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Physico-Chemical and Microbial Quality of Locally Composted and Imported Green Waste Composts in Oman

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ABSTRACT

In this work the physical, chemical and microbial properties of four locally composted green waste composts (*GWCs*) *namely Almukhasib, Growers, Plantex, and Super along with four imported GWC* (*Florabella, Mikskaar, Potgrond, and Shamrock*) *were studied to evaluate the quality of these composts with the acceptable standards. All composts showed normal physical properties, except the bad smell from sulfur reducing bacteria in Almukhasib, light brown color Plantex and one viable weed seed in Shamrock compost. The germination indexes of the composts comparable to the standard* (90%) *were 100% for Mikskaar, followed by Shamrock* (92%), *Florabella* (97), *Potgrond* (95%), *Plantex* (98%), *Growers* (77%), *and* 5% *for both Super and Almukhasib. The physical and chemical properties vary considerably as follows*: *pH* 3 - 10.5, 5.1 - 6.5 (*standard* 5 - 8), *electrical conductivity* (*EC*) 0.4 - 10.2 $mS\cdot cm^{-1}$, 0.8 - 1.8 $mS\cdot cm^{-1}$ (*standard* 0.0 - 4.0 $mS\cdot cm^{-1}$), *moisture content* (*MC*%) 29% - 43.7%, 64% - 74% (*standard* 35% - 60%) *and water holding capacity* (*WHC*%) 92% - 200% *and* 400% - 800% *for the locally produced and imported composts, respectively. Wide ranges in the chemical properties were expressed as ammonia concentration* 512.4 - 1640.1 $mg\cdot kg^{-1}$, 459.4 - 656.5 $mg\cdot kg^{-1}$ (*standard* < 500 $mg\cdot kg^{-1}$), *organic matter* 17% - 67.6%, *and* 53.3% - 66.2% (*standard* 35%) *for the locally composted and imported composts, respectively. The concentrations of the heavy metals* (*Zn, Ni, Pb, Hg, As, Cd, and Cr*) *were lower than the recommended levels. The average of the bacterial colony forming unit per gram of locally produced and imported composts ranged between* 260 - 1740 *CFU/g and* 330 - 2870 *CFU/g, whereas the fungal CFU were* 10 - 2800 *CFU/g and* 27 - 1800 *CFU/g, respectively. The most probable number* (*MPN*) *for coliform bacteria was* 43 - 1100 *CFU/g for locally produced composts, and* 23 - 480 *CFU/g for the imported composts. Therefore, these composts can not be used directly without effective treatment as substrate for plant growth, soil amendment and as biofertilizer*.

Keywords: *Aspergillus Niger, Coliform Bacteria, Physico-Chemical Properties, Green Waste Compost, Heavy Metals, Oman*

1. Introduction

Composting is a natural decaying of the organic matter to stable compost by aerobic and anaerobic actions of bacteria, fungi and other organisms [1-3]. This process has the potential of managing organic materials in the waste stream such as leaves, farm wastes, animal manure, paper products, sewage sludge and domestic wastes [1,4]. Green waste compost (GWC) is a biodegradable waste that originates from pure plant materials of garden trimmings or garbage collected from vegetable and fruits markets [5]. It provides benefits for soil biological activity, and nutritive value to plant growth [6-8]. It improves the physical and chemical properties of the soil [9], enhances plant growth [10,11], remediates contaminated soil [7,12-14], and suppresses some of these soil borne disease [15,16].

Quality control of the compost significantly promotes the recycling of the organic wastes [17]. The compost must comply with certain national and international standards and quality grading [5,18]. The qualities of the compost include physical, chemical and biological properties such as moisture content, odor, carbon and nitrogen contents, phytotoxic substances, harmful elements, weeds, nutrient contents, plant pathogens and effectiveness to plant growth and soil amendment [19]. These can be maintained by the maturation of the compost and varied with the degree of transformation achieved by the organic materials [17]. Nonetheless, there is no single method that can be adopted universally to all compost types due to the wide range of feedstock, composting processes [20-22], and widely different chemical characteristics of organic wastes [23,24]. On the other hand, pathogens are commonly present in sewage and household wastes, both of which are commonly composted [25]. Therefore, composting is an efficient method for destruction of pathogens to safe and acceptable level for human, animal and plant uses [21,26].

In Oman, land is the major non-renewable resource facing the challenging threat of soil degradation. Sustainable agriculture must be environmentally safe and must produce adequate amounts of quality foods with minimum purchased fertilizers and rely, as much as possible, on the renewable resources of the farm itself [27,28]. This is especially important in 90% of the farms that exist in the third world, where agricultural inputs are often not available or affordable [27]. Thus, compost is one of the important low cost inputs for meeting nutrient requirements of crops [29]. In Oman, green waste composts are imported from other countries at high cost and economic burden, therefore, compost industry was locally developed for production of high quality composts with affordable prices to the small village farmers. The present study was conducted to evaluate the physical, chemical and microbial properties of locally produced and imported green waste composts in order to determine their ability to meet the acceptable standards.

2. Materials and Methods

2.1. Compost Samples

Four locally produced green waste composts (Almukhasib, Growers, Plantex, Super), and four imported composts (Florabella, Mikskaar, Potgrond, Shamrock) were selected. The samples were collected according to the Gulf standard number GS0901/1997 [5]. Five samples of 1 kg each were collected from the compost bags, mixed to form composite samples and were then divided into four working samples. The samples were kept 5˚C for further analysis.

2.2. Hydrophysical Characterization

Immediately after collection, the samples were visually inspected for free flowing, hard lumps, objectionable odor, and color. The particle size of the composts was determined according to the Gulf standard number GS01167/2002 using three replicates of 100 g oven dried samples [18]. The samples were placed on 12 mm sieves and shaken for 5 min at 100 shakes per min [30]. The percentage of the particles greater than 12 mm was calculated as percentage by mass of the remaining materials on the top of the sieve to the mass of the test sample [31].

For testing the phytotoxicity of the compost samples and the presence of the viable seeds and plant parts, six plastic pots (10 × 15 cm) were filled with the compost samples. Three pots were seeded with 100 seeds of *Phaseolus mungo* (mungbean) and the remaining three pots were kept without seeds. As a control, another 100 seeds of *P. mungo* were inoculated into plastic trays with moistened cotton and incubated in the green house of the Biology Department, Sultan Qaboos University and were moistened daily for 17 days. The pots were examined regularly for seed germination.

The hydrogen ion concentration (pH), moisture contents (MC%), electrical conductivity (EC), and water holding capacity (WHC %) of the composts were measured using basic standard procedures and techniques [32]. The pH was determined in triplicate with the pH meter. For calculation of the moisture content, immediately after the collection of the samples, moisture content was determined by the oven method [33]. Replicates of 10 g were placed in glass Petri dishes; soft lumps were crushed with a spatula and dried at 105˚C in an electric oven for 16 hours. The moisture content was determined as a percentage to the initial weight.

For detection of electrical conductivity (EC) of the composts samples, replicates of 2 g from each sample were mixed in 5 ml of distilled water and the mixture was filtered through filtration unit with regular Whatman filter paper No. 42 (Whatman International Ltd, Maidstone, UK). The electrical conductivity of each filtrate was measured by electrical conductivity meter.

For determination of the water holding capacity (WHC%) of the composts, 500 g from each sample were added to pre-weighed dry sieve and pressed evenly. The samples were saturated with water, kept covered over-night, and then the dripped water was wiped off the sieve with fine tissues. The sieve with the moistened sample was weighed, placed in desiccators, allowed to dry and then reweighed to calculate the amount of water held by the samples. The WHC was calculated as percentage mass of the absorbed water to the mass of the dried sample according to the gulf standard No. GS01/2002 [18].

2.3. Chemical Analysis

The organic matter (OM) of dried ground samples was determined by measuring the loss of mass through ignition at 550˚C according to the modified combustion method suggested by many authors [21,34,35] and adopted by the Gulf standard NO. GSO1167/2002 [18]. From each sample, 10 g were used instead of 5 g in order to increase the degree of the method accuracy. The samples were dried to constant mass in an oven at 105˚C and cooled in desiccators to avoid moisture absorption from the atmosphere. Ten grams from each sample were put into an oven-dried porcelain dish, placed in the furnace and the temperature was increased to 550˚C to convert the sample into ash. The percentage of the organic matter was calculated in triplicates as percentage loss of mass to the mass of the original test sample as a result of ignition.

The ammonia-nitrogen contents of the compost samples were determined in triplicate using Kjeldahl method (Kjeltec Foss, Tecator AB, Hogana, Sweden, N-analyzer). For this, 0.5 g from each sample and one keltab catalyst (SeK_2SO_4) were added to a digestion tube and mixed with 10 ml of sulfuric acid. The tubes were digested for 3 hours, allowed to cool and the concentration of the ammonia was measured.

For the heavy metal concentrations in the compost samples, 5 g from each sample were mixed with 25 ml of distilled water and the mixture was filtered with Millipore filter papers. Ten ml from the filtrate were analyzed with Inductive Couple Plasma (ICP-MS OPTIMA, 3100 RL Spectrometer, Perkin Elmer and Norwalk, USA).

2.4. Enumeration of Microorganisms

The microorganisms including both fungi and bacteria were isolated from the compost using agar plate method. One gram from each sample was added to a test tube containing 9 ml sterile distilled water, vortexed, and serial dilutions were prepared. One ml was aseptically inoculated on Potato Dextrose Agar (PDA) for fungal growth, and similarly Nutrient Agar (NA) was inoculated for bacterial growth. The inoculated PDA plates were incubated at 28˚C for 7 days, and the NA plates were incubated at 37˚C for 48 hours. At the end of the incubation period, the number of colony forming units (CFU) per gram of the compost was calculated. The isolated fungi were identified using different taxonomic books and monographs. The presence of coliform bacteria in the compost samples was screened using the standard table of the most probable number (MPN).

2.5. Statistical Analysis

Duncan's multiple range and one way ANOVA were used for comparison between the compost types with p = 0.05. The analysis was carried out using statistical package software SPSS (version 11.0).

3. Results and Discussion

3.1. Physical Properties

Four locally produced green waste composts (Almukhasib, Growers, Plantex, and Super), and four imported composts (Florabella, Mikskaar, Potgrond, and Shamrock) were examined for their physical, chemical and microbial properties. The visual inspection showed that all the samples were physically uniform, free flowing, no hard lumps, dark brown to black in color, free from objectionable odor, absent of foreign seeds and particle size less than 12 mm, except the bad smell of Almukhasib, light brown color of Plantex, and one viable weed seed in shamrock (**Table 1**). These characteristics indicate the good quality of the composts, the completion of the degradation process and compost maturity as suggested by many authors [23,36]. The bad smell of the composts is due to production of hydrogen sulfide by sulfur reducing bacteria or faecal coliforms present in animal dropping mixed with plant materials without any pretreatment [23]. These odorous fumes contained hydrogen sulfide, methylmercaptan, and methylsulfide, and were present in large quantities at the initial stage of composting which decreased rapidly with maturation [19]. The presence of viable weed seeds and brown color of the composts was associated with compost immaturity [36].

Seed germination indexes in compost or compost extracts are common biological methods to evaluate the degree of the maturity of the composted materials (the decomposition of phototoxic substance) and acids produced during the early active composting stages [24,37]. In the present study, the germination percentages of the mungbean seeds in the tested composts were reported (**Table 1**). The germination percentages (in parenthesis) of the mungbean seeds in each of the corresponding compost were as follows: Mikskaar (100%), Shamrock (92%), Florabella (97%), Potgrond (95%), Plantex (98%), Growers (77%), and 5% for Super and Almukhasib. The germination levels in locally produced Super (5%), Almukhasib (5%) and Growers (77%) which were lower than the acceptable index (>90%) can be attributed to the phytotoxic effects of the organic acid and ammonia toxicity produced during the active composting process [37, 38]. Therefore, these composts were not suitable for many potential uses. In the present study, the ammonia concentration of the imported composts were: Mikskaar (617.9 $mg \cdot kg^{-1}$), Shamrock (656.5 $mg \cdot kg^{-1}$), Florabella (570.5 $mg \cdot kg^{-1}$), Potgrond (459.4 $mg \cdot kg^{-1}$), whereas the locally produced composts showed relatively higher ammonia concentration for Super (1640.1 $mg \cdot kg^{-1}$), Growers (1156.4 $mg \cdot kg^{-1}$), Almukhasib (804.2 $mg \cdot kg^{-1}$), and Plantex (712.4 $mg \cdot kg^{-1}$) (**Table 2**). Similarly, the electrical conductively (EC) which indicates the salt contents of the compost is injurious to plant roots and prevents their growth [39]. Therefore, the low level of germination of the bean seeds in locally produced composts may be associated with the high electric conductivity of Super (10.2 $mS \cdot cm^{-1}$), Almukhasib (5.4 $mS \cdot cm^{-1}$) and Growers (7.5 $mS \cdot cm^{-1}$) which were higher than the upper standard limit (4 $mS \cdot cm^{-1}$) (**Table 3**). The imported Mik-

Table 1. Physical properties of the locally produced and imported green waste composts.

Properties	Locally produced composts				Imported composts			
	Almukhasib	Growers	Plantex	Super	Florabella	Mikskaar	Potgrond	Shamrock
Free flowing	+	+	+	+	+	+	+	+
Hard lumps	–	–	–	–	–	–	–	–
Objectionable odor	+	–	–	–	–	–	–	–
Normal color	+	+	–*	+	+	+	+	+
Particle size < 12 mm)	+	+	+	+	+	+	+	+
Foreign seeds	–	–	–	–	–	–	–	+**
Germination %	5	77	98	5	98	100	95	< 90%

*Light brown color compost; **presence of only one germinated weed seed.

Table 3. Hydrophysical properties of the locally produced and imported green waste composts.

Properties	Locally produced composts				Imported composts				Standards
	Almukhasib	Growers	Plantex	Super	Florabella	Mikskaar	Potgrond	Shamrock	
pH	10.1 a [a]	7.8 b	3.0 e	8.1 b	5.2 d	6.4 c	5.6 d	5.1 d	5 - 8
Electrical conductivity (mS·cm^{-1})	5.4 c	7.9 b	0.4 e	10.2 a	1.2 d	0.4 e	0.8 e	1.8 d	0 - 4
Moisture content (%)	29 f	35 e	43.7 d	33 e	65 c	74 a	70.5 b	64 c	35 - 60
Water holding capacity (%)	92 g	200 e	200 e	144 f	400 d	646 c	800 a	57 b	

[a]Within rows, number with different lower case letters differ significantly (P < 0.05).

Table 2. Chemical properties and heavy metals concentration (ppm) in the locally produced and imported green waste composts.

Properties	Locally produced composts				Imported composts				Standards
	Almukhasib	Growers	Plantex	Super	Florabella	Mikskaar	Potgrond	Shamrock	
Ammonia (mg/kg)	804.2 c [b]	1156.4 b	712.4 d	1640.1 a	570.5 g	617.9f	459.4h	656.5e	<500
Organic matter %	17 g	22 f	67.6 a	25 e	53.3 d	64 c	66.2 b	65 bc	35
Copper (Cu)	0.05 bc	0.11 a	0.03 c	0.04 c	0.05 bc	0.08 b	0.12 a	0.06 bc	150 - 250
Nickel (Ni)	0.03 a	0.03 a	0.04 a	0.04 a	0.02 a	0.03 a	0.03 a	0.03 a	50 - 70
Lead (Pb)	0.02 a	0.02 a	0.03 a	0.03 a	0.01 a	0.03 a	0.03 a	0.02 a	120 - 150
Cadmium (Cd)	0.08 a	0.04 b	0.03 b	0.08 a	0.08 a	0.03 b	0.03 b	0.02 b	3 - 5
Arsenic (As)	0.04 a	0.04 a	0.05 a	0.05 a	0.04 a	0.03 a	0.05 a	0.04 a	15 - 25
Chromium (Cr)	0.34 e	0.54 b	0.29 f	0.39 d	0.45 c	0.50 b	0.19 g	0.57 a	100 - 150
Zinc (Zn)	114.4 b	60 e	100 c	18.8 g	30.0 f	79.4 d	120 a	120.7 a	350 - 500
Mercury (Hg)	0.0059 a	0.0059 a	0.0059 a	0.0059 a	0.0059 a	0.0059 a	0.0059 a	0.0059 a	1.5 - 3

[b]Within rows, number with different lower case letters differ significantly ($P < 0.05$).

skaar (0.4 mS·cm^{-1}), Shamrock (1.8 mS·cm^{-1}), Potgrond (0.8 mS·cm^{-1}), Florabella (1.2 mS·cm^{-1}), Potgrond (0.8 mS·cm^{-1}), Florabella (1.2 mS·cm^{-1}), and the locally produced Plantex compost (0.4 mS·cm^{-1}) displayed higher levels of germination and their electrical conductivity was within the standard limit (0 - 4 mS·cm^{-1}) which is not harmful to the plant growth. In a similar study, it was found that the electrical conductivity varies considerably and ranged between 0.12 and 17.08 mS·cm^{-1} [40]. This wide range of electrical conductivity expressed the diversity of the chemical and microbial properties of the various compost products.

3.2. Hydrophysical Properties of the Compost

The hydrogen ion concentrations (pH) for the compost varied at the beginning of composting process and ramped from 7.3 to 7.7 as the composting proceeded up to 8.8 - 9.6 [2]. All the screened composts, except the locally processed Almukhasib, showed acceptable pH value (5 - 8.0) (**Table 3**). However, the highly acidic Plantex (pH 3) may be due to production of phytotoxic organic acids during immature composting process which causes immediate growth injuries [38]. Therefore, the addition of this compost to soil may modify the pH of the final mix and buffer the soil pH [1].

The moisture contents of the composts ranged between 3.1% - 82.7% and varied considerably with the variation in the composted materials [40]. The moisture content values for the compost was considerably high in the first 3 weeks of composting after which it increased significantly in the later weeks [1]. Therefore, the addition of compost provides excellent drought resistance and great efficient water retention. In the present research (**Table 3**), the moisture contacts of the imported Shamrock is 64%, followed by Florabella (65%), Potgrond (70.5%) and Mikskaar (74%), which were higher than the acceptable limits (35% - 60%), comparable to and locally produced Plantex (43%), Growers (35%), Super (33%), and Almukhasib (29%). The moisture content ranged between 50% - 60% and was considered as the optimal level for further composting [41]. Therefore, the compost with higher moisture content will inhibit aerobic degradation and enhance the unpleasant odor from the growth of anaerobic sulfate reducing bacteria. Yet, the ideal moisture content depends on how one plans to use the compost.

Water retention capacity of substrate is generally considered as the quality determining factor [30,42]. The highest saturation of the compost is 75% and the good compost must have high water holding capacity and low filtration rate for supporting the plant growth. In the present study (**Table 3**), the water holding capacity (WHC%) of the tested composts was found to be more than their actual weight. The water holding capacity of the imported composts ranged between 400% and 800% (Florabella 400%, Mikskaar 646%, shamrock 757%, Potgrond 800%) which is significantly higher than the locally processed Almukhasib (92%), Super (144%), Growers and Plantex compost (200%). Therefore, these composts can be used separately or mixed with sandy soil of low water holding capacity if they satisfy the other quality control parameters and the essential requirements for the plant growth.

3.3. Chemical Properties of the Compost

Wide range in the values of the chemical properties of the compost expressed the diversity of various compost products and the raw materials used [40]. The total carbon contents (TC) for various composts were in the range of between 16.9% - 51.0%. A approximately 11% - 27% of the total carton was lost during the 7 days of active composting, and 62% - 66% during the whole composting time [43]. In the present results (**Table 2**), the total organic matter for the imported Potgrond (66.2%), Shamrock (65%), Mikskaar (64%), Florabella (53.5%), and locally produced Plantex (67.6%), were relatively higher than the standard set by the Gulf countries (35% and optimum 40% - 60%) [5]. On the other hand, the organic contents of the locally produced Super (25%), Growers (22%), and Almukhasib (17%) were below the standard limit. The high organic matter contents of the compost indicate the presence of uncomposted organic materials that can be degraded slowly by microorganisms and eventually used by higher plants [44].

Heavy metals, as harmful elements, are one of the determinant factors for compost quality [19]. They may come from sewage water, addition of manure from chicken and other animal dung, and from soil added to the composted materials. They are released from compost and negatively affect the plant during the slow degradation process. On the contrary, compost reduces the mobility of some toxic metals to the plants through formation of some complexes. In this study, although there are significant variations in the heavy metals concentrations (Zn, Ni, Pb, Hg, As, Cd, Cr) between the screened composts, the concentration levels of heavy metals in the compost samples were lower than the acceptable limits recommended by the Gulf countries [5]. Similar standard limits were adopted in Germany [45], and Canada [46]. Nonetheless, the high contents of heavy metals may be due to addition of these metals to animal feeds [19] or contamination during the composting process [47].

3.4. Microbial Estimates of the Compost

It is natural to have large numbers of bacteria and fungi in the compost during composting process and they are essential for slow degradation of partially decomposed organic materials [1]. The pathogenic fungi and bacteria were normally detected in composted household wastes, and sewage sludge [25]. Nonetheless, composting is an efficient method for destruction of pathogenic microorganisms in the compost to a safer level for humans, animals and plants [21,26]. Reasonable amounts of microorganisms are still present in the compost at maturity [1]. In the present study, the average of the bacterial colony forming unit per gram of the compost were as follows: Plantex (260 cfu/g), Almukhasib (280 cfu/g), Shamrock (330 cfu/g), Growers (1490 cfu/g), Potgrond (1720 cfu/g), Super (1740 cfu/g), Mikskaar (2580 cfu/g), and Florabella compost (2870 cfu/g), whereas the colony forming unit of fungi in the compost were Almukhasib (10 cfu/g), Shamrock (30 cfu/g), Super (190 cfu/g), Florabella (200 cfu/g), Mikskaar (270 cfu/g), Plantex (360 cfu/g), Potgrond (1800 cfu/g), and Growers (2800 cfu/g) (**Table 4**). It is evident that the imported Florabella, Mikskaar, and the locally produced Super composts have the highest bacterial colonies, whereas the imported Potgrond, and the locally produced Growers and Plantex contain relatively high numbers of fungal colonies. These large numbers of bacterial and fungal colonies were responsible for the slow degradation of the organic matter as suggested by several authors [21,23,48]. Most of the fungi involved in the slow degradation of the screened composts belong to the thermophilic genus and moisture tolerant *Aspergillus*. In the present study (**Table 4**), *A. niger* was the predominant species recovered from all compost types (100%) at the later stage as reported by many authors [1, 48,49]. This fungus was followed by *A. fumigatus* (75%), *A. sparsus* (50%), yeasts (50%), *A. flavus* (37.5%), where the remaining fungi such as *A. restrictus*, *A. versicolor*, *Cladosporium* spp., and *Penicillium* spp. were recovered from 50% of the compost types, and to a lesser extent *Acremonium* sp. and *A. ochraceous* (12.5%). In similar studies, different species of *Aspergillus* and *Penicllium* were isolated from the compost [1,8,48].

Various pathogenic bacteria were isolated from different composts and composted materials [1,21]. The major faecal coliforms found in the raw materials composed of *Escherichia coli*, where in the finished compost the majority of the faecal coliforms were probably of non-faecal origin [21]. Therefore, the species composition of the faecal coliforms can vary considerably depending on the composted materials and composting system. In the present results, the most probable number (MPN) was used to determine the faecal contamination of the composts. Our findings (**Table 4**) showed that locally produced Almukhasib was highly contaminated with coliforms (1100 cfu/g), followed by the imported Florabella (480 cfu/g), Potgrond (240 cfu/g), and to a lesser extent by locally produced Plantex (150 cfu/g), Growers (93 cfu/g), Super (43 cfu/g), and the imported Mikskaar (43 cfu/g) and Shamrock (23 cfu/g). The presence of higher number of coliforms in the locally processed Almukhasib, followed by imported Florabella and Potgrond indicates the possible contamination of these composts with sewage water or other animal products during composting process, which was confirmed by isolation of coliform bacteria as suggested by many researchers [1,21]. Therefore, there is a high possibility of transmission of serious diseases during handling and usage of these composts in addition of expected infestation of the cultivated plants with serious pathogenic bacteria.

4. Conclusions

It is apparent that all the investigated composts were free from most of the physical constraints, except the light brown color of Plantex, bad smell of Almukhasib and viable seed in Shamrock which indicates immaturity of the composts. The locally processed composts contain phytotoxic acids, ammonia, and with high electrical conductivity which affect the seed germination. The moisture contents of the imported Florabella, Mikskaar, Potgrond, and Shamrock were higher than the locally pro-

Table 4. Microbial properties of the locally produced and imported green waste composts.

Properties	Locally produced composts				Imported composts			
	Almukhasib	Growers	Plantex	Super	Florabella	Mikskaar	Potgrond	Shamrock
Bacteria (CFU/g)	280h *c	1490 e	260 g	1740 c	2870 a	2580 b	1720 d	330 f
Fungi (CFU/g)	10 h	2800 a	360 c	190 f	200 e	270 d	1800 b	30 g
MPN (CFU/g)	1100 a	93 e	150 d	43 f	480 b	43 f	240 c	23 g
Acremonium sp.	-	-	-	-	-	-	+	-
Aspergillus flavus	-	-	+	+	-	-	-	+
A. fumigatus	-	+	+	+	-	+	+	+
A. niger	+	+	+	+	+	+	+	+
A. ochraceous	-	-	+	-	-	-	-	-
A. sparsus	+	-	-	+	-	+	-	+
A. restrictus	-	-	-	+	-	+	-	-
A. versicolor	-	-	-	-	+	-	-	+
Cladosporium sp.	-	+	-	-	-	-	+	-
Penicillium sp.	-	-	-	+	+	-	-	-
Yeasts	+	+	-	-	-	-	+	+

[c]Within rows, number with different lower case letters differ significantly (P <0.05).

duced Almukhasib, Growers, Plantex, and Super composts. The water holding capacity was significantly higher in all composts and meets the standard limit. The total organic matters were higher in the imported composts in comparison with the locally composted materials. The heavy metals contents of all composts were below the acceptable limits. The composts were contaminated with variable levels of saprophytic fungi and coliform bacteria. It is evident the imported composts were relatively better than the locally produced composts, however, none of them meet most of the recommended characteristics [50]. Therefore, they can not be used directly and without any treatment as media for plant growth, soil biofertilizer and for soil amendment. Therefore, there is a high necessity for setting detailed legislation, regulation policies, proper testing methods, quality control measurements, and strong quarantine regulations for exportimport and local production of green waste composts. Attention should be given to the local production of high quality composts which serve the environment, waste management, recycling industry and satisfaction of the local markets.

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