison and assessment of alternative mitigation strategies for an environmental phenomenon is a critical task and can be very sensitive to the factors which participate in the process. As such, careful planning is required before any analysis is started: Fig. 1 shows the general flowchart for the methodology that is used