PROCESS SAFETY AND ENVIRONMENTAL PROTECTION xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Process Safety and Environmental Protection

journal homepage: www.elsevier.com/locate/psep

A cost effective method for decentralized sewage treatment

Abbas Jorsaraei[a,*], *Mahdi Gougol*[a], *Jules B. Van Lier*[b]

[a] *Research Institute of Petroleum Industry (RIPI), West Blvd., Near Azadi Sports Complex, Tehran, Iran*
[b] *Section Sanitary Engineering, Department of Water Management, Faculty of Civil Engineering and Geosciences, Delft University of Technology, P.O. Box 5048, 2600 GA Delft, The Netherlands*

ABSTRACT

The aim of this research was to upgrade the performance of a conventional septic tank (CST) for on-site treatment of sewage with negligible costs. Although CST is known as an inexpensive pre-treatment system, a complementary treatment is required to reuse its output effluent. In this work, the quality of treated wastewater reached to the standard level for irrigation by the innovational changes made in the structure of CST for converting it into an advanced septic reactor (ASR). The modification consists adding some pipe and trays without using any mechanical or electrical equipment.

ASR was operated at ambient temperatures in laboratory and pilot-scale. The effects of up-flow velocities (V_{up}) of 0.4, 0.5, 0.7, 1 and 1.5 m/h and hydraulic retention times (HRT) of 36, 24 and 12 h on the ASR treatment performance were studied.

For optimum V_{up} of 1 m/h and HRT of 24 h and biomass specific methanogenic activity (SMA) of 0.31 mg COD/g VSS d the maximum removal of chemical oxygen demand (COD), biochemical oxygen demand (BOD5) and total suspended solids (TSS) were 86.2%, 79.4% and 95%, respectively.

The results showed that ASR is an appropriate alternative for CST for sewage on-site treatment by a low cost modification.

Keywords: Decentralized treatment; Anaerobic treatment; Advanced septic reactor; Wastewater treatment; Economy and reuse

1. Introduction

Collection, treatment and discharge of domestic sewage can be done in centralized or decentralized systems. For scattered buildings and residential areas without a centralized system, on-site treatment of domestic sewage in a decentralized system not only would avoid dealing with costly centralized systems, but it allows the sewage owner to reuse the treated effluents. Due to the existence of soluble organic substances in domestic sewage, biological treatment techniques (aerobic or anaerobic or a combination of both) are generally incorporated. Selection of treatment system on-site is based on factors such as appropriate efficiency, low cost and minimum energy and maintenance requirement.

Aerobic processes are far less attractive than anaerobic processes under the same conditions due to their high costs related to procurement, operation and maintenance equipments such as pumps and air blowers (Van Lier et al., 2002), but anaerobic systems are more attractive because of process simplicity, low operational costs, biogas production and no need to energy resources (Darwish et al., 1999). The need for energy efficiency and CO_2 emission reduction potentials are main driving forces for applying anaerobic technologies in recent environmental engineering trends (Al-Jamal and Mahmoud, 2009).

Due to existing nutrients (N,P,K) in domestic sewage treated effluents, it would have nutrients which is suitable for irrigation. The most simple, ancient and applicable process for on-site anaerobic treatment system is a septic tank, but unfortunately the treatment efficiency is low due to the occurrence of very low sludge residential time (SRT) so it is known as a pretreatment unit which its function is storage and

* *Corresponding author*. Tel.: +98 21 4825 5177; fax: +98 21 4473 9590.
E-mail address: abbasjt@gmail.com (A. Jorsaraei).
Received 28 January 2013; Received in revised form 16 April 2013; Accepted 18 April 2013
0957-5820/$ – see front matter © 2013 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.psep.2013.04.001

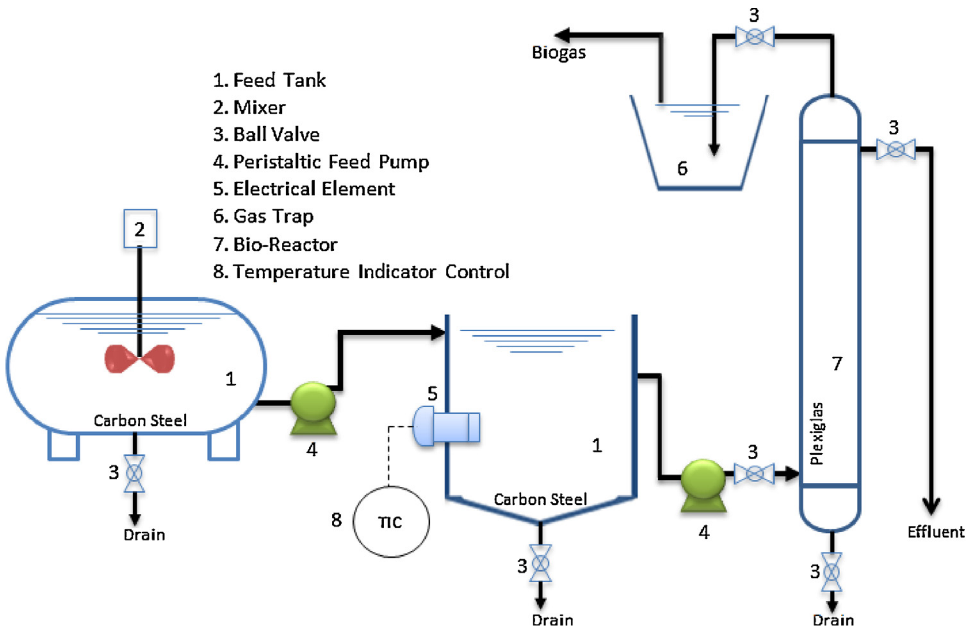

Fig. 1 – ASR setup in laboratory scale.

sedimentation of influents suspended solids (Elmitwalli et al., 2002; Panswad et al., 1997). If the efficiency of a conventional septic tank (CST) is enhanced through partial improvement in its structure or in its operating manner, it would be possible to apply it as a treatment system whilst benefiting from its advantageous such as ease in construction, operation, performing, and maintenance or no need of energy resources. In that case, this advanced septic reactor (ASR) would be not only able to settle suspended solids like CST but can remove soluble substances similar to an advanced and expensive anaerobic treatment system such as up-flow anaerobic sludge blanket (UASB). This kind of systems has become known as a UASB-septic tank (UST) which is applied for decentralized on-site treatment of sewage (Van lier and Lettinga, 1999).

Various modifications have been suggested for efficiency enhancement of CST (Lettinga et al., 1993; Bogte et al., 1993; Al-Jamal and Mahmoud, 2009), nevertheless, all the presented ideas suggest a new system and deny the possibility to improve the existing septic tanks. For instance, the changes introduced by Sabry (2010), Viet Nguyen et al. (2007) and Luostarinen et al. (2005, 2007), need to use some energy consumption equipments such as pumps and along with a complete new structure.

This article presents the results of an innovative ASR which have been designed in Iranian Research Institute of Petroleum Industry to investigate the performance for sewage treatment of Tehran to reuse in irrigation.

2. Materials and methods

2.1. *Experimental setup (laboratory scale)*

ASR was designed by some modification in CST consist of changing flow direction from horizontal to up-flow by extending the inlet pipe to the bottom of the reactor and applying distribution trays with uniform holes on them which was installed in lower part of the reactor. The reactor was made of Plexi-Glass in the laboratory scale as Fig. 1 with a capacity of 100 L, a height of 4 m and a diameter of 18 cm.

In the first stage, the sewage feed was prepared in the feed preparation storage tank in reference to the characteristics presented in Table 1 and was pumped into the injection storage tank by a pump. From this tank, sewage entered to the bioreactor by using a dozing pump in up-flow regime. Sewage was treated whilst passing through the sludge blanket and the treated effluent, produced biogas and the biological sludge were separated in the top section of a gas-liquid-solid (GLS) separator.

For removing CO_2 and H_2S from produced biogas it passes through a storage tank containing dilute caustic soda solution where the aforementioned gases will be solute and remove in caustic solution and the exiting gas mostly contains methane as a clean biogas.

2.2. *Synthetic wastewater composition*

For the preparation of the influent to the bioreactor, a diluted solution of molasses from a sugar factory, industrial phosphoric acid, urea fertilizer and caustic soda from the petrochemical industry of Iran, hydrochloric acid from Merck Co. and industrial methanol from an alcohol producing factory were used. By using relations C:N:P (1:5:500) to (1:5:350) (Lettinga et al., 1991) ammonium and phosphate were added and for adjustment of pH, HCl and NaOH along with sodium carbonate solutions and sodium bicarbonate from Merck Co. for buffering were used and industrial methanol was used as an aiding feed (Kargi et al., 2005).

Table 1 – Features of synthesized sewage at laboratory scale.

Item	Range	Average
BOD_5 (mg/L)	680–2000	1330
COD (mg/L)	1000–4000	2500
P-PO4 (mg/L)	7–26	17
N-NH3 (mg/L)	35–104	89
T (°C)	25–37	32
pH	7–9	8.2
VFA as acetic acid (mg/L)	206–744	450