Effect of organic loading rate on anaerobic digestion of fruit and vegetable wastes: Process performance and biogaz potential

M. Jraou[1], F. Feki[1],S. Loukil[1], S. Sayadi[2] and S. Khoufi[1]

[1] Laboratory of Environmental Bioprocesses, Center of Biotechnology of Sfax B.P. 1177, 3018 Sfax
[2] Center for Sustainable Development, College of Arts and Sciences, Qatar University, Doha, 2713, Qatar
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e-mail: mouna.jraou83@gmail.com

The rising amount and complexity of solid waste added to modern economy is causing a serious hazard to ecosystem and human health. About 11.2 billion tones of solid waste are generated all over the world annually. The decomposition of the organic fraction is the cause of 5% of global greenhouse gas emissions. Fruit and vegetables wastes (FVW) constitute an important fraction of solid wastes.The worldwide production of FVW is growing with population growth (Omre, 2018) and waste amounts are increasing respectively. FVW have a composition that makes them the cause of several environmental, social and economic troubles (Enrika, 2017): volatile organic compounds emission, leachate, public health hazard and vegetation toxicity (Azadeh, 2011). Owing to their important biodegradability and high moisture content, the anaerobic digestion (AD) is a key option for their valorization. Additionally, the AD has several benefits such as biogas production, energy recovery, pathogens destruction and fertilizer production (Al-Wahaibi, 2020). FVW are mainly composed of carbohydrates (70 to 90%) and minor proportion of cellulosic materials therefore they have a high potential to be converted to value added product like bio-methane (Díaz, 2017). Nevertheless, the hydrolysis of these components is hard and represents a limiting factor for anaerobic digestion (Mlaik, 2019). On another hand, many factors could affect the performance of AD process like reactor configuration, feedstock characteristics, and operational conditions. The organic loading rate (OLR) is an important parameter because it indicates the amount of volatile solids to be fed into the digester (Azadeh, 2011). The biogas production performance depends strictly on the organic load (OLR) and HRT. High organic loading leads to an increase of microorganism activity and consequently system instability. A suitable OLR and hydraulic retention time are essential for steady anaerobic digestion system (Liu, 2018).

The aim of this study was to assess the effect of increasing organic loading rate on the performances and treatment efficiencies of a continuous stirred tank reactor (CSTR) treating FVW. Volatile solids removal as well as biogas yield evolution and CH_4 proportion under different OLR were determined. A CSTR at pilot scale (1 m^3) was operated under batch mode in mesophilic condition (38ºC ± 1°C). A fixed hydraulic retention time of 10 days was applied at different OLR ranging from 8 to 14 kg VS/m^3.

Table 1. Feedstock characteristics.

Sampling month	November	December	January	February
TS %	8.82	11.78	9.465	9.83
VS %	8.12	10.8	8.74	9.02
S_{COD} (mg/l)	88510	96617	94405	94805
% Fruits	44.75	46.93	58.5	46.58
% Vege-tables	55.25	53.07	41.5	53.42

TS: total solids, VS: volatile solids, S_{COD}: soluble COD

The FVW used in this study were collected from the wholesale market of Sfax-Tunisia. Fresh samples were sorted, crushed and directly used for the reactor feeding. Wastes are composed of fruits (Tomatoes, grenadine, orange, apple, strawberry and lemon) and vegetables (onion, squash, potatoes, carrot, turnip and pepper). **Table.1** illustrates the characteristics of the different FVW samples.

Anaerobic digestion of raw FVW proved the effectiveness of the process for the treatment of fruit and vegetable wastes, the production of biogas, VS removal and biosystem stability. The performance of biogasification was influenced by the increase of the organic loading rate. Optimal gas production was achieved at OLR of 8 g VS/ L reactor with a biogas yield of 1.42 L/g MV. At higher OLR, the biogas yield has a tendency to decrease. Methane concentration attains its maximum of 77.3 % at an OLR of 14 g MV/ L reactor. However steady performances were achieved at the different tested organic loading rates. The digester showed high performance at OLR of 12 g VS/L reactor with methane concentration of 73.2 %, VS removal of 87.75 % and biogas yield of 1.36 L/ g VS.

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