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Organic Fertilizer Production from City Waste : A Model Approach in a Southeast Asian Urban Environment

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INTRODUCTION

According to projections of the United Nations, about 67 % of the overall world population will reside in urban areas by the year 2025 compared to 50 % only in 1995 (UNFPA, 1996) Particularly in low-income countries, city administrations are faced with huge challenges, among those the proper disposal of an abundance of refuse from households, commerce and industry by safe means, and the sufficient supply of cheap but nutritious food rich in vitamins and minerals to feed the population of these expanding urban centers.

In European countries, the daily average production of garbage is about 3 to 5 kg per capita. In developing countries the amounts are smaller, about 1 to 1.5 kg daily. However, due to logistical constraints, garbage disposal is generally considered as a major source of ecological problems such as release of bad odor, occurrence of flies, as well as contamination of the underground aquifer by nitrate, heavy metals and bacteria. The percentage of organic materials in city waste of developing countries reaches up to 80%(Katzir, 1996) which can be used for organic fertilizer production if appropriate technologies are available.

Composting is basically a process for decomposition of organic solid wastes (Airan and Bell, 1980). The decomposition process is accomplished by various microorganisms including bacteria, actinomycetes and fungi. In the process of composting, microorganisms break down organic matter and produce carbon dioxide, water, energy in forms of heat humus, and the relatively stable organic end product (Rynk *et al*., 1992)

Under optimal conditions, composting proceeds through three phases:

- the mesophilic, or moderate-temperature phase,
- the thermophilic, or high-temperature phase,
- a cooling and maturation phase.

Different communities of microorganisms predominate during the various composting phases. Innitial decomposition is carried out by mesophilic microorganisms, which rapidly break down the soluble, readily degradable compounds. The heat they produce causes the compost temperature to rapidly rise. As the temperature rises above 40°C, the mesophilic microorganisms become less competitive and are replaced by others that are thermophilic. At temperatures of 55°C and above, many microorganisms that are human or plant pathogens are destroyed. During the thermophilic phase, high temperatures accelerate the breakdown of proteins, fats, and complex carbohydrates like cellulose and hemicellulose, that are the major structural molecules in plants. As the supply of

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these high-energy compounds becomes exhausted, the compost temperature gradually decreases and mesophilic microorganisms once again take over for the final phase of maturation of the remaining organic matter (Golueke, 1972; Rymshaw *et al.*, 1992)

Of the many elements required for microbial decomposition, carbon and nitrogen are the most important. Carbon provides both an energy source and the basic building block making up about 50% of the mass of microbial cells. Nitrogen is a crucial component of proteins, nucleic acids, amino acids, enzymes and co-enzymes necessary for cell growth and function. The ideal C/N ratio for composting is generally considered to be around 30:1 by weight. At lower ratios, nitrogen will be supplied in excess and will be lost as ammonia gas, causing undesirable odors. Higher ratios mean that there is not sufficient nitrogen for optimal growth of the microbial populations, So the compost will remain relatively cool and degradation will proceed at a slow rate (Rymshaw *et al.*, 1992). In general, materials that are green and moist tend to be high in nitrogen, and those that are brown and dry are high in carbon. High nitrogen materials include grass clipping, plant cuttings, and fruit and vegetable scraps. Brown or woody materials such as rice straw, corn cobs, wood chips, and sawdust are high in carbon (Table 1).

As composting proceeds, the C/N ratio gradually decreases from 30:1 to 10-15:1 for the finished product. This occurs because each time that organic compounds are consumed by microorganisms, two-thirds of the carbon is given off as carbon dioxide. The remaining third is incorporated along with nitrogen into microbial cells, then later released for further use once those cells die (Golueke, 1972)

Another essential ingredient for successful composting is oxygen. As microorganisms oxidize carbon for energy, oxygen is used up and carbon dioxide is produced. Without sufficient oxygen, the process will become anaerobic and produce undesirable odors, including the rotten-egg smell of hydrogen sulfide gas (De Bertoldi *et al*., 1989)

Adequate amounts of phosphorus, potassium, calcium and trace minerals such as iron, boron, copper, and others are essential to microbial

Table 1 C/N ratio of different organic materials (Dickson *et al*., 1991).

Materials high in Carbon	C/N
straw	40-100:1
wood chips or sawdust	100-500:1
bark	100-130:1
mixed paper	150-200:1
newspaper or corrugated cardboard	560:1
Materials high in Nitrogen	**C/N**
vegetable scraps	15-20:1
coffee grounds	20:1
grass clippings	15-25:1
manure	15-25:1

metabolism. The mineralization of organic P in organic wastes differs widely. depending on the form and the percentage of P or C:P ratio (Bowman and Cole, 1987). P is a structural component of many biochemicals (nucleic acids, co-enzymes, phospho-proteins and phospho-lipids). Consequently, both plants and soil organisms actively compete for P as orthophosphate in the soil solution. Mineralization of organic P depends primarily on the activity of soil microorganisms, however, also invertebrates, especially earthworms, have an important regulatory function in this process. Surface casting earthworms can increase the short-term availability of P in plant residues by 2- to 3-fold through the release of inorganic P in plant material by physical disruption which is especially important in soils of low P status (Mansell *et al*., 1981). The net functional contribution of invertebrates, however, depends largely on their ability to stimulate microbial activity (Hutchinson and King, 1982).

A pH between 5.5 and 8.5 is optimal for compost microorganisms. As bacteria and fungi digest organic matter, they release organic acids. In the early stages of composting, these acids often accumulate. The resulting drop in pH encourages the growth of fungi and the breakdown of lignin and cellulose. Usually the organic acids become further broken down during the composting process. If the system becomes anaerobic, however, acid accumulation can lower the pH to 4.5, severely limiting microbial activity. In such cases, aeration usually is sufficient to return the compost pH to acceptable ranges (De bertoldi *et al*., 1989).

Microbial activity generally occurs on the surface of the organic particles. Therefore, decreasing particle size, through its effect of increasing surface area, will encourage microbial activity and increase the rate of decomposition. On the other hand, when particles are too small and compact, air circulation through the pile is inhibited. This decreases O_2 available to microorganisms within the pile and ultimately decreases the rate of microbial activity.

MATERIALS AND METHODS

In cooperation with the city government of Cagayan de Oro, Southern Philippines, fruit and vegetable leftovers from public markets are segregated by the market vendors, collected and delivered to the research location. In the experiments, organic farm residues (plants and animal manures), agro-industry refuses (coffee sludge and coffee ground) as well as local rock phosphate are added to the city waste in different combinations to investigate the effects on compost maturity and compost quality.

The maturity of the composts is determined by monitoring of compost temperature and compost pH (Popp, 1997), as well as by seedling germination tests (Zucconi *et al*.,) The finished compost is analyzed for organic matter and nutrient contents as well as for heavy metal residues.

Composting is recognized as an environmentally beneficial activity. However, inappropriate composting technologies can result in ecological disturbances, particularly the release of foul odors due to anaerobic decomposition or the leaching of nitrate into the groundwater. Procedures to optimize the aeration of compost heaps and to minimize the leaching of nitrate, especially during rainy season, are additionally investigated.

EXPECTED RESULTS

The following results will be available at the end of the project:

- economical and environmentally friendly procedures to produce compost from city waste of standardized quality in a tropical urban environment are developed,

- standards to detennffie compost maturity under the local conditions are known,
- an inventory of materials suitable for composting is established.

Further trials will be conducted to determine the inorganic fertilizer equivalencies of city-waste-compost (expressed in terms of inorganic N, P and K equivalents) used as organic fertilizer for vegetable production in tropical urban environments. Nutrient cycling studies of N, P, and K in representative vegetable sequences (Solanaceae, Brassicaceae, and Legumes) with special emphasis on the fate of N in plant tissue, soil and water will be done.

LITERATURE CITED

Airan D. S. and J. H. Bell. 1980. Natl. Waste Process. Conf.,pp 121-129. Washington D.C. Am. Soc.Mech. Eng., New York.

Bowman R.A. and C.V. Cole. 1978. Soil Sci. 125:49-54.

De Bertoldi M., M.P. Ferranti, P. L'Hermite and F. Zucconi. 1989. Elsevier Applied Science, London.

Dickson N., T. Richard and K. Kozlowski. 1991. Northeast Regional Agricultural Engineering Service, Cornell University, 152 Riley-Robb Hall, Ithaca, NY.

Golueke C.G. 1972. Rodale Press, Emmaus, PA.

Hutchinson K.J. and K.L. King. 1982. *In* K.E. Lee (ed.). Proc. 3rd Australasian Conf. Grassl. Invert. Ecol., South Australian Govt. Printer Adelaide, 331-338.

Katzir R. 1996. Workshop on Market Gardening, Farm Associations, and Food Provision in Urban and Peri-Urban Africa. Netanya, Israel, June 23-28,1996.

Mansell G. P., J. K., Syers, and P. E. H., Gregg. 1981. Soil Biol. Biochem. 13:163-167.

Popp L. 1997. Shaker Verlay Anchen.

Rymshaw E., M.F. Walter and T.L.Richard. 1992. Dept. of Ag. & Bio. Eng., Cornell University, Ithaca, NY.

Rynk R., M. van de Kamp, G.B.Wilson, M.E. Singley, T.L. Richard, J.J. Kolega, F.R. Gouin, L. Laliberty, Jr., K. Day, D.W. Murphy, H.A.J. Hoitink and W.F. Brinton. 1992. NRAES, Cornell University, Ithaca, NY.

UNFPA. 1996. United Nations, Geneva.

Zucconi F., A. Monaco, M. Forte and M. de Bertoldi. Biocycle 22:27-29.