

**OPTIMIZATION OF BIOGAS AND METHANE PRODUCTION BY ANAEROBIC CO-DIGESTION OF SEWAGE SLUDGE AND WHEAT STRAW UNDER MESOPHILIC CONDITION: EFFECT OF C/N RATIO AND VOLATILE SOLIDS ORGANIC LOADS**

M. ELSAYED<sup>1,2,\*</sup>, Y. ANDRES<sup>1</sup>, W. BLEL<sup>3</sup>, A. GAD<sup>4</sup>, AT AHMED<sup>5</sup>

<sup>1</sup>GEPEA UMR CNRS 6144, 4 rue Alfred Kastler, 44307 nantes cedex 3, Ecole Des Mines De Nantes, NANTES, France .

<sup>2</sup>Sanitary and Environmental Engineering, Faculty of Engineering, Aswan University, Aswan, Egypt.

<sup>3</sup>CNRS, GEPEA, UMR 6144, CRTT, Université de Nantes, CNRS, GEPEA, UMR 6144, CRTT, 37 boulevard de l'Université, BP 406, F-44602 , Saint-Nazaire, France.

<sup>4</sup>Sanitary and Environmental Engineering, Faculty of engineering, Assiut university, Assiut, Egypt.

<sup>5</sup>Sanitary and Environmental Engineering, Faculty of engineering, Aswan university, Aswan, Egypt.

\*Corresponding author: M. ELSAYED- Tel.: +330783106853

E-mail addresses: engzezo1111@yahoo.com.

## **Abstract**

**Purpose of the study:** The objective of this study was to optimize biogas and methane production from the anaerobic co-digestion of wheat straw (WS) and primary sludge (PS). These two substrates, found abundantly in Egypt, may induce environmental issues and can be recycled in the methane production. Indeed, in Egypt, no development occurred in the energy field in addition to the lack of fossil energy resources. Thus, the methane production from wastes as PS and WS will be a suitable solution for renewable energy production. Batch digestion tests were carried out in 500mL glass digester under mesophilic temperature at  $37 \pm 1^\circ\text{C}$  with a VSinoculum/VSubstrate ratio of 2 and over a 30 days period. In this study, two steps were performed; in the first step, six mixtures of 12, 10, 8, 7.50, 6 and 3 gVS/L were carried out to investigate the best volatile solids organic loads for optimum gas generation. In the second step, different mixtures of WS and PS depending on its C/N ratio (35, 25, 20, 15 and 10) were carried out to investigate the optimum C/N ratio for effective biogas and methane production.

**Results:** For the first step, the result showed that the amount of gas generated from the digested feedstock increased gradually with the increasing of VS organic loads to the optimum value of 491.10 ml/gVS<sub>add</sub> at organic loads of 7.50 gVS/L, which showed a higher biogas production of 1.59, 1.29, 1.31, 1.16 and 2.03 time than the other organic loads of 12, 10, 8, 6 and 3 gVS/L respectively. The biogas production from all organic loads was higher than the digesting of PS alone. The maximum cumulative methane yields (CMYs) was observed at organic loads of 7.50 gVS/L. The highest VS removal rates of 71.77 and 69.87% were obtained at organic loads of 7.50 and 6 gVS/L.

For the second step, the cumulative methane yields (CMYs) for co-digestion of PS and WS at C/N ratios of 35, 25, 20, 15 and 10 were 1.29, 1.62, 1.33, 2.44 and 2.16 time higher than digesting PS alone, respectively. The maximum CMYS was observed at C/N ratio of 15 (333.90 ml/gVS<sub>add</sub>) with an increase of 89 %, 50.93 %, 83.61 % and 13.12 % compared with the other C/N ratio of 35, 25, 20 and 10 respectively. The maximum VS removal rates for the co-digestion of PS and WS recorded at C/N ratios of 10 and 15 were 63.59% and 61.68% compared with digesting PS or WS alone.

**Conclusions:** In general the optimized organic loads which gave the highest cumulative biogas and methane yields correspond to a range of 6 to 8 gVS/L. The optimal C/N ratio for CMYs was recorded at 15. This result showed the positive synergy of optimize the VS organic loads for biogas production caused by best utilization of the feedstock without accumulation, also improving the buffer capacity of the anaerobic digestion system and enhancing the biodegradability of the feedstock.

## Step 1

Table 1. Cumulative methane yields, volatile solids removal rate and pH for anaerobic co-digestion of PS and WS

	12 gVS/L	10 gVS/L	8 gVS/L	7.5 gVS/L	6 gVS/L	3 gVS/L	PS	WS
VS removal rate (%)	64.22	55.24	65.47	71.77	69.87	68.44	58.42	67.87
pH	7,45	7,52	7,32	7,22	7,28	7,33	7,66	7,52
CBYs (mL/g VSadd)	309.40	381.31	375	491.10	425	241.70	201.10	285.82
Methane content (%)	65.77	58.14	66.38	68.00	68.43	62.46	47.33	61.22
CMYs (mL/g VSadd)	203,49	221,69	248,93	333,95	290,83	150,97	95,18	174,98

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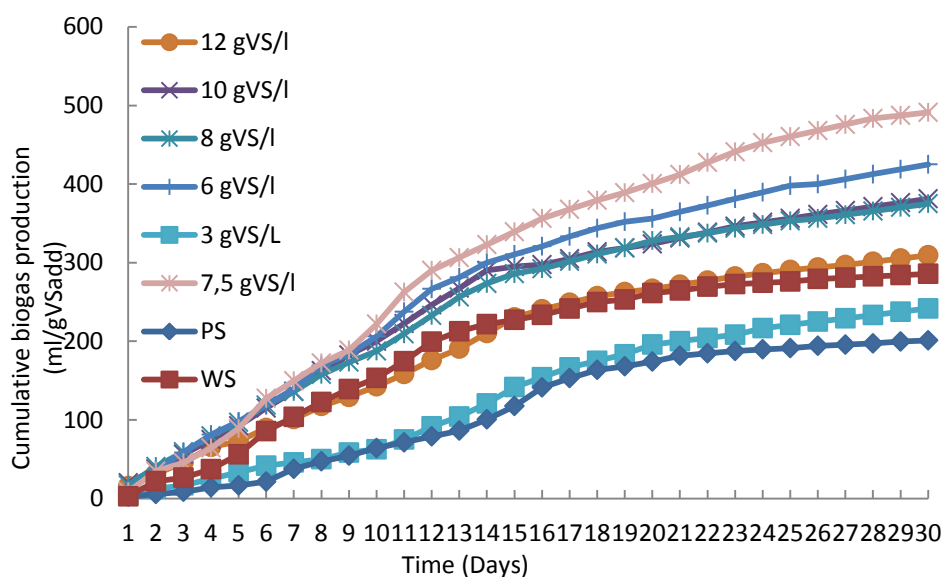


Fig. 1. Cumulative methane production from the co-digestion of PS and WS under different organic loads.

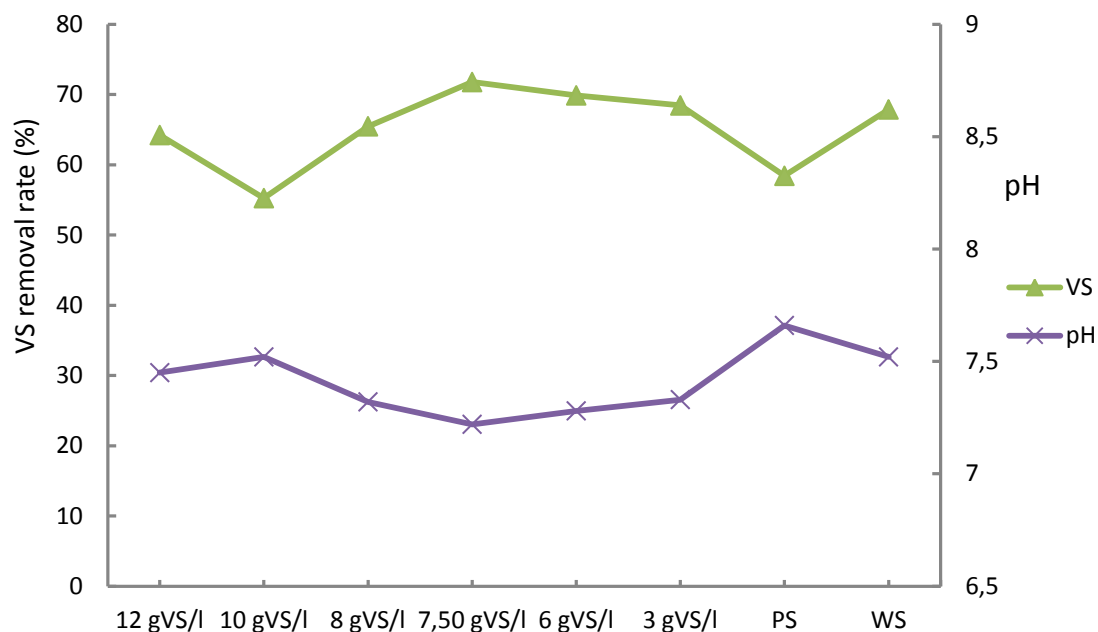


Fig. 2. Volatile solids removal rate and pH for the co-digestion of PS and WS under different organic loads.

## Step 2

**Table 1**

Cumulative methane yields, volatile solids removal rate and pH for anaerobic co-digestion of PS and WS

	C/N 35	C/N 25	C/N 20	C/N 15	C/N 10	PS	WS
VS removal rate (%)	57.20	59.80	56.38	61.68	63.59	50.58	55.88
pH	7,65	7,26	7,21	7,60	7,21	7,66	7,52
Cumulative methane yields (mL CH <sub>4</sub> /g VS)	176.70	221.30	181.90	333.90	295.20	136.80	243

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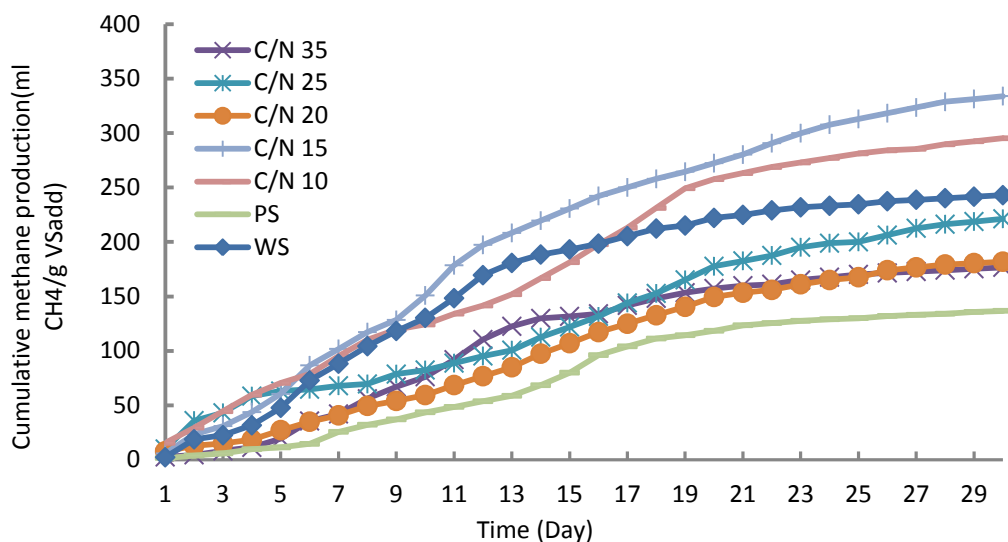


Fig. 1. Cumulative methane yields production from the co-digestion of PS and WS with different C/N mixing ratios.

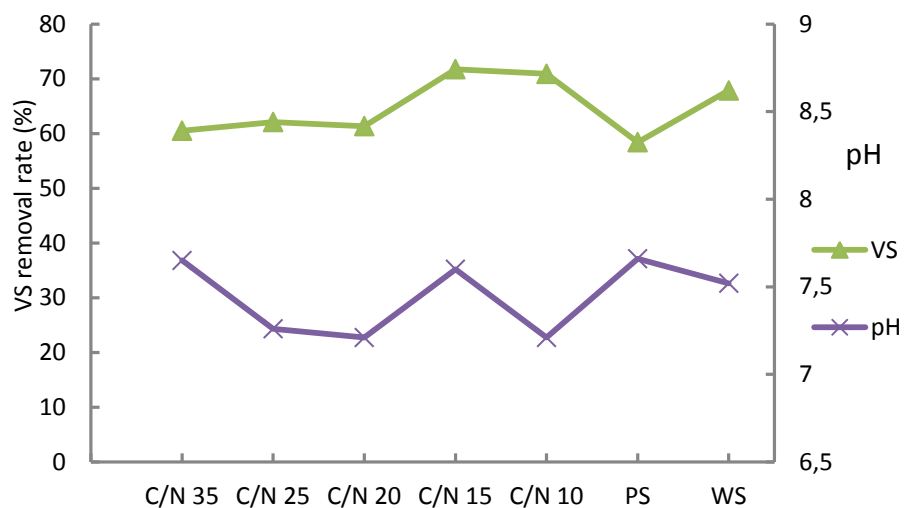


Fig. 2. Volatile solids removal rate and pH for the co-digestion of PS and WS under different C/N mixing ratios.