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Anaerobic up flow fluidized bed reactor performance as a primary treatment unit in domestic wastewater treatment

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KEYWORDS

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Abstract The fluidized bed UASB performance was studied in this experiment as a primary unit the anaerobic unit the advantage of better generated sludge characteristics and smaller tank volume.

The reactor performance was investigated for the treatment of domestic wastewater with unexpected industrial water flows at different operational temperatures (14–25 °C) and loading rates. For each temperature range the reactor performance was studied under different hydraulic loadings HRT (6, 4, 2.5 h).

The best methane yield rate and COD total removal rate are 0.285 l/g COD total and 70.82% respectively at warm working temperature 19 °C with OLR 7.76 kg COD/m^3/day and HRT 6 h.

On the low temperature operation, the average COD removal of the reactor was 55.28% and 50.33% for HRT of 4 h and 2.5 h respectively. The methane production dropped to 0.1623 & 0.0988 L CH_4/g COD with average organic loading rate of 5.34 & 10 kg COD/m^3/day for HRT of 4 h and 2.5 h respectively.

The efficiencies of Total nitrogen removal ranged between 2.23 and 10.83% with an apparent decrease during the low temperature high rate stages. Nitrite removal was in the range of (23.08–77)% with up to the 2 mg/L in the effluent water when obtaining high organic loading and warm temperature. These results demonstrated that the domestic wastewater could be anaerobically treated in a fluidized bed UASB reactor with very low HRT reaching 2.5 h.

Abbreviations: UASB, up flow anaerobic sludge blanket; GSS, gas-solid separator; HRT, hydraulic retention time; SRT, sludge retention time; WWTP, wastewater treatment plant; OLR, organic loading rate

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Introduction

The conventional aerobic processes that are widely used for the treatment of domestic wastewater have at least three distinct disadvantages: their relatively high electrical requirement, the high operation cost and the high excess sludge production which requires treatment and disposal that further increases the operational cost.

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On the other hand anaerobic processes produce methane gas that can be collected and used as an energy source in addition to the low energy consumption. The sludge production is also minimal, and additional important benefit is that the anaerobic sludge can be preserved while not being fed for long periods of time at temperature below 15 °C [1].

The feasibility of the up flow anaerobic sludge blanket reactors UASB for adequate sewage treatment has been investigated since 1980 at both pilot and full scale installations [2], but at the moment, it is largely restricted to countries with a relatively cold climate [3].

The anaerobic fluidized bed and the expanded granular sludge bed reactors, with HRTs of about 2–4 h [4] and the UASB reactor, with an HRT of 4–8 h [5] offer good results, while the attached growth process named anaerobic filter needs a longer HRT on assuming constant organic loading rates for all systems.

As domestic wastewater flows are relatively huge in large cities and should be treated at short HRTs to be more feasible and often are at ambient or low temperatures, complex substrates could leave the reactor before being biodegraded. In UASB systems, with relatively adequate HRT, the sludge bed acts as a filter to the SS, thereby increasing their specific residence time. In this way, the UASB reactor may achieve high COD and SS removals at a relatively short HRT if compared to the conventional primary sedimentation tanks. Consequently one of the aims of the study was to study the influence of the low HRT on the reactor performance.

Material and methods

The Experimental work was carried out at El Berka wastewater treatment plant. Using domestic wastewater from the primary sedimentation channel the experimenting set up was started by the UASB reactor.

The reactor consists of a column portion (130 cm) of about 23 L and a gas–solid separator (GSS) portion (20 cm) of about 6.28 L. The reactor total volume is about 25.60 L this volume was used to calculate the organic loading and the hydraulic retention time. The UASB was operated over 100 day under different temperature ranges (15–25) °C.

The up flow velocity was varied according to the hydraulic retention time HRT variation, no recirculation was applied. Effluent recycle was not necessary to fluidize the sludge bed as sufficient contact between the wastewater and sludge is guaranteed even at low organic loading rate in UASB reactor [6]. Fig. 1 shows the reactor setup and the influent water characteristics are shown in Table 1.

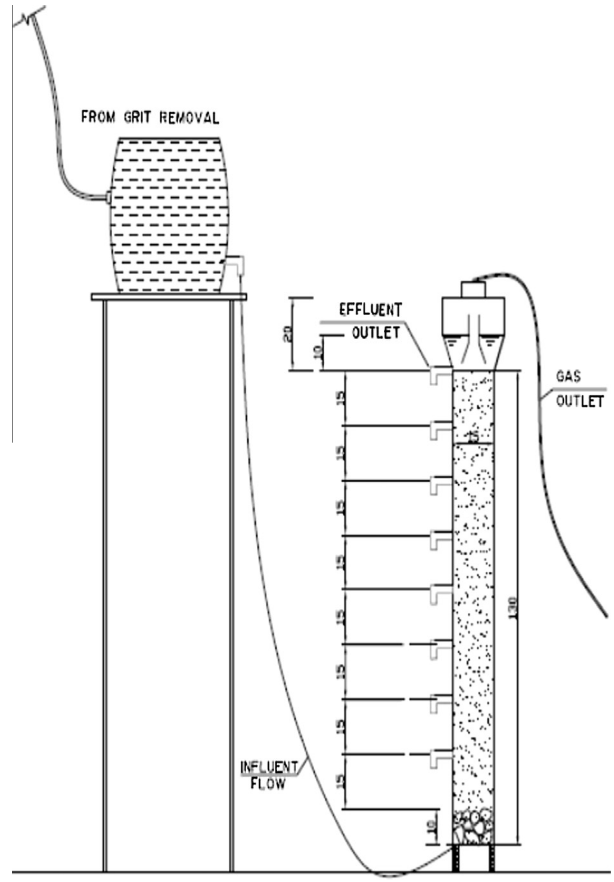

Fig. 1 Reactor set up.

Experimental methodology

The reactor was operated at ambient temperature, no heat exchange was introduced. The reactor was operated in the autumn/winter time where the temperature falls down in winter reaching about 15 °C. The average influent wastewater temperature during the experiment is shown in Table 2.

The experiment routine water analysis was done according to the standard method for water and wastewater analysis [4], the physical and chemical analysis included the measure of chemical oxygen demand (COD) and the sulfate concentration of influent and effluent was analyzed by DR-2800 spectrophotometer (HACH company, USA) in accordance with manufacturer's manual. Raw samples were used for total COD and 0.45 μm-filtered samples for dissolved COD. After sampling,

Table 1 Influent water characteristics.

Parameters	Unit	Min.	Average	Max.
pH-value	–	6.71	7.44	7.93
Chemical oxygen demand(COD)	(mg/L)	400	1105	2240
Biological oxygen demand(BOD)	(mg/L)	178	695	1913
Total suspended solids (TSS)	(mg/L)	172	788.60	2080
Total volatile solids (VSS)	(mg/L)	120	532	1410
Total nitrogen (TN)	(mg/L)	47.20	52.75	58.30
Ammonia (NH_4–N)	(mg/L)	15	28.10	41.60
Nitrate (NO_3–N)	(mg/L)	2.5	7	11.50
Nitrite (NO_2–N)	(mg/L)	9	11.50	14