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COMPOSTING IN BANGLADESH

Md. Mofakhrul Islam Shah
October 2015

LIST OF ABBREVIATIONS

BARI	:	Bangladesh Agricultural Research Institute Bangladesh
BBS		Bureau of Statistics
BAU	:	Bangladesh Agricultural University
BSMRAU	:	Bangabandhu Sheikh Mujibur Rahman Agricultural University
BSS		Bangladeh Sangbad Sangstha
CCAC	:	Community Care Access Centre
CCDB	:	Christian Commission for Development in Bangladesh
CMES	:	Centre for Mass Education in Science
FAO	:	Food and Agriculture Organization
GKSS	:	Grameen Krishok Shohayak Sangstha
GS	:	Grameen Shakti
IAPP	:	Integrated Agricultural Productivity Project
IGES	:	Institute for Global Environmental Strategies
NATP	:	National Agricultural Technology Project
RDA	:	Rural Development Academy
RDRS	:	Rangpur Dinajpur Rural Service
RUSTIC	:	Rural Unfortunates Safety Talisman Illumination Cottage Solid
SSB		State Bioconversion
UNCRD	:	United Nations Centre for Regional Development

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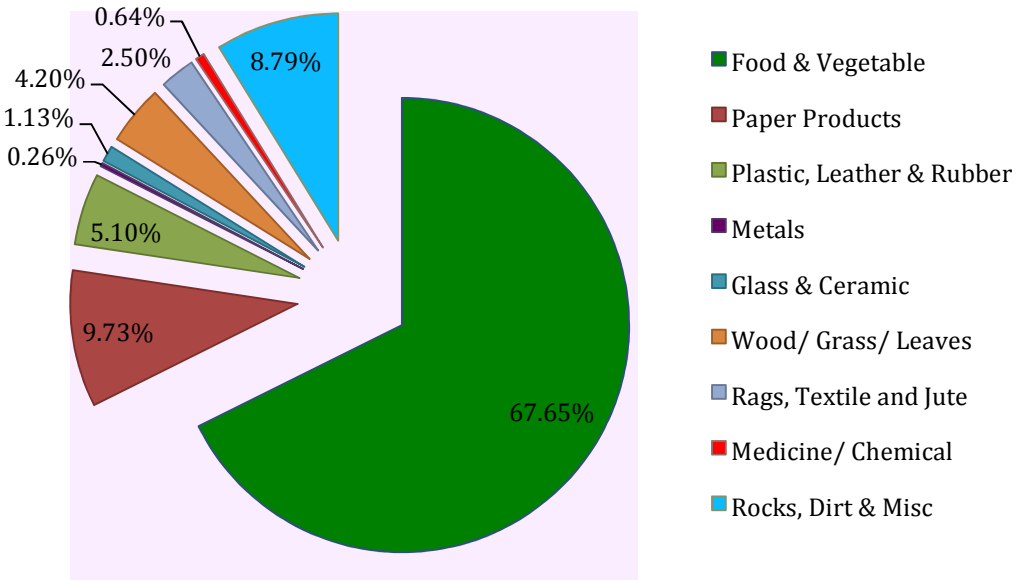
INTRODUCTION

The term ‘Composting’ was appeared first in the English language in 1587 and the verb ‘to compost’ in 1757 (Mish, 1988) was cited by Fitzpatrick et al. (1998). Composting refers to the biodegradation/bioconversion process, which is controlled by bio-oxidative activities. It is also refers to as an exothermal biological oxidation of organic matter by a group of different microorganisms. It involves a heterogeneous organic substrate, carried out through thermophilic phase and releases phyto-toxin, with leading to the production of carbon dioxide, water, minerals and stabilized organic matter (Haug, 1993 and Campbell et al., 1995). Composting is an aerobic biological process, naturally in which different microbes plays an active role to biodegrade the organic matter into humus, a relatively more stable product (Lau et al. 1992; Liao et al., 1993 and Georgacakis et al., 1996). Composting is generally considered advantageous over landfilling and incineration because of lower investment and operational cost, minimal environmental pollution, and beneficial use of the end product (Wei et al., 2000; Charest and Beauchamp, 2002). Composting process means of producing a valuable end product, by treating of organic wastes without causing a major disruption to the surrounding ecosystem. The product must have some economic values for agriculture use.

Composting is not an innovative process, it is quite old, but recently people interest has turned towards it. However, composting is not anything except bioconversion process (Boopathy, 2000). Recently, bioconversion or bioremediation is already recognized a safe, natural non-hazardous potential avenue of waste elimination (Colwell, 1994; Desai and Banat, 1997). Therefore, composting might be rejuvenated as tool of waste elimination by exploiting the principle of solidstate bioconversion (SSB) process. Baseline information on selected sector of waste (Waste Concern, 2009) is presented in Fig.1. It is also reported average per capita urban waste generation is estimated as 0.41 kg/capita/day and average per capita agricultural waste generation is estimated as 1.68 kg/capita/day (based on rural population in 2008). Agricultural waste is measured as 65 million metric ton annually.

Fig.1. Average Physical Composition of Urban Solid Waste



High organic matter	>>(more than 70%)
High moisture content	>>(more than 50%)
Low calorific value	>>(less than 1000 Kcal/Kg) Lack of space for disposal of solid waste

Bangladesh is predominantly an agro-based country. Agriculture is the mainstay of the Bangladesh economy and the means of support for the livelihood of the majority of the people. It accounts for 48.1% of national employment (Bangladesh Bureau of Statistics [BBS], 2011). In Bangladesh, the crops are cultivated in three different growing seasons as cited by Chowdhury & Hassan (2013) namely Kharif-I (mid March to mid July), Kharif-II (mid July to mid October) and Rabi (mid October to mid March). Intensive cropping practice is common in Bangladesh, which requires higher level of land fertility. In order to regenerate the fertility, farmers mostly rely on chemical fertilizers without or less application of compost. Out of the required chemical fertilizer, local manufacturers provide 77% and the rest 23% is imported from abroad (Mamun-ur-Rashid, 2013). Such a fertilizer management practice leaves a massive deterioration of soil fertility status resulting less than 2% organic matter content. In order to overcome this situation, composting/ vermicompsot has been loosely use as one of the feasible alternatives.

The following section outlines the present status of compost and composting technologies, organics recycling and organic waste to agriculture, and innovative programs and practices in composting for the agricultural sector in Bangladesh.

Composts and composting technologies currently being utilized by farmers, especially poor farmers in Bangladesh

Composting and uses of compost are being practiced in Bangladesh. No doubt it is the quite old practice for soil improvement and crop production. The use of compost fertilizers however are gaining popularity day by day amongst farmers in Bangladesh (BSS, 2015a). Once its uses were cramped with in the rural areas by poor farmers but recently its demand is gradually increasing and its circle is extended to peri urban and urban areas. Wherever it happens women are directly involved in the whole process. In rural areas, the reasons for practicing compost by the poor farmers are usually to protect their soil from ill effects of chemical fertilizer, avoid high priced inorganic chemicals and to ensure the use of a variety of available organic wastes. The organic wastes, which are usually generated, collected and compiled in household premise for composting, are:

- Crop residues
- Kitchen scraps
- Fruit and vegetable peels
- Grass clippings
- Dry leaves
- Twigs
- Hay
- Ashes
- Cow dung
- Farmyard manure
- Wastes from poultry and animal shade

These putrescible materials are being used traditionally for composting as they do not need (and are not willing) to spend extra money.

What composting technologies are being used by farmers, particularly the large number of poor farmers, in Bangladesh

Traditionally composting is practiced as 'trench and pit' systems and sometimes as 'static pile', and it takes six months to one year to be ready for application. Almost every farmer processes compost to his/her household premises in a small scale in order to use in the upcoming cropping season. Farmers are largely motivated to do composting especially for cultivating winter vegetables such as tomato, brinjal, cabbage, cauliflower, radish etc. Still farmers are not aware of and/or lacking in modern techniques of composting. They could not therefore exploit the full potentials of their resources and ultimately fail to get the maximum benefit. Large-scale production of compost/composting process is still missing in rural Bangladesh.

The picture of vermicompost is quite different, not common to every farmer. Although vermicompost has been widely used all over the world including neighbouring country India, it usage is limited to Bangladesh. Yet in Bangladesh, no remarkable research initiative has been made on vermicompost (Mamun-ur-Rashid, 2013). It is, however, becoming popular in farming community in some parts of Bangladesh (BSS, 2015_b). As cited by Mamun-ur-Rashid (2013), one of the farmers in Manikganj district secures bumper production of eggplants by using only vermicompost presented in Fig. 2. Yadav, Makin, & Khan, (2014) conducted a study on vermiculture technology and proved that nonpoisonous and environmental friendly vermicompost production has a great potential in Bangladesh by earthworm culture. The practice of vermicompost is progressing well in some specific areas of Bangladesh under the tutelage of the Department of Agricultural Extension. Alongside the men, women are also are involved in processing and practising vermicompost technology in rural Bangladesh as shown in Fig. 3.

Fig. 2 Eggplants are cultivated by using vermicompost only

Fig. 3. A woman is separating worms through sieving in Mymensingh District (left) while others are dealing with raw vermicompost in Nilpharmari district (right).

Existing example of good practices is prevalent in the areas of Meherpur district (West part), Mymensigh disctric (Middle) and Rangpur district (North) of Bangladesh.

What methodologies, what scale, who is doing it, what are they composting/vermicasting?

Farmers being trained by the Department of Agricultural Extension and some other NGOs practise vermicompost techniques as proposed by Uddin (2015).

Elements used for preparing vermicompost

- Two species of worms: Red Wigglers (Eisenia f*etida*) and Red Earthworms (Lumbricus *rubellus*)
- Cow dung (60 days of age)/ Household waste/ Straw/ Leaves and twigs Ring/ House (One feet high)
- Sprayer for sprinkling water
- Polyethene Sheet
- Sieve
- Bucket
- Shovel

Production technology

- Farmers first collect the desired amount of raw cow dung considering the capacity of their house. Then they placed the raw cow dung in the polyethene sheet or floor surface for sixty days in a pile covered with polyethene or sack. As a result partial decompose of the cow dung takes place and it becomes odorless.
- The house is then filled with processed cow dung leaving 2 inches blank on the top.
- Selective worms are released in the house. But the number of worms varies. In a favorable condition, 5000 worms can release 100 kg compost from 200 kg cow dung within 25-30 days. After releasing the worms, farmers lightly sprinkles water in the house. The use of water is critical; either too little or too much water may kill the worms.
- The house is built in a sunny place and fenced it with net to protect from natural enemies such as ants, termites, frogs, chicken and ducks, and other birds.
- The house is covered with sack in order to maintain the natural activities of the worms.
- During sieving if growers identify any other undesirable worms (other than the selective type), they drop it out for composting in the next.

Vermicomposting is currently being practiced by the farmers in 27 districts of Bangladesh under the National Agricultural Technology Project and Integrated Agricultural Productivity Project of the Department of Agricultural Extension (DAE). In order to promote the technology, DAE provides composting materials such as ring, cements, tin and worms to the poor farmers for preparing vermicompost. In addition to DAE, some other NGOs are also working with poor farmers including women to practice the vermicompost technology. For instance, Rural

Development academy intensively works in Bogra and Serpur districts, Unnyaon Dhara covers Dhaka region, CCDB works in Manikgonj, Centre for Mass Education in Science (CMES) and Annapurna Agro Service work in Nilphamari district and Hungers Banglasdesh covers all over the Bangladesh (Pers. Comm, Controll Room, DAE, 2015).

Is anyone using urban or peri urban organic waste?

There is no empirical evidence that farmers have started using urban and peri urban organic waste for their composting/vermicompost practices in Bangladesh yet. Around 40=60% of total generated urban wastes are collected for landfilling and dumping; the remaining are kept as open dumped were mentioned by Dhaka North City Corporation (DNCC) in 2007, which was reported by Climate and Clean Air Coalition (www.unep.org/ccac). The urban wastes composted organic substances however are mostly used by urban people in pot cultivation. Recently some NGOs come forward to handle. As reported by UNCRD (2010), the World's First Compost project has been established in Bulta, in the Narayanganj district with the objective of reducing the emission of 89,000 tonnes of green house gas (GHG) in the coming years. Vegetable wastes have been collected using the project's own transport networks and taken to the compost plants. Normally this organic waste is left behind in the city and on the landfill and causes flooding during the rainy season, health hazards and environmental pollution. The project will reduce methane gas (which is 21 times more harmful than CO_2) through managing daily waste of 700 tonnes and producing 50,000 tonnes of compost yearly. Besides, the project is said to create employment for 800 urban poor, including women.

Information about organics recycling and organic waste to agriculture in rural and periurban areas

Cropping intensity is too high in Bangladesh (174%) i, e. a single land is being utilized several times for crop production by the farmers. For these practices increased amount of chemical fertilizers, pesticides and herbicides are being applied for increased crop production. However, the rate of decreasing soil health is higher than the ongoing practices for its improvement. Therefore, it needs to take proper attention to sustain/or improve proper soil health for enhancement of crop growth and yield. The agricultural extension workers are alarming them about the terrible consequences of it and motivating them for using compost and green manuring for soil health improvement. Moreover, farmers are also well experienced about the negative impact of excessive uses of chemical fertilizers. But in reality, the agricultural extension workers do not have sufficient

sustainable technologies to back up farmers. Use of organic waste may be used as a supporting tool for land management and protecting and increasing the fertility of soil as well as agricultural production to the multiple extents (Uddin, 2015).

Identify and summarize Agricultural Extension work / programs focusing on composting and vermiculture, with a particular focus on poor farmers and/or women

There are several types of compost producers as reported by Rashid (2011) in Bangladesh. Mostly, compost has been produced by private companies like Annapurna Agro service, Waste Concern; autonomous organizations like Rural Development Academy (RDA); NGOs like Grameen Shakti (GS), Grameen Krishok Shohayak Sangstha (GKSS); research/academic institutes like Bangladesh Agricultural University (BAU), Bangladesh Agricultural Research Institute (BARI); and by farmers through traditional methods (mainly using cowdung and ashes). Therefore, by category, several actors are playing role in our compost market sector: entrepreneurs (eg. Achme Laboratories, Rash Agro Enterprise, Farmers), service providers (eg. RDA, GS, Paragon Agro, Rangpur-Dinajpur Rural Service), development facilitators (eg. donor agencies, Katalyst, Innovision Consulting Pvt. Ltd.) and research and extension institutes (eg. BAU, BARI, BSMRAU, RDA).

Recent activities/programs on composting and vermiculture by agricultural extension workers in Bangladesh however are not sufficient and well organized. As usual the agricultural extension workers are merely advocating to the farmers for improvement their soil health by application of compost and green manuring. Also farmers are following their advice to prepare compost but the practicing technique of composting is quite traditional and insufficient. In majority cases agricultural extension workers couldn't provide them any innovative techniques, necessary inputs, practical demonstration for composting process for enhancement of quality or value added compost. Extension workers however, do not have necessary skill and expertise on improved techniques of composting. There is therefore ample scope to help farmers including poor farmers and women by introducing proper project/program by the concerned authorities.

Comparatively the waste (including organic wastes) generation scale is higher in urban and periurban areas than the rural areas. Therefore, the scope of recycling wastes as compost in these areas is also higher than the rural areas. Extension workers activities in urban and peri-urban areas are not intensive as in rural areas. But in some peri-urban areas composting of urban organic wastes

are being practiced by some NGOs and commercial people. Most of them are practiced it as traditional methods of composting. Semi-improved technique is being practiced by few NGOs. Produced compost is utilized in homestead kitchen garden in peri-urban areas and pot cultivation and roof garden in urban areas. Sustainable composting project needs continuous supply of sufficient amount of decomposable organic wastes as inputs. By the establishment of well equipped composting and vermicomposting plant in peri-urban areas may ensure quality compost supply to all communities such rural farmers, farmers from peri-urban areas and the people who are uses for roof gardening and pot cultivation.

Identify programs/projects that include urban or peri-urban organic waste as an input. Uses of composted urban organic wastes for crop production by farmers are rare. In rural areas, farmers use their own homestead organic wastes (mostly crop residues, cow dung and kitchen waste) for compost production and use it for the sake of their self-cultivation. Generally they do not purchase compost and it is not available in the market as well. But in some specific areas in Bangladesh the uses of vermicompost become popular but not among the poor farmers. Because special type of earthworm and cow dung are required for its production. Both of them are difficult to manage for poor farmers. Urban wastes are not using for production of vermicompost as well. Some NGOs including Waste Concern has undertaken some projects in order to promote composting in some areas of Bangladesh. Some of them are presented below verbatim.

1. Name of the Project: Feasibility Study on Scaling-up of Compost Production and Distribution in Rangpur and Dinajpur District of Bangladesh
   Location: Rangpur and Dinajpur, Bangladesh
   Name of Client: Swisscontact-Katalyst
   Duration of the Project: November 2006 to March 2007
   Objectives of the Project: The broad goal of this study is to come with two major outputs, one is to get an actual overall picture of raw material supply for composting and demand for compost in the Rangpur and Dinajpur and the other one is to prepare an effective business plan to promote sustainable agriculture in Bangladesh. This study will enable to assess the feasibility of compost production, marketing and its use in agriculture in urban and peri-urban areas of greater Rangpur region.
2. Name of the Project: Technical Advisory Services for the Implementation of the Community based Composting Project in Bangladesh

Location: Kushtia Municipality, Bangladesh

Project Partners: Department of Environment (DOE), Government of Bangladesh, UNCRD, LGED, and Department of Agriculture Extension

Name of Client: Institute for Global Environmental Strategies (IGES)

Duration of the Project: October 2007 to March 2008

Project Background: The United Nations Centre for Regional Development (UNCRD), under its 3R Initiative, is providing assistance to Bangladesh in implementing demonstration projects to promote 3R in Bangladesh, with financial support from Ministry of the Environment of Japan, through IGES. Waste Concern has been engaged to replicate its model of community based composting system from municipal organic waste in Kushtia municipality.

Objective of the Project: Promotion of 3R (reduce, reuse and recycling) in Bangladesh

Tasks Under the Project: Construction of one community-based composting plant (1.5 ton capacity) in Kushtia Municipality in Bangladesh integrated with house-to-house waste collection. Green house gas emission reduction from the project will also evaluated along promotion of source separation of waste in the municipality. Waste Concern shall carry out a baseline study, prepare IEE report as well as technical design and drawings along with cost estimate and tender documents.

3. Name of the Project: Capacity Building for Composting Activities under Special Programme for Food Security Project in Chak Singa, Bagha, Rajshahi

   Location: Rajshahi, Bangladesh

   Name of the Client: Food and Agriculture Organization (FAO) of the United Nations Duration of the Project: October 2005 and July 2006

   Objectives of the Project: The main objectives of the project are to provide following services:

   - Conducting training sessions (compost unit construction, compost process control);
   - Conducting field survey on availability of biomass for composting as well as soil quality;
   - Providing periodical supervisions to ensure quality output; Preparation of following materials:
     a) Script for capacity building of trainers and farmers, based on which PMU will prepare a Video-CD;
     b) Written manual for farmers;

c) Written manual for trainers, describing how to facilitate farmers to process composting and utilize the produced compost; and
d) Posters, particularly on raw material selection and process control.

4. Project Name: Intervention to Improve Existing Composting Technology of Local Compost Producer "Annapurna Agro Service" Based at Domar, Nilphamari, Bangladesh
   Location within country: Dinajpur, Bangladesh
   Name of client: Winrock International, Business Development Service (BDS).
   Duration of the Project : September 2004 to December, 2004 Narrative description of project and services provided
   - Assess the facilities, raw material and process analysis of a compost fertilizer producer in the greater Rangpur area.
   - Analysis of raw materials and present compost produced by them.
   - Facilitate to improve/develop the composting technology for good quality compost production.
   - Prepare an economic analysis on the cost and benefit of using identified appropriate and affordable composting technology.
   - Analysis of finished compost produced by the semi aerobic composting technology. Recommendation of compost use in agriculture.
   - Build up capacity of the local service provider to produce quality compost followed by appropriate composting technology to cater the need of the farmers.
   - Prepare on economic analysis on the cost and benefit of using the identified appropriate and affordable technology of composting.
   - Recommend application dose of compost along with other chemical fertilizers for maize production in greater Rangpur.
5. Promotion of Composting and Resource Recovery in Dhaka
   Project Period: 2000-2001
   Waste Concern, with support from Oxfam-UK has introduced a pilot barrel typecomposting project in two slums of Dhaka city. Under this project Waste Concern will supply specially designed barrel to slum dwellers for composting, which not only solves the waste disposal problem at source but at the same time has created income generating activities for the slum dwellers.
6. Barrel Type Composting for Slums in Dhaka

Project Period: 1998-2000

Waste Concern, with support from UNDP's LIFE program has introduced a pilot barrel type-composting project in two slums of Dhaka city. Under this project Waste Concern has supplied specially designed barrel (as shown in Fig. 4 and Fig. 5) to slum dwellers for composting, which not only solves the waste disposal problem at source but also has created income generating activities for the slum dwellers.

Fig. 4. Organic Waste being disposed the green Barrel

Fig. 5. Composting harvested from the in Green Barrel (after four months)

Are there any examples of composted (or vermicast) urban organic waste being used by farmers?

Going through the empirical literature it is found that farmers are getting composted urban organic waste being processed by two organizations, which are presented below.

Only a small portion of Dhaka's organic waste is diverted before being transported to the city's landfills or deposited in open spaces. However, on small scale, private composting company is currently collecting (for a fee) and processing approximately 100 metric tons of organic waste per day, and selling the compost to local farmers (CCAC, 2007)**.**

Roy, Rahman, & Dev (2013) conducted a study on compost fertilizer and found that about 70% of the total produced 520 tons of municipal solid wastes per day in Khulna city is organic and suitable for preparation of compost fertilizer. Among the NGOs involved in solid waste management only

Rural Unfortunates Safety Talisman Illumination Cottage (RUSTIC) at present is producing about 30 tons compost per month on its own plant of 0.47 acre land using only 46 tons (0.53%) from 8730 tons. Additional 5663 tons of compost per month can be produced from the unused 8684 tons (99.47%) of organic wastes.

Information on innovative programs and practices in composting for the agricultural sector in Bangladesh

Commercially some NGOs are conducting the project on composting by using urban organic wastes and kitchen wastes in urban and peri-urban area. Generally it is a small scale project and the composting is practicing mostly as windrow and static pile system. In majority cases, neither they use any mechanical device nor they apply any potential microbes for composting. Most of the activities are doing manually. The existing scenario/practicing is not recognized as innovative approach of composting.

Identify the innovative programs and practices, especially those that involve poor farmers and/or women.

Based on the informed literature two NGOs are identified, namely GETCO Agro vision and Rural Development Academy are using *Trichoderma* spp for composting process. It is reported by Rashid (2011), Innovision has been facilitating for the development and promotion of *Trichoderma*- enhanced composting (TEC) technology and its sustainable link-up at the farmers' end. Through the collaboration with GETCO Agro Vision, 60 contract seed growers have received extensive trainings on this TEC technology. The TEC refers to the use of *Trichoderma*, the soil borne, natural fungus, as an activator in the decomposition process which efficiently reduces the de-composting-duration and ensures some value addition (eg. bio-pesticide) in the final product (Tricho-compost). By this time, demonstrations and field days on the benefits of using Trichocompost have created huge response among so many farmers in the community, showing a high potential of its increase usage. Until now, nearly 160 farmers in Rangpur, Dinajpur and Meherpur districts became directly knowledgeable about the TEC technology.

It is also reported by Husain (2011) that Rural Development Academy (RDA) is going to produce *Trichoderma* (a soil borne fungus which speeds decomposition of organic material) activator in its newly established culture laboratory at Sherpur, Bogra. Katalyst partnered with RDA to develop the technology and also to popularize it among the farmers. This intervention has engaged the Integrated Pest Management (IPM) unit of Bangladesh Agriculture University (BAU). The objective of this partnership was to develop technology, provide technical support and train the staff. Two scientific officers were recruited and trained on *Trichoderma* compost production by BAU under this intervention.

RDA will incorporate the information on benefits of using Tricho-compost in their current and future training modules. The Scientific Officers will conduct six training programs for 180 Local Service Providers (LSPs) and Plant Doctors of RDA on *Trichoderma* based compost production technology and marketing. These LSPs and the Plant Doctors will work as sales agents of RDA to market the *Trichoderma* activators in their respective localities. RDA will also initiate promotional activities to increase awareness on using compost among the farmers. The promotional activities include plot demonstration and field days, distribution of pictorial leaflets on the importance and benefits of Tricho-compost. A video documentary on the use of compost fertilizer will also be developed to help farmers understand better.

Obviously undertaking these innovative approach is quite encouraging and will play a tremendous role for further flourishment of composting process. The performance of *Trichoderma*-enriched composted through SSB technique of organic wastes is quite satisfactory in field crop production. It is not only influence yield of crop and improve of soil health but also enhance nutritional quality (Molla, Haque, Haque, & Ilias, 2012). Moreover, the application of *Trichoderma*-enriched bioorganic fertilizer minimizes NPK uses and most of the cases it reduced the 50-70% cost of Nfertilizer uses as optimal dose for corn, tomato and bottle gourd cultivation (Haque, Haque, Ilias, & Molla, 2011; Molla, Fakhru'l-Razi, Hanafi, & Alam, 2005; Molla et al., 2012)). Presently our poor farmers and /or women are not practicing it. But there is potential scope to involve poor farmers and women at composting process of organic wastes by ensuring availability of potential non-phytopathogenic, beneficial and capable of fast decomposing microbes.

Where are the opportunities?

There are ample opportunities on production of value added compost in Bangladesh by exploiting huge generated urban organic wastes i.e. municipal solid wastes (MSW) in major cities, and ensuring participation of available poor farmers and/or women along with application of innovative techniques. There are more than 522 towns and cities (UNCRD, 2010) where thousand of tons of waste are generated from domestic, industrial, commercial, health care facilities and agricultural sources. In Dhaka city solid waste generation rate is approximately 4520 metric tons per day, more than 80% of it is organic matter (APO, 2007; Dhaka North City Corporation). Alamgir & Ahsan (2007) conducted a study on solid waste management and reported that potential for waste recovery and reduction based on the waste characteristics are evaluated and it is predicted that 21.64 million US$/yr can be earned from recycling and composting of municipal solid waste. A number of studies have been conducted to determine the composition of wastes including moisture content and calorific value. The data show that the moisture content in city waste is significantly higher and the calorific value is much lower, which determines the viability of composting or anaerobic digestions rather than waste combustion (Yousuf & Rahman, 2007).
In near future Rural Development Academy will ensure proper distribution of produced *Trichoderma* activator through developing a marketing channel. If successful, RDA will expand their commercial production of *Trichoderma* and gradually RDA will be a potential service provider in the commercial compost manufacturing sector in future. Besides, RDA will continue the promotional activities on using *Trichoderma* to cater to the future expanding market. It is expected that as a result of these activities, the growth in supply and usage of low cost demand of compost at farmers' level will increase (Husain, 2011).

With the advent of renewable energy technologies, there has been a strong growth in the number of biogas plants across the country. Both large-scale commercial biogas plants and home-based small-scale biogas plants are increasingly being installed in Bangladesh. Every household, which has a small poultry farm, and/or, a few cattle are the potential customer for a biogas plant. The bioslurry (by-product generated from bio-gas plant) is an excellent compost source. This bio-slurry can be collected from large bio-gas plants owned by large scale poultry or dairy farms and marketed commercially or it can be used by the small scale plant owners for their own agricultural crops (Rashid, 2011).

What needs to happen next?

Using an efficient composting technology and its promotion is a prime need at this moment. All the following activities would hopefully contribute to the development and delivery of quality compost available at the doorstep of farmers and practically its usage in cropland.

- A continuous promotional campaign is essential to develop awareness on commercial value of waste management through information, education and demonstration projects.

- Initiative should be taken to motivate farmers across the country about the benefits of using compost and its actual usage in crop field in a sustainable manner.

- Continuous promotional activities such as demonstrations and field days on the benefits of using compost technologies should be organized to raise awareness about the benefits of using compost and popularize the increased rate of compost application practice.
- Training on sustainable innovative technologies of composting should be given to potential growers with a particular focus on poor farmers and/or women.

- Development and promotion of value added composting (TEC) technologies and its sustainable link-up at the farmers' end should be facilitated and strengthened.

- Availability of compost should be linked with increased number of producers both at commercial and individual farmers' end.

- Finally, a suitable policy and regulatory environment within the country are imperative to encourage investment by all types of stakeholders for maintaining soil health.

- Concerted efforts should be made to encourage all households to purchase and use compost bins available in the market. As part of the strategy, the City Corporations/ Pouroshavas should provide market information; negotiate with the suppliers and arrange for higher purchase systems; and also develop appropriate subsidies for the poorer sections to obtain the bins.

- Concerned authorities should provide subsidies to potential producers for establishing physical facilities for producing value added compost such as composting shed, composting pad, separator, cutter and sieve for composting substrate, mixer or equipment

for tern over periodically, inoculum of non-phytopathogenic beneficial microbes and water spraying operating system, vessel for composting etc.

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2 Organic Waste Recycling and On Farm Composting in Bangladesh – Dr Tariq Bin Yousuf

Organic Waste Recycling and On-Farm Composting in Bangladesh

By Dr Tariq Bin Yousuf*

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Organic waste recycling and its utilization

Agriculture, horticulture, home gardening, nurseries, and municipal gardens and parks are the major markets for compost. In the developed countries compost is also used in landscaping, land reclamation, landfill cover, top soil blender and golf courses. Two types of market exist for compost – one is the high value-low volume and the other is the low value-high volume market. In the high value-low volume market, the customers are willing to pay a high price and want good quality compost. In the low value-high volume market, the customers want bulk volume at a lower price (Dulac 2001). In Bangladesh, Compost production from urban waste is very insignificant. There is a problem from both demand and supply side. In the urban areas, compost is mostly used in nurseries. However, the nursery owners used to make compost of their own by using leaves and cow dung. Some nurseries sell compost of others. But the demand is very slow. In the peri-urban areas, both cow dung and poultry litter are used as soil conditioner for agricultural land. In the rural areas, the farmers use to keep cow dung in a trench, put their daily waste in it, and keep them for 2/3 months. After that they use it in vegetable cultivation.

The most important areas of compost application are:

- Agriculture could be the largest potential market for compost in Bangladesh. However, this sector is mostly controlled by the Chemical Fertilizer dealers. The Agriculture Extension Department of Government of Bangladesh is a big avenue for compost promotion through block supervisors. This channel is used only for demonstration purpose not for marketing gateway of compost. The potential use of compost in (peri-) urban areas for crop cultivation is highly demanded. (Peri-) Urban agriculture can ensure food security, improve the

environment and contribute to urban economies. International funding and research agencies are increasingly recognising the great potential of organic waste in urban agriculture and are advocating for bringing agriculture back into the towns and cities. In Bangladesh, this market is not explored or utilized as yet.

- Horticulture, the growing of fields of fruits and vegetables in the (peri-) urban areas, is a promising market for compost. Organic farming is becoming a growing industry that utilises food wastes to produce fresh foods for the city dwellers. Asia has the growing and exporting potential for organically grown products. The growing interest in organic methods of farming and exporting by Asian countries such as Japan, China, Sri- Lanka, Philippines, Indonesia, Malaysia and India is increasingly recognising the great potential of organic solid waste reuse and recycling in urban lands (Silva 1995). Bangladesh, with the help of the Hortex organic programme, is producing and exporting baby pineapples and organic vegetables (Caldas 2001). Organic farming is more expensive than the traditional farming. Organic foods and vegetables are more highly priced than the conventionally grown foods. The market for organic foods is limited but people from the United States, European Union and Japan who usually buy organic products are motivated by an increased awareness of health and safety (Hart and Pluimers 1996). In Bangladesh, due to uncontrolled use of pesticides and chemical fertilizers, one type of customers buys organic vegetables from malls. But the supply side is poor and the cost is abnormally high.
- Home gardening in yards, containers, roof-tops and balconies is very popular. The urban residents grow ornamental plants and flowers to beautify their houses and sometimes vegetables to supplement their household diets. They use compost buying from the markets. They buy it from nurseries.
- Nurseries in the urban areas grow ornamental plants and flowers. The nurseries are the main suppliers of saplings for city plantation and greening programmes and are potential users of compost.
- Landscaping, public parks and green belts maintained by municipal agencies have a large usage of compost. But due to lack of initiative, the composts from organic wastes are not used much.

Composting initiative in Bangladesh

Composting in Mymensingh Municipality (Yousuf 2015)

In 2004, DPHE and UNICEF implemented the 'Environmental Sanitation, Hygiene and Water Supply in Urban Slums and Fringes Project' in four City corporation and ten Municipalities namely Mymensingh, Noakhali, Comilla, Bogra, Jessore, Barisal, Patuakhali, Rangamati, Bandarban, and Khagrachari. The pilot scheme on solid waste management and composting had been implemented under the project. The purpose of the pilot project was to promote the concept of community based solid waste management with 3R (reduce, reuse, recycle of waste) principles by introducing decentralized small scale composting and recycling with a target of reducing the burden of waste of Municipality and generate income and employment opportunities for the urban poor. As part of the pilot project, composting facility in the name of Eco-park was developed. Mymensingh Municipality provided land for the composting facility. Box-type composting with four chambers were constructed and for compost demonstration, flower garden was established. The project invested BDT 1 to 1.5 million for each plant with the assumptions that the plant will generate 100 percent operational costs within six months. However, it was found that not a single compost plant was achieved its objective through regular production and marketing of compost and thus able to demonstrate successful and self-sustainable composting plant. The operation of the composting plant was stopped after the project period.

In 2007 UNICEF engaged CARE Bangladesh to review the operational challenges of the composting plant. The review findings revealed that municipal management and relevant staff members did not receive required support to make them functional as a financially viable unit. The reasons identified were: i) problems with regular and quality waste collections ii) lack of community mobilization and support and iii) no marketing strategies. The plant became liability to the Municipality. Community participation is very important to ensure the supply of the right quantity and quality of waste to the compost plant. Quantity of waste was not sufficient to utilize the full production capacity of the composting plant. Municipality had shortage of waste collection vans. There was no source segregation system in the household level to get the right kind of input in the plant. There was no marketing strategy in place, any packaging, pricing and promotion initiatives as well.

Having come to know the challenges, the composting plant was tried to revive and brought into operation in 2009 by Practical Action by GIZ support. Practical Action engaged Grameen Monobik

Unnoyan Shanstha (GRAMUS) to operate the composting plant. For the efficient collection of waste from Ward- 4, 6 & 8; three CBOs (MATI, TUS and SBSKS) were engaged, 16 rickshaw vans were provided. Power tillar trolleys were provided by the Municipality for collection of waste from the said wards and transported to composting facility. Six more chambers of Box composting were constructed. 4 tons of compost was produced with a brand name GMTS Eco Compost. The compost was tested and demonstrated in Bangladesh Agriculture University. GRAMUS applied certification for marketing of their compost and they have got the approval recently. They sold the compost to the buyers who are their microcredit buyers. For the sales promotion, they organized farmers meeting in nearby areas. After the project period when the waste collection of the pilot wards was taken by the ward councilors from the CBOs, it was hard for GRAMUS to get waste in the composting facility. It was also difficult for them to sale the compost without certification. From February 2015, they stopped the operation of the plant and hoping to start again after getting the certification of selling compost. During the field visit, it was found that another 10 chambers of box composting was constructed from UNICEF-UPPR Community based Integrated Solid Waste Management project spending 20.26 lac BDT but the plant was not started its operation. A new construction of composting project (with 10 chambers box-type) from Department of Environment under Programmatic CDM has been started. The operation of the composting plants in Mymensingh Municipality is challenging; however GRAMUS has a plan to start operation in a larger scale after getting the certification from Ministry of Agriculture which they have got recently.

Under the Practical Action-GIZ program, 4 units of vermin-composting, 9 units of barrel composting and 1 unit waste to bio-gas plant were constructed but none of the initiatives was found operational. Only the bio-gas digester was found operational but the feedstock was cow-dung not kitchen waste.

The success of any composting plant comes from selling of compost. However, in Mymensingh, the private entrepreneurs were struggling for the marketing permission of compost which they have received recently. Service chain for waste collection is established but the compost value chain has still scope to improve.

Quality of Compost

Quality is important in creating a demand and achieving a market for compost. Compost should be fully decomposed, should be clean, pathogen free and absence of obnoxious odor. In addition compost should be free from both physical and chemical contaminants and acceptable to the endusers.

In Bangladesh, source-segregated wastes are not collected for the composting plant and compost may be contaminated by glass pieces, plastics, heavy metal etc. Heavy metal contamination may be caused by discarded household items such as batteries (Hg, Cd, Zn), bulbs (Hg), paints (Cr, Pb, Cd) and used medicines. There is a general concern of pollutants in urban solid waste derived compost and there is a fear of contamination of vegetables produced from waste derived compost.

GRAMAUS carried out test of their compost quality in Agricultural University Lab, the SDRI lab. In addition, they have purchased some equipment to run their own lab.

Nutrient Analysis of GRAMAUS Compost

S.No.	Institute	Date	N (%)	P (%)	K (%)	S (%)	PH	MC (%)	OC (%)
1	BAU	28.06.2011	1.008	0.704	1.705	0.34	8.57	9.92	9.979
2	BAU	09.03.2011	1.68	0.708	1.273	0.117	7.24	12.43	15.676
3	BAU	03.02.2011	0.784	0.37	1.364	0.05	7.25	14.89	16.24
4	BAU	08.06.2010	0.336	0.559	0.426	0.36	7.35	12.25	14.63
5	BAU	24.06.2010	1.4	0.364	1.3	12.86	7.29	37.05	10.764
6	BAU	11.11.2010	1.176	0.0136	1.109	0.122	7.15	18.3	7.187
7	BAU	11.11.2010	1.028	0.067	1.109	0.147	7.4	27.9	12.579
8	SRDI	25.11.2010	1.09	2.5	0.94	0.15	7.7	27.13	16.14
9	SRDI	06.09.2010	0.84	0.44	0.83	0.07	8.2	42	11.23

Composting in Peri-Urban and Rural Areas

Xplore business limited has developed a model to ensure easy access to quality compost fertiliser to the farmers. This model has created opportunities for Small Compost Producers to expand their businesses throughout the country and also help them to increase their capability of producing and marketing their product. It has ensured an effective and sustainable channel for quality compost production and distribution such that farmers are benefitted.

Annapurna Agro Service is a private compost producing company located in the Nilphamari district of Bangladesh. Their main work is to establish a production and distribution network for compost fertilizer in the northern parts of the country. Their developed model works for ensuring smooth transfer of vermi composting technology to the farmers.

Innovision Consulting Pvt. Ltd. facilitates several input companies in the fertilizer sector as implementing partners directly with some promotional activities at their market distribution level like dealers' trainings and farmers' meetings. These activities support to build-capacity of fertilizer input companies also. The activities like dealers' trainings and farmers' meetings are undertaken to disseminate the information on importance of balance fertilization and benefits of applying sufficient amount of compost in the crop land. Currently, micronutrient fertilizer companies like National AgriCare and Paragon Agro, mixed fertilizer company like NAAFCO Pvt. Ltd., have directly trained nearly 400 top distributors/dealers throughout the country. Also, Innovision has facilitated these companies to conduct meetings directly engaging 40,000 farmers' to promote the increased practice of balance fertilizer application and sufficient compost usage to obtain better yield performance and to regenerate the soil fertility of Bangladesh.

RUSTIC receives about 65 tons solid wastes per month from Khulna City Corporation (KCC) trucks. It produces about 25-30 tons compost fertilizer in the name of "RUSTIC Compost Jaiba Sar". RUSTIC has its own compost plant on 0.47 acre land at Rajbandh adjacent to KCC landfill site. RUSTIC received its certification from the Ministry of Agriculture in 2012. The existing shed of RUSTIC was constructed in 2002. RUSTIC sells its fertilizer at the cost of BDT 7 per kg. at wholesale rate. As dealers ACI Ltd. takes 12 tons, Sikder Seeds takes 2 tons and the Reza & Sons takes the remaining amount. They sell the fertilizer to the farmers of Khulna, Satkhira, Natore, Munshiganj, Mollhat and other areas of the country at the rate of BDT15 to BDT 25 per kg. The farmers apply the

fertilizer to their paddy fields, betel-nut farms, nurseries and vegetables gardens etc. The fertilizer is packed in 20 kg. and 40 kg. packs/sacks. RUSTIC Compost contains about 10% cow dung.

The Focus Nursery & Horticulture Farm produces Super Compost using cow dung, water hyacinth, shrubs/trimmings, *Neem leaves, Dhan Chitta, Khudipana* (small hyacinth) and sawdust etc. It sells about 1.2 tons fertilizer i.e. 600 packs per year (300 packs in seasons-June to August and 300 packs in rest of the 9 months). Retail price is BDT 50 per pack, i.e. BDT 25 per kg. The wholesale price is BDT 8 per kg., i.e. 50 kg. sack is sold at BDT 400. About 150 packs of fertilizer have been sold in the Tree Fair.

Both-Aids Earth worm (Vermi), water and cow dung is used to produce Vermi-Compost. Water is used through sprinkling/spraying. Both-aid is a company that helps small farmers in urban and rural areas with technical assistance and guidance to produce Vermi-Compost. It then collects at wholesale rate from the farmers and sell to the agro-forestry nurseries and farms at reasonable discounted rate. A small plant can produce about 200 kg. Vermi-Compost per month. A plant of Boyra area produced Vermi-Compost during 2011-2012 and supplied to Department of

Agriculture and Both-aid's representatives. It supplied about 400 kg. fertilizer to Both-aid representative in 2012 for selling in the Khulna Tree Fair 2012. Wholesale price of VermiCompost is BDT 12 to BDT 14 per kg. and its retail price is BDT 20 per kg.

Christian Commission for Development in Bangladesh (CCDB) under its project Comprehensive Poverty Reduction Programme (CPRP) is running the vermi compost programme at Koyer Chala, Bakta, Enayetpur, Rangamatia, Kanchichura and Nischintapur villages in Phulbaria, Mymensingh to make the rural poor women self-reliant through producing vermi compost. The vermi compost can be produced easily at home stead using a cement slab ring or a big earthen bowl (chari) to keep the earth worms. Once bin is ready, bedding materials like sand, small pieces of brick is put in it. The worms put in the bin are covered with a layer of bedding, gunny bags or other structure to protect the worms against sun, downpours and birds. Twenty kgs of cow dung along with 20 kgs of bio-waste like straw, hyacinth and vegetable waste are kept in the bin as feedstock for half kg worms. The amount of bio-compost what the earthworms eat up, they release its half amount as \'tea dust like\' stool which is called vermi compost. Later the vermi compost is separated through chaloni (sieving/straitening). At initial stage a grower will get 20 to 25 kg vermi compost after 45 to 60 days. But the harvest period is reduced when the worms' number increases at the bins. The surplus worms

can be sold at BDT 1500 per kg. One kg vermi compost is sold at BDT 8. Now some 200 women are involved in vermi compost production in Phulbaria. The vermi compost improves soil organic matter, maximizes retention of nutrients in the soil and maintains balanced soil level etc.

Company name	Faruk Fertiliser Limited
Product	Nutrient enriched organic fertiliser from poultry litter Brand name: Chook Chook Product variety : 7 product designed according to Fertiliser Recommendation Guideline for betel leaf, root and tuber crops, rice, sugar cane, pot and garden plants , banana and vegetables
Location of the facility	Kaliakoir (40 km away from Dhaka city)
Price	BDT 40/kg
Production capacity and sale	Production capacity 1200 ton/year, sale : 600 ton/year
Nutrient content	N-7.8%, P-8.45 %, K- 3.75 %, OM 25.36 %
Package	2 and 12 kg bag, information inscription of ingredients, nutrient value, benefits, application dose and procedures
Distribution	250 chemical fertiliser dealers in 46 districts, nursery retailers
Promotion	Free samples, advertisement in newspaper, poster, leaflets

Company name	Aftab Fertilisers and Chemical Limited
Product	Nutrient enriched organic fertiliser from poultry litter Brand name: Power super organic fertiliser Product variety : For rice and potato
Location of the facility	Bazitpur (180 km away from Dhaka city)
Price	BDT 15/kg
Production capacity and sale	Production capacity 200 ton/year, sale : 200 ton/year
Nutrient content	N-8%, P-20 %, K-14 %, S- 5% OM 40 %
Package	1/2 and 1 kg bag, information inscription of ingredients, nutrient value, benefits, application dose and procedures
Distribution	Own pesticide distribution channel
Promotion	Dealer incentives, advertisement in local newspaper and magazines, leaflets

Company name	Bangladesh Environmental Products and Management Limited
Product	Nutrient enriched organic fertiliser from a mixture of cow-dung, bone meal, dry blood Brand name: Susoma organic fertiliser Product variety : For rice, fruits and orchard
Location of the facility	Savar (20 km away from Dhaka city)
Price	BDT 25/kg
Production capacity and sale	Production capacity 100 ton/year, sale : 100 ton/year
Nutrient content	N-8%, P-6 %, K-4 %, OM 30%
Package	15 kg bag, information inscription of ingredients, nutrient value, benefits, application dose and procedures
Distribution	Fertiliser dealers

Promotion	Demonstration plots at Bangladesh Agriculture Research Institute (BARI) and Bangladesh Rice Research Institute (BRRI), leaflets

Alternative agriculture/ecological agriculture introduced by **UBINIG, CDA and PROSHIKA** seems to be a significant step towards bringing back the original biodiversity and ecosystem, conserve the native gene pool and enrich the self-fertility of the soil. UBINIG is trying to conserve or revive the natural ecosystem or resources through its "Nayakrishi". The organization is practicing ecological agriculture at its training center and also motivating the farmers to practice it. CDA is doing farmer-centered research as Regenerative Agriculture, which is mostly concerned about soil conservation. Their activities are confined at Dinajpur district where the soil is hard and dry. The compost preparation of CDA is easier. PROSHIKA is trying to restore the original ecosystem through its ecological agriculture programme. Different kinds of bio-degradable organic matter (leaf, rice straw, household garbage) mixed with cowdung are used for compost preparation, it can make soil soft, moist, and fertile. PROSHIKA uses shal leaves, rice straw, and other crop remnants as mulching for Ginger. Some of the villagers grow pulses, dhaincha in their field and mix with the soil by tillage before crop cultivation as green manuring.

Making quick compost is an option followed by the farmers to make soil fertile. Materials they use for quick compost are cowdung, rice bran (kura), ash, oil cake, chicken and duck manure. First they smash the oil cake which is then mixed with ash, rice bran, chicken and duck manure. After 2-3 days this mixture is mixed with cow dung and kept for 15 days to make it suitable for use. It can be preserved for a long time after drying.

Rural Development Academy (RDA), Bogra as a service provider for commercial Trichoderma, the active de-composting agent for compost, and promoting Trichoderma-enhanced composting technology both at the commercial and individual farm level. Trichoderma is a soil borne beneficial fungus, which enhances the de-composition of organic materials within 4-5 weeks. In Bangladesh decline of soil fertility is due to intensive use of lands without proper replenishment of plant nutrients. Crop residues and cowdung are used as fuel hence farm yard manures or compost are seldom applied in the soil. Organic matter is considered as the life of soil because it increases soil porosity (helps aeration) water and temperature holding capacity, add micronutrients and acts as substrate for the soil microbes. A good soil should have an organic matter content of

3.5%. The organic matter content of our top soil (medium and highlands) has gone down from 2% to 1% over the past 20 years. Similar is the picture of organic carbon and micronutrients. Realizing the problem emphasis has been given for the improvement of soil health in the Agriculture Policy of the Government. As a result the Department of Agricultural Extension (DAE) has been trying to making awareness and encouraging the farmers to make compost using crop and household residues, water hyacinth etc- throughout the country. A large number of farmers have already adopted the technology as evident from the large number of compost heaps by the road side. The information on the exact number of farmers involved and the quantity of compost produced is not available at one point at this moment. This indicates that awareness has been created among the farmers to improve their soil with compost.

Biogas is a potential renewable energy alternative to the energy produced from firewood or kerosene etc. This technology uses cowdung, poultry litter, water hyacinth and other biomass wastes to produce biogas thereby ensuring a smoke free, ordor-free and healthy cooking environment for rural women. Bioslurry is obtained as a by product from the biogas plants. Bioslurry is a 100% organic fertilizer which can play vital role in restoring fertility as well as organic matter status of the soil. It is environment friendly, has no toxic or harmful effects and reduce the use of chemical fertilizers to a great extent. Analysis showed that it contains both macro and micro nutrients besides organic matter. The infrastructure Development Company Ltd (IDCOL) with financial support of Netherland Development Organization is providing technical and financial support in promoting biogas plant in the country with 28 partner organization. Among these organizations Grameen Shakti is the lead agency which shares more than 50% of biogas plants being constructed in the country. A small biogas plant costs BDT. 24000 of which

BDT 9000 is given as subsidy by IDCOL and the rest is either the farmer's own or can take loan from Grameen Shakti or other organization. These organizations have installed 6000 biogas plant during the last 2 years. Currently more than 30000 biogas plants of varying gas producing capacities (2-6 m^3) run with cowdung and poultry litter for domestic purposes and some large sized ones in poultry and dairy farms are in operation in the country. These biogas plants produce 200000 tons of bioslurry on dry weight basis worth of BDT 1120 million (@ BDT. 5/kg wet basis) (16.23 million $), which is equivalent to 9000 t of urea + 25000 t of TSP + 3200 t of MoP plus other secondary micronutrients. Grameen shakti is going to market their bio-slurry in the brand name of "Grameen Shakti Joibosar" soon.

On farm composting in Bangladesh

Composting from solid waste is very new in Bangladesh. Waste Concern, a local NGO first started community-based composting project in Dhaka in the year 2001. It then replicated through PRISM Bangladesh in Khulna City. Through UNICEF, composting plants were constructed in 14 municipalities. The composting plants were located either in the community or in the dump site of the municipalities. The sizes of the composting plants were 1 to 5 ton capacity. It was found from the mass flow analysis of the composting plant that most of the composting plants were operating below the design capacity. The only large size composting plant (130 tons/day capacity) has been operated by World Wide Recycling (WWR) and Waste Concern (WC) in Dhaka taking the wastes from kitchen markets. However, at present most of the plants become redundant or scaled down in operation because of lack of compost marketing initiative. The total compost production from the composting plants is very insignificant, only 2 percent of the total generated wastes. On the demand side, there is no established market for compost. Most compost plants found difficulty in marketing their compost. However, WWR & WC have been successful in marketing compost through the distribution network of Advanced Chemical Industries (ACI). There are few but some good initiatives on on farm composting in Bangladesh:

Kazi and Kazi Tea Estate Ltd. is practicing organic farming; located at Tetulia Upazila of the Northwestern district of Panchagarh. The farm size is 2500 acre (1012 ha) out which at present the tea garden is 800 acre, medicinal plants 500 acre (254 plant saplings) and the rest is cultivated with rice, wheat, vegetables, pasture etc. organically. They have also a diary farm of 2000 cattle heads maintained on organic feeds only. At the beginning they started intensive green manuring with leguminous crops like dhaincha, cowpea, mungbean, blackgram etc. in addition to heavy use of organic manures like cowdung, compost etc. Later on they have established 40 biogas plants where their own cowdung is used. The bioslurry is now being used as manure. Not only that, after plantation of tea saplings, they are continuously growing green manuring crops intermittently to enrich the soil. They have specially selected medicinal shade trees which protect tea plants from pests. In order to ensure that all resources used in the garden are fully organic, they do not use chemical fertilizer or pesticide. The garden is certified organic by the SGS Organic Production standard in accordance to the EU Regulation 2092/91. They produce about 250 tonnes of tea every year and sell at BDT 350/kg

in the local market where as the normal tea price is BDT 200/kg. Thus the total value of their tea is Tk. 87.50 million (1.27 million US$). They also export some tea to USA, Japan and UK.

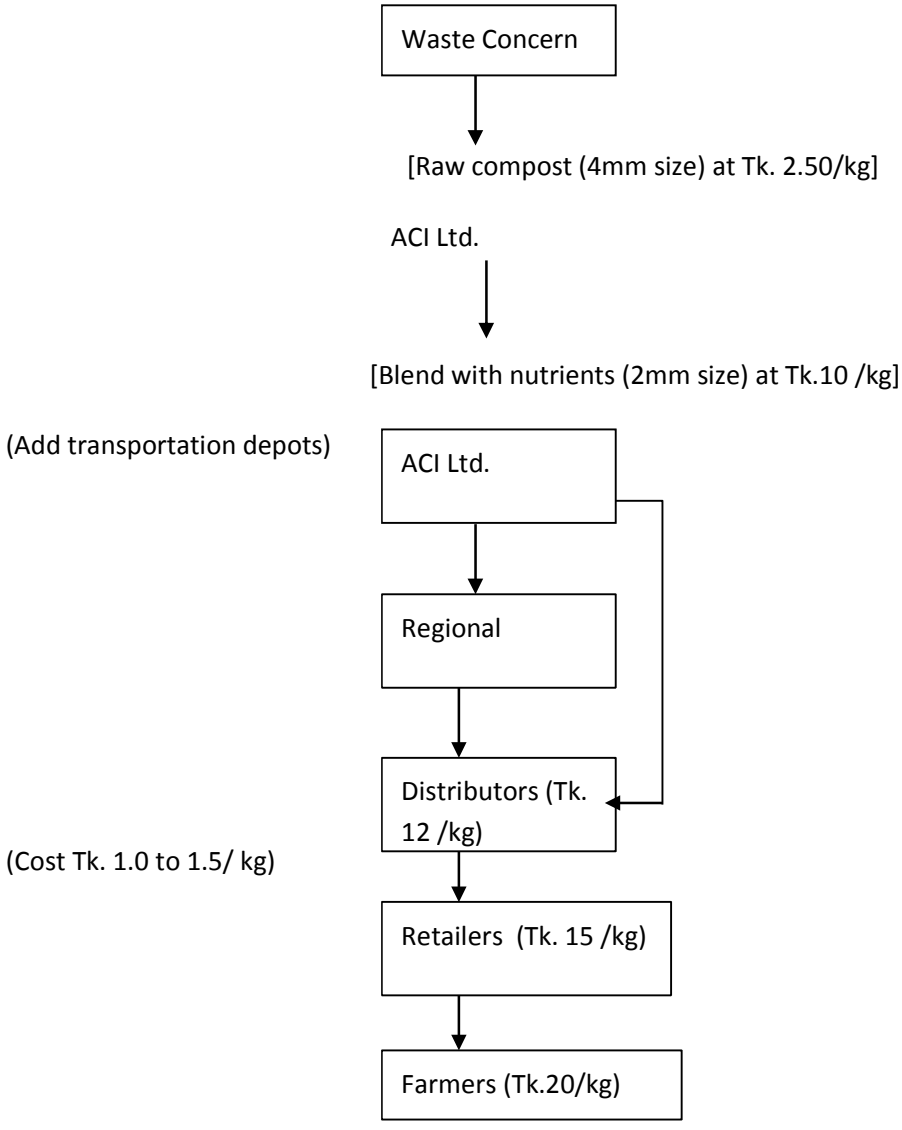
PROSHIKA has been trying to promote organic vegetable cultivation through their group farmers. They are providing eco-friendly agro-technology and necessary training to the growers as well as marketing facilities for their products. PROSHIKA selected 775 farmers of 25 villages from 10 Upazilas around Dhaka city and provided training on organic vegetable cultivation. They used mainly compost and quick compost for cultivation and IMP technique (including sex pheromone, detergent etc.) for insect control. Last year they produced 3000 tonnes of organic vegetables in 600 acres of land. In addition PROSHIKA produced 38 t on 11.52 acres in their own farm in Manikganj.

PROSHIKA arranged to sell these vegetables in the super market, like Agora, Nandan etc. BDT 1-2 Tk./kg higher prices than normal vegetables. Thus the total value of the produce is around BDT 45.57 million (0.66 million $) @ BDT 15/kg. Initially they faced some problems in marketing and storage and competition with normal vegetable price. However, PROSHIKA has a plan to expand this programme in future where they will develop their own market chain and will create awareness among consumers through vivid publicity. If these can be done organic vegetables will occupy a significant place in the market.

Practical Action, Bangladesh has introduced pit culture of sweet gourd in the barren unfertile sandy river basin and char in the Gaibandha district in 2005 where other field crops are almost impossible to cultivate. It is a very simple and unique technology for the displaced communities (by rivers erosion) living on the edge of mighty rivers and fragile environment in Bangladesh. The technique is very simple i.e. after flood water recedes the river basin dries up in the mid October – November – farmers make pits of 1 m3 size. Then 10-15 kg compost/cowdung is mixed with the pit soil and left for 15 days. Next 4/5 seeds are planted in each pit and the pit is soaked with water. After germination 2/3 healthy seedlings are kept in each pit and the rests are uprooted. They cover the pits with straw mulch to conserve moisture. Farmers soak the pits 2/3 times a week with water carried in pitchers or buckets. When the seedlings are 25-30 days old then quick compost is applied @ 1 kg/pit and at 60-65 days apply 2nd time at the same rate. The compost is mixed well with soils and irrigation is applied immediately.

In Dhaka, Waste Concern has utilised the marketing network of a Advanced Chemical Industries (ACI) Ltd. Waste Concern made an agreement with ACI Ltd. to buy raw compost from the plant.

ACI Ltd. improves the quality of the raw compost by removing the physical contaminants and grinding it into smaller sizes. They then blend the compost with chemical fertiliser to increase its nutrient balance and made it attractive to the end-users. ACI ltd. sells the blended compost through its distribution network. Profit margins were shared among the network members from distributor to retailers.



Distribution and marketing network of compost

ACI ltd. is a large chemical and pharmaceutical company having sale centres in 64 districts. They only utilise five marketing depots at Bogra (229 km),Barisal (277 km), Mymensingh (100 km),Chittagong (300 km) and Sylhet (250 km) districts for experimenting and popularising the compost among the farmers. ACI adds transportation cost on an average Tk 1.2/kg which allowed them to sell compost at the same price throughout the country.

For promoting compost ACI ltd. involves marketing officers who usually communicate the product benefits and utility to the farmers through leaflets and verbal discussion. The product is branded as WWR organic fertiliser and sell in 40 kg bags. The distributors or retailers usually sell the product to the farmers on a 'push sale' basis. Waste Concern also sells raw compost to fertiliser dealers at Mirershari (190 km) and Fatikchari (280km). At Mirershari, the dealer uses to sell the compost at a price of Tk. 7/kg and in Fatikchari at Tk. 8/kg. The fertiliser dealers identify transportation costs as one of the problems which fixed the selling price comparatively higher than the chemical fertilisers.

Future of composting in Bangladesh

Organic agriculture is gradually growing and gaining acceptance of the farmers. High and medium high land particularly adjacent to the homestead areas, fruits and vegetables are suitable to grow in the organic system. With rising awareness and consciousness on environmental, ethical and welfare issues, consumers now expect their food to be produced and processed with greater respect for the environmental safety and organic practices are the right option to fulfill the demand of the consumers. The community engagement in ensuring the right quality and quantity of wastes is important. However, due to lack of community participation in source-segregation of waste, the quality of compost is a major issue to reach through and getting market of the product. In most cases, the plant management is not aware of the standard of compost and demand of the customer. They do not have any separate business plan or marketing strategy for the plant. Standardization and certification process is complex and lengthy which discourages the commercial possibility of the compost product. Demand and marketing part of compost has not yet created widely in Bangladesh. The main challenge of the composting plants is to identify potential markets for the compost. There is a need of co-ordination body among the Local Government, Ministry of Agriculture, Ministry of Finance including the Private sectors such as Bangladesh Fertilizer Association, Bangladesh Organic Products Manufacturing Association etc. for effective marketing and sale of the compost product. The Ministry of Agriculture must take a leading role in demand creation and market development for the compost.

The Ministry of Agriculture through its research and development wing such as Bangladesh Agriculture Research Council (BARC) do mapping on the agro-ecological locations for finding out opportunity of compost demand and sale. The Department of Agricultural Extension (DAE) in collaboration with the Private Fertilizer and Pesticides companies can build up marketing infrastructure and distribution network for compost along with promotional activities so far. The present status of composting is summarized below:

- **Present capacity of production and consumption of compost is very insignificant and it does not bring any impact on compost demand and sale.** At this present state of production and consumption of compost, it is difficult for the composting projects to sustain their activities by creating demand or developing markets for the product.
- **Farmers in the peri-urban areas have basic knowledge about the benefits of organic fertiliser use. But due to lack of knowledge and experience and concern about harmful materials contained in waste derived compost, farmers are uncertain or sceptical about waste derived compost.**
- **Nurseries are be the largest potential outlets for compost in urban areas. But the nurseries are not aware or lack information about waste derived compost.**
- **City procurement policies have no provision for compost use**. Waste derived compost has not yet received attention of the city authority as an effective organic fertiliser.
- **Agriculture policy of government is supportive to chemical agriculture to bring selfsufficiency in food production.** Government provided tax incentives, credit support and loan facilities to promote chemical agriculture which might affect the natural demand of compost and be detrimental to the development of a market for waste derived compost. Small-scale compost manufacturers could hardly survive or sustain their activities if they would sell their compost on credit.
- **Agriculture extension department is a good avenue to create compost demand but compost from city waste is poorly linked with the agricultural community.**
- **Landownership is an important issue for influencing the farmers' decision to use organic fertiliser in their lands.** Farmers who cultivates their own lands are more interested to use organic fertiliser but they are reluctant to use waste derived compost. Shared or rented croppers are neither interested to use organic fertiliser nor waste derived compost. Small land hold farmers do not find any incentive to use organic fertiliser for the long-term sustainability

of land productivity. They are more inclined to chemical fertilisers for a quick return on their investment.

- **Compost demand depends on perceptions of its value, on its quality, comparative price and accessibility to potential users.** Compost from city waste is contaminated with sharp objects and chemicals or even heavy metals. The potential users are discouraged from using compost for quality and safety reasons. Compost is selling at a higher price than both the locally available organic fertilisers and the chemical fertilisers in some places. Due to higher price and small quantity production, compost would not compete or maintain demand against the locally available organic inputs.
- **Compost sale through established marketing networks is effective but is discouraging due to the margin of profits shared among the network members that cause a many fold increase in the compost price.** The compost market is mainly confined to rural farmers. Long distance delivery increased the price which may be beyond the purchasing capacity of the potential customers.
- **Credit support to poor farmers and sales incentive to dealers is good for the aggressive sale of compost but would be risky for small-scale compost manufacturers as it might affect cash flow and compost production.**

Compost is the end product of decomposition of organic waste. Generally, compost is not rich in essential nutrient constituents but it is importantly considered as a soil conditioner and used for balanced fertilization in agricultural crop production. Farmers in Bangladesh mostly rely on chemical fertilizers for higher production without or less application of compost. Despite huge potential, compost sector in Bangladesh is facing three major constraints: complicated and timeconsuming licensing procedure, weak market demand for compost; and lack of awareness among farmers on benefits of using compost. However, compost has a high market potential considering the challenge of motivating farmers' attitude towards its increased usage through a strengthened demand-driven supply channel. Government policy is supportive to composting, however the intervention in terms of promotion and incentives is still insignificant. Government has to give more administrative and fiscal incentives to composting to make it popularize among the farmers. More promotional and awareness activities through the government agriculture wing should be taken to bring compost in field along with the chemical fertilizer. At present, Waste Concern is only organization tried to

popularize the waste derived composting. But it is not wide spread. More organizations should come forward with building capacity and fiscal incentives from Local Government. In the different donor assisted project, composting from municipal waste is getting priority as part of the integrated waste management system. The utilization of the composting materials, the demand creation and marketing mechanism should be developed. Local government Ministry along with the Ministry of Agriculture should work together for the promotion of compost in Agriculture as well as its utilization in city park and landscape management. The quality control of compost, scaling up of the composting facility, bank loan facilities, credit system and licensing system should be made easier and friendly to the compost manufacturer. Under the programmatic CDM, three composting projects have been constructed under the purview of Ministry of Environment. The Municipalities under the Local Government Ministry should be involved and capacity should be enhanced by incorporating the composting plants under the programmatic CDM system which will ensure the compost demand and marketability.

The following recommendations are outlined for further improvement of Solid waste management including composting:

i) It is essential to identify goals of the composting projects, whether they are planned for demonstration of waste minimization program or to some extent production compost for commercial marketing.

ii) Political support is needed for composting projects to succeed. Enactment and implementation of policies and legislation, incentives and disincentives for organic waste recycling could have a positive impact on overall solid waste management including composting.

iii) Community should organize primary waste collection and the private business sector should operate the composting facility. Setting up a dialogue with the community people and engaging them in the planning and decision making process is likely to increase public confidence. This will ensure sustainability of the project since it empowers the local community, encourages them to contribute and gives them a sense of responsibility and commitment.

iv) Composting can significantly reduce waste stream volume and offers economic advantages to the local authorities. Inadequate understanding of the economics of composting is a challenge for the composting projects. A realistic accounting system with

full economic assessment of composting likely to generate business environment and encourage private sector investment.

v) Chemical fertilizers enjoy large subsidies, which affects the natural demand for compost and distorts the market. Therefore organic composts must be provided the similar subsidies or incentives to create a more level playing field for compost and allow its widespread use.

vi) The price of compost depends on transport distance and the price of the alternative products. Compost should receive transport subsidies or price incentives to compete the alternative organic materials in the market.

vii) A Co-marketing policy for compost with chemical fertilizer would be encouraged that make compost more competitive in the agricultural market.

viii) Mixed waste has led to production of inferior quality compost which in turn creates marketing problems. Public awareness and incentives should be introduced to encourage source-segregation of waste.

ix) Quality of compost increases confidence and create demand among farmers. Registration and certification of compost should be made mandatory and enforced. In that case, the certification process could be made easier and less bureaucratic.

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2015

Composting methods in India

DR. ANURADHA SINGH, DR. MAHESHVENKATARAMAIAH AND
KIM RUSSELL

INNOVATIVE FARM AID

Contents

Introduction

Rapid urbanization in the last few decades has contributed to India's growth and is slated to change it from a largely rural to a majority urban country in the next decade. One of the consequences of this urbanization is increasing volumes of solid waste. Urban organic waste includes that collected from households, markets, hotels, wedding halls among others. In contrast rural waste is largely agricultural in nature but suffers as 'pollution sinks' for the encroaching urban sprawl. [1]

The Indian Government has been proactive in its support towards SWM by initiating on October 2nd 2014, the Swachh Bharat Abhiyan (Clean India Drive) which aims to have a 'Clean India' by 2 October 2019, at an estimated cost of over US$9.4 billion. One of the major objectives of this mission is 100% collection and processing/disposal/reuse/recycling of municipal solid waste (MSW) as well as providing support to urban local bodies in designing, executing and operating waste disposal systems. Despite initiating the Swachh Bharat Abhiyan as well as outlining guidelines in the Municipal Solid Waste Management Manual (2000), the prevalent system is far from satisfactory. [2]

The ground reality is that waste is predominantly disposed off in landfills, and partly by incineration. 3R (reduce, reuse, recycle) is seldom used in practice, despite it being part of the policy envelope for a while. Lack of financial resources, institutional weaknesses, improper choice of technology and public apathy towards waste are some of the challenges faced by SWM.[1] Therefore, authorities face the challenge of reinforcing their available infrastructure for efficient waste management and ensuring a scientific disposal of the wastes. The key will be to start looking at means and technologies to recover resources from waste management.

This study explores the current practices in organic waste recycling and composting in rural and urban areas of India. A summary of the current scenario with respect to organic composting prevalent in India is made. A brief overview of the composting industry is given with regards to the situational analysis. Further, data collection and analysis, field visits and interviews were conducted both at the urban and rural level to understand better and document the current practices. In conclusion, we have a discussion on how the organic waste is currently being recycled in India and the challenges faced in turning waste to compost.

Initial investigations and contacts

We were recommended by ACIAR, Australia to contact **Dr. S.S Khanna** (Former member – ICAR,

Bhopal, Madhya Pradesh and an Ex-Advisor to Planning Commission, Govt. Of India and a stalwart of Soil Science in India), regarding his expertise on integrated nutrient management using city compost.

- We were initially unable to find the details of Dr. S.S Khanna from the ICAR website or elsewhere. We then explored the internet and came across a technical report [A] of Dr. S.S Khanna and **Dr. Ashok K. Patra** – existing Director – Indian Institute of Soil Science [IISS] Bhopal. We used the search engine Google and by using the keywords 'Dr. Ashok K Patra ICAR' in the query box, and were able to retrieve the contact details of the same :

  Dr. Ashok K. Patra,

  Director, Indian Institute of Science, Bhopal, Madhya Pradesh – 462038

  Telephone (Office): +91-755-2730946, Fax: +91-755-2733310

  Mobile: +91-9811733465

  E-mail: director@iiss.res.in, patraak@gmail.com www.iiss.nic.in

- We then called up Dr. Ashok K. Patra and requested him to give us the mobile number of Dr. S.S Khanna and he was kind enough to do so.

  Dr. S.S Khanna,

  Mobile: +91-9810532352

- We then had a telephonic conversation with Dr. S.S Khanna and he explained that he wasn't in the best of health. However, Dr. Khanna was very encouraging with his words and informed us that he was going to be in our hometown Bangalore, for a workshop between 30th November – 4th December 2015 and would be willing to meet up with us then. In the meantime he suggested that we contact **Dr. M.C Manna** to gather insights regarding city and farm composting. He also gave us the following details:

  Dr. M.C Manna,

  Principal Scientist & Head,

  Soil Biology Division, Indian Institute of Science, Bhopal, Madhya Pradesh – 462038

  Mobile: +91-9424444568

  E-mail: madhabcm@yahoo.com; mcm@iiss.res.in

We were also informed that both Dr. Patra as well as Dr. Manna were mentored by Dr. Khanna himself and were carrying on his legacy with regards to nutrient management. Dr. Khanna asked us to request Dr. Manna for some of their joint and separate publications and copies of some bulletins issued. Dr. Khanna was also very keen that we visit ICAR and meet up with Dr. Patra and Dr. Manna in person for a better understanding of the city composting methods and ways to

improve upon the soil health. We were advised to ensure that we would have to take prior appointments with them as they were usually busy with other commitments.

- Finally, we had a telephonic conversation with Dr. Manna and he also reiterated what was told to us by Dr. Khanna. Since he was on his way out of station, he told us that upon his return he would send us a bulletin and other documents in this regard. Dr. Manna recommended us to purchase a book authored by him and published in 2012 by FDCO (Fertilizer Development and Consultation Organisation):

  COMPOST HANDBOOK – research-production-application by
  Drs. MC Manna, A. Subba Rao, Asha Sahu and UB Singh
  Edited by Dr. HLS Tandon,
  ISBN: 81-85116-65-2
  Price: Rs. 600/- in India and US $60/- outside of India

- In conclusion, we would like to summarise that we will meet up with Dr. Khanna during his visit to Bangalore to discuss further about nutrient management. We will contact Dr. Manna, if still required, for the papers that he mentioned to share with us. Upon further instructions from your end, we can purchase the handbook on 'Compost' and are also willing to visit Bhopal and meet Dr. Patra and Dr. Manna, if necessary.

In the meantime, it was decided to go ahead and gather information independently and were able to source the bulletin mentioned prior, on Rapid Composting as it was available online[B,C]. With the time constraints we gathered information on City and Farm Composting from various other sources in order to be able to compile this report within the time frame given.

[A]: MC Manna et al., Rapid Composting Technique: Ways to enhance Soil Organic Carbon, Productivity and Soil health, ICAR-IISS Technology Folder 2015. (See Annexure 1)

[B]: MC Manna and Asha Sahu., Rapid Composting Methods, Silver Jubilee Year, IISS (1988-2013). (See Annexure 2)

[C]: IISS Newsletter, Volume 17, Number 2, July-December 2014. (See Annexure 3)

OBJECTIVES:

1. Current Practices in Organic Waste Recycling and composting in rural and urban areas of India

Excessive use of chemical fertilizers and pesticides has adversely impacted the environment with soil degradation being the major impact. Growing concerns relating to land degradation, threat to ecosystems from over and inappropriate use of inorganic fertilizers, atmospheric pollution, soil health, soil biodiversity and sanitation have rekindled the global interest in organic recycling practices like composting. The potential of composting to turn on-farm waste materials into a farm resource makes it an attractive proposition. [3]

The following Fig.1 outlines some of the common composting methods prevalent in the world today.[3]

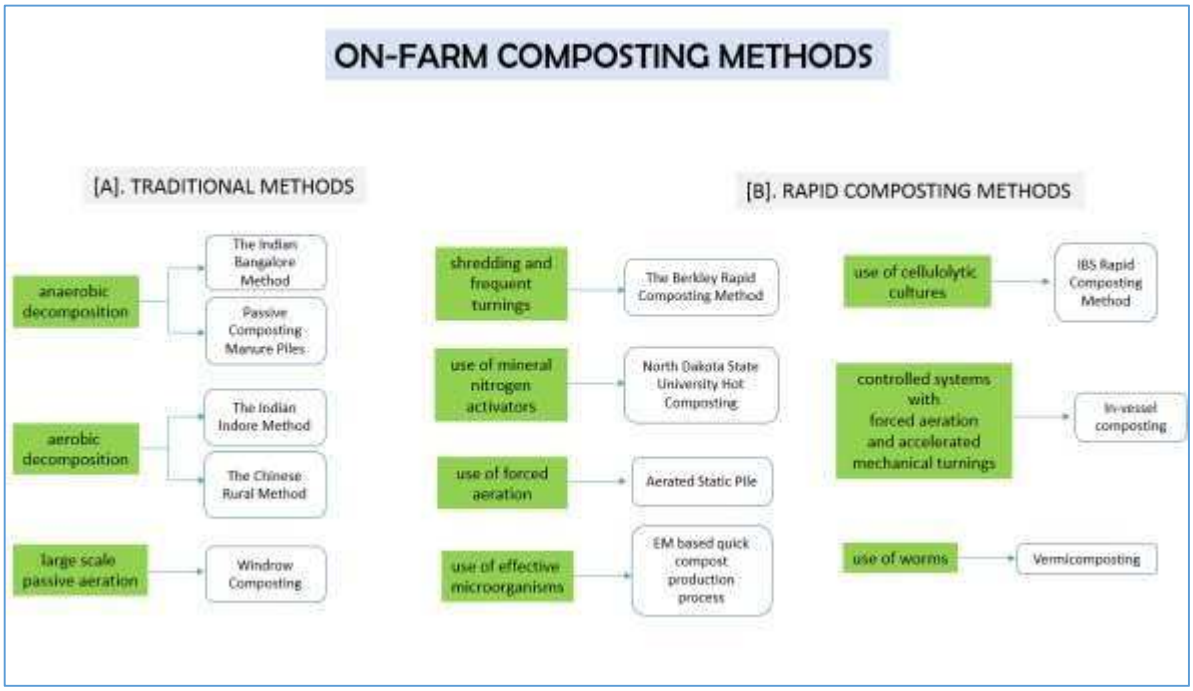


Fig. 1: Common on-farm composting methods

On-farm composting methods can be broadly classified into Traditional and Rapid Composting Methods and the same have been outlined above. Traditional methods based on passive composting approach involve simply stacking the material in piles or pits to decompose over a long period with little agitation and management. (The City to Soil method of composting used in Armidale Australia suits this minimal turning approach. http://www.scribd.com/doc/52218938/Groundswell-Compost-

Process)

Below we discuss the common methods we observed or obtained information about during our research.

1. ***'Indian Bangalore method'*** [Bangalore is a city is South India, in Karnataka] permits anaerobic decomposition for a larger part of operations and requires 6-8 months for the operations to complete. This type of composting uses night soil and refuse and does not require turnings. Loss of organic matter and nitrogen is negligible and percentage recovery of compost is more by this method.

2. ***Passive Composting of Manure Piles*** involves simply stacking the materials in piles to decompose over a long time period with little agitation and management. This is the most common and prevalent technique used in large-scale composting plants in India. The process has been used for composting of animal wastes and produces malodour due to presence of anaerobes (Pic.. 1 & 2).

Pic..1: Passive Composting of Manure Piles observed in Kakol, peri-urban Bangalore

Pic..2: Passive Composting of Manure Piles followed by vermicomposting observed at Gowardhan Farms, Karlapura, peri-urban Bangalore

3. ***'Indian Indore method'***, [Indore is a city in central India, in Madhya Pradesh] which slightly enhances passive aeration through a few turnings - thereby permitting aerobic decomposition; reduces the time requirement; and enables production in about 4 months of time.

4. ***Chinese rural composting*** methods, based on passive aeration approach through turnings/ aeration holes, provide output in 2-3 months.

5. ***'Passively Aerated Windrows'*** eliminates the need for turning by providing air to the materials via pipes, which serve as air ducts (Pic.. 3). Active composting period could range between ten to twelve weeks. We observed this method being followed during our visit to an NGO called Saahas.[4]

Pic. 3: Bin composting with aeration pipes on the floor of the bin observed in ''Kasa to Rasa'' Unit- an initiative of the NGO Saahas, Koramangala, Urban Bangalore

6. ***Bin composting*** involves provisions for forced aeration in the bin floor; little turning of the composting material; and movement of material from one bin to another (Pic.. 3).

7. ***'Berkley Rapid Composting'*** involves accelerated aerobic decomposition through measures like chopping of raw materials to small size (Pic.. 4, 5); use of mineral compounds like ammonium sulphate, chicken manure, urine and turning of the material on daily basis.

Pic. 4: Like with the 'Berkley Rapid Composting' the waste is scrapped to smaller bits using this shredder, at ''Kasa to Rasa'' unit – Saahas, urban Bangalore

Pic. 5: Like with the 'Berkley Rapid Composting' the waste is shred to smaller bits, at ''Kasa to Rasa'' unit – Saahas, urban Bangalore

8. ***Vermicomposting*** based on the use of worms results in high quality compost. We visited and observed this being used exclusively ranging from small units where local schools like VidyaShilp Academy located in Bangalore to several composters. While VidyaShilp Academy uses kitchen waste as the starting material along with worms resulting in high quality compost, we visited a

site where some commercial composters used cow dung which was the by-product of a dairy farm as starting material.

We observed a combination of above methods of Passively aerated windrows (Pic.. 6), Bin composting (Pic.. 3), Vermicomposting (Pic.. 7) and some parts of the Berkley Rapid Composting method (Pic.. 4, 5) being followed during our visit to an NGO called *Saahas* (http://saahas.org/)[4] which runs a unit called "*'Kasa to Rasa'*" (from waste to wealth) where household waste is collected from the local community in and around Koramangala, Bangalore.

Pic. 6: Following the addition of activators like beneficial microbes, aerobic composting at 'Kasa to Rasa' unit – Saahas, urban Bangalore

Pic. 7: Final stage vermicomposting to hasten and better the quality of compost at 'Kasa to Rasa' unit – Saahas, urban Bangalore.

9. ***Bokashi based composting***: Apart from the above methods, some urban households in Indian cities are purchasing commercial composting kits like the SmartBin

(http://www.greentechlife.in/smartbin/)[5] which is based on the Japanese Bokashi method and uses organic waste generated in the kitchen. This method is based on anaerobic fermentation and is provided with a lid to press down the waste. Layering is done by alternating kitchen waste with microbes and allowed to decompose for 4 weeks (Pic.. 8). This results in *smartbrew* – a soil conditioner as well as a *Pic.kle* which is layered with dry compost and cured for a month or so.

Pic. 8: Smart Bin composting of kitchen waste based on Bokashi method.

The methods above are popular in India as they require very little capital investment and does not require any sophisticated infrastructure and machinery. Small farmers find them easy to practice, especially in those situations where manual labour is not a constraint. However, the low turnover and longer time span are the major bottlenecks.

ACTIVITIES: Practice mapping and analysis

2. Summary of current practices in on farm composting and composting in agriculture

Indian farmers are yet to realize the ill effects of modern agriculture which uses chemical fertilizers, growth regulators and pesticides excessively. There is an increasing awareness about organic agricultural practices in the world and organic farming is the need of the hour. In India, the practice of on farm composting and composting in agriculture is varied and is not followed on a large scale. The general techniques listed above such as the 'Indian Bangalore method', Passive Composting of Manure

Piles, 'Indian Indore method', passively aerated windrows, Chinese rural composting, bin composting, Berkley rapid composting, vermicomposting, Bokashi based composting, etc., are generally used.

Some of the more commonly used practices are discussed below.[6]

NADEP method of composting: developed by a farmer, Narayan Rao Pandhari Pande, in Maharastra, India and is widely popular. This method is based on the principle of aerobic decomposition with natural flow of optimum air. Here, a tank is built of specific dimension with holes for aeration. The tank is filled in layers with organic waste, a slurry of cow dung and water, soil, and the layers repeated. The tank top is sealed with dung and soil paste to prevent loss of moisture. Cracks are not allowed to develop on the heap to prevent gas leakage. After 15-20 days, when the substrate shrinks down, a second filling is made in a way similar to that adopted in the beginning. The top is then arranged in a hut like shape and replastered. The moisture level of the mass is maintained at 15-20 percent by sprinkling with water and dung slurry through holes. Normally the substrate takes 3-4 months to attain maturity without turning.

Padegaon method: This method is recommended for composting resistant substrates like sugarcane trash and cotton stubbles. These materials are shredded and trampled to make a layer that is 30 cm thick. This layer is drenched with a slurry consisting of wood ash, cow-dung and soil. Four or five such layers are added to the pile. Since the material is very resistant to decay, the heap is turned each month, retrampled and sufficient water added to keep it moist. The material is ready for use in about 5 months. The compost compares very well in composition with farm yard manure.

Indore method: Sir Albert Howard (1924-26) at Indore, Madhya Pradesh, developed this method in which cattle urine is effectively absorbed in rice straw, straw dust and other organic wastes from cattle shed. This waste is spread evenly in a pit to form a layer 10-15 cm in thickness. To this, cow dung slurry made with urine and inoculum from 15 day old compost pit is added. Water is then sprinkled and the layering repeated to fill the pit within seven days. The material is eventually turned thrice; twice with 15 days interval post filling of the pit and third turning after one month of the first turning. To provide succulent biomass, seeds of sun hemp are grown on compost heaps and during the first turning, the green plants are turned in. During rainy season the piling of 20 cm carbonaceous material (leaves, hay, straw, saw dust, wood chips, corn stalks etc.) and 10 cm nitrogenous materials (fresh grass, weeds, digested sewage, sludge, poultry litter) in alternate layers is repeated until the pile is one metre high. The method is highly labour intensive and less suitable to those farmers who do not have enough cattle and irrigation facilities. The method being aerobic in nature, hastens the maturity period and results in substantial loss of organic matter and nitrogen.

Though not technically considered as composting, the practice of **Green manuring** is widely prevalent on Indian farms. Green manuring is the practice of ploughing or turning undecomposed green plant tissues into the soil. This improves the physical structure as well as the fertility of the soil and also prevents soil erosion and leaching. The green-manure crop supplies organic matter as well as additional nitrogen, particularly if it is a legume crop, due to its ability to fix atmospheric nitrogen. Green manures breaks down gradually in the soil incorporating nutrients for the next crop.

3. Situational analysis of current practices in organic waste recycling

Organic composting is yet to receive its due in India as it is plagued by the bottlenecks indicated by the SWOT analysis in Fig.2. Although there are several positives such as sufficient raw material to compost, the methods utilized are not up to the mark due to lack of awareness. With the Prime Minister of India flagging off the Swachh Bharat Abhiyan in 2014, there is tremendous opportunity for waste management to be applied for uplifting the socio-economic impact in agriculture. However the preference of farmers for chemical fertilizers to obtain high yielding produce quickly, poses a threat to accept organic composting easily as the latter is a slower process.

Fig.2: SWOT analysis of Organic Composting in India

Below we describe a case of a situational analysis regarding organic composting in India. The following is a report on the article which we came across during our research and has been published on August 22, 2011 by the Hindu business line.[7]

This article reports how chemical fertilizer companies are making inroads into the business of organic composting from urban waste and are increasingly incorporating it in their product portfolio. One example includes Coromandel International Ltd (CIL), which annually sells around 35 lakh tonnes (lt) of chemical fertilisers (1 lakh refers to one hundred thousand in India). In 2010-11, CIL also marketed 50,000 tonnes of compost produced from MSW, which it planned to double later that year. The moderately priced compost at Rs. 5/kg, would generate a revenue worth Rs. 50 crore (1 crore refers to 10 million in India) – a fraction of the company's Rs. 8,000-crore operational revenues. But it is a business growing by over 20 per cent a year and perhaps projects a brand image for the company of turning organic and being environmentally sustainable. Besides CIL, Nagarjuna Fertilisers & Chemicals, Zuari Industries, FACT, Kribhco and National Fertilisers Ltd are also selling MSW-based compost, though the quantities they are doing are only a few thousand tonnes each.

An interesting observation made was that none of the fertiliser concerns, including CIL, were manufacturing the compost themselves but were obtaining them from composting firms like IL&FS Environmental Infrastructure & Services Ltd (IEISL), Hanjer Biotech Energies, Ramky Enviro Engineers and A2Z Infrastructure Pvt Ltd. These firms estimate India's total MSW-based compost production to be over 2.5 lt with the potential being much larger, given that roughly 500 lt of MSW is generated annually by the cities and towns here. That works out to 140,000 tonnes per day (tpd), with Delhi and Mumbai alone contributing 9,000 tpd each, Chennai and Kolkata 5,000-6,000 tpd, and Bangalore and Hyderabad 4,000-5,000 tpd. From every 100 tonnes of MSW, 15-20 tonnes of compost can be made. (*Note: the figures are of 2011*)

IEISL operates composting units at Delhi, Jalandhar, Mysore, Kozhikode, Erode, Pollachi, Mettupalayam, Udumalpet and Coonoor that can together process 1,480 tpd of MSW. By the fiscalend of 2011, it aimed to add another 900 tpd through new facilities at Jaipur and Tiruchi and expanding its 200-tpd plant at Delhi to 500 tpd (A2Z Infrastructure has the country's single biggest facility of 1,800 tpd at Kanpur, followed by Hanjer Biotech's 800-tpd unit at Nagpur).

The USP (Unique selling proposition) of these composting firms was that they receive the raw waste free of cost from municipal authorities, which they process, bag and sell either to fertiliser companies or under their own brands (such as IEISL's “Harit Lehar”). The processing cost comes to about Rs. 1.80/kg (~AUD$42.00/ tonne), with bagging and transport adding another Rs.1.30/kg or so (~AUD$29.00/ tonne).

Although the NPK content in MSW-based compost tyPic.ally ranges between 0.5 and 1.5 per cent each and is way below the levels in urea (46 per cent N), DAP (18 per cent N and 46 per cent P) or muriate

of potash (60 per cent K). Continuous farming has led Indian soils to have a very low OC (organic carbon) which cannot be refurbished through green manuring or putting back crop residues. As the addition of compost would increase the OC content in their soils, fertilizer firms affirm that farmers will be able to easily see a dramatic improvement in the nutrient use efficiency of the chemical fertilisers applied by them. Fertilizer companies project its compost's OC content of over 12 per cent as its USP and are smartly proposing that farmers should now purchase both its compost as well as its chemical fertilizers. IEISL, similarly, claims that farmers near Agra in Uttar Pradesh have increased peracre yields of wheat from 16 to 21 quintals (Quintal – 100Kg) by using its compost along with regular fertilisers. [7]

In our view, these firms are clever in that they are marketing both products simultaneously by claiming to reduce the need to apply a lot of chemical fertilizers and can now claim to do their bit towards environmental sustainability.

Post World-war II era saw a rapid expansion of the agrochemical industry where companies like Monsanto, DuPont, Syngenta and Dow among others, established a profound degree of control over agricultural practices. The surmounting public pressure and the gamut of scientific evidence curtailed the use of DDT and many other chlorinated pesticides in the 1970s. Executives and corporate scientists saw the potential for limitless advances—and ever-expanding marketing potential—in the incorporation of technological advances into the genetics of seeds. During the 1990s, Monsanto alone spent nearly $8 billion acquiring leading commercial seed suppliers in the U.S. and internationally; DuPont and others quickly followed suit, leading to today's widespread proliferation of the seed industry.[8]

Thus, seed agribusiness emerged from a period when the future of chemical agriculture appeared very much in doubt as it was tainted with wartime origins. Just like agrochemical companies invested in agribusiness seed companies to shake their image of being companies that just manufacture chemicals that are harmful for the environment, similarly chemical fertilizer companies could be trying to foray into the composting business when the landscape of agribusiness changes from one that is predominantly influenced by the green revolution to that of organic revolution.

METHODS: Composting and organic waste practices analysis

4. Current practices of on-farm and other composting in agriculture

A. Case study peri-urban set up – Shreesh Krishi Organics, Kunigal.

We visited a farm composting unit called Shreesh Krishi Organics, (*Krishi* means agriculture in Sanskrit) as a part of this study at Kunigal, 70 kms away from Bangalore. We interviewed the founder Mr. Lakshmi Prahlad on the operating procedures and learnt that raw material such as sugarcane waste is obtained from farms around the area. Farm waste that would otherwise be incinerated was passed through a shredder in preparation for rapid composting. No monetary transaction takes place with the farmers and Shreesh Krishi simply exchanges waste for compost. They are able to generate about 50 tonnes of compost per month and had initially approached several fertilizer companies for selling the same but found them to be apathetic. He then approached farmers and now runs this business for a cause by just word of mouth publicity.

Pic. 9 (a) Banner of Shreesh Krushi Organics displaying their products (b) Slurry of Panchagavya

The composting is done in 3 stages

a) Preparation of Jeevamrutham[9] slurry
b) Preparation of Panchagavya[10,11] slurry (Pic. 9-b)
c) Addition of the above two slurry to vermicompost

a) Preparation of Jeevamrutham slurry: Jeevamrutham (*Jeevamrutham* means 'Elixir of Life' in Sanskrit) is a traditional organic fertilizer used in India. In order to prepare Jeevamrutham in the traditional way, the following raw materials are required:

- Cow dung- 10 Kg
- Cow urine-10 Litres

- Black Jaggery- 2 kg
- Besan (Chick Pea Flour)- 2 Kg
- Water – 200 Litres
- Plastic Drum- 200 Litres capacity

Procedure:

200 litres of water is taken in a container. A slurry is prepared with cow dung and mixed well. Next, powdered jaggery and chick pea flour is added and mixed well. The drum is covered using a jute bag and allowed to ferment for a week by mixing every two days. This mixture should be used within 2-3 days of mixing. After a week, beneficial microbes develop in the mixture which can then be used with irrigation water, sprinkler or drip system.

At Shreesh Krishi Organics, Jeevamrutham is prepared by the addition of tender coconut water, milk, curds, cow dung, cow urine, legumes, microbes in a certain ratio and allowed to ferment for about a week.

b) Preparation of Panchagavya slurry: Panchagavya (*Pancha* means five and *gav* means cow in Sanskrit; *Panchagavya* means a mixture of five cow products). This is a traditional fertilizer and pesticide used in India from time immemorial. The quality standards of Panchagavya are mentioned in Ayurvedic Pharmacopoeia of India. CSIR (Council of Scientific and Industrial Research, India) has obtained some patents also regarding Panchagavya.

In order to prepare Panchagavya in the traditional way, the following raw materials are required:

- Cow dung – 5kg
- Cow Urine – 5 Litres
- Milk- 2 Litres
- Curds – 2 Litres
- Ghee (clarified butter) -1/2 kg
- Yeast – 2 tsp
- Tender coconut water – 2 Litres
- Plantain – 1/2kg

Panchagavya can be used either as a foliar spray or as liquid fertilizer after dilution. Panchagavya is known to increase farm yield and boost immunity. Both these concoctions will be ready for use within 20 days of preparation and can be replenished regularly if there is ample amount of cow dung and urine supply in the farm.

At Shreesh Krishi Organics, Panchagavya is prepared by mixing Cow dung, cow urine, with ghee and banana in certain ratios. This mixture is fermented for 3 days followed by sequential addition of tender coconut water, milk and curds and fermented for 5 days each, after every addition.

c) **Addition of the above two slurry to vermicompost:** Farm waste such as leaves of sugarcane, arecanut, coconut, neem (a natural pesticide), pongamia (rich source of nitrogen in a form easily available to plants) etc, is shred using a shredder. The shred pieces are mixed with cow dung and earthworms and decomposed aerobically for 2-3 months. The temperature in the pit reaches upto 70^0C which is effective in destroying any random seeds thereby preventing weeds. The fermented mix from above is spread out and allowed to dry in the sun to reduce the moisture content as well as destroy some unwanted bacteria and then passed through a sieve. To this preliminary compost neem cake, pongamia cake, panchagavya and jeevamrutha is added, stirred and fermented for a period ranging from 15days – 3 months. Once again the product obtained is sun dried and passed through a crusher and sieved. This is followed by bed lay and the serial addition of biofertilizers like *Trichoderma*, VAM, *Azolla*, etc., and turned periodically after each addition. This process is repeated for 15 days. The resulting product is then finally ready for packaging and sales at the price of Rs.11/- per kilo.

B. NADEP Composting: Another way of composting by aerobic decomposition, is the prevalent practice of NADEP composting, especially in Western India. Although, the NADEP composting was known for about past two decades, its application has become popular in India only in the recent years. Aerobic decomposition by the NADEP composting is found to produce better nutrient levels than the conventional anaerobic composting. [12]

NADEP gets its name from its farmer inventor named N.D. Pandhari Pande (also popularly known as “Nadepkaka”) living in Maharashtra (India). NADEP is not popular for the quality of its compost but rather because it can deliver large quantities of compost with minimum human effort in a short period of time.

S. No.	Source	Nutrient composition due to NADEP Composting %		
		N	P	K
1	Diversified agriculture, Lucknow, U.P.	0.5-1.5	0.5-1.0	1.0-2.0
2	Organic Farming, Department of Agriculture, Lucknow, U.P.	0.5-1.5	0.5-0.9	1.2-1.4
3	Utthan, An NGO, Allahabad, U.P.	1.5	1.0	1.4
4	Aranya Varta, Karauli, Rajasthan, An NGO	1.5	1.0	1.4
	Acceptable adopted unified values	1.5	1.0	1.4

Table1: Nutrient compositions in NADEPED compost reported from different NGOS in India[12].

The NADEP method of making compost[13] involves the construction of a simple, inexpensive rectangular brick tank with enough spaces maintained between the bricks (partial honeycomb

pattern) for necessary aeration (Pic. 10). The recommended size of the tank is 10 ft (length) x 6 ft (breadth) x 3 ft (height). All walls of the NADEP tank are provided with 6" vents by removing every alternate brick after the height of 1ft from below, for aeration. The tank can be erected with bricks and mud mortar or cement mortar. The location of the tank and the method of construction of the tank is of paramount importance. The tank should be at a level that is slightly higher than the ground level of the area. Places where water collects should be avoided. As wind may be a problem, the length of the tank should be squared to the predominant wind direction. It is also important to locate the tank under a tree and close to a source of water since some water is required to maintain the humidity of the compost.

Establishment: Raw materials for filling the NADEP tank are

- 1,500 kg of dry and green agricultural waste
- 90-100 kg of cattle dung or biogas slurry
- 1675 kg fine sieved dry soil preferably mixed with cow's urine
- 1500 L water (Same quantity as that of organic waste)

Pic. 10. NADEP composting pit with holes for natural aeration

- NADEP composting requires that the entire tank should be filled in one *go* within 24 hours and a maximum of 48 hours, as this would otherwise affect the quality of the compost. Before charging

the tank with the materials, it is advisable to wet the inner walls and the tank bed with cowdung slurry. The tank is layered as indicated in the figure below (Fig.3).

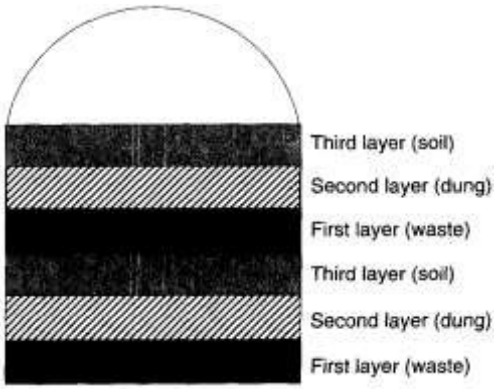


Fig.3 NADEP tank showing the various layers used for composting[13]

- Usually, the standard tank can take 11 or 12 series of layers. This is followed by sealing the tank by covering the top with a three-inch layer of soil. This is then plastered with cowdung slurry carefully so that no cracks emerge. Due to microbial activity, the compost layer goes down in a matter of 15-20 days. The tank should then be opened and the layers filled and packed with soil and cow dung slurry as mentioned before. Moisture levels are maintained at 15-20% by sprinkling with water or applying the dung slurry every now and then.

- Typically the compost takes 90-120 days to be ready for use after a round of sieving. The filtered compost should be used and the remains placed back into the tank for the next composting process. Each large tank can be harvested three times in one year. The expertise required for erection of the tank is available in every village and so are the other materials required, including dung, soil and organic waste like straw, hay, etc.

C. Rice Straw Composting[14]: ICRISAT is an international organisation working on sustainable ecological farming in Africa and India. The below video shows how once the crops have been harvested, instead of incineration the waste can be converted into organic compost.

D. (a) Green Manuring[15]:

Green undecomposed material used as manure is called green manure. Green manuring is a common practice and extensively followed practice in India and is created by leaving uprooted or mown crop parts to wither on a field so that they serve as a mulch and soil amendment[16]. It is obtained in two ways: by growing green manure crops such as leguminous plants which can fix the atmospheric nitrogen or by collecting green leaves and twigs of plants grown in wastelands, field bunds and forest. Typically, they are ploughed under and incorporated into the soil while green or shortly after flowering. The most important green manure crops are sun hemp, cowpea,

pillipesara, clusterbeans, green gram, pearl millet and dhaincha (*Sesbania rostrata*). Dhaincha (*Sisbania rostrata*) is commonly used for green manuring in paddy wheat cropping system. The *Sisbania* fixes nodulation on roots and its stem and under both dry and flooded condition, it gets ready for inversion as green manure in 50- 55 days and decomposes fast, in about 20 days. It releases all nutrient particularly nitrogen very fast and with application of average doze of chemical fertilizer it produces significantly higher yield than control. It was found to supplement 25-50% nitrogen and produce remarkable yield of hybrid varieties of paddy in the cropping season (2011-2012) in Bihar, India. But, its effect on increasing yield of subsequent crop of wheat is insignificant. In India, green manuring followed by cultivation of potato crop in ridge and furrow system of planting, inter cultured frequently is known to produce remarkably high yields of potato13. We visited one such potato farm in Shantigrama, 160 km from Bangalore, where such a system was practised.

(b) Green Leaf Manuring[15]:

Application of green leaves and twigs of trees, shrubs and herbs collected from elsewhere is known as green leaf manuring. Forest tree leaves are the main sources for green leaf manure. Plants growing in wastelands, field bunds etc., are another source of green leaf manure. The important plant species useful for green leaf manure are neem, mahua, wild indigo, *Glyricidia*, Karanji (*Pongamia glabra*) calotropis, avise (*Sesbania grandiflora*), subabul and other shrubs.

E. Farm Yard Manure: In peri-urban and rural areas, it is common practice in farms to simply dump cow dung and other organic waste in a pit and allowed to decompose for a minimum of 2 years, to obtain Farm Yard Manure (FYM). This FYM is left in piles on the farm and then spread over the farm land before the monsoon. During the monsoon the FYM will further decompose and seep into the soil. If this FYM is not decomposed properly, lots of weeds tend to grow.

F. Enriching of soil nutrients

- To grow monocots like Rice, and to introduce a Nitrogen source, leguminous plants will be grown and before planting the rice the leguminous plants will be ploughed into the soil and decomposed anaerobic condition by flooding with water.
- Also for other crops such as potatoes once it is harvested, the unusable potatoes, leaves and stumps of the plant will be ploughed back into the soil for decomposition.

5. Current organic waste practices

CITY COMPOSTING

A. Case study local school – Vermicomposting in VidyaShilp Academy

VidyaShilp Academy is an International School located in Bangalore and caters to about 2000 students on campus and is aiming to be a self-sustained green school. The school provides students, teachers and help-staff with lunch and thereby generates a lot of kitchen waste. They have an outreach program where their unit 'ShilpGreenergy' converts organic waste from the garden and kitchen is converted to vermicompost on campus[16]. The waste is initially sun-dried and then transferred to pits under shed. Cow dung and water is mixed in a ratio of 1:3 along with the organic waste in a pit and allowed to decompose for a month or so (10kg dung + 30L water + 60kg waste). This is then transferred to the next pit where it is provided with about 2kg earthworms and sprinkled with buttermilk after 15 days. This is covered with moist cloth and allowed to decompose for 3 months. The compost is periodically sent for analysis of quality. The compost is then sieved and packaged in bags of 5kg. This is then sold to parents at the cost of Rs. 20/kg. The same compost is used as manure for fertilizing the sprawling garden on campus.

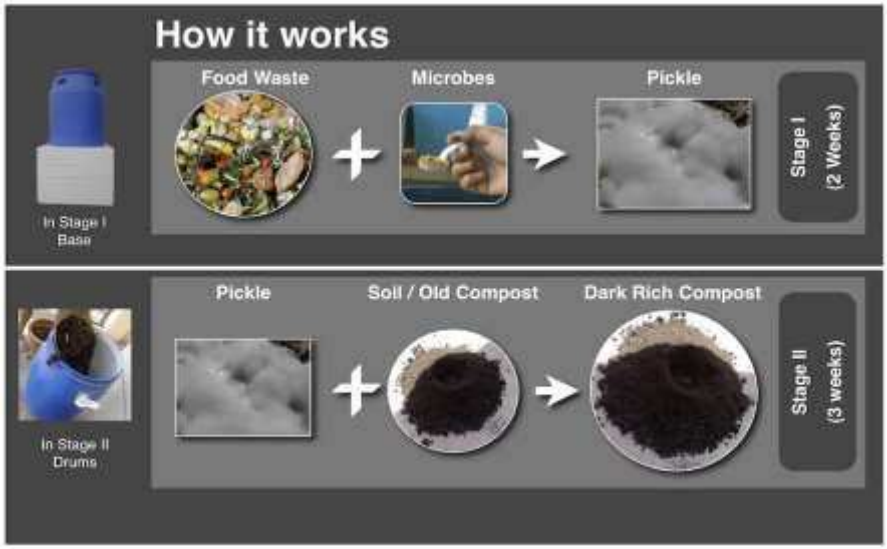
B. Case study household – Urban set up

Bangalore City is also referred to as the Garden City of India where many residents are interested in home and terrace gardening and are increasingly not only becoming aware of the benefits of composting. One way of doing it is through the 'Smartbin' which is manufactured by Greentech Life[17] and is based on the Japanese Technology of Bokashi (Pic. 11). Smartbins are a very convenient compost systems for small urban families. Two bins of 20L capacity each is sold along with 2 packs of Bio Bloom (beneficial microbes) for the price of about Rs. 2295/-. It works in 2 stages: In stage 1[18] food waste is thrown into these bins, just like one would in the regular kitchen's dustbin. The difference is, we press the waste down with any plastic plate, to generate anaerobic conditions and sprinkled with a teaspoon of Bio Bloom microbes and covered. Bio Bloom stops the waste from rotting and converts it to Pickle (hence no smell). Bio Bloom microbes convert the food waste to Pickle and the carbon to amino acids thereby preserving all nutrients. Each Smartbin takes approximately 3 – 4 weeks to fill for a family of 4. Once full, they are kept aside for a couple of weeks to finish the Pickling. While this is happening the second bin is started. Liquids (Smartbrew) is drained about twice a week through the taps and used as a soil conditioner. In stage 2[19], that Pickle is layered with dry compost generated in previous batches through Smartbin. This layering is done only once in a month or so and left in separate containers to cure for 3 – 4 weeks at the end of which is nutrient rich compost.

Pic. 11. Smart Bin – a Bokashi based method of composting at home

The advantages of using this is that it is low maintenance due to following reasons

- Rs. 12/- per person per month
- no constant mixing or turning
- no moving parts
- no electricity required
- no technical skills necessary odourless



Pic. 12. Steps involved in Smartbin composting

A family of 4 can generate about 6 – 10 kg of high grade compost per month this way (Pic. 12). Home gardeners at the end of the day are happy not only to have generated compost which can be used in their gardens but also to have recycled and have done their bit for sustaining the environment.

C. Case study city composting – urban set up; Kasa Rasa – Koramangala, Bangalore

Kasa Rasa (*Kasa* means waste in Kannada; *rasa*-essence; it basically refers to garbage juice) is a decentralised waste management unit run by a local NGO Saahas (http://saahas.org/) along with the help of public institutions like the Municipal Corporation manages waste in several parts of Bangalore to the tune of about 7 tonnes per day. A second entity, Saahas Waste Management Pvt Ltd provides professional services to all waste generators, including companies, apartment complexes, institutions and communities.

We visited a Kasa Rasa unit[20] in the locality of Kormangala and interviewed an intern of Saahas, Ms. Khushbu Birawat who shared with us the following information. This unit required initial investment of Rs. 45 lakh. It is supported by organisations such as, CHF International, Caterpillar Foundation, Robert Bosch, and Tetra Pak India. BBMP has provided 2,500 sq ft space of the land for the unit, while CHF International and Robert Bosch funded the unit with Rs. 39 lakh and Rs. 6 lakh, respectively.

The waste is collected after source segregation from local neighbourhood which is collected by BBMP pourakarmikas and the staff of Kasa Rasa. Reaching out to a radius of 5 km for segregated waste - organic waste and dry/recyclable waste is sorted by Saahas field staff and taken out for recycling. For residences or offices serviced directly by the staff, there is a nominal fee to cover transportation and labour costs. Residents can also bring in waste directly to the centre. It has a capacity to compost upto two tonnes of waste per day.

The organic waste is channelized after weighing to a trough and segregated. The Centre has an organic waste converter (OWC) which includes a shredder for rapid composting and dry leaves are mixed to maintain the C:N ratio. This is then shifted to curing tanks which have pipes at the bottom to blow air to maintain a condition of aerobic composting (Pic. 13). A mesh is placed above these pipes and the waste added. This is left to decompose for about 30 days where the temperature of the waste pile reaches to 65-70^{0}C, upturned and allowed to curate for an additional 10 days. This is then piled up to aerate and decrease the moisture content and then shifted to a pit to include vermicomposting in order to increase the quality of compost and decrease the time taken for composting (Pic. 14). These are sieved and then packaged and sold at a retail price of Rs.15/- per kilo in a kiosk outside.

Pic. 13. Staff of Kasa Rasa filling the compost tank for aerobic decomposition of waste

Pic. 14. Steps involved in preparation of compost at Kasa Rasa[21]

RESEARCH QUESTIONS:

6. How is organic waste currently being recycled?

Organic waste is currently being recycled largely under the PPP (Public Private Partnership) model.

A few example of the same in the state of Karnataka is discussed below.

A. Composting Plants in Karnataka under the PPP model[22]

a) **Bruhat Bengaluru Mahanagara Palike (BBMP)**: The Karnataka Compost Development

Corporation Limited (KCDC) (a Govt. of Karnataka organisation) established a composting plant at Bangalore city in 1975. The KCDC plant receives 200 tpd of MSW everyday and produces around 30 tpd (15% yield) of compost by following windrow composting and vermicomposting. The company is selling the mechanical compost at the rate of Rs. 3.80/kg and vermi-compost at Rs.4.05/kg. The KCDC has a contract with Department of Agriculture to sell city compost.

b) **Mysore City Corporation**: Mysore City Corporation has entrusted IL&FS with the O&M of composting facilities in 2008 on land lease & royalty basis. The plant receives 150 tpd of waste and produces 18 tpd (12-13 percent of yield) of compost by following windrow composting method. The company has tie-ups with Coromandel, Zuari, SPIC, KRIBCO etc for selling of city compost at a price of Rs. 2500 – 3000 per ton of compost.

c) **Mangalore City Corporation**: Mangalore City Corporation has entrusted M/s Unique Waste Management Pvt. Ltd with the O&M of composting facilities in 2013 on tipping fee basis. The plant receives 290 tpd of waste and produces 30 tpd (10-12% of yield) of compost through windrow composting and vermi composting methods. The company supplies compost to IL&FS, Kozhikode, Kerala on bulk basis and sells the compost at a price of Rs. 4.25/ kg of compost (bagged) and Rs. 3.0/kg for un-bagged compost on bulk basis.

d) **Belagavi City Corporation**: The Belagavi City Municipal Corporation entered into an agreement with M/s Ramky Enviro Engineers Ltd., Hyderabad in 2007, for establishment of scientific processing & disposal facilities on BOT basis. At present, the plant receives an average of 150 tpd of Municipal Solid Waste. The MSW is composted by windrow aerobic method of composting. As per the agreement the compost is sold to local farmers and industries at the rate of Rs 3.50/- and approximately 450 tonnes per month (15 tpd) of Compost is generated. The company has entered into an agreement with Godavary Gold Fertilizers, Krishak Barati Cooperative (KRIBCO) Ltd, Balaji Agro Agencies, Coromandel International Ltd, Vardhaman Agro agencies and Local dealers for selling its compost.

e) **Shimoga City Corporation**: Shimoga City Municipal Corporation entered into a contract with M/s Ramky Enviro Engineers Ltd., Hyderabad in 2008, for the establishment of scientific processing and disposal facilities on BOT basis. At present, the plant receives on an average, 90 – 100 tpd of Municipal Solid Waste. The MSW is composted by windrow aerobic method. The compost generated is only 10% to 12% on MSW Receipts (9-10 tpd). M/s. Ramky Enviro Engineers Ltd. sells the city compost to the farmers in their own brand namely, Ramky Shakthi and also are selling the

organic manure to some agro and fertilizer agencies like., Kribhco Pvt Ltd., Coromandel International Limited, and Balaji Agro Agencies. The price of compost is Rs. 3.00/- to Rs.4.00/- per kg and it may vary depending on the placement of order.

Overall, from the five major plants mentioned above, around 103 tonnes of compost (103 x 250 days = 25,750 tonnes /annum) is being produced every day. In the rest of the cities, considering the yield of 10%, the compost produced is around 70 * tonnes per day (70 x 200 days = 14,000 tonnes / annum). Thus the total compost produced / annum is 39,750 tonnes /annum (i.e. 25,750 + 14,000).

7. How are farms using compost and composting technologies already?

On farm composting is at its rudimentary stage. Most farmers apply FYM or do NADEP composting. Many complete the composting process with vermicomposting in the last stage to hasten the process as well as obtain better quality compost.

8. What systems and processes are currently being used?

FYM is the most commonly used organic manure in India which farmers apply to crops traditionally in rainfed areas. It consists of mixture of cattle dung, the bedding used in stable and remnants of straw fed to cattle. The cattle dung together with stable waste and house sweepings is heaped loosely. The loose heap is exposed to sun and the raw organic matter allowed to dry up. During rains, it gets drenched and all the soluble nutrients get leached out from the manure. Also, while the organic matter decomposes, the ammonia etc., escapes into the atmosphere. The wastage of nitrogen rich urine, the loss of nitrogen due to the fermentation of exposed cattle dung, washing away of soluble mineral elements by leaching etc. reduce the manure value of the FYM. Traditional method of preparing and storing FYM is generally faulty as no scientific procedures are followed resulting in low quality compost.[23] Eventually, farmers lose interest in FYM and start to mainly depend on chemical fertilizers which was not sustainable in the long run.

Unscientific handling methods can be reduced by storing the dung in stone or brick lined pits, mixing large quantities of straw and other vegetable matter with cattle dung and keeping the heap compact and moist. This encourages bacterial decomposition of raw organic matter, prevents loss of soluble mineral elements through seepage and minimizes nitrogen losses. The quality of manure also improves by the concentrated feeds given to the cattle. Manure from cattle fed on cereal straws, grass hay is much less valuable than that from animals fed on legume hays, grains and concentrates. Use of preservatives also enhances the quality of the manure. Gypsum and super phosphate have proved most promising in preventing escape of ammonia.[23]

Various methods of composting are continuously been researched both under aerobic and anaerobic conditions. NADEP composting process facilitates aerobic decomposition of organic matter and is prevalent in several parts of India.[24] The compost made out of this process has been tested by several institutions like IIT – New Delhi, Gandhigram University, Centre for Science, Wardha etc. including the farmers field and found to be useful. The advantages of this simple method is that it is inexpensive, sourced from the farm itself, yields good compost and has support network on how to use in every village. Moreover subsidised loans are given to farmers to construct the NADEP Pit.[23]

As discussed earlier, the ingredients for making NADEP compost are agro-wastes, animal dung and soil in the ratio of 45:5:50 by weight. The ingredients are added in layers starting with vegetable matter followed by dung and soil in that order. Each layer can be about 45 kg vegetable matter, 5 kg of dung mixed in 70L of water and 50 kg of soil so that 30 layers will fill the tank. The nutrients produced in the manure are absorbed by the soil layers thus preventing their loss. About 22-50 L of water is to be sprinkled twice a week after the tank is loaded. The material loaded is left in the tank for complete decomposition of the material which takes about 3 months. With production of 3 tonnes to 3.5 tonnes of compost produced per cycle, about 9 to 10 tonnes of compost can be made annually from one tank. The compost can be stored for future use, preferably in a thatched shed after air drying and maintaining it at about 20% moisture level by sprinkling water whenever needed. By following the procedures suggested above, the compost could be preserved for about 6 to 8 months. It is advisable to sprinkle cultures like *Trichoderma*, *Azotobacter*, among others in layers to the compost in order to enhance the compost quality, which helps absorb the nutrients better. [23]

The disadvantages of this practise is that some farmers find it difficult to layer as recommended and this method requires more labour than traditional methods. Layering is difficult in the rainy season and there is the added expense on transporting silt when the unit is away from the field. Since this method of compost can be prepared with minimum quantity of cow dung, it can be considered as very popular model.[23]

Apart from these two common practices, there has been a renewed movement to revive old Indian traditional methods like the application of Jeevamrutham, Panchagavya coupled with vermicomposting as discussed earlier. Some farmers exchange their farm waste for compost manufactured by others as discussed with the example for Shreesh Krishi Organics.

9. What is common practice?

The most common practice on farm is incineration of organic waste. It is widely believed that this practice can get rid of disease causing organisms, in particular viruses. Green manuring is mainly practised in order to enrich the soil with nitrogen. Farmers are largely ignorant and consider the above two practices to be the most economical way to 'compost'. Dumping farm waste and allowing it to decompose naturally for a period of 2 years is another popular practice. Comparatively, farmers with better resources and knowledge prefer to either apply FYM, NADEL compost and or Vermicompost. Traditional practices include application of Jeevamrutham, Panchagavya, Amritpani, etc to the plants in order to boost their natural immunity and promote better growth. This is in keeping with the view that prevention is better than cure and that holistic development of the plant is of paramount importance.

OBJECTIVES: Innovative practices in organic waste recycling and composting in India

ACTIVITIES:

1. India: Business case study

Existing waste management systems in India have shortcomings but greater government investment and private sector involvement offers significant market potential. Most municipalities in India invest at least 10% of their total budget in SWM.

Case Study of Composting by a Firm

Firms like Waste Capital Partners[25] is comprised of both for-profit and non-profit entities – Waste Ventures India and Waste Impact respectively. Waste Ventures India employs staff from lowincome groups to work with municipal systems to process MSW to nutrient rich compost which is then sold to farmers. The non-profit arm, Waste Impact, based in Bangalore meanwhile works with various waste management players to test several methods of socially inclusive and financially/environmentally sustainable waste management practices. Waste Capital Partners aims at professionalizing the informal sector by linking waste Pickers and scrap dealers to multinational companies.[26]

Waste Ventures provides the following services[25]

- 'SwachhWorks' solution includes professional doorstep collection of waste, scientific and ecofriendly on-site processing of organic waste, and recycling of dry waste.

- Recycling Pickup & Processing service offers responsive and reliable recyclable Pickup direct to the doorstep for a variety of dry waste.
- Municipal Waste Management (MWM) service helps small cities do something responsible about their waste and comply with national waste regulations. Standard service includes collections and processing of both organic and dry waste, and monetizing the by-products (typically compost and recyclables) to support operations and increase affordability to the municipality.

2. International Innovative Program Search

Internationally, there are various innovative approaches to compost waste. Innovations could range in terms of design of the composting bin to design of operations. Some innovative composting methods (Pic. 15) have been listed from around the world most of which are in the table top format but can be scaled for commercial purpose.[27]

1. **Envirocycle's Mini Composter/ Compostmaker:** comes pre-assembled with a compact design. Its quick composting cycle takes only 4-6 weeks.

2. **The Jarst mini composter:** carries out composting within a flower pot that can rest on any countertop.

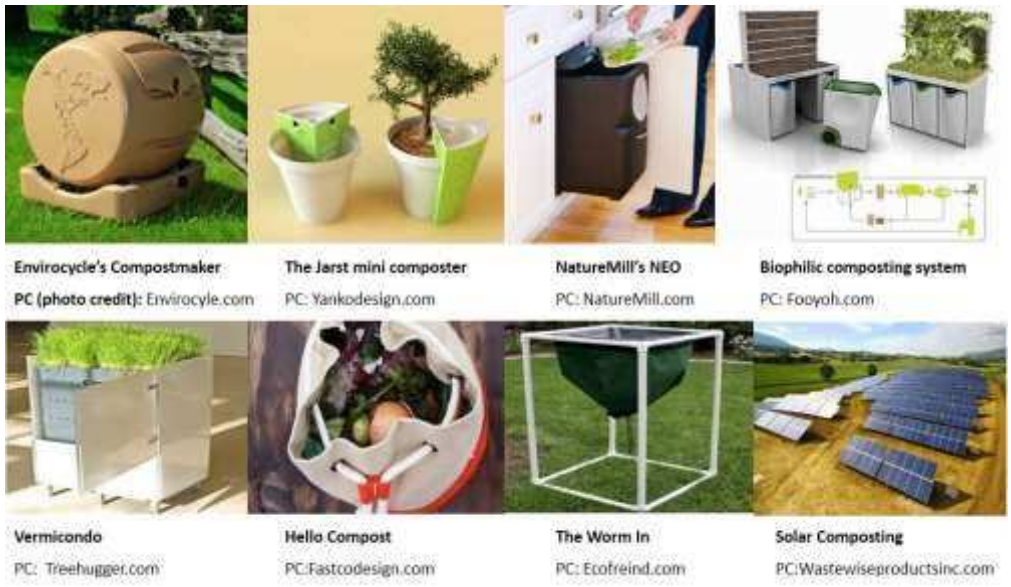
3. **NatureMill's NEO:** takes the hassle out of manual compost mixing with an automatic mixer. It can be used both indoors and outdoors.

4. **Cooler Solutions Inc. idea for the biophilic composting system:** allows an office to reduce up to 33% of their organic waste. This can provide nutrients for indoor plants that help to improve the air quality and atmospheres of the offices.
5. **Vermicondo:** is the luxury solution to worm composting. The product mimics the aesthetics of cabinets and can be stored seamlessly in a kitchen or pantry. This product's design allows worms, who travel vertically, to break down waste most effectively.

6. **Hello Compost:** is a composting system that turns waste into food as opposed to, leftover food into waste. Families are able to store their green waste in odour- containing freezable bags until they are sent to Project EATS, a New York-based urban agriculture non-profit organization, where they are assigned a value and used to grow fresh produce by local farmers. The families are then sent a portion of fresh produce based on that value.

7. **The Worm In:** is essentially a woven bag on a PVC stand, this decomposer needs to be fed in the mixture of raw materials, which is food scraps and earthworms, before being zipped from the top. As worms consume the fresh materials of food inside the bag, they keep moving upwards leaving behind fresh castings resulting in compost. Due to a ventilation system, the final mixture is extremely well developed and rich in nutrition. Also, after the process is complete, the bag can be taken out and cleaned with comparative ease and reattached.

8. **Solar Composting:** streamlines the process of organic waste disposal by harnessing the energy of the sun to regulate the temperature and airflow during composting cycles. This process ensures the best quality fertilizer possible.



Pic. 15 Innovative methods of composting

http://compostingtechnology.com/products/compost-systems/earth-tub/

9. **Black Soldier Fly Composting:** BSFL (Black Soldier Fly Larvae) Composting[28] is an alternate to vermicomposting and uses the potential of black soldier flies to provide promising solutions to two of modern agriculture's growing problems: the high cost of animal feed and the disposal of large amounts of animal waste. Many farms currently operate as linear systems, purchasing animal feed and then paying to eliminate waste from farm animals. Use of black soldier flies may be instrumental in closing the loop between animal waste and animal feed.[29]

   BSFL will feed on a range of organic waste ranging from animal waste to food scraps and can eat up to 8-10 times their own weight. As the BSFL mature, they grow into ½- inch-long grubs, at which point they remove themselves from the compost bin and turn into pupae. The larvae process the

nutrients in the food and leave behind a compost tea that can be sprayed directly on plants as a fertilizer. The leachate left behind continues to feed new larvae. The pupae can immediately be fed to chickens as a good source of protein or can be dried and processed into feed for use at a later time.[28]

Pic. 16 BSFL composting : when the larvae pupate, they leave behind a shell which can be used as chicken feed[31]

Pic. 17 BSFL can devour 8-10 times their weight of the organic waste

Portland researchers Radu Popa and Terry Green founders of DipTerra (www.dipterra.com) promote black soldier flies as food scrap composting helpers. The empty larvae shells can be used as chicken feed or turned into wound dressing products, and the larvae themselves can be used to make biodiesel or as feed for farmed fish. The advantages of using this method is that it doesn't require one to aerate the woody debris and is much easier to move the liquid compost tea than it is to haul huge piles of solid compost.[31]

Pic. 18 Radu Popa and Terry Green testing a commercial-scale black soldier fly composting system[31]

Innovative commercial composting solutions[32]

Green Mountain Technologies from USA has a pipeline of commercial composting solutions which cater to different sizes of consumers. Their products include:

1. **In-vessel systems**
    a) Containerized Compost System
    b) Earth Cube – neighbourhood composting system
    c) Earth flow
    d) Earth Tub
2. **Aerated pile systems**
    a) GMT TAP (Turned Aerated Pile System)
    b) Earth Pad ASP (Aerated Static Pile)

1. In-vessel systems (Pic. 19)

a) **Containerized Compost System:** First, composting takes place in controlled batches with airtight vessels (CompTainers™) that can be moved and emptied by roll-off trucks. Second, each CompTainer is closely controlled to optimize decomposition, meet regulatory requirements and minimize odours. The unique aeration system integrates up to 50 CompTainers into a single system. A small building for receiving & mixing plus a bio-filter to remove odours, results in a completely enclosed compost system at a fraction of the cost of other in-vessel systems.

b) **Earth Cube:** is an in-vessel neighbourhood composting system.

c) **Earth flow:** is an automated, mid-size, in-vessel patent pending composting system designed for on-site composting at universities, corporate campuses, resorts and other organizations. Since mixing, aeration and moisture addition is automated, this system requires very little labour beyond loading and unloading compost. The Earth Flow is fully enclosed to provide excellent control over moisture, odours, vectors, and leachate.

d) **Earth Tub:** is designed specifically for on-site composting of food-waste. It is a fully enclosed composting vessel featuring power mixing, compost aeration, and bio-filtration of all process air. This self-contained unit is ideal for composting at schools, universities, restaurants, hospitals and supermarkets.

Pic. 19 Various options for in-vessel composting by Green Mountain Technologies

2. Aerated pile systems (Pic. 20)

a) GMT TAP (Turned Aerated Pile System): has 4-8 temperature controlled aeration zones with the aeration piping installed below the surface. This allows a compost turner to freely and efficiently turn and water the compost. This design allows for the most efficient handing, smallest footprint, and the highest throughput possible. A six acre site with two equipment operators can process over 300 tonnes per day from the initial grinding process to the final load out making this the most streamlined and profitable system available today.

Odours are managed using bio-filters and bio-covers to meet the most stringent air quality regulations. Water runoff is collected, treated and re-used to the greatest extent possible allowing facilities in most climates to meet zero water discharge. The TAP provides a complete and powerful turnkey solution.

b) **Earth Pad ASP (Aerated Static Pile):** state-of- the-art composting systems for municipal and commercial clients as well as agricultural by-products and manures. Our designed facilities (over 20) have led the Pacific Northwest and Northeastern States for composting curbside collected yard debris, food wastes, and agricultural wastes, without odour problems or other permit violations.

Pic. 20 Aerated-pile composting options -GMT TAP and Earth Pad ASP[32]

METHODS:

3. Identification of innovations and or potential models for pulling urban organic waste out of waste stream for benefit of farmers and urban poor

As far as we are aware, there is a clear distinction with regards to the compost consumed in the rural and urban areas of India. Urban India is becoming increasingly aware of the benefits of organic composting, terrace gardening, self-sustenance and impact on environment due to land-filling. The government has made it mandatory for buildings (houses, apartments, etc) which generate over 50 kg of waste to manage their own waste. Thus, apartment complexes have come up with innovative ways to do composting and use that for their own personal terrace-gardens or the communal ones. They are thus self-sustained. How this benefits the low-income group is that they are hired to manage the waste and also in gardening. As discussed earlier, MSW composting units like 'kasa rasa' convert organic waste collected from the local neighbourhood and are sold for the urban population mainly in kiosks held outside. Rural India does not purchase city compost as it is expensive and would rather do

it themselves on their farm. Since the farms in India are not large, there is no need for them to purchase compost in large quantities and can thereby avoid the huge costs of transport. Otherwise they prefer to buy compost generated by local commercial enterprises where they can haggle the price, take on credit or simply exchange their farm waste for compost. Lack of awareness and a general sentiment that anything urban is expensive prevents them from even trying to venture in this regard. We have discussed below innovative models or methods of community city composting below simply because people using this are educated, aware and rich who can afford to invest in such a venture, which is moreover mandatory. It has become a status symbol in the urban society to say that they have their own composting unit which is fancy in outlook as well; also giving them an elitist feeling that they are the torch bearers of society who do their bit for the environment.

COMMUNITY CITY COMPOSTING[33]

Method 1: Platform Composting by activist Dr. Meenakshi Bharath at Malleswaram, Bangalore (Pic. 21)

Pic. 21 Platform Composting

Type: Easy, simple, cost-effective and a hassle-free aerobic solution to compost both kitchen and garden waste.

Equipment: Shredder

Infrastructure and Procedure: Cement blocks, wooden logs and coconut branches piled to provide a one-foot-high gap between the platform and the ground so that the leachate that trickles down is quickly absorbed by the ground beneath and air travels up the pile from the bottom. The only accelerator needed here is cow dung. Sour curd is added to introduce beneficial bacteria into the pile.

Method 2: Pelrich Byobins of Pelican Biotech & Chemicals Labs Pvt. Ltd, at Renaissance Regalia, Malleswaram, Bangalore (Pic. 22)

Type: Simple, aerobic composting of home and garden waste, additional vermicomposting

Equipment: Each Byobin comes with a capacity of 600 litres and can accommodate a maximum of 15kg of waste per day. It is sun- and rain-proof. Four perforated pipes run around the inner circumference to aerate the pile and also pump out the excess hot air that gets accumulated during the process. A net separates the bottom from the rest of the bin and this is where the leachate collects. It needs to be taken out through an outlet fitted at the bottom once in 2-3 days to increase air circulation.

Pic. 22 Pelrich Byobins system

Infrastructure and Procedure: Waste both vegetarian and non-vegetarian should be spread uniformly in the bin and a thick layer of Pelrich Composorb—a cocopeat-based inoculant—should be laid on top of it. Dry leaves can be added on top of the Composorb layer to avoid insect-related issues. Once the bin is filled up, it is left undisturbed for 15 days. On the 16th day, the top dry layer is removed into another container. Repeat this every alternate day. Further composting of wet waste will go on in the bag. In the next 10-15 days, all the compost can be taken out and the bin will be ready for the next cycle. This is followed by vermicomposting (Pic. 23).

Cost: Each Byobin: Rs 16,500/-
Operational cost: Composorb - Rs 1,200/100L bag, 0.75 bag/bin/month = Rs 900 (recurring cost/month).

Contact: Dr C N Manoj, Chief Executive, Pelican Biotech & Chemical Labs Pvt. Ltd., 1/77, NC John Estate, Kuthiathode, Cherthala, Alappuzha, Kerala-688 533. Ph: 91-478 – 2560206, 3212999; Mobile: 91 – 9447365542. Email: manoj@pelicanbiotech.com; www.pelicanbiotech.com.

Method 3: Up'Grade by Reap Benefit Method, Bengaluru (Pic. 23)

Type: Up'Grade is a cocopeat-based inoculant which added to waste to compost aerobically

Equipment: Milk Crate and Shredder

Infrastructure and Procedure: Up'Grade is a cocopeat-based inoculant loaded with micro-organisms which helps degrade the organic material aerobically. This method does not allow loss of highly nutritious leachate preventing the need to drain out the leachate making the compost that much more nutritious.

Pic. 23 Up'Grade system use simple craters for composting

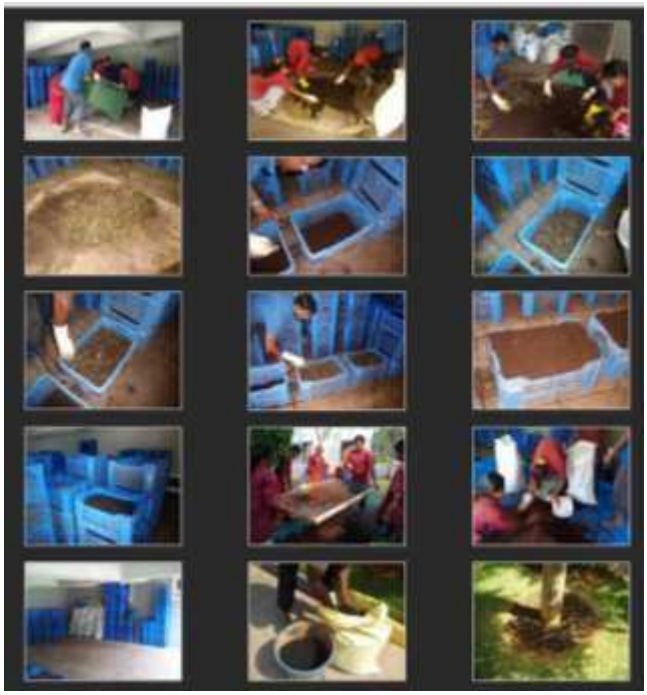
The kitchen waste is shred and a 2" thick layer of Up'Grade is added to the bottom of a crate to prevent moisture content from dripping down. Up'grade and shredded waste is mixed in the ratio of 1:3 and mixed thoroughly with rakes. The crate is filled with this mix and upto 3-4" is left free on top and maintained in moist conditions. A final layer of Up'Grade is sprinkled on the top to prevent fruitflies

from entering the crate. Crates are staked and left undisturbed for 20-25 days followed by sieving of the compost. Small chunks of semi-done compost is rejected and rodents are kept at bay (Pic. 24).

Cost: Each crate - Rs 300-350/-.

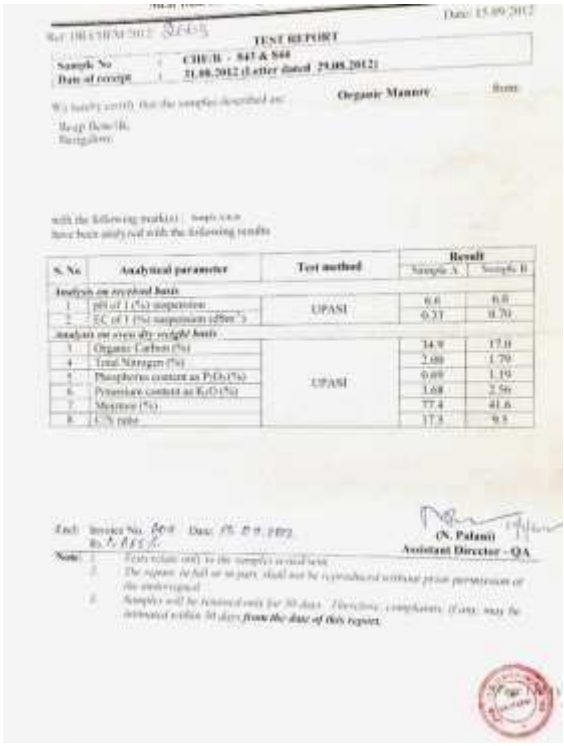
Operational cost: Each kilo of Up'Grade costs Rs 8, plus transportation cost. A tonne of Up'Grade per month at Rs 9,000/-.

Contact: Reap Benefit, #1023, 3rd Cross, 13th Main, HAL 2nd Stage, Indiranagar, Bangalore – 560038, India. +91-9986615136/ +91-9886361805, info@reapbenefit.in.



Pic. 24 Steps in Up'Grade system of composting

A report of the Compost quality from compost obtained this way is shown below (Pic. 25).



TEST REPORT

Sample No : CHCB - 847 & 848
Date of receipt : 21.08.2012 (Letter dated 29.08.2012)

Organic Manure

S. No.	Analytical parameter	Test method	Result	
			Sample A	Sample B
	Analysis on as received basis			
1	pH of 1 (%) suspension	UPASI	6.6	6.8
2	EC of 1 (%) suspension (dSm⁻¹)		0.33	0.70
	Analysis on oven dry weight basis			
3	Organic Carbon (%)	UPASI	34.9	17.0
4	Total Nitrogen (%)		2.00	1.79
5	Phosphorus content as P_2O_5 (%)		0.69	1.19
6	Potassium content as K_2O (%)		1.68	2.56
7	Moisture (%)		77.4	41.6
8	C/N ratio		17.5	9.5

(N. Palani)
Assistant Director - QA

Note:
1. Results relate only to the samples tested here.
2. The report in full or in part, shall not be reproduced without prior permission of the undersigned.
3. Samples will be retained only for 30 days. Therefore, complaints, if any, may be intimated within 30 days from the date of this report.

Pic. 25 Quality of compost obtained by Up'Grade system

Method 4: Digestor method of Sudh Labh, Sovereign Park, Basavanagudi, Bangalore (Pic. 26)

Type: Layered methodically in digester for aerobic composition

Equipment: Rectangular box-like structure with 1.5m x 2m x 1.68 m dimensions and walls made of fibre reinforced plastic sheets. On all the four sides, the walls are riddled with holes to let the air in. The top is left uncovered. Four perforated pipes jut out of the digester—taking the hot air out from the composting mass and letting fresh air in, simultaneously. The digester can hold 500 kg of waste, in all. Two hatches at the bottom—front and back—have been provided to take out the mature compost. It has a section in the bottom to collect the leachate dripping down from the digester.
Interestingly, in a month, just one bucket of leachate has come out from the entire organic mass.

Infrastructure and Process: The digester needs to be installed under a roof to protect it from rainwater. A detachable roof is as an option to those who prefer keeping it out in the open. A step-up stool, a plastic tub, a rake and a couple of other basic tools are part of the package. This digester takes in both vegetarian and non-vegetarian waste. When starting the first batch, four blocks of cocopeat is spread evenly at the bottom to absorb leachate. A layer of kitchen waste is alternated with a layer each of dry leaves and saw dust on top of it to absorb extra moisture. Once a week, neem powder is sprinkled and 250 ml of effective micro-organisms (EM) solution and microbes' powder is added. Every

alternate day before adding the fresh waste, the rake is used to turn the mass aerate. Design is the best feature of this product as one does not have to invest in another digester to let the compost mature in the first one. The mature compost is removed from the bottom hatch even as one goes on adding fresh waste on the top.

Cost: Each digester costs Rs. 40,000/-

Operating cost:

- Cocopeat blocks: 25 kg, twice a month: 50 x 6/kg = Rs 300/-
- Neem powder: 1 kg = Rs 40/-
- Sawdust, 2 sacs: Rs 60 x 2 = Rs 120/- Daily Dump EM solution, 1L = Rs 65/-
- Daily Dump microbes powder, 2 packets = Rs 45 x 2 = 90/-

Contact: Sudh-Labh, No. C-3, 906, L & T South City, Bannerghatta Road, Bangalore 560076, Phone: +91 98456 90778. www.sudh-labh.in.

Pic. 26 Digester method of composting

Method 5: Tallboy composting by Rite-Ways, Esteem Classic, Rajajinagar, Bangalore (Pic. 27)

Pic. 27 Tallboy composting system

Type: Aerobic composting of pulverised waste

Equipment: Tallboy is paired up with a pulveriser which not just chips and shreds, but *pulverises* the kitchen waste and dry leaves. It is efficiently designed and takes up very little space in a corner. Fitted with a 5-hp motor, it takes care of 80-100 kg in one hour.

Infrastructure and Process: Tallboy is basically a stand with 16 ringed hooks into which inverted water bottle containers have to be inserted. The mouth of the container is closed and the bottom portion is cut open to let the air in. Each container can take in 18-20 kg of pulverised waste. That would mean the entire stand can hold up to 300 kg. A crate or a shallow container is required to collect the pulverised waste.

Segregated kitchen waste is pulverised along with a few handfuls of sawdust or cocopeat to take out the moisture content. Dry leaves and sawdust (or cocopeat) are added for brown content to the matrix; in other words, carbon content. To this mix, a few spoons of Bacterite (microbes) is added. The container is filled with the mix while leaving the top 2-3" free and iInserted it into a Tallboy ring and left aside for 15 days. The compost is ready in 15 days, as the pulveriser speeds up the process by breaking down the raw material into almost chutney-like consistency. What could have taken at least 7-10 days for the bacteria is done by the pulveriser in a matter of minutes. The compost is left moist and not dried so that microbial activity goes on even after the compost is harvested. ~20kg compost is generated per day (Pic. 28).

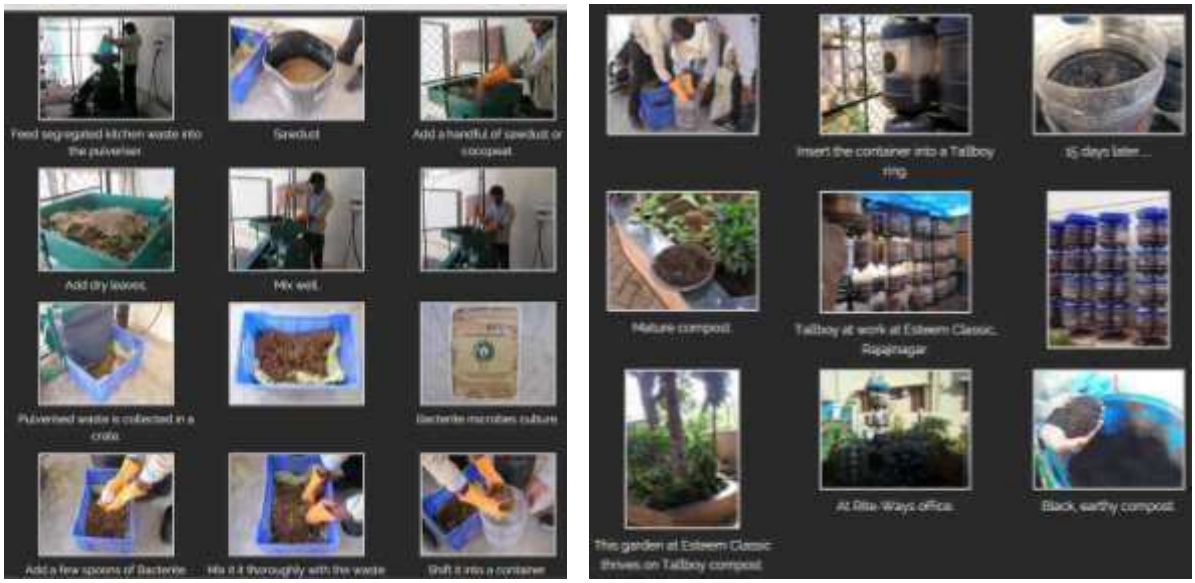
Cost:

- Pulveriser: Rs 1,68,000
- Cost of one Tallboy stand: Rs 26,800
- Total number of Tallboys needed for a 100-home community: 3 (3 x 26,800 = Rs 80,400)
- Total: Rs 1,68,000 + Rs 80,400 = Rs 2,48,400

Operation cost: Power consumption for pulverising 50-60kg waste plus labour cost, Bactrite cost details unavailable.

Rite-Ways buys back compost if the quality is good.

Contact: Rite-Ways Enviro Private Limited, #43, 2nd Floor, 9th Cross, Sharadamba Nagar, Jalahalli Village, Bangalore 560013, Karnataka, India. T: +91 80 2345 2279,+91 9945.801.176 | E: solutions@rite-ways.com | riteways.net | rite-ways.com.



Pic. 28 Steps involved in Tallboy composting system

Method 6 : Marigold composter by Prudent Eco Systems, Sobha Lotus, Brookefield, Bangalore (Pic. 29)

Type: Portable, solar based aerobic composting and although it lacks PV panels, it gets its name mainly because it absorbs sunlight through its roof made of high-quality acrylic.

Pic. 29 Marigold composting system

Equipment: The steel-bodied container sits below the rain-proof acrylic roof and the gap in between is covered with a strong perforated steel plate which lets in enough air. The roof can be easily open or shut and thus prevent rodents entering the pile. Right below the container, another plate collects leachate, if any.

Infrastructure and process: To one bucket of kitchen waste, ½ a bucket of dry leaves, cocopeat or sawdust is added to absorb the extra moisture. The entire pile is thoroughly mixed once a day with a rake to aerate the decomposing mass. A 100-unit community needs six extra-large composters of 300 L capacity each. Each composter will hold nearly two days of kitchen waste (approximately 100 kg) and the suggested quantity of dry leaves or cocopeat. By the 12th day, the sixth composter will be filled up. On the 13th day, the semi-compost from the first composter is removed and transferred to jute bags that Prudent Eco Systems sells at just Rs.30/- a piece. The semi-compost stays in the bag for further breakdown for 20 days more before sieving and applying it to plants (Pic. 30)

Pic. 30 Steps involved in Marigold Composting system

Cost: Rs 24,000/- per bin

Operational cost: Apart from labour cost, the recurring cost of cocopeat/sawdust and accelerators is there.

Contact details: Prudent Eco Systems Pvt Ltd, No 59/5, 1st Floor, 6th Main, 17th Cross, Malleswaram, Bangalore-560 055. Contact person: Latha (9886003355); E-mail: latha@prudentecosystems.com.

Method 7: Barrel Digester from Sudh labh at Mars Meadows, Rajajinagar, Bangalore (Pic. 31)

Type: Aerobic composting

Equipment: The digester is the ubiquitous five-foot-tall blue drum made out of high-density polyethylene thermoplastic. It is drilled with enough holes to aerate the contents inside and fixed to a one-foot-high MS iron stand which is coated with epoxy paint to avoid rusting. Underneath this, a plastic container can be placed to collect leachate, if any. The stand protects the barrel from being knocked down by strong winds and also helps keep the bottom aerated and the surface clean. A hatch at the bottom allows to take out the compost as and when it is ready.

Infrastructure and Process: A shredder is not used in this method. First, the bottom is layered with five kg of cocopeat, dry leaves and mature compost to absorb the moisture. A thin layer of kitchen waste is added on top of this. About 100-200g of Bio Clean powder (microbes) are added followed by a layer each of kitchen waste (around 5kg), Bio Clean (100-200g) and some dry leaves. Once a week, a handful of neem powder mixed in water is sprinkled and added on this decomposing mass. Dry leaves, cow dung, cow urine, Panchagavya solutions or sour curd are also added.

Capital investment: Rs 6,000/-

Operational cost: each batch will require the below ingredients

1. Bio Clean powder with neem powder if used along with browns (dry leaves): Rs 300/-

2. Bio Clean powder with neem powder without browns: Rs 500/-

Contact details: Sudh-Labh, No. C-3, 906, L & T South City, Bannerghatta Road, Bangalore 560076, Phone: +91 98456 90778. http://www.sudh-labh.in.

Pic. 31 Barrel Digesting system

Method 8: Steel bin composting by Saahas Waste Management Pvt. Ltd., Brigade Millennium, J P Nagar, Bangalore (Pic. 32)

Type: Portable aerobic composting with shredder

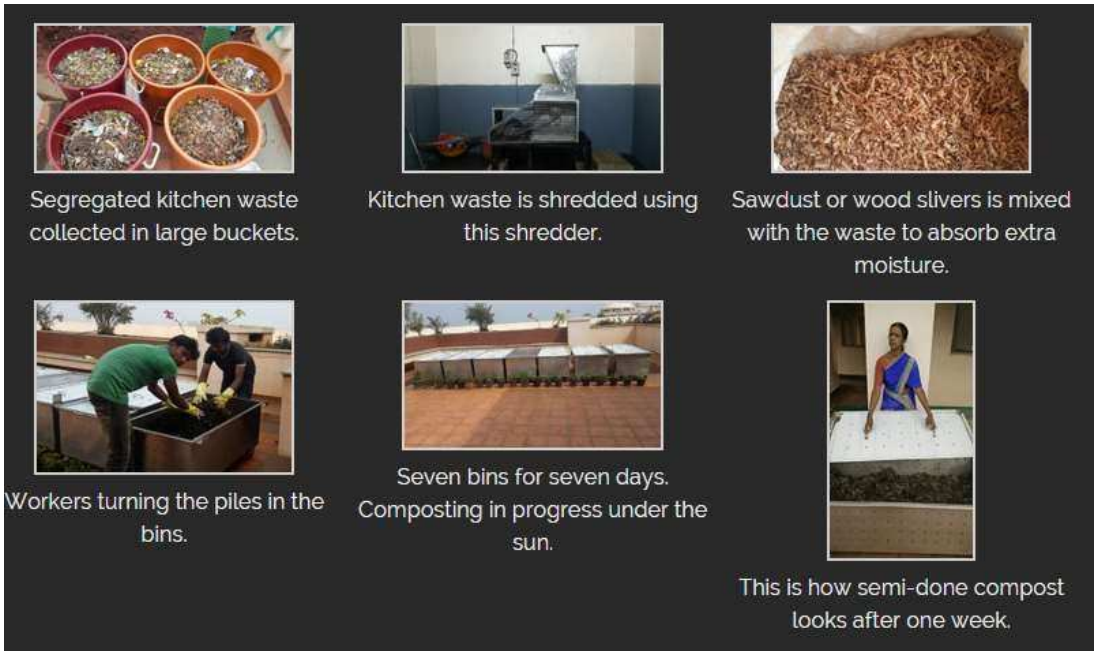
Equipment: There are two sets of steel bins: the first seven are meant for processing fresh wet waste and the second set of seven bins are for curing. The first set is made of stainless steel to withstand the challenging internal environment during the first few stages of composting.

Infrastructure and Process: The size: 2f (w) x 4ft (L) x 2ft (H). Each bin can take in one day's kitchen waste mixed with dry leaves scooped up from the community garden. The bins have enough holes on all sides to let the air in and are fixed with sturdy wheels making it very comfortable for the staff to move them around as needed. The lid is easy to operate with hooks on two ends. The bottom has a hole which lets out leachate. A plastic tray is placed at the bottom to collect the same. The second set

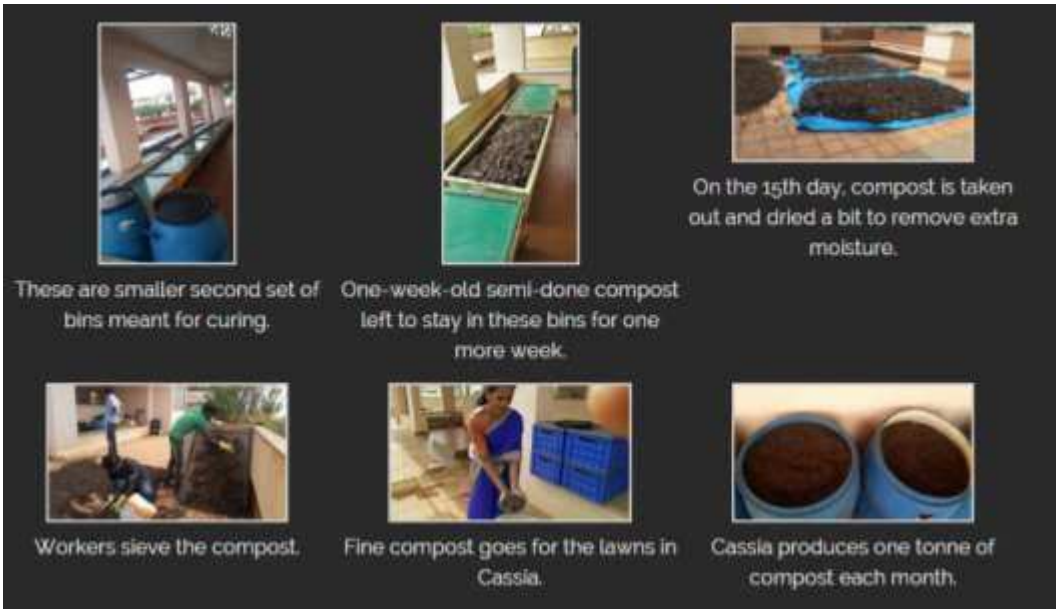
of seven bins is made of mild steel which are smaller in size: 2ft (w) x 4ft (L) x 1ft (H). They are meant to process the 7-day-old semi-compost. A shredder is also placed in a waste processing room at the ground level.

Cost: Details unavailable

Contact: 433, 8th cross Jayanagar 1st block Bangalore 560 011, Bengaluru, Karnataka 560004; Phone**:** 080 4168 9889.



Pic. 32 (a) Steps involved in Steel Bin Composting system



Pic. 32 (b) Steps involved in Steel Bin Composting system

RESEARCH QUESTIONS:

4. What are the innovative practices that engage the poor especially women and youth?

In India, by and large there is a dearth of innovative practices that engage the greater community. We describe one such case where a rural area has involved the entire local community in an innovative yet inexpensive manner to achieve solid waste management.

A. Case study of community involvement to manage waste in Kolar.

Kolar is a rural city located about 70 kms away from Bangalore with a population of 1.5 lakh people. Late District Commissioner of Kolar, Mr. DK Ravi singlehandedly turned the tables around regarding the waste management in Kolar through his clear vision and sheer determination, despite facing several bureaucratic challenges and public apathy.[34]

Kolar had launched a manic hunt for landfills to dump its garbage but a series of villages around Kolar refused to budge resulting in garbage piling up inside the city. The district administration swung around and launched campaigns including door-to-door campaigns on segregation at source and one-on-one meetings with every stakeholder: offices, restaurants, canteens, schools, hospitals, shop-owners, meat shops, hair-cutting salons, fruit and vegetable vendors, etc. The people held protests and refused to segregate but the administration held its own refusing to collect garbage till segregated. Within a few weeks, the attitude of the people seemed to change. The innovation in this model is that it is humane, scientific and local and not expensive or imported. Moreover this model is sans any contractor or middlemen.[35]

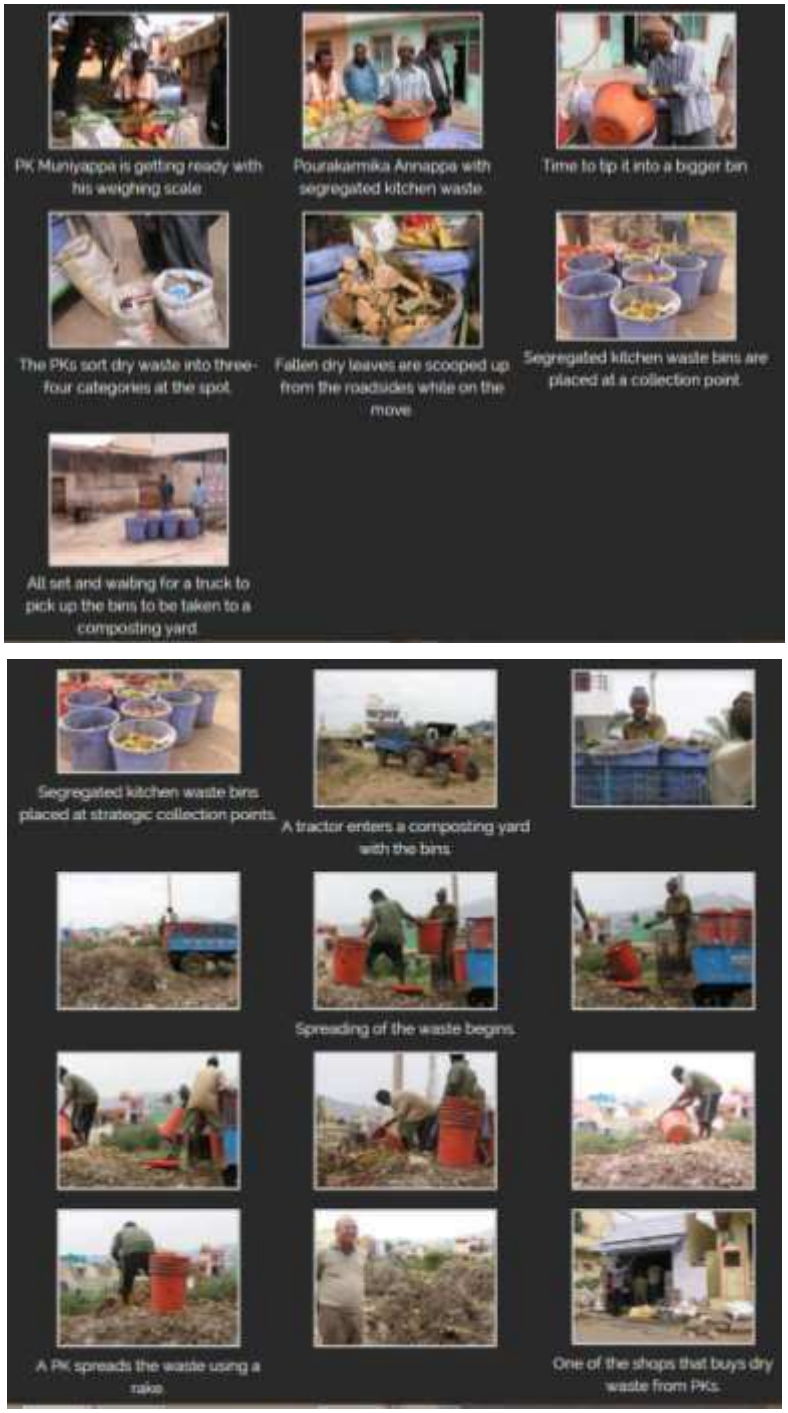
This model involves the local youth as well as women where workers are referred to as ***pourakarmikas*** (PKs) and the steps followed are outlined below.[35]

1. Each cart, fitted with four bins, is pushed by two PKs—gloved and armed with a weighing scale. PKs blow the whistle as they enter the streets and people walk out of their houses with bins and put their segregated waste into separate bins. Sometimes PKs also help them with unloading.
2. Along the way, the staff also scoop up fallen brown leaves from roadsides and dump them into one of the bins.
3. They weigh the segregated waste and make a mental note of it.
4. At each strategic location, there is a collection point (Pic. 33). When the bins get full, the PKs place them at this spot. A truck wandering with empty bins exchanges as many as required for filled bins.

5. The district administration has tied them up with local *kabadiwallahs* and *raddiwallahs* (scrap or junk dealers). The PKs sell them plastic, paper waste and other recyclable items like rubber, metal, etc. The revenue generated goes back to the PKs as an incentive. What cannot be sold (low-grade plastic) goes to a yard where three separate sheds have been built to store such inerts.

Pic. 33 Compost bins kept at several places in Kolar for collection of organic waste

Each PK is monitored by a supervisor or route manager who checks the level of compliance on each street or road. He verifies the weight and sees if it is lower than the average quantity. If it is low, that means segregation is suffering in that street. He talks to the PKs concerned and tries to fix the problem. Monitoring is carried out by systematic waste auditing and the statistics are computed at the corporation office every day by the route managers. The organic waste thus collected reach open-air composting yards set up in a few specific spots in Kolar.



Pic. 34 Steps involved in Swachh Kolar Drive

Right after the Pick-up, the PKs spread the wet waste evenly on raised platforms and let it sundry. Due to lack of manpower and sufficient water, systematic composting is not carried out. Three months later, the dry biomass is ready to be sold to farmers who buy it through auction and take it back to their land. Farmers spread this compost in their fields, plough the land and let it 'cure' for some time before sowing (Pic. 34).[36]

Clinics and hospitals were approached to incinerate hazardous sanitary and bio-medical waste coming out of households. Resistance was overcome with the reasoning that "We clear your wet and dry waste, so you take care of our sanitary waste." Total population of Kolar city: About 1,50,000.

Total number of health inspectors: One.

Total number of supervisors: 10

Total number of PKs at work: 150.

Total number of push-carts: 75.

The waste generated by 1,50,000 people is collected, sorted, part of it sold to recyclers and wet waste is sent for composting in just five hours!

5. What are the enablers and barriers for urban organic waste recycling and use of recycled urban organic waste by farmers?

The enablers for urban organic waste recycling is the basic need for a clean city and the drive to do so is largely due to the awareness generated by the Swachh Bharat Abhiyan. Any building which generates more than 50 kg garbage a day has to manage its own waste, according to the Municipal Government. This initiative has been received positively and has been a huge success in urban apartment complexes. More and more housewives are composting at home as it banishes transport of organic waste to landfill as well as obtaining a nutrient rich compost which can be utilized in the gardens. Composting at source will decreased the load on other waste management facilities and hence retain the latter's design life in the long run.

The barriers for urban organic waste recycling is lack of awareness in the general public, apathy to source segregate, time-consuming process and expensive to set up the composting unit.

The enablers for using recycled urban organic waste by farmers is that the compost generated in this manner has a better C:N ratio, which not only improves the soil nutrient condition upon application, but is sustainable in the long run. Increased reliance on compost will decrease the dependence on expensive chemical fertilizers.

The barriers for using recycled organic waste by farmers is that it is expensive, lack of awareness, difficult and costly to transport, insufficient quantity of supply, lack of consistency in the quality of compost. Private players are purchasing in bulk and selling back to the urban consumers for which they command better prices thereby creating a situation where there is insufficient quantities available for farmers to buy. Farmers prefer to carry on with their old practices and are not ready to adapt the new methods easily.

SUMMARY

Waste management in India is plagued by many problems such as a general lack of awareness, people being stuck in old ways, refusing to adapt new technologies or methods, and an overall apathy. However, the movement to manage waste including composting has been ignited and many catalysts in this process include the likes of NGOs, activists, housewives and corporates. Waste management is all about people management. Unless the local government administration is working in tandem with the catalysts listed, it is very difficult to sustain it in the long run. Source segregation is at the crux of this movement. Farmers must be educated with awareness programs and campaigns which highlight the short-term gains but long-term loss of using chemicals on their farms. The importance with regards to the quality of various kinds of compost must be made available to farmers. Kiosks must be set up in every village where the urban and rural organic waste recycled compost can be sold at subsidised rates along with the assurance of consistence in the quality of compost. Revival of traditional agricultural practices must be coupled with innovative methods to achieve the success with on-farm composting.

Our research has emphasised the importance of segregating organic waste at source. Various methods of composting at different levels have been discussed and highlighted the results obtained upon participation of community. Involving urban community in creating awareness and understanding of environmental issues, the benefits of various kinds of composts and their quality thereof is the need of the hour. Co-marketing of compost with chemical fertilizers by the fertilizer companies and their agents as a “Basket Approach” is recommended.

Farmers from the rural area infuse the urban population with organic matter mainly in the form of fruits and vegetables. Urban consumers discard 50-60% of this organic waste which does not recycle back to the rural farm but ends up in the landfills. This results in an imbalance of nutrients recycled and is therefore of utmost importance that in order to maintain an equilibrium in the environment, the urban organic matter reaches back to the rural soil in the form of compost. We are of the opinion that there is tremendous opportunity for growth in this market.

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