**Use poultry manure product of Biogas and its role in growth in Barley plants**

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**Abstract**

The accumulation of raw poultry residues in enormous quantities causes the release of odors and the leakage of toxic elements into the surface and groundwater , which negatively affects human health and the environment. So the bioreactor named the fixed-dome model as an anaerobic digester was designed and installed in the poultry field at the agricultural advisory office of college of agriculture at the University of Basra in Karmat-Ali, Iraq. Anaerobic organic fertilizer produced from anaerobic digestion pathway when raw poultry manure was fermented an aerobically for 56 days in the designed bioreactor, to study the use efficiency for anaerobic produced organic fertilizer and raw poultry manure when added at 150Kg N ha-1 at 0 , 25 , 50 , 75,and 100 % of the recommended dose which was equal to a chemical recommendation for nitrogen as urea fertilizer while P and K were applied in a field experiment as traditional fertilizers( superphosphate and potassium sulfate respectively) to grow barley plants ( *Hordeum vulgare* L.). Results showed that doses at 100% of anaerobic organic fertilizer were produced in the bioreactor with a significant increase in plant growth parameters as plant height , dry weight of shoot and amounts and their uptake of N and P elements in plants within 60 days of planting as compared to the rest treatments , so the biogas technology for the production of anaerobic organic fertilizer can help partly or mainly to reduce amounts of traditional doses of fertilizer.

***Keywords****: anaerobic fermentation ,**Barley, sustainable agriculture, biogas technology, poultry manure.*

***\* Paper cited by a master's thesis of the second author***

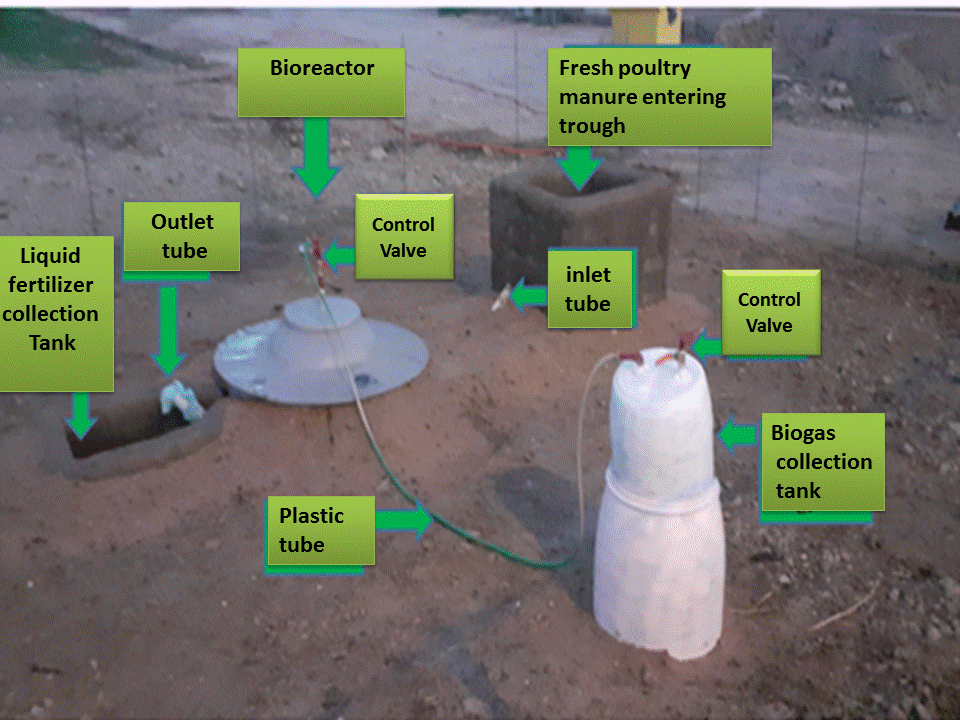
**1. Introduction**

The overpopulation of the world، which could be expected to nine billion in 2050 [1] , then accelerated the need for food with sustainable management led to finding renewable energy sources as a biogas technology which could support agriculture exercises when investing natural input resources as plants residues, manures , and human activities. that produced from these exercises or recycling, so the main output to ward off risks of greenhouse gases [ 2]. Anaerobic digestion is a methanogenic approach by incorporates multi-specific anaerobic organisms activation in the full absence of oxygen gas pressure conditions [ 3] for producing beneficial materials such as anaerobic organic fertilizer accompanied by multi gases such as CH4, CO2,H2S and other chemical compounds as sources for energy clean and friendly to the environment. By biochemist process pathway happened in manufactured anaerobic digestion [4] recent researches certain in the anaerobic digestion process could take place through a series of stages from the hydrolysis step to acidogenesis, acetogenesis processes then methanogenesis to improve produced biogas and mature anaerobic organic fertilizer [ 5], in addition to the anaerobic digestion can prevent environmental pollution when recycling plants residues، manures and industrial wastes [ 6] anaerobic decomposed organic manure accompanied with biogas production [ 7]affected significantly when increasing 3.79 g pot-1 of shoot dry weight of treated *Spinacia oleracea* L. with 100% added of produced anaerobic organic fertilizer compared shoot dry weight 2.57 g pot -1 at control treatment (100% mineral application dose ). Anaerobic organic fertilizer has high-quality characteristics to improve chemical physical and biological soil properties as pH, EC, and NPK are essential elements for plant nutrition[ 8], locally, [ 9]found the best treatment of anaerobic decomposed organic fertilizer with a significant effect on the plant biological parameters as tubers and total yield of the potato crop of  *Solanum tuberosum* L. so anaerobic organic fertilizer can be instead of mainly or partly traditional recommendation fertilizers added in agriculture experiment.

1. **Material and methods**

**2.1. Design and installation of bioreactor units**

Bioreactor Fixed-dome model was designed and manufactured from fiberglass material at 1000 liters sized in the hole (125 cm diameter and 110 cm depth), making two holes on both sides of the tank (2.5-inch diameter) as Inlet pipe and outlet pipe with whole (1 -inch diameter) in a tank top with tight valve than supplied with raw poultry manure (Table 1) which mixed at 350 kg raw manure: 600 liters water, then accumulated produced slurry manure during 56 days anaerobic digestion, a calculate suitable amounts to conduct field experiment.



**Figure 1 .** Local designed fixed- dome model.

**Table 1.** Some characteristics of poultry manure before anaerobic digestion.

|  |  |  |
| --- | --- | --- |
| **Unite** | **Value** | **Properties** |
| - | 6.50 | pH (5:1) |
| dSm-1 | 21.22 | EC (5:1) |
| g kg-1 | 21.88 | Total N |
| g kg-1 | 9.34 | Total P |
| g kg-1 | 17.19 | Total K |
|  | 593.78 | Organic matter |
|  | 344.42 | Organic carbon |
| W/W % | 78 | PW |
| - | 15.74 | C/N |
| - | 36.88 | C/P |
| % | 22 | Total solid |

**Table 2.** Some properties of soil in study.

|  |  |  |
| --- | --- | --- |
| **Unite** | **value** | **Properties** |
| ــــــــ | 7.46 | pH(1:1) |
| dSm-1 | 6.80 | ECe |
| g kg 1 | 3.47 | O.M |
| 0.28 | Total N |
| mg kg 1 | 38.62 | Available N |
| 18.31 | Available P |
| 96.93 | Available K |
| Mmol L- | 16.18 | Ca++ |
| 14.23 | Mg++ |
| 7.71 | Na+ |
| 26.50 | SO4-2 |
| 10.43 | Cl-1 |
| 6.24 | HCO3-1 |
| g kg -1 | 80.41 | Sand |
| 477.35 | Silt |
| 442.24 | Clay |
|  | Silty clay | Soil texture |
| CFU g -1 | 510x71 | Bacteria |
| 310x3 | fungi |

**2.2. Agriculture field experiment design**

A factorial field experiment was conducted at soil chemical, physical properties as in table (2) in same poultry farm, an agriculture experiment field designed as a completely randomized complete block design (RCBD) revised least significant at 0.05. The experiment included two factors in three replicates of the treatments control, anaerobic organic fertilizer produced from anaerobic digester (P) , raw manure (R) , 0% +100%Chemical fertilizer commendation (NPK ) as 25% anaerobic organic fertilizer 25% Chemical fertilizer commendation (NPK ) as 50% + anaerobic organic fertilizer 50% Chemical fertilizer commendation (NPK ) as 75% + anaerobic organic fertilizer 25% Chemical fertilizer commendation (NPK ) as 100%. Chemical recommendation (N, P, K) was added at 150 N kg ha -1as urea, 80 P kg ha -1 and 116 K kg ha-1 that mixed with soil. Both raw and organic manure were added as lines in amounts that appear at( table 3).

**Table 3.** Calculated amounts of application fertilizers in study .

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Manure | R0 | R25 | R50 | R75 | R100 | R25 | R50 | R75 | R100 | C | Unit |
| Produced | 0 | 0 | 0 | 0 | 0 | 1.45 | 2.9 | 4.35 | 5.80 | 0 | Lm-1 |
| Raw mw | 0 | 0.78 | 1.56 | 2.34 | 3.12 | 0 | 0 | 0 | 0 | 0 | K g-1 |
| Urea | 32.60 | 24.45 | 16.30 | 8.15 | 0 | 24.45 | 16.30 | 8.15 | 0 | 0 | g m-2 |
| Super phosphate P | 39.00 | 29.25 | 19.5 | 9.75 | 0 | 29.25 | 19.50 | 9.75 | 0 | 0 |
| K sulphate | 27.40 | 20.55 | 13.70 | 6.85 | 0 | 20.55 | 13.70 | 6.85 | 0 | 0 |

After 60 days of planting, main parameters were taken as indicators to response plants to added treatment in the study as Plant height, dry weight of shoots, root, and content of N, P elements and their uptake and recovery perc. of plants during 60 days of planting as according to references in the known text.

1. **Results and discussion**
   1. **Plant height**

Results showed in the (table 4) that the highest significant effect of produced manure (P) in the bioreactor by anaerobic digestion which was 60.40 cm on raw manure (R) on plants height (Hordeum vulgare L.) was 51.77 cm, while the lowest height was 38 cm at control (C) may be that refer to the positive effect of anaerobic digestion in a bioreactor in improving characteristics of produced organic manure, which agrees with [10 ] at the (table 4) results referred to the significant effect of level added of treatments when added at levels 25 , 50 , 75 ,and 100% on plants height from 48.67 cm at no added treatment to 50.0, 50.17 , 50.67 , 50.78 cm at levels 25 , 50 , 75 , 100% respectively, that agrees with [11 ] who certain to the role of most organic manure to improve soil properties then plant growth.

**Table 4 .** Effect of organic manure on plant height in study.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Average | 100 | 75 | 50 | 25 | 0 | Level  Kinds |
| 60.40 | 65.00 | 63.00 | 61.00 | 59.00 | 54.00 | **P** |
| 51.77 | 49.33 | 51.00 | 51.50 | 53.00 | 54.00 | **R** |
| 38.00 | 38.00 | 38.00 | 38.00 | 38.00 | 38.00 | **C** |
|  | 50.78 | 50.67 | 50.17 | 50.00 | 48.67 | **Average** |
| Levels RLSD0.05 | Kinds × Levels RLSD0.05 | | | | | Levels RLSD 0.05 |
| 0.467 | 6.689 | | | | | 4.981 |

|  |
| --- |
| **2.1. Shoot dry weight g (m2)-1**  From table (5) results showed that produced organic manure P was significant superiority (303.31 g m2   on raw manure R (249.99  g m2 shoot dry weight compared to no added treat. Was (145.92 g m2 , [11 ] referred to as the beneficial anaerobic digestion process by anaerobic and bacteria for maturity raw manure in full absent oxygen, at the same table (4) results conducted to the significant effect of levels addition 75% and 100% on the rest application In shoot dry weight 233.96 ، 234.52 g m2   as compared with no added which was 231.63 g m2 , There was a significant effect for interaction between kinds and levels of organic manure on shoot dry weight, so the treatment from P100( produced manure at 100% application ) was superior addition 332.59 g (m2)-1 as compared to145.92 g (m2)-1, so that conducted Importance of anaerobic digestion as [12 ]. |

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| * 1. **Nitrogen content**   Results in the (Table 6) referred to a significant increase in N- Content in plants after 60 days of growth in the produced application (P) compared to (R) were 30.39 ,24.67 g kg-1, respectively. When the control was 18.46 g kg-1, that agrees with [13 ] who certain roles of anaerobic bacteria in decomposed raw organic material and release essential nutrients like nitrogen in slurry fertilizer so that support importance of increase addition levels either produced or row manure in a study at 24.51 , 24.98 , 25.30 g kg-1 of levels 50 , 75 , 100% respectively. |
| **Table 6.** Effect of kinds and levels of organic manure on N- Content in barley plants. |
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| --- |
| **2.2 Phosphorus content in plants**  From the (table 7) results showed that a significant effect for produced manure and Raw poultry on phosphorus content in plants when increased to 2.71 and 2.21 g kg -1 compared to no added was 1.73 g kg -1, as agreed with [13 ] , in addition, to study conducted there were the significant effect of increasing levels application on P content from 2.07 g kg -1 at no added level to 2.22, 2.28 and 2.39 g kg -1 at levels 50, 75 ,and 100% respectively, so most of organic manure can encourage phosphate availability in soil then absorbed by the plant [14 ] . Application on P content when it was3.27 g kg -1 at treatment P100 of produced. Also, results referred to significant interaction between kinds and levels of manure in anaerobic digester designed. |
| **Table 7 .** Effect kinds and levels of organic manure on P- Content in barley plants. |
|  |
| |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Average | 100 | 75 | 50 | 25 | 0 | Levels  Kinds | | 30.39 | 34.25 | 32.68 | 30.03 | 28.76 | 26.25 | **P** | | 24.67 | 23.20 | 23.80 | 25.04 | 25.07 | 26.25 | **R** | | 18.46 | 18.46 | 18.46 | 18.46 | 18.46 | 18.46 | **C** | |  | 25.30 | 24.98 | 24.51 | 24.10 | 23.65 | **Average** | | Levels RLSD0.05 | Kinds × Levels RLSD0.05 | | | | | Kinds RLSD0.05 | | 0.851 | 2.711 | | | | | 2.494 | |

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| 1. **3. Uptake nitrogen in plants**   From the (table 8) results referred to a significant increase in N uptake in barley plants during 60 days of planting when it increased from 3.27g m-2 at control to 9.27 and 6.18 g m-2 produced (P) and raw (R) manure added respectively, that agrees with [15 ] who referred to role anaerobic digestion as a pathway to improve available N then C/N ratio In decomposed manure to encourage its absorbed by plants. In addition applied levels supported the positive effect of produced manure at levels 50 ,75 , and% 100 were 6.43, 6.01, and 6.24 g m-2 respectively compared to no added level (5.70 g m-2 ). |
| **Table 8.** Effect of the type and level of organic fertilizer on the nitrogen absorbed in barley plant (g m-1). |
| |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Levels  Kind | 0 | 25 | 50 | 75 | 100 | Average | | P | 7.20 | 8.41 | 9.09 | 10.25 | 11.39 | 9.27 | | R | 7.20 | 6.49 | 6.24 | 5.77 | 5.22 | 6.18 | | C | 2.69 | 2.69 | 2.69 | 2.69 | 2.69 | 2.69 | | Average | 5.70 | 5.86 | 6.01 | 6.24 | 6.43 |  | | Levels RLSD0.05 | Kinds × Levels RLSD0.05 | | | | | Levels RLSD 0.05 | | 0.745 | 0.609 | | | | | 0.301 | |

**Phosphorus uptake in plants**

In the (table 9) results referred to the significant increase in P uptake in barley plants during 60 days of planting when it increased from 0.25 g m-2 at control to 0.83 and 0.55 g m-2 at produced(P) and raw(R) manure added respectively, which agrees with [16 ] who referred to role Anaerobic digestion as a pathway to improve available P, then C/P ratio Anaerobic

**Table 9.** Effect kinds and levels of organic manure on P-uptake in barley plants.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| levels  Kind | 0 | 25 | 50 | 75 | 100 | Average |
| P | 0.61 | 0.71 | 0.82 | 0.92 | 1.09 | 0.83 |
| R | 0.61 | 0.58 | 0.55 | 0.53 | 0.49 | 0.55 |
| C | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Average | 0.49 | 0.51 | 0.54 | 0.57 | 0.61 |  |
| Levels RLSD0.05 | Kinds × Levels RLSD0.05 | | | | | Levels RLSD 0.05 |
| 0.046 | 0.045 | | | | | 0.048 |

In decomposed manure to encourage its absorption by plants. In addition applied levels supported the positive effect of produced manure at levels 50 %,75%, and %100 were 0.54 ، 0.57 and 0.61 g m-2 respectively compared to no added level (0.49g m-2 )

**Nitrogen recovery**

As a (table 10), results showed that a significant effect of produced manure in the anaerobic digestion method and raw manure, was 41.74% , 29.27 % respectively, As agreed with [17 ]. Moreover, results showed that a significant effect To levels of application to increase recovery ratio to 35.33 , 36.25 and 36.90 at 50 ,75 , %100 respectively as compared to control was 34.35%, as [18 ] who referred to that N- recovery is positive Indicator to the high efficiency of anaerobic digestion in bioreactor technique.

**Table 10.** Effect kinds and levels of organic manure on N-recovery % in barley**.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Level  Kinds | 0 | 25 | 50 | 75 | 100 | Average |
| P | 34.35 | 38.42 | 40.77 | 45.58 | 49.60 | 41.74 |
| R | 34.35 | 30.98 | 29.89 | 26.92 | 24.20 | 29.27 |
| Average | 34.35 | 34.70 | 35.33 | 36.25 | 36.90 |  |
| Levels RLSD0.05 | Kinds × Levels RLSD0.05 | | | | | Levels RLSD 0.05 |
| 3.638 | 3.718 | | | | | 0.862 |

**Conclusions**

Anaerobic digestion significant positive role in improving the quality and amounts of available nutrients like N, and P in soil and increasing plant growth, moreover it can be replaced mainly or partly by chemical recommendation fertilizers like urea and superphosphate added to soil .

**References**

[1 ] FAO. 2015 World fertilizer trends and out look to 2018,Rome .pp 53,.

[2 ] Dhillon R. S., and von. Wuehlisch, G.) 2013. “ Mitigation of global warming through renewable biomass“. *Biomass and bioenergy J.,*vol. 48, 75-89,.

[3 ] Mao C.; Feng, Y.; Wang, X. and Ren, G. 2015 “ Review on research achievements of biogas from anaerobic digestion“. *Renewable and sustainable energy reviews*. 45: 540-555,.

[4 ] Abdeshahian P. Lim JS.; Ho WS.; Hashim H. and Lee CT2016 “ Potential of biogas production from farm animal waste in Malaysia“ . *Renew Sustain Energy Rev*. 60: 23–714.

[5 ] Ray N., H. S.; Mohanty, M. K. and Mohanty, R. C. 2013 “ Anaerobic digestion of kitchen wastes:“biogas production and pretreatment of wastes“, a review”. *International Journal of Scientific and Research Publications*, pp. 3-11.‏ ,.

[6 ] Atelge M.R.; Krisa, D.; Kumar, G.; Eskicioglu, C.; Nguyen, D.D.; Chang, S.W.; Atabani, A.E.; Al-Muhtaseb, A.H. and Unalan, S. 2014. “ Biogas Production from Organic Waste: Recent Progress and Perspectives“. *Waste Biomass Valorization*. 1–22, 2018.

[ 7] Hossain N. N.; Islam, M.; Alamgir, M. and Kibria, M. G2014. “ Growth response of Indian spinach to biogas plant residues“. *IOSR Journal of Pharmacy and Biological Sciences*. 9(2): 1-6.

[8] Shih Y. J.; Abarca, R. R. M.; de Luna, M. D. G.; Huang, Y. H. and Lu, M. C. 2017 “Recovery of phosphorus from synthetic wastewaters by struvite crystallization in a fluidized-bed reactor: effects of pH, phosphate concentration and coexisting ions. Chemosphere”. 173: 466-473.

[9] AL-zubaidiI B .. 2020 “ Interaction effect of organic fertilization and quality of irrigation water treated with biogas products of some properties and potato ( *Solanum tuberosum* L.) “ MS.c. thesis Al- Muthana University , Iraq .

[10] Islam ,M. R.; Rahman, S. M. E.; Rahman, M. M.; Oh, D. H. and Ra, C. S. 2010 “ The effects of biogas slurry on the production and quality of maize fodder“. *Turkish Journal of Agriculture and Forestry.* 34(1): 91-99.

[11] Eifediyi, E.K. and Remison, S.U., 2010. Growth and yield of cucumber (Cucumis sativus L.) as influenced by farmyard manure and inorganic fertilizer. *Journal of Plant Breeding and Crop Science*, *2*(7), pp.216-220.

[12] Alburquerque , J. A ..; De la Fuente, C.; Campoy, M.; Carrasco, L.; Nájera, I., Baixauli, C. and Bernal, M. P. 2012a “Agricultural use of digestate for horticultural crop production and improvement of soil properties“. *European Journal of Agronomy*. 43: 119-128,.

[13] Nkoa,R. 2014 “Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates“: a review. *Agronomy for Sustainable Development*. 34(2): 473-492,.

[14] Chaudhari, S., Upadhyay, A. and Kulshreshtha, S., 2021. Influence of organic amendments on soil properties, microflora and plant growth. In *Sustainable Agriculture Reviews 52* (pp. 147-191). Springer, Cham.

[15] Hupfauf, , Bachmann, S., Juarez, M. F. D., Insam, H. and Eichler-Löbermann, B. 2016 “ Biogas digestates affect crop P uptake and soil microbial community composition“. *Science of the Total Environment J.,* 542, 1144-1154.‏.

[16] De Boer H. C., 2008 “ Co‐digestion of animal slurry can increase short‐term nitrogen recovery by crops“. *Journal of Environmental Quality*, 37(5), 1968-1973.‏

[17] Kolar L.;Kuzel, S.; Peterka, J.; Stindl, P. and Plat, V.2008 “Agrochemical value of organic matter of fermenter wastes in biogas production“. *Plant, Soil and Environment.* 54(8): 321-328,.

[18] Cooper J., 2008 “ Soil tests and their value as indices of N availability to crops. Soil nitrogen, research and extension“. Vander Burgt GL, Timmernans Ir. B.(eds), Lois Balk Inst, The Netherlands.