Australian Journal of Basic and Applied Sciences, 7(7): 768-776, 2013
ISSN 1991-8178

Demand, Practices and Properties of Compost in the Western Region of the Kingdom of Saudi Arabia

[1]A. Alzaydi, [2]S. Alsolaimani and [3]M. Ramadan

[1]Professor, Center of Research Excellence in Environmental Studies, King Abdul Aziz University, Jeddah, Saudi Arabia.
[2]Professor, Dept. of Agriculture, Faculty of Met., Env., and Arid Land Agriculture, King Abdul Aziz University, Jeddah, Saudi Arabia.
[3]Professor, Dept. of Env. Sci., Faculty of Met., Env., and Arid Land Agriculture, King Abdul Aziz University, Jeddah, Saudi Arabia.

Abstract: There is a gap between production and import of compost in the Kingdom of Saudi Arabia (KSA). Because the organic waste stream dominates about 67% of the Saudi MSW, it is planned to improve the existing compost plants and/or design new plants to encourage recycling into quality compost in order to save two third of landfilling cost, and reduce the amount of the expensive imported compost. It is also realized that good planning requires categorization of the existing local compost and practices. The current study, for the first time in Saudi Arabia, aimed to identify data related to compost types, quantities, utilization methods, and practices. This has been done through two specially designed questionnaires directed to the major producers and users. It also aimed to determine the compost physical and chemical prosperities of randomly selected samples frompotential selected cities such as Jeddah/ Makkah Al-Mukarrama, Al-Madinah Al-Munawarah, Al-Taif, and Yanbu. The results of interviews which included a total of 153 sample units showed that governorate representing the highest percentage (59.09%) for using compost, 41.31% of compost types are vegetative-animal.The highest percentage(42.37%)of the compost used to increase soil fertility, while the lowest (7.97%) used for decreasing the chemical fertilizers. Three fourth of the compost was local from Saudi Arabia.The winter season is the peak demand time(43.55%). The major complain was in the high decayed level (33.66%). Regarding the environmental problems, unpleasant odor was the highest (65.64%).The most preferred factors for the users at purchase were the price issue (31.37%), odor (27.35%), and N, P, and K contents (21.15%). Around 33% of the users see the compost demand will increase in large amounts.The statistics showed that the main variables positively and significantly affect the quantity of the used compost are winter season, cultivated area, number of nurseries and home gardens, in addition to the educational level by about82%.The variables that negatively affect the quantity are the price and the unpleasant odor of the compost. The physical and chemical properties of the randomly collected samples from eight manufactured compost types showed that none of the studied composts agreed with the typical range for water content and bulk density. The mean particle size distribution shows the fraction between 4 and 6.3 mm was the most abundant, followed by the fraction between 2 and4 mm. The average "coarseness index" was 61.45%, implying excessive aeration and low water retention. The pH results showed that two types only followed the optimal pH range for growing media. The EC results are higher than the established limit for an ideal substrate. One type only has organic matter concentration adequate for potting media. Total nitrogen (TN) ranged between 0.47% and 3.19%, and none of the studied composts agreed with the typical range of (1.0-2.0%). Six of the current studied composts were immature. The results of micro-nutrient and toxic metals violated in some cases the limits of EU standards. All the measured parameters showed highly significant differences among compost types. Based on the obtained results, improving the efficiency of the composting process, environmental awareness educational programs and quality control of composts are requested before supplying these materials to the market.

Key words: Compost - quality – properties - organic fertilizer – practices – demand – utilization - KSA.

INTRODUCTION

Composting not only helps reduce the amount of waste going to landfills but it produces a valuable soil amendment which can improve the texture and fertility of the soil. While composting occurs naturally, the

Corresponding Author: Professor, Center of Research Excellence in Environmental Studies, King Abdul Aziz University, P.O. Box 80216, Jeddah 21589, Saudi Arabia.
E-mail: ayadalzaydi@gmail.com - alzaydi@kau.edu.sa

process can happen faster with the help of different systems, each designed to manage various types and quantities of organic material (Alzaydi*et al*., 2012; Dhir *et al*., 2003).

Composting of organic waste is a complex process and many of the biochemical and microbialdetails are not known. Because the microbial activity is influenced by oxygen levels, particle sizes of the feedstock material, nutrient levels and balance (indicated by the carbon/nitrogen), moisture content, temperature, acidity/alkalinity, and pH, any changes in these factors are interdependent; a change in one parameter can often result in changes in others(Alsamarrai and Alzaydi, 1996).

The end-use markets can be agricultural, residential, commercial, and municipal. Compost can also be used for many engineering purposes; in bioremediation and pollution prevention (Cole *et al*., 1995), disease control for plants and animals (Marvil *et al*., 1997), erosion control and landscaping (Pfafflin*et al*., 1992), composting of contaminated soils (Weston, 1993), reforestation, wetlands restoration (Lynch, 1995), habitat revitalization (Bonnette *et al*., 1995).

In Saudi Arabia,compost is widely used with very limited published data and often with no or little quality control processes (Alzaydi *et al*., 2012 and Alzaydi, 1996a, 1996b). The organic waste stream in Saudi Arabia dominates over 67% of the municipal solid waste stream; an average of about 40% of food alone, 13% cardboard, 5% paper, 6% yard waste, and 3% woods, making over 5 million tons/year of organic waste that can be targeted for beneficial composting programs at a net benefit(Alzaydi, 1995, 1998, 2012).

There is also an increasing trend for organic farming in Saudi Arabia that did not exist prior to 2005 (Alredhaim, 2013). Currently there are 78 organic farmers, 280 registered for conversion, 16247 hectares of organic farms, and 2216 hectares for conversion.

The potential market, therefore, for finished compost in Saudi Arabia is much larger than the supply and to be studied. The authors have estimated that by about 2015, the compost demand will target 500,000 tons/ year.

This demand, the availability of an abundant free organic raw material, relatively cheap labour, the readiness of the end-use markets whether agricultural, residential, commercial, or municipal for the many applications of the finished compost, and the significance cut on imports, have all necessitated the need to identify potential producers, end users and their practices and the existing compost quality and properties.

Also, quality control during compost production should ensure adequate chemical and physical properties (Inbar *et al*., 1993), as well as an adequate degree of stability and maturity (*Benito et al*., 2003). The beneficial effects on crop production and soil quality reported in literature (Hoitink *et al*., 1997 and *Atiyeh et al*., 2001) are directly related to the physical, chemical and biological properties of the composts (He *et al*., 1995).

The aim of the current study is to identify data related to compost types, quantities, utilization methods, and practices. This has been done through two specially designed questionnaires directed to the major producers and users. It also aims to evaluate the main physical and chemical properties of the 8 different randomly selected compost types in order to assess their suitability as growing media for plants.

Methodology and Approach:

To implement this aim, two questionnaires have been used: one for the users to collect information about the compost utilization and quality and the other for the compost producers.

The cities that have been covered in the Western Region of Kingdom of Saudi Arabia included Jeddah/ Makkah Al-Mukarrama, Al-Madinah Al-Munawarah, Al-Taif, and Yanbu. The users or organizations that have been studied included agricultural companies, farms, nurseries, private gardens, and contractors. Randomized Stratified Sampling Design in the statistical analysis was followed (El-Nakhlawy, 2008 & 2010). Accordingly the analysis covered questionnaires completeness, honesty of the interviewees,translating into numerical data,calculation of the frequency and relative frequency tables, weighed means and standard deviations, combined frequency, correlation between the main variables in the study, and multiple partial regression equations concerning the compost demand.The final studied sample units were 153 classified as shown in Table (1).

Table 1: Distribution of the studied sample units.

City	Organization				
	Agricultural. Companies	Farms	Nurseries	Home Gardens	Contractors
Jeddah/Makkah	3	6	5	25	5
Al-Madinah Al-Munawarah	4	22	4	10	4
Al-Taif	5	1	10	8	3
Yanbu	4	16	4	10	4
Total (153)	16	45	23	53	16

Eight compost types from the major producers were selected randomly from the Western Region of the KSA. Ten samples were collected from each type over a period of 3 months and transferred to the laboratory the same day for the physical and chemical parameters and analysis.

The physical properties of the collected composts were determined according to the methods of De Boodt and Verdonck, 1972, De Boodt *et al*., 1974, and WHO, 1978. Samples were passed through a series of sieves, from<0.25 mm to >6.4 mm, to determine their particle size distribution.

The samples were analysed for total organic carbon (TOC) by the dry combustion method at 540 °C for 4 h (Abad *et al*., 2002) and total N (TN) by Kjeldahl digestion (Bremmer and Mulvaney, 1982). Electrical conductivity (EC) and pH were analysed in a 1:5 (v/v) water extract. After water extraction (1:5 v/v), metals were determined by atomic absorption and P was determined by colorimetric methodfollowing Murphy and Riley (1962) method. The other parameters were analyzed in accordance with WHO, 1978. All results reported in the tables are the means.Least significant difference was used to compare analytical results ($p < 0.05$).

RESULTS AND DISCUSSION

Interview Statistical Results:

The results of the interviews and the statistical correlations that included the relative frequency distribution tables, weighed means, standard deviations are given in Table (2) as follows:

Social Characteristics:

Employers are representing the highest users (71.75%) and 28.25% farmers. The engineering position was the highest frequency (33.90%) followed by technicians, workers, and managers.

Table 2: Relative distribution of the various studied factors.

Social traits of the users (Mean + SD*)						
Position		Job title				
Farmer	Employer	Manager	Engineer	Technician	Worker	Others
28.25± 22.71	71.75± 26.77	12.44± 12.63	33.90± 14.35	24.27± 6.60	24.03± 17.37	5.36± 5.64

Agricultural application location and size of the covered cultivated area (Mean + SD*)					
Agricultural application location				Size of the cultivated area	
Village	City	Governorate	Less than 1000 m^2	1001-2000 m^2	>2000 m^2
13.82±20.44	27.12±5.86	59.09±21.95	35.94±36.06	24.04±15.68	40.02±27.69

Compost kind & storage type (Mean + SD*)							
Compost kind			Compost storage				
Vegetative	Vegetative-Animal	Fertilized	Have a Store	No store	Open air	Closed and unconditioned stores	Conditioned stores
32.74± 11.61	41.31± 17.46	25.95± 13.95	48.57± 13.68	51.43± 13.68	51.98± 11.86	43.26± 6.40	4.76± 5.48

Reasons for compost utilization (Mean + SD*)				
Increasing soil fertility	Increasing water retention of the soil	Increasing organic matter in the soil	Decreasing chemical fertilizers	Environmental reasons
42.37±22.94	31.56±10.93	17.92±10.87	7.97±5.74	0.0±0.0

Compost source & location (Mean + SD*)						
Compost source		Compost location				
Saudi	Imported	Arabic	European	North America	South America	Others
75.49±8.81	24.51±8.81	4.99±5.40	17.78±10.03	0.87±1.94	0.87±1.94	0.0±0.0

Amount of compost used / year (Mean + SD*)				
<300 kg	300-600 kg	601 – 900 kg	901-1200 kg	>1200 kg
12.50±5.89	17.48±14.94	16.85±8.95	21.12±10.09	32.05±18.81

Spending on compost/year and price level (Mean + SD*)						
Spending on compost/year**				Price level		
<SR5000	SR5000-10000	SR10001-15000	>SR15000	Low	Acceptable	High
37.76±19.03	46.67±16.46	8.81±10.40	6.76±10.93	1.25±2.79	78.50±8.31	20.25±10.25

Compost peak season demand time (Mean + SD*)			
Winter	Spring	Summer	Replanting the seedling in land
43.55±15.46	27.88±8.87	10.33±7.44	18.24±4.51

Local compost problems (Mean + SD*)					
High inorganic content	High moisture content	High decayed level	Bad Packaging	No data on the package	High weed & other crop seed contents
12.69±7.05	17.05±15.19	33.66±10.78	11.10±9.74	2.44±3.55	23.06±4.56

*Standard deviation , **SR1.00 = US$ 0.286

Table 2: cont. Relative distribution of the various studied factors.

Environmental problems of the used compost (Mean + SD*)					
Unpleasant odor		Dust	High microbial organisms	Fire due to non-proper storage	
65.64±9.90		24.82±7.89	8.78±6.43	0.78±1.69	
Preferred characteristics at purchase (Mean + SD*)					
Odor	Price	Packaging	Particle size	N, P&K contents	Composition data on the package
27.35±7.86	31.37±22.53	7.43±3.72	8.08±7.28	21.15±9.97	4.62±1.64
Prediction of the future compost demand (Mean + SD*)					
Increasing with large amount		Increasing with low amount	Stays as is	May decrease	
32.6±20.23		34.13±6.25	25.63±13.64	7.64±10.51	
*Standard deviation , **SR1.00 = US$ 0.286					

Location and Size of the Covered Cultivated Area:

The highest relative frequency (59.09%)was the governorate, 40.02% ofthe cultivated area size with greater than 2000 m², followed by 35.94% with less than 1000 m².

Price and Price Bracket:

Most compost users (85%) spent around SR 10,000 (USD 2700) or less per year and around 15% more than 10,000SR/year. As for the price of compost, 78.5% indicated that the price was acceptable while 20.25% had concerns about its high price.

Peak Demand Time:

The winter season is the peak demand time for the compost (43.55%), followed by spring season (27.88%), replanting seedling in land (18.24%), while summer is the lowest demand time.

Local Compost Problems:

The major complain was in the high decayed level (33.66%), followed by high weed and crop seed contents (23.06%), high moisture contents (17.05%), high inorganic contents (12.69%), bad packaging (11.10%), and no data on the package (2.44%). SD's are low except for high moisture content (15.19).

Environmental Problems of the Used Compost:

The highest frequency of the environmental problems of the compost was the unpleasant odor (65.64%), dust (24.82%), high microbial organisms (8.78%), and fire due to non-proper storage (0.78%), with low SD's variations within the studied sample units according to Table (2).

Preferred Compost Characteristics:

The most preferred factors for the users at purchase were the price issue (31.37%), odor (27.35%), N, P, and K contents (21.15%). These three factors represent 80% of all other factors. The price however was highly variable between the different samples as shown in Table (2).

Prediction of the Future Compost Demand:

Around 67% of the studied sample units show that the compost demand will increase as 32.6% see the increase will be in large amounts, while 34.13% see the increase will be rather low. On the other hand, 25.63% saw the compost demand stay as it is, and only 7.64 % indicated that the demand will be decreased in the future.

Correlation Between the Main Affecting Variables:

The correlation coefficients between certain variables and other main affecting variables are calculated in terms of significance at 0.01 probability level. The correlation between the "used compost quantity" and the other main affecting variables is given in Table (3); the governorate location showed positively strong correlation (0.91), the cultivated area was positively intermediate correlation (0.67). The number of nurseries & home gardens were positively strong correlation (0.96). The Job of engineering was positively intermediate correlation with the compost quantity (+0.71).

The correlation coefficients between "compost storage" and the other main affecting variables are presented in Table (3). It shows positively strong correlations between "compost storage" and closed unconditioned stores (0.96) and Governorate (0.85), while the correlation with open air was negatively strong correlation (0.76).

The correlation coefficients between the "imported compost quantity" and the main affecting variables are shown inTable (3). This quantity was positively strong correlated with European source (0.91), and positively intermediate correlations with City (0.58), and Governorate location (0.72), while negatively intermediate correlations were detected with the Saudi compost and village location with values of – 0.67 and – 0.76, respectively.

Table 3: Correlation coefficients between compost quantity, storage, import and local Saudi compost with other related affecting variables.

Used Compost quantity	Variables					
	Governorate		Engineer		Cultivated area	Nurseries and home gardens
	0.91		0.71		0.67	0.96
Composed storage	Closed unconditioned stores				Open air	Governorate
	0.96				- 0.76	0.85
Imported compost	European	Arabic	Saudi	Village	City	Governorate
	0.91	0.22 NS*	- 0.67	- 0.76	0.58	0.72
Local Saudi compost	Decayed level	Weed and crops seed contents	Moisture content	Unpleasant odor	Dust	Microbial content
	0.62	0.68	0.42*	0.79	0.50*	0.22 NS
NS: Considered not significant at 0.05 probability level, * Significant at 0.05 probability level						

The correlation coefficients between "local Saudi compost" and the main affecting variables are given in Table (3). The "local Saudi compost" positively correlated with the decayed level, weed and crops seed contents, moisture content, unpleasant odor and dust with values of 0.62, 0.68, 0.42, 0.79 and 0.50.

Regression between the Quantity of Used Compost and the Main Affecting Variables:

The partial multiple regression equation after fitting all variables is as follow:

$$Y= 18.71 + 23.93X1 - 18.13X2 - 9.13X3 + 15.7X4 + 14.6X5 + 8.87X6 \quad (1)$$

Where:
Y= quantity of the used compost.
X1 = winter season,
X2 = price,
X3 = unpleasant odor,
X4 = cultivated area,
X5 = number of nurseries and home garden, and
X6 = education level.

Equation (1) shows that the main variables positively and significantly affect the quantity of the used compost in the studied regions are winter season, cultivated area, number of nurseries and home gardens, in addition to the educational level by about 82%. The variables that negatively affect the quantity are the price and the unpleasant odor of the compost.

Physical and Chemical Properties of the Compost:

Physical Properties:

The results of the physical parameters are presented in table (4).The water content ranged between 10.75 % in Green Land compost and 53.2% in Asedco compost. Based on the typical range mentioned by Alexander, 1994of (45-50%), none of the studied composts are within this range.

The bulk density showthat the highest was obtained from Fakieh compost (1.28 gm/cm3) and the lowest one was from Asedco compost (0.16 gm/cm3). It should be mentioned that the lower the bulk density the better the compost. Based on the typical range for bulk density given by Alexander, 1994 of (0.53-0.59 gm/cm3), none of the studied composts satisfy this range.

The particle size distribution and hence the inter-particulate porosity affect the balance between water and air content for each moisture level (Raviv *et al*., 1986). The best substrate is with medium to coarse texture, equivalent to a particle size distribution between 0.25 and 2.5 mm, which allows retention of enough readily available water together with adequate air content. On the other hand, Handreck (1983) studied the particle size and physical properties of container media and concluded that the fraction smaller than 0.5 mm, and in particular between 0.1 and 0.25 mm, has the highest influence on porosity and water retention. It should be emphasized that the smaller the particle sizes the better compost. Decreasing the particle size of the compost beside its higher organic matter content increases the contact area between the soil particles which constitute bigger aggregates and provide better structural soil stability.

It has been found from the current study in Table (5) that the composts ranged between 23.83% and 46.8% for the particle size between 0.425 mm to 2 mm. This range is not high enough to be the best according to Raviv *et al*., 1986. It has been also found that the percentage of compost below 0.25 mm ranges between 0.97 % in Gulf compost and 35.03% in Green Land. This range is also considered not enough according to Handreck (1983) and will not have a good influence on porosity and water retention.

The mean particle size distribution shows that the fraction between 4 and 6.3 mm (22.37%) was the most abundant, followed by the fraction between 2 and 4 mm which was rather coarse. Richards *et al*. (1986) defined a “coarseness index” as the cumulative volume percentage of particles larger than 1 mm. The average "coarseness index" expressed as weight percent in the samples (above the available size of 0.85 mm) was 61.45%, implying excessive aeration and low water retention (Benito, et al., 2006).

Table 4: Physical characteristics of the collected compost samples.

Compost brand	Bulk density (g/cm^3)	Water content (%)
Super Grew	0.42 d	42.45 b
Green Land	0.4 d	10.75 f
Mukhasib	0.34 e	21.85 d
Najoom –Al-Gharab	0.72 b	26.05 c
Asedco Compost	0.16 f	53.2 a
Al-Bustan	0.67 c	22.75 d
Gulf Compost	0.64 c	27.7 c
Fakieh Compost	1.28 a	14.15 e
$LSD_{0.05}$	0.03	2.14
Significance	**	**
Values followed by different letters are significantly different **significant at the 0.01 probability level		

Table 5: Particle size distribution ofthe collected compost samples.

Compost brand	>6.4 mm	6.3-4.0 mm	4.0-2.0 mm	2.0-1.7 mm	1.7-0.85 mm	0.85-0.425 mm	0.425-0.25 mm	<0.25 mm
	Weight %							
Super Grew	10.47	14.10	23.50	4.89	19.52	13.97	6.52	7.09
Green Land	5.08	4.76	5.85	1.36	9.63	19.33	18.59	35.03
Mukhasib	4.22	10.45	20.41	3.33	15.87	19.92	12.47	13.26
Najoom Al-Gharab	14.57	6.89	9.35	1.45	8.55	13.87	14.95	30.26
Asedco Compost	11.07	8.88	16.14	3.65	18.03	25.12	10.37	6.62
Al-Bustan	0.00	4.68	24.78	5.22	19.97	19.61	12.52	12.85
Gulf Compost	17.79	28.92	19.60	3.12	14.94	11.77	2.76	0.97
Fakieh Compost	0	100	0	0	0	0	0	0

The tables of the physical parameters shows that there is a highly significant difference among compost types with regard to bulk density, and Water content.

Chemical Analysis:

The results shown in table (6) indicate that the pH ranged between 5.68 in Gulf compost and 8.48 in Najoom Al-Gharabt. Only two types, Gulf compost (5.68) and Fakieh (5.98) are within the optimal pH range for growing media (5.2–6.3; Bunt, 1988). According to the typical ranges of test parameters in quality compost recommended by Alexander, 1994 (6.8-7.3) only 3 of the studied composts satisfy this range. The compost with high pH value obtained in the present study should be mixed with other materials when used with plants sensitive to alkaline conditions. Decreasing or increasing pH value over or below 7 may cause many problems specially the availability of the micro nutrients or toxic metals to the plants.

Composts should have low salinity because roots develop directly into them. The EC results of the current study ranged between 0.69 dSm^{-1} in Asedco compost and 38.55 dSm^{-1} in Mukhasib compost. This means that all the measured EC were higher than the established limit of (0.5 $dS\ m^{-1}$) for an ideal substrate (Abad et al., 2001) and the typical range mentioned by Alexander, 1994 of (0.35-0.64 dS/m^{-1}). In general, increasing in EC indicates that the salt concentration in the compost is high and may cause salinity problem in the soil.

The results of the current study show that the values of the organic matter are different among compost types. It ranged between 16.2% Najoom Al-Gharab and 83.12% in Asedco compost. Increasing organic matter content in the compost is considered one of the positive featuresbecausehigher organic matter enhances the physical properties of soil. Abad,*et al.* (2001) stated that a value for total organic matter above 80% should be adequate for potting media. This means that Asecdo compost is the only compost that satisfies these criteria. Based on the typical range for organic matter mentioned by Alexander, 1994 of (35-45%), only one compost type, Mukhasib, agreed with this range.

The total nitrogen (TN) content ranged between 0.47% (4.69 g/kg) in Najoom Al-Gharab and 3.19% (31.89 g/kg) in Fakieh Compost. According to the typical range indicated by Alexander, 1994 of (1.0-2.0%), none of the studied composts fall within this range. Since plants need large amount of Nitrogen fertilizers, the best compost is the one which contains high nitrogen content.

The C/N ratio,which indicates the maturity of compost, varied between 6.28 in Fakieh compost and 72.65 in Asedco compost. According to Rosen *et al.* (1993) a C/N ratio between 15 and 20 is ideal for ready-to-use compost. However, Inbar *et al.* (1990) cautioned that the C/N ratio is only one parameter by which maturity should be gaugedand specific chemical analyses are equally important. On the other hand, Benito *et al.*, 2003 recommended that a value of C/N around 30 should be sufficient to determine the maturity. According to the range of C/N values proposed by both authors, six of the current studied composts will be immature.

The results revealed that Phosphorus content in the investigated compost types ranged between 8.53 mg/kg in Asedco compost and 114.47 mg/kg in Gulf compost. According to the typical range mentioned by Alexander, 1994 (0.6-0.9%), none of the studied composts agreed with this range. It has been emphasised that increasing the availability of Phosphorus in the soil is required for maximum productivity.

The highest potassium content was found in the Super Grow compost (33.03 g/kg) and the lowest one was in Najoom Al-Ghareb (1.86 g/kg). According to the typical range mentioned by Alexander, 1994 of (0.2-0.5%), 5 composts were in agreement with this range.

The results of the extractable nutrient content in the current study (phosphorus and potassium) show direct correlation to the electrical conductivities measurements as shown inTable (6).All the measured parameters show highly significant differences among compost types.

Table 6: Means of chemical properties of the collected compost samples.

Compost brand	pH	EC (dSm^{-1})	Nitrogen (mg/kg)	Nitrogen %	Phosphorus (mg/kg)	Potassium (mg/kg)	Organic matter (%)	TOC (%)	Carbon / Nitrogen Ratio
Super Grew	6.95 e	20.7 c	5607.46 c	0.56	44.74 c	33033.03 a	34.42 b c	19.37	34.54 b
Green Land	7.47 c	2.64 g	7294.93 c	0.73	35.79 c	2582.58 e	30.23 Cd	15.51	21.39 d
Mukhasib	7.68 b	38.55 a	5971.46 c	0.60	32.88 c	24774.77 b	35.6 b	22.64	37.91 b
Najoom Al-Gharab	8.48 a	9.37 f	4689.07 c	0.47	47.82 c	1861.86 c	16.2 e	8.98	19.16 d
Asedco Compost	6.44 f	0.69 h	6021.87 c	0.60	8.53 d	2342.34 e	83.12 a	43.75	72.65 a
Al-Bustan	7.34 d	12.99 e	6283.2 c	0.63	94.91 a b	4357.36 d	26.28 d	13.14	27.38 c
Gulf Compost	5.68 h	15.5 d	21069.076	2.11	114.47 a	25375.17 b	34.59 b c	17.30	7.65 e
Fakieh Compost	5.98 g	23.35 b	31892 a	3.19	93.65 b	24024.02 b	33.92 b c	16.96	6.28 e
LSD 0.05	0.04	0.77	5872.2		20.62	2672.2	4.67		4.27
Significance	**	**	**	**	**	**	**	**	**

EC, Electrical conductivity; TOC, total organic carbon
Values followed by different letters are significantly different ($p < 0.05$)
**Significant at 0.01 probability level.

Micro-Nutrient in Different Type of Compost:

The results of the micro-nutrient compared with limits for compost proposed by Eu and USA compost standards, were presented in Table (7). The comparison shows that some of the studied composts have violated the limits of EU standards for Zn and Copper elements, as some European countries have strict regulation. The table also shows that there are highly significant differences for each element for the different composts.

Table 7: Means of Micro-Nutrient in different types of collected compost samples.

Compost brand	Micro-Nutrient		Toxic Metals			
	Zinc (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Cr (mg/kg)
Super Grew	245.61 e	54.74 e	9.22 d	2.41 d	30.27 d	24.38 d
Green land	45.11 g	56.54 d	9.72 c	2.21 f	28.87 e	26.96 f
Mukhasib	270.67 c	21.45 h	5.11 g	2.9 d	0.0 h	22.25 h
Najoom –Al-Gharab	60.15 f	57.94 c	10.42 b	1.8 g	0.7 g	30.67 e
Asedco Compost	60.15 f	23.76 g	0.0 h	2.51 e	16.14 f	26.17 g
Al-Bustan	716.79 a	122.41 a	24.26 a	4.51 b	127.51 a	229.17 a
Gulf Compost	516.29 b	61.85 b	8.62 e	5.21 a	49.52 c	42.61 c
Fakieh Compost	280.65 d	49.82 f	7.12 f	3.71 c	54.14 b	49.62 b
LSD 0.05	1.04	0.144	0.03	0.008	0.177	0.3
Significance	**	**	**	**	**	**
Heavy metals limit EU- Range (Brinton, 2000)	210 - 4,000	70 - 600	20 - 200	0.7 - 10	70 - 1,000	70 - 200
Heavy metals limit USA biosolids (Brinton, 2000)	2,800	1,500	420	39	300	1,200

Toxic Metals:

A major concern about heavy metals is that if their concentrations in edible portions of plants are excessively high, then there can be a danger to humans. A plant root mechanism operates to help protect the plant from high concentrations of some heavy metals. The plant will exhibit toxicity symptoms or even death before the heavy metal concentration would become high enough to be detrimental to the human food chain. However, some heavy metals exhibit an exception to the root barrier protection mechanism. They can be present at concentrations in the plant that would be harmful to human health without being toxic to the plant. In some plants, selenium can also accumulate to very high concentrations without showing toxicity.

Table (7) shows the results of toxic metals present in the studied composts compared with limits for compost proposed by Eu and USA compost standards. The comparison also shows some of the studied composts have violated the limits of EU standards for all the measured elements the limits of EU standards. The table also shows that there are highly significant differences for each element for the different composts.

Conclutions:

It has been concluded based on the obtained results that in the Western Region of Saudi Arabia the method of compost storage is unsafe; one fourth was mainly imported from Europe;78.5% think the price of compost is rather reasonable; there are many complaints from the used compost, 67% show the compost demand will increase in the future; the main variables positively and significantly affect the quantity of the used compost are winter season, cultivated area, number of nurseries and home gardens, in addition to the educational level, while the factors negatively affecting the quantity are the price and the unpleasant odor of the compost. Most of the measured physical and chemical parameters are not within the typical quality ranges of compost, the average “coarseness index” implying excessive aeration and low water retention. Three quarters of the current studied composts were immature. The micro-nutrient and toxic metals concentrations violated in some studied composts the limits of EU standards. Based on the obtained conclusions, improving the efficiency of the composting process, environmental awareness educational programs and quality control of composts are requested before supplying these materials to the market.

ACKNOWLEDGEMENT

The authors would to express their thanks and appreciation to the management of the Center of Research Excellence in Environmental Studies for their encouragement and financial support.

REFERENCES

Abad, M., P. Noguera, S. Burés, 2001. National inventory of organic wastes for use as growing media for ornamental potted plant production: case study in Spain. Bioresour. Technol., 77: 197-200.

Abad, M., P. Noguera, R. Puchades, A. Maquieira, V. Noguera, 2002. Physico-chemical and chemical properties of some coconut coir dusts for use as a peat substitute for containerised ornamental plants. Bioresour. Technol., 82: 241-245.

Alexander, R.A., 1994. Standards and guidelines for compost use, Biocycle, 35(12): 37-41.

Alredhaiman, K.N., 2013. International and National Trends in Organic Farming, Paper 51, International Conference on Agricultural Technologies in Arid Lands, March 19-21, KACST: King Abdul Aziz City for Science and Technology, Riyadh, Saudi Arabia.

Alsamarrai, H.S. and A.A. Alzaydi, 1996. A Practical Approach to Municipal Solid Waste Recycling in the Gulf Region, SADACA Environmental Group, Jeddah, Kingdom of Saudi Arabia.

Alzaydi, A.A., 1995. SKAB Company, Municipal Waste Characterization of 44 Districts in Jeddah City, Report Submitted to the Ministry of Municipalities and Rural Affairs, Jeddah, Saudi Arabia.

Alzaydi, A.A., 1996a. AZM Environment & Development Company, Municipal Waste Characterization at 7 District in Makkah City, Report Submitted to the Ministry of Municipalities and Rural Affairs, Jeddah, Saudi Arabia.

Alzaydi, A.A., 1996b. SKAB Company, Municipal Waste Characterization of 100 Districts in Riyadh City, Report Submitted to the Ministry of Municipalities and Rural Affairs, Jeddah, Saudi Arabia.

Alzaydi, A.A., 1998. SKAB Company, Additional Municipal Waste Characterization in Jeddah City, Report Submitted to the Ministry of Municipalities and Rural Affairs, Jeddah, Saudi Arabia.

Alzaydi, A.A. and S. Alsolaimani, 2012. Utilization of Organic MSW to produce Various Types of Compost in the Western Region, Kingdom of Saudi Arabia, FinalReport, contract No. 1/S/1, Center of Excellence in Environmental Studies, King Abdul Aziz University, Jeddah, Saudi Arabia.

Atiyeh, R.M., C.A. Edwards, S. Subler, J.D. Metzger, 2001. Pig manure vermicompost as component of a horticultural bedding plant medium: effects on physicochemical properties and plant growth. Bioresour. Technol., 78: 11-20.

Benito, M., A. Masaguer, A. Moliner, N. Arrigo, R.M. Palma, 2003. Chemical and microbiological parameters for the characterisation of stability and maturity of pruning waste compost. Biol. Fert. Soils, 37: 184-189.

Benito, M., A. Masaguer, A. Moliner, R. De Antonio, 2006. Chemical and physical properties of pruning waste compost and their seasonal variability. Bioresource Technology, 97(16): 2071-2076.

Bonnette, J. and R.E. Green, 1995. Report on the effectiveness of composts in stimulating tree seedling growth and reducing soil erosion. Clemson: U.S. Southeaster Forest Service.

Bremmer, J.M., C.S. Mulvaney, 1982. Nitrogen-total, in: Page, A.L., Miller, R.H., Keeney, D.R. (Eds.), Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties, Agronomy series No. 9 (second ed.), ASA, SSSA, Madison, WI, pp: 595-624.

Brinton, W.F., 2000. Compost Quality Standards and Guidelines (Final Report), Prepared for New York State Association of Recyclers in America. Report to NYSAR3 by Woods End Research Laboratory, Inc.

Bunt, A.C., 1988. Media and Mixes for Container-Grown Plants. (second ed.) Unwin Hyman Ltd., London, UK.

Cole, M.A., X. Liu and L. Zhang, 1995. Effect of compost addition on pesticide degradation in planted soils. In *Bioremediation of recalcitrant organics*. Edited by R.E.Hinchee, D.B. Anderson, and R.E. Hoeppel. Columbus: Battelle Press.

De Boodt, M., O. Verdonck, 1972. The physical properties of substrates in horticulture. Acta Hortic., 26: 37-44.

De Boodt, M., O. Verdonck, I. Cappaert, 1974. Method for measuring the water release curve of organic substrates. Acta Hortic., 37: 2054-2062.

Dhir, R.K., M.D. Newlands and J. Halliday, 2003. Recycling and Reuse of Waste Materials. Thomas Telford Publishing, Thomas Telford Ltd, London, UK.

El-Nakhlawy, F.S., 2008. Principles of Statistics, Experimental Design and Analysis in the Biological Experiments. Sci.Pub.Center, KAU, Jeddah, Saudi Arabia.

El-Nakhlawy, F.S., 2010. Experimental Design and Analysis in Scientific Research, Sci. Pub. Center, KAU, Jeddah, Saudi Arabia.

Handreck, K.A., 1983. Particle size and the physical properties of growing media for containers. Commun. Soil Sci. Plant Anal., 14(3): 209-222.

He, X., T.J. Logan, S.J. Traina, 1995. Physical and chemical characteristics of selected US Municipal solid waste composts. J. Environ. Qual., 24: 543-552.

Hoitink, H.A.J., A.G. Stone, D.Y. Han, 1997. Suppression of plant diseases by composts. Hort Science, 32: 184-187.

Inbar, Y., Y. Chen, Y. Hadar, H.A.J. Hoitink, 1990. New approaches to compost maturity. Bio Cycle, 31(12): 64-68.

Inbar, Y., Y. Chen, H.A.J. Hoitink, 1993. Properties for establishing standards for utilization of composts in container media. In: H.A.J. Hoitink, H.M. Keener (Eds.), Science and Engineering of Composting: Design, Environmental. Microbiological and Utilization Aspects, Ohio State University, USA, pp: 668-690.

Lynch, Mary, E., 1995. Report on Wetland restoration of barren flood area with the use of compost. Pittsburgh: National Recycling Congress.

Marvil, J., J. Pinochet and R. Rodriguez-Kabana, 1997. Agricultural and municipal composts residues for control of root-knot nematodes in tomato and peppers. Compost and Utilization, 5(1): 6-15.

Murphy, J., J.P. Riley, 1962. A modified single solution method for determination of phosphate in natural waters. Anal. Chem. Acta, 27: 31-36.

Pfafflin, J. and E. Ziegler, Ed., 1992. Encyclopaedia of Environmental Science and Engineering, Vol.1, A-I, Gorden and Breach Science Publishers, Philadelphia, USA.

Raviv, M., Y. Chen, Y. Inbar, 1986. Peat and peat substitutes as growth media for container-grown plants. In: Y. Chen, Avnimelech (Eds.), The Role of Organic Matter in Modern Agriculture, Martinus Nijhoff Publishers, Dordrecht, pp: 257-287.

Richards, D., M. Lane, D.V. Beardsell, 1986. The influence of particle-size distribution in pinebark: sand: brown coal potting mixes on water supply, aeration and plant growth. Sci. Hortic., 29: 1-14.

Rosen, C.J., T.R. Halbach, B.T. Swanson, 1993. Horticultural uses of municipal solid waste components. Hortic. Technol., 3: 167-173.

Weston, R.F., Inc, 1993. Windrow composting demonstration for explosives-contaminated soils at the Umatilla Depot Activity. Hermiston. Document No: CETHA-TS-CR-93043.

WHO International Reference Center Disposal, 1978. Methods of analysis of sewage, sludge, wastes, solid wastes, and compost, Dubendort, Switzerland.