Compost Marketing Guidelines for Solid Municipal Waste Management in India

by

Ellen Huang

B.S.E. Civil and Environmental Engineering
Duke University, 2012

SUBMITTED TO THE DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF

MASTER OF ENGINEERING IN ENVIRONMENTAL ENGINEERING AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2015

© 2015 Massachusetts Institute of Technology. All rights reserved.

Signature of Author: 

Department of Civil and Environmental Engineering
May 21, 2015

Certified by: 

Dr. David Langseth of Civil Environmental Engineering Senior Lecturer Thesis Supervisor

Accepted by: 

Professor Heidi Nepf Donald and Martha Harleman Professor of Civil and Environmental Engineering Chair, Departmental Committee for Graduate Students
Compost Marketing Guidelines for Solid Municipal Waste Management in India

by

Ellen Huang

Submitted to the Department of Civil and Environmental Engineering on May 21, 2015 in Partial Fulfillment of the Requirements for the Degree of Master of Engineering in Civil and Environmental Engineering at the Massachusetts Institute of Technology

Abstract

India has a waste problem. With the world’s second largest population at 1.252 billion individuals, a population density of 382 persons per square kilometer and consumer behavior demanding a higher standard of life and preferences for more goods, the Indian municipal waste management systems are struggling to keep up with the increasing amounts of waste coming from households.

Composting is a way to divert waste away from landfills and reclaim value by transforming waste into a new product. The Indian Government has accepted the value of compost and has promulgated in 2000 that it is a recognized form of agricultural fertilizer. Due to this legislation, waste recycling start-ups have sprung up but they struggled to make ends meet due to poor market demand. Compost’s main competition, chemical fertilizers, are embedded into Indian agricultural practices since the Green Revolution. Additionally, the Indian government subsidizes the chemical fertilizers to promote agriculture at both the small- and industrial-scale.

Compost currently does not receive subsidies from the federal level. Thus, companies need to independently develop sustainable business models for compost production and sales if they are to meet government mandates regarding waste management. A key element of such sustainable business models will be the marketing practices, on which this thesis focuses.

Keywords: Marketing, Solid Waste Management, Compost, India

Thesis Supervisor: Dr. David Langseth
Title: Senior Lecturer of Civil and Environmental Engineering
Acknowledgements

First, I would like to thank the MIT Tata Center for this research opportunity; my advisor, Dr. David Langseth for his guidance and patience; my project teammates, Ching-ching Liu and Julie Karceski for their contributions to this project and their company while in India. I would also like to thank A2Z Infrastructure Ltd., Sanpurn(e)arth, and Ecofil for providing me access and information to their composting facilities; Pankaj Aggarwal, for being a wonderful host in Muzaffarnagar; and the students and faculty at Shri Ram Group of Colleges for the translation help and collaboration. Finally, I thank my classmates, friends, and family for their love and support.
# Table of Contents

Introduction.................................................................................................................................................................................. 10  
1.1 Background on Municipal Solid Waste Management in India...................................................................................................... 11  
1.2 Advancements in Municipal Solid Waste Management in India.................................................................................................... 12  
1.3 Waste Management Options in India........................................................................................................................................... 13  
1.4 Report Structure ........................................................................................................................................................................... 14  

Scope of Project.................................................................................................................................................................................. 15  
2.1 Objectives....................................................................................................................................................................................... 15  
2.2 The Composting Process .............................................................................................................................................................. 15  
2.2 Marketing Process .......................................................................................................................................................................... 16  

Literature Review .................................................................................................................................................................................. 17  
3.1 Compost Awareness, Pricing, and Demand...................................................................................................................................... 17  
3.2 The Potential of Compost............................................................................................................................................................... 18  
3.3 Compost Application and Interaction with Soil ................................................................................................................................. 18  
  3.3.1 MSW Compost Application in Muzaffarnagar............................................................................................................................... 20  
  3.3.2 Effects of MSW Compost on Vegetables........................................................................................................................................ 21  
3.4 Sustainable Composting Business Case Studies ................................................................................................................................. 21  
  Case Study 1 - Decentralized Composting Initiatives in India........................................................................................................... 21  
  Case Study 2 - Composting as a Social Business Enterprise in India .................................................................................................. 24  
  Case Study 3 – Composting in Dhaka Bangladesh ............................................................................................................................ 24  
3.5 Challenges and Limitations of Compost........................................................................................................................................ 25  

Observations and Data Collection ...................................................................................................................................................... 27  
4.1 Interviews of Farmers at Agricultural Fair ..................................................................................................................................... 27  
4.2 Interview of A2Z Compost Users ................................................................................................................................................. 29  
4.3 Interviews of Composting Firms: A2Z Group ................................................................................................................................. 31  
  4.3.1 Waste Collection Process in Muzaffarnagar................................................................................................................................. 31  
  4.3.2 Waste Operations Process in Muzaffarnagar ............................................................................................................................... 31  
  4.3.3 Marketing Operations in Muzaffarnagar ..................................................................................................................................... 31  
4.4 Interviews of Composting Firms: Sanpurn(e)arth .......................................................................................................................... 34  
4.5 Interviews of Composting Firms: EcoFil......................................................................................................................................... 34  

Discussion and Analysis........................................................................................................................................................................... 37  
5.1 Compost Opportunities based on Interviews ................................................................................................................................. 37  
5.2 Marketing Guidelines derived from Case Studies............................................................................................................................ 38  

Phone Application and Game Development ........................................................................................................................................ 41  
6.1 Phone Application................................................................................................................................................................................. 41  
6.2 Game Development ........................................................................................................................................................................... 42  

Conclusions and Future Work .............................................................................................................................................................. 44  

Works Cited............................................................................................................................................................................................ 45  

Appendices.................................................................................................................................................................................................. 50  
Appendix A: Notes from Interviews Conducted in Muzaffarnagar ................................................................................................. 50  
Appendix B: Summary Tables of Interview with Farmers and Composting Firms........................................................................ 82 
Appendix C: Notes from Interviews Conducted in Indore ................................................................................................................ 87
Appendix D: Notes from Interviews Conducted in Mumbai ............................................................... 95
Appendix E: COUHES Questionnaire ................................................................................................. 105
Appendix F: Phone Application Screenshots ..................................................................................... 108

List of Figures

Figure 1: Suggested Application Rates of Compost (Pfeiffer 1954) .................................................... 20
Figure 2: A2Z Mass Balance Sheet from Operations Manager (Saifi 2015) ........................................ 20
Figure 3: First Screen to Select Cash Crop of Interest ........................................................................ 108
Figure 4: Second Screen with Various Chemical Deficiencies Listed ................................................ 108
Figure 5: Phosphorus Deficient Sugar Cane Plants Display Purple-Edged Leaves .......................... 109
Figure 6: Calcium Deficient Sugar Cane Tend to have Necrotic Tips ............................................. 110
Figure 7: Sulfur Deficient Sugar Cane Leaves Display Streaking and Purple Leaf Margin ............. 111

List of Tables

Table 1: Overall Waste Composition in India (Annepu 2012) ................................................................ 12
Table 2: Understanding the Market (Ali 2004) .................................................................................. 40
Table 3: Farmer Interview Summary Table ......................................................................................... 82
Table 4: Farmer Interview Summary Table (continued) ..................................................................... 82
Table 5: Chemical Fertilizer Usage Among Interviewed Farmers ....................................................... 83
Table 6: Chemical Fertilizer Usage Among Interviewed Farmers (continued) .................................... 83
Table 7: Purchase Receipts from Muzaffarnagar .................................................................................. 84
Table 8: Purchase Receipts from Indore ............................................................................................... 86
Chapter 1

Introduction

Waste management is a significant concern worldwide, particularly in population-dense countries like India (Sharholy et al. 2008). Municipal solid waste management focuses only on waste generated by households, and not industrial, hazardous, and agricultural wastes. Increasingly, municipal solid waste management practices are receiving enhanced scrutiny by local governments and scientific researchers alike. As of 2000, around half of all municipal solid waste in the world is landfilled, and 30 percent of that waste is the organic fraction (Mata-Alvarez, Mace, and Llabres 2000).

In the developed world, many waste management plans aim for ‘zero-waste;’ instead of disposal, waste management planners try to find a myriad of ways to reuse and repurpose both synthetic materials and organics and avoid landfilling (Ngoc and Schnitzer 2009). In 2011, the United States generated 250 million tons of waste, which included materials that could be recycled and composted (EPA 2013). Less than 12 percent was used for energy recovery.

Landfilling waste is highly undesirable due to space considerations, especially in nations with a high population density. Additionally, incineration can be toxic to the environment. The content of municipal solid waste (MSW) oftentimes contains chlorinated compounds, which can form hydrogen chloride and byproducts during incineration (Hartmann and Ahring 2006).

Moving towards more sustainable waste management practices, experts envision a hierarchy of waste treatment methods: first minimization, then recovery, than incineration, and landfilling as a last resort (Hartmann and Ahring 2006). But these plans oftentimes require advanced planning as well as investment and experience in technology that can make waste management less attractive in developing nations.

In less economically developed countries, the challenge is to implement a model that focuses on resource recovery, oftentimes in the absence of existing waste management. Municipal solid waste can be rich in resources, and also highly varied in composition, generally consisting of food waste, paper, plastic, metal and glass; hazardous household items, such as electric light bulbs, batteries, and discarded medicines are also common (Ngoc and Schnitzer 2009).
Wilson (2007) identified six broad drivers for waste management practices: public health, environmental protection, resource recovery, institutional responsibility and public awareness. Additionally, he noted that the resource value of waste ('waste picking') could provide a livelihood for the urban poor. Given the high removal rate of valuable recyclables, via waste pickers, and the high fraction of municipal solid waste that is food waste, the bulk of the remaining waste is organic.

Resource recovery, particularly of organics, presents an opportunity to close the energy and nutrient loop. As Hansen et al. (2006) noted, “Waste treatment options allowing recycling of the content of organic matter and nutrients to agricultural land might be a method for closing the cycle between city and agriculture and simultaneously reduce the production and use of commercial fertilizers.”

Additionally, improved waste management practices can lead to lower global warming emissions. Eriksson et al. (2005) observed “landfilling of all waste contributes most to the global warming potential of the studied scenarios,” and also noted that recycling of nutrients and materials led to lower global warming emissions than incineration.

The focus of this report is to address waste management ‘recovery’ within a viable financial model. The goal is to address existing waste management technology, specifically anaerobic digestion, and address a method through which it can be improved upon.

1.1 Background on Municipal Solid Waste Management in India

India is home to more than 1.2 billion people, and, with a rapidly growing economy, is finding a foothold in the developed world. Economic growth averaged seven percent per year between 1997 and 2011 (Central Intelligence Agency 2014). As a result of rapid economic growth and urbanization, lifestyle changes have been correlated to an increase in per capita waste generation of about 1.3% per year (Ambade et al. 2013). Currently, 1 out of every 3 people in India lives in an urban area and this statistic is expected to increase up to 1 in every 2 in the next 10 years (Dimpal 2012). Like many developing countries, India faces swelling waste management problems and currently lacks appropriate infrastructure and policies for dealing with these challenges (Annepu 2012). With an economy still nimble enough to adapt to emerging markets, India also has enormous opportunities in waste management.

In particular, cities in India face serious problems in the management of municipal solid waste (Kumar et al. 2009). Waste generation rises as population and urbanization increases. If India continues utilizing current methods of waste disposal, such population changes will require more land for the ultimate disposal of municipal solid waste (Idris, Inanc, and Hassan 2004). The annual load of solid waste in Indian cities rose from 6 million tons in 1947 to 48 million tons in 1997. At the current growth rate of 4.25% per year, annual waste will reach 300 million tons by 2047 (Sharholy et al. 2008). Additionally, Kumar et al. observed that in most urban centers in
the nation, waste is merely disposed of into low-lying areas and unregulated landfilling is common in most cities. Other issues include lack of proper vehicle transportation of waste, lack of coordination between civic bodies leading to poor waste management, and lack of public concern and accountability for waste disposal and littering (Dimpal 2012).

As a heavily agricultural nation, India creates high volumes of organic waste. Rural and urban areas of India face distinct and pervasive waste management problems, and both are ripe for improved management strategies. An overview of MSW composition in India by regions is provided in Table 1.

Table 1: Overall Waste Composition in India (Annapu 2012)

<table>
<thead>
<tr>
<th>Region</th>
<th>MSW (TPD)</th>
<th>Compostables (%)</th>
<th>Recyclables (%)</th>
<th>Inerts (%)</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metros</td>
<td>51,402</td>
<td>50.89</td>
<td>16.28</td>
<td>32.82</td>
<td>46</td>
</tr>
<tr>
<td>Other Cities</td>
<td>2723</td>
<td>51.91</td>
<td>19.23</td>
<td>28.86</td>
<td>49</td>
</tr>
<tr>
<td>East India</td>
<td>380</td>
<td>50.41</td>
<td>21.44</td>
<td>28.15</td>
<td>46</td>
</tr>
<tr>
<td>North India</td>
<td>6835</td>
<td>52.38</td>
<td>16.78</td>
<td>30.85</td>
<td>49</td>
</tr>
<tr>
<td>South India</td>
<td>2343</td>
<td>53.41</td>
<td>17.02</td>
<td>29.57</td>
<td>51</td>
</tr>
<tr>
<td>West India</td>
<td>380</td>
<td>50.41</td>
<td>21.44</td>
<td>28.15</td>
<td>46</td>
</tr>
</tbody>
</table>

1.2 Advancements in Municipal Solid Waste Management in India

As a response to a public interest litigation that was filed against the government of India in 1996 for failing to manage MSW properly, the Supreme Court of India appointed an expert committee called the Burman Committee to make recommendations and improve the situation (Joseph 2013). The Supreme Court made composting of biodegradable municipal solid waste mandatory based on recommendations from this Committee report in 1999. The Supreme Court then directed the government of India, state governments and municipal authorities to take action. As a response, the Ministry of Environment and Forests issued the Municipal Solid Waste (Management and Handling) Rules of 2000 under the Environmental Protection Act of 1986, mandating specific policies and regulations regarding MSW management (Ministry of Environment and Forests 1991). Furthermore, the MSW Rules required biodegradable waste be processed by composting, vermicomposting, anaerobic digestion or any other biological processing that would effectively stabilize the waste (Ministry of Environment and Forests 1991). In 2007, the Supreme Court indicated compost and biomethanation technologies were
appropriate for the typical quality of MSW found in India. Such typical traits included high organic waste (40-60% by weight), high moisture content, and low calorific values (Rawat, Ramanathan, and Kuriakose 2013). In tandem, the Government stipulated that around 25% of all fertilizer come from composted-derived soil amendments. However, government subsidies of urea based fertilizer and common practices of bundling compost with traditional fertilizer create difficulties for MSW composting facilities to sell only compost (Kanhal 2014).

1.3 Waste Management Options in India

Though the wealthy are usually able to contribute their waste to recycling programs and other waste management practices, the fact remains that more than 90 percent of municipal solid waste in India is disposed of into open dumps (Silva and Naik 2007). Additionally, Kumar et al. noted that such open dumping is improper because “open dumps pose environmental hazards which cause ecological imbalances with respect to land, water, and air pollution.” This is staggering not only in its scale, but also is a detriment to human and environmental health. It is a significant lost opportunity in reuse and repurposing of waste.

Gupta et al. (1998) noted that in India:

“Uncontrolled dumping of waste on outskirts of towns and cities has created overflowing landfills, which are not only impossible to reclaim because of haphazard manner of dumping, but also have serious environmental implications in terms of groundwater and pollution and contribution to global warming.”

Additionally, nearly half of municipal solid waste is comprised of organic matter. In fact, in cities with a population between two and five million, 56 percent of municipal solid waste is organic material (Sharholy et al. 2008). Organic waste, rich in energy and nutrients, can be digested aerobically (also known as composting) or anaerobically. Composting, a fast-growing option in India, produces soil amendments that can be sold as fertilizer.

Comprehensive collection of municipal solid waste is generally viewed as a first-world priority, due to lack of resources, expertise, and political will in the developing world (Silva and Naik 2007). Improvements in waste management practices take a considerable amount of time to trickle down to the poorest. Additionally, due to lack of lack of adequate storage capacity, waste is often dumped directly on the road (Kumar and Goel 2009). In Muzaffarnagar, A2Z has considerably improved cleanliness of wealthier neighborhoods, but the low-income districts are not as active in the disposal process (observation, August 12, 2014).

The mindset towards waste in poor neighborhoods is generally explained by expectations and priorities. Low-income neighborhoods do not generally have municipal solid waste collection and disposal (Sharholy et al. 2008). Paying for waste disposal is not a high priority for the poor, and they also have not grown up with the expectation of clean streets.
The impact of reduced waste on quality of life could be significant. The portion of organic waste in municipal solid waste generally increases as socio-economic status decreases, so the poorest have the most to contribute, in terms of volume, and the most to gain, in terms of public health (Sharholy et al. 2008). Improper disposal has an enormous effect on human health and the environment, as disposal sites tend to be located in poorer districts. Organic waste can contain pathogenic bacteria, such as Salmonella, Escherichia coli, and heavy metals such as copper, cadmium, lead, mercury and arsenic (Shyamala and Belagali, n.d.).

### 1.4 Report Structure

Chapter 2 covered the objectives of this thesis and then described what was composting and marketing. The process of composting was documented more thoroughly by Liu (2015). Liu (2015) studied various composting facilities around the world with respect to relevant government regulations, perceptions, and social values.

Chapter 3 provides a literature review on the demand for compost in India and the scientific basis behind integrating compost as an agricultural practice. This information helped to develop the questionnaires for Chapter 4’s interviews with farmers and compost businesses.

Chapter 5 analyzes the data collected and presents conclusions on how to best market to the Indian consumer. From there, Chapter 6 presents an alternative method of marketing compost through a pilot phone application and gamification. Finally, Chapter 7 concludes and points to future research options to create further acceptance of compost as a viable fertilizer product.
Chapter 2

Scope of Project

2.1 Objectives

The question is, "How to market effectively MSW compost in India?" The objective is to provide recommendations to those operating compost plants who wish to expand their markets and for anybody who plans on starting a composting enterprise. The motivation for addressing this question is the Indian government mandate regarding producing and using compost from municipal waste that was discussed in Chapter 1. As a companion activity, I believe that there should be increased emphasis on educating farmers regarding agricultural sustainability. This type of outreach program would ideally be sponsored by the government to enhance its credibility.

According to the World Health Organization, approximately Rs 6,500 per person have been lost due to poor sanitation and lack of hygiene due to public health impacts (PTI 2014). In 2014, the Indian Prime Minister (PM) Narendra Modi implemented the Swachh Bharat Abhiyan, translated to Clean India Mission. This initiative has only been partially successful. PM Modi did generated awareness regarding lack of cleanliness in India's streets and general surroundings, but he has not been able to convince the citizens to perform actual cleaning. Therefore, it is clear that additional methods need to be employed. I see a parallel between the Clean India mission and the mandate regarding compost production and use. General education and awareness, if useful, but not ultimately successful, if the end users do not follow through. To partially address this issue, the use of gamification will be explored in this document as a means of more readily engaging existing and potential compost users.

2.2 The Composting Process

The purpose of composting is to convert organic material into effective soil amendment material, called compost. In this particular case, the feedstock is MSW. Compost produced from MSW can be used in various industries, primarily agriculture, horticulture, and forestry.
To accomplish decomposition, Indian compost producers commonly use mechanical separation to sort the MSW into compostable and non-compostable materials and then use a windrow-based process and subsequent additional mechanical sorting. Liu (2015) describes this and alternative processes in detail.

In general, windrow composting is controlled by the removal of carbon dioxide and excess water vapor, involving substantial loss of mass. To achieve 1 ton of waste with 25% of dry matter by weight, the waste mass has to lose 100 m$^3$ of carbon dioxide and 600 m$^3$ of water vapor (Jakobsen 1994).

2.2 Marketing Process

Marketing is the process of promoting and selling products or services. Among the issues one needs to consider in marketing are sales, public relations, pricing, packaging, and distribution (Welborn-Nichols 1993). Marketing is about allocating resources (i.e. time and money) to enhance sales of a product. There are two main areas of concern for marketing. First are the various elements of the market environment, and second is the specific link between product promotion. Regarding the first, factors such as legislation, technology, and competition can shape the market environment in ways that necessitate business adaption.

One of the primary challenges for a compost business is creating and/or finding a market for compost. Since compost is a much bulkier product than chemicals, transportation is a major concern. Diesel prices are high but at-home delivery increase service quality in the eyes of the customer. Further compounding this problem is compost's relatively short shelf life. During the rainy season in India, windrows must be stored under monsoon sheds, but this limits the production capacity as the sheds only have so much area.

Marketing is meant to increase information availability. Farmers need to be educated on the importance of using compost versus chemical fertilizer. Compost perpetuates the soil fertility and productivity of the soil while chemical fertilizers disrupt the microbial activity and eventually lead to leached fields (Mani 2014).

Overall, the key to running a successful business operation is customer satisfaction. Market research is meant to answer the key following questions: Who are the customers? What do they need and want from compost? And finally what is the right price?
Chapter 3

Literature Review

3.1 Compost Awareness, Pricing, and Demand

Sahmia Khan, project manager of Chemists Without Borders, conducted a study in Hyderabad, Andhra Pradesh, India regarding the business potential of composting for small-scale entrepreneurs (Khan 2013). Hyderabad has a population of 7.5 million and thus has started facing the challenge of managing their people’s 3800 million tons of solid waste. The survey encompassed 27 peri-urban villages, 2 fertilizer markets, 3 vegetables, and fertilizer shops around Hyderabad City.

In the villages, 65 farmers and 20 fertilizer retailers were interviewed. According to the compiled results, apparently only 20% of farmers were even aware of organic compost from municipal waste. Of the 20% of farmers, the 50% of the farmers did not perceive compost positively. This was probably due to the origin of compost, being organic waste. Meanwhile, the fertilizer sellers did not have such a negative attitude towards the compost. Around 10 of the 20 shops sold compost, of which 3 expressed positivity towards the product.

In addition to being asked what their awareness level of compost, farmers were also questioned on what they thought was a reasonable price to pay for it. The best price was supposedly Rs 2.30-2.50 (translated to US dollars $0.046-0.05) per kilogram. In comparison, the 2012 market price for compost was Rs. 5 ($0.10) per kilogram.

While, this does not demonstrate much demand for compost, both did express interest and curiosity, though they did not have much of a knowledge base. They wanted to learn more and were willing to consider compost as an alternative to the chemical fertilizer. Thus demand for compost can still be anticipated. Just in the city of Hyderabad alone, Khan estimated that there will be demand for municipal waste compost between 1000-1200 MT per day. Revenue would be expected to be $3,791 per day for all the participants involved.
Before composting production, Khan (2013) recommends there should first be a focus on environmental awareness with campaigns conducted by both public and private agencies (Khan 2013).

3.2 The Potential of Compost

According to estimates from the National Solid Waste Association from a report in 2003, the organic fraction of solid waste is 40-85% of the waste (Zurbrugg et al. 2004). With such high organic waste fraction, there should be plenty of feedstock for compost production.

Dr. Radha Kale argues that only 16% of applied chemical fertilizers can be absorbed by the plant because the rest needs to be broken down by bacteria before being assimilated into the plant (Shah 1997). Microorganisms in organic manure or fertilizer accelerate chemical reactions in the soil and liberate carbon dioxide from the ground. The organic acids that are produced during the decomposition process release phosphates which can then be utilized by the next cycle of crops. Also compost can act as a binding agent and increase the soil’s overall water absorptive quality, percolation, and holding capacity. Thus, according to Dr. Kale, compost is a better product to help plants grow.

Furthermore, manufactured chemical fertilizers might not be able to keep up with the demand for higher crop yields due to population gains. According to the National Center for Agricultural Economics and Policy Research, the crop yields and consumption rate of fertilizer have been declining (Prasad 2012). With imbalanced emphasis and use of NPK, India’s soils are suffering from multi-nutrient deficiencies, lacking secondary and micronutrients.

<table>
<thead>
<tr>
<th>Chemical Deficiency</th>
<th>Percentage of Indian Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>42%</td>
</tr>
<tr>
<td>Zinc</td>
<td>48.50%</td>
</tr>
<tr>
<td>Boron</td>
<td>33%</td>
</tr>
</tbody>
</table>

It is estimated that by 2025, food grain requirements for India will be 300 million MT/year. To meet that demand, it is estimated that 45 million MT of N + P2O5 + K2O will be necessary. Of that amount 10 million MT of N + P2O5 + K2O could come from organic options such as compost (Prasad 2012). Thus, compost can play a sizable role in future to maintain optimal crop output levels.

3.3 Compost Application and Interaction with Soil

As stated in Section 3.2, while chemical fertilizers and compost have similar nitrogen, phosphorus, and potash values, they do not interact with the soil in the same fashion.
When chemicals are applied to the soil, they are not immediately available for plant uptake. For example, when phosphate applied to acidic soil, only 2-10% by weight of the phosphate is available for plant use (Pfeiffer 1954). The bulk of the phosphate ends up “tied down” to the soil, in other words, unavailable. If the soil conditions are optimal with active microorganisms, the phosphate maybe be freed up to be used in the future.

Meanwhile, compost’s individual NPK constituents behave differently. Nitrogen in compost is in its organic form. The dominant forms of nitrogen used by plants are ammonium (early in the season for synthesis of amino acids and proteins) and nitrate (in the late season). There is also nitrite and nitrous oxide but in lower quantities, since nitrite is toxic to plants. (University of Nebraska 2015). Therefore, compost with organic nitrogen will contain some ammonium and nitrate and very little ammonia and nitrite.

Low nitrogen amounts in compost (1 to 2% by weight) actually produce comparable plant growth results as the application of fertilizers with high concentrations of nitrogen (about 6-16% by weight) (Pfeiffer 1954). While fertilizer will be able to shock the plant system into rapid with growth after 6 weeks of application, the effects were not long-lasting. Meanwhile, compost will slowly but steadily release nutrients 3 to 6 months after application. If the soil is rich in organic material, the compost can be expected to continue to release nutrients 2 to 3 years after application.

Thus, one usually cannot use too much compost on a garden plot or farm land (Pfeiffer 1954). It is important to note that the kind of compost Pfeiffer studies compost derived from garden wastes. Maximum applications have been observed at 150 tons per acre but the average amount is 5 to 20 tons per acre. If the compost is dehydrated, well-manufactured, and/or concentrated, as little as 1 ton per acre may be sufficient (Pfeiffer 1954). NPK (nitrogen, phosphate, potash) values of compost do not determine the maximum amount of applicable compost; instead, there are a multitude of factors to consider.

Plant growth results vary depending on the type of compost, especially the organic matter content. Average farm-grade compost regularly contains a lot of earth and thus organic matter content is low. Most compost have a range of 12-20% by weight of organic matter; a rarity is 20-30%. On the lower end 6-9% by weight have been observed (Pfeiffer 1954).

There is also differentiation among raw compost versus well-digested, humified compost (Pfeiffer 1954). The effect upon the soil is different despite having the same organic matter content due to mineral content and water content. Humified compost is preferred since raw compost requires additional time to degrade before proper nutrient release.

The upper limit of compost that is still effective can be calculated using the maximum acceptable nitrogen per acre for crops. For most crops, the maximum is 200 pounds of nitrogen per acre and in many cases, 50-120 pounds is a more acceptable range (Pfeiffer 1954). Compost or manure that contains 1% by weight of nitrogen means there are 20 pounds of nitrogen per
ton. With 10 tons of 1% compost spread on an acre of land, then the maximum of 200 pounds of nitrogen is reached. This is basis for the rule of thumb that 10-20 tons of compost per acre should be used.

3.3.1 MSW Compost Application in Muzaffarnagar

Despite the rule of thumb stated by Pfieffer of 10 tons of compost application per acre, a closer examination of a cited table indicates a suggested application rate of 1 ton per acre for compost derived from garbage and industrial waste (Pfieffer 1954).

<table>
<thead>
<tr>
<th>Type of Compost</th>
<th>% Analysis of Compost</th>
<th>Lbs. Plant Food per Ton Compost</th>
<th>Suggested Application Rate in Lbs. per Acre at Given Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufactured (Dry) From Garbage and Industrial Wastes</td>
<td>2 2 1 20-40 below 20</td>
<td>40 40 20</td>
<td>1 5</td>
</tr>
</tbody>
</table>

Figure 1: Suggested Application Rates of Compost (Pfieffer 1954)

According to A2Z mass balance sheet, out of 100 kg of waste, there is 17.95 kg of usable material transformed into compost. Therefore about 18% of the incoming waste is processed into compost (Liu 2015). Based on the approximate values given in Indore by Chaunhan (2015), that would mean 17.95% of 120 MT/day = 13.98 MT/day = 5102 MT/yr of compost produced.

Based on the receipts given, the average quantity of compost purchased per trip is 3.21 MT. Assuming that farmers apply the compost twice a year, each farmer would need to purchase 6.42 MT of compost on their fields. So for the Muzaffarnagar A2Z plant to sell out its compost, they would need 794 farmers to consistently purchase compost on 397 acres. The A2Z marketing director estimated that currently there are 700 farmers who purchase from the Muzaffarnagar plant, but there is still plenty of compost stored on site. This indicates that farmers might not purchase compost consistently. With these calculations, it shows that if A2Z
in Muzaffarnagar can convince their farmer customer base to regularly purchase compost from them twice a year, they would be able to use up all the compost that is being produced. This would justify further compost production and transform it into a more desirable product to manufacture.

3.3.2 Effects of MSW Compost on Vegetables

Unlike standard compost formed from garden or farm waste, MSW compost faces a few challenges such as increased levels of trace elements and heavy metals. This is primarily due to the lack of presorting and thus inorganic materials mixing into the composting materials (Liu 2015).

When Giannakis et al. (2014) performed a study using traditional fertilizer and MSW compost on tomato and lettuce plants, the plants to which compost was applied showed lower growth levels than the plants with conventional fertilization. The problem was diagnosed as a sharp cut in NO$_3$-N content (Giannakis et al. 2014).

In the Giannakis et al. study, nitrogen was the only macro-nutrient that performed poorly. Potassium, phosphate, magnesium, calcium, and iron were found to be at the appropriate levels to promote plant growth. The concerns for heavy metals were unfounded as the levels were similar to soil unamended by the MSW compost and thus public health was not impeded (Giannakis et al. 2014). It is to be noted that MSW compost originated from Greece and thus might not display the same contaminant levels as India.

3.4 Sustainable Composting Business Case Studies

Case Study 1 - Decentralized Composting Initiatives in India

There are advantages operating solid waste management in a decentralized fashion. As the community is more involved in the endeavor, environmental awareness is enhanced. The operations are more adaptable and flexible, able to change to fit the users’ needs. These initiatives benefit the municipality since the organic waste is treated locally and thus diverted from the waste stream. The community actions also reduce the transportation and disposal costs. Cities that have supported decentralized efforts include Bangalore, Chennai, Pune, and Mumbai.

There are three primary types of decentralized composting organizations:

1. Community-based enterprise

These operations are small and highly involve the local community. Typically, residents spearhead the initiative, responding to problems in waste management such as
unreliable secondary collection services from the municipal board.

In Mumbai, there are neighborhood schemes called Advanced Locality Management (ALM) (Ali 2004). There is no distinct structure to ALMs and they can address various aspects of urban life and sanitation. These ALMs have formed to give residents a forum to convey issues regarding waste collection, road repair, lighting, water supply, or drainage problems to the municipal authorities. Of the 670 ALMs in Mumbai, 284 have box composting activities. The goal of the municipality is eventually to have one composting site per ward. The main challenge to overcome is odor complaints.

The compost produced is usually sold in the neighborhood since the marketing is limited to the word-of-mouth by the core members of the community composting initiative. Prices for compost range from Rs 6/kg in Pune to Rs 20/kg in Mumbai (Ali 2004). The income levels of the residents can be inferred based on the pricing; the higher the prices are the more middle to high income users of compost.

2. Medium-scale private sector composting start-ups enterprise

These groups are usually run by entrepreneurs or NGOs. Typically, they work in conjunction with the municipality and use land that is provided either free or at a discounted rate. Their compost feedstock is usually derived from waste from vegetable or flower markets along with residues from agro-industries. This removes the need for presorting that should occur if using household wastes.

An example is Vermigold, a vermi-composting company located in Mumbai. Their main goal is to provide composting design and solutions to organizations (e.g. hotels, colleges, etc.). They design vermi-compost plants and sell their clients compost and worms as starter and feedstock. These are produced on land they receive from the municipality at reduced rent. Unfortunately, the compost and worms are their only source of income as they do not receive a collection fee for the market waste they collect as feedstock. The product sells irregularly so Vermigold faces high risk of closure.

Most of these enterprises, like Vermigold, struggle from difficult market situation, weak marketing, and poor sales strategies. They have trouble making ends meet. Three out of four companies Drescher and Zurbrugg interviewed lacked accounting records of the amount of compost produced and sold (Zurbrugg et al. 2004). These business organizations play an important role providing job opportunities to low income groups. Both men and women can be hired to collect, sort waste, and then create compost. Therefore, it is to the community benefit to keep them in business.

To survive, the company has to capture the consumer quickly and operate more efficiently than the municipality. Excel Industries Limited got into the marketplace early and developed innovative products such as a machine which cuts down the amount of
time that it takes for solid waste to decompose to compost (Shah 2014). Private industry typically has to innovate to be able to expedite the composting process in order to compete with the more subsidized groups funded by the government entities or NGOs.

3. Company and institutions composting on premises

The motivation for starting a composting endeavor is typically for environmental reasons or cost savings. Cost savings may be derived from cutting fees to municipality for transport of waste from premises to waste processing facilities.

In these situations, operations are handled by the employees of the company/institute or by a hired private contractor. Unlike enterprises, the compost produced is used on campus landscaping and/or gardens so there is no need for marketing outside off-campus. Decisions are made by department heads in charge of waste management and thus changes can be made easily and quickly. On the flip side, there is usually little engagement with the rest of the community.

Bin composting was the most preferred form of composting in conjunction with vermicomposting or open pit composting (Ali 2004).

TATA Power Company has a corporate housing colony in Mumbai which utilizes pit composting (Ali 2004). The company hired a waste picker co-operative to collect waste form the 520 households on site, sort the waste, sell recyclables, and compost the organic fraction in shallow beds. It provides jobs to 18 wastepickers and 2 supervisors. The compost is utilized on campus as it's not up to nutrient requirements to sell to the public.

The urban poor tend to benefit from such initiatives as they can outcompete private contractors with better services.

While there are advantages to decentralized composting, there are still aspects that prevent it from reaching its full potential.

There was a severe lack of documentation regarding mass balance flow and financial figures as mentioned above with Vermigold (Zurbrugg et al. 2004). When Drescher and Zurbrugg interviewed employees, nobody knew who the customer was. The market segment hadn’t been identified. The only exception was Terra Firma from Bangalore because they marketed their compost through a large fertilizer distribution company. Therefore, a marketing strategy first needs to be developed to identify the appropriate customer bases and then to assess how best to generate demand for the compost product. Otherwise, partnerships should be formed with companies that already have established customer networks and supply chains.
If companies had better documentation they could improve relations with municipal authorities and open for possibility for additional assistance either in the form of land usage with low rent or education programs. The role of the municipal authorities would be to lead appropriate organic waste management, to remove rejected material from decentralized compost operations, and to assist in marketing activities.

**Case Study 2 - Composting as a Social Business Enterprise in India**

M.K. Bhalerao was from the city of Saoner in the state of Maharashtra (Ali 2004). After retiring, he identified a need to deal with the waste dumping ground near the outskirts of town. The dump site was both an odor issue and health hazard, polluting the surrounding waters. He decided to start a social enterprise of composting and named it Krishi Udyog (Amol’s Society Business). The purpose was four-fold:

1. Improve the environment
2. Provide occupations to a large number of unemployed in the area
3. Improve the fertility of his and neighboring farmers’ lands
4. Occupy himself profitably in his retirement

His brand was dubbed Bhoosampda. Unfortunately, while he figured out how to create the compost and negotiate a contract with the municipality authorities, he had difficulty selling his product to other farmers. Inorganic fertilizers demonstrated results very quickly and it is immediately obvious if they were not used. As discussed earlier, while compost is more sustainable and long-lasting, the results of the compost may take three to four years to emerge (Ali 2004). Since many Indian farmers own small plots of land and live from harvest-to-harvest, they can’t afford to wait for so long.

Bhalerao had to employ multiple tactics to promote his compost brand Bhoosampda over Excel Limited, his main compost competitor. First, Bhalerao priced his product to half (Rs2224/ton) that of Excel’s (6354/ton). Second, he focused his market on the local market, within Nagpur and the neighboring districts. Third, he employed sales agents to help him sell Bhoosampda and awarded them 20% of sales as commission. Fourth, he focused on excellent customer service: free home delivery and cash discounts for prompt payment.

He is currently looking to increase his sales through a partnership with a bigger company in the agricultural supplies market. The goal is to sell the compost through their network of farmers.

**Case Study 3 – Composting in Dhaka Bangladesh**

Waste Concern is an NGO that strives to improve solid waste management in Dhaka. They have been establishing composting plants in Dhaka. They currently process 3 tons of compost a week and so have focused classified their primary customers into two categories.
• Individuals, such as middle-class households with gardens.
  Selling price: To10/kg (equivalent to Rs8.19/kg)
• Commercial entities, such as private chemical fertilizer processing companies.
  Selling price: To2/kg (equivalent to Rs1.64/kg)

In Bangladesh, farmers can charge a premium if their produce is grown with organic farming methods. So there is an incentive to purchase the product. One challenge is the investment required, because in the first year, farmers might have to buy an extra-large quantity of compost to restore the soils structure.

Waste Concern has chosen to partner with MAP Agro, a commercial entity, to market their product. They purchase 300 tons of compost every month from Waste Concern. The compost is blended with their chemical fertilizer and resold. Although Waste Concern could have made higher profits by selling the compost themselves, they no longer have to be concerned about marketing. MAP Agro also made it clear they intended to ramp up their order 10 times the present amount. Waste Concern was able to elevate their brand through the credibility of a well-established company. Being able to focus on just making compost allows Waste Concern to focus all their resources on compost production.

3.5 Challenges and Limitations of Compost

Starting a compost enterprise has its challenges. Finding land to start operations can be particularly difficult especially in densely populated cities. In many areas, land is a shortage and thus the compost company needs to work in conjunction with the authorities to justify land for business rather than housing area for the poor. The location should be sited near collection areas and near landfill site (for dumping waste). The transportation costs, available labor, and cost of land need to be optimized.

As stated in Case Study 1, enterprises need to have the support of the municipality and the public. While there is some public awareness regarding solid waste issues, the public is reluctant to perform any actions such as presorting (Kakar and Kakar 2007). If there was separation between organic and inorganic waste at the household level, then the quality of compost could be greatly improved with higher nutrients and fewer contaminant concerns with glass and plastics.

Additionally, there is the challenge of collection of revenues. In Muzaffarnagar for A2Z Group, only 30% of the households pay their Rs per month fee for door-to-door waste collection (Aggarwal 2014) because they do not perceive the benefits of taking away a material that is considered worthless. In general, waste collection firms have to rely on subsidies from the local city government to break even.

Saha et al. (2010) performed an assessment of municipal solid waste compost quality with feedstocks from 29 Indian cities. It was shown that that they have normal pH and electrical
conductivity. Unfortunately, compost produced from cities tended to have lower nitrogen and phosphorus contents compared to compost with feedstock from rural areas. Heavy metals content in compost from larger city feedstock is even more problematic. The cities with larger populations (over 1 million individuals) had 86% more zinc, 155% more copper, 194% more cadmium, 105% more lead, and 43% more nickel, and 132% more chromium compared to smaller cities.

Saha et al. (2010) found that partial segregation did not improve the quality of compost with regard to fertilizer characteristics and heavy metals. In 1985, the Fertilizer (Control) Order was promulgated which defined the quality control protocol for compost. Saha et al. (2010) determined that the majority of compost samples conformed to the following promulgated compost requirements with the following: bulk density, pH, electrical conductivity, total nitrogen, and C:N ratio. Unfortunately, the compost samples were not up to par with total organic carbon, total phosphorus, and total potassium requirements. Thus, very few composting samples were high enough quality to market and distribute.

Finally, it is difficult to find a good dependable labor force. Places that work with waste are stigmatized (Ali 2004); therefore the turnover rate for waste laborers are relatively high (Chaunhan 2015). In Bangladesh, Rouse found that waste workers would lie to their friends about where they worked. The composting plant would be referred to as “office” or “fertilizer factory”.

26
Chapter 4

Observations and Data Collection

4.1 Interviews of Farmers at Agricultural Fair

During January 2015, interviews were conducted with the assistance from Shri-Ram Group of College, located in Muzaffarnagar, Uttar Pradesh (UP). Muzaffarnagar is known as the Sugar Bowl of India since it has 11 sugar mills and 4,000 small units that produce jaggery (Jai 2013). The area is in the upper Ganga-Yamuna doab region and has fertile soil. It is considered one of the most developed and prosperous cities of UP (Jai 2013).

There are numerous farmers in the area that supply the sugar mills of Muzaffarnagar. According to Dr. Ashwani Kumar from the Shri-Ram Group, these farmers are split up geographically by the government so that they know which sugar mill to send their sugar cane harvest to every year. It was these farmers that I reached out to. Shri Ram College kindly provided space to work from and also translators. Dr. Kumar was our primary translator due to his bioscience background and also his experience as farmer as well. With Dr. Kumar and Dr. Sachin Pol's help, we were able to identify the agricultural fair as a prime location to locate farmers.

Through interviews, we came to the understanding that while all farmers interviewed knew about compost made from MSW, many chose to use cow manure instead. We also learned that cost of a product was not the only factor that farmers took into account. By far the most important factor when selecting fertilizers was quality of the product. Farmers were attracted to one brand IFFCO in particular because they got results with it and thus earned their brand loyalty.

According to the director of the agricultural center, the agricultural fair draws around 1000-1500 farmers from the surrounding area per event. It is located within a federally run agricultural center, also referred to as KVK. The agricultural center provides multiple services, including honey extraction, pesticide/herbicide research and development, sample herb gardens, vermicomposting demonstrations, and a soil testing facility.
The soil testing facility was an area of particular interest for this work because this was where farmers found out whether they needed fertilizers and if so, which types. We learned from the soils laboratory director that the testing was done for free (not the case for every soils testing laboratory around the country) and once the soil deficiency was diagnosed, specific chemical fertilizers would be recommended. Recommendations would extend so far as to the particular brand of the chemical.

Three farmers were interviewed at the KVK. They were asked about the primary crops grown, farm plot size, and what kinds and in what quantities of chemical fertilizers they were using. There were varying measurements for the plot sizes: bigha, hectare, and acre. Refer to Appendix B. Bigha was one of the most common units of measurement for the area of land, but the actual precise measurement varied considerably, depending on where you were located. According to Dr. Kumar, in UP, 5 bigha equaled to 1 acre and 1 hectare equaled to 6.2 bigha. The farmers interviewed had range of farm sizes from 7 bigha to 100 bigha.

Based on those I spoke to while at the agricultural fair, compost is a well-known product. In fact, many farmers actually use a home-made version also known as Farm Yard Manure (FYM). It is made from raw cow dung that has been placed in a sand pit for 3 months and allowed to ferment. It is not supplemented, so there is only 5-10% nutritional value leftover after the fermentation phase according to Dr. Kumar (Appendix A notes). All interviewed farmers did use FYM but seemed to do it more out of habit and/or tradition than actual growth effectiveness.

Of all the farmers interviewed at the agriculture fair, all of them used chemical fertilizer. The dominant brand mentioned for the various chemicals was government-manufactured IFFCO. The reason provided by the farmers was that the IFFCO chemicals provided by the government from are relatively inexpensive and have good results. Additionally, its government ties lend credibility to its quality. The other brands recognized by the interviewed farmers were was KRIBHCO and IPL (Indian Potash Limited). The interviewed farmers all indicated a strong preference towards IFFCO; they would only purchase KRIBHCO if IFFCO was out of supply or did not supply the particular fertilizer type. There were also locally produced chemicals but the farmers were not aware of any brand names. The chemical source would only be referred to the generic label, “local market”.

The specific kinds of fertilizers used were a consistent cocktail of chemicals. Urea, potash, DAP, and NPK were the most common, but there was also mention of single phosphate fertilizer. Refer to Appendix B for the fertilizer usage amounts and pricing. It was not clear if the chemical lists provided were exhaustive. The farmers would always seem to remember more when prompted by either the translator or the farmers who were bystanders observing in the interview.
Regarding payments, farmers were normally required to pay up front in cash for fertilizer. Initially, I hypothesized that there would be a purchase plan to pay off the compost in installments so that farmers could pay in increments, leveling out their cash flow.

It is interesting to note that according to the soils laboratory director, the leading soil nutrient deficiency is potassium, which can be mitigated with the use of potassium sulphate, K2SO4. Yet none of the interviewed farmers stated that they used any sort of potassium supplement to improve crop yields. Other common deficiencies were iron and zinc for sugar cane and sulfur for rice. Again, these were not chemicals that farmers seemed to purchase or use regularly.

4.2 Interview of A2Z Compost Users

In addition to interviewing the farmers at the agricultural fair, I was able to speak to farmers who actually purchased MSW compost from A2Z or were planning to. Most of them had already used the product for 5-6 years. They provided a juxtaposition to the farmers who exclusively used chemicals and occasionally home-made FYM. These interviewed farmers originated came from the same region, Punjab, which is known to be a fertile area of India. They moved to Muzaffarnagar because they could buy more land in Muzaffarnagar than in Punjab.

Based on interviews, I was able to determine that this group of farmers was using MSW compost largely due to the influence of an enthusiastic advocate. This particular farmer was persuaded during a seminar conducted at a government approved agricultural fair. A2Z offered an introductory discount for those who were willing to try out the compost, Rs1250/10 bags. This farmer accepted the introductory offer, and after noticing improved results, he persuaded his son and then neighboring farmers to try out the product as well. It is important to note that the advocate was a strong, leading figure in the community who also owned the largest plot of land among those that I interviewed. Due to his respected status, he was able to lend credibility to the compost product.

This was not his first time trying to use compost on his fields. Before the A2Z compost, he had tried out vermicomposting. He stated there were good results but production was stopped because the vermicompost heaps were high maintenance with the constant turning to produce aeration and required a large amount of land that could have been used for additional crops. Finally, the amount of compost from the process was only enough for personal use in their vegetable and wheat gardens.

In addition to trying out compost, he was also part of a seed program where the government tested alternative strains of various crops. The earnings from the seed program allowed him to be more financially independent than those who relied upon the sugar cane factories as their sole source of income. This created a positive feedback loop that allowed the farmer to be more financially secure than others and thus able to take on more risks.
Additional proof of the effectiveness of an enthusiastic advocate was provided by a farmer who was planning on purchasing A2Z compost in the future. His primary crops were rice and wheat, though he also had a dairy that provided plenty of FYM to use on his fields. He initially stated that he was under the impression that the A2Z compost didn't have good results. Nonetheless due to the excellent feedback and good results that he had witnessed from his neighbor, he was going to try it out now.

Of those who used compost, they all had preference for the compost in loose form. This makes sense since it was less expensive, and they plan on immediately using the compost. Most of the farmers opted to pick up the compost with their own tractors-pulled trailers but there were two who opted for delivery. Compost was purchased two to three times a year depending on the farmers’ schedules and were paid in full each time.

In addition to the compost purchases, the interviewed farmers also utilized chemical fertilizers to supplement and boost the overall soil nutrition levels. The most commonly mentioned were urea, potash, zinc, sulfur, and NPK. The list was longer than the chemical list from the agricultural fair but should be unsurprising since the farmers seemed to have more financial leeway because they had larger plot sizes.

I also asked about other compost competitors or other organic options. FYM was also used on the fields since they all had access to cows or a dairy producer who had an excess of cow dung. Selrich, a private company in Delhi, formerly produced a biofertilizer for which they charged Rs3000/ton. Unfortunately, production on the biofertilizer stopped; for reasons unknown to the interviewed farmers. Additionally, there was a product called pressed mud. It was locally produced at the sugar cane plants, made from the byproducts of the sugar factory processes. The farmers described it as very nutritionally rich, and thus a desirable product. On top of that, it was very cost effective being Rs15-20 per quintil, much less expensive than normal fertilizer. The only reason why it was not a common option was due to its low availability. Thus farmers did not expect it to be routinely available for regular use.

Pesticide and herbicide use was noted in the farmers’ responses, but the farmers indicated that since the products were considerably more expensive, they were used sparingly. The particular brand mentioned most often was DuPont Indofyl and it was primarily applied to sugar cane and wheat, which are two of the cash crops grown in the Muzaffarnagar region.

The A2Z MSW compost product was successfully used by this group of farmers due to their satisfaction with the product effectiveness and price: all the farmers interviewed who were current users of A2Z MSW compost indicated satisfaction and provided positive feedback regarding the product. The only improvement they wanted was to be recognized for growing produce organically. They think it would be a step in the right direction to have some sort of organic food certification. This way they would be able to differentiate from others and also further justify the switch over to exclusively using compost.
Refer to Appendix B for summary tables of the interview.

4.3 Interviews of Composting Firms: A2Z Group

The first company visited was A2Z Group in Muzaffarnagar. I was able to interview the collection, operations, and marketing directors.

4.3.1 Waste Collection Process in Muzaffarnagar

In the morning, waste is collected household-by-household before being dumped into secondary waste collection sites. By the afternoon, vehicles would be sent out from A2Z facility to collect from the secondary waste sites; these vehicles would typically operate in pairs as a truck and backhoe. The waste is brought in and weighed. Usually at this point the waste has been stripped of its primary valuable recyclables, such as plastic and cardboard, as waste pickers have already gone through them. Therefore the only leftovers are generally organic waste and plastic films and other materials deemed non-recyclable.

4.3.2 Waste Operations Process in Muzaffarnagar

The waste is not separated further before it arrives in the processing facilities. The only separation is done with mechanical rolling sieves, as described by Liu (2015). Based on the size, the facility will transform the waste into either refuse derived fuel (RDF), compost, or unusable (thus sent to the landfill).

When asked, the A2Z Muzaffarnagar operations director stated that the RDF was actually the preferred form to manufacture (Ahsan 2015). Not only did they sell more RDF, but they also could charge more by weight. This is because there are a lot of industries in Muzaffarnagar (paper recycling, steel mills, and sugar cane factories as the primary industries) that purchase RDF as a form of fuel to burn either in loose form or bricks.

Meanwhile, compost demand just wasn’t as high since most of the farmers in the area relied upon chemical fertilizer. Additionally, compost was more difficult to store as it took up more room. Therefore, to increase production of compost, there needs to be justifiable reasons.

4.3.3 Marketing Operations in Muzaffarnagar

The marketing director, Sandeep Kumar, said their current marketing approach revolved around demonstrations. They take 10 farmers in a village, preferably with farm plots located near the main roads. They request that 20% of the land would use compost and 80% of the land would use whatever was previously employed (Kumar 2015). The farmers would fertilize 20% of their crops with compost and 80% of their crops with the usual (i.e. chemicals), and the yield
results were recorded at the harvest. It turns out that the compost-based crops either did equally well or even better than the standard.

The target villages are located near the A2Z plant. The target is annually implementing the demonstration in 10 villages with 10 farmers each. Additionally the marketing representative takes photographic evidence each time to compare crop yields.

The farmers are not compensated for participation in the MSW compost trials, but they are given discounted compost the introductory pricing described above. I was informed that the success conversion rate to compost was 100% (Kumar 2015).

In Muzaffarnagar, A2Z’s customer breakdown are 40% local (e.g. farmers) and 60% commercial (e.g. retailers). Commercial businesses are more optimal customers since they have a steadier demand (Kumar and Verma 2015). Farmers buy seasonally, tending to purchase compost in the months of September through December.

Receipt books were obtained of sales to farmers during the months of April to September of 2013 (Kumar 2015). While these months were not in the peak season, they were able to provide us with some estimates. I found the average quantity of compost purchased during that time frame was 3.21 MT. While A2Z indicated that compost sold to farmers for Rs3000/MT, the average rate was lower at Rs2326/MT. This indicates that A2Z does not stick to their Rs3000/ton price point for farmers. More than likely there is some flexibility in pricing. Compost can be given out at a discounted rate due to promotion or previously agreed upon terms with a long-term buyer. Overall the total spent on average was Rs7132/visit.

Marketing to the commercial sector seemed simpler. A2Z Group would send half a kilogram sample of compost to the company and the company would analyze the sample for the requisite nutrients that has been promulgated by the federal government. If they are satisfied with the results, they can put in orders that could be shipped in bulk or bagged. Compost producers form contracts which delineate a minimum level of production; therefore, the compost producer can guarantee certain amounts of income and demand.

A2Z Group would like to expand to customers such as nurseries, school and kitchen gardens, but do not currently have specific strategies for how to approach these potential customer groups (Kumar 2015). As of now, they demonstrate the product in a public setting, most likely a seminar. The interested individuals can obtain half a kilogram at a discounted price of Rs20 to use in their personal gardens. If they like the results from the compost, they can order more over the phone to be directly delivered to their homes. Unlike chemical fertilizers, A2Z does not have middlemen or supply chains. Instead, everything is shipped directly from them to the customer or the customer picks it up on site.
4.3.4 Overall A2Z Marketing Strategies

In Indore, I interviewed the head Director of A2Z marketing, Rohit Chaunhan. He was able to provide descriptions of all the A2Z plant operations with a focus on their marketing efforts.

A2Z annual plant incoming waste levels are as follows (Chaunhan 2015):

- Kanpur: 1500 MT
- Punjab: 1000 MT
- Indore Narache: 600 MT
- Varanasi: 600 MT
- Aligarh & Moradad: 220 MT
- Muzaffarnagar: 120 MT
- Fatehpur: 55 MT

According to their mass balance sheet, about 18% of the waste will be transformed into compost (Ahsan 2015).

The A2Z compost selling season is mid-March to the end of the June and then a follow-up from, October through December (Chaunhan 2015). This is in part due to the seasons in India. Rainy season is from July to September and operations slow down during this time. I was able to obtain another data set for the compost sold in Indore from December 2014 to January 2015.

The average quantity of compost sold was 8.2 MT and the rate was Rs2756/MT. The average total spent Rs11504/visit.

A2Z struggles with balancing revenue and costs. Diesel costs are a predominant concern as they can make up approximately 50% of any A2Z plant’s budget. Also the municipal board expects to receive “compensation” for each ton received. In the Indore area, it’s estimated to be around Rs21/ton. Cost of production is estimated to be around Rs1400/MT; of that amount, about 13% or Rs180 comes from segregation costs.

The director is planning to implement a presorting program since A2Z had just recently won contracts to collect the waste from 2 of the 4 zones of Indore as well as processing all of it. Residents will be asked to sort their waste into two bins. It is anticipated to take 6 months to a year to implement. The possible incentives include waiving the user charges or some sort of recognition award.

With mounting costs, A2Z is looking to diversify further to enhance their business. The RDF products at their Indore location are marketed as PVC pipe material along with road filler (also called fluff). They are planning on building waste to energy plant and promote energy collection through incineration of their waste. They also are studying the potential of anaerobic digestion to derive methane from their organic wastes.
When asked how to better compete with chemical fertilizer and further promote compost, the marketing director stated that obtaining a subsidy for compost from the Ministry of Fertilizer would make compost more economically viable for farmers. For the farmers, A2Z charges Rs3500/MT for bagged compost and Rs3000/MT for loose compost. From there with transportation and packing of material, the cost goes up to Rs5400/MT. Therefore, if the government could subsidize Rs3000/MT, the final price of Rs2400/MT would be a far more persuasive and competitive price.

4.4 Interviews of Composting Firms: Sanpurn(e)arth

Sanpurn(e)arth is a firm that develops environmental waste management solutions for their clients. They are located in Mumbai, which is a mostly centralized solid waste collection system. Instead, Sanpurn(e)arth favors a decentralized approach where waste is handled locally since petrol is a very expensive resource. For example, campuses and corporate offices could treat their wastes on site.

Their business model revolves around design and/or management of waste systems. For example, they would first create the blueprints for a biogas facility, supervise the building process, and then operate and maintain the facility.

They work in conjunction with the NGO, SMS (Stree Mukbi Sanghatana, translated to Women Liberation Organization). This is a self-help group for female waste pickers and gives them a voice for collective bargaining. One of Sanpurn(e)arth’s primary goals is the employment of waste pickers. Children unfortunately also comprise a large percentage of the waste pickers.

Aside from biogas, they also perform vermicomposting in batches. We visited a compost pit while on the campus of the Tata Institute of Social Sciences (TISS). The feedstock is primarily leaves, garden waste, and other yard waste. The compost produced does not go off-campus. Instead it is used for gardens and landscaping. Therefore, they have a guaranteed consumer of their end product.

Their focus is not selling product. It’s about servicing the client. They find clients through networks. They focus on non-profits and those who partner with SMS or other NGOs. Most of their projects actually come to them looking for zero waste solutions or waste audits. The ultimate vision is to change the way waste management is run while being environmentally friendly and engaging the informal sector (i.e. waste pickers).

4.5 Interviews of Composting Firms: EcoFil

EcoFil operates a waste processing facility similar to those operated by A2Z Group. They were started 18 years back in 1997 through investors from the USA and Singapore. The core business was initially water and wastewater, but they have since expanded into MSW, opening up a
plant in Navi Mumbai in 2012. Their feedstock is heavily organic due to the presence of a nearby vegetable marketplace. With 180 vehicles going through their weigh station on a day-to-day basis, they process an average of 500 metric tons a day. Their waste is classified as 60-65% organic with 25% as compostable and 5-7% recyclable (Kumar and Verma 2015).

They produce 3 products from the waste: compost, RDF, and plastic granules. Compost is their main money maker, selling 60-100 tons per day. They place heavy focus on forming contracts with various retailers such as KRIBHCO, RCF, DPAC, and Tata Chemical. With Tata Chemical, they recently signed a 3-year contract in January 2015.

To sell in Maharashtra, there are different rules to follow compared to Uttar Pradesh. The state issues a marketing license to the firm, enforcing a singular price for all customers. Therefore retailers will check the product, then for the marketing license, and sign a co-marketing permission contract. This allows the reselling rights. The whole process takes around 1 month to complete.

EcoFil has the following contractual agreements for minimum purchases with the following retailers:

- KRIBHCO: 10,000 MT/year
- Tata Chemical: 5,000 MT/year
- Other clients’ average: 20-25,000 MT/year

I was informed by Kumar and Verma (2015) that there were two seasons of interest:

- **Kharif**: May-September, the rainy season
  - Crops Grown: Onions, Sugar Cane, Rice, and Wheat
  - Tend to receive more plastic in waste
- **Rabi**: November-March
  - Crops Grown: Cotton, Mangoes, Other fruits, and Grapes
  - Tend to receive more organic matter from the nearby vegetable market

The demand for compost is higher during Kharif season but as discussed by Liu (2015), compost production drops substantially, up to 50% during this season. Thus, EcoFil has to manufacture and store compost in anticipation of the rainy season, around 3000-4000 metric tons.

Other customer groups that EcoFil sells to include the local horticulture, nurseries, and farmers. They can sell around 5 to 10 tons of compost per customer.

EcoFil has similar concerns as A2Z with regard to staying in business. EcoFil’s main source of income is the sales of compost and RDF. Unlike the A2Z Group, EcoFil does not receive a tipping fee. In other words, they do not receive money per tonnage of waste received. This is because they do not collect the waste themselves. It is delivered by another firm that has the tender to collect waste around the city of Mumbai.
Kumar and Verna (2015) project that the waste received will increase as Mumbai's population continues to grow. As of 2012, they estimated the city population to be 8-10 lakhs and it's projected to grow to 15 lakhs (Note: lakh is an Indian unit equivalent to 100,000). Therefore, they anticipate increasing compost production in the future as they are unable to keep up with the current demand for compost. They have little to no compost stored on site at any given time except on Sundays (they don't ship out on that day) and during the rainy season.

To derive additional profits, EcoFil is also looking to diversify. They are planning on building a pyrolysis plant to process 5 MT/day of plastic and tire waste into fuel. Additionally, they are also expecting to build a biogas plant and divert some of their organic waste to produce methane.
Chapter 5:
Discussion and Analysis

This chapter will analyze the information collected during literature review and interviews conducted in India in January 2015. The purpose is to find untapped marketing opportunities for compost production firms.

5.1 Compost Opportunities based on Interviews

The interviewed farmers that I spoke to are diversifying their crop portfolio. The farmers are now looking into planting some potatoes, additional wheat, and cauliflower. With these additional crop types, they may run into nutrient deficiencies that sugar cane previously did not exhibit. Compost might be able to provide a more holistic nutrient management approach.

Government-run soil testing facility should also recommend compost as a product along with their chemical fertilizer recommendations. They are a critical source of information as the farmers trust their judgments. Additionally, the local compost producer's information should be dispensed once quality has been established. This is because compost is a fairly bulky product so farmers would only be able to reach the local distributors before it becomes cost ineffective to purchase the product.

There is certainly room for improvement in the marketing department of A2Z because it currently is made up of one marketing director. In fact, each plant only has one person on the marketing team whose role it is to make calls and educate customers about the products A2Z had to offer. If more people could be hired, then there could be increased outreach to potential customers.

I recommend that A2Z Group establish more farmers who can act as representatives of their brand. These representatives could effectively become salespersons as they demonstrate how well the compost can perform. A2Z could further encourage these individuals to reach out to others by offering a commission on every sale they make. Based on my research, enthusiastic compost users are the best marketing tool.
To become a stronger company, A2Z will need to diversify its product portfolio. One way is to transform compost. Currently, compost is either in bagged or loose form. Chaunhan (2015) stated that A2Z is researching how to manufacture their compost in granular form. This way the compost somewhat mimics the look and feel of chemical pellets. It also makes the spreading of compost easier since it’s frequently spread in the fields by hand by the laborers. The current powdery form of compost is not able to be thrown the same distances; thus becomes more labor intensive.

5.2 Marketing Guidelines derived from Case Studies

Crucial aspects of a business models related to marketing include opportunities and threats; competition; market segments, characteristics, and trends; and product, price, place, and promotion (Ali 2004). Each of these is discussed below:

1. Opportunities and Threats to Business

Having a good product is not enough. One needs to be able to capitalize upon opportunities while mitigating threats. To properly understand the marketing environment, holistically, areas of concerns are political, legal, regulatory, cultural, economic, and technological.

In the case of both A2Z and many other compost producers, they have the advantage of being the only local compost producer due to the waste collection contracts they have with the local municipalities. Chaunhan (2015) informed us that municipal boards issue contracts on a 7- to 10-year basis. With that contract, it can be protective to A2Z’s local compost market since it become prohibitively expensive for farmers to travel long distances to procure compost.

Kumar and Verma (2015) indicated that EcoFil is looking to increase their compost production. They can capitalize on the composting technologies developed by other firms such as Excel that can reduce the time it takes for waste to degrade into compost form (Shah 2014).

2. Competition

For the most part, fertilizer is the main competition for compost producers. IFFCO, KRIBHCO, and IPL are some brands that were prevalent in the Muzaffarnagar area that competed for the same customer as A2Z. On the flip side, Tata Chemical is both a distributor of A2Z Compost but also provides seller of chemical fertilizers. Therefore, it is possible to cooperate with chemical fertilizer companies, especially since they have the better developed customer networks.
In addition, it is important to understand what the competition is doing and what advantages they have. In Case Study 2, Section 3.4, Bhalerao studied his competitor Excel Limited and then marketed his compost product as a lower cost product with better services (e.g. free delivery and reduced price with on time payments). He also motivated the salespeople through a generous commission of 20% of all sales they make.

During interviews, A2Z Group identified Ramky Infrastructure Limited and Jinal Urban Infrastructure as competitors as they also operate in the municipal solid waste collection and processing. Both Ramky and Jindal primarily operate in the southern parts of India but eventually they may end up competing for the same contracts as the companies look to expand. Therefore it is critical that A2Z Group find a competitive edge to contest with these groups.

3. **Market Segments, Characteristics, and Trends**

Market segment include what kind of customer to appeal to. The focus should primarily be farmers as they are largest consumers (by volume) of compost. But there are other groups to appeal to including nursery owners, tea growers, government retailers, and urban household gardeners (Ali 2004). It is important to research the characteristics of each group such as their potential buying power and how much do they need the product. This will help guide decisions on whether to appeal to such markets.

A2Z is not looking currently to expand their market segment but EcoFil plans on increasing the number of contracts it has with commercial retailers. Kumar and Verma (2015) indicate that they hope to capitalize upon sustainability initiatives that the government has touted in the past. Thus they might be able to establish connections with other large consumers of compost who are environmental conscious such as college campuses that have extensive landscaping and gardens.

Below is a table to better analyze whether a customer segment is worth pursuing for a business.
1. A rural farmer needs compost for his fields which have very poor soil. He realizes this, and wants to buy some. However, although he thinks the price is reasonable, he is simply unable to pay for the product as he is too poor.

2. A wealthy householder uses compost for growing flowers on his balcony. He wants compost but does not have a great need for it (his plants would grow without it, and he could afford chemical fertilizers).

3. A nursery owner needs compost for healthy plant growth, and wants to buy quantities monthly. He is a successful businessman and would be able to pay the price, but considers it too expensive, so is unwilling, despite the impact on his yields.

4. A tea grower does not want compost but has been advised that his soils are degrading and he needs to add soil conditioner. He is able and willing to buy compost.

5. The Government wishes to see an expansion in organic farming and subsidizes compost and provides loans to farmers.

Table 2: Understanding the Market (Ali 2004)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Need</th>
<th>Want</th>
<th>$$$</th>
<th>Market?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A rural farmer needs compost for his fields which have very poor soil. He realizes this, and wants to buy some. However, although he thinks the price is reasonable, he is simply unable to pay for the product as he is too poor.</td>
<td>3</td>
<td>3</td>
<td>x</td>
<td>3 x</td>
</tr>
<tr>
<td>2. A wealthy householder uses compost for growing flowers on his balcony. He wants compost but does not have a great need for it (his plants would grow without it, and he could afford chemical fertilizers).</td>
<td>x</td>
<td>3</td>
<td>3</td>
<td>3 3</td>
</tr>
<tr>
<td>3. A nursery owner needs compost for healthy plant growth, and wants to buy quantities monthly. He is a successful businessman and would be able to pay the price, but considers it too expensive, so is unwilling, despite the impact on his yields.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>x x</td>
</tr>
<tr>
<td>4. A tea grower does not want compost but has been advised that his soils are degrading and he needs to add soil conditioner. He is able and willing to buy compost.</td>
<td>3</td>
<td>x</td>
<td>3</td>
<td>3 3</td>
</tr>
<tr>
<td>5. The Government wishes to see an expansion in organic farming and subsidizes compost and provides loans to farmers.</td>
<td>x</td>
<td>3</td>
<td>3</td>
<td>3 3</td>
</tr>
</tbody>
</table>

4. Product, Price, Place, and Promotion

A business needs to find out what the customer needs and wants from compost. Next how to best reach the customer with both information and delivery of the product. Information is key to promoting compost over competitors. The consumers need to understand both the environmental benefits and the potential yield benefits. Refer to Section 3.3.

Additionally, accurately pricing to balance both the business’ bottom line and the customer happiness are critical. Based on the literature review and interviews conducted, pricing should vary regionally based on the income levels of the consumers, around Rs2000-3000/MT.

Finally, promotion of the product is key and as stated earlier, having enthusiastic customers who can act as representatives greatly increase the chances of converting an individual to the brand. Sandeep (2015) stated that they will continue to promote the A2Z product through seminars and village demonstrations. The demonstrations are particularly powerful since the local farmers can see the difference and judge for themselves.
Chapter 6

Phone Application and Game Development

There are two parts to the implementation of alternative compost marketing. The first one is the development of a phone application to increase access to soil information to farmers. Phones were selected to be the vehicle of information because of their prevalent usage in India. In 2012, it was estimated that 74% of the Indian population, over 880 million people, had access to cell phones (Chatterjee 2012). The second is to implementing the concept of gamification. Gamification increases user interaction with information due to presenting said information in an engaging format and interface (Franzoni and Sauermann 2014). Each one is discussed below.

6.1 Phone Application

The purpose of this phone application was to give access to farmers who have limited access to a government soil testing lab so that they can self-diagnose of soil deficiencies. This will help improve stakeholder interaction because in the recommendation section, we would be promoting the use of compost in any applicable situation. At the end of the day, though, this application is meant to help the farmer and to even the playing field for both small and large farmers.

MIT App Inventor (appinventor.mit.edu/) was selected to be the interface for development for the phone application due to compatibility with Android phones and prerequisite of little to no programming knowledge. The application was based on a poster that was observed while visiting a soil laboratory in Muzaffarnagar.

The MIT App inventor user interface was simple and straight-forward. The first screen displayed the most common forms of crops found in India. The focus was with Muzaffarnagar cash crop (i.e. sugar cane, corn, wheat and rice) since I was able to physically survey the farmers in the area. Next, it was meant to showcase the various soil deficiencies that commonly occur
within the plants. When the farmer selects which chemical deficiency he suspects, the screen would display a short description of what symptoms to look for, recommendations on how to fix the deficiency, and then finally a graphical representation to compare what the classic symptoms look like all summed up in the plant growth pattern. Note, that while the text in the screenshots is in English for ease of development, it should be translated into Hindi when actually implemented. Text should be kept to a minimum and more emphasis should be placed on the visual aspect, just in case of a literacy issue. In addition, plants included in the initial pilot version of this application were the primary crops grown by Muzaffarnagar farmers based on the interviews conducted in January. The most commonly mentioned crops were sugar cane, corn, wheat, and rice. Emphasis was placed on leaf-based crops since diagnosis is entirely based on visual inspection by the farmer.

Refer to Appendix C for screenshots of the phone application.

During the actual development process, there were some issues. The screen space was limited to the screen display. Thus, the idea of multiple images to corroborate diagnosis was scrapped. Instead, the format of information displays was altered to have only one descriptive image, a short description to help fill in any addition details, and recommendations on how to mitigate the deficiencies.

6.2 Game Development

The purpose of game development is to increase stakeholder interaction by letting people play a game while integrating important environmental concepts, also known as gamification (Franzoni and Sauermann 2014). The idea originated from the successful implementation of Foldit. In the 1990s, scientists were studying protein structures and shapes since the orientation and folding patterns affected the interactions with cells, viruses, and other biological components of the human body. David Baker and his lab group developed an algorithm called Rosetta that allowed his group to compute energy levels of randomly chosen protein shapes. This was then developed into web-based software Foldit to allow volunteers use human intuition to find the optimal shapes. By playing with the shapes, the volunteers learned more optimal protein shapes and were able to outperform the computer.

This implementation is a game that teaches farmers the importance of agricultural sustainability. The game is also about keeping one's crops healthy. The initial idea was to study Farmville, which was a farming social networking game. Upon closer examination, the underlying programming is complex and unnecessary to further perpetuate the teaching aspect. Upon testing and studying other games that are popular, Plants vs. Zombies was the selected choice. The objective of Plants vs. Zombies is the player acts as a gardener and defends the home base from zombies with projectile firing plants.

The game is based on a similar premise where the plants would be the major crops grown in India, such as sugar cane, cotton, pulses, coffee, etc. (General Knowledge Today 2014). These
crops would be transformed to be able to shoot projectiles. Meanwhile, instead of zombies as the antagonists, common pest forms would take their places. Common pests such as borers, aphids, and termites are featured (National Centre for Integrated Pest Management 2009).

Compost and fertilizer would come up as power-up options. Fertilizers allow the plants to shoot faster but would eventually cause the ground to be drained of nutrition. Thus, the plant would wither and die. Meanwhile, compost would not have such dramatic results, but allows the plants to increase in speed overall for the entire duration of the level.

The platform for development is also developed by MIT and is called Scratch. It allows programming of stories, games, and animations.
Chapter 7

Conclusions and Future Work

This was a study to evaluate the market environment for MSW compost and then use that evaluation to suggest potential methods of increasing MSW compost sales. As stated in Chapter 3, current Indian compost production firms struggle to pin down a market segment and appeal to the customers within that group. Compost production companies have two categories of customers: wholesale and retail.

The wholesale sector customers are those who purchase the compost primarily for resale to others. They are generally the large corporate entities who enter into yearly contracts with to buy the compost in bulk. These wholesale customers in turn sell through their customer networks and retail stores. The product eventually reaches the individuals whom the compost firms also try to sell directly to.

Retail customers are the customers who use the compost they purchase and are primarily from the agricultural and horticultural fields. Farmers who were interviewed emphasized the need for quality and good crop results. With the help of enthusiastic advocates of the brand, more farmers would be willing to take the first step and try out a new product.

With a better focus on the customer segments and data documentation, Indian compost businesses should be able to turn composting into a profitable endeavor. Compost production additionally produces social benefits such as environmental improvement and employment of lower-income individuals.

In future works, research can be done to find additional markets for compost producers to expand into to aside from farmers, horticulturalists, and retailers.
Works Cited

Aggarwal, Pankaj
2014  Waste Collection in Muzaffarnagar.

Ahsan, Saifi
2015  A2Z Operations in Muzaffarnagar.

Ali, Mansoor, ed.
2004  Sustainable Composting: Case Studies and Guidelines for Developing Countries. Loughborough University, Leicestershire, UK: Water, Engineering and Development Centre.

Ambade, Bhushan, Sunil Sharma, Yukti Sharma, and Yagya Sharma

Annepu, Ranjith
2012  Sustainable Solid Waste Management in India.

Central Intelligence Agency
2014  India. Central Intelligence Agency.

Chatterjee, Patralekha

Chaunhan, Rohit
2015  A2Z Composting Operations.

Dimpal, Vij

EPA

Eriksson, O., M. Carlsson Reich, B. Frostell, et al.
Franzoni, Chiara, and Henry Sauermann

General Knowledge Today

Giannakis, G.V., N.N. Kourgialas, N.V. Paranychianakis, N.P. Nikolaidis, and N. Kalogerakis

Gupta, Shuchi, Krishna Mohan, Rajkumar Prasad, Sujata Gupta, and Arun Kansal

Hansen, T.L., G.S. Bhandar, and T.H. Christensen

Hartmann, H., and B.K. Ahring

Idris, A., B. Inanc, and M.N. Hassan

Jai, Shreya

Jakobsen, Svend Tage

Joseph, Kurian
2013 Municipal Solid Waste Management in India. Municipal Solid Waste Management in Asia & the Pacific Islands.

Kanhal, Mohit 2014  *A2Z Infrastructure Limited Case Study.*


Kumar, Rama, and Anil Verma 2015  *EcoFil Marketing and Operations.*

Kumar, Sandeep 2015  *Marketing Operations at A2Z in Muzaffarnagar.*

Liu, Yeqing 2015  *Comparative Analysis of Composting as a Municipal Solid Waste Treatment Process in India.* Massachusetts Institute of Technology.


Pfeiffer, Ehrenfried

Prasad, Rajendra

PTI

Rawat, M., A.L. Ramanathan, and T. Kuriakose

Saha, J.K., N. Panwar, and M.V. Singh

Shah, Esha

Shah, Saurabh

Sharholy, M., K. Ahmad, G. Mahmood, and R.C. Trivedi


Silva, M.Q.R., and T.R. Naik

University of Nebraska

Welborn-Nichols, Jan

Wilson, D.C.

Zurbrugg, Christian, Silke Drescher, Almitra Patel, and H.C. Sharatchandra
Appendices

Appendix A: Notes from Interviews Conducted in Muzaffarnagar

DATE: January 12, 2015
MEETING @ Paper Mill
PARTICIPANTS: Pankaj Aggarwal, Julius, Kate, David L., Raluca, Ching-Ching, Ellen, Cecilio, Sarah, and Libby
+ Follow-up Participants: Akshay, and Shelley

Background
Muzaffarnagar is in recession.
So paper mills collectively shut down for a couple of days to trigger demand.

Regarding the pyrolysis process...
- IITB professor is developing a catalyst which they hope will improve the efficiency of the process.
- 2500 tons of waste paper (industrial grade) processed per day
- 125 of 2500 tons are waste plastic. 10 tons go to municipal waste.
- Currently they’re struggling with low efficiency levels.
  - Of the 10 tons of plastics, they can only produce 2 tons of oil and 1 ton of carbon.
  - The rest comes off as gas. They’re hoping to capture the gas as cooking gas.
  - On the bright side, the oil has high calorific value around 8500. Ideal range hovers between 8000 to 9000.
- History
  - Friend in Dubai who talked about oil generated from plastic waste. Basic process is to heat up the plastic in an anoxic environment and plastic will melt back into oil.
  - Went to China & Ohio with Professor Fine
  - 3 batches with the equipment from China were a failure. No oil.
  - 6-7 months later, they attempted again; it worked.

Municipal Board
- Employs 1200 workers
- 850 clean the city aka street sweepers
- 45 secondary waste sites.

History Regarding A2Z
- 3-4 years back, there was no A2Z Group contract for waste management. All collected waste was landfilled in one of two landfills. 220 tons (verify number) of generated waste per day. One landfill location in the city and one near the Kali River.
- Now under A2Z contract they make fertilizers and refuse derived fuel (RDF).
- About 28% of the waste is composted. (according to A2Z handout at tour, about 18% of total incoming waste by weight ends up a finished product compost, out of about 53% of the incoming waste that enters into the composting process)
- Rest goes to RDFs. (according to A2Z handout at tour, 38.5% by weight goes to RDF.
- ~2% are landfilled → stones, etc.
• 20-30 year contract for A2Z → this was all done before Pankaj.
  ○ State government gave money to subsidize A2Z's work

• Before A2Z
  ○ The flow of waste is: Garbage from household → (collected by tricycles) → secondary collection points (45) → landfills (by tractor-trolley)
  ○ Very smelly
  ○ Waste used to be thrown near the river.
  ○ Bridge nearby was 40-50 meters high. The garbage piled up nearly to the height of the bridge.
  ○ Lake was also half-filled by trash.

Q: When was waste collection formalized?
A: Maybe last 50-100 years. Population was small back then. No plastic; basically only organics.

The original plan
A2Z picks up garbage from every household every day (daily collection). Households would separate beforehand.
A2Z tricycles would have 4 boxes for separation: food waste, paper, plastic, and wet/dry. (or was it paper, plastic, wet - including food waste, and dry?)

Go to each house; AtoZ would blow a whistle and then housekeeper would give it to them separately. Bins were provided to each household.

Separated waste would go to others bins provided by A2Z at no charge to the households. Bins would be taken by A2Z loaders. Every day 2-3 times a day (?). Bins go directly to A2Z for processing - not accumulated at secondary waste sites. The idea was the secondary collection sites would be replaced by these bins.

300 bins spread throughout the city so there would be no open garbage.

Q: What was A2Z's community outreach regarding the education of waste collection?
A: Unknown. Pankaj's guess was some leaflets.

General sentiment of the population
• They want a very clean city. Households don’t want secondary collection sites.
• Their houses are very clean but the trash is thrown into/onto the streets.
• They think the duty of keeping the city clean is for the municipal board.
• Households don’t understand that without their support, the municipality can’t do anything
• No sense of civic duty

Only 30% of households would pay.
Paid $0.50/month. If the household doesn’t pay, then the waste is just not collected by A2Z.

Commercial
• $0.60/month
• none of them pay.
• they do have clean shops. Dust and garbage are placed into drains.
No sense of civic responsibility

The mount of collection has stayed the same.

**A2Z Challenges**
- insufficient staff
- nobody wants to give money
- everybody wants to take money from A2Z

650 rupees/metric ton ← amount government pays to take from secondary collection sites

Mayoral officers want a percentage of that money

A2Z directly collects household fees but then it’s given to the municipal board / deposited in municipal accounts

*Could the city charge a waste tax?*
Yes, they are planning on it; they also issued notices to HH to penalize them for not paying the fee -- but households fight collectively. AtoZ wants an official municipal notification -- but this rule must pass through government

Pankaj thinks this will pass in 2 - 3 months -- or be added to the electricity bill

Corruption is prevalent.

State government has to give approval for their new plan regarding waste collection changes.

Lots of officers are fighting. Everybody does pay a local tax -- even informal sector (said Pankaj).

**What’s Happening Now**
Household garbage → (collected by) → A2Z Group & Private Sweepers → Secondary Collection Point (without separating) → Collected by A2Z …

**Monthly Household Fee**
Rs 50 - 60 ← about how much private sweepers will charge each household
Sweepers also drain waste (toilets), clean waste from rooms and remove trash
They used to fight with AtoZ -- Pankaj says they are a strong union; they have always existed

Rs 30 ← A2Z’s fee amount
AtoZ only does collection and via a whistle to collect the waste-- Pankaj pointed to the additional services provided by the private sweepers

If waste tax came through - AtoZ would try to employ private sweepers (?) confirm
AtoZ can’t currently pay its people more due to their contract with the municipality
Private companies thought they were going to lose their jobs so they had their unions fighting A2Z. In reality, the public likes the services offered by the private firms. People still give money to private industry because their workers will go into their houses and clean everythings.

A2Z is working hard, but they have to recognized by the government so that the budgets can be altered. That way they can get their fee from the electricity bill (or some form of utilities).

Currently there is a bill waiting to be passed. Hopefully in the next 2-3 months.

Additional Challenges
Indians are very social people. Everybody knows each other. Therefore it is difficult to be too hard on the populace due to elections.

Pankaj has been in office for 2.5 years for a 5 year term. He has not decided if he will be looking for re-election.

A2Z group struggles to work elsewhere; only works in Muz as Pakaj pays them a tipping fee from the municipal board. He’s of the environmentally friendly stance.

Q: What is A2Z’s biggest barrier to success?
A: They can’t collect their fee. Pankaj is trying to raise the fee and adding it into the utility bill.

Ideas: Cow Dung Fee
He also has an additional idea of charging for cows.
Rs 350/cow/month unless the cow owner can show that dung is used for fuel or fertilizer
~10,000 cows/buffalo in Muzaffarnagar
Cow dung is thrown into secondary collection sites or dung is diluted down and flushed into the drain, eventually clogging it.

If the cow owner uses cow dung as fuel or fertilizer, then he can have a fee exception. Otherwise he will have to pay Rs 350/month. There are a lot of dairies with 30-60 cows.

There should be a separate bin for cow dung with a private contractor. The bill for this idea has yet to be passed.

Idea: Banquet Hall + Drumshalla Fee
20 banquet halls in Muzaffarnagar -- for rich
- All of them use disposable plates, bowls, etc.

200 dharam shalas (plus temples and schools can serve as these) -- for middle class and poor
- They provide social service space like a hotel.
- Rooms and space, etc. for functions
- Middle + low class utilize this service for marriages + other social function
- They also use disposable crockery.
- Organic waste tends to be to animals

Marriage functions/engagements
Must be planned according to the stars/matching horoscopes. Thus time of engagement must be determined by priests. Out of 365 days, only 50 days are lucky enough (for Hindus).

In theory, venkat owners should plan ahead of time and the city can provide vehicles to take the garbage left behind. Separated on the spot. Right now, everything just goes to secondary collection sites. Pankaj wants to plan something so that the city can collect more of this.

There are also very big processions.
- Few thousand people will participate
- 2-3 km long
- every 100-200 meters, there are food stands.
- everything is given out in plastic containers
- municipalities send out rolleys to collect some waste

Q: How is payment done for A2Z?
A: In zones. Supervisor for each. They make invoices and give them to households. They keep on giving the invoices to unpaid households as well. It’s done on a monthly basis.

For normal city operations, there is the water tax + house tax. Bill is sent to households and money should be deposited at the municipal board. January - March is tax collection time

If the household doesn’t pay, then a team will be sent to recuperate the money.

--------

Regarding customs
Culturally toilets have to be cleaned daily. There are 2 doors. One for user and one for cleaner. Can’t be done by self -- not culturally accepted.

Q: How organized are the private sweeper unions?
A: 2-3 unions. They can come together and are very effective at striking.

Q: Do members pay a fee?
A: Very small or none. Usually the unions have other sources of income, e.g. extorting money from A2Z. They are a source of power in the city. They have thousands of workers at their disposal. If they’re not paid, they can wreak havoc: attacking drivers, breaking bins, etc. They used to charge AtoZ a fee or mess up AtoZ’s trucks until Pankaj stopped that. They still feel threatened by AtoZ

Hospitals
Medical waste is supposed be handled and sent to Meerut where it’s incinerated. Each hospital has a contractor for waste collection.

Unfortunately a lot of them dump into secondary waste collection sites.
In theory, any hospital who dumps should be given a notice. But with corruption, the notice server can be paid off with extra Rs 100 or 50.

**Additional Participant: Shelley**
Monitors effluent characteristics of paper mills, e.g. pH, COD, BOD, etc.
She will notify anybody if they’re getting dangerous close to their limits.
She has a lab.

Pankaj is from separate party than the ruling Uttar Pradesh party. Pankaj is in the Congress party.
Political situation in UP is unfavorable. Jaipur and Delhi are models of city waste collection -- but they are larger so not everyone knows each other.
Executive officer in the municipal board is the person who implements.

**Pankaj’s vision**
- Plan how to separate waste and how to handle it
- Proposal other ideas on what to do with banquet halls
- He will have A2Z representative and executive municipal board chief executive come to our meetings to help with implementation of ideas.

Cow dung can be sold to farmers
Heap becomes fertilizer
Sell to paper mills to store/dry used in boiler and aeration tank to make MLSS

Used as a fertilizer

Hire a contractor
- 150-200 rupees
- Would provide his own manpower
- Has to be private otherwise people will not do good work.
- Government will provide them vehicles.
- The contractor will be given the option to either sell the cow dung or send the dung to government controlled facilities.

If cow dung is pressed to remove water, after 50-10 days it can be utilized for fuel.
Otherwise they can also be used for biogas, methane gas generation.
Pankaj can recognize the value of private workers.

DATE: January 12, 2014
MEETING @ Shri-ram University
PARTICIPANTS. Dr. Kulshretsta along with various professors from engineering and architecture professors

From the school, there are 4 departments working with us:
- Architecture and Planning
- Biotechnology
- Engineering (Mechanical)
- Management
45 wards

Muz Development Authority
- Group that is concerned with development within the city
- Infrastructure (roads, etc.)
- They will hand over the infrastructure to municipal board once construction is completed. For service and operation purposes.
The university has divided the city into 3 different sectors
Outside of the municipal responsibility - the panchayat is the government official - don’t have much money

Old GT Road and Railway are used as physical delineation markers.

DATE: January 12, 2014
MEETING @ Classroom
PARTICIPANTS: Students + Professors + Dr. Kulshreshtha

Our project was introduced as waste management investigation.

Get list of participants from Kate’s email.
Dr Ravit - who is in charge of all the schools -- the four branches
Dr. Asif mobile Nos are: +919675421591, +919808074586 Coordinates and works under Dr Ravit
Mr. Vikrant from Arch & Planning: +918899171114,
Dr. Ashwani from Bio Tech. +917417076417
Mr. Aditya from Arch: +919456097345
Mr. Rishabh Tyagi from Civil Engg: +919897551718
Dr. Kulshreshtha, Chairman and CEO - sckulshreshtha@rediffmail.com
Loosely - list of numbers
- 4-5 students and 2 faculties from Bio Sciences
- 3 students and 1 faculty from Civil Engg
- 2 students and 1 faculty from Arch and Planning

4 groups are represented
Cartography
Civil Engineering
Engineering & Management

30-35 students

3 strata
- social background
- economic background
- physical background

social background
- 3 indicators
  - Religion (i.e. Hinduism vs. Muslim)
  - Caste
Literary education

economic background
  Occupation
  Income
  Land/property value

Physical background
  Which sector of the 3 sectors of the city)
  ● Old city (Section 1 - poorest, oldest area; minorities live here)
  ● GT Road - Trans Railway = Section 2 - civilized; most of Muz is in this area)
  ● Trans-railway - East of Trans Railway
    ○ New Railway - planned in checkerboard pattern; “New Mundi” or the new
      wholesale market area

House facing street or not
Housing type/what it’s made of

9 characteristics
Subjective and statistical values

High/medium/low income

Census In 2011 limited the population counting to municipal limits even though the city boundaries have
really extended far beyond that.

In the unofficial areas aka unrecognized, there aren’t paved roads or drains.

45 wards within municipal city limits; outside of the city, the areas are separated into colonies

Architecture group
1. Trans-railway (west side) à architectural students
2. Center section bioscience
3. East section – Engineering Students
Surveying has already been conducted at 30-40 households. Perhaps 60 total?

The bioscience professor has collected samples of waste from various household’s. During interviews
voice has been recorded using mobile phones.
He is classifying the samples.

Architectural department is mapping the city
By religion (generalized, dominant groups of a particular region)
And caste, etc.

PRESENTATION by individual groups

Divided city based on income, land value (property value) to determine the wealthy of households who
live in the area.
Located dumping sites

According to bioscience
200 grams -> degradable
60 gram à non-degradable wastes

They need to plan how to decompose

Libby à how to create a business model connecting the waste private management with informal sector

SCHEDULE

1. Visit A2Z
2. Trash Tour of the City (Orientation)
3. Waste Sorts
   a. Secondary Sites
   b. Households
4. Compost
   a. Value Chain (households, STP)
   b. Quality
   c. End Users (Farmers)
   d. Map Household Collection
   e. Catchment Area A2Z
   f. Map Bulk Generators
   g. Map Informal Sector Value Chain

DATE: January 13, 2014
MEETING @ Classroom
PARTICIPANTS: Students + Professors + Dr. Kulshreshtha

Lots of fog today! Some went on the AtoZ tour in the morning - others did the city tour in the morning.

For those who did the city tour in the morning, we learned: (Sarah, Kate, and Raluca + Shri Ram folks)
On Indian census, under 18 year olds and those without ID cards are not included on the census <--
confirm this is correct -- as can’t easily find the same on the census site
Muzaffarnagar has expanded beyond the city boundary in the past ten years
Cow pies in rural areas sell for 2 rupees/cow pie

For waste audit -
  50 randomly selected households in three wards will be audited
  Wards represent income levels
    High -- 12: Ghandi Colony; 6: New Mandi B Bazar
    Middle -- 13: Patel Nagar; 14: Civil Line Dakshini
    Low -- 15: Ram Leela Tilla; 18: Laddawala; 19: Mahmood Nagar
DATE: January 13, 2015
CAR RIDE to A2Z
PARTICIPANTS: Himani, Priyanka, Jasveer

3 sectors
1. West: Trans-GT Road (oldest)
2. Center: Area between GT road & railroad track
3. East: Trans-Railway Area
   a. Majority of individuals are Hindu

According to Himani, the bioscience students went to the west sector.
Conducted interviews,
Wrote on auditing sheets (must obtain these!!!) delineating
   ● Religion
   ● Caste
   ● Any suggestions that the household could think of (e.g. they should improve door-to-door
collection etc, any problems they’re having with waste collection)

Both government and A2Z collect waste

Rs 200-300/month → that’s how much households pay the private sectors

A2Z goes door to door
Those who don’t pay are skipped. The workers have lists of who doesn’t pay.

The waste sorts were picked up around 1 pm after A2Z has already gone to the household to pick up the
previous day’s wastes.

7-8 am → A2Z collection times
10 am → sometimes around this time too

1 kg per household total
There were further classifications of waste that were written out in the waste auditing sheet.

According to architecture students,
To develop their maps,
1. Google Map
2. Snip image
3. Trace the image in AutoCAD
Their professors have obtained government maps which delineate the wards. These are uploaded so that
they can see the ward divisions.

No ward officers exist for the outskirts.
Surveying was done selectively outdoors. Most things are done on campus on computer.
DATE: January 13, 2015
INTERVIEW regarding A2Z Compost Distribution
PARTICIPANTS: Sandeep (Marketing Director at A2Z) + Dr. Rina (Translator) + Shri-Ram Students

To convince farmers, they conduct demonstrations. From each village, 10 farmers are selected. These farmers must have at minimum 10 hectares of land and the farm is located near the main road. With these farmers, the demo with hypothetically 10 hectares:
- 2 hectares → compost
- 8 hectares → whatever they're currently using

Photographic evidence shows the difference (will email)

Villages are generally located near the A2Z plants.
1. Kanpur, UP
2. Moractaba, UP
3. Aligar, UP
4. Indore, MP

Every year, they target 10 villages with 10 farmers each.

There is no compensation offered to the farmer aside for free compost for the demo.

Q: Success Rate?
A: 100%

Q: Distribution Radius?
A: ~20 km from the plant. There is a Rs 1000 fee for one dumper. Cost for compost rises based on diesel costs (aka transportation costs).

Farmers pick up compost from the plant. A2Z can send the compost as well.

For commercial ventures, A2Z will send a ½ kg sample to the interested company. That way they can do lab analysis to their heart’s content. If they’re satisfied, they can make orders.

Q: What is the price for farmers?
A: Rs 2500/metric ton for bagged compost. Rs 2000/metric ton without bags. (these numbers do not include transportation costs)

Q: What is the price for commercial groups?
A: Rs 1500/metric ton. Usually these companies order at minimum 2000-3000 metric tons.

Commercial Segment Customers
- Kribhco = government company
- NFL
- Greenstar
- Tata Chemical
The private company takes the compost raw and bags it themselves. All the other companies have A2Z bag the compost first with their branded bags.

Q: What are the markets you’re looking to expand into?
A: Nursery, School Gardens, Kitchen Gardens

No free services → same price is offered to everyone

Q: How to promote A2Z? Ads?
A: Seminars. They will also distribute ½ kg bags to interested potential customers for Rs 20. If the customer is interested in purchasing more, then they can phone A2Z. Everything is directly handled by A2Z. There are no middlemen.

Q: Who are your main customers?
A: Farmers (40%) & Commercial (60%)

Q: Feedstocks?
A: There isn’t separation. Nonetheless there is emphasis that there is no hospital waste.

Q: How many farmers do you service?
A: About 700

Q: When do farmers buy compost?
A: Usually around September - December & March

Q: How do farmers pay?
A: Full payment upon delivery.

Q: How do commercial entities pay?
A: 15 days upon delivery.

They do a meeting to convince all the farmers to use compost.

DATE: January 15, 2015
DATE: January 13, 2015
CAR DRIVE though Muzaffarnagar for city tour
PARTICIPANTS: Ching-ching + Julius + Professor Sachin Gol + Driver

The locations of the secondary waste collection sites
- Circular Road + GT Road
- GT Road + close to heart of the city
- GT Road
- GT Road
DATE: January 14, 2015
LAB TOUR
PARTICIPANTS: Professor Ashwini Kumar + David L + Ching-ching + Ashu + Students

For the liquid fertilizer
Liquid Fertilizer = Kitchen Waste + Brown Sugar + Water
3 months of fermentation with lactic acid bacteria
Can be stored in plastic bottles
Mixture is filtered after fermentation with a muslin or cotton cloth with just gravity, no pressurization
Solids = compost
Liquid = fertilizer/cleaning agent
Bio-insecticide usage is possible as well
Due to acidic nature, it can be used for cleaning purposes.

The poster is presented to every class to gain environmental awareness. The professor treats it as a social cause. Poster is in pptx form and will be uploaded separately. Get dropbox link.
Rucchi = student making liquid fertilizer at home (need to speak to her)

pH is acidic
Contains ethanol

Anaerobic fermentation since they have to open the bottle periodically to release pressure.

Professor Ashwini actually has 7 different containers at home which are chronologically ordered for each step in the fermentation/composting process.

Orange/lemon peels can make it smell nice but otherwise it has a rather unpleasant odor.

For solid compost,
They can create compost using the following recipe

Drum of 50 L
15 kg of cow urine
1 kg of brown sugar
1 kg of powder of pulses (chickpea flour)
1 kg of soil from Banyan tree/mango tree (this is due to microorganism growth present within the soil)

For 1 hectare application, you need x3 of the above recipe

To collect cow urine, you can dig small pits under the cows and use it for urine collection.

Procedure
1. Tightly cover the drum to prevent unexpected additions to the recipe
2. Mix daily with stick, etc.
3. Repeat and do for 20 days to allow for sufficient decomposition

Apparently, productivity doubles after 3 years of usage on the land.
Farmers are adopting the procedure so it’s well-received.

Typical farm around 2 hectares in size.

Names for Compost: Natural Farming and/or Zero Budget Farming
Indian Name: Prakartik Khati

Trials on Land on Campus
1. Urea
2. A2Z
3. Natural Compost
4. Liquid Fertilizer

Of these 50 L of compost, it is mixed into a 250 L drum and diluted with water to the top. This is then applied to the farmland.
DATE: January 14, 2015
INTERVIEW with Shri-Ram Students

PARTICIPANTS
1. Himanshu Kahyap
2. Shekhar Chaudhary

Where?
1. Muzaffarnagar, Village Mustafabad
2. Muzaffarnagar, Village Mandi

Village Population?
1. 6,000
2. 8,000

Distance from City Center?
1. 5 km
2. 15 km

Primary Crop?
1. Sugar cane & wheat
2. Sugar cane

Size of Farm?
1. 20 bigha
2. 80 bigha

1 bigha = 816 yards (verify)

Size of family
1. 4
2. 10

Number of Laborers?
1. Just family
2. 4-5

Growing Season?
Sugar Cane (has a 6 month growing season)
Growing --> April - May (sowing) + October (sowing)
Harvest --> Nov, Dec, Jan, Feb, March

Wheat (takes 4 months to grow)
Growing --> Nov & Dec
Harvest --> April

Amendments?
Salespersons of various fertilizers?
They sometimes come around but not really. Instead farmers are part of co-ops from where they can buy various fertilizers.

Brands?
IFFCO <-- urea (50 kg per bag)
Government brand
Sugar can factories obtain urea from government

No tax for IFFCO

It's low cost and amount depends on amount of land.

How do farmers pay?
Paid in full

Fertilizer can be picked up by retail stores owned by the sugar cane factories

Application of fertilizer on farm land?
Approximately 2-3 times/season (unsure)

KRASHAB <-- local brand (private brand)
urea, etc.
No subsidy
Have to pay tax per bag
More importantly, they don't have good output. It might be cheaper than IFFCO (even with tax) but IFFCO is much better quality.

Water Quality?
They have man-made canals for field irrigation. The water used to be for drinking; it was very clear. But that was 20 years back. Now the water is a cloudy brown and they only use it for the fields.

Drinking water comes from government supplies or they can use submersible pumps to retrieve groundwater.

DATE: January 14, 2015
FOLLOW-UP QUESTIONS
PARTICIPANTS: A2Z Managers + Ching-Ching + Students

Questions regarding the production/mass balance spreadsheet. Hopefully some clarification is below,

For composting process,
70 kg (start) --> 17.95 kg (final)

For RDF production,
28 kg (start) --> 8.4 kg (final)
8.4 kg → shredder makes RDF
19.6 kg is lost to landfill

Basically, the A2Z person confirms that there is a ~50% reduction in material between start to end product.

**Windrow Composting**
Dimensions for window are about 2.5 meters high and about 3.5 meters wide.
There are no alterations in operations based on season.

During the dry season, the moisture in windrows are low. During the cold season, the moisture is high. They will add water to windrows to increase moisture content but not artificial additives.

The water moisture is just checked manually. They want to maintain around 45%. Water will be added if too dry. Store compost in monossoon shed if moisture content is too high.

Temperature of the compost pile can vary from 45°C and 18°C. Windrow will be moved to monsoon shed if it’s too warm to help cool down.

Increase height of windrow if too cold.
Decrease height of window if too warm.

Nitrogen: carbon ratio
0.8% : 12-15% ← as measured in Kanpur
To improve the fertilizer value of the compost, they will add cow dung.

100 mm → 35 mm → 16 mm → 4 mm → compost
Various constituents come out to make either RDF or goes into landfill.

Average production of compost → 1000 metric tons/month
30 tons per day on average

January - March → low production (5000-600 metric tons)
March - December → high production (1200 metric tons)

Loose RDF → 1.5 rupees/kg → 90% of production and 500 metric tons goes into boilers
Briquette RDF → 5 rupees/kg (this only contributes to about 10% of production).

Which chemical characteristics does Kanpur measure?
pH, P, COD, BOD, DO

Gurgaon in Haryana (State near New Delhi) ← headquarters for A2Z Group
DATE: January 14, 2015
HOUSEHOLD WASTE COLLECTION
PARTICIPANTS: Kate Mytty, Aditya, Ruchi, Himani
Conducted the waste collection for the middle-income area.

We initially wanted to interview and collect waste from the high-income households. We started with a visit to a high-income apartment society - but we didn’t have permission to survey the households so weren’t allowed to collect waste. What was amazing there was in the apartment complex, some people would lower their waste from buckets attached to strings to reach AtoZ’s wastepicker. When we moved to a middle-income area, the A2Z collector would whistle down the street to alert households to bring their waste out. Waste was thrown from the roofs of households down in the A2Z cart – I didn’t realize you had to look up to be cautious of flying waste – ha!
The woman at one household showed us the collection site where they stored their waste for the kabadiwala – this included electronics, plastic, newspaper and metal. She calls her kabadiwala whenever she needs waste picked up; that same kabadiwala walked by and said he served 8 – 11 households daily.

The afternoon was our first waste sort. Data for which is included in the weekly report.

DATE: January 14, 2015
CAR RIDE to Agriculture Science Fair
PARTICIPANTS: David L. + Ching-ching + Ashwani + Madhusudan Reina Ati (sp?) (nickname: Love)

Sugar cane farmers are not getting paid for 2013-2014 so prospects are grim. The government isn’t putting pressure on factories to pay.

Pinna = Amit’s village
Brassica is like wheat.
Farmers went on strike for 1 month in front of fences of sugar cane factories.

DATE: January 14, 2016
INTERVIEW @ Agriculture Fair
PARTICIPANTS: Ashwani + David + Ching-Ching + Love + Various Farmers

INTERVIEW 1

Village?
Mandi, Mahaksingh

Population?
5,500

Product?
Sugar cane, rice, wheat

Fertilizer?
- Urea → IFFCO → 20 bags (bag = 50 kg) → Rs 334/bag
- DAP → IFFCO → 10 bags → Rs 900/bag
- Potash → IPL (Indian Potash Limited) → 2 bags → Rs 1200/bag
- Single phosphate → Local company → 5 bags → Rs 450/bag
- Compost from cow dung/buffalo → home-made → about 1 metric ton/hectare

Why IFFCO?
It is cheap and has good results. Also being from the government adds to its credibility.

Land size?
2 hectares of land
20 bags of 50 kg of urea

Traditional foods?
rotti, chapati from wheat flour, rice, dhal, pulse, vegetables (e.g. gobi = cauliflower, gram, carrot)
milk, raw sugar, butter milk, butter

How to make compost?
Use raw cow dung, spread it in a sand pit and wait for 3 months
The dung is then cut and spread in the field once every 6 months.

How do they pay for it?
1. Full payment → Potash + Phosphate
2. Installments → urea + DAP

Why mixed fertilizers?
They have to mix to grow crops.

How much do you get for sugar cane?
Rs 350/quintile/acre

DATE: January 14, 2015
INTERVIEW @ Agriculture Fair
PARTICIPANTS: Ashwani + David + Ching-Ching + Love

Name?
Mohammad Ali

Village?
Budinakhurd, which is 10 km from MZN

Population?
4,000

Primary Village Crop?
Sugar Cane

Fertilizers?
- Urea → IFFCO & KRIBCO → 40-50 bags
- DAP → IFFCO → 20 bags
- Potash → Local market → 5 bags
- NPK → Local market → 6 bags
- Compost → homemade

Growing season?
April - June

Harvest season?
October - March

Plot Size?
100 bigha ~ 5.5 hectares

Additional Crops?
Brinjal = vegetable, Rice, Wheat
80% is sugar cane

Vegetables in the future?
Plans on growing more brinjal and cauliflower because sugar cane is not selling. They are selling vegetables in Ghaziabad.

Why does he buy NPK?
Soil conditions are different and NPK yields good results.
Center recommends dosages for growing optimization.

Family Size?
Whole family helps on the farm; there are 4 members.

How often does the center make recommendations?
They bring samples of soil for testing and the government pays for the testing.

Do they (the center) recommend brands?
Yes

DATE: January 14, 2015
TOUR OF GARDEN @ Agriculture Center
PARTICIPANTS: Director of center + others

They have 28 herbs for display to create awareness of the medicinal value of these plants. In addition, they are trying to show there are alternative plants to grow.

Chlorophyllium → energy booster
Rs 200/kg

Citrinello → mosquito repellent

The center was founded in 1995 and then was taken over by the government in 1998
HONEY PROCESSING EQUIPMENT TOUR

Honey can be processed into 500 g or 1 kg bottles
Farmers can bring in their honey to be processed.

Rs 200/kg → cost of honey
Processing fee at plant
Rs 12/kg

TOUR OF LAB
Studying insecticides + management of crop diseases

5 kg/hectare
Rs 130/kg

They are currently developing 2 products that are supposed to manage the insects. They plan on attacking burrowing insects next.

TOUR OF SOIL LAB

When a farmer submits their soil sample, the lab checks the following chemical characteristics: pH, EC (electroconductivity), organic carbon, P2O5, and K2O

Testing usually takes 2-3 hours and it's all performed in front of the farmer

To check the effectiveness,
H2O + ZnSO4 ← (mix and precipitation) → H2O + NPK

They recommend fertilizers based on purity levels

Desired amounts
- pH: 7.5-7.7
- Org C: 0.4-0.8
- P2O5: 15-18 kg
- K2O: 100-180 kg/hectare
- EC

Services?
Soil test which looks at
- organic carbon: 0.9 - 1%
- amendment: FYM, vermicomposting
  o add organic matter
- NPK
  o 18% N
  o 46% P2O5
- Urea, ammonia sulphate
- Potash (60% K) → private
• Minor Elements
  ○ Fe, Mo, Zn, Cu, Cd
• pH of soil
  ○ Angelo Marmol? (some sort of scientific name)

The soil testing lab doesn’t recommend synthetics
Prefer FYM, manure, vermicomposting, vermiwash

For additional information.
Dr. B. K. Singh
Scientist & Discipline: Plant Pathology
Mobile: +91 94 5056 7598

Horticulture Exp & Training Center
Company Bag Saranepur
100 km from MZN

Leading nutrient deficiency?
Potassium which can be supplemented by potassium sulphate (K2SO4).
Next would be zinc deficiency.
After that,
Iron - sugar cane
Sulfur - rice

Other forms of compost?
Pressed mud = byproduct from sugar factory (10% of compost) and contains all the nutrients
Rs 1000/100 quintle → less expensive than normal fertilizer
There is low availability for this. Can only provide for 10-15% of production capacity.

FYM (Farmer Yard Manure) → 90% of production capacity.
Manure (homemade)

About 1500 farmers come to this agriculture center
About 1000 from April - December.

Vermicomposting demonstration
Takes about 45 days in the summer and 70-80 days in the winter
Requires 60% of water content.
And then use a 30-45 mm sieve for debris removal.

Cool chamber → stores vegetables. Thus it allows for 1 week of no spoilage.

INTERVIEW @ Agriculture Fair
PARTICIPANTS:

Name?
Satbir
Village?
Badhadi, 11 km from MZN

Population?
3,500

Crop of village?
Sugar cane + rice

Farm plot size?
7 bigha

Crops?
Sugar cane, wheat, sorghum
in the winter, brashim → fodder crop

Fertilizer?
- Urea → IFFCO → 5 bags
- DAP → IFFCO → 2 bags
- NPK → IFFCO → 1 bag
- Potash → local
- Manure → home-made → 5 bull carts for fields ~ 50 quintil

After germination, application after ½ month. Once per season. Apply during sowing.

Crops for the future?
Intercropping system. Between the sugar cane rows, there is chili in between, tomatoes, and cucumbers. They also grow flowers around the fields (e.g. roses and sunflowers)

Cucumbers are produced in greenhouses.

INTERVIEW

Name?
Devvrat Balyan

Village?
Kutbi, 20 km from MZN

Plot Size?
45 bigha

Crops?
Garden of mangoes and guava
Used to grow tumeric
Also grows vegetables, typically for personal use.
Fertilizers?
- Organic fertilizer
- Vermicomposting → Cow dung + leaves from trees → 40 quintil/year
- NPK → IFFCO → 15 bags
- Urea → IFFCO → 10 bags

Selling prices?
Mango → Rs 15-20/kg → 650 x 25 = 16250 kg/yr
Guava → Rs 15-20/kg → 200 x 25 = 5000 kg/yr

Where is produce sold?
Delhi

They also hire a person to garden and sell

Honey is also produced under the mango and guava trees.
18-25 * 25 = 450 - 625 kg/year
Processed on the farm. They can get Rs 95-130/kg.

DATE: January 15, 2015
HOUSEHOLD WASTE COLLECTION
PARTICIPANTS: Kate Mytty, Aditya, Ruchi, Himani, Julius was also here and interviewed the AtoZ collector; Sarah and Cecilio and their team were nearby working with kabadiwalas and wastepickers

This visit was to the high-income area. We walked with AtoZ’s wastepicker and an AtoZ management team member (whose name I unfortunately didn’t catch). We spent maybe an hour in the neighborhood – after walking down one ‘high income’ block, the next block was a ‘low income’ area – which immediately changed back into a high-income area. It was interesting to see the gradients of income represented in the houses there.

We walked past one high income area where the AtoZ collector didn’t collect door-to-door waste. I inquired as to why and the manager said that private sweepers served this area. He suggested that A2Z worked best in low and middle-income areas where private sweepers weren’t as common. This area seemed to have more sporadic household sized waste deposits – which seemed to be on account of private sweepers dumping their waste on the road.

One kabadiwala walking by had a giant refrigerator (there may be a small picture of this). Vegetables were sold on carts moving through the street.

Aditya gave me the numbers of the Muz population for the entire metro area (within and outside the boundary):
1991 – 7 lakh
2001 – 9 lakh
2011 - 11 lakh
Julius and Libby had an interview with the Balmikis (sometimes spelled with a V) and found that they are part of the Dalits; they are employed as private waste sweepers and by the city and by AtoZ. There are 10,000 Balmikis in Muz; 890 employed by the municipal government; 1000 private sweepers 535 employed by AtoZ.

For the waste collection - Unfortunately, while we were collecting the waste, at some point we started following a second A2Z collector and the original waste collector from AtoZ ended up continuing to collect waste beyond the point we had surveyed; somewhere we failed to mention we needed the waste for his cart before he collected more. Thus, by the time we returned to the original waste collector, he had collected more waste than we needed and had counted households for.

DATE: January 15, 2016
INTERVIEWS with A2Z Farmers
PARTICIPANTS: A2Z Farmers + Sandeep

Name: Baljinder Singh
Village: Talada Jansath, 22 km from MZN
Population: 3000
Crop: Sugar cane
Plot: 100 acres (40 hectares)
Crops:
- Sugar cane (all year)
- Potato (3 months - winter)
- Wheat (6 months - winter)
- Rice (4 months - rainy season)
- Poplar Trees (5 years)
- Mango Garden

Workers? 20 from nearby villages

Fertilizers?
- A2Z Compost (30 metric tons - loose)
- Urea → IFFCO (200 bags)
- Potash → Tata IPL (50 bags) → Rs 670/bag
- Zinc → Dayal (5 quintil ~10 bags) → Rs 3000/bag
- Sulfur → Crystal (5 quintil ~ 10 bags) → Rs 900/10 kg
- NPK → IFFCO (100 bags) → Rs 1100/bag

Transport?
A2Z delivers the compost. They bring it one time during the sowing season (which is once per 6 months)

Soil sampling?
Annual testing. From different field randomly.

Do they make their own compost?
They used to do vermicomposting, but it was very manpower consuming, high maintenance. It did produce good results. It also required a huge amount of land. The amount they got was only enough for vegetable production and wheat for personal use. Thus they don’t do it anymore.

Why A2Z?
Results are good and they got to buy 10 bags for trial (was charged a discounted rate Rs 1250)

Yields?
Soil testing results are good.

Most common soil problem?
Phosphate
NPK or single-phosphate
The A2Z compost supplements these issues.

When did they start using A2Z?
4 years ago

Any other compost?
FYM

Where does he sell his product?
Sugar cane factories & also the land is being used as research units for seed production (wheat & sugar cane), hybrid research, specialized sugar cane varieties. For the research, there is allocated 10 hectares for sugar cane and 40 hectares for wheat. They are paid Rs 100/quintil extra.

They grow vegetables for personal use. Also grow potatoes, rice, poplar trees and they’re sold in the local market. He has cold storage for the potatoes

How did he find out about A2Z?
A2Z seminar.

How often are the seminars?
Government organizes. A2Z has a booth and sells the product.

INTERVIEW
Name: Jangsingh (which means battlefield aka fighter)
Village: Naipura Janseth, 22 km from MZN
Population: 500
Main Crops: Sugar Cane, Wheat, Potato, Rice
Plot Size: 20 acres
Personal Crop: Sugar cane, potato, chili, vegetables for personal use
Workers: Just his family members (8)

Fertilizers?
- Urea → IFFCO → 100 bags
- Potash → IPL → 35 bags
- Sulfur → Tata → 25 bags
- Zinc → IFFCO → 25 bags
- NPK → IFFCO → 70 bags

Amount of Compost?
15 tons/year. 3 deliveries. They pick it up via tractors/trolleys.

How did they hear about A2Z?
Seminar

Any other brands of compost?
Biofertilizer Selrich (private company in Delhi). Costs Rs 3000/ton.

How well did it work?
The production stopped.

Cow Dung?
FYM ← they buy from a local dairy

Why did they switch?
Comparing A2Z to Selrich, it’s the same quality but A2Z is cheaper.

Vermicomposting?
Yes still doing it. The compost is used for own vegetables and nursery for rice.

Feedstock for vermicomposting?
Cow dung, dry leaves of sugar cane, kitchen waste

Transition crops?
No need because they are also part of the seed program run by the government.

Will they continue to use vermicomposting in the future?
They will continue with both vermicomposting and A2Z compost.

Cold Storage?
They use Baljinder’s. There is a 60,000 bag storage capacity. 50 kg/bag.

Where do they sell produce?
Sell in MZN market.

INTERVIEW

Name: Arun Kumar
Village: Talar Jansath, 22 km from MZN
Population: 4000
Main Crop: sugar cane, rice, wheat
Plot Size: 25 acres
Personal Crops: sugar cane, rice, wheat

Fertilizer?
- A2Z Compost → 12.5 ton/year → loose, 3 times per year
- Urea → ICFCO → 150 bags
- DAP → IFFCO → Rs 1200/bag → 100 bags
- Sulfur → local → Rs 1200/bag → 4 bags
- Zinc → IFFCO → 5 bags
- NPK → IFFCO → Rs 1200/bag → 40 bags

Cash payment

Soil testing?
Yes

Soil Deficiency?
Phosphate & Zinc, which can be supplemented by A2Z compost

He uses FYM. Usually it's his own but sometimes he'll buy from others.

Comparison to other products?
Production using A2Z compost is good.

Pesticides/Herbicides?
Corajen → Bayer in Germany. Purchased locally.
Buys 25 bottles (100 mL) → Rs 1800/mL

Purpose for Corajen?
Against stem borers, root burrowers, and other various pests of sugar cane. Sugar cane is the plant that requires the most pesticides.

Workers on farm?
5. No family yet.

Where does he sell his product?
Sugar cane factory
Seed program. He entered the program via sugar cane industries recommended the scientists to speak to him.

Has he used any other compost?
No

How did he find out about A2Z?
Word of mouth from Balinjinder

How long has he been using A2Z compost?
4 years and he’s very happy with the results.
INTERVIEW

Name: Lovepreet Singh
Village: Talada Jansath
Population: 3000
Plot Size: 50 acres
Crops: Sugar cane, wheat, rice, poplar trees
Workers: 6

Fertilizers?
- A2Z Compost → bags + loose → total = 10 metric tons
- Green manure → from leaves of plants n = sani + lobia + phanch (in Hindi) → spreads on 5 hectares
- FYM
- Urea → IFFCO → (5 bags/hectare)
- DAP → Tata → (3 bags/hectare)
- Sulfur → Crystal (on demand)
- Zinc, if needed → Dayail (on demand)
- Potash → IPL → (2 bags/hectare)

Vermicomposting?
Used to do this

Soil sample testing?
Yes. No deficiencies found.

How did you hear about A2Z?
Aeminar

Compost?
Sugar mills are making compost. Processed mud. Costs Rs 15-20/quintil for farmers.

Why pressed mud?
More nutritional value

Pay for everything in cash

Pesticides/Herbicides?
Spread according to requirements
DuPont Indofyl used based on need in field for sugar cane and wheat

Produce sent to?
local market in MZN

Very happy about A2Z
Improvements for A2Z?
It’s always good to continuously improve. It'll be good for human beings.

Organic food certification?
Not available for MZN farmers. Also not economically viable at this time.

How long has he used A2Z?
5-6 years

Previously used FYM before A2Z.

INTERVIEW

Name: Gurpal Singh
Village: Talada Jansath
Plot: 8 acres
Crop: Rice & Wheat, no sugar cane
Workers: 3 and Family: 4

Fertilizer
- No A2Z Compost
- Urea → IFFCO → 35 bags
- Potash or NPK → IFFCO → Rs 1050/bag → 25 bags
- Sulfur → Sygenta → Rs 1050/bag → 15 kg
- Zinc → IFFCO → 40 kg
- DAP → IFFCO → 10 bags
- Cow dung (FYM) from his own buffalo → applies all over 2x per year

He has his own dairy.
Does not perform vermicomposting.

Has he heard of A2Z?
In the future, he’s thinking about using it. Heard it from the neighbor Balijinder.

Why is he planning on using A2Z?
The results are very good. In addition, he’s heard good feedback.

Has he heard of any other brands aside from A2Z?
None

Awareness level of compost?
They want to use organic but the problem is that they're not getting financially compensated for going organic. And yes, farmers are aware of compost.

Where have farmers heard of compost?
Seminar. They give presentations about the product.
Soil testing?
Yes

Deficiency?
Zinc

Primary income?
Crops provide the primary income.

How much does he get for milk?
Rs 30/L

How does the dairy industry work?
The wholesaler picks up the milk.

Where are the crops sold?
in Muzaffarnagar.

Why hasn’t he used compost before?
A2Z didn’t have good results. His neighbor though changed his mind.

Date: January 16, 2015
Interviews at the college
Participants: Kate Mytty, Julius, Libby, Shruti
Location: Shri Ram College

A2Z collected waste too early in the day so we didn't end up being able to do another waste collection. Instead, we stayed at the college for interviews.

Interview 1:
Sanitary Food Inspector
And Health Inspector (only focuses on solid waste)

Structure of City:
3 Inspectors per city zone (3 zones in the city)
1 Chief Sanitary Officer – Jagendra Singh
1 supervisor per ward
They report on A2Z and private sweepers – what is clean or not
Biodegradable or non-biodegradable

He’s not happy with what the city is doing with solid waste; people aren’t aware of A2Z’s work, the municipal work and private sweepers work
What are they happy with?
- Awareness:
  - Wealthier families are more aware about waste
  - Challenges – below poverty line not aware
  - They said - People don’t have an issue with money or the ability to pay but the problem is that people are not properly aware of waste management
  - Their main concern is awareness
- As a result of the inadequate waste collection – there is malaria and cholera – while never officially studied, that was their observations
  - What can be done to raise awareness?
  - Proper seminars from government, private sector and NGOs – the youth are powerful
  - They noted Modi is also concerned
  - Who is doing this work now?
  - Small, privately run group of individuals
    Follow up: Find pamphlets and names of these individuals

Initially A2Z was doing great work – they had good intentions and were doing all the right things – but bins were always full and people were also not aware
- That said – A2Z helped improve the city – the city was “quite better” than it was before
- A2Z was supposed to create a customer service number for people to call – but they didn’t (or weren’t able to) – so the number goes to the health inspector
  - 4 – 5 complaints come in per day in each zone (3 zones)
- A2Z collects 115 – 120 metrics tons of waste per day – they have confirmed
  - 200 – 300 grams of waste per day per household (they have also confirmed)
  - Does the city own the land for secondary waste collection sites?
- Government owns the grounds of all the dumping sites
  - There are 800 government sweepers
  - 40 – 45 supervisors
  - 3 sanitary food inspectors
  - 1 health officer
  - Health issues related to solid waste?
    - No survey
    - Haven’t faced issues
  - What are big environmental issues related with waste?
    - Concerned about the cleanliness of the ward not the impact on health
    - When speak about environment – more concerned about dumping sites
    - Say that dumping site collection are not well organized between the timing for the A2Z household collectors dumping their waste and the municipal workers
      In the morning:
      - A2Z Household collection > secondary sites > tractors clean up secondary sites > in the afternoon, municipal workers dump their waste in the secondary sites
      - They want primary waste to go directly to the A2Z plant
      - Municipal sweepers only sweep wards; A2Z workers go door to door
      - Each sweeper does 3 – 4 rounds per ward per day
      - Private sweepers:
    - There is potential to engage private sweepers if needed
## Appendix B: Summary Tables of Interview with Farmers and Composting Firms

### Table 3: Farmer Interview Summary Table

<table>
<thead>
<tr>
<th>No.</th>
<th>Village</th>
<th>Population</th>
<th>Plot Size</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mustafabad</td>
<td>6000</td>
<td>20</td>
<td>bigha</td>
</tr>
<tr>
<td>2</td>
<td>Mandi</td>
<td>8000</td>
<td>80</td>
<td>bigha</td>
</tr>
<tr>
<td>3</td>
<td>Madi</td>
<td>5500</td>
<td>2</td>
<td>hectares</td>
</tr>
<tr>
<td>4</td>
<td>Budinakhurd</td>
<td>4000</td>
<td>100</td>
<td>bigha</td>
</tr>
<tr>
<td>5</td>
<td>Badhadi</td>
<td>3500</td>
<td>7</td>
<td>bigha</td>
</tr>
<tr>
<td>6</td>
<td>Kutbi</td>
<td>45</td>
<td>45</td>
<td>bigha</td>
</tr>
<tr>
<td>7</td>
<td>Talada Jansath</td>
<td>3000</td>
<td>100</td>
<td>acres</td>
</tr>
<tr>
<td>8</td>
<td>Naipura Jansath</td>
<td>500</td>
<td>20</td>
<td>acres</td>
</tr>
<tr>
<td>9</td>
<td>Talara Jansath</td>
<td>6000</td>
<td>25</td>
<td>acres</td>
</tr>
<tr>
<td>10</td>
<td>Talada Jansath</td>
<td>3000</td>
<td>50</td>
<td>acres</td>
</tr>
<tr>
<td>11</td>
<td>Talada Jansath</td>
<td>8</td>
<td></td>
<td>acres</td>
</tr>
</tbody>
</table>

### Table 4: Farmer Interview Summary Table (continued)

<table>
<thead>
<tr>
<th>No.</th>
<th>Crop 1</th>
<th>Crop 2</th>
<th>Additional Crop</th>
<th>Family Size</th>
<th>Laborers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sugar Cane</td>
<td>Wheat</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Sugar Cane</td>
<td>Wheat</td>
<td>Rice</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Sugar Cane</td>
<td>Wheat</td>
<td>Rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sugar Cane</td>
<td>Wheat</td>
<td>Rice, Brinjal</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sugar Cane</td>
<td>Rice</td>
<td>Wheat, Sorghum, Barshim</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mangoes &amp; Guava</td>
<td>Tumeric</td>
<td>Vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Sugar Cane</td>
<td>Potato</td>
<td>Wheat, Rice, Poplar Tree</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Sugar Cane</td>
<td>Wheat</td>
<td>Potato, Rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Sugar Cane</td>
<td>Rice</td>
<td>Wheat</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Sugar Cane</td>
<td>Wheat</td>
<td>Rice, Poplar Trees</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Rice</td>
<td>Wheat</td>
<td></td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
### Table 5: Chemical Fertilizer Usage Among Interviewed Farmers

<table>
<thead>
<tr>
<th>No.</th>
<th>Urea (bags)</th>
<th>DAP (bags)</th>
<th>Potash (bags)</th>
<th>Phosphate (bags)</th>
<th>NPK (bags)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>10</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>45</td>
<td>20</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td></td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>200</td>
<td></td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td></td>
<td>35</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>150</td>
<td>100</td>
<td></td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>250</td>
<td>150</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>35</td>
<td>10</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 6: Chemical Fertilizer Usage Among Interviewed Farmers (continued)

<table>
<thead>
<tr>
<th>No.</th>
<th>FYM?</th>
<th>Vermi?</th>
<th>MSW Compost (MT)</th>
<th>Zinc (bag)</th>
<th>Sulfur (bag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>yes</td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td>12.5</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>yes</td>
<td></td>
<td></td>
<td>40</td>
<td>15</td>
</tr>
</tbody>
</table>
Table 7: Purchase Receipts from Muzaffarnagar

<table>
<thead>
<tr>
<th>No</th>
<th>Date (DD/MM/YYYY)</th>
<th>Particulars</th>
<th>Qty (MT Ton)</th>
<th>Rate (Rs/MT)</th>
<th>Amount (Rs)</th>
<th>Grand Total (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3/4/2013</td>
<td>Loose Compost</td>
<td>6.245</td>
<td>200</td>
<td>1244</td>
<td>12440</td>
</tr>
<tr>
<td>3</td>
<td>4/4/2013</td>
<td>Mgreen city corporation - 40 bags</td>
<td>2</td>
<td>2500</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>4</td>
<td>5/4/2013</td>
<td>Mgreen city compost - 23 bags</td>
<td>1.15</td>
<td>2500</td>
<td>2875</td>
<td>2875</td>
</tr>
<tr>
<td>5</td>
<td>9/4/2013</td>
<td>Mgreen compost - 3 bags</td>
<td>0.15</td>
<td>2500</td>
<td>375</td>
<td>375</td>
</tr>
<tr>
<td>6</td>
<td>11/4/2013</td>
<td>Mgreen compost - 20 bags</td>
<td>1</td>
<td>2500</td>
<td>2500</td>
<td>2500</td>
</tr>
<tr>
<td>7</td>
<td>13/4/2013</td>
<td>Mgreen city compost - 10 bags</td>
<td>0.5</td>
<td>2500</td>
<td>1250</td>
<td>1250</td>
</tr>
<tr>
<td>8</td>
<td>14/4/2013</td>
<td>Mgreen city compost - 8 bags</td>
<td>0.4</td>
<td>2500</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>9</td>
<td>16/4/2013</td>
<td>Mgreen city compost - loose</td>
<td>5.085</td>
<td>2000</td>
<td>10170</td>
<td>10170</td>
</tr>
<tr>
<td>10</td>
<td>25/4/2013</td>
<td>Mgreen city compost</td>
<td>6.43</td>
<td>2000</td>
<td>13860</td>
<td>13860</td>
</tr>
<tr>
<td>11</td>
<td>25/4/2013</td>
<td>Mgreen city compost - 50 bags</td>
<td>2.5</td>
<td>2500</td>
<td>6250</td>
<td>6250</td>
</tr>
<tr>
<td>12</td>
<td>25/4/2013</td>
<td>Mgreen loose compost</td>
<td>1.57</td>
<td>2000</td>
<td>3140</td>
<td>3140</td>
</tr>
<tr>
<td>13</td>
<td>27/4/2013</td>
<td>Mgreen city compost</td>
<td>2.5</td>
<td>2500</td>
<td>3250</td>
<td>3250</td>
</tr>
<tr>
<td>14</td>
<td>27/4/2013</td>
<td>Mgreen city compost - 12 bags</td>
<td>0.6</td>
<td>2500</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>15</td>
<td>1/5/2013</td>
<td>One bag city compost</td>
<td>0.05</td>
<td>2500</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>16</td>
<td>1/5/2013</td>
<td>Mgreen city compost - loose compost</td>
<td>6</td>
<td>2000</td>
<td>12000</td>
<td>12000</td>
</tr>
<tr>
<td>17</td>
<td>1/5/2013</td>
<td>Mgreen city compost - 65 bags</td>
<td>3.25</td>
<td>2500</td>
<td>8125</td>
<td>8125</td>
</tr>
<tr>
<td>18</td>
<td>7/5/2013</td>
<td>Mgreen City compost - 100 bags</td>
<td>5</td>
<td>2500</td>
<td>12500</td>
<td>12500</td>
</tr>
<tr>
<td>19</td>
<td>9/5/2013</td>
<td>Mgreen city compost - 30 bags</td>
<td>1.5</td>
<td>2500</td>
<td>3750</td>
<td>3750</td>
</tr>
<tr>
<td>20</td>
<td>11/5/2013</td>
<td>Mgreen city compost - 40 bags</td>
<td>2</td>
<td>2500</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>21</td>
<td>11/5/2013</td>
<td>Mgreen city compost - 5 bags</td>
<td>0.25</td>
<td>2500</td>
<td>625</td>
<td>625</td>
</tr>
<tr>
<td>22</td>
<td>22/5/2013</td>
<td>Mgreen city compost - loose compost</td>
<td>2.235</td>
<td>2000</td>
<td>4470</td>
<td>4470</td>
</tr>
<tr>
<td>23</td>
<td>23/5/2013</td>
<td>Mgreen city compost - loose compost</td>
<td>1.24</td>
<td>2000</td>
<td>2580</td>
<td>2580</td>
</tr>
<tr>
<td>24</td>
<td>6/6/2013</td>
<td>Own Bag - Bho Prash(Bag Label) - 40 Bags</td>
<td>2</td>
<td>2000</td>
<td>4000</td>
<td>4000</td>
</tr>
<tr>
<td>25</td>
<td>12/6/2013</td>
<td>Mgreen city compost - 50 bags</td>
<td>2.5</td>
<td>2500</td>
<td>6250</td>
<td>6250</td>
</tr>
<tr>
<td>26</td>
<td>13/6/2013</td>
<td>Own Bag - 120 Bags</td>
<td>6</td>
<td>2000</td>
<td>12000</td>
<td>12000</td>
</tr>
<tr>
<td>27</td>
<td>13/6/2013</td>
<td>Own Bag - 55 bags</td>
<td>2.75</td>
<td>2000</td>
<td>5500</td>
<td>5500</td>
</tr>
<tr>
<td>28</td>
<td>13/6/2013</td>
<td>Mgreen city compost - 1 bags</td>
<td>0.05</td>
<td>2500</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>29</td>
<td>14/6/2013</td>
<td>Own Bag - 120 Bags</td>
<td>6</td>
<td>2000</td>
<td>12000</td>
<td>12000</td>
</tr>
<tr>
<td>30</td>
<td>14/6/2013</td>
<td>Mgreen city compost - 140 bags</td>
<td>7</td>
<td>2500</td>
<td>17500</td>
<td>17500</td>
</tr>
<tr>
<td>No.</td>
<td>Date</td>
<td>Description</td>
<td>Quantity</td>
<td>Price</td>
<td>Total</td>
<td>Subtotal</td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>--------------------------------------------------</td>
<td>----------</td>
<td>--------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>31</td>
<td>21/6/2013</td>
<td>Mgreen city compost - 2 bags</td>
<td>0.1</td>
<td>2700</td>
<td>270</td>
<td>270</td>
</tr>
<tr>
<td>32</td>
<td>21/6/2013</td>
<td>Mgreen city compost - 1 bags</td>
<td>0.05</td>
<td>2500</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>33</td>
<td>25/6/2013</td>
<td>Mgreen city compost - 55 bags</td>
<td>2.75</td>
<td>2500</td>
<td>6875</td>
<td>6875</td>
</tr>
<tr>
<td>34</td>
<td>28/6/2013</td>
<td>Own Bag - 40 Bags</td>
<td>2</td>
<td>2000</td>
<td>4000</td>
<td>4000</td>
</tr>
<tr>
<td>35</td>
<td>29/6/2013</td>
<td>Own Bag - (170 x 50 = 8.5 tons, 50x25=1.25 tons)</td>
<td>4.75</td>
<td>2000</td>
<td>14500</td>
<td>14500</td>
</tr>
<tr>
<td>36</td>
<td>3/7/2013</td>
<td>Own Bags (Bhoo-Prash) (100 bags 5kg = 500kg, 100 bags 10kg = 1000kg)</td>
<td>1.5</td>
<td>2000</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>37</td>
<td>5/7/2013</td>
<td>Mgreen city compost - 100 bags (1kg), 100 bags (2kg)</td>
<td>0.3</td>
<td>3000</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>38</td>
<td>27/7/2013</td>
<td>Mgreen city compost - loose</td>
<td>5.31</td>
<td>2000</td>
<td>10620</td>
<td>10620</td>
</tr>
<tr>
<td>39</td>
<td>27/7/2013</td>
<td>Mgreen City Compost - 2 bags</td>
<td>0.1</td>
<td>2500</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>40</td>
<td>30/7/2013</td>
<td>Own Bags - 60 bags</td>
<td>3</td>
<td>2000</td>
<td>6000</td>
<td>6000</td>
</tr>
<tr>
<td>41</td>
<td>12/8/2013</td>
<td>Own Bags (150 x 10kg = 1.5 ton, 100 x 5kg = 500kg)</td>
<td>5</td>
<td>2300</td>
<td>11500</td>
<td>11500</td>
</tr>
<tr>
<td>42</td>
<td>15/8/2013</td>
<td>Mgreen city compost - 100 bags</td>
<td>5</td>
<td>2400</td>
<td>12000</td>
<td>12000</td>
</tr>
<tr>
<td>43</td>
<td>16/8/2013</td>
<td>Mgreen city compost - 100 bags</td>
<td>5</td>
<td>2400</td>
<td>12000</td>
<td>12000</td>
</tr>
<tr>
<td>44</td>
<td>16/8/2013</td>
<td>Mgreen city compost - 200 bags</td>
<td>10</td>
<td>2580</td>
<td>25800</td>
<td>25800</td>
</tr>
<tr>
<td>45</td>
<td>22/08/2013</td>
<td>Mgreen city compost - 100 bags</td>
<td>5</td>
<td>2580</td>
<td>12400</td>
<td>12400</td>
</tr>
<tr>
<td>46</td>
<td>22/08/2013</td>
<td>Mgreen city compost - loose</td>
<td>5</td>
<td>2000</td>
<td>10000</td>
<td>10000</td>
</tr>
<tr>
<td>47</td>
<td>3/9/2013</td>
<td>Mgreen city compost - loose</td>
<td>5</td>
<td>2686</td>
<td>40240</td>
<td>40240</td>
</tr>
<tr>
<td>48</td>
<td>3/9/2013</td>
<td>Mgreen city compost - 300 bags</td>
<td>15</td>
<td>2000</td>
<td>11070</td>
<td>11070</td>
</tr>
<tr>
<td>49</td>
<td>17/09/2013</td>
<td>Mgreen city compost - loose</td>
<td>5.535</td>
<td>2000</td>
<td>11070</td>
<td>11070</td>
</tr>
<tr>
<td>50</td>
<td>24/9/2013</td>
<td>Mgreen city compost - 40 bags</td>
<td>2</td>
<td>2500</td>
<td>5000</td>
<td>5000</td>
</tr>
</tbody>
</table>

---

85
Table 8: Purchase Receipts from Indore

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Product/Brand</th>
<th>Quantity (MT)</th>
<th>Rate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>307</td>
<td>12/27/2014</td>
<td>Organic Compost</td>
<td>20</td>
<td>1650</td>
<td>33000</td>
</tr>
<tr>
<td>311</td>
<td>12/30/2014</td>
<td>Organic Compost</td>
<td>10</td>
<td>2900</td>
<td>29000</td>
</tr>
<tr>
<td>312</td>
<td>12/31/2014</td>
<td>Organic Compost</td>
<td>2</td>
<td>3000</td>
<td>6000</td>
</tr>
<tr>
<td>313</td>
<td>1/3/2015</td>
<td>Organic Compost</td>
<td>1</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>316</td>
<td>1/6/2015</td>
<td>Organic Compost</td>
<td>3.375</td>
<td>2500</td>
<td>8438</td>
</tr>
<tr>
<td>319</td>
<td>1/9/2015</td>
<td>Organic Compost</td>
<td>0.95</td>
<td>3000</td>
<td>2850</td>
</tr>
<tr>
<td>320</td>
<td>1/9/2015</td>
<td>Organic Compost</td>
<td>25</td>
<td>3000</td>
<td>750</td>
</tr>
<tr>
<td>324</td>
<td>1/14/2015</td>
<td>Organic Compost</td>
<td>3</td>
<td>3000</td>
<td>9000</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td></td>
<td><strong>8.1</strong></td>
<td><strong>2756</strong></td>
<td><strong>11505</strong></td>
</tr>
</tbody>
</table>
Appendix C: Notes from Interviews Conducted in Indore

Ask Rohit about similar MSW mass balance chart & fill in existing information
mass balance comparison between different facilities -- look into literature
different procedures for different yields?
pull in information to verify hypotheses about issues

DATE: January 19, 2015
MEETING @ A2Z, Trenching Ground,
PARTICIPANTS: Ching-Ching, Ellen, Rohit Chauhan, Vikash Kumar Jha (wasn’t really
present due to inspectors)

[Notes about Rohit Chauhan’s Position in A2Z]

MSW Collection & Transport in Indore
Indore Municipal Corporation (local govt board) operates door to door collection in all
4 zones of Indore
- 85 wards total
- Fees collected by municipality
- 50 Rs/month for households
- 500-1000 Rs/month for hotels
A2Z only collects from secondary collection bin locations & transports to waste
processing facility
- Gov’t pays A2Z 325 Rs/MT (tipping fee)
- A2Z pays Gov’t 21 Rs/MT for waste (royalties)
- Actual payment ~300 Rs/MT (adjusted tipping fee)
- 20-30 year contract for transport from secondary collection
- No biomedical waste
- ~300 tons of garbage per day from secondary collection sites in 1 zone (4 zones
total)
  - thus 570-800 metric tons/day

Operations
- They run about 60% of staff during day and 40% of staff at night
- They may collect twice from certain sites that collect waste faster.

Current Processing and Distribution at A2Z
- Indore facility constructed after Muzz facility
- Regulated by Central Pollution Control Board (National) & state board
- A2Z contracted for 500 MT/day (actual capacity ~600 MT/day)
- 7 year contract expires in 2016
- All waste processed on same day (otherwise, organic component will be spoiled)
- 4 sheds total (1 for each section): Presorting & RDF; Semi Finish Line; Finish Line; Final Compost
- Presorting 100mm sieve (2 conveyer belt output)
  - Front loader loads waste into conveyer belt input
  - <100mm => falls from conveyer into truck for further processing to compost
  - >100mm => falls from conveyer to pile for RDF
- RDF (non compostable material/non-inerts/larger organics such as coconut shells)
  - blower separates lighter plastics (polyeurethane: bags & films) from conveyer
    - plastics shredded & bagged
    - sold as binder for road construction @ 21 Rs/kg
    - shredder = 1.5-2 MT processed/day
    - plans to buy larger shredder (5 MT capacity)
  - heavier plastics melted @ 200C
    - Goes through extruder to be shaped into flat plastic discs ("plastic lumps")
    - sold as raw material for PVC piping for drainage system
    - 2500 Rs/MT
    - 1 MT capacity/day
  - Excess plastic stored outside to be used for planned W2E plant
  - ~3-4 commercial customers per RDF product
  - Planned: balistics machine to sort out stones (inerts) during RDF processing
- Compost windrows (<100mm)
  - 7 sets of 4 windrows (1 for each day of week) all outside
  - Windrows turned/moved every 7 days for total of 28 days in windrows
  - New windrow (1st) sprayed with inoculum (bacteria culture) @ 1L + 9L water per 10 MT
  - Windrow dimensions: 1.5 to 2m height, 3m width
  - At time of visit, some windrows higher than others due to mechanical problems in loading trucks
  - Empty monsoon shed (used during monsoon season to store as many windrows as possible)
- Semifinish Line Machine (35mm & 16mm)
  - 3 shifts (formerly 2 shifts with 2 machines)
Second semifinish line machine = damaged from recent fire (will be repaired by March)

- >35mm => RDF: blower to separate plastics from inerts
- <35mm => further processing for compost
- >16mm => landfilled
- <16mm => further processing for compost

- Curing Phase
  - 24 sheds kept for 15-20 days for further decomposition
  - Same inoculum sprayed 1L:9L water solution per 30-40 tons

- Finish Line Machine (4mm)
  - Extra finish line machine planned for extra 300-400 metric tons A2Z will be contracted for in future

- Final product
  - 15-20% moisture content & min 12% carbon (see handout)
  - If glass is present in compost (rarely), manually sort through 2mm sieve
  - In offseason, finished compost is stored up to 4 months
  - Before packing, spray with different inoculum + water solution (bacterial culture to stabilize) to maintain moisture level (15-25%)

**Sampling**
- Sampling data collected through onsite lab (moisture, carbon, nitrogen etc) (see photo)
  - Checked to FCO specifications (see photo)
  - Samples that don’t pass are sent back through production process (~1% of total compost produced)
  - No chemicals need to be added to compost
    More complex/thorough sampling conducted in delhi (guragon headquarters) in bigger labs or third party as requested by government
  - In situ temp sampling conducted with thermometer probe every 1 per 2 days in windrows

**Sales**

**Compost**
- Customers mainly public companies
- Public: Coramanda Godavari - 1850 Rs/ton (compost + packing only)
- Private: Green Star Jyothi - same
- Public: KRIPCO - 4000 Rs/ton (including delivery)
- Offseason => stored
- Growing season = compost selling season: March to June (monsoon season) & Oct to Nov (max 6 months total)
RDF
- July to Sept/Oct: no sales (no road construction in monsoon season)

A2Z Challenges
- Monsoon season -> high moisture content
  - Hard to process windrow through 35mm & 16mm sieves due to particles sticking together from moisture => high upkeep => lower productivity in monsoon season
  - Plans for indoor storage
- Winter weather (fog & cold temp -> lower productivity
  - 30% drop in productivity in Alegar & Muzz in winter due to fog
  - On other hand, May -Jun = high temp => increase productivity
- Indian garbage = very wet => rust easily => 1-1.5 year life for collection bins (will be fixed with source segregation)
- Lack of good quality plastics in waste due to ragpickers & kabadiwhallas -> resistance to A2Z process
- Hard to find ppl to work in waste due to stigmatism
- In UP: hard to get timely payment for work (more gov’t corruption & political issues)
  - Currently certain costs are quite high
    - 50% of revenue go into diesel costs. With a monthly revenue of 90-95 lakhs, about 50 lakhs will go to fuel.

Future Plans
A2Z operation of door to door collection in 2 of 4 zones
- Will start Feb/March
- Collect from west and north zones (22 wards total out of ~43 wards)
- Source segregation at households: inorganic vs. organic
- Incentivize households to sort with waived fees/awards
- Education programs for households segregation
- Will eliminate presorting (100 mm) > organic waste goes straight to windrows & inorganic to RDF
- Will be paid on a per ton basis → Rs 325/ton
  - With tender for door-to-door operations, they are going to be paid Rs 1900/ton
  - Unfortunately they have to pay the municipal government a tipping fee of Rs 21/ton

Installation of Waste to Energy Plant
- mass incinerator for extra waste (to generate electricity)
Incorporation of kabadiwhallas & ragpickers into system

Subsidy of Compost
- Petition to govt for subsidies to stay competitive to chemical fertilizers
- *[insert specified cost subsidy]*

Mass Balance (Estimates):
60% organic waste
  - 40-50% losses (moisture/decomposition)
38-40% Grade 4 RDF (100+ mm) >> 26% Grade 1 RDF (Finished product) & 8-10% landfilled (sand, metal, stones etc.)

General A2Z Comments
All facilities operating @ about breakeven due to small tipping fees & small profit margins on compost

Operating in 25 cities
  - 6 operating plants: Muzz, Indore, Aligarh, Moradabad, Kanpur, Fatehpur (all in UP except Indore)
  - 65% cities in UP, rest in MP, Punjab, North & East India

Business Aspects
Cost of Production: Rs 1400/metric ton produced
If they could get households to segregate, Rohit estimates that A2Z could save Rs. 180/ton

Markets:
- Farmers (15%)/local market
- Institutions (~85%)
- To market, A2Z will approach the big farmers to start using the compost first. In addition, they will hold seminars promoting compost as a way for increasing water retention capacity, etc.

Expansion
- Cooking gas from cow dung (done in Haryana)
  - Take cow dung and place into tank of water (50-20 L)
  - Dilute with water
  - After time, bacteria will generate gas for cooking purposes.
- Anaerobic digestion in facilities
- Gujerat
  - the city is pushing for more organic fertilizer
thus A2Z is looking to promote their product there

Follow up Qs:
- How are the stones sorted from RDF currently?
- # of 2nd collection sites in Indore?
- equipment investment cost (capital)?
- Operational costs (daily/monthly)?

Ellen’s Notes

DATE: January 19, 2015
MEETING @ Indore A2Z Facility
PARTICIPANTS
1. Vikash Kumar Jha
2. Rohit Chauhan

Presorting
100 mm screen
60% compostable
40% shredding polyethene/plastic (up to 5 mm)

Secondary Collection → this is what A2Z does
Door-to-Door → Indore Municipal Corporation (local government board)

The waste is supposed to be dumped into A2Z bins (that are green and yellow) where A2Z workers pick up the . Unfortunately the reality is that the waste usually piles up around the bins. Some makes it in, but most is just outside where the waste pickers will go through for valuables (e.g. plastics, paper, etc.). They also take from a nearby trench area that is on A2Z facility property. Kabadiwallas also exist in Indore. Thus the quality of plastic A2Z gets is pretty low like in Muzaffarnagar.

A2Z has bided for Indore tender. They won 2 zones (out of the 4 zones of Indore) where they plan on implementing sole segregation at the end of February or beginning of March. They will educate households. Will take about 6 months to a year to implement.
The incentives: If they do it in 1+ months, waive their user charge and/or some sort of award.

7 year contract (2016) for secondary waste collection

Pay on per ton basis
Rs 325/ton

New tender with the door-to-door
Rs 1900/ton

Rs 1500-2000/ton

Some negative:
Rs 21/ton to municipal government tipping fee
It is hard to run operation at such cost levels.

50% of costs is diesel costs. 90-95 lakhs total per month. 50 lakhs alone for fuel.

Collection rate: 750-800 metric tons/day
There is a morning shift and a late afternoon/evening shift. About 40% of staff run the night shift.

RDF amount drops to about 26% (once through sorting).
Landfill gets about 8-10%
Moisture loss also accounts for mass lost in the process.

60% goes into windrow composting
45-50% moisture loss + decomposition
Microbial mixture → Innoculum (a proprietary mixture of microbes developed in-house by the centralized labs of Kanpur)

In some cities, the organic carbon is more. They have Muslim community therefore meat content increases.

Quality control → no need to do any modification.

Indore industries?
- Soya beans (UK), also known as soy beans
• Other agricultural industries

Compactor dimension = 1.1 m^3

----------------------------------------

LPG = liquified petroleum gas → cooking gas (red cylinders). Replaces methane.

The RDF is used as a binding agent for roads.

They’re planning on doing waste to energy plants through mass incineration. Looking to do that in the future.

Air quality is an issue as well. They have pollution control orders. The national board has a set of measures.
Appendix D: Notes from Interviews Conducted in Mumbai

DATE: January 22, 2015
MEETING @ Tata Institute for Social Sciences
PARTICIPANTS: Chandra Sekhar, Jibi Jacob (jibi10@gmail.com), Ching-ching

Ideas for project elaboration/expansion
How to decrease time
1. Treat better to decrease time
2. Increase efficiency
3. Know when the product is complete
4. Supply - can you define more markets

Composting
1. Balance equipment cost vs human labor
2. There’s trade-off between level of sophistication

DATE: January 22, 2015
MEETING @ TISS
PARTICIPANTS:

Environmental waste management
Natural processes
Recycling, plastics, glass, etc.
Reuse of waste is critical make it into a resource again

Do it in decentralized approach.
- Mumbai is mostly centralized
- Transportation Is very expensive, wasteful with use of petrol.
- Make things smaller→ locality (individual entities, ie. campuses, corporate offices)

Segregation
- Generators separate dry and wet
- So they do sorting
- Behavioral change
  ○ They do a top-down approach
  ○ Get heads to care.
• Corporate and education sector/establishment with hierarchy. Generally assimilate faser.
• The households are trickier. Do 50 at a time. Got to convince the all.

Lots of projects.
Looking at localities (e.g neighborhoods)

Collect waste and it goes to one facility
Compost with biogas plant \(\rightarrow\) for large commercial ventures
3rd aspect \(\rightarrow\) they managed and handle system. They employ waste pickers.

Waste is handled differently. Hire waste pickers and then salary is balanced against taking valuable recyclables. Big goal \(\rightarrow\) employ waste pickers.

In Mumbai, waste pickers are primarily women but higher-ups are male.
Children are also a big percentage of waste pickers.

SMS = Stree Mukki Sanghatana (Women Liberation Organisation)
Ran self-help groups for women waste pickers. Formed collective bargaining groups.
Separate organizational entity to help them get additional rights. Right now, they have 3000 pickers organized. That was 15 years ago. Now they take up projects. And he helps with management.

Studies education and health issues \(\rightarrow\) how with waste pickers

Municipal Corporation (local board) \(\rightarrow\) it's difficult for them to handle waste. Split into 24 parts.
• Driver + waste pickers on vehicles + truck per ward (depends on size) \(\rightarrow\) supplied by government.
• Picks up dry waste only \(\rightarrow\) facility \(\rightarrow\) segregated \(\rightarrow\) sorted (new project - still developing, it's a few years old)
• Dry waste sheds = simple, not good condition
• Need supervisor to coordinate & segregate/maintain
• Need additional funds from dry waste collected (not enough)
• Create more funds from foundation grant
  - equipment
  - infrastructure
  - human resource cost for 1 year

Partnership of 7 wards with SMS
Waste pickers get nearest trader. They can get a better value for the collection and so they don’t get taken advantage of. Value evaluation. Shed is nearby on campus. Process is separate from institutions. Government has to step in. Value adding for dry waste.

Install 100 biogas plants → requires a bill to be passed.

Waste management has lots of money.
2500 croes
Rs 10,000,000 = 1 croe
Lots of money involved

Any disturbance will have people not liking the change.

Bulk collection & transports → tipping fee

Facility

Dumping Deonar Ground + 2 more
Deonar: started big facility
2000 tons/day ← original capacity because another firm’s facility isn’t working. Now 6000 tons/day.

UPL: United Phosphorus Limited
Manage facility of Deonar. This was 7-8 years ago or 8-10 years ago.

Before it was just a dumping ground.

100 hectares + 400 meter high ← dimensions of Deonar.

Company Aspects
1. Partnership with SMS
2. Individual establishment of biogas facility
3. Institution + Neighborhood → wet + dry waste → biogas & compost

White bag = compost → will be used for apartments. This compost isn’t being sold.

Mixing happens every day.
Dry leaves cover: carbon/nitrogen.
Build temperature structure to get past building codes.

**Biogas explanation**
Biodegradable material
Compost with aerobic and anaerobic
Initial design

2 digestor based
21 days digestion
1st digestor: aerobic
Predigestor: 4 days
Main digestor: 12 days

Manure tank ← liquid fertilizer, used internally for gardens

100 kg of waste + 100 L of H2O (10% of hot and 90% room temperature)

Water is pumped in.

People, specifically kitchen workers, are responsible for screening the input. They take the food from the kitchen and then cutting happens. Motor breaks things down.

Weight waste to measure them and also not to overfeed the system.

The whole idea is based on cow stomach with the multiple stomachs aka multiple stages of digestion.

After the food is added in, hot water goes in next. An air compressor pumps in air and mixes the material. Unfortunately food usually has oil content, which floats. They use an air pump (2-4 hours a day) to break up the oil to prevent an anaerobic environment from occurring. This is not automated (could be a part of the process which could be modified to make everybody’s life easier).

They do regular weekly checks, 2-3 times, with the pH (desired around 3-4).

If the digestor overloads, the pH drops and/or you see undigested materials.

Filter water system ← blue tank.
If the slurry is lighter color, it means the slurry is more acidic and indigestion has occurred.

Dome 1 has ½ tons on top. The output from the system is 60% methane, and it goes into a 10 m³ balloon size.

The system can process 500 kg. The regular feed is 300-350 kg. They were paid for installation and operating maintenance. The pay is on a monthly basis.

For every 100 kg of waste, 6-8 m³ is biogas. 8-10 g of manure. 80% is water.

Below 200 kg of waste, they will go for composting. Above 200 kg, they will opt for biogas.

Biogas requires just 1 worker for maintenance.

**Vermicomposting**

This campus has 2 beds
Other campus has 5-6 beds.

The feedstock is leaf & garden & yard waste.

Usually 1 worker maintains. They need 2 workers when transferring material from one bed to another.

30-45 days → in ventilated brick apparatuses.
30-45 days → in stretched out, rectangular vermicomposting piles.

Compost is sieved for extra large pieces and used internally.
Rs 50-60,000 for vermicomposting with the size we saw.

Q: How much did the first biogas plant cost?
A: 11 lakhs (this was 3.5 years ago). Now it’s probably closer to 15-16 lakhs now.

Q: How much for operation maintenance?
A: Rs 10-12,000/month (in-house so they don’t charge much)
Rs 16-18,000 (commerically)

Q: How much does the former rag picker make?
A: Rs 7000/month (employed by SMS & company) & Rs 4-5000/month (estimated value, not guaranteed)
Q: Do you hope to employ more people?

Q: How much did the 1000 kg plant cost?
A: 3 lakhs. Today that would be around 7-8 lakhs.

Q: How much biogas does the 100 kg plant produce?
A: 50-60 kg feed per day → 3 m³ of gas

Q: Do you have any brochures?
A: Soft copy brochure (will email in English)

Q: Which is the most common way your customer finds you? (ie. internet, word-of-mouth)?
A: Networks + word of mouth (80%)

Waste comes to plant. Everything is added to cost.

Annual contract. They have to re-bid.

SMS (non-profits) → they pass it on.
Awareness groups → implementation partner
Existing clients
Facility management companies → they different roles to fill.
Channel partners → biogas plant → they take a commission for finding clients for biogas plant construction.
Commercial building → commission (10%)

15-20% of total cost goes to the company

Product selling → not main focus (convenient source of revenue but not primary)
Focus is servicing the customer
Can’t do it on such a small-scale
Registered as for-profit company.

They want to expand.

Q: What is your ultimate vision?
A:
• Change the way waste management is done
• Environmentally friendly
• Engage informal sector
• Let it be profitable enough to sustain

Mumbai generates 100,000 tons/day of waste. They believe decentralized waste management is the solution.

Pricing model?
• Installation → Construction
  ○ Markup 15-20% from actual cost
• Corporate maintenance
  ○ Manpower → charge based on that
  ○ Rs 11,000/person
  ○ health insurance is provided for
• Management/Administrative Fee
  ○ 15-20% markup
  ○ time-based
• Tend to charge by the hour
  ○ Training
  ○ Consulting Fee

Contact information → Jayanth (jyanth.sespl@gmail.com)

----------

MEETING @ IITB
PARTICIPANTS: Srinivas Seethamraju, Ching-ching Liu, and Ellen Huang

Solid Waste Management
• Energy process
• Biomas → liquid
• Manufacturing process

Process Intensification ← Ph.D. thesis
He wants to condense stuff into one piece of equipment.
Focus → biogas + Center of Solutions in Rural Areas

3 Composting Technology for Organic Waste
• Composting
• Biogas
• Bricketting (RDF)

Possible Contacts for Future Use at the Centre for Environmental Sciences and Engineering
1. Professor Anurag Garg (a.garg@iitb.ac.in)
2. Professor Munish Chandel (munish.chandel@iitb.ac.in)

---------------

MEETING @ Ecofil
PARTICIPANTS: Rama Kumar (marketing director), Anil Verma (operations), Ching-ching Liu

Site Visit will cover
• How they segregate
• Process for compost
• Additional products
• Quality check

History
• They started 18 years back
• Waste and wastewater was their core business
• MSW sector was started in 2012.
• They started plants in MP and Maraysta. Both do 500 MT/day.
• Every contract they get is for 30 years.

Site Tour
• Leachate Treatment Plant
  ○ HCl + Alum + Wastewater → Precipitate
• Weigh Station
  ○ 180 vehicles/day
  ○ 6-7 tons on average per trucks
• They process 500 tons/day with same day processing. It’s mixed waste, but they have a lot of high quality and quantity organics from the APM Market. 185-190 tons of food waste.
  ○ 60-65% is organic waste
  ○ 25% is compostable
  ○ 5-7% recyclable
  ○ 5% inert ← manually sorted out, e.g. backpacks
- They use a 100 mm sieve

- Windrows
  - 30 days, every 7 days they’re turning it
  - Maintain temperature in windrow at 65 degrees C.
  - They use 1 kg of culture → 20 L of water per metric ton of waste
  - Height of 3 feet is preferred
  - 2 heaps/day, 150 MT/heap
  - 40-45 degrees C ← starting temperature

- 3 trommels
  - 50 mm
  - 14 mm
  - 4 mm → compost

- 3 byproduct
  - compost
  - RDF
  - plastic granules (recyclable)

They test each and every batch. Every batch is 100 MT. 1-2 batches per day. Sample 3 times on average.

Dust removal unit → cleans off the plastic. Shred and wash it. The high density polyethylene is shredded and melted down to make pellets/lumps.

Compost is their main money-maker (60-100 tons sold per day)

Clients include
- Krbhco
- RCF
- DPAC
- Tata

Manufacture and store about 3-4000 MT during rainy season. Production drops 50% during rainy season.

Q: How does the contracting process work?
A: Tata checks for operating license. Initial papers are signed. Then there is a co-marketing permission agreed upon therefore Tata will have permission to buy and then resell. The whole process takes about 1 month.

Krbhco → 10,000 MT/year
Tata → 5,000 MT/year
Around average → 20-25,000 MT/year

Contract only delineates minimum

Future
- Pyrolysis → 5 MT/day
- Biogas → form compostable materials
- Pyrolysis → tires + plastics
- Plan to expand to 2 other locations.
Appendix E: COUHES Questionnaire

Informal interview questions for “Organic Municipal Waste Management Technology Optimization Study”

Investigator: Ellen Huang, CEE, ehang7@mit.edu
Faculty Sponsor: David Langseth, CEE, lanseth@mit.edu
COUHES number: 1412006752

Individuals will be asked a series of questions in an informal interview relating to their livelihoods and interactions with compost and/or other fertilizer forms (i.e. chemical, cow dung, poultry dung, etc.). Some of the questions may arise from the visual ethnography conducted for the first part of the proposed study.

There are two versions as there are two main groups of interest: local Muzaffarnagar farmers and compost business entrepreneurs.

Below is the question bank for the informal interviews with local farmers:

1. What is the size of your plot of land?
2. What is the produce grown on the land?
3. Does your family help with the farm work? If so, how many family members do you have and which of them help you? If not, what are their designated roles in the household?
4. What does a standard growing season look like?
   a. When do you plant?
   b. How long does it take for the plants to grow?
   c. When do you harvest?
5. Do you add any amendments to the soil to help you grow your product?
6. What kind of amendment(s) do you buy?
   a. Any particular brand?
   b. Do you know what the specifications?
      i. See if you can find old packaging
      ii. e.g. 10:10:10 ← nitrogen:phosphorus:???
   c. How do you obtain your amendments?
      i. Do you have a supplier connection?
      ii. Did you purchase from a store-front?
      iii. Are the amendments delivered?
      iv. How do you pay? (i.e. in cash, credit, check, etc)
        1. Do you pay in full?
        2. Do you pay in installments?
v. Do you make multiple purchases throughout the growing season?
d. How much do you pay for chemical fertilizer (if applicable)?
e. How much do you purchase at any one time?
f. Has this amendment improved your yields?

7. What factors influence your purchasing decision-making? Why did you buy the amendments?

8. Do you know what compost is? (show either a picture or physical example → zip lock baggie of the product and/or empty package bag)

9. If so, have you used compost, presently or in the past?
   a. How much do/did you pay for (by weight)?
   b. How much did you get total (by weight)?
   c. Do you remember the total cost (in rupees)?

10. If not, do you have any other farmers who use compost?
    a. Could you introduce us?
    b. Do you know about their level of success using compost?

11. What do you think is a reasonable price for compost? (in rupees/kg)

12. What would convince you to purchase compost vs. chemical fertilizer?

13. Have you noticed any water quality issues in surrounding areas?

14. Have you noticed any degradation in quality of life since using chemicals?

15. Is it possible to take a walk around of the land plot and take some pictures?

Below is the question bank for the informal interviews with composting firms:

1. What processes do you use for composting?

2. How much do you charge per kilogram of compost?

3. What challenges has your firms faced?
   a. How have you overcome them?
   b. What are you currently still trying to overcome?
   c. More specific questions:
      i. Quality control and consistency
         1. What kind of feedstock?
         2. Do you have any issues with the inputs?
      ii. Process development
         1. Have you made any changes to your production to improve quality? (e.g. change windrow turnover rate to improve aeration)
         2. Did you have to change your composting process?
      iii. Marketing/Distribution
         1. How do you market your product?
         2. Have you had any problems changing perceptions of compost?
      iv. Growing pains (tied to efficiency levels)
4. What major breakthrough successes did you have?
   a. Overcoming growing pains?
   b. Convincing the customer?
5. Who is your main customer?
   a. Who else are your customers?
   b. Which segments are you trying to break into?
6. Are you looking to expand into other sectors?
7. Looking back, is there anything you wish you could have done?
Appendix F: Phone Application Screenshots

Figure 3: First Screen to Select Cash Crop of Interest

Figure 4: Second Screen with Various Chemical Deficiencies Listed
Older leaves first show symptoms of P deficiency. Leaf reddening usually occurs with P deficiency when the plant is young and when growing temperatures are <10°C (50°F). Phosphorus deficiency causes short and slender stalks. Older leaves prematurely die back (note leaf sheaths).

Recommendations: Bone meal and/or compost
Figure 6: Calcium Deficient Sugar Cane Tend to have Necrotic Tips
Figure 7: Sulfur Deficient Sugar Cane Leaves Display Streaking and Purple Leaf Margin

Young leaves affected by SO2 toxicity. Symptoms are mottled chlorotic streaks running the full length of the leaf blade. Sulfur-deficient leaf (right), with symptoms of chlorosis and purple leaf margins contrasted with a healthy leaf (left) treated with ammonium sulfate. Leaves are narrower and shorter than normal; stalks are slender.

Recommendations: Compost