Proposal for Sustainable Soil Production in Desert Areas : Producing Compost with Materials Procured Locally

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Abstract

Desertification is one of the environmental problems facing the planet today. Developing countries affected by desertification must also cope with difficult social problems such as rapid demographic growth. In other words, as desert land is an extremely unfavorable environment for productive activities, there is an urgent need to increase food production in those countries.

There are roughly two categories of policies for incresing food production. The first one consists of "improving the profitability of presently available land" and the second one, "securing new land."

We examine the case of Egypt, a country affected by the problems mentioned above.

In this experiment, we used organic manures made from trash compost, water hyacinths or tomato residues. These fertilizers are completely different from industrial fertilizers. The main feature of organic manure is that it can contribute to improved soil quality. In particular, the composts produced for the experiment meet Egypt's quality standards and are expected to contribute considerably to crops in quantitative terms.

An analysis of the composts revealed that each had its own features. Better results could be obtained if each type of compost were used in the most suitable way.

The next step will be to perform cultivation tests using composts that have been specially produced for this purpose. As the production of compost requires heavy work, showing the results (better crops) to the farmers seems the best way to promote the use of compost.

Key words : compost, desertification, tomato residues, trash, water hyacinths.

1. Introduction

Presently, a demographic explosion is taking place in developing countries. It is therefore necessary to increase food production to meet rising needs. There are roughly two categories of policies for increasing food production. The first one consists of "improving the profitability of presently available land" and the second one, "securing new land."

Improvement of plants and the agricultural environment - soil, water supply, etc. - are possible ways to raise profitability. However, as the El Niño phenomenon has pointed out, the natural environment has been undergoing profound changes in recent years, which have been affecting the agricultural environment.

As for new land, there are in most cases reasons unexploited arable land has not been farmed, such as the exclusion of human activities for environmental reasons. However, it can be said that all arable land has been developed. Let us examine this issue, taking the example of Egypt.

The Nile and its delta provide Egypt with one of the world's best environments for agriculture, which brought the ancient Egyptian civilization prosperity. Like other countries, Egypt has to cope with rapid population growth. As the Nile delta did not suffice anymore to feed the whole population, the Egyptian government opted for the conquest of new land. It was desert land, which had never been farmed before due to poor conditions. As part of a national project, agricultural waterways were drawn from the Nile to the desert land so as to create minimum conditions to turn the environment into arable land. Egypt now hopes that this newly cultivated area will help solve the nation's food problems.

If human and water resources have been made available in Egypt's desert lands, nothing has been done regarding the soil. Farmers are just doing the only thing they know, that is using chemical fertilizers. These poor farmers do not have the financial resources necessary to give enough nutritious substances to the land (money to purchase earth and fertilizers). As the soil is extremely degraded desert land, something has to be done to ensure successful crops and sustainable farming.

Agriculture is based on three fundamental factors : "land, water and people." If one of these elements happens to be missing, it is a great obstacle to agricultural activities.

As we explained above, the water factor depends on material efforts, that is, the securing of water resources and financial investments.

The human factor can easily be solved, as demographic growth is the original problem. Settlers or farmers living in nearby areas can be recruited. It would even be a positive measure in terms of job creation.

However, no concrete measures have been put forward as far as soil creation is concerned. Addressing this issue is essential to the success of the endeavor.

In this chapter, we examine the possibility of using local materials that can contribute to soil improvement. More specifically, we examine compost production based on local materials and its use in restoration of the soil.

In particular, nitrogen in the soil is a good indicator of soil fertility, along with phosphoric acid. Let us focus on nitrogen contained in the soil of the desert land. The total carbon/total nitrogen (C/N) ratio will be used as an indicator, which will give us quantitative information on the formation of nitrogen in the soil and its relation with crops.

C/N varies widely depending on the organisms contained in the soil. For example, if C/N is high (20 or more), at the time of decomposition, organic nitrogen in the soil is used by microorganisms, thus depriving crops of nitrogen intake. On the other hand, if C/N is low (10 or less), organic nitrogen is rapidly released by organisms and can be thus supplied to the crops. In Japan, a C/N of 30-40 is usually considered appropriate. As the soil is generally rich in Japan, creation of an environment which is favorable for microorganism activity in order to avoid an excess of nitrogen is seen as a prerequisite. Another reason C/N stands at a high level in Japan is that periodic rainfalls make it easy for nitrogen fertilizers to mix in the soil.

On the other hand, in arid regions, as it is hard for microorganisms to live, decomposition of organic nitrogen is extremely slow. As a result, humus particles tend to accumulate on the surface and disappear due to erosion. Moreover, as rainfalls are scarce, nitrogen fertilizers do not mix in the soil.

As the soil is extremely poor and lacks nutrients, C/N shonld be at a very low level so that the necessary amount of organic nitrogen can be easily provided to the crops.

Therefore, we can surmise that C/N, an indicator of soil quality, stands at 1-25 (JICA 1995) in Egypt's arid lands, which is much lower than in Japan.

Our report focuses on the production of compost from materials easily provided by farmers in Egypt's arid lands. We will also formulate a proposal for the efficient and sustainable production of compost so as to improve the soil in these desert areas in the future.

2. Materials and Methods

2.1 Materials

(1) Trash

One and half tons of sorted municipal solid wastes (trash) were obtained from the Alexandria Compost Plant. Sorting of non-compostable materials was carried out before forming the heap. The heap was completely turned three times during the fermentation period (5 weeks), and turned one time during the maturation period (4 weeks). The process of decomposition in this trial was almost complete after 9 weeks.

(2) Water hyacinth & tomato residues

A Half ton (500 kg) of water hyacinths was obtained from the bank of the Nile river at El-Kanater El-Khayria, and formed into the first heap. Another half ton of tomato residues was obtained from the wastes of tomatoes cultivated at the farm in the previous year, and formed into the second heap. The two heaps were completely turned 6 times during the fermentation period (6 weeks). The process of decomposition in this trial was almost complete after 11 weeks.

2.2 Site preparation :

Site preparation for a heap operation is a relatively simple step. A hard, solid, level ground area should be provided to prevent drainage of surplus liquids. Although theoretically no drainage or seepage should come from the piles, arrangements should be made for intercepting and collecting seepage if it should occur. Ideally, but not necessarily, the prepared area should be sheltered by a roof. Roofing is especially appropriate where winters are characterized by heavy rains.

2.3 Layout of the experiment :

(1) Trash

Domestic wastes were obtained from the Alexandria Compost Plant, and upon arrival, the wastes were discharged at the site. Stones, glass, crockery, tins and other solid indigestible materials were picked out before forming the heap. The following table shows the composition of the wastes and quantities of its components :

Table (1)

Component	Weight composition
Vegetables & Putrescibles	73.07%
Mixed Paper	0.06%
Textiles and Bones	0.02%
Mixed Glass	0.55%
Mixed Plastics	0.09%
Ferrous Materials	0.06%
Inerts and Rejects	26.6%

(2) Water hyacinth & tomato residues

A weight of 1500 kg of the sorted wastes was used in forming the heap. The heap was formed on the surface of the ground as evenly as possible by alternate layers of wastes. Ammonium nitrate (15 kg) and superphosphate (10 kg) were added to the heap to accelerate the composting process and enrich the produced compost with nitrogen and phosphorus. Each layer received an appropriate amount of the mineral fertilizers and water and was left to ferment. The heap was 2.25 m long, 1.0 m wide and 0.8 m high. The heap was established in 1998, commencing with the start of the fermentation period, which lasted for 4 weeks. The maturation period started on 12/10/98 and lasted for another 5 weeks. The heap was turned three times during the fermentation period and once during the maturation period to ensure an aerobic process. The composting process in this trial was complete after 9 weeks. The compost produced was sieved by a 2 cm diameter screen (table (4)).

2.4 Sampling

The temperature inside the heap was determined daliy (by thermometer) at the site. Samples for moisture determination were taken before every turning of the heap. The volume of the heap and the weight per cubic meter, along with estimation of chemical analyses, were determined at the start when forming the heap, at the end of fermentation period (after six weeks for trash ; after four weeks for water hyacinth & tomato residues) and at the end of maturation period (after eleven weeks for trash ; after nine weeks for water hyacinth & tomato residues).

2.5 Chemical analyses :

Chemical analyses were carried out at the laboratories of the Soil, Water and Environment Research Institute, Agriculture Research Center.

The chemical determinations included :

- Moisture content : representative laboratory samples of about 300-500 grams were weighed on a weight tin plate. The plates were put into a ventilated drying oven at 105°C for about 18 hours. After samples had been dried to a constant weight, moisture content percent was calculated.
- Organic matter (volatile solids) and ash, according to WHO 1978.
- Total nitrogen : the total nitrogen content of the pulverised laboratory oven dry samples was determined by the macro-Kjedahl method using Gerhardt kieldatherm as the method described in Black *et al.*, 1965.
- Carbon dioxide : carbon dioxide was monitored in the compost using a Fyrite Analyser.

3. Observations & Results

3.1 Temperature of the heap :

Figure (1) shows temperature changes during the composting process by the aerated pile method. During the composting process in compost heaps or windrows, the temperature is considered to be a reflection of the metabolic activity of the microbial populations involved in process (Finstein & Morris, 1975). The temperature in the compost heap increases during the first few days, remains between 60 and 70°C for several days and then decreases gradually to a constant temperature (Golucke, 1978 ; Harada *et al.*, 1981). Consequently this parameter may be considered a good indicator of the end of the bio-oxidative phase in which the compost achieves some degree of maturity. On this point Stickleberger (1975) stated that a compost is matured enough when its temperature remains more or less constant and does not vary with the turning over of the material. Raising heat in the decomposing mass is essential for two main reasons :

A sufficiently high temperature of the mass is required for a long enough period in order to destroy pathogens. In fact pathogens are killed not only by high temperatures, but also by the formation of antibiotic substances in the composting mass.

3.2 Odor :

The generally unpleasant odor of domestic refuse decreases during the first stages of the aerated composting process and practically disappears by the end of the composting process.

3.3 Color

(1) Trash

During composting of domestic refuse, a gradual darkening of the material takes place. The final product, after a sufficiently long period of maturation, is a dark brown color.

Remarks : Through the third turning some spots in the heap were black as a result of compactness in these spots but they subsequently disappeared.

(2) Water hyacinth & tomato residues

During composting of water hyacinth and tomato residues, a gradual darkening of the material takes place. The final product, after a sufficiently long period of maturation, is a dark brown color.

3.4 Reduction in Volume of Wastes :

In situations where refuse with a particularly high content of organic/vegetable matter is to be handled, one might expect a correspondingly higher output of compost. Due to the high moisture content of such organic matter, however, this tends rather to result in additional process losses through evaporation.

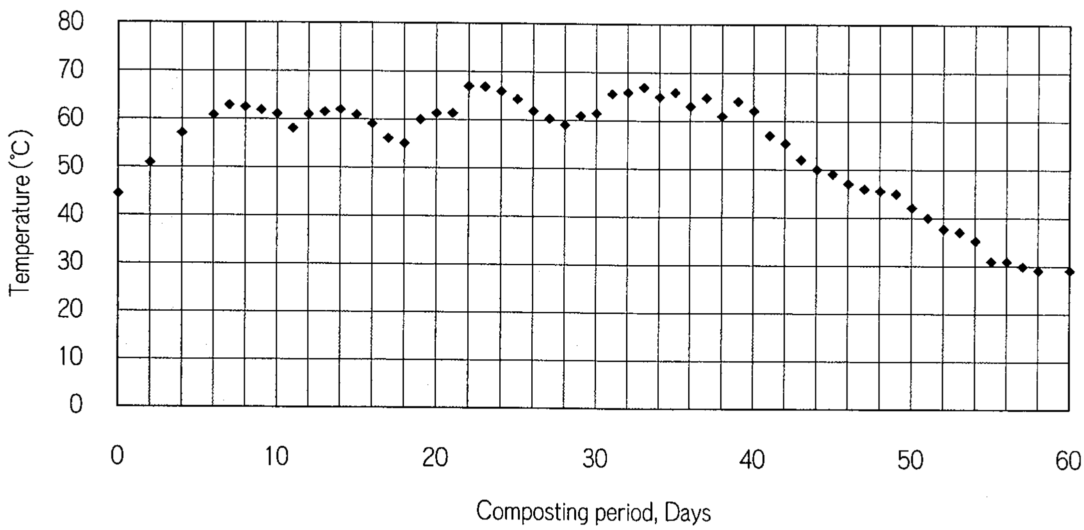

Figure (1) : Temperature changes during the composting process of trash

Table (2) : Changes in the moisture content and volume during the composting process of trash

	Date of turning	Periods (Days)	Moisture Content (%)		Height (cm)		Volume (m^3)	Volume Reduction (%)
			Before Turning	After Turning	Before Turning	After Turning		
Initial	Fresh waste 16.9.98	Initial	35.8	55.0	80	80	1.8000	
Fermentation	First turning 24.9.98	9	30.9	54.1	60	70	1.3500	25.0
	Second turning 1.10.98	16	37.8	53.9	60	70	1.3500	25.0
	Third turning 12.10.98	27	*	40.6	55	70	1.2375	32.25
Maturation	Fourth turning 28.10.98	43	25.8	38.6	55	70	1.2375	31.25
	Maturation	61	25.8	—	55	—	1.2375	31.25

Table (3) : Chemical changes during the composting process of trash

Determination data	Density (kg/m^3)	Moisute Content (%)	Nitrogen			%		C/N ratio
			Total (%)	ppm NH_4	ppm NO_3	Organic Matter	Organic Carbon	
Fresh waste 16.9.98	827	35.8	0.8486	197	0.0	39.67	23.00	27.1 : 1
After mixing 24.9.98	860	30.9	0.9036	1150	9.8	38.06	22.08	24.4 : 1
After fermentation 28.10.98	892	38.9	0.9791	1769	0.0	30.72	17.82	18.2 : 1
After maturation 16.11.98	1004	25.8	0.9981	1105	293	21.42	12.42	12.4 : 1
After screening 7.12.98	910	23.4	0.7599	858	445	16.76	9.72	12.8 : 1

Table (4) : Chemical changes during the composting process

Residues	Determination Date	Density (kg/m^3)	Moisture Content (%)	Nitrogen			%		C/N Ratio
				Total (%)	ppm NH_3	ppm NO_3	Organic Matter	Organic Carbon	
Water Hyacinth	Fresh	680	64.4	1.38	67	30	76.26	44.22	32.1 : 1
	After fermentation	510	56.1	1.46	108	22	50.21	29.12	19.9 : 1
	After maturation	480	48.2	1.48	70	63	47.30	27.43	18.5 : 1
Tomato	Fresh	710	54.6	1.96	120	100	83.64	48.51	24.8 : 1
	After fermentation	450	55.0	1.83	158	69	57.42	33.30	18.2 : 1
	After maturation	460	45.3	1.79	91	120	52.10	30.22	16.9 : 1

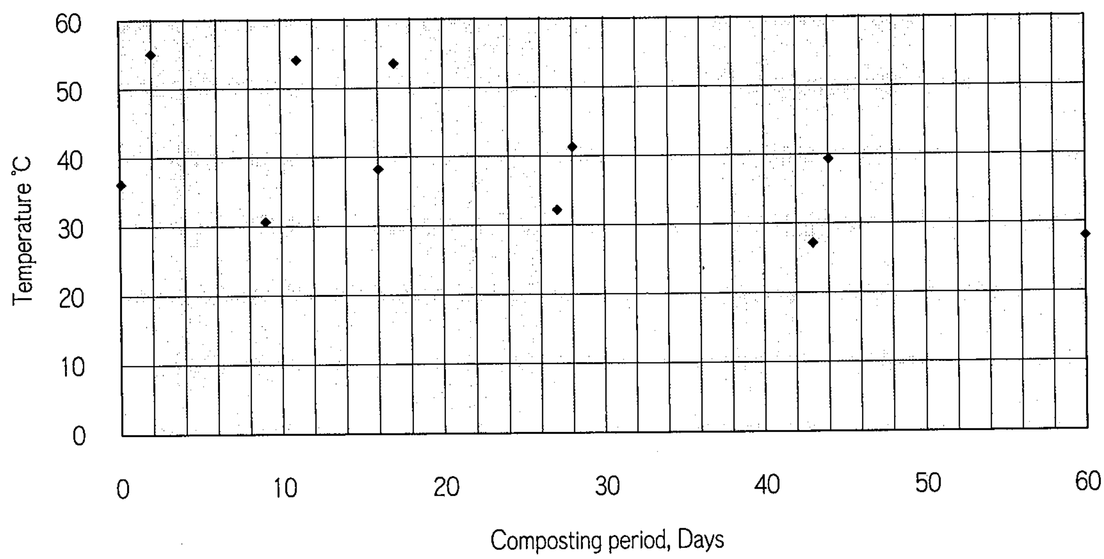

Figure (2) : Average moisture content during the composting process of trash

3.5 Moisture content

Water is a basic requirement for the metabolism of micro-organisms. The optimum moisture content of refuse prepared for composting is highly dependant on the composition of the incoming refuse. In general, biological activity is greatly reduced at moisture content below about 30%, whereas at levels above about 70%, anaerobic conditions are likely to be created. Tables (3) and (4) show the changes in moisture content throughout the composting process. Water is added to the heap at regular intervals (during turning) to maintain optimum moisture levels for the biochemical reactions. Moisture content decreases during the maturation period to about 20% in the end product (Fig (2)).

3.6 Carbon dioxide :

Carbon dioxide is a by-product of the aerobic composting process, and therefore it is an indicator of an aerobic process and must be tested. An excess of CO_2 suffocates microorganisms, which means a 20% volume of CO_2 is the absolute maximum. Also, when CO_2 reaches 20%, it means that the process is leading to putrefaction of nitrogen compounds and bad smells, ammonia and hydrogen sulfide will appear.

3.7 Chemical changes :

Nitrogen is the main nutrient required by microorganisms in the assimilation of the carbon substrate in organic wasted. Phosphorus, potassium and other trace elements also play a significant role in cell metabolism. For composting however the carbon/nitrogen (C/N) ratio is particular importance, as the other nutrients are usually available in refuse in more than sufficient quantities.

Research on nitrogen availability in relation to the carbon substrate, indicates that the C/N ratio should be in the range of 25-35 : 1 to achieve favorable conditions for refuse composting. Higher values tend to slow the rate of decomposition, whereas lower values result in nitrogen losses through mineralization into nitrogen compounds such as ammonia.

Results of analysis of nutrient changes during the composting process are illustrated in Tables (3) and (4).

4. Discussion

Organic manures made from trash compost, water hyacinth or tomato residues, are completely different from industrial fertilizers. The main features of organic manures are mentioned below. Their most notable characteristic is that they can contribute to improved soil quality (Takenori Yamaguchi, Shuji Yamakawa, Noriko Oura, 1998).

- Contributing to the supply of organic matter for humus formation
- Improving the pH value of soils
- Providing essential macro-and trace elements
- Improving the capacity of the soil to bind and retain nutrients
- Encouraging the propagation of soil micro-organisms
- Increasing the volume of the soils
- Improving soil aeration
- Making heavy soils easier to work
- Improving the water-retaining capacity of soils
- Reducing soil erosion

The use of compost is an efficient way to solve soil problems in desert lands.

The composts produced in the experiment had a C/N ratio of 20 or less, which thus meet Egyptian standards. As already explained, it is preferable to have a lower C/N ratio in desert lands than in Japan. This factor should have a positive impact on crops in quantitative terms.

The manures were roughly divided into 3 categories : trash compost, water hyacinth compost and tomato residues.

Water hyacinth and tomato residues had a higher water content. Therefore, in terms of soil moisturizing, water hyacinths and tomato residues were more effective in desert lands. The percentage of organic matters was also 3 times higher in water hyacinth compost and tomato residues compared to trash compost. The first two types of compost appear thus better options for improving soil quality in degraded desert lands.

However, trash compost has a lower C/N ratio and, therefore, should act faster on crops. According to the results of the experiment, trash compost should be used if increasing crops in the short term is the goal. Howerer, if the objective is to gradually improve desert land, weter hyacinth compost and tomato residues are better alternatives.

Another vital point is to use composts that fit the desert land, while gradually gaining a better understanding of the features of the various types of compost.

The next step is to perform cultivation tests using composts that have been specially produced for this purpose. As the production of compost requires heavy work, showing the results (better crops) to the farmers seems the best way to spread the use of compost.

In this experiment, we used compost made from trash, water hyacinths and tomato residues, but we need to study the possibility of using other types of compost (manures containing cattle or poultry excrements, a percentage of each ingredient and so on) and make comparisons in terms of economic viability and working hours.

While making a big contribution to the soil in desert lands, this series of experiments should also help form a sustainable society based on permanent cultivation and recycling (Bill Mollison, 1991).

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