# ROTARY IN-VESSEL BIO-CONVERTING OF AGRICULTURE WASES INTO COMPOST

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**ABSTRACT**

**This study was aimed to convert agricultural waste to organic fertilizer and find the best combinations from agricultural waste, that were used in the research, Composting has always shown to be a reliable and ecologically beneficial technique for removing large amounts of bio-waste. Bio-waste is produced in a variety of sorts (forest residue, farms, agricultural, food industry, and municipal garbage) and is expanding on a daily basis, offering a management and disposal challenge. Millions of tons of cereal vegetable crops, industrial crops, dates and fruits, are produces in Iraq, there are about 20 million tons per year of agriculture waste materials in Iraq, according to estimates, and only a small part of it is used. Composting is an alternate method of material recovery that has no negative consequences. The composting was performed for study with agricultural waste from tree leaves, twigs, date palm, rise husk as a carbon source and manure (sheep, horses, poultry), and vegetable and fruit market waste as a nitrogen source to determine the appropriate mixing, proportion, and combination, as well as the influence of sludge on mixtures. Six distinct experiments were conducted to investigate the alterations in physic-chemical and biological changes during composting utilizing the rotary drum method. Consequently, the compost generated by all experiments had a pH of 6.95–8.00, electrical conductivity of 1.42–2.03 dS.cm$^{-1}$, a drop in the percentage of overall organic carbon of 16.4–13 percent, a percentage rise in total nitrogen of 0.86–0.19 percent, and a C:N ratio of 8.8–13.7. In this research, the optimal proportions from the various combinations attempted were discovered in drum (B2).**

**Keywords: drum method composting*; stability; maturity*; agriculture wastes; *germination index***



**التحويل الحيوي لمخلفات الزراعة الى سماد عضوي بتقنية الاسطوانة الدوارة**

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**المستخلص**

**هدفت هذه الدراسة إلى تحويل المخلفات الزراعية إلى سماد عضوي وإيجاد أفضل مجموعات المخلفات الزراعية التي تم استخدامها في البحث, أثبت التسميد العضوي دائمًا أنه طريقة مستدامة وصديقة للبيئة وطريقة للتخلص من الكمية الهائلة من النفايات الحيوية. تتولد النفايات الحيوية بأشكال مختلفة (مخلفات الغابات، المزارع، الصناعات الغذائية، والنفايات البلدية) وهي تتزايد يوميًا ، مما يخلق مشكلة في إدارتها والتخلص منها. وينتج العراق ملايين الأطنان من محاصيل الحبوب والخضروات والمحاصيل الصناعية والتمور والفواكه ، ويوجد نحو 20 مليون طن سنويا من مخلفات الزراعة في العراق حسب التقديرات، ولا يستخدم إلا جزء صغير منها. عملية تحويلها الى سماد عضوي هي الحل البديل لاستعادة الموارد دون أي آثار جانبية. تم إجراء عملية أنتاج السماد العضوي المخلفات الزراعية من أوراق الشجر والأغصان ونخيل التمر وقشر الأرز كمصدر للكربون والسماد (الأغنام والخيول والدواجن) ومخلفات سوق الخضار والفاكهة كمصدر للنيتروجين من أجل التوصل الى أفضل التوليفات وتأثير الحمأة عليها. تم تحديد التغيرات في الصفات الفيزيائية والكيميائية والبيولوجية أثناء عملية الانتاج باستخدام تقنية الأسطوانة الدوارة في ست تجارب مختلفة. أخيرًا ، وجد أن السماد العضوي الذي تم إنتاجه من خلال جميع التجارب يحتوي على درجة حموضة 6.95-8.00 ، أيصالية كهربائية 1.42 - 2.03 ديسيسمنز.سم⁻١ ، وانخفاض في النسبة المئوية للكربون العضوي الكلي 16.4 - 13٪ ، وزيادة النسبة المئوية في إجمالي النيتروجين 0.86 - 0.19٪ ، نسبة C: N 8.8 - 13.7 ,تم التوصل أفضل النسب في التركيبات وكان افضلها الوعاء (B2) في هذه الدراسة.**

**الكلمات المفتاحية: سماد دوار داخل الوعاء؛ استقرار؛ نضج؛ مخلفات الزراعة.**

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## INTRODUCTION

Municipal Solid Waste Management (MSWM) issues occur as a consequence of improper dumpsites, which lead to the buildup of solid waste, the discharge of pollutants, and the creation of unsanitary circumstances which have a significant impact on human and environmental health. Local administrative organizations did not provide a suitable solid waste management framework, and they lacked lengthy master planning and collaboration on municipal solid waste management (3). Currently, commercially viable recyclable trash easily meets the approach in waste recycling systems requiring minor modifications to boost efficiency. On the opposite, a significant percentage of biodegradable garbage in the waste stream should be handled. As a result, relevant technology that is also ecologically beneficial has to be used. Composting is a great alternative solution. One of the primary challenges in agriculture is the loss of soil quality associated with excess and intense utilization chemical fertilizers. Bio fertilizer is an option to reducing the usage of chemical fertilizers (5, 6, 20). Compost is the solid, brownish byproduct of aerobic organic biodegradation. Composting enhances soil quality, oxygenation, texture, and water retention capacity. It loosens clay soils and aids in the retention of water in sandy soils. Compost increases soil fertility and promotes healthy root development in vegetation. The organic stuff in the compost feeds microorganisms, which maintains the soil healthy and balanced. The organic material can produce nitrogen, potassium, and phosphorus, which will be useful to plants (29, 35). Composting is initiated by microorganisms (bacteria, fungi, and actinomycetes). It can be facilitated by soil microorganisms (Earthworms, centipedes, millipedes, slugs, ants, sow bugs, mites, fly maggots, nematodes, spiders, beetles, and so on) that decompose organic materials into relatively simple inorganic substances. With their enzymes and hormones (4, 7). macroorganisms break down complicated stuff into smaller components by digging, sucking, chewing, digesting, and excreting. Temperature, Carbon to Nitrogen levels, pH, air, and moisture levels are the most important parameters for directing organisms that compost. To decompose organic materials, microorganisms produce acids (25). Composting is an aerobic process that converts organic waste into nutrient-rich compost under thermophilic conditions. The importance of aeration and water contents in sustaining the thermophilic condition cannot be overstated. Aeration is necessary to keep the aerobic process going. If solid waste with high moisture content is not correctly handled, it creates leachate and emits an unpleasant odor. The moisture level is critical for composting because it allows for optimal aeration and increases the rate of microbial activity and free air space. The use of a bulking agent helps manage the moisture content and aeration. Several studies have employed varied bulking agents, including leaves (17) to ensure optimum moisture content, free spaces, and aeration. There are several composting processes, each with its own set of benefits and drawbacks. As a result, the composting technique to be used is determined by the author's aim and type of waste to be composted. Composting in an isolated location, such as a container, structure, or vessel, is referred to as in-vessel composting. To improve the composting process, in-vessel technologies rely on a range of forced aeration and mechanical rotation approaches. Composting on a rotary drum is an efficient and decentralized method. It aids in correct mixing and aeration, as well as the production of stable and mature compost. The rotary drum is simple to set up at the site of organic waste production. (22) As bulking agents, the author of the present study used the capacity of the 250-litre rotary drum to compost cow manure, mixed vegetable waste, sawdust, and compost. (18) in 2010, employed sewage sludge, olive mill waste, and winery waste in a closed rotary drum reactor with enforced aeration with a capacity of 100 liters. The purpose of this study was to look into the impact of different process parameters on fertilizer reliability, including temperature, pH-value, moisture content, electrical conductivity EC and, carbon to nitrogen ratio, and chemical oxygen demined, throughout the composting of agricultural waste (tree leaves, twigs, date palm, rise husk) as a carbon source and (sheep manure, horses' manure, poultry manure), and vegetable and fruit market waste as a nitrogen source.

## MATERIALS AND METHODS

Raw materials of agricultural waste (AW), tree leaves, twigs, date palm, and rise husk (RH) were used as a carbon source, while vegetable and fruit market waste (VMFW), Mature Compost (MC), sheep manure (SM), horse manure (HM), poultry manure (PM), and Raw activated sludge used as a nitrogen source, To achieve the best composting conditions, a compromise must be made in terms of particle size. As a result, the particle size fraction of tree leaves, twigs, and date palm, which accounted for the highest percentage, are shredder into pieces (1.25-1.75) inches using the equipment shredder (Flora best 2800W) as shown in the Figure 1, Waste fruits and vegetables are manually cut to a size (0.5-1) inches using a knife, and (Mature Compost, sheep manure, horse manure, poultry manure, and Raw activated sludge) Its particle size fraction > 0.5 inches, as a raw material. The compost mixture's C/N ratio was estimated using the following Eqs. (1) – (3) (16):

$$Q = \frac{M_1D_1 + M_2D_2 + M_3D_3}{D_1 + D_2 + D_3} \quad \ldots\ldots \quad (1)$$

Where $D_n$ is weight of material n (wet weight basis), Q is humidity goal percentage, and $M_n$ is moisture content (%) of material n.

$$\boldsymbol{C/N = \frac{D_1(C_1\times(100-M_1)) + D_2(C_2\times(100-M_2)) + D_3(C_3\times(100-M_3)) + \cdots}{D_1(N_1\times(100-M_1)) + D_2(N_2\times(100-M_2)) + D_3(N_3\times(100-M_3)) + \cdots}} \quad \ldots\ldots \ (2)$$

where $C/N$ is C/N ratio of compost mixture, $D_n$ is weight of material n (wet weight basis), $C_n$ is carbon (%) of material n, $N_n$ is nitrogen percentage of material n, and $M_n$ is moisture content percentage of material n. By simplifying and rearranging the above equation, the mass of the third material required would be Eq. (3)

$$\boldsymbol{D_3 = \frac{\frac{C}{N}D_1N_1(100-M_1) + \frac{C}{N}D_2N_2(100-M_2) - D_1(C_1\times(100-M_1)) + D_2(C_2\times(100-M_2))}{C_3(100-M_3) - \frac{C}{N}N_3(100-M_3)}} \ \ldots.. \ (3)$$

The composting process consisted of six experiments lasted about 40 days, with the following raw materials Table (1):

**Figure 1. Shredder equipment (Flora best 2800W)**

**Composter design** Figures (2) and (3) depict a schematic representation of a pilot-scale rotary drum composter with a size of 250 L that operates in batch mode. To complete the composting process, six rotating drum composters were built. The composter is 0.9 m in length and 0.6 m in diameter and is built of a 4 mm thick metal sheet. The inside surface of the drum was coated with an anticorrosive coating layer to keep it from rust. The drum was fixed on two rollers linked to a steel platform and was turned manually by its handle (Iron rod1.6 cm diameter), which is fitted with six 17.5 cm in length blades welded horizontally within the drum to provide proper mixing, agitation, and waste aeration throughout rotation. To fill the waste mixture within the drum as necessary for the experiments, a 60 40 cm hatch gate was employed. Opening the gate following everyday hand turning to preserve the aerobic state within the drum. Depending on the outcomes of previous research with in-vessel composting reactors (24), a composting time of 35 days was chosen to ensure appropriate degradation and stability. After each 12 hours, one full rotation of the rotary drum was performed to make the material on the top section go to the middle area, where it was exposed to greater temperatures. Through opening the hatch gate, the aerobic state was sustained

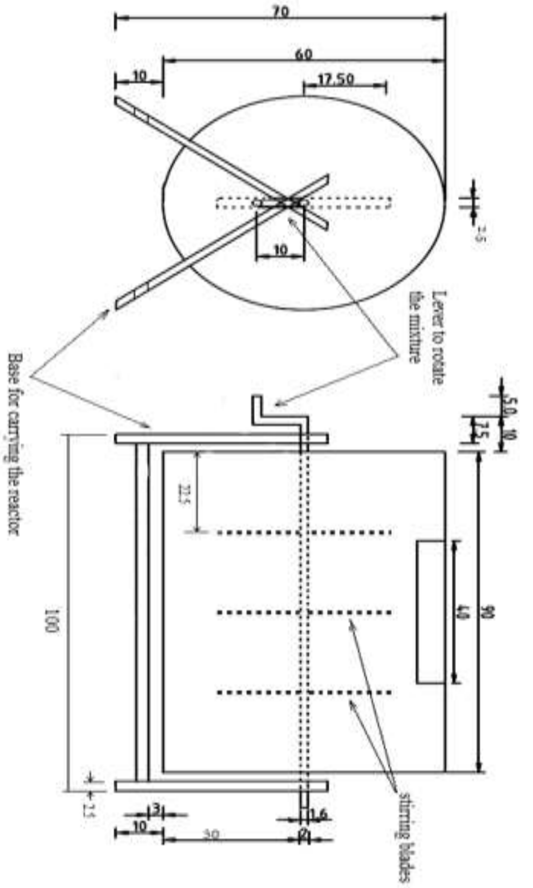


**Figure 2. Pilot scale rotary drum composter**

**Figure 3. rotary drums composter**

**Table 1. Details of the composting experiments**

| Experiment no. | Mixture | Ratio % | Weight (Kg) |
|---|---|---|---|
| A1 | AW:VFMW:SM | 9 : 0.5 : 0.5 | 72: 4 : 4 |
| A2 | AW:VFMW: SM:RAS | 20 : 0.3 : 0.3 : 0.3 | 80: 1.2 : 1.2 : 1.2 |
| B1 | AW:VFMW: HM | 6 : 0.5 : 0.5 | 72 : 6 : 6 |
| B2 | AW:VFMW: HM:RAS | 20 : 0.3 : 0.3 : 0.3 | 80 : 1.2 :1.2 :1.2 |
| C1 | RH:VFMW:P M | 1.4 : 0.37 : 0.37 | 80 : 1.2 :1.2 |
| C2 | RH:VFMW:P M:RAS | 1.1: 0.3: 0.3: 0.3 | 50 : 15 :15 :15 |

**AW: Agricultural waste from tree leaves, twigs, date palm (dry and wet), RH: Rise husk, VMFW: Vegetable and Fruits market waste, SM: sheep manure, HM: horse manure, PM: Poultry manure, RAS: Raw activated sludge.**

**Sampling and analysis** Compost samples of about 200 g (to avoid disruption of neighboring materials) were taken from various points, namely the top, mid span, and end points of the rotary drum composter. All the samples were mixed together to make a homogenized sample. Triplicate homogenized samples were taken on day 0 as well as days 1, 4, 8, 12, 16, 19, 20, 24, 28, 32, and 35 of the composting period and kept at 4°C for biological examination of the moist samples within 2 days. The sub-samples were promptly air dried and powdered to go through a 0.2 mm filter before being kept for physicochemical examination. Throughout the composting process, the temperature was measured every 6 hours with a digital thermometer at three various points within the rotary drum composter, namely the top, mid span, and end terminals, and the mean of the measurements was recorded. Each sample was tested for these parameters: pH and electrical conductivity (EC) (1:10 w/v waste to water extract), ash (550°C for 2 hours; loss ignition method), total nitrogen using the Kjeldahl method, NH4-N and NO3-N using KCl extraction (31), and organic carbon (OC) content calculated according to Mohee et al (26). Clesceri LS, Greenberg AE 1989 (9), available and total phosphorus (acid digestion) using the stannous chloride technique, potassium (acid digestion) using flame photometry Clesceri LS, Greenberg AE 1989 (9). Biodegradable organic matter was measured as COD by the dichromate method (9). The concentration stability COD and $NO_3$ evolution were used to assess the compost samples' stability, and $NO_3$ evolution (24).

## RESULTS AND DISSCUSCION

### Physicochemical parameters effects on the composting process

**Partial size**Before being composted, the organic portion of composted materials from solid waste, which comprises various sizes and forms of the material, irregular shapes, and various sizes of materials, should be decreased by shredding the organic components. The bulk density, internal friction, and flow properties of composted elements are all affected by particle size. Most importantly, a smaller particle size enhances the pace of biochemical response throughout the aerobic composting process. Furthermore, the particle sizes of materials have a greater impact on the surface area of the particles when microbes bind to them. Most of the fertilizer produced from the mixtures passed through the 12.6 mm sieve.

**Carbon to nitrogen ratio(C/N Ratio)** To determine the outcome of the organic bacterial activity, the quantity of overall content and total nitrogen was measured at the beginning and end of the 35-day composting period. It was noticed that there was a decrease in C/N solid for all containers. The activity of thermophilic bacteria is increasing as composting progressed, and as a result, certain refractory degradable compounds may be biologically destroying (15). Table (2), the percentage of C/N decreased from the initial value of 25 for all reactors to 13.89, 14.73, 14.35, 11.11, 16.29, and 15.42, for reactors A1, A2, B1, B2, C1, and C2 Straight, despite the fluctuation of the decrease in the values it was within the acceptable range of fertilization. A value of around or below 15 can be regarded adequate when the original value is between 25 and 30 (21). There are also international research that reached the same results (10).

**Table 2. Carbon %, Nitrogen %, and C/N Ratio in initial and final composting**

| Material mixtures | Carbon | | N | | C/N | |
|---|---|---|---|---|---|---|
| | initial | final | Initial | Final | initial | final |
| A1 | 48 | 35 | 1.92 | 2.52 | 25 | 13.89 |
| A2 | 46.8 | 30.4 | 1.872 | 2.064 | 25 | 14.73 |
| B1 | 48 | 31 | 1.92 | 2.16 | 25 | 14.35 |
| B2 | 46 | 30 | 1.84 | 2.7 | 25 | 11.11 |
| C1 | 52 | 36 | 2.08 | 2.21 | 25 | 16.2 |
| C2 | 48 | 37 | 1.92 | 2.4 | 25 | 15.42 |

**Temperature**

Figure (4) depicts the temperature profiles of the reactors. Following reactor loading, all reactors had a quick rise in temperature, suggesting clear microbial activity. Since the original waste combination was high in microorganisms present in manure and sludge, the lag period on the curves was less than one day. The quick breakdown of accessible organic matter and nitrogenous chemicals by microorganisms raised the temperature of composting mixes in all reactors. The temperature grew from the ambient temperature to more than 55, 55,62,64,49, and 54 °C within A1, A2, B1, B2, C1, and C2 during the course of five days, indicating the start of the composting process. As shown, in reactors B2, and B1 the waste mixture passed from an initial mesophilic phase, temperature less than 40 ℃ to a thermophilic phase rabidly. Hitting high temperatures can significantly contribute to the achievement of compost stabilization and the decrease of retention time in the bioreactor (20). The other reactors rose lower than this temperature may be due to microbial activity of different microorganism's species found in different manure. The temperature variations in the compost continued the trend identical to that of a typical composting operation. Microbial activity, organic matter breakdown rate, and temperature all eventually fell to ambient levels as the organic matter became more stable towards the completion of the procedure. Whereas the maturation process occurred at the last stage of composting, as determined by the other physicochemical characteristics examined in this research. An identical temperature trend was reported in local pilot size bioreactor composting tests (8) also, worldwide (16). Several researchers found that the ideal composting temperature range is 52 to 60 ºC, (8), (16).

**Moisture Content** As indicated in Figure (5), the first waste compositions were created to have a high moisture content of 55%, 53%, 60%, 51%, 54%, and 56% for A1, A2, B1, B2, and C1, C2 (9). The moisture content was maintained at appropriate values of roughly 50–70% to achieve consistent moisture content, as seen in Figure (5). At the last stage of composting, moisture content steadily increased to 66%, 65%, 65%, 64%, 55%, and 55% on the 35th, for A1, A2, B1, B2, and C1, C2, respectively.

**pH value** pH regulation is a key factor in assessing the microbial environment and waste management. Throughout the composting process, the pH-value of the compost fluctuates with time. The pH of composting material will fluctuate based on the pH-time curve depicted in Figure (6). In the first few days of composting the pH values reach the lowest value, the pH drops to 4.5 or less. At this stage, the organic mass is at ambient temperature, the multiplication of indigenous mesophilic organisms begins, and the temperature rises rapidly. At this initial stage the products are simple organic acids, which cause the drop in pH-value. Bacteria and fungi digest organic matter, they release organic acids".(28) the acidity values of mixtures A1, A2,C1,C1 decreased on the third day to their lowest value, and returns to record a gradual rise to reach neutral value, at 11 day, after that, the acidity value of the last readings is stabilizing. The pH tends to rise towards neutral again when these acids have been converted to carbon dioxide by microbial activity. The acidity values of waste combination in B1 and B2 rise somewhat in the first five days, then climb further to achieve neutral (pH 7) suggesting an excellent quality compost and within the specified range of (6–8.5). During twelve days, the pH value falls slightly during the cooling stage and reaches to a value in the range of 7 to 8 in the mature compost. This observation was connected to (27), and (8) indicating that the moderate reduction in pH at the conclusion of the process was caused by the creation of sodium acetate and acetic acid compounds, which function as buffers.

**Electrical conductivity (EC)**

The electrical conductivity value of the compost is reflected by the level of salt in the compost, suggesting its potential phyto-inhibitory impact on plant development if beneficial to soil (16). For the enhancement of agricultural soils, the acceptable level of electrical conductivity required in compost should be lower than 4 $dS.cm^{-1}$ (12). Figure (7) show the initial rate of electrical conductivity measurement in the range between (1.53-1.19) $dS.cm^{-1}$ for all waste mixtures, a slight increase after four days and it turns to a very sharp rise in eight days, the highest value is recording in mixtures C1 (11.47 $dS.cm^{-1}$), on the eighth day also had the lowest value during this peak, the B1 mixture recorded a value of 4.39 $dS.cm^{-1}$, buildup of salts and nutrients, caused a significant increase in the EC value at the start of the process (23).The release of mineral cations such as ammonium ions and phosphate. The volatilization of ammonia and the precipitation of mineral salts are two probable explanations for the reduced EC values in the latter stages of composting (34). (See Figure (7)). The high EC values suggested that all composting studies required more maturation before being safe for plant application. The values at the conclusion of composting stabilized at 2.02, 1.67, 1.4, 1.6, 1.51, and 1.58 for vessels A1, A2, B1, B2, C1, C2, which were identical to the findings reported by (34).

**Chemical oxygen demand (COD)**

Chemical oxygen demand (COD) removal occurs as a result of waste decomposition. the COD value of waste mixture 2880, 3189, 2890, 3130, 2778, and 2610 $mg.l^{-1}$ in A1, A2, B1, B2, C1, and C2 reactors respectively at the beginning (initial values), it was reduced to 733,617, 654, 596, 577, and 612 after two weeks and stabilizes after this period of the experiment with 78% removal efficiency approximately Figure (8). The decrease in COD value could be driven by the fact that increased alkalinity inhibited the development of volatile organic acids. As a result, high COD levels are addressed in anaerobic conditions via methane transformation. When the biological organic content of the compost decreases, COD decreases, leading to lower carbon dioxide emissions and, eventually, compost stability (20). The similar outcome was attained (22).

**Inorganic nitrogen ($NH^{4+}$, $NO_3$)**

As seen in Figure (9), the ammonium nitrogen values in the compost drop as it matures. Ammonium levels are high in early phases of the composting process, but they drop as the composting process matures. The maximum content of $NH^{4+}$ was recorded after 1 day in the thermophilic phase. As the composting process progressed, the decrease in $NH^{4+}$ content coincided with an increase in $NO_3$, the nitrification process is typically quick, and any $NH_3$ generated as a result of ammonification is quickly nitrifying to $NO_3$ (36). The final ammonia, and nitrate nitrogen concentrations after 35 days were 92, 85.71, 63.8, 55, 82 and 48.49 ppm, and 98.3, 106.4, 173.2, 192.7, 84.4 and 80.5 in drum composter A1, A2, B1, B2, C1and C2 respectively. The concentration of nitrite $NO_3$ in the beginning of the compost is very low as shown in Figure (10), with concentrations not exceeding 4 ppm, and a rapid rise is recording during the first three days after the compost, and then the nitrite levels rise slowly to almost stabilize after 30 days. Nitrogen mineralization always happens at the same time as Nitrogen immobilization, which works in the other direction, (11). Nitrogen is lost in the form of gases by the processes of reverse nitrification and volatilization of ammonia, which causes serious environmental problems (1). The final concentration of $NO_3$ is higher in drams that contain sewage sludge in their waste mixtures. Compost application resulted in lower nitrogen mineralization rates than sewage sludge, bio-solids, manures, or other non-composted organic additions. (32). the nitrification index (NH+4/NO3), or the ratio of inorganic forms, was also used to measure compost maturity. The greatest values were obtained throughout the thermophilic period, accompanied by a significant decline during the cooling phase Figure (11). The resultant ratio of $NH_4/NO_3$ was <1 at the conclusion of the operation in acquired compost, as nitrate grew and ammonia decreased with composting progress (as ratio $NH^{+4}/NO_3$) were 0.94, 0.81, 0.37, 0.29, 0.97 and 0.6 for the vessels A1, A2, B1, B2, C1 and C2 respectively, for mature compost, if a ratio $NH_4/NO_3$ < 0.5 Very Mature, 0.5-3 Mature, and > 3 Immature (9). The results in these tests were close to (25).

**Germination Index GI**

Table (3) shows the phytotoxicity findings of 35-day composts reported as the germination index (GI) (3), the seed germination data indicated in tables (2-7) that cress seeds germinated in varying percentages because of being exposed to the final mixes, ranging from 73.7 % to 92.4 %. A GI of higher than 80% indicates a phytotoxic-free and mature compost, whereas a score of less than 50% indicates a compost with a high level of phytotoxicity. These limitations have been followed in several compost investigations, (31). All the composts obtained, except for A2 and C2 had a GI greater than 80%. Indicating that phytotoxic substances had vanished during composting, (33). The results are, 83.7, 73.7, 84.1, 92.4, 86.7and 76.2 for A1, A2, B1, B2.C1and C2 It this is similar to what he got (31) the results.

**Table 3. Germination Index**

| mixture | Mean no of germinating seeds | Growth Index G (%) | Mean root length(c) | Root length Index L (%) | Germination Index GI (%) |
|---|---|---|---|---|---|
| A1 | 44 | 88 | 3.33 | 95.1 | 83.7 |
| A2 | 43 | 86 | 3 | 85.7 | 73.7 |
| B1 | 46 | 92 | 3.2 | 91.4 | 84.1 |
| B2 | 49 | 98 | 3.3 | 94.2 | 92.4 |
| C1 | 46 | 92 | 3.3 | 94.2 | 86.7 |
| C2 | 46 | 92 | 2.9 | 82.8 | 76.2 |
| CONTROL | 48/50 | -- | | | |

**Table 4. Quality of bio fertilizer product**

| NO | Parameters | Description and optimum limits | Mixture approval of specifications A1 | A2 | B1 | B2 | C1 | C2 |
|---|---|---|---|---|---|---|---|---|
| 1 | color | It is dark brown or dark brown | brown | dark brown | brown | dark brown | brown | Brown |
| 2 | texture | To be squishy | squishy | Squishy | squishy | squishy | squishy | Squishy |
| 3 | Odor | The smell is acceptable as the smell of dirt sprinkled with water | smell is acceptable | smell is acceptable | smell is acceptable | smell is acceptable | smell is acceptable | smell is acceptable |
| 4 | weight | Weight per cubic meter does not exceed 700 kg/m 5 | 360 | 370 | 390 | 400 | 540 | 560 |
| 5 | temperatur e | It is 5 -10° C higher than the outside air temperature | 7 up the ambient | 7 up the ambient | 7 up the ambient | 7 up the ambient | 7 up the ambient | 7 up the ambient |
| 6 | Humidity rate | % that the moisture content does not exceed 30 | 30% | 30% | 30% | 30% | 30% | 30% |
| 7 | pH | 5.5 – 8.5 | 8.1 | 7.8 | 7.45 | 7.3 | 6.92 | 6.95 |
| 8 | Oxygen | that is not less than 5% | 5% | 5% | 5% | 5% | 5% | 5% |
| 9 | Total content N | that is not less than 1% | 2.52 | 2.064 | 2.16 | 2.7 | 2.21 | 2.4 |
| 10 | $NH_3$ nitrogen | Less than 500 mg/kg | 92 | 85.71 | 63.8 | 55 | 82 | 48.49 |
| 11 | $NO_3$ nitrogen | It is between 200 and 300 mg/kg | 98.3 | 106.4 | 173.2 | 192.7 | 84.4 | 80.5 |
| 12 | Organic matter | not less than 30% | 35 | 30.4 | 31 | 30 | 36 | 37 |
| 13 | C/N Ratio | ≤ 20:1 | 13.89 | 14.73 | 14.35 | 11.11 | 16.2 | 15.42 |
| 14 | Electrical Conductivit y EC | ≤ 10 $dS.cm^{-1}$ | 2.02 | 1.67 | 1.4 | 1.6 | 1.51 | 1.58 |
| 15 | Particle size | < 12.5 ×12.5 mm | < 12.6 mm | < 12.6 mm | < 12.6 mm | < 12.6 mm | < 12.6 mm | < 12.6 mm |

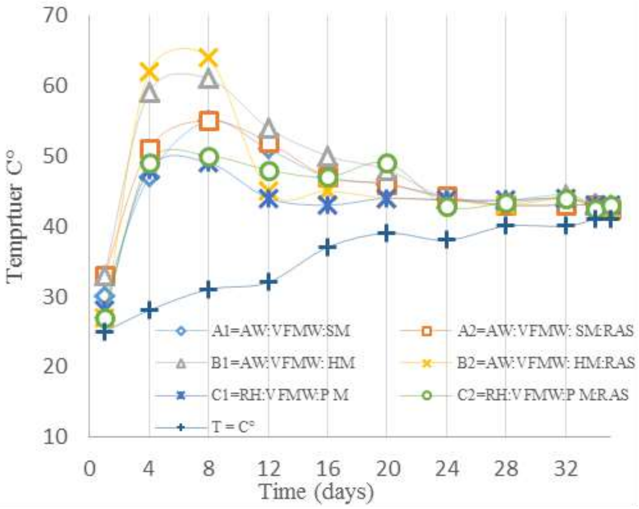


**Figure 4. Temperature profile of waste mixture Vs. Time**

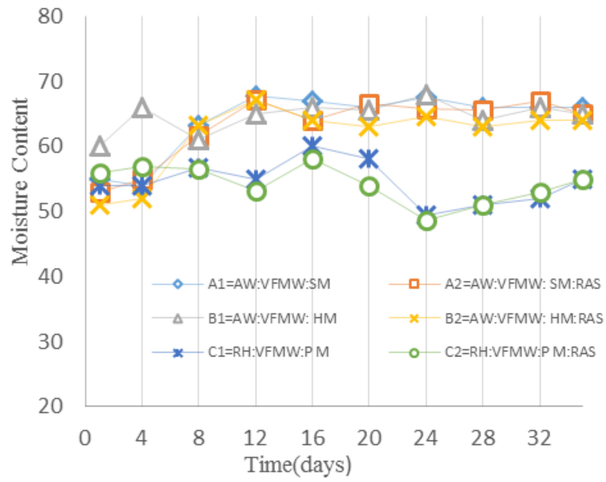


**Figure 5. Moisture Profiles of waste Mixture Vs. Time**

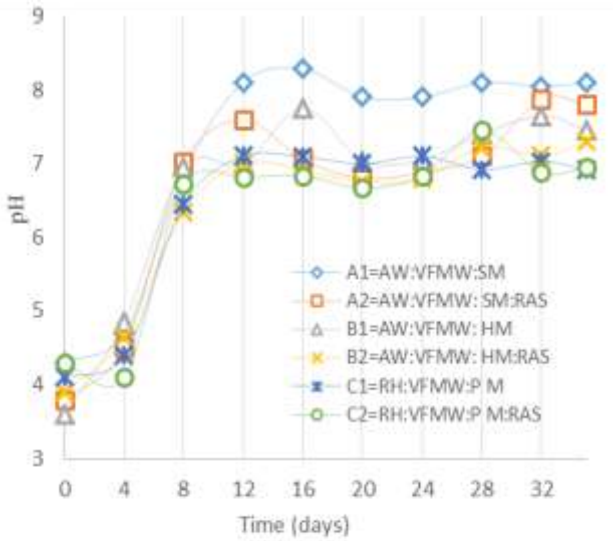


**Figure 6. pH Profile of waste mixture Vs. Time**

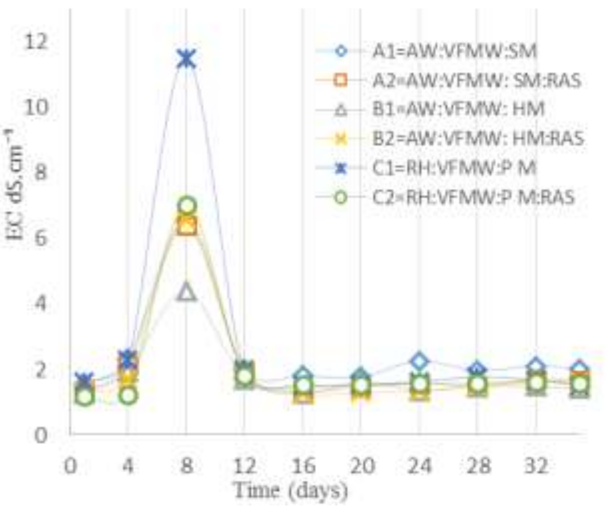


**Figure 7. Electrical Conductivity Vs. Time**

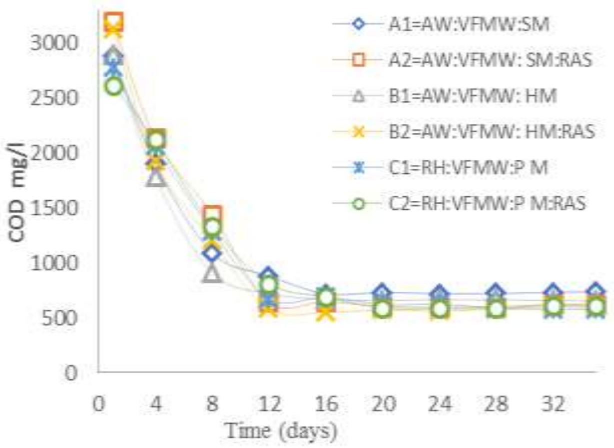


**Figure *8.* Chemical oxygen demand Vs Time**

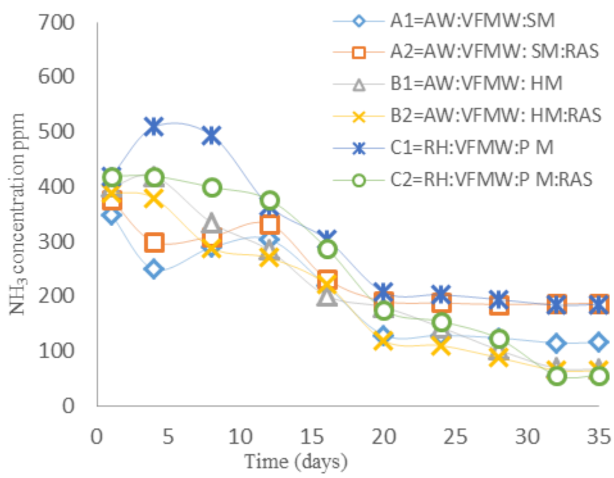


**Figure (9) Ammonia concentration vs time**

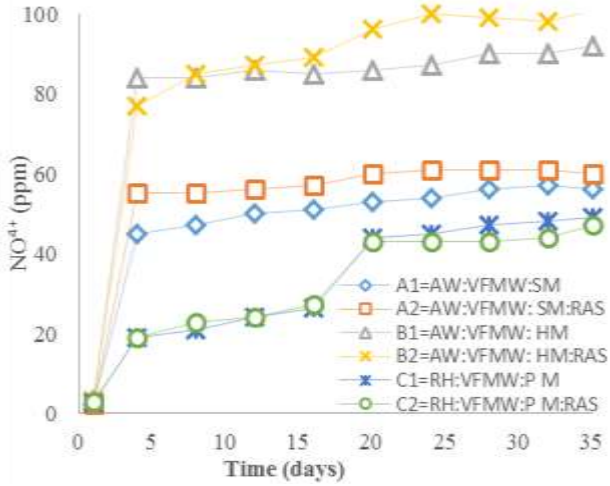


**Figure 10. Nitrite concentration vs time**

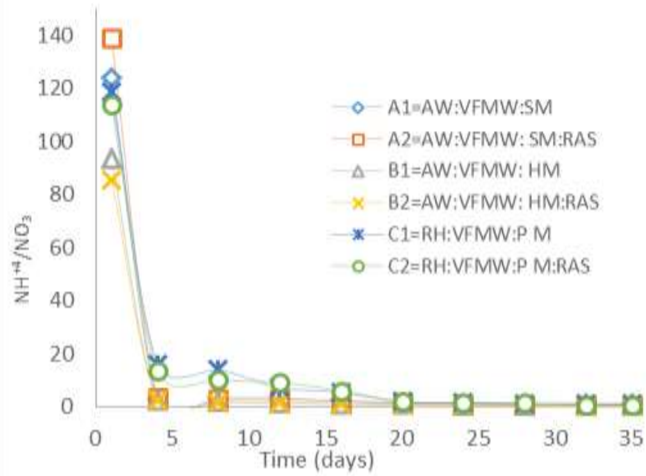


**Figure 11. Nitrification index ($NH^{+4}/NO_3$)**

**Figure 12. Laboratory images of germination factors**

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