Journal of Fertilizers & Pesticides

Hamouda et al., J Fertil Pestic 2016, 7:1
http://dx.doi.org/10.4172/2471-2728.1000161

Research Article Open Access

Some Physical and Chemical Properties of Bio-fertilizers

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Abstract

An experiment was conducted to study the effect of fermentation conditions on the properties of bio fertilizer from cow manure. The results indicated that the lowest value of bulk density was 946.63 kg/m^3 at temperature of 50°C, 300 rpm agitation speed and 5 liter/min, ventilation rate while the highest value (983.17 kg/m^3) obtained at temperature 30°C, 500 rpm agitation speed and 1 liter/min ventilation rate. The lowest moisture content was 79.87% at temperature of 30°C, agitation speed of 200 rpm and ventilation rate of 1 liter/min while the highest value was 83.19% at temperature of 50°C, agitation of 500 rpm and ventilation rate of 5 liter/min. The electrical conductivity increased from 11.6 ds m^{-1} at the start of fermentation to 35.07 dS m^{-1} at the end of fermentation period depending on the treatments under study. The pH decreased from 8.13 at the start of fermentation to 6.77 at the end of fermentation period. The total solid of the biofert decreased from 21.2% at the start of fermentation to 16.81% at the end of fermentation period, where the lowest value was 16.81% at temperature of 50°C, agitation speed of 500 rpm and ventilation rate of 5 liter/min and the highest value (20.13%) recorded at temperature of 30°C, agitation speed of 200rpm and ventilation rate of 1 liter/min. The lowest TN% was 0.41% at 50°C fermentation temperature, agitation speed of 500 rpm and ventilation rate of 1 liter/min while, the highest value (1.18%) obtained at temperature of 35°C, agitation speed of 300rpm and ventilation rate of 5 liter/min. The O.M% decreased from 34.2% at the start of fermentation to 10.97% at the end of fermentation period. Regarding the microbial changes, all treatments showed disappearance of pathogenic microorganisms at temperature of 50°C, at all agitation speeds and ventilation rates.

Keywords: Dairy manure; Biofert; fermentation; Agitation; Pathogenic; Ventilation

Introduction

Animal slurry is widely used as a fertilizer in organic farms. Dairy cattle typically produce between 42 kg and 64 kg (depending on body weight) of manure per day, so if they are housed for 50% of the year that corresponds to 7.6-11.6 tonnes per cow. In many developing nations, animal faeces have been composted and used to fertilize farm fields [1,2]. Many factors, including the type and concentration of substrate, temperature, moisture, pH, etc., may affect the performance of the anaerobic digestion process in the bioreactor [3,4]. The anaerobic digestion of organic waste is also an environmentally useful technology. [5] described the benefits of this process to reduce environmental pollution in two main ways: the sealed environment of the process prevents exit of methane into the atmosphere, while burning of the methane will release carbon–neutral carbon dioxide (no net effect on atmospheric carbon dioxide and other greenhouse gases). On the other hand, the anaerobic process has some disadvantages such as long retention times and low removal efficiencies of organic compounds [6]. Consequently, various physical, chemical and enzymatic pre-treatments are required to increase substrate solubility and accelerate the biodegradation rate of solid organic waste [7,8]. In the described manner of treating the liquid manure its temperature is augmented; our findings show that in the summer time that it is possible to supply the air from outside the barn to the aerator pump whereas in winter it is recommendable to supply warmed air from the barn interior. In this way the liquid manure heating is accelerated and at the same time the barn microclimate, from which the bad smell is removed, is improved. If during aeration the temperature of the liquid manure rises to 25-30°C, germination of the weed plant seeds, coming from the ingredients of the feed meal through the animals' digestive tract into the liquid manure, is reduced and a considerable number of parasites and disease-causers are destroyed. It has been found out that the fly larvae and the rodents, which are regular companions in the liquid manure storages; do not have optimal conditions for the procreation after a short time of the liquid manure aeration and homogenization. The main objective of this work was to study the possibility of using dairy manure in Biofert production to eliminate the pollution effect and contribute in agricultural bio fertilizer sacristy problem. To achieve this goal, the fermentation temperature, and agitation speed and ventilation rate as the most important factors affecting the physical, chemical and microbiological properties the Biofert were studied.

Materials and Methods

Materials used

Dairy manure: This waste was obtained from animal farms at Sekem, Sharkia Governorate, Egypt. The main components of this waste was: Total nitrogen (TN) of 1.42%; Phosphorus (P), of 0.012% ; Potassium (K), of 0.015%; Organic Matter (OM), of 34.2% and C/N, of 13.97 ; Moisture, of 78.8% pH, of 8.13 and Electrical Conductivity (EC), 11.6 dSm^{-1}(9280 ppm).

Measurements and instrumentation

Scanning thermometer was used to measure temperature (model, Digi-Sense 69202-30 measuring range from-250 to1800°C ±

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Received August 15, 2015; **Accepted** January 04, 2016; **Published** January 10, 2016

Citation: Hamouda R, Bahnasawy A, Ali S, Ramadan EIS (2016) Some Physical and Chemical Properties of Bio-fertilizers. J Fertil Pestic 7: 161. doi:10.4172/2471-2728.1000161

0.1%,USA). Dissolved oxygen was measured by a dissolved oxygen meter (model, HI9143 measuring range from 0.01 to 300% O_2 ± 1.5% full scale % O_2, Italy). The pH was measured by the pH meter (model, ORION230A measuring range from 2 to 19.999 ± 0.005, USA). Electrical conductivity was measured by EC meter, ICM model ORION 105 measuring range from 0 to 199.990 0.1, USA). Ammonia (NH_3) as nitrite (NO_2) and nitrate (NO3) was measured by kjeldahl digestion (model, Vapodest measuring range from 0.1 mgN to 200gN ± 1.5% full scale % N,Germany). The total phosphorus was measured by the spectrophotometer (model, 6320 D measuring range from 0.1 to 1000 Concentration ± 1 nmλ,UK). The total potassium was measured by the flame photometer (model, Jenway PFP7 measuring range from 0 to 10 ± 0.2 ppm,USA). Voltage (volt) and current (ampere) were measure by the Avometer (model, DT266 clamp meter measuring range from 200 to 1000A, China).

BioFlo 110 fermentor: A 20 L batch fermentor was used for the production of biofert from dairy manure. The experimental set–up (Figure 1) consisted of the fermenter, the air supply and the computer based data acquisition and control system. The fermenter and all accessories were chemically sterilized using 2% potassium metabisulfite solution and then washed with hot water several times before starting the experiment in order to remove any chemical traces. The reactor was then filled with 20 L of dairy manure. .the reactor was operated at air flow rate 1, 2 and 5 L/min and mixing speed of 200, 300 and 500 rpm. The dissolved oxygen and temperature of the reactor were monitored continuously. The experiment was devoted to study physical, chemical and microbiological properties of nutrient solution (Biofert) as affected by temperature with (30°C, 35°C, and 50°C), aeration rate (1, 2, and 5 L/min) and agitation rotation speed (200, 300, and 500 rpm). A total of 81 runs including 3 replicates were conducted.

Biofert analysis

Physical and chemical analysis: Bulk density was calculated as a ratio between dry weights of the sample (g) to its volume (cm^3), according to [8]. Electrical conductivity measurements were run in 1:1 Biofert water extracts according to [9], using EC meter, ICM model 71150. Total nitrogen was determined Kjeldahl digestion method as described by [10]. Soluble nitrogen forms were determined according to the method described by [11]. Total phosphorus was determined using spectrophotometer method [12]. Total potassium was determined using flame photometric method [13]. Microbiological analysis was performed according to [14].

Results and Discussion

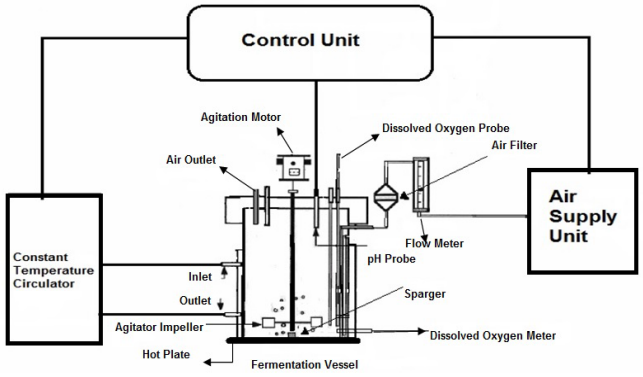

Figure 1: The experimental-setup

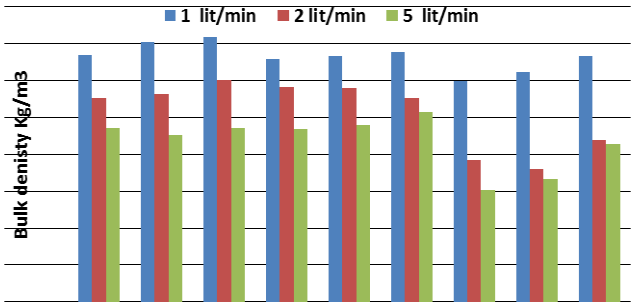

Figure 2: The effect of fermentation temperature, agitation speed and ventilation rate on bulk density of Biofert.

This study was carried out to investigate the properties of the biofert that produced under different condition of fermentation temperatures, agitation speeds, and ventilation rates. Physical, chemical and microbiological properties were studied. These properties are: moisture content, bulk density, total solid, electrical conductivity, hydrogen ion concentration, total nitrogen, organic matter, phosphorus, potassium, and microbial changes.

Physical properties

Biofert bulk density: Figure 2 shows the bulk density (BD) of the biofert as affected by the fermentation temperature, agitation speed and ventilation rate. The results indicated that the BD decreased with increasing the ventilation rate at different agitation speeds and fermentation temperature, where, it decreased from 970.60 to 951.04 kg/m^3. On the other hands, the BD increased with increasing the agitation speed, where, it increased from 966.41 to 970.28 $kg/m^3$with changing the agitation speed from 200 to 500 rpm at 30°C, from 967.19 to 962.83 kg/m^3 at 35°C, and from 946.32 to 953.66 kg/m^3 at 50°C . Regarding the effect of the fermentation temperature, it could be seen that, the BD of the biofert where they were 967.80, 967.59, 955.95 at fermentation temperature 30°C, 35°C and 50°C, respectively. The BD decreased with increasing the ventilation rate, where, it decreased from 970.60 to 951.04 kg/m^3. Multiple regressions analysis was carried out to find a relation between fermentation temperature, agitation speed, ventilation rate and the biofert Bulk density, the best form obtained was as follows:

$$BD = 993.99 - 0.75T + 0.02A - 3.11V \quad R^2 = 0.82 \qquad (1)$$

Where:-

BD is the bulk density, kg m^3

T is the fermentation temperature, °C

A is the agitation speed, rpm

V is the ventilation rate, L / min

Biofert moisture content: Figure 3 shows the effect of fermentation temperature, T (30°C, 35°C and 50°C), agitation speed, A (200, 300, and 500 rpm) and ventilation rate, V (1, 2, and 5 L/min), on the moisture content (MC) of the resultant biofert. It could be seen that the lowest moisture content (79.87%) was obtained at 30°C fermentation temperature, 1 L/min ventilation rate and 200 rpm agitation speed, meanwhile, the highest MC of the biofert (83.11%) was recorded at 5 L/min ventilation rate and 500 rpm agitation speed. At 35°C fermentation temperature, the lowest moisture content (80.12%) of Biofert recorded at 1 L/min ventilation rate and 200 rpm agitation speed, meanwhile, the

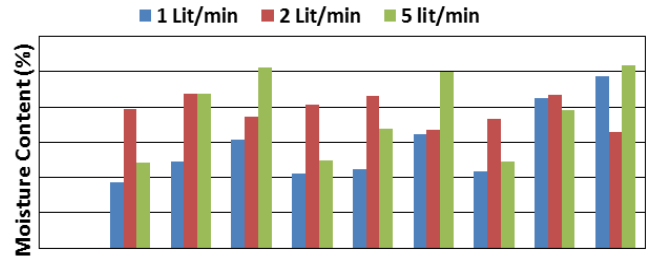

Figure 3: The effect of fermentation temperature, agitation speed and ventilation rate on the moisture content of the Biofert.

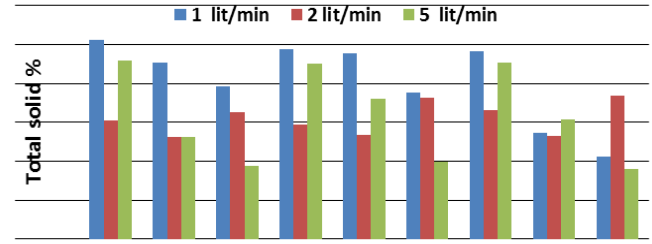

Figure 4: The effect of fermentation temperature, agitation speed and ventilation rate on the total solid of Biofert.

highest MC of the Biofert (83.01%) was recorded at 5 L/min ventilation rate and 500 rpm agitation speed. At 50°C fermentation temperature, the lowest moisture content (80.18%) of Biofert recorded at 1 L/min ventilation rate and 200 rpm agitation speed, meanwhile, the highest MC of the Biofert (83.19%) was recorded at 5 L/min ventilation rate and 500 rpm agitation speed.

Biofert total solid%: Figure 4 shows the effect of fermentation temperature (T), agitation speed (A) and ventilation rate (V) on the total solid (TSS) of the biofert. The results showed that the TSS varied slightly from 18.20 to 18.64% as fermentation temperature changed from 30-50°C. TSS varied from 17.55 to 19.26% as the agitation speed changed from 200 to 500 rpm. On the other hand, TSS ranged from 18.10 to 19.08% as the ventilation rate changed from 1 L/min to 5 L/min.

Chemical properties

Biofert electrical conductivity (EC): Figure 5 shows the effect of fermentation temperature (T), agitation speed (A) and ventilation rate (V) on the EC of the biofert. It could be seen that the biofert EC increased with increasing all treatments under study (T, A and V). The average EC increased from 29.54 to 33.97 ds/m. as the fermentation temperature from 30°C to 50°C, on the other hand, the EC increased from 28.33 to 30.96 ds/m as the agitation speed increased from 200 to 500 rpm at 30°C, 31.91 to 33.60 ds/m at 35°C and from 33.11 to 34.61 ds/m at 50°C for the same previous range of the agitation speed (200 to 500 rpm). These results could be attributed to with increasing these factors (T, A and V) caused increasing in the water evaporation while result in increasing of the salinity of the biofert solution. It means that the mineralization process of organic wastes increased gradually which led to release cations and anions showing the highest peak at the end of fermentation [15]. The best fit for the relationship between the electrical conductivity, temperature, agitation speed and ventilation rat was as follows:

$$EC = 21.02 + 0.19T + 0.006A + 0.64V \; R^2 = 0.75 \quad (2)$$

Where, EC is the electrical conductivity dsm-1 (ds/m=800 ppm)

Biofert hydrogen ion concentration (pH): Figure 6 shows the effect of fermentation temperature (T), agitation speed (A) and ventilation rate (V) on the pH of the biofert. The results indicate that the pH ranged from 4.79 to 5.48 as the fermentation temperature changed from 30°C to 50°C and from 4.61 to 5.79, as the agitation speed changed from 200 to 500 rpm. The pH ranged from 4.95 to 5.29 as the ventilation rate varied from 1 L/min to 5 L/min.

Changes in biofert total nitrogen (TN)%: Figure 7 shows the effect of the fermentation temperature, agitation speed and ventilation rate on the TN% of the biofert. It could be seen that the TN% increased slightly with the agitation speed, where, it ranged from 0.61 to 1.06% as the agitation speed changed from 200 to 500 rpm .On the other hand, TN was affected by the ventilation rate, where it increased from 0.68 to 1.00% as ventilation rate increased from 1 to 5 L/min. TN% ranged

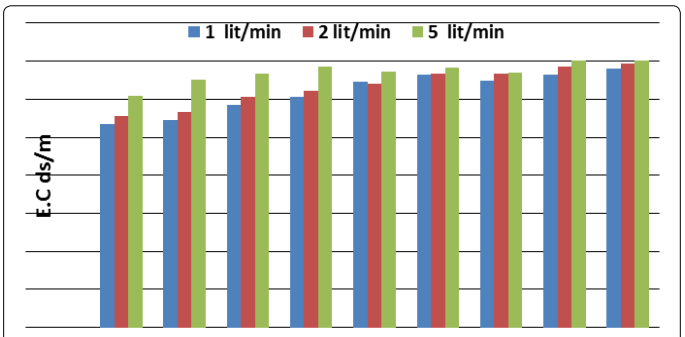

Figure 5: The effect of fermentation temperature, agitation speed and Ventilation rate on the electrical conductivity of Biofert.

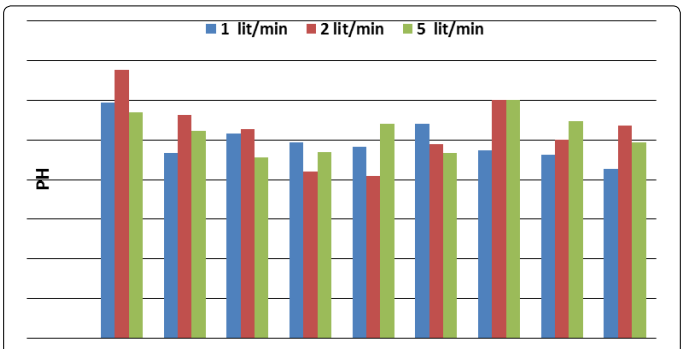

Figure 6: The effect of fermentation temperature, agitation speed and Ventilation rate on pH of Biofert.

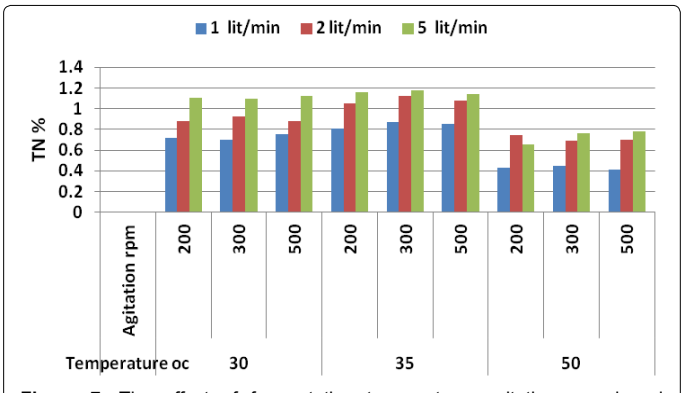

Figure 7: The effect of fermentation temperature, agitation speed and Ventilation rate on total nitrogen (TN)% Biofert.

from 0.63 to 1.04% as the fermentation temperature ranged from 30°C -50°C. The best fit for the relationship between the total nitrogen, Temperature, agitation and ventilation rat was as fallowed equation:

$$TN = 1.30 - 0.017T + 4.87A + 0.072V \quad R^2 = 0.72 \tag{3}$$

Where, TN is total nitrogen (TN), %.

Changes in biofert organic matter (O.M)%: Figure 8 shows the effect of O.M% of the biofert as affected by the fermentation temperature, agitation speed and ventilation rate. It could be seen that the O.M% ranged from 11.53-16.07% depending on the agitation speed. On the other hand, the OM changed slightly as the ventilation rate varied, where it changed from 13.57 to 13.84% where the VR varied from 1 to 5 L/min. Regarding the effect of fermentation temperature, it was found that the OM decreased from 15.01 to12.64% as the fermentation temperature increased from 30 to 50°C. Regression analysis was carried out to find a relationship between the organic matter, temperature, agitation and ventilation rat, and the most appropriate form is shown as follows:

$$OM = 18.47 - 0.06T - 0.007A + 0.29V \quad R^2 = 0.77 \tag{4}$$

Where, OM is organic matter (O.M), %.

Changes in biofert phosphorus: Figure 9 shows the effect of fermentation temperature, agitation speed and ventilation rate on the total phosphorus content of the biofert. It seems that the T.P increased by increasing the fermentation temperature, agitation speed and ventilation rate under study, where it increased from 145.59 to 275.70 ppm as the ventilation rate increased from 1 L/min to 5 L/min , on the other hand,

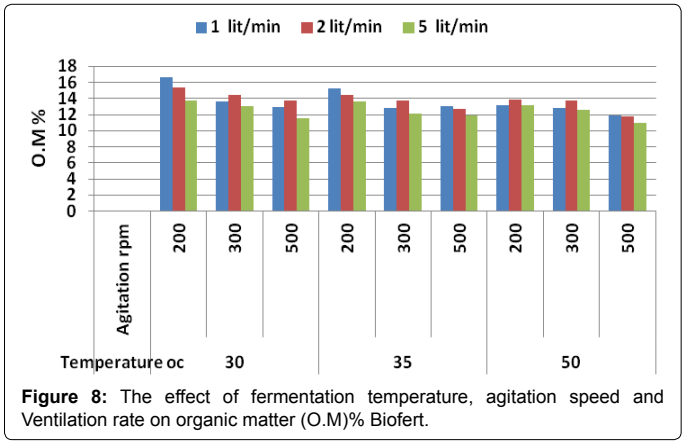

Figure 8: The effect of fermentation temperature, agitation speed and Ventilation rate on organic matter (O.M)% Biofert.

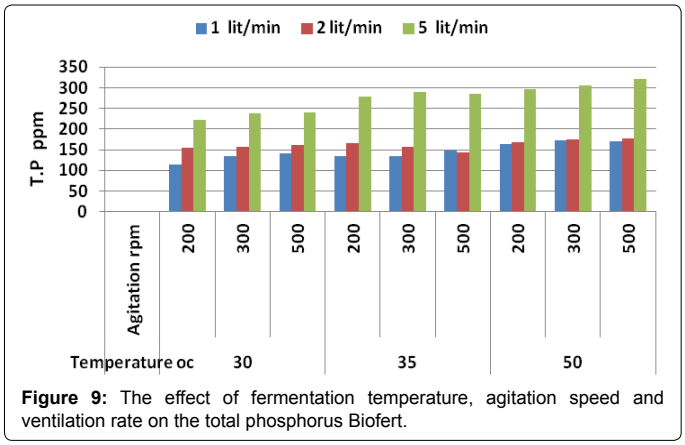

Figure 9: The effect of fermentation temperature, agitation speed and ventilation rate on the total phosphorus Biofert.

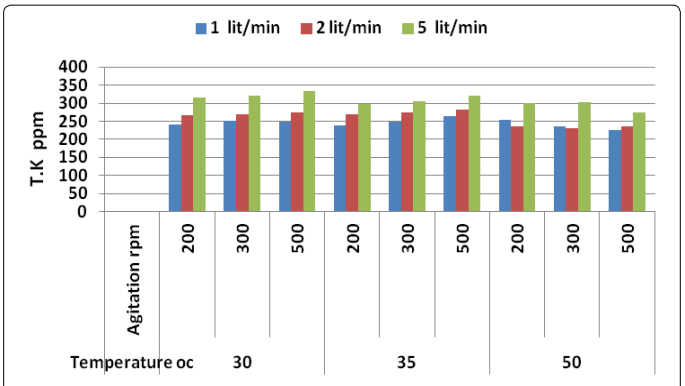

Figure 10: The effect of fermentation temperature, agitation speed and Ventilation rate on the total potassium Biofert.

it increased from 163.44 to 223.33 ppm with increasing the agitation speed from 200-500 rpm. The T.P increased from 173.81 to 216.96 ppm with increasing the fermentation temperature from 30°C-50°C.It could be conducted that the effect of ventilation rate on the T.P was higher than the effect of both agitation speed and fermentation temperature. But agitation speed effect was higher than the effect of fermentation temperature. The decreases of phosphorus concentration in the first stage of composting could be due to the microbial immobilization of available phosphorus [10], while the increase of phosphorus during the further stages of composting (mesophilic) could be due to either the microbial mineralization of organic phosphorus or the chelation of unavailable phosphorus with the organic acids, that found during the microbial decomposition of organic wastes. These data are in agreement with those of [16,17]. The best fit for the relationship between the total phosphorus, Temperature, agitation and ventilation rat was as fallowed equation:

$$TP = 15.88 + 2.03T + 0.03A + 33.75V \quad R^2 = 0.94 \tag{5}$$

Where, TP is Total phosphorus, ppm

Changes in biofert potassium: Figure 10 shows the effect of fermentation temperature, agitation speed and ventilation rate on the total potassium (T.K) content of the biofert. It could be seems that the T.K increased from244.63 to 295.30 ppm as the ventilation rate varied from 1 to 5 L/min. It increased from 274.89 to 286.44 ppm, 268.89 to 289.11 ppm, and 238.11 to 245.00 ppm at 30°C, 35°C and 50°C, respectively as the agitation speed increased from 200-500 rpm. Concerning the effect of fermentation temperature, it was found that the T.K decreased from 280.74 to241.19 ppm as the temperature increased from 30°C to 50°C. These data are in harmony with those of Singh and Sharma (2002) who found that the significant increase in potassium concentration by the end fermentation period could be due to the mineralization of organic matter. The best fit for the relationship between the total phosphorus, Temperature, agitation and ventilation rat was as followed equation:

$$Tk = 275.07 - 1.33T + 0.015A + 15.785V \quad R^2 = 0.89 \tag{6}$$

Where, Tk is Total potassium, ppm.

Microbial changes: Figures 11a-11c shows the microbial load of tested human pathogens (E.coli, Salmonella sp and Shigella sp) during biofert process as affected by ventilation, agitation and temperature. Results clearly depicted that a sharp decrease in the counts of all tested human pathogens with the increase of ventilation up to 5 L/min .The reduction percentages of all tested were ranged from 88.18 to 99.82%. It means that the ventilation levels had a deleterious effect on the proliferation of human pathogens. On the other hand the increase of

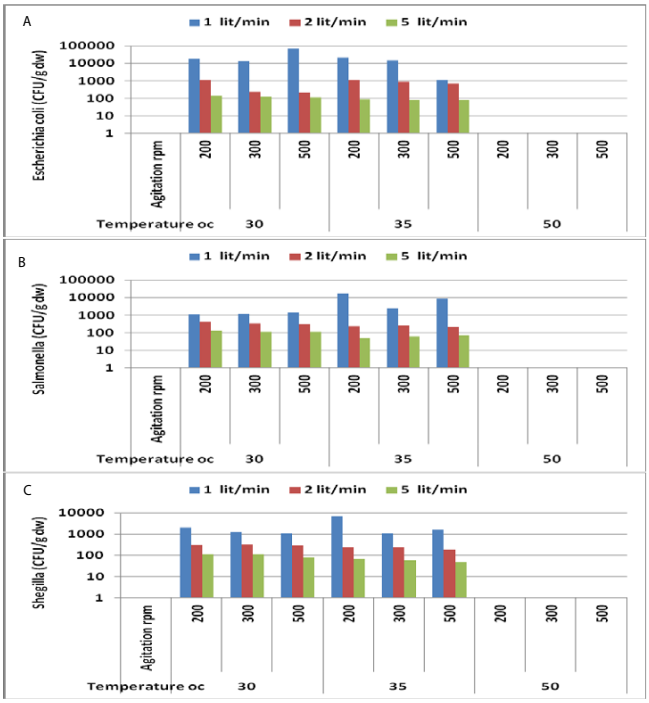

Figure 11a,11b,11c: The effect of fermentation temperature, agitation speed and Ventilation rate on Total account of Pathogenic (CFU/gDW) on biofert.

dissolved oxygen led to increase the biological activity of saprophytic microorganisms and consequently increase their metabolites especially antagonistic agents and antibiotics. The two levels of temperatures being 30°C and 35°C did not show a distinct difference whereas 50°C completely destroyed all human pathogens during biofert process. Agitation also exhibited the same trend of both tested temperature. This result is in line with [14] who observed that the disappearance of pathogens could be explained on the basis that when a beneficial microbe fills an ecological niche that would otherwise be exploited by a pathogen. For example, a beneficial organism may out-compete a pathogen for energy, nutrients, or "living space," thereby decreasing the survival of the pathogen.

Conclusions

This study was carried out to investigate the most important factors affecting the biofert production such as temperature, agitation speed, and aeration rate to obtain the proper factors for optimum production of the nutrient solution. The most important results could be summarized as follows:-

The results indicated that the lowest value of bulk density was 946.63 kg/m^3 at temperature of 50°C, 300 rpm agitation speed and 5 liter/min, ventilation rate while the highest value (983.17 kg/m^3) obtained at temperature 30°C, 500rpm agitation speed and 1 liter/min ventilation rate.

The lowest moisture content was 79.87% at temperature of 30°C, agitation speed of 200rpm and ventilation rate of 1 liter/min while the highest value was 83.19% at temperature of 50°C, agitation of 500rpm and ventilation rate of 5 liter/min.

The electrical conductivity increased from 11.6 ds m^{-1} at the start of fermentation to 35.07 ds m^{-1} at the end of fermentation period depending on the treatments under study. The pH decreased from 8.13 at the start of fermentation to 6.77 at the end of fermentation period.

The total solid of the biofert decreased from 21.2% at the start of fermentation to 16.81% at the end of fermentation period, where the lowest value was 16.81% at temperature of 50°C, agitation speed of 500 rpm and ventilation rate of 5 liter/min and the highest value (20.13%) recorded at temperature of 30°C, agitation speed of 200rpm and ventilation rate of 1 liter/min.

The lowest TN% was 0.41% at 50°C fermentation temperature, agitation speed of 500 rpm and ventilation rate of 1 liter/ min while, the highest value (1.18%) obtained at temperature of 35°C, agitation speed of 300 rpm and ventilation rate of 5 liter/min.

The O.M% decreased from 34.2% at the start of fermentation to 10.97% at the end of fermentation period. The lowest value of O.M % was 10.97% at temperature of 50°C, agitation speed of 500rpm and ventilation rate of 5 liter/min while the highest value was 16.63% at temperature of 30°C, agitation speed of 200rpm and ventilation rate of 1 liter/min.

The total phosphorus and potassium increased by increasing the fermentation temperature from 120 to 322 ppm, and from 150 to 334.33 ppm, respectively by the end of fermentation period.

Regarding the microbial changes, all treatments showed disappearance of pathogenic microorganisms at temperature of 50°C, at all agitation speeds and ventilation rates.

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Citation: Hamouda R, Bahnasawy A, Ali S, Ramadan EIS (2016) Some Physical and Chemical Properties of Bio-fertilizers. J Fertil Pestic 7: 161. doi:10.4172/2471-2728.1000161