

## Effect of pH on biogas production during anaerobic digestion

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**ABSTRACT.** The disposal of organic waste is one of the most important problems facing society at the present time, as letting it ferment in the open produces unpleasant odors and causes many diseases. It also contributes significantly to increasing the phenomenon of global warming as it helps to produce toxic gases that affect the environment and cause global warming Including methane gas resulting from the process of decomposition of waste.

Therefore, the process of anaerobic decomposition is the best solution for disposing of waste in a safe way and at the same time biogas is produced that can be used for the purpose of cooking and heating, as this process produces good quality fertilizer that is used for the purpose of fertilizing the soil.

This research is subjected to studying the effect of different pH on biogas production and studying the concentrations of methane and carbon dioxide during the fermentation period, which reached 55 days. The results are presented in clear curves to facilitate the study.

The substrate used is corn with the addition of suitable primers to speed up the fermentation process. The results showed that the highest production of biogas and methane gas was at the digester whose pH was 7, followed by the digester that had pH 6.5, 5.5 and 4.5, respectively.

### 1-INTRODUCTION

Anaerobic digestion (AD) is a biological process through which the decomposition of organic matter is carried out by different groups of microbes and this process takes place in an environment without oxygen that produces Biogas, which generally consists of (40-70% methane and 30-60% carbon dioxide) in addition to small proportions of other gases[1].

The process of digestion is anaerobic an efficient and widely used waste treatment technique for the purpose of producing biogas and producing a nitrogen-rich by-product that can be used as fertilizer for soil remediation[2][3] Due to the success of this technique, the anaerobic digestion process has been widely used to treat the organic fraction of municipal solid waste (OFMSW) in addition to the organic industrial and agricultural waste[2]. The goal of the AD process is to eliminate waste and generate methane, which is a source of renewable energy.

[4] states that the AD process can achieve a net energy output of 100-150 kWh per one ton of municipal solid waste (MSW). While other waste disposal methods, such as incineration, burying waste and composting, there are great concerns about the possibility of pollution to the air or groundwater.[5] Depending on the total solids ratio (TS), the AD process can be classified into two types which are either liquid AD (L-AD) or solid state AD (SS-AD). Generally speaking, TS content of L-AD falls in the range of 0.5-15% whereas SS-AD is typically operated with TS content of 15% or more[6].

When comparing L-AD and SS-AD, we find that L-AD has a shorter retention time and higher reaction rate, while we note that SS-AD has more benefits than L-AD, which is that it needs a smaller reactor size when in use, and minimal material handling. , Lower heating energy input, and reduced overall parasitic energy loss[7].

When compared with the effluent from L-AD, we find that the digestion of SS-AD is much easier due to its low water content[3] . Whereas, food waste, sewage sludge and animal manure are generally treated by L-AD, while the glycosylose biomass such as food processing residues, crop residues and organic fractions of solid waste (OFMSW) is treated with SS-AD. Both L-AD and SS-AD are used for the purpose of converting feedstocks into biogas, [8]. The volumetric methane production in the SS-AD system was 2 to 7 times greater in contrast to the L-AD system.

In this study, starch was chosen because it is composed of D-glucopyranosyl units, and it is considered one of the important and promising natural raw materials that can be used in various applications instead of petrochemical plastics[9]. Starch has many advantages Including the low cost, biodegradability of starch and its wide availability around the world[10], although its applications are limited due to its hydrophilic properties and due to its poor mechanical strength. Also, due to the ability to microbial attack, these problems can be addressed by Mixing starch with some compounds (other synthetic polymers) [11].

However, there are several factors that directly affect the anaerobic digestion process such as the substrate for inoculation and the activity of the vaccine and from previous studies it was noted that the ideal ratio has not been clearly documented in the anaerobic digestion process so far and this has a negative impact on the comparability of the results of the literature[12] .

## **2. Materials And Methodology**

### **2.1 Experimental Setup**

The digester was manufactured and prepared in this work to produce biogas which is a device consisting of four widely identical anaerobic digesters (metal containers) with a capacity of 16 liters. Each digester has three holes (for adding the substrate, for discharging the produced biogas, and for emptying the substrate after the completion of the process Anaerobic digestion) and each opening contains an airtight valve as shown in Figure (1).

The digestion process inside the digesters was carried out according to an uncontrolled process with respect to temperature, but according to conditions. Mesophilic, where the temperature ranges between (13-24 ° C). Each digester was sealed tightly to prevent leakage of the biogas produced and to make the digestion anaerobic. Measurement sensors needed to calculate methane and carbon dioxide concentration were attached to each digester, in addition to a sensor for measuring pH and a digital sensor for measuring temperature for the purpose of taking readings during each day of the operation. Manufacturing. A cylindrical tank was designed containing a movable piston used to collect biogas produced during this process.



Figure (1) shows the device used in the process of anaerobic digestion

## 2.2 Substrate Samples Preparation

Corn was used as a basic support in this work, in addition to using a vaccine for the purpose of speeding up the digestion process (sheep rumen fluid) with constant mixing rates in each digestion as shown in Table (1).

Table (1) shows the mixing ratios of the substrate

| Features              | corn   | Vaccine (sheep rumen fluid) | water  |
|-----------------------|--------|-----------------------------|--------|
| Digesters 1,2,3 and 4 | 3.6 kg | 1.2 kg                      | 7.2 kg |

The pre-mechanical treatment of corn plants was accomplished through the use of a knife and an electric mixer, as reducing the volume helps to accelerate the digestion and production of biogas due to the increase in surface area exposed to bacteria that degrade the substrate and produce biogas.

Where the pH was fixed at the beginning of the anaerobic digestion process inside each digester by adding percentages of acetic acid, the PH was (6.5, 5.5 and 4.5) in the second, third and fourth digests respectively, while the first digester was left without adding acetic acid and the pH value was (7) As shown in Table (2).

Each digester was purified with inert gas (nitrogen) for 5 minutes to form an anaerobic environment. Then all digesters were closed tightly as shown in Fig. 1. The digestion time from the start of the process to the end of the biogas production was (55) days. During this period, measurements are continuous of biogas concentrations, pH, temperature, carbon dioxide and methane.

Table (2) pH value in each digester

| Features | Digester 1 | Digester 2 | Digester 3 | Digester 4 |
|----------|------------|------------|------------|------------|
| pH value | 7          | 6.5        | 5.5        | 4.5        |

## 3. Results and Discussion

Results of tests conducted on four digesters containing equal proportions of corn, water and pollen (sheep rumen) as shown in Table (1). However, each digester was treated with adding percentages of acetic acid at the beginning of the digestion process in order to stabilize the pH value, where the value was PH as shown in Table 2. The optimum conditions for producing the largest possible amount of biogas at different pH values are discussed.

Through the results of the experiment and Figure (2), we note that the highest production of biogas was in the first digester, where production started on the sixth day from the beginning of the digestion process at a production rate of (625.73 mL/d) and the highest daily production was (1425 mL/d) per day (36). The second digester started production on day (7), with a production rate of (501.73 mL/d), and the third digester, production started on day (9), at a production rate of (228.45 mL/d). As for the fourth digester, its production was low compared with the rest, where the rate of Its daily output (88.45 mL/d) This discrepancy in production is due to the change in pH and temperature as shown in Figure (3).

The first digester, whose pH value is 7, has the highest productivity of biogas, because this value is within the appropriate level of pH 6.4-7.6[13] that helps bacteria to produce biogas, and then comes the second and third digester, while the fourth digester which Its pH value of 4.5 has the lowest biogas productivity due to the low pH associated with the accumulation of VFAs, which causes toxicity to methane-generating bacteria [14].

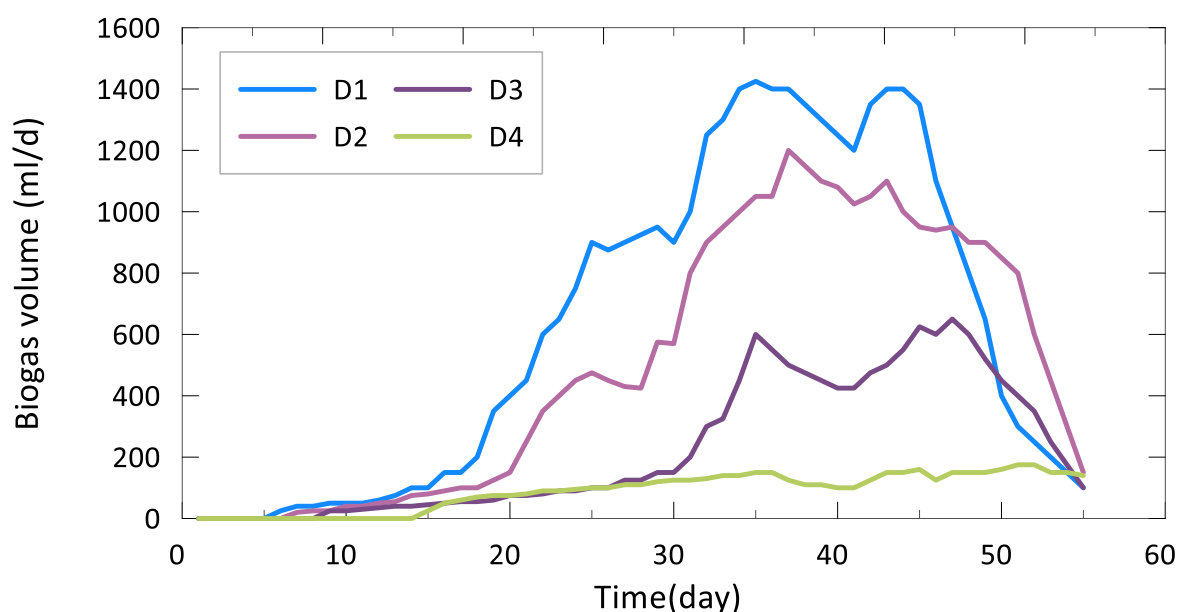


Figure (2) biogas production over time

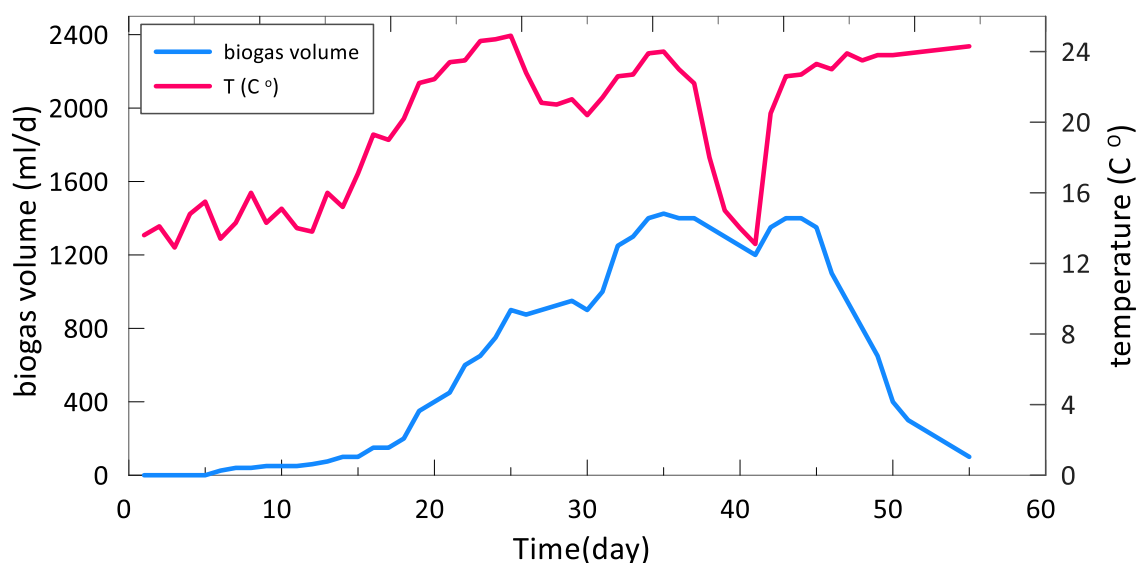


Figure (3) The relationship between biogas production and temperature with time in the digester (1)

Through Figure (4), we notice the decrease in the pH of the four digesters during the first days of the digestive process, and this may be due to the fact that the molecular compounds that have a short chain Turn into VFAs. The accumulation of VFAs within the substrate causes a decrease in the pH.

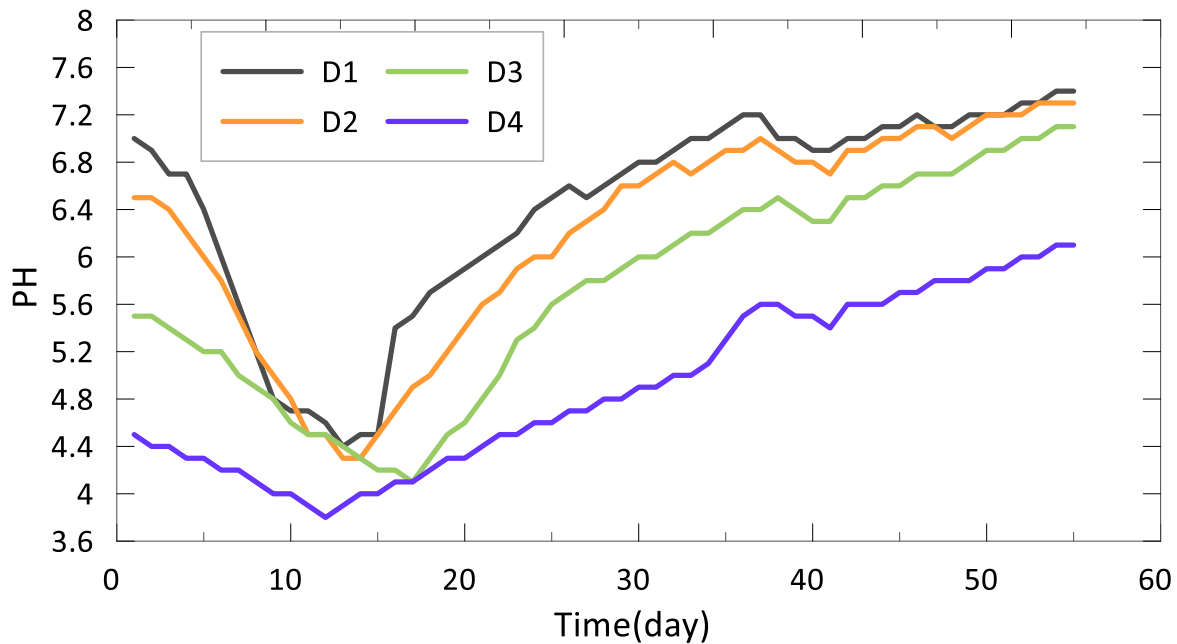


Figure (4) pH value over time

Through Figure (5), we note the production of methane gas in the four digesters, as the amount of gas produced was 17.8, 15.9, 10.4 and 2.1 g / kg vs, with a daily production rate of 0.32, 0.29, 0.19 and 0.039 g / kg vs in the first digester And the second, third and fourth, respectively.

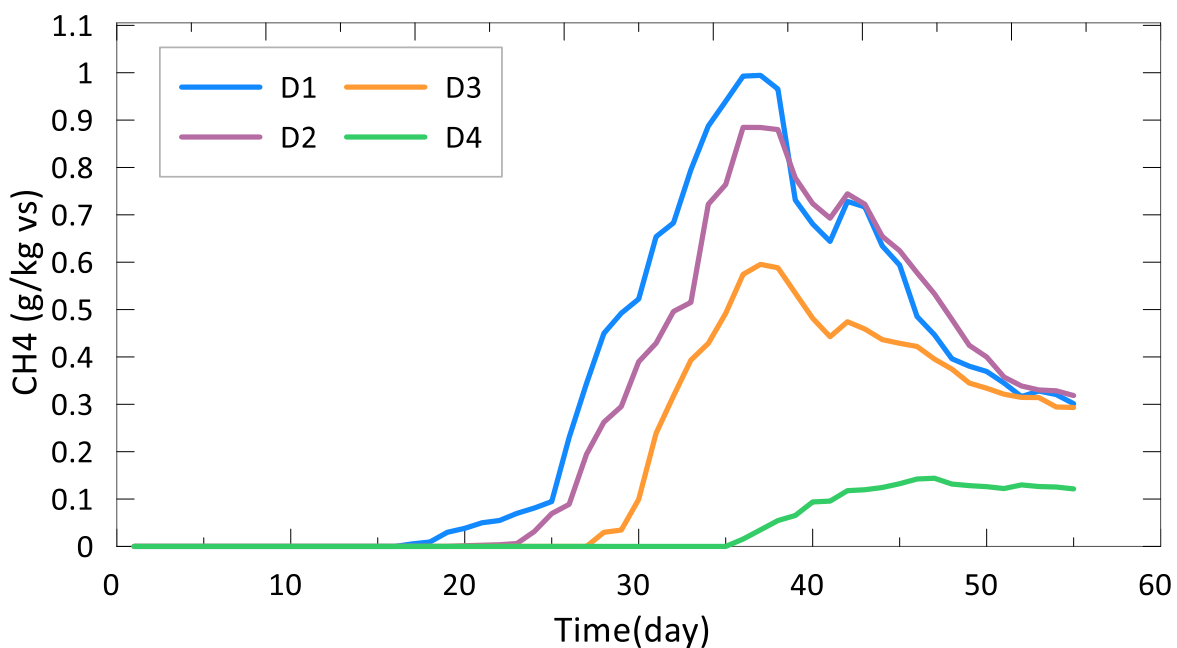


Figure (5) Methane production over time

With regard to carbon dioxide, we notice the variation in production in the four digesters, as the production was 10.13, 10.39, 7.27 and 4.16 g / kg vs in the first, second, third and fourth digester respectively, and it is noted that the highest production was in the second digester and the lowest production was in the fourth digester while The highest daily production in the first digester was on Day (26) at a rate of (0.310544 g / kg vs), as shown in Figure (6).

Through the results, we notice that the rate of carbon dioxide production is higher than methane at the beginning of the digestion process and with the rise in temperature and the pH value, The process is reversed so that the methane gas begins to rise as the hydrogen dioxide decreases until the end of the digestion process.

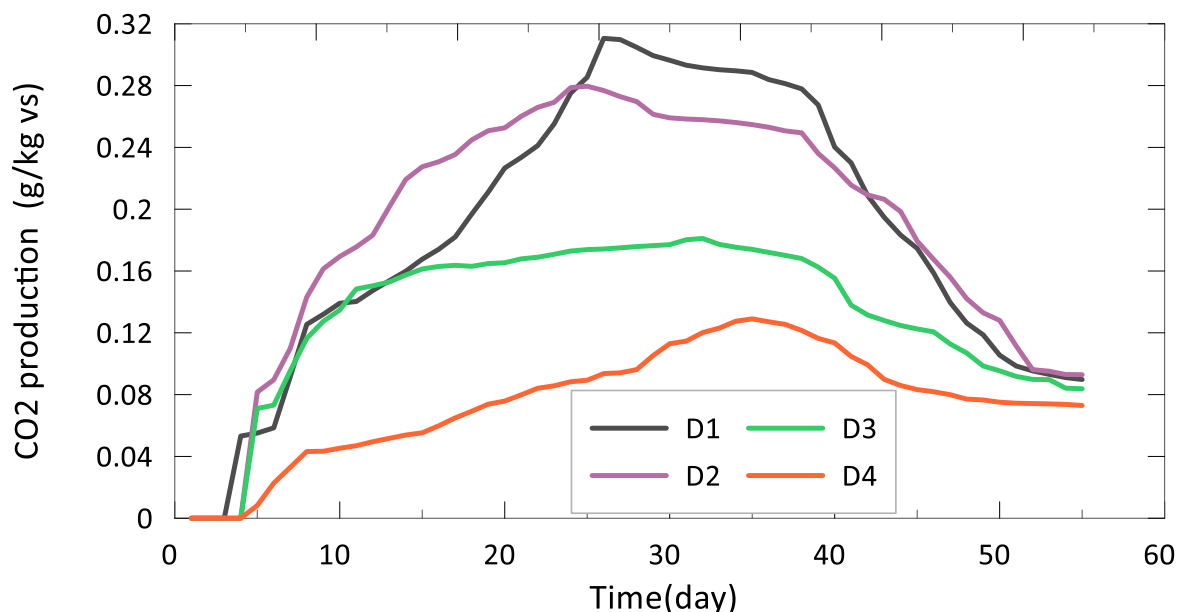


Figure (6) CO<sub>2</sub> production over time

During the first days of biogas production, the results showed an increase in the percentage of carbon dioxide compared to the production of methane. This is due to many reasons, including the fact that the percentage of carbon dioxide is high at the beginning of the digestion process because its production occurs in the second stage of the anaerobic digestion process.

Converting propionate and butyrate into carbon dioxide, acetate, and hydrogen. Or another reason may be acid-forming bacteria. It grows faster than methane-forming bacteria.

#### 4-Conclusions

The main objective of this study is to measure the effect of the pH on the quantity and quality of the biogas generated during this 55-day experiment, so that the substrate components are 30% of corn, 60% water and 10% of the prefixes (sheep rumen fluid) in Mesophilic conditions. Four different pH values were tested (7, 6.5, 5.5 and 4.5) at the beginning of the digestion process. The results showed that the best production of biogas and the best daily production of methane was against the pH value of 7, and this value is considered the ideal value for the growth of bacteria. Methane These results are identical to the output obtained from [15].

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#### Nomenclature:

|      |                      |
|------|----------------------|
| AD   | Anaerobic Digestion  |
| VS   | Volatile Solid       |
| VFAs | Volatile Fatty Acids |

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