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Recycling of Agriculture and Animal Farm Wastes into Compost Using Compost Activator in Saudi Arabia

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Abstract: Saudi Arabia, as well as other countries in the Near East region, is characterized by erratic weather conditions, limited area of fertile arable lands, and with acute water shortage. Although agricultural residues (AGR) production in the region is huge (more than 440 million tons), most of these residues are either burned in the field or utilized in an inefficient way. Utilization of AGR as compost may contribute to expansion of arable lands through its use for reclamation of soil and reduce irrigation requirements. This study was conducted at Al Khalidiah farm, Riyadh, Saudi Arabia to assess compost production at large commercial scale using several types of agricultural and animal by-products with addition of a BZT®Compost Activator (based mainly on microorganism, enzymes and yeast). In this study, two types of compost piles were made at the farm. The first pile of compost was made of different agriculture residues, namely: animal wastes (quail, goat and sheep manure), brownian agricultural wastes (windbreaks residues, date trees, citrus and olive trees pruning) and green landscape grasses (50%, 25% and 25%, respectively) and was treated with a tested compost activator. The same agriculture residues combination was also made for the second pile as traditional compost (control or untreated compost) without the activator. The two piles were turned every 5 days; then moisture, temperature was checked and values were recorded every five days. Composite samples were collected regularly for testing chemical and biological parameters such as: nitrogen, potassium, organic matter, organic carbon, C/N ratio, heavy metals, total viable bacterial counts, yeast and molds, total coliform, fecal coliform and salmonella detection. The results showed a specific decrease in C/N ratio of compost activator treated pile to 15:1, combined with production of compost free of *Salmonella*, total coliform, fecal coliform, mycotoxins and heavy metals. The tested Compost Activator stimulates the composting process with concentrated bacteria and enzymes, the same bacteria and enzymes that occur in nature. This accelerated method provides good quality compost product in shortest time, as little as 35 days in comparison with 68-180 days for the traditional compost without activator materials (the traditional method).It could be concluded that the commercial compost product made from agriculture residues and treated with the tested compost activator is a safe alternative to chemical fertilizers and the best soil amendment that nature provides. These agricultural residues, when fully exploited could have an important role in bridging the food gap in Saudi Arabia.
Key words: *agricultural residues, organic wastes, recycling, animal wastes, BZT® Compost Activator*

Introduction

It is important nowadays to improve soil health by providing the much needed organic matter, least soil become impoverished. The scope and potential for recycling variety of resources in agriculture is vat by any standards. Agriculture wastes recycling can bring tremendous benefits to agriculture and land management in long run. In addition there are the benefits of a cleaner environment, a healthier habitat and an intelligent use of all available recyclable resources without condemning them as wastes. Towards this end agriculture solid waste compost could serve as a valuable organic matter source given the shortage of organic nutrient source (Prakash, *et al*., 2007)**.**

Defining quality standards for organic agriculture and animal wastes is a very difficult task given the heterogeneity of residues that occur in farm wastes and processing methods adopted. Integrated nutrient management combining both inorganic and organics result in wholesome improvement of the soil. This can be done by adopting the technology of “composting”(Xi, *et al*.,

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2005).The term composting refers to controlled biological decomposition process that converts organic matter to a stable, humus-like product. The process depends upon microorganisms which utilize decomposable organic both as an energy and food source. The composting process converts a material with potential odor and other nuisance problems into a stabilized product that is reasonably odor and pathogen free. In addition, the volume and weight of the composted product is less than that of the original raw waste because composting converts much of the carbonaceous material to gaseous carbon dioxide. Heat generated during the process destroys pathogenic organisms and weed seeds that might be present in the raw waste, and helps to drive off moisture. The degradation process takes place in the presence of air (aerobic) and results in elevated process temperature and the production of CO_2, water and stabilized organic residue. The key feature of the composting process is the generation of heat by biological activity during the decomposition of the substrate materials. By forming the waste into large masses under appropriate conditions, they will reach high temperature, resulting in rapid degradation. More importantly, these temperature have a sanitizing effect upon the waste, reducing the numerous of pathogenic organism (Iyenger & Bhave, 2005).

Keeping in view, the benefits of farm organic agriculture and animal manure wastes as well as its inherent limitations such as analysis and slow action, a study was taken up to investigate the possibility of conversion of solid agriculture waste into enriched compost in short incubation time and to evaluate their nutritional quality.

The carbon: nitrogen ratio (C:N) affects the rate of biological activity. Carbon: nitrogen ratios of 15:1 to 35:1 are acceptable. If the C:N ratio is less than 25:1, organisms cannot utilize all of the nitrogen available, and nitrogen is then lost as ammonia. This, in turn, results in an unpleasant odor, possible air pollution, and loss of potential fertilizer value. When the C:N ratio exceeds 30:1, the rate of decomposition decreases. Green landscape wastes and animal manure can be mixed with the carbonaceous material to lower the C:N ratio to 30:1, or below (Nagavallemma, et al., 2004)

Temperature is a good indicator of biological activity in the compost pile, and is easily measured. Moisture content, oxygen availability, and microbial activity all influence temperature. Two or three days after organic wastes are mixed and placed in piles; thermophilic microbes should begin to dominate. These organisms prefer a temperature of 37.7 °C to 65.5 °C . As long as a pile temperature is increasing, it is functioning well and should be left alone. As the temperature peaks, and then begins to decrease, the pile should be turned to incorporate oxygen into the compost. After turning, the pile should respond to the mixing and incorporation of oxygen, and temperature should again cycle upwards. Ideally, the turning process should be continued until the reheating response does not occur again; indicating that compost material is biologically stable (Cayuela et al., 2004)

The main aim of this article is to speed up the natural composting process using BZT®Compost Activator. Break down organic waste to the best, safest fertilizer. Whether its grass, leaves and yard debris, agricultural manure and litter or industrial bio-solids, the natural way to solve this problem of organic waste build up is through short time composting using these microencapsulated bacteria and enzymes. Mother Nature can break organic wastes but it can take many months or years to accomplish. To Speed up this natural process, BZT®Compost Activator that contain identified strains of natural bacteria and enzymes was applied to obtain a finished compost in the shortest time possible.

Material and methods

Agriculture and animal samples preparation

The investigation on the biodegradation and recycling of agricultural wastes includes characterization of ingredients; composting and testing the components in the field was done at *Al Khalediah Farm*, Riyadh, and KSA. The main raw materials used for compost preparation were agriculture farm wastes and animal manure. Agricultural farm wastes include Brownian wastes such as windbreaks residues, date trees, citrus and olive trees pruning, and green landscapes such as landscape grass, vegetables and fruits. Agriculture solid wastes were sun dried and shredded to 1-2 inches using a Mourbark shredding Machine Animal manure was collected from the quail and sheep section.

Characterization of organic materials used for composting

The organic wastes collected from different sources were analyzed for pH, electrical conductivity, temperature, organic carbon, total nitrogen, total phosphorus, total potassium using standard procedure (APHA,1992), and total micronutrients were analyzed by standard procedure given by(APHA,1992) using Atomic absorption spectroscopy .

Microbial activity and temperature measurements of Compost Piles

Piles compost samples were biologically analyzed during the composting process. Microbial analysis included total viable bacterial counts (cfu/g), molds and yeasts counts (cfu/g), total coliform (MPN/100g), fecal coliform (MPN/100g), salmonella detection (cfu) and mycotoxins detection by ELISA. Analysis was done according to (Jackson, 1973) and (Wong& Lin, 2002).

Biological treatments adopted for composting and composting methods

For the preparation of compost, followed the Turned Windrows method as per as (Fleming, 2001). Under this process the agriculture wastes were mechanically shredded to 1 -2 inches using a large scale USA Mourbark grinder machine (8 tons/h), cans and iron wastes were separated electromagnetically and then a good basic compost pile layered in browns, greens and animal manure or course and fine as a rule of thumb. The pile composting constructed ratio was 1:1:2 (brown: greens: animal manure, respectively). Piles mixed solid waste volume of 15 X 2.5 X 1.2 (Length x Width X Height) were used and the required operating condition of moisture, temperature, air were maintained throughout the composting as per as standard process (Hasen et al., 2001). Layers were alternated and each layer was inoculated by BZT®Compost Activator to aid the rapid decomposition. 29g of BZT® Compost Activator, a dry powder of microencapsulated bacteria and enzymes dissolved in 1.9L of warm water and sprayed regularly above all 0.9m x 1.2m x 0.3m high stack and mix systematically. N:P:K ratio was adjusted to 10:10:1 using Nitrovose fertilizer. Pile moist was kept and turned every 5 to 7 days. Homogenized samples were collected each 5 days intervals for microbial and chemical determinations. Pile temperature was monitored each 5 days through the center of the compost piles at different locations.

Results and Discussion

Organic matter recycling is a vital for supplementing plant nutrients and maintenance of soil productivity. Organic matter resources have therefore to be identified, characterized and utilized in the crop production practices suitably. Large quantities of agriculture and animal manure waste materials are originated from agriculture farms need to be evaluated to meet plant nutrient requirements.

Physical composition of agriculture and animal manure wastes

Agriculture waste composition was observed very demographically. Prior to segregation, the solid urban wastes consisted of some reusable material such as plastic, metals, glass and paper which totally constituted to about 10%. This was separated and further used in recycling industries. Agriculture matter and other decomposable is the predominant constituent which are present to an extent of 90%.

Chemical composition of organic wastes

The chemical compositions of various organic materials used for preparing the compost are given in Table 1.Agriculture waste includes brown (citrus old branches, palm leaves) is one of the potential organic carbon residues and law nitrogen residues , which on recycling yield valuable and nutrient moderate waste. The brown waste was found to be slightly acidophil in nature (pH 5.70) and was fairly low in N (0.96%), P (0.0018%), fairly rich in K (0.70%) and Ca (0.72%). The organic carbon was 39% with a C: N ratio of 40:1. Green leaves were rich in N (2%) and was used to supplement N to initially counter the nitrogen depletion and it had C:N ratio of 18:1. Animal manure used as an additive or inoculums for the compost treatments. This mainly served as a starter material for composting.

Data from the research showed that proportioning of mixed wastes had resulted to desirable C/N ratio (30:1) as generally agreed by many researchers (Sincero *et al.*, 1996., Landerth & Rebers, 1996), moisture about 65% and temperature 60°C were maintained which had been recommended by other researchers for composting process(Tiwari *et al.*, 1989., Diaz & Golueke, 1989, Davis et al., 1998).

It also enhances the decomposition of cellulosic plant material (Tiwari *et al.*, 1989) and it had 2.5% N with a C: N ratio of 10:1. Also results explained that animal wastes were highly rich in Fe

(826 mg/kg), Cu (22 mg/kg) and Zn (152.60 mg/kg) when compared with brown and green leaves. Hazard heavy metals like Cd and Pb were found to be negligible in agriculture and animal wastes.

Table 1. Chemical Composition of raw materials used for composting

Characteristics	Brown	Green leaves	Animal wastes
pH	5.70	6.2	7.00
Ec(μs cm^{-1})	1445.0000	1296.00	1363.00
Organic carbon (%)	39.00	36.00	25.00
Nitrogen (%)	0.96	2.03	2.50
Phosphorus (%)	0.0018	0.14	0.27
Potassium (%)	0.70	2.20	0.36
Calcium (%)	0.72	0.76	0.86
Nitrates (mg kg^{-1})	1.60	0.75	0.11
Fe (mg kg^{-1})	500	500	826
Cu (mg kg^{-1})	6	14	22
Cd (mg kg^{-1})	ND	ND	ND
Zn (mg kg^{-1})	22.60	38.80	152.60
Pb (mg kg^{-1})	ND	ND	ND
C : N ratio	40 : 1	18 : 1	10 : 1

Chemical characteristics of the matured compost

The data on chemical properties of the composted solid wastes are given in Table 2. The pH of the BZT®Compost Activator treatment and control treatment was neutral to slightly alkaline within the experimental time. This may be due to the natural buffering of the waste used. Highest pH was recorded in 15 and 25 days compared to others. The results in the present study concurred with the observation of **(**Diaz & Golueke, 1989) who reported that the agricultural compost was slightly alkaline in nature and had a marked buffering capacity. The composting process is relatively insensitive to the pH of its feedstock (Fleming, 2001**).** Finished compost generally ends up with a pH around neutral, usually between 6 and 8, according to tests performed on finished, stable compost (Diaz & Golueke, 1989). Therefore, properly cured compost is suitable for most plants, although certain acid-loving plants may need a lower pH (which can be attained by the addition of a supplement, such as sulfur) .Both the percent of organic carbon and nitrogen varied between treatment intervals. The carbon content was lowest in matured compost (25-30 days) when compared to the initial treatment (0 days) which was due to the activity of BZT®Compost Activator. The N content was highest in matured compost when compared to the initial treatment. pH in mixed wastes was 6.5 and after starting up of the processes, increased to about 7.0 and in compost product reached to 7.95 in windrow which were accordance with(Markel, 1981).

Table 2. Chemical properties of the composted materials

Times	BZT ® Compost Activator					Control				
Days	pH	Organic C%	N%	C:N ratio	NO3 %	pH	Organic C%	N%	C:N ratio	NO3%
0	6.5	28.77	0.97	30:1	1.24	7.0	38	0.98	38:1	1.17
5	7.0	26	1.40	19:1	1.28	7.32	29	0.74	39:1	0.62
10	6.46	25	1.40	14:1	1.32	6.4	29	0.74	39:1	1.62
15	8.35	25	1.42	18:1	1.20	8.00	30	1.03	29:1	1.24
20	8.00	22	1.51	15:1	1.48	8.15	29	1.04	28:1	1.24
25	8.67	26	1.60	16:1	1.48	8.47	28	1.50	19:1	1.13
30	7.95	23	1.62	15	0.0018	7.90	28	1.50	19:1	1.50

Data given in Table 3 recorded that enrichment of agriculture and animal manure wastes with BZT®Compost Activator yielded compost with high P content (0.68%), K (0.86%) and Ca (1%). The enrichment of compost with BZT®Compost Activator increased the decomposition rate, which may be due to availability of microencapsulated bacteria and enzymes essential for the increased decomposition activity and nutrients availability. From this investigation it can be stated that enrichment of agriculture waste with animal manure and BZT®Compost Activator resulted in value added compost. According to (Radhakrishna *et al*., 1995) enrichment of compost with nutrients like P in the form of Nitrovos phosphate resulted in high value compost due to higher degree of decomposition. Also results recorded that the treatment with BZT®Compost Activator resulted in trace elements availability such Fe, Cu and Zn (2092 ppm, 20 ppm and 164 ppm for Fe, Cu and Zn respectively) which are totally matched with European standards.

Physicochemical analysis of compost from the point of view N, P, K, Organic Carbon, Organic matter and heavy metals (Cd, Fe, Cu, Zn, Ni and Pb) agreed with WHO criteria (World Bank. Integrated resource recovery, 1987) and USEPA. The data presented in table 2 showed that the windrows system was more effective for nutrients marinating. Considering the high volume of agriculture and animal wastes, aerobic composting may be considered as an important. It could be concluded that windrow system may be recommended for better method for recycling of agriculture and animal wastes.

Table 3. Major and heavy metals properties of the compose piles.

	BZT ® Compost Activator								Control							
Day	K%	Ca%	P (mg/kg)	Fe ppm	Cu ppm	Cd ppm	Zn ppm	Pb ppm	K%	Ca%	P (mg/kg)	Fe ppm	Cu ppm	Cd ppm	Zn ppm	Pb ppm
0	1.93	0.86	0.0024	818	14	ND	61.4	ND	1.80	0.94	0.23	1824	20	ND	109	ND
5	1.56	0.60	-	3458	10	ND	165	ND	1.80	0.76	-	1992	24	ND	112	ND
10	1.76	0.68	-	2756	30	ND	141	ND	1.80	0.64	-	2858	34	ND	144	ND
15	1.98	0.64	-	3530	32	ND	160	ND	1.90	0.90	-	2252	18	ND	115	ND
20	0.56	0.56	-	2552	20	ND	168	ND	0.98	0.98	-	2308	22	ND	145	ND
25	0.86	0.60	-	3442	32	ND	163	ND	0.90	0.98	-	1854	22	ND	134	ND
30	-	1.00	0.68	2092	20	ND	164	ND	0.94	0.94	0.002	1013	13	ND	98	ND

Temperature and Biological characteristics

The data on biological and chemical properties of the composted solid wastes are given in Table 4. Biomass content (Total viable counts) showed a marked increase after 5 days and a marked decrease at the end product. Further more results showed that total coliform, faecal coliform, mycotoxins and salmonella detection dramatically decrease with the compost pile temperature rises.

Table 4. Temperature and biological properties of the processed composed material

	Treatment (BZT ® Compost Activator)						Control					
Days	TVC (cfu/g) x 10^5	Total coliform (MPN/100g) x 10^5	Molds & Yeasts(cfu/g)	*Salmonella* detection (cfu/g)	Mycotoxine (ppb)	Average pile temperature	TVC (cfu/g) x 10^6	Total coliform (MPN/100g)	Molds & Yeasts (cfu/g)	Salmonella detection (cfu/g)	Mycotoxine (ppb)	Average pile temperature
0	0.5	30	1 x 10^4	+ve	8.35	42 – 45	3	5 x 10^5	1 x 10^3	+ve	8.35	42-45C^o
5	70	0.71	-	+ve	ND	65	4	5 x 10^3	-	-ve	ND	54
10	100	Nil	-	-ve	ND	66	4	1.5 x 10^6	-	-ve	ND	66
15	40	Nil	-	-ve	ND	69	1.85	<10	-	-ve	ND	65
20	84	Nil	-	-ve	ND	70	9	Nil	-	-ve	ND	70
25	5.2	Nil	5.2x10^6	-ve	ND	55	0.17	Nil	1.1x10^5	-ve	ND	69
30	0.33	Nil	2.2x10^4	-ve	ND	50	24	Nil	2.7x10^3	-ve	ND	68

Achievement to maximum temperature (over 55 ^{o}C) in windrow systems in related times 10 days ensured hygienic characteristics of compost and destruction of pathogen and parasite according to WHO criteria 15 and USEPA regulations for PSRP and condition in windrows composting system, according to PFRP regulations of U.S.EPA (Davis, et al.,1998). Also data from this research showed that in the early stage of composting, characterized by a high content of easily degradable substrate, it could be expected that the microbial counts represents an higher percentage compared to the stabilized compost, were the substrate availability is greatly decreased. Furthermore, reference to the content of the total coliform, faecal coliform and Salmonella was dramatically decreased with the compost pile temperature rises. The good correlation parameters measuring different aspects of the microbial pool could imply that all the parameters depend on a common factor such as the availability of easily degradable substrate. In the first stage of the composting process the more readily degradable substances such as sugars, fats, starch and proteins are rapidly consumed and degraded. With the ongoing process the cellulose, hemicellulose and other polymers are attacked and humifications occur in the residual organic matter (Chen, et al., 1997). Therefore, during the process there is a decrease of the substances more recalcitrant to microbial decomposition. It is probable that this substrate availability dynamics have a remarkable effect on the behavior of the size and activity of microbial diversity and enzyme activities in BZT®Compost Activator as it is a dry powder of microencapsulated bacteria and enzymes. Nevertheless the aim of the present work was not to study microbial dynamics in compost, but to investigate the useful application of microencapsulated bacteria and enzymes on the fastest degree of compost maturity and to be more economically in production.

Conclusion

The results of the study clearly indicate that the Biodegradation and recycling of agriculture wastes using microencapsulated bacteria and enzymes can be transformed to enriched composts within only 35 days. This is an important message of practical significance if adopted by urban farmers. Thereby the soil health and in turn the productivity of soil can be maintained for feature agriculture. This point gains importance given the fact that the quantum of cultivable land around KSA is fast dwindling. Therefore the essence of the present study is that the urban farmers in KSA and Arab countries should be motivated to practice agriculture and animal waste recycling through bioremediation measures.

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