Effect of fermentation time on the Properties of fermented poultry waste by different methods

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Abstract

Following the scientific management of organic waste (poultry) may contribute to reducing environmental pollution and human health, as the current study was conducted with the aim of recycling (Recycling) poultry waste accumulated in the field of poultry farming at the research station - Faculty of Agriculture - Karma site and the extent of the impact of the period on the fermentation of organic waste, specifically animal (poultry waste) fermented by different fermentation methods and its impact on the rest of the factors to produce highly decomposed organic fertilizer free of pathogens. Several traditional fermentation methods (compost and water immersion) were followed. and modern (bioreactor), and for a fermentation period of 90 days with an estimate of most of the qualitative characteristics of the organic fertilizer produced and within periods of 15 - 30 - 45 - 60 - 75 - 90 days. The results of the experiment of incubation of poultry waste showed that all the studied traits have changed with the progress of fermentation time and in the same direction, the results showed that fermentation in the bioreactor unit has given the highest values of total nitrogen, total phosphorus and potassium 32.53, 16.72, 20.86, $g.kg^{-1}$ for the elements mentioned sequentially, while the lowest values of pH 6.68 and C/N ratio 9.96 compared to other fermentation methods.

Keywords: Bioreactor, Compost, Soaking in Water, Poultry Waste, Fertilizer

Introduction

The treatment of soil with organic residues from different sources (animal - plant - and others) is an agricultural practice that began in ancient times and with the beginning of human knowledge of agriculture (Al-Fares, 2017), as organic and animal matter, in particular, has a role in improving the chemical, physical and biological properties of the soil in addition to fertility, in addition to that organic matter as added fertilizers may be fully or partially complementary to the traditional mineral recommendation of nitrogen, phosphate and other fertilizers, which are often exposed to several obstacles and problems and in most
Soils that lead to the loss of the largest part of them, which limits or reduces the maximum productivity of crops **(** Ren *et al* .,2020; Cai *et al* ., 2021; Tang *et al*., 2021 **).** The process of recycling (Recycling) animal waste (such as poultry, for example) is one of the promising scientific methods that support soil fertility and crop productivity, on two sides, The first is to find a safe way to get rid of the accumulations of these residues and their negative impact on the environment and human health, and the second hand is to improve the quality and specifications of the effective unit of the nutritional value of those residues (Ali et al., 2014) (Duncan, 2005) (Escobar and Hue, 2008). Especially when treated as organic fertilizer free of pathogens, bush seeds, and others Saveyn and Eder, 2014). The use of organic fertilizer (compost) decomposed air method is beneficial in improving the content of soil of organic matter as this method is one of the means of biological treatment (bio) of organic waste, whether of plant or animal origin by beneficial bacteria that work to decompose these materials when appropriate environment of moisture (60) % and optimum temperature (60 – 70) We get a good organic fertilizer that works to enrich the soil with living organisms when added to it and install Atmospheric air nitrogen and dissolving phosphorus and potassium, so it is easy for the plant that absorbs it regularly, so it grows with high efficiency (Al-Madini, 2012). Water immersion is a normal practice used by field farmers in Basra Governorate that benefits the soil (Abdulkareem, 2010). With the rapid development of modern agriculture, the use of anaerobic organic waste fermentation was resorted to in the reactor unit. Biological, which is a source of clean renewable energy (renewable energy) and the use of biotechnology (biogas) or what is known as a bioreactor is one of its main outputs is an organic fertilizer with high-quality specifications that differs in its properties from organic fertilizer prepared by traditional methods, including compost and immersion in water (Arnos, 2022) (Zubaidi, 2020) (Jurgutis et al.,2020) (Zhang,2021) (Amjid et al. 2011). The results of recent research studies confirmed by Arnous (2022), Zubaidi (2020), Jurgutis *et al.* (2020), and Amjid et al. (2011) that the use of biotechnology or what is known as the bioreactor that one of its main outputs is an organic fertilizer with high-quality specifications that differs in its properties from the organic fertilizer prepared by traditional methods, including compost and immersion in water. The fermentation process is affected by several factors including temperature, starter addition, continuous stirring, pH, C/N, C/P, and fermentation duration. This study aimed to recycle (Recycling) poultry waste accumulated in the field of breeding Poultry and the extent of the effect of the period on the fermentation of organic waste, specifically animal (poultry waste) fermented by different fermentation methods (anaerobic fermentation in the bioreactor unit, compost fermentation, and water immersion fermentation) and its impact on the rest of the factors

Materials and methods

Poultry waste was collected from the poultry breeding field of the College of Agriculture - the University of Basra, the site of Karma Ali, foreign materials were removed from them, mixed well, and dried in the oven at a temperature of 50 ° C, then ground and sieved from a sieve with a capacity of 1 mm openings and estimated for its primary characteristics as shown in Table (1): -

Table (1): Some characteristics of raw poultry manure before anaerobic digestion

properties	Value	unite
pH**(5:1)**	7.20	**-**
Ec**(5:1)**	19.6	dS m^{-1}
organic matter	769.20	g kg^{-1}
organic carbon	447.20	
total –N	35.70	
total-P	17.15	
total-K	19.27	
C/N	12.53	**-**
C/P	26.07	**-**
PW	80.53	**(**w:w**)**

1- Fermented soft poultry waste (Table 1) by anaerobic fermentation in the locally manufactured bioreactor and established and designed from a previous study at the research station of the College of Agriculture - University of Basra - Karma Ali, foreign substances were removed and mixed with water and by 250 kg Waste: 500 liters of water in addition to its moisture content of 80% Taking into account the mixing to make the mixture homogeneous with providing it with a starter and after the stability of the basic fertilizer properties of anaerobically fermented fertilizer such as nitrogen and the ratio C: N Especially after 90 days of fermentation, samples were taken for post-fermentation analysis as in Table (2).

2- Poultry waste taken from the poultry field was immersed in plastic tanks filled with water prepared in a way that allows gas exchange between the perforated pipes embedded in the tanks and the surrounding atmosphere, taking into account the maintenance of a constant water level inside the tank throughout the fermentation period.

3- The composting method is summarized in preparing the ground by digging a hole with dimensions (length * width 1 * 1 m, depth 1.5 m), including three layers The first layer was placed 8-10 cm of fronds and placed on top of it a layer of soft poultry waste and a thickness of 2 cm and covered with a layer of soil to a depth of 3 cm and with the succession of the mentioned layers with mixing for homogeneity, then add a certain amount of urea fertilizer. Moistened with R.O. water by 60%. The pile was covered

with plastic wrap, taking into account the need to stir every three days for ventilation during the fermentation process, which took 3 months.

Table (2) some Characteristics of fermented poultry waste for 90 days in different ways

properties	unite	compost	soaking in water	Biogas
pH(5:1)	-	7.02	7.20	6.92
Ec(5:1)	dS m^{-1}	19.86	24.10	10.97
organic matter	g kg^{-1}	445.9	567.9	557.3
organic carbon		259.24	330.17	324.01
total –N		25.90	29.57	32.53
total-P		14.89	16.07	16.72
total-K		18.90	19.37	20.86
C/N	-	10.09	11.16	9.96
C/P	-	17.41	20.54	19.37

pH: Potting in a suspension of organic waste: water (5:1) using a pH meter. Liquid manure (separated from the bioreactor) has been estimated directly using a pH meter, as reported by Page *et al*. (1982).

EC : Estimated in an organic waste suspension: water (5:1) using Ec-meter while liquid fertilizer (separated from the bioreactor) was estimated directly using Ec-meter, as reported in Page *et al*. (1982).

Total nitrogen: Estimated in steam distillation digestion solution as reported in Bremner (1970).

Total phosphorus: It was estimated in the digestion solution after modifying the acidity of the mixture, and using a color spectrometer at a wavelength of 700 nm in the blue color method as reported in Murphy and Riley (1962).

Total potassium: Estimated in the digestion solution using a flame photometer after adjusting the acidity of the solutions according to Page *et al*. (1982).

Organic matter

It was estimated according to the loss-on-ignition (LOI) method, where the model was burned at 550 ° C for 8 hours as reported in ECS (1999) from which organic carbon was calculated.

C/N Ratio: It was calculated from the quotient of organic carbon divided by total **nitrogen.**

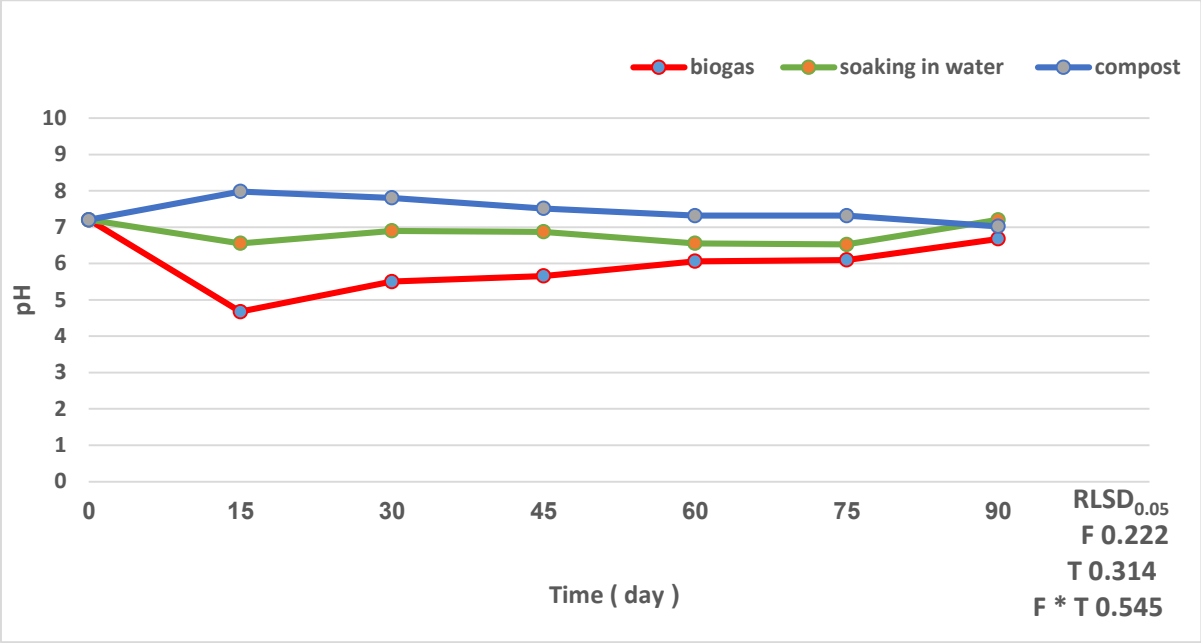
C/P Ratio : **(**Calculated from the quotient of organic carbon divided by total phosphorus.

Results and discussion

pH :

The results of Fig (1) showed that there is a significant effect ($P<0.05$) of fermentation periods for fermented poultry waste in different ways, specifically by immersion in water and bioreactor methods in the pH of fermented waste, as the pH of fermented waste decreased by water immersion and bioreactor methods from7.2 (beginning of fermentation) to 6.5 and 4.6 within 15 days for two methods mentioned sequentially, while the pH of the waste prepared by the traditional compost method rose to 8, as it was noted that regardless of the method in which the poultry waste was fermented, the microbial activity is the main factor causing the change in the properties of the subject materials, including their pH (Abu Hmaid,2017) It is worth noting that in both methods of water immersion and bioreactor may have optional anaerobic microorganisms (water immersion) and compulsory anaerobic (bioreactor) in The possibility of converting the fermentation medium to acidic, especially the beginning of fermentation, because the developing anaerobic bacteria work to break down easily degradable materials and convert them into Organic acids in the pH phase (Macias-Corral et al. 2008). The results of Fig (1) showed that there was a slight rise in the pH of fermented waste in the bioreactor unit over 75 days, as the pH of the fermented manure in this way did not exceed 6 compared to the other two methods (immersion in water and compost), which indicates a state of stability and a specialized type of compulsory anaerobic microorganisms according to the biological system, which is consistent with (Mao *et al*.,2015)

It was shown that the pH index of anaerobically fermented materials decreases from 7 (beginning of fermentation) to 6.8-5.2 (end of anaerobic fermentation), attributing this to the predominance of what is known as hydrolysis and Acidogenesis, especially when combined with methane-releasing bacteria. Methanogens drop pH from 7.2 to 5.3 due to the breakdown of organic fatty acids (VFA) (Getachew, 2012).

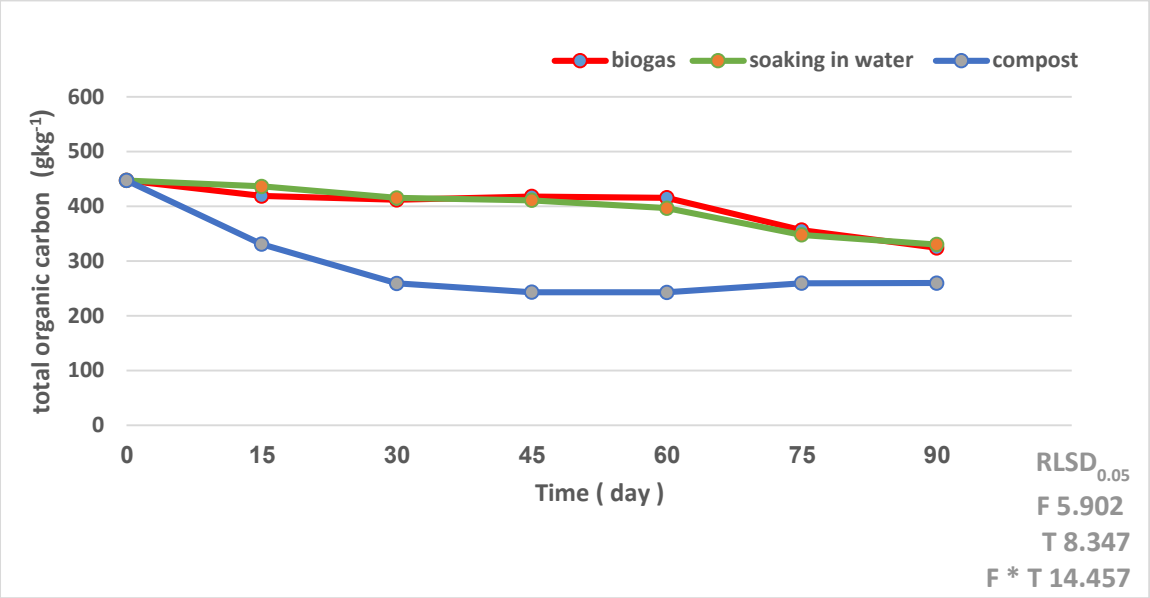


F: Fermentation method T: Time

Fig 1: Effect of fermentation duration on the pH of fermented organic fertilizer by different methods

Total organic carbon

The results of Fig (2) showed that there is a significant effect ($P<0.05$) in reducing the organic carbon of fermented poultry waste by different methods by increasing the fermentation time compared to the period of 0 days and for all fermentation methods as the results showed that all fermentation methods followed the same behavior in decreasing their carbon content with the progress of fermentation time, the decrease was clear in the treatment of anaerobic fermentation in the bioreactor unit compared to compost and immersion in water and all fermentation periods may be because the carbon in the fertilizers Anaerobically fermented in the bioreactor unit is more easily biodegradable than the carbon in aerobically fermented fertilize RS (Odlare Ital, 2011). This also came in agreement with Al-Jumaili and Al-Azzawi (2016) who obtained the continued decrease in the percentage of organic matter in anaerobic conditions compared to aerobic fermentation and pointed out that the difference in decline between anaerobic fermentation and aerobic fermentation increases in breadth with the passage of fermentation periods, attributing the reason for this to the availability of appropriate environmental conditions for the growth The proliferation of microorganisms is mainly responsible for degradation and therefore a continuous decrease in organic carbon.



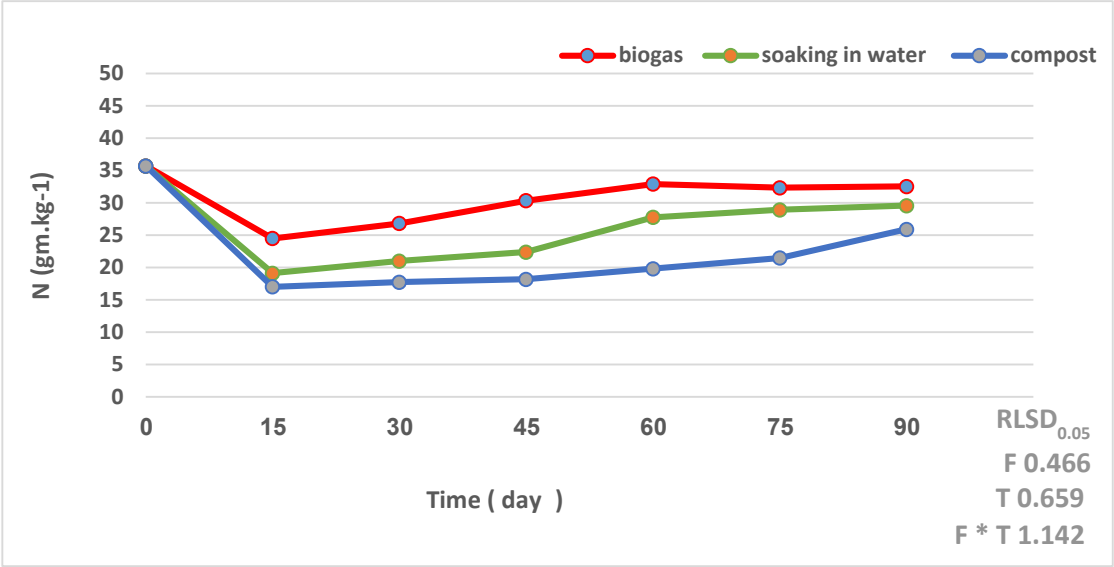
F: Fermentation method T: Time

Fig 2: Effect of fermentation duration on the total organic carbon content of fermented organic fertilizer by different methods

Nitrogen content

The results of Fig (3) showed the effect of fermentation time on the nitrogen content of poultry waste prepared in different ways, as it is clear from the results that the percentage of nitrogen decreased during the first 15 days and for all fermentation methods compared to the period of 0 days due to the consumption of nitrogen microorganisms and then took to increase their nitrogen content and have followed the same behavior in all fermentation methods, and the method affected significantly the nitrogen content and it was the highest value of nitrogen content in poultry waste prepared anaerobically in the bioreactor unit compared to other methods For all fermentation periods, the highest nitrogen value was 32.53 g kg^{-1} at 90 days of fermentation in the bioreactor unit compared to compost and water immersion, at which the values reached 25.90 and 29.57 g kg^{-1} for the methods mentioned sequentially, these results were identical to what was obtained Abdulkareem (2010) for the products of the decomposition of poultry waste prepared in three ways (air, anaerobic and water immersion). This may be due to the decrease in the compost pile after fermentation and the disintegration of the raw materials involved in the composition of these residues as a result of the loss of easily degradable compounds and the release of CO_2, thus increasing the release of nitrogen at the expense of losing weight in the compost pile (Orrico et al., 2012). It is expected that nitrogen loss in the form of ammonia gas will occur in all fermentation methods used in the study except for the anaerobic fermentation method, these results were similar to what happened to Jacob et al. (1995), who proved that the rapid collection of waste and fermentation under anaerobic

conditions far from the encouraging effects of loss cases will lead to maintaining the high nutritional value of organic waste.

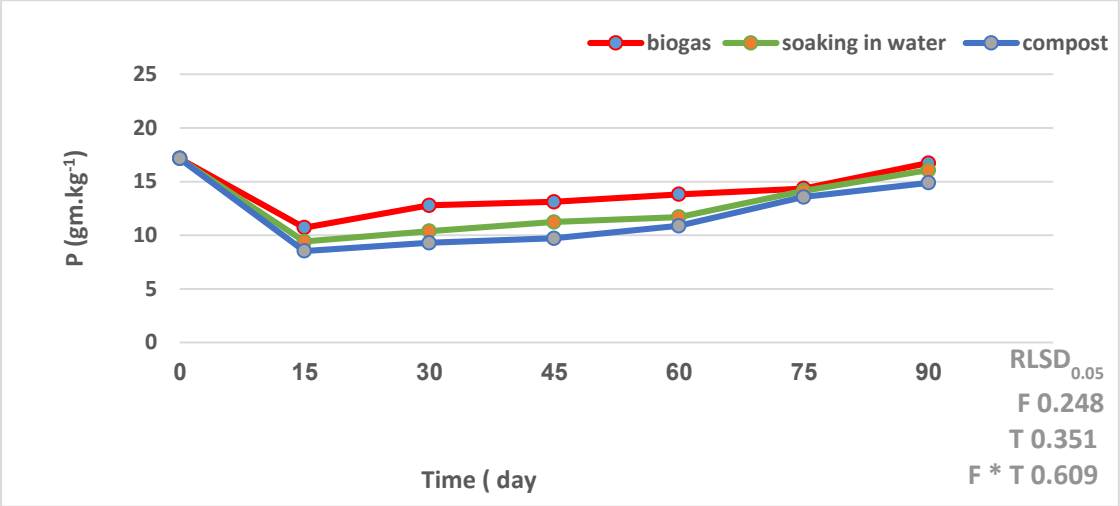


F: Fermentation method T: Time

Fig 3: Effect of fermentation duration on the total nitrogen content of fermented organic fertilizer by different methods

Phosphorus content

The phosphorus content in the waste prepared in different ways increased with the increase in the period of fermentation, specifically after the first 15 days of fermentation, where all methods followed the same behavior (Figure 4) and reached the highest phosphorus content after 80 days of fermentation This result is consistent with many studies, which indicated that the element phosphorus is an essential element in the process of producing organic fertilizer and proved an increase in the percentage of phosphorus in the final yield of organic fertilizer and attributed this increase to the decomposition of organic residues During the fermentation process and the release of this element from fermented residues due to the activity of microorganisms in addition to the decrease in the unit weight in the compost pile with time (Samaha, 2018). The loss of dry matter and the decrease in unit weight as a result of the fermentation of organic residues, regardless of the method, leads to an increase in its nutrient content (Yagodin, 1984). The decomposition products (Figure 8) under anaerobic conditions (bioreactor) showed the highest significant amount of phosphorus, which amounted to 16.72 g kg-1 compared to compost and immersion in water 14.88 and 16.06 g kg-1 These results were consistent with Al-Assafi et al. (2010), and also consistent with Abed et al. (2015) who found that the highest movement of phosphorus liberation reaches after 80-120 days and that the concentration of phosphorus in anaerobically fermented residues is higher than aerobic fermented residues with an increase of 57.67% and 45.99% of the content of Total phosphorus in the mixture and for the methods mentioned sequentially.

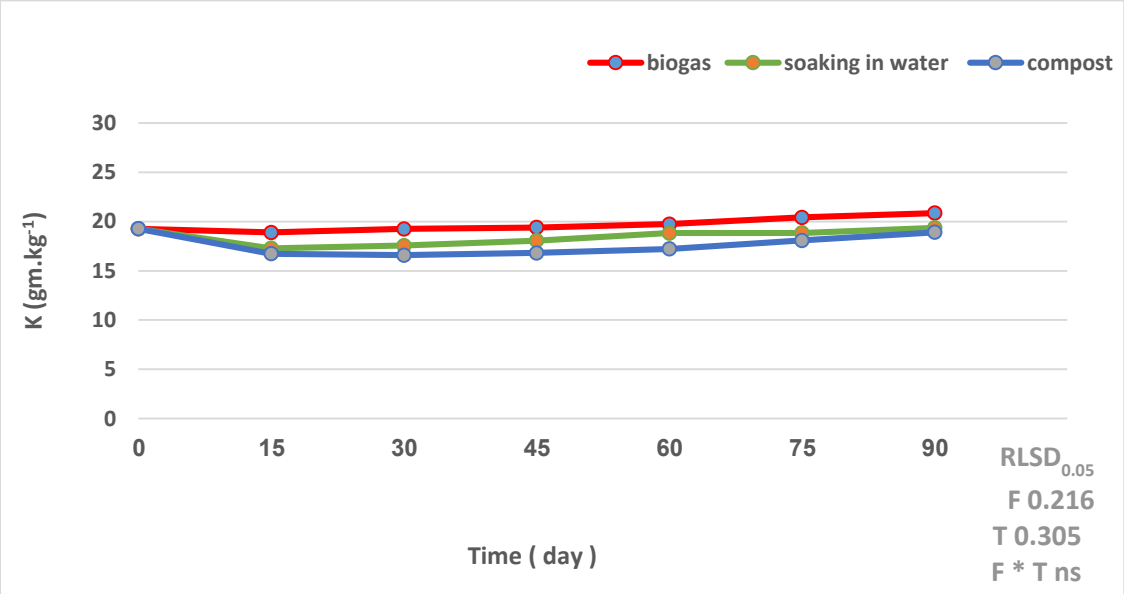


F: Fermentation method T: Time

Fig 4: Effect of fermentation duration on the total phosphorus content of fermented organic fertilizer by different methods

Potassium content

The results of Fig (5) showed the effect of fermentation time on the potassium content of poultry residues prepared in different ways, It is noted from the figure that the potassium content in fermented residues in different ways increased significantly with time and this increase was associated with what the conditions and period of fermentation did in reducing the weight of dry matter for soft animal fertilizers (Ashour, 1995), which led to an increase in potassium content in fermented poultry The results showed that the treatment of anaerobic fermented manure (bioreactor) was significantly superior to the rest of the fermentation methods (compost and immersion with water) and all fermentation periods, as the highest value of potassium content in the products of the fermentation process reached 20.86 g kg-1 for anaerobic fermented waste, while it reached 18.90 and 19.37 g kg-1 for the mentioned methods sequentially compared to the period of 0 days, which amounted to 19.27 g kg-1. It is also seen from the figure that the overlap between time and method was not significant in the potassium content of poultry waste.

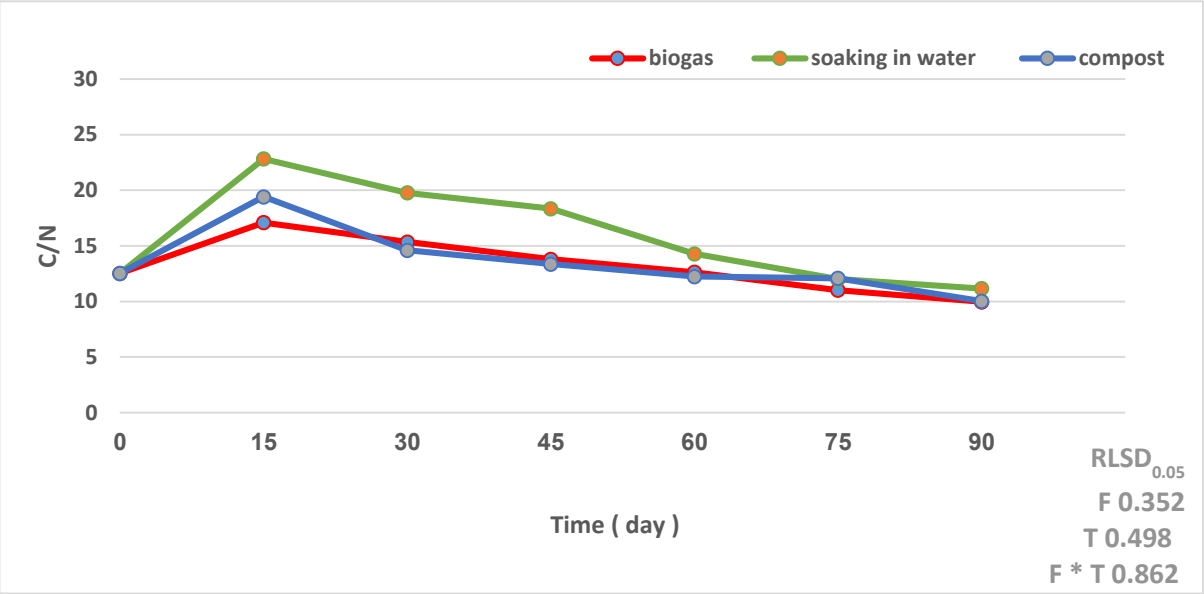


F: Fermentation method T: Time

Fig 5: Effect of fermentation duration on the total potassium content of fermented organic fertilizer by different methods

C/N ratio

The C/N ratio is used as an indicator of the rate of degradation, where a decrease in the C/N ratio or a narrowing of the value between nitrogen and carbon indicates that there has been significant decomposition (Al-Assafi et al., 2010), Fig (6) shows the difference in the C/N ratio. For organic residues prepared in different ways over time, the results obtained showed that increasing the fermentation period leads to a decrease in the percentage of C/N significantly and all fermentation methods have followed the same behavior by giving them a gradual decrease significantly with the progress of the fermentation period The reason for the decrease in the percentage of C/N over time is due to the decrease in the percentage of carbon during the decomposition and increase in the percentage of total nitrogen These results are consistent with the findings of Abdel-Hadi (2008) and Al-Fadhli (2011) and (Šubová *et al*., 2021). The results also showed significant differences between the fermentation methods at the end of decomposition and the superiority of anaerobic fermented manure by giving the lowest C/N ratio, which amounted to 9.96 compared to compost and water immersion, which amounted to 10.02 and 11.16 respectively, they proved Yan et al (2021) that the C/N ratio of 8.84 is the optimal ratio for fertilizer produced from bioreactor units, and this ratio is considered to have a stronger effect in promoting corn growth. soil moisturizing and availability of biology. Awasthi et al. (2014) showed that a C/N ratio equal to or less than 25 is an indicator of fertilizer maturity, while Iqbal et al. (2015) indicated that C/N less than 20 is evidence of acceptable organic fertilizer and if it drops to 15 or less, it is more acceptable.

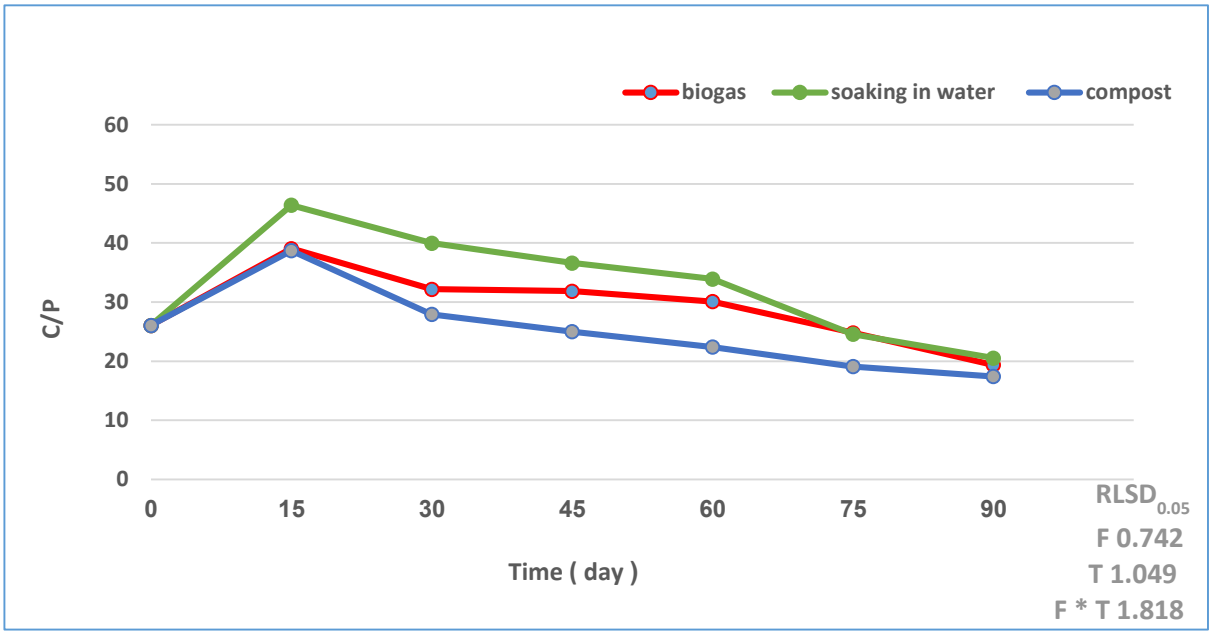


F: Fermentation method T: Time

Fig 6: Effect of fermentation duration on C/N ratio of fermented organic fertilizer by different methods

C/P ratio

Fig (7) shows the effect of fermentation time on the ratio of C/P in poultry waste prepared in different ways, as the effect of time significantly on the values of c/p for poultry waste and notes a gradual decrease significantly in the ratio of C/P in all fermentation methods during the decomposition process with time as a result of the high rate of decomposition of C and the increase in phosphorus concentration (Islam, 2021), as the release of phosphorus increases with the increase in the duration of fermentation (Figure 8), and the method also significantly affected the values of C/P and the values reached 17.44, 20.55 and 19.37 for each of the compost, water immersion, and bioreactor sequentially.



F: Fermentation method T: Time

Fig 7: Effect of fermentation duration on C/P ratio of fermented organic fertilizer by different methods

Conclusions

1- The results of the incubation experiment showed that all the studied traits have changed with the duration of fermentation and in the same direction, and the results showed that fermentation in the bioreactor unit has given the highest values of total nitrogen, total phosphorus, and potassium 32.53, 16.72, 20.86, g kg-1 for the elements mentioned sequentially, while the lowest values of pH 6.68 and C/N ratio 9.96

2- The process of anaerobic fermentation with a unit and the bioreactor and the establishment of this group does not negatively affect the environment at all stages of construction and production and supports sustainable agriculture through environmental preservation and recycling of organic waste and can be established in most circumstances because it does not need complications in raw materials and implementation

3- Fermentation of poultry waste prepared in different ways for 90 days gave the best results for the basic elements

Recommendations

1- Exploiting animal waste, especially abandoned poultry waste, by converting it into high-quality organic fertilizer free of pathogens, reducing the percentage of unpleasant odors, and working to clean the environment to contribute to sustainable agriculture and achieve a return for agricultural crop Continuity of research in this field and the work of a developed study to maintain all conditions of the device

2- The need to provide a bioreactor device for each farm supported by a separation device to establish an integrated unit and project with an economic return for the agricultural crop

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