Co-treatment of Municipal Wastewater and Food Wastes Using a UASB reactor Coupled to Submerged AnMBR

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Abstract:

The treatment of domestic wastes where they in liquid form (wastewater) or solid form (organic and inorganic) is of major environmental and public health concerns in several developing countries. Unfortunately, and due to several ongoing crises, a considerable portion of the domestic wastes generated in Lebanon are disposed of, untreated, in aquatic reservoirs and unsanitary landfills.

Whilst several technologies (the vast majority of which aerobic in nature) have been utilized for the treatment of domestic wastewater, more recently, anaerobic methods have gained traction as they may proffer several advantages over conventional aerobic methods, such as negligible energy consumption, low sludge production, and energy recovery in terms of biogas.

Although anaerobic treatment of wastewater has received a wider research interest in the past decades, there is sparse literature/research on the anaerobic simultaneous co-treatment of municipal wastewater and the organic fraction of municipal solid wastes. It is hypothesized that mixing the organic component of municipal solid waste with domestic wastewater will result in a higher chemical oxygen demand (COD) content of the wastewater, thus more biogas will be produced, it also enhances the nutrients, C/N ratio and mineral content of the mixture that could promote the biomass activity, provides more buffer capacity that could absorb the acid shock resulted from prompt acidification of biodegradable material, and increase the COD/SO_4-S ration which would promote methanogenic activity.

In this work, the ability of anaerobic reactors to co-treat both substrates was investigated. The impacts of a combined influent on biomass activity, sludge quantity and quality, effluent quality and biogas production were studied. The experiments were conducted using a large lab-scale (12 liters) up-flow anaerobic sludge blanket reactor (UASB) under mesophilic conditions (35°C) coupled to a flat sheet ceramic membrane. The USAB has been in continuous operation for three years and the experiments were conducted sequentially in three phases.

In phase one, the performance of the USAB reactor in treating synthetic wastewater only was investigated under different operating conditions, e.g., different hydraulic residence times (HRT 24,16,12,6 hours), various up-flow velocities, and organic loading rates to infer its optimal operating parameters. The stability of reactor, activity of biomass, amount of accumulated sludge and volume of methane produced were recorded. During the first year, and after a six months adaptation period for the reactor, synthetic

wastewater (750 ±100 mgCOD/L) was fed at different HRTs and OLR. It showed propitious performance with COD removal efficiencies varying between 75-85%. Although only minor sludge withdrawal was made for analysis, it took almost two years for the sludge level to reach the outlet of the reactor. The volume of biogas produced was 180 mlCH_4/gCOD with methane content between 65-75%.

After one year of continuous operation, phase two was commenced, and both wastewater and food wastes were co-treated in the same UASB at similar optimal conditions, and thorough analyses were conducted to determine the impact of co-treatment on reactor performance. Food wastes were added according to the ratio that represents daily production per capita (200 Liters WW + 500 grams food wastes). This increased the COD content of the influent to 1150 ±150 mgCOD/L. The reactor demonstrated a stable operation with COD removal efficiency around 75% with no signs of perturbations. The alkalinity in the effluent was always higher than the influent which kept the reactor's pH level in the range 7.2-7.5.

Finally, in order to achieve an effluent quality that comply with local discharge regulations, a polishing step (phase three) was introduced. The UASB was coupled to a submerged ceramic flat sheet membrane of nominal pore size 0.1 µm and effective area of 0.15 m^2. This combination accomplished many merits: it enhanced effluent's quality (overall COD removal efficiency was 95%), and decoupled SRT from HRT which provided the ability to operate the reactor at high hydraulic loads without risking biomass flushing out of the system. Methane production had also increased to 240 mlCH_4/gCOD.

The significance of this research lies in the potential of achieving major energy consumption and cost reduction in treatment of both domestic wastes as compared to conventional aerobic processes, substantial cut in organic wastes collection and transport expenses, potential increase in biogas production, and a much lower sludge yield.