IMPROVING THE PERFORMANCE OF COMPOST EXTRACTION SYSTEM USING MAGNETIC TREATMENT

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ABSTRACT

The compost extract is primarily a liquid fertilizer, brewed by immersing organic compost in water in specified proportions and allowing the nutrients to leak as aerobic fermentation process. It is used as foliar fertilizer and soil amendment to supply the plant with water-soluble nutrients as well as to improve soil structure and water holding capacity. The aim of the research was to construct and evaluate the performance of a compost extract system to reach the optimum production parameters. Farm animal wastes were used as compost source. The performance of the manufactured system was studied under the different magnetic pumping period of (6,12,24 h/day);three dilution ratios of (1:10,1:15,1:20) ,different aeration period of (6,12,24 h/day).It has also been evaluated taking into consideration the following indicators: system productivity and specific energy requirements as well as physicochemical properties of compost extract.

The experimental results showed that the highest value of unit productivity was 13.45 kg.day-1 with 1.29 kWh.Kg-1 specific energy.

Based on the results, it can be concluded that the best dilution ratio is 1:20 and the preferable operating parameters for the compost extract production is 12 hours of aeration or magnetic pumping time. Furthermore, using a magnetic unit during pumping lead to improve the values of nutrients concentration N, P, and K. They were 1100, 97.8 ٦ and 5544 ppm, respectively compared with no magnetic treatment.

1. INTRODUCTION

The animal residues in Egypt have to be used as an energy source to be a safe and environmentally friendly source instead of becoming a source of pollution and disease. Firstly, there are different techniques to recycle animal wastes in several ways as composting and energy production. In other words, using animal wastes

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as an integral portion of sustainable development instead of considering it as undesired residues. Compost production considered the perfect method for recycling animal wastes. Quite recently, considerable attention has been paid to the composting process.

The composting process is the aerobic fermentation of the organic materials by microbial action under controlled conditions and as it's known that the animal wastes are rich in organic matter, which needed to keep crop healthy and increase production. **Hussein et al, (2010)** proved that brewing the agricultural residues in order to produce compost is the perfect method for recycling, aid the organic re-fertilizing to the soil and minimize the production cost. As a consequence, the composting process considered as one of the best famous recycling processes to organic waste to close the natural loop. **Mistry and Mukherjee, (2015)** reported that the prevalent compost extract production process is commonly described as actively aerated compost extract, which is the product through the following widespread process: Generally, the compost is filled into a permeable bag and submerged in water then supply aeration by air pump directly or by recirculation of the water for 12-24 hours. Molasses and yeast extract added as process additives in order to substantially enhance the microorganism's communities. This is in agreement with **Radovich and Arancon, (2011)** where they described the compost extract as an extract that is fermented, either anaerobically or aerobically, with microbial food sources. Such trend is commercially increasing and is resulting in microbiologically enriched compost extract, commonly called "compost tea". **Hegazy et. al., (2015)** found that the long incubation time is not preferred, whereas oxygen consumed by aerobic microorganisms, especially when the aeration pump is not used, hence, the anaerobic microorganisms take the opportunity to grow. As reviewed by **Matouk et al., (2017)** the production of compost tea is not disseminating in Egypt nowadays, whereas ordinarily, most producers produce it under the non-aerobic condition which lead to decrease in the quality of the produced tea and be a source of different diseases to the plant and the soil. At the same time today the using of liquid organic fertilizers has gained much global attention, whereas it's content of useful microorganism support the organic farming. **Pane et al., (2014)** mentioned the benefits of using

compost teas in agriculture such as bio stimulation and improvement of crop yield and quality suppression of plant pathogenic microorganisms and supplying the plant with water-soluble nutrients.

Shrestha et al., (2011) explained that the production of high-quality compost extract depends on several factors, such as: adding nutritional sources, dilution rate and water quality, level of aeration, compost quality and age, and incubation time. **Naidu et al., (2010) and Pane et al., (2012)** noted that many compost tea producers include additives in order to increase the populations and diversity of microorganisms and to increase the level of plant disease suppression. Different additives can be used as molasses, and kelp extract. Most likely the dilution ratio between compost and water be ranged between 1:1 to 1:50 but the most commonly used ratio of 1:3 to 1:10 but it was noticed that the highly diluted extract could pose the risk of microbial contamination as reviewed by **Scheuerell and Mahaffee, (2004)**. This is in agreement with **Hegazy et al., (2015)** reported that the numbers of all microbial groups have decreased as the dilution rate increased. **Pane et al., (2012)** recorded that the physicochemical properties (pH, E.C., total N, P, and K) are very substantial factors in determining the compost extract value, where it is the most necessary as a nutritionals for the plant. It also found that the pH values were slightly decreased with an increase in the incubation period. The magnetically treated water is considered as an environmentally friendly technique. The magnetically treated water is produced when water passes through the magnetic field of the permanent magnetic device, which is installed on feed pipeline, thus enhance all water and salt molecules internal vibration cited by **Babu, (2010)**.This concurs with **Hilal et al., (2012)** found that the magnetically treated water (MTW) removes the surplus of the soluble salts; decrease the pH values, due to that MTW desolves soil salts and filter them away from the root zone. However, the mechanism of action of magnetic field treatment in compost tea production is still unknown until now and this is one of the targets of this research. Another study conducted by **Abou El-Yazied et al., (2012)** showed that the magnetic field leads to pH reduction as a result of the high level of the organic acids, whereas the magnetic leads to improve

elements levels, except sodium because its small positive susceptibility to magnetic fields, rather than other elements which are diamagnetic.

This paper presents a pilot study to find the optimum levels of the major production variables, in particular, the compost dilution ratio, aeration periods and the impact of the magnetic treatment during compost extract production.

2.MATERIALS AND METHOD

Multiple experiments were carried out through the year of 2019 at the Department of Agricultural Engineering, Faculty of Agriculture, Zagazig University in order to constructed and evaluate the performance of a compost extract production system to reach up to the optimum production parameters. The compost extraction process was done in four different experiments to measure the effect of both aeration and magnetic pumping periods plus the dilution ratio between compost and water.

Compost extraction system

The local compost extract system was constructed at the Electrical Engineering Laboratory, Agricultural Engineering Department, Faculty of Agriculture, Zagazig University. Low-cost local materials were used for constructing to overcome the high-cost requirement in case of using the ready manufactured unit.

The extraction system consists of extraction unit (aerobic tank) with a working volume of 50 liters for brewing, strainer bag, electric control panel, air compressor, and every air compressor, water pump, magnetization unit, and a small tank with plastic T-valve. Each air compressor has two stones both of them put at the bottom of the aerobic tank in order to supply enough oxygen. The compost extract system is shown in Fig. (1).

Magnetic unit

Tesla Miter has used to measure the magnetic intensity of magnet pieces. Four magnetic pieces were carefully fixed outside a metal cylinder together. The total magnetic force generated from each cylinder was evaluated. The magnetic device was installed in the pathway of pumping compost extract. Each magnetic cylinder has two tubes attached to it, one connected to the pump to introduce extract from digestion tank and the other one located at the end of the cylinder to discharge the magnetized extract into the top tank, then the magnetized extract return to digest tank by opening tap, thus it is a

closed cycle. Thus, it gave magnetic intensity to the compost extract. The magnetic intensity for each magnetic treatment was 1600 kaws.

Fig. 1: The compost extraction system.

The used compost and the additive material

The utilized compost was obtained from animal wastes (mainly cow and rabbit residues) which totally dried in the sun for two weeks to prepared for experiments. The used waste specifications are illustrated in Table (1).

Table 1: Characteristics of utilized wastes.

Waste	N ppm	P ppm	K ppm	Organic matter,%	Organic carbon,%	C/N
Cow dung	21000	3218	2.23	69.87	40.53	19.30
Rabbit dung	22400	9485	1.86	70.17	40.70	18.17

A sugar cane residue (bagasse) from the juicing process was added as cheap source of carbohydrates to accelerate the composting process, in addition, to be used as nutrient additives and microbial supplements for microbial population increasing in compost extract. Sugar cane residues were used in all experiments with 12.5%.

Production procedure

Generally, the low-cost compost extract produced by covering compost with water, stir the combination and soak for a period. In this research experiment, the aerobic tank (50-l plastic bucket), with a working volume of 20-l for brewing was filled with tap water and left for 24 hours in order to remove chlorine before starting the experiment. The dried animal wastes were filled and sealed in nylon bags and have been submerged in the water inside the digestion tank. In the end, each of the buckets was supply with sugar cane residue as a microbial food source. Undoubtedly, both mixing and aeration are very essential to compost tea extraction, whereas the mixing process leads to improve bacteria population, also the air stones uses during extraction process to support the aerobic fermentation and prevent the occurrence of anaerobic fermentation. The specifications of the aeration and pump unit are shown in Table (2).

Table 2: Specifications of the aeration and water pump unit.

Air compressor	Fine Bubble Diffusion – Two outlets
	3.5 l/min air delivery per bucket through air stones
	Voltage: 220V
	Frequency: 50Hz
	Power : 5W
Water pump (Multi-function submersible pump)	Power : 50W
	Voltage: 220V
	Frequency: 50Hz
	F.MAX:2900 L/H H.MAX:3m

Experimental design and treatments:

Each compost extraction was done in four different experiments with three replications, in order to find out the optimum conditions for compost extract production. Different conditions were studied such as magnetic pumping, dilution ratios and aeration periods.

The extraction system performance was experimentally evaluated under the following different parameters:

1. The first experiment was done without aeration or pumping or magnetic (control).
2. The second experiment was done to study the effect of aeration at three different periods namely (6, 12 and 24 h per day).
3. The third experiment consisted of three different magnetic pumping periods namely (6, 12 and 24 h per day).
4. The fourth experiment was done to study the effect of pumping extract without a magnetic treatment at 24 h per day only.

Each experiment was done under different dilution ratios between compost and water of (1:10, 1:15, and 1:20) on a weight/weight basis.

It is worth mentioning that the periods of operation of both aeration and magnetic pumping occurred as follows:

- The timer was set on for one hour and off for three hours to have 6 working hours per day.
- The timer was set one hour on and one hour off to have 12 hours per day.

Measurements and determinations

1. Physicochemical analysis of compost extract

The analysis of compost extract samples and cow and rabbit wastes were done in accordance with **AOAC (2002)**. A pH meter (Jenway3020 digital) was used for estimating the pH values. Total nitrogen and total potassium were measured using an atomic absorption device while total phosphorus was estimated using the chromatography device. The percentage of the organic matter was derived using the equation below; The percentage of organic matter = 1.724 x percentage of organic carbon where the organic carbon was obtained using the dichromate oxidation method.

2. System productivity

The productivity was calculated by the following equation, as mentioned by **Badr, (2013)**:

$$\mathbf{SP = \frac{W_e}{t}}$$

Where: SP = system productivity ($g.h^{-1}$), We = Weight of extraction sample (g), and t = extraction operation time (h).

3. Energy requirement

Specific energy requirement was calculated as follows:

$$\mathbf{ER = \frac{PC}{SP}}$$

Where: ER = Energy requirement, $Wh.g^{-1}$ and PC = Consumed power, W.

3. RESULTS AND DISCUSSION

The experimental results will be discussed under the following items:

Effect of different experimental parameters on system productivity:

As may be seen below the unit productivity is affected by the aeration and magnetic pumping periods. Concerning the effect of the aeration period, results show that increasing aeration period from 6 to 12 hours per day, at different dilution ratios of 1:10, 1:15 and 1:20, increased the unit productivity from 6.78 to 6.79, from 10.09 to 10.12 and from 13.43 to 13.45 $kg.day^{-1}$, respectively. Any further increase in aeration period more than 12 up to 24 hours per day at the same dilution ratio tend to decrease unit productivity from 6.79 to 6.76, from 10.12 to 10.08, and from 13.45 to 13.42 $kg.day^{-1}$, respectively. Whereas the higher aeration period more than 12 hour /day led to destroy the beneficial microorganism populations in the extract, so it becomes unable to carry out the extraction process. On the other hand, if the aeration period less than 12 hour /day the unit productivity tends to decrease because the oxygen becomes limited, and the brief anaerobic periods are not undesirable, whereas anaerobic conditions make many beneficial microorganisms inactive or kill them. In addition, the development of the biofilm takes place, hence reduces producing compost extraction.

As to the effect of magnetic pumping, results show that increasing magnetic pumping from 6 to 12 h, measured at different dilution ratios of 1:10, 1:15 and 1:20, increased the unit productivity from 6.79 to 6.83, from 10.12 to 10.13 and from 13.43 to13.45 $kg.day^{-1}$ respectively, because of increasing the pumping period leads to create desirable air conditions. Moreover, the magnetic pumping process improves the extraction process by increasing the extract flowing through the unit. Correspondingly, any further increasing in pumping more than 12 up to 24 hours per day measured at the same dilution ratios led to decrease the unit productivity from 6.83 to 6.77, from 10.13 to 10.08, and from 13.45 to 13.42 $kg.day^{-1}$, respectively. This approach is similar to the effect of the aeration period. Increasing the pumping time more than12 h/ day lead to decreasing system productivity because of the overly quick or forceful blending, maybe causing the microorganism population to be destroyed. It is, however, important to note the limitations of unit productivity if the pumping period lower than 12 h/day, whereas decreasing pumping time makes oxygen-limited and this is not adequate for aerobic

organisms. The representative values of the system productivity versus magnetic pumping periods at different dilution percentages are given in Fig. 2.

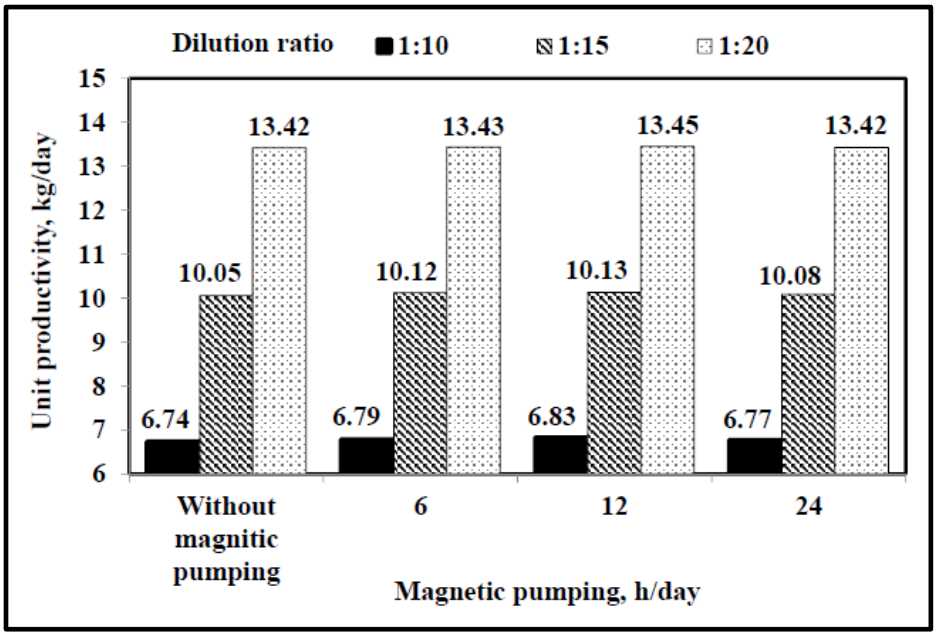

Fig. 2:Effect of magnetic pumping on system productivity.

There is also, another point that has to be considered, the positive effect of using magnetic pumping compared to aeration unit under the same dilution ratio, whereas the unit productivity-increasing more with magnetic pumping treatment. This is due to the increase of the oxygen availability also its contribution to the extraction process by increasing extract flow through the unit tubes.

Influence of different experimental parameters on energy requirements: The specific energy requirements are more sensitive to different parameters such as dilution ratios, aeration and magnetic pumping periods.

Results show that increasing aeration periods from 6 to 12 hours per day, measured at different dilution ratios of 1:10, 1:15 and 1:20, increased the specific energy from 106.16 to 212.05, from 71.33 to 142.31, and from 53.62 to 107.08 $Wh.kg^{-1}$, respectively. Representative values of specific energy versus aeration periods at different dilution percentages are presented in figs (3).

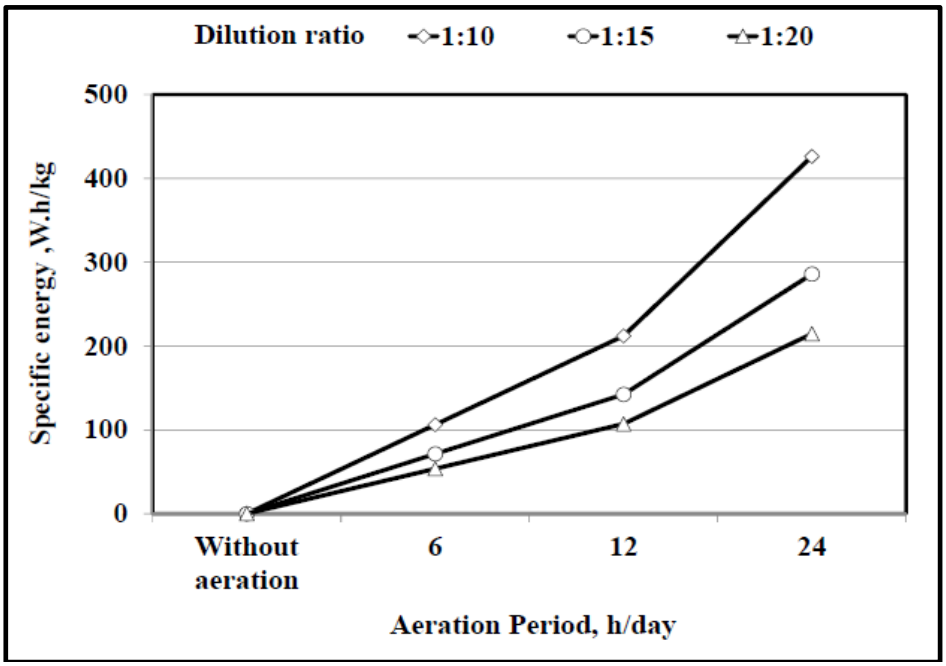

Fig. 3: Effect of aeration period on energy requirements.

As well results show that increasing magnetic pumping from 6 to 12 hours per day, measured at different dilution ratios of 1:10, 1:15 and 1:20, increased specific energy from 1485.43 to 2530.69, from 996.30 to 1705.63, and from 750.38 to 1284.95 $Wh.kg^{-1}$, respectively.

The required specific energy is most connected to the aeration and magnetic pumping periods due to the increase of consumed ampere required for operating and normally, the required energy requirements are too related to the power consumed.

The obtained results show that increasing aeration periods from 12 to 24 hours per day, measured at different dilution ratios of 1:10, 1:15 and 1:20, increased the specific energy from 212.05 to 426.20, from 142.31 to 285.79, and from 107.08 to 214.63 $Wh.kg^{-1}$, respectively. Also, it is noticed that increasing magnetic pumping from 12 to 24 hours per day, under the different dilution ratios of 1:10, 1:15 and 1:20 led to specific energy increase from 2530.69 to 4680.23, from 1705.63 to 3141.79, and from 1284.95 to 2360.01 $Wh.kg^{-1}$, respectively. The required specific energy, increased by increasing the aeration and magnetic pumping periods as a result of the

increase of both pumps working time that causes an increase of ampere consumption required for operating. Representative values of specific energy versus magnetic pumping periods at different dilution percentages are presented in figs (4).

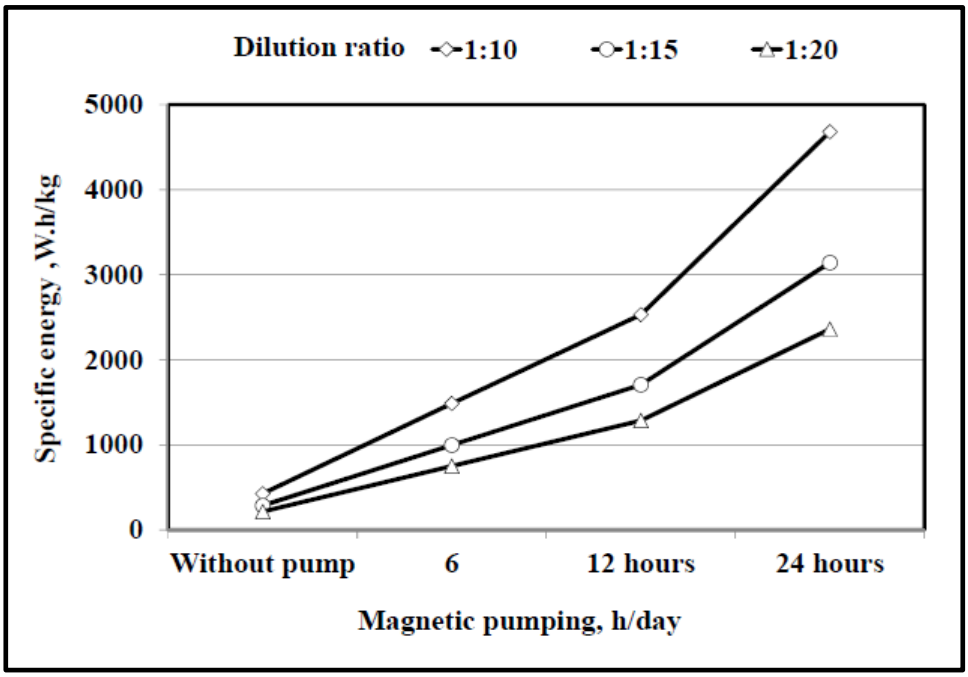

Fig. 4: Effect of magnetic pumping on energy requirements.

Influence of some experimental parameters on physicochemical properties under different dilution ratios:

The overall measurement of the different physicochemical analyses (NPK, organic matter, pH and C/N) are summarized in Figs (5), (6), and (7). The results show the effect of the different aeration and magnetic pumping periods on compost extract properties.

All analysis was done at 1:20 dilution ratio only because it was the best ratio based on the results obtained. This corresponds with **Matouk et al., (2017)** findings that the dilution of 1:20 is perhaps the most suitable to extract all the nutrients from the compost.

In general, the result showed that concentration values of N, P, and K after 72 h of fermentation increase with the increase in the aeration and magnetic pumping periods from 6 to 12 hours per day. Correspondingly, any further increase in aeration and magnetic pumping more than 12 up to 24 h lead to

decrease the concentration values. Representative values of nutrients versus aeration and magnetic pumping for different periods are presented in Fig. (5).

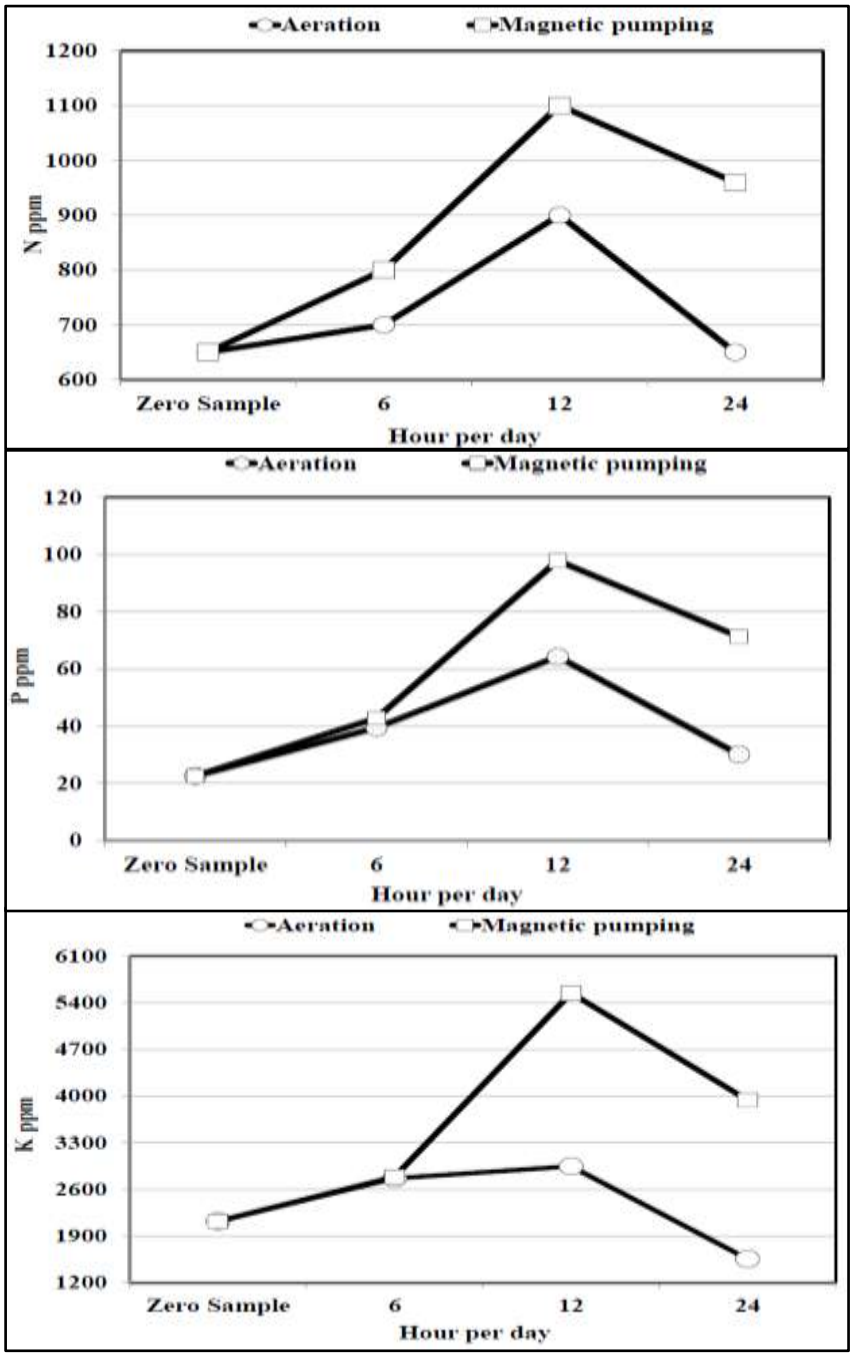

Fig. 5: Effect of aeration and magnetic pumping periods on N, P, K

It is important to note that the increase in concentration values of N, P, and K in case of using the pump with a magnetic treatment compared to aeration only at the influence of different periods of 6, 12 and 24 hours, whereas the values of increase in N were from 700, 900, 650 to 800, 1100, 960 ppm, respectively, also the values of P increased from 39.42, 64.26, 30.04 to 42.76, 97.86, 71.27 ppm, respectively and the values of K were increased from ٢٧٦٦.٣٣, ٢٩٤٦.٩٨, ١٥٥٨ to ٢٧٨٨.٩٢, ٥٥٤٤, ٣٩٤٠.٦ ppm, respectively

It was also noticed that the values of organic matter percentage taken the same increasing trend such as nutrients concentration. The increase in concentration values of N, P, K, and organic matter % occurs with the increase of the aeration and magnetic pumping from 6 to 12 hours per day as a result of the availability of oxygen to aerobic organisms. Correspondingly, increasing magnetic pumping period from 12 to 24 hours make an undesirable condition, whereas destroying or inactivate the aerobic organisms. The effect of aeration and magnetic pumping periods on organic matter % is shown in Fig. (6), while the effect on C/N is illustrated in Fig. (7).

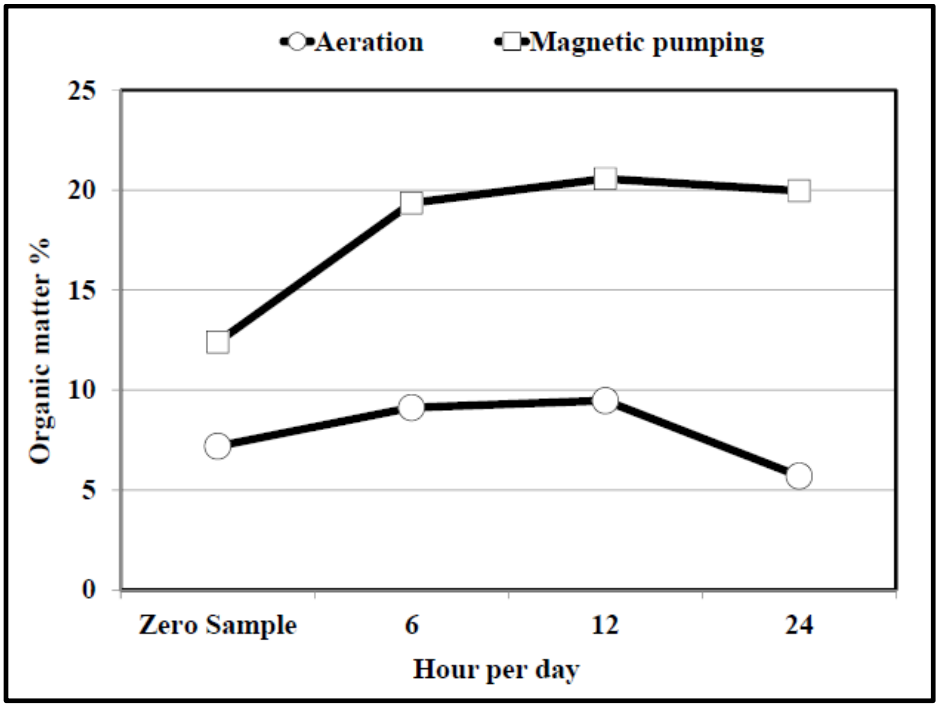

Fig.6: Effect of aeration and magnetic pumping on organic matter.

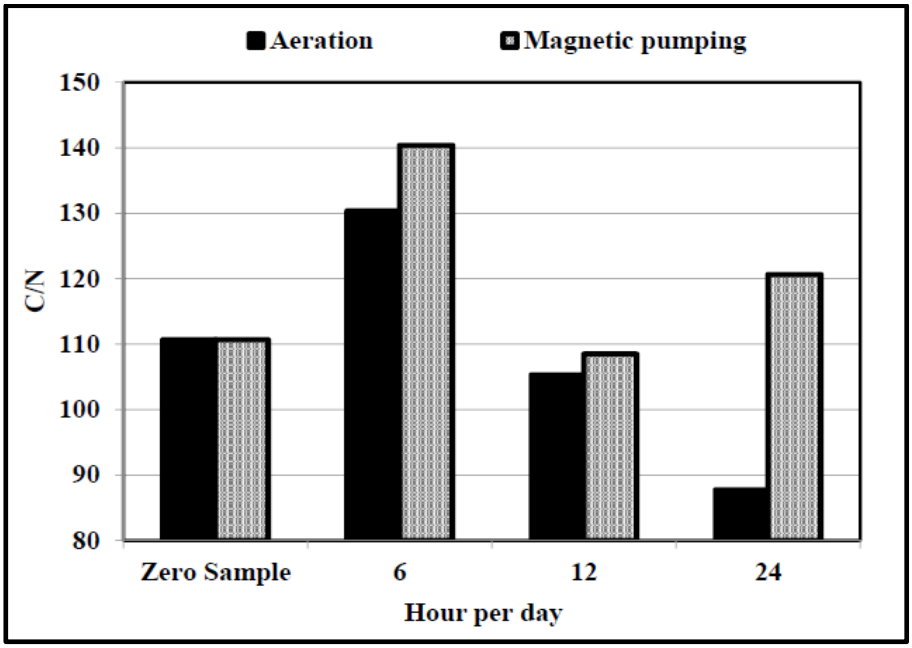

Fig. 7: Effect of aeration and magnetic pumping period on C/N.

Based on the results, the highest and lowest pH levels of aerated compost extract ranged from 7.50 and 7.76, respectively. Likewise, the pH levels of magnetic pumping compost extract ranged from 7.78 and 8.1, respectively. In contrast, the pH values of the non-aerated extract were slightly alkaline (7.18), this matched with **Gorliczay et al., (2018) and Islam et al., (2016)** who noted that the pH values of the non-aerated extract decreased during the incubation as a result of increased the anaerobic bacteria which lead to increase CO_2 production and forms a weak acid.

Influence of magnetic treatment on physical-chemical properties:

Study the effect of magnetic treatment on compost extract properties is one of the main objectives of this research. The differences in properties between using pumping without magnetic and magnetic pumping in the extracted compost at 72 h are illustrated in Table (3)

Table 3: The differences in properties between using pumping without magnetic and magnetic pumping

Characteristics	N, ppm	P, ppm	K, ppm	Organic carbon, %	Organic matter, %	C/N Ratio
Magnetic pumping	960	71.26	3940.60	11.58	19.96	120.62
Pumping without magnetic	900	49.64	3556.70	7.72	13.31	85.77

It can be seen from the above analysis that, magnetic using has positive effect on facilitating nutrient extract. This matches the results obtained by **Tai et al.,** (**2008**) who reported that the water properties were modified due to the exposure to the magnetic field, it becomes more able to flow and more energetic, thus the birth of new knowledge called magneto biology. In addition, it was pointed out that, magnetized water inhibits harmful metals such as lead and nickel and on the other side it improves the percentage of nutrient elements like phosphorus, potassium, and zinc.

4.CONCLUSION

The findings of this research are quite convincing, and thus the following conclusions can be drawn:

- Among the tested dilution ratios, the dilution of 1:20 (w/w) seems to be most appropriate in terms of unit productivity.
- The aeration process caused the fermentation conditions to be aerobic. It is one of the most important factors affecting the unit productivity and concentration of N, P, K, and organic matter % when producing compost extract.
- The optimum operating parameters for the compost extract production are 12 hours of aeration or magnetic pumping time, in terms of providing suitable aeration conditions for microorganisms.
- Magnetic pumping during compost extraction is better than aeration by using an air compressor, in terms of increasing the unit productivity and nutrients concentration.
- The magnetic pumping treatment leads to improve and facilitate nutrient extraction compared to pumping without magnet.

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الملخص العربى

تحسين أداء نظام استخلاص الكمبوست باستخدام المعالجة المغناطيسية

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تمثل المخلفات العضوية مشكلة حرجة وبخاصة الحيوانية منها لاسيما المشاكل البيئية التى قد تنتج عن عدم استغلال هذه المخلفات الاستغلال الأمثل مما يسبب أضرار كبيرة بالبيئة فضلاً عن خفض القيمة الاقتصادية لها. لذا يمكن الاستفادة من هذه المخلفات بإعادة تدويرها وتصنيع منتجات سمادية لتعظيم القيمة المضافة من خلال استراتيجيات متكاملة لتحقيق التنمية الزراعية المستدامة مما له الأثر فى رفع معدلات التنمية الزراعية وزيادة الإنتاجية وزيادة رقعة الأراضي المستصلحة وتعظيم الاستفادة من المخلفات الزراعية وترشيد استخدام الكيماويات الزراعية من أسمدة ومبيدات والذى يؤدى الى حماية البيئة من التلوث وتحقيق الأمن الغذائي الصحى فى مصر وذلك من خلال عملية استخلاص للعناصر السمادية وجعلها أيسر في الامتصاص بالنسبة للتربة والنبات والتي تعرف بعملية استخلاص الكمبوست. وعملية الاستخلاص هذه هي عملية تخمر هوائي للكمبوست مع إضافة الماء له والتي تعرف بنسبة التخفيف مع إضافة محفز كمصدر غذائي للكائنات الدقيقة في المخمر الهوائي بالاضافة الى مصدر متجدد للأكسجين وتوافر درجة الحرارة المناسبة للتحلل خلال فترة التخمر.

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وفيما يلى الأهداف الخاصة بهذا البحث:

- تجميع وتقييم أداء وحدة محلية التجميع لإنتاج مستخلص الكمبوست.
- تحديد ظروف التشغيل الأفضل لكل من تدفق الهواء والضخ لمستخلص الكمبوست ونسبة التخفيف والتي تؤثر بدورها على آداء الوحدة.
- دراسة تاثير استخدام وحده مغنطة فى مسار ضخ المستخلص على مدى تيسير العناصر الغذائية فية.

ومن ثم أجريت هذه الدراسة بهدف تحسين أداء نظام استخلاص الكمبوست باستخدام المعالجة المغناطيسية للوصول إلى أفضل معايير للتشغيل تحت مستويات مختلفة لفترات التهوية وأيضا الضخ والمغنطة (٦-١٢- ٢٤) ساعة فى اليوم بنسب تخفيف بين الكمبوست والماء بقيم (١:١٠ – ١:١٥ – ١:٢٠)، ولتقييم أداء الوحدة تم أخذ القياسات التالية: إنتاجية النظام ومتطلبات الطاقة بالإضافة إلى الخواص الفيزيائية والكيميائية لمستخلص السماد. استخدامت كلا من مخلفات الابقاروالارانب بعد تجفيفها جيدا لمده لا تقل عن اسبوعين فى الشمس المباشره.

وقد أظهرت النتائج المتحصل عليها أن أعلى قيم لإنتاجية الوحدة كانت ١٣,٤٥ كجم فى اليوم متطلبة طاقة بمقدار ١,٢٩ كيلوواط.ساعة لكل كجم. علاوة على ذلك ، كانت قيم تركيز العناصر الغذائية لكل من النيتروجين والفوسفور والبوتاسيوم (١١٠٠ – ٩٧,٨٦ - ٥٥٤٤) جزءًا في المليون على التوالي تحت تأثير فترة ضخ مغناطيسية قدرها ١٢ ساعة في اليوم ونسبة تخفيف بلغت ١:٢٠.

لذا توصى الدراسة بما يلي:

- من بين معدلات التخفيف المختبرة ، نسبة التخفيف ١:٢٠ (وزن مخلف / وزن مياة) كانت الأنسب من حيث إنتاجية الوحدة.
- عملية التهوية او الضخ لها تاثير قوى على إنتاجية الوحدة وتركيز N و P و K و والنسبة المئوية للمواد العضوية عند إنتاج مستخلص السماد العضوي وقد كانت افضل معدل للتهوية او الضخ ١٢ ساعة فى اليوم حيث توفر ظروف مفضلة للكائنات الدقيقة.
- استخدام المعالجة المغناطسية عند استخلاص الكمبوست يؤدى لتحسين المستخرج من المواد الغذائية الميسرة ومن ثم تحسين جودة المستخلص.