May 2016

Evaluating Waste Management Systems: Kataula and IIT-Mandi

Antonios Aimilios Tachiaos
Worcester Polytechnic Institute

Cameron Kevin DiSpirito
Worcester Polytechnic Institute

Michael Stewart McConnell
Worcester Polytechnic Institute

Follow this and additional works at: https://digitalcommons.wpi.edu/iqp-all

Repository Citation

This Unrestricted is brought to you for free and open access by the Interactive Qualifying Projects at Digital WPI. It has been accepted for inclusion in Interactive Qualifying Projects (All Years) by an authorized administrator of Digital WPI. For more information, please contact digitalwpi@wpi.edu.
Evaluating Waste Management Systems: Kataula and IIT-Mandi

An Interactive Qualifying Project submitted to the Faculty of WORCESTER POLYTECHNIC INSTITUTE in partial fulfilment of the requirements for the degree of Bachelor of Science

by
Cameron DiSpirito
Yashu Madaan
Michael McConnell
Aimilios Tachiaos
Amar Yadav

Date:
2nd May 2016

Report Submitted to:
Dr. Paul Bhavender and Dr. Atul Dhar
Indian Institute of Technology Mandi
and
Dr. Stephen McCauley and Dr. Ingrid Shockey
Worcester Polytechnic Institute

This report represents work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review. For more information about the projects program at WPI, see http://www.wpi.edu/Academics/Projects.
Abstract

Mandi District in Himachal Pradesh India is experiencing increased waste generation due to economic growth and the expansion of the Indian Institute of Technology-Mandi campus. This project’s goal was to develop recommendations to improve solid waste management at the IIT-Mandi campus and village of Kataula. Data on local practices, waste composition, and resident preferences were collected using waste audits and interviews. Findings indicated a need for better separation techniques on campus and a waste collection system in Kataula. Improvement guides were developed and delivered to address these concerns.
### Authorship

<table>
<thead>
<tr>
<th>Section</th>
<th>Author</th>
<th>Editors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Mike</td>
<td>Mike</td>
</tr>
<tr>
<td>CH 1</td>
<td>Aimilios, Cam, Mike</td>
<td>Aimilios, Cam, Mike</td>
</tr>
<tr>
<td>CH 2</td>
<td>Aimilios, Cam, Mike</td>
<td>Aimilios, Cam, Mike</td>
</tr>
<tr>
<td>CH 3</td>
<td>Aimilios, Cam, Mike</td>
<td>Aimilios, Cam, Mike</td>
</tr>
<tr>
<td>CH 4</td>
<td>Aimilios, Cam, Mike</td>
<td>Aimilios, Cam, Mike</td>
</tr>
<tr>
<td>CH 5</td>
<td>Mike</td>
<td>Aimilios, Cam</td>
</tr>
<tr>
<td>CH 6</td>
<td>Cam</td>
<td>Mike</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>Mike</td>
<td>Cam, Aimilios</td>
</tr>
<tr>
<td>Packet for Kataula School</td>
<td>Cam</td>
<td>Mike, Aimilios</td>
</tr>
<tr>
<td>Packet for Kataula Village</td>
<td>Aimilios, Cam, Mike</td>
<td>Cam, Mike</td>
</tr>
<tr>
<td>Packet for IIT Campus</td>
<td>Mike</td>
<td>Cam, Aimilios</td>
</tr>
<tr>
<td>Prototype design and implementation</td>
<td>Mike, Cam, Aimilios, Amar, Yashu</td>
<td>NA</td>
</tr>
<tr>
<td>Poster and Presentation design</td>
<td>Mike, Cam, Aimilios, Amar, Yashu</td>
<td>NA</td>
</tr>
</tbody>
</table>
Acknowledgements

There are a number of people without whom this project would not have been possible. The team would first like to thank our advisers Professors Shockey, McCauley, Bhavender, and Dhar. They provided much needed guidance and support throughout the project. Additionally, we would like to express our great gratitude to Coronel Naik the campus superintendent. He provided the team with insight into how the campus has operated and evolved its waste management system. He also provided us with needed experimental permissions and materials. Without the Coronel’s support this project could not have been a success. Finally, we would like to thank all the faculty of the Kataula primary school who were willing to meet with us on numerous occasions and provide essential insight into local operations. We sincerely hope that our recommendations can help improve their community in a meaningful way.
Table of Contents

Abstract........................................................................................................................................................................................................... i
Authorship............................................................................................................................................................................................................. ii
Acknowledgements ....................................................................................................................................................................................... iii
Table of Contents................................................................................................................................................................................................... iv
Chapter 1: The Growing Challenge of Waste Disposal ........................................................................................................................................................................... 1
Chapter 2: Local Context and Logistics ................................................................................................................................................................. 2
  2.1: Current waste initiatives in the state ............................................................................................................................................................... 2
  2.2 Stakeholders ............................................................................................................................................................................................... 2
  2.3: Logistics and infrastructure for waste management ................................................................................................................................................................. 3
  2.4: Considerations ............................................................................................................................................................................................... 4
Chapter 3: Methodology: Gauging Waste Metrics and System Effectiveness ............................................................................................................................... 5
  3.1: Document municipal solid waste metrics ............................................................................................................................................................... 5
  3.2: Evaluation of waste collection programs and infrastructure ............................................................................................................................................................................ 6
  3.3: Gauging perceptions and preferences ............................................................................................................................................................... 6
  3.4: Development of recommendations ............................................................................................................................................................... 6
Chapter 4: Results and Discussion ............................................................................................................................................................................................... 7
  4.1: Documentation of municipal solid waste metrics ............................................................................................................................................................... 7
  4.2: Waste collection programs and infrastructure ............................................................................................................................................................... 8
  4.3: Gauging perceptions and preferences ............................................................................................................................................................... 11
  4.5: Discussion ........................................................................................................................................................................................................ 12
Chapter 5: Project Outcomes ............................................................................................................................................................................................... 14
  5.1: Recommendations for the IIT-Mandi campus ............................................................................................................................................................... 14
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2: Recommendations for Kataula</td>
<td>15</td>
</tr>
<tr>
<td>Chapter 6: Conclusions</td>
<td>15</td>
</tr>
<tr>
<td>Works Cited</td>
<td>16</td>
</tr>
<tr>
<td>References</td>
<td>18</td>
</tr>
<tr>
<td>Appendix A: Campus Map</td>
<td>20</td>
</tr>
<tr>
<td>Appendix B: Interview Guides</td>
<td>21</td>
</tr>
<tr>
<td>Basic interview</td>
<td>21</td>
</tr>
<tr>
<td>Student interview</td>
<td>21</td>
</tr>
<tr>
<td>Waste management employee interview</td>
<td>21</td>
</tr>
<tr>
<td>Appendix C: Supporting Pictures</td>
<td>22</td>
</tr>
<tr>
<td>IIT-Mandi Campus</td>
<td>22</td>
</tr>
<tr>
<td>Katindhi</td>
<td>24</td>
</tr>
<tr>
<td>Kataula</td>
<td>26</td>
</tr>
<tr>
<td>Navley</td>
<td>29</td>
</tr>
<tr>
<td>Appendix D: Final Presentation Poster</td>
<td>31</td>
</tr>
<tr>
<td>Appendix E: Deliverables</td>
<td>32</td>
</tr>
</tbody>
</table>
Chapter 1: The Growing Challenge of Waste Disposal

Mandi District in the Indian state of Himachal Pradesh sits at the crossroads of three national highways. It has become a popular trade and tourist center in the state (Directorate of Census Operations in Himachal Pradesh, 2011). Consequently the city has been growing rapidly. Mandi District is also the new home of the Indian Institute of Technology (IIT-Mandi) campus. With the area serving as a hub for tourism, commerce, and education, a need has emerged for improved waste management practices in the Mandi district. Improper waste management can be hazardous to the environment, human health and the visual aesthetics in a region. Over the last few years, the state government has begun a push for more sustainable waste management practices, yet success has been sporadic. A study conducted by Ascenso Enviro Private Limited in 2008 identified an inadequate regional waste management system characterized by unregulated dumping of trash from communal waste bins and a disorganized system of private disposal firms (Ascenso Enviro, 2008). A more recent IIT-Mandi study in 2014 found many of these issues were still unresolved (Panwar et al., 2014). Furthermore, the waste management systems in the campus and nearby villages need to be improved to prepare for the population influx that the growing IIT campus (see Figure 1) will bring. This will increase strain on the current waste system in which the majority of campus waste ends up at the Mandi municipal dump shown in Figure 2. Therefore, the goal of this project was to develop improvements for the waste management systems in the IIT-Mandi campus and the villages of Katindhi, Kataula, and Navlay. To meet our goal, at each location, we:

1. Documented local solid waste metrics.
2. Identified and assessed waste collection programs and infrastructure.
3. Gauged perceptions and preferences with regards to waste management.
4. Developed a set of recommendations for improved waste management systems in the IIT-Mandi campus and the village of Kataula.
Chapter 2: Local Context and Logistics

2.1: Current waste initiatives in the state

In response to the increase in waste generation, along with prompting from the national government, the authorities of Himachal Pradesh have begun to implement a number of initiatives which address the waste management issues in the state. The first national waste management policy was developed at the start of the century and is referred to as the Municipal Solid Wastes (Management and Handling) Rules, 2000. These regulations outlined the operational expectations for solid waste management from generation to disposal. Unfortunately, according to the State Pollution Control Board, municipal governments did not utilize or construct new infrastructure, as required this lead to the rules being largely ineffective (Directorate of Urban Development, 2015).

In an effort to mitigate some of this unhandled waste, the state of Himachal Pradesh banned the use of traditional plastic bags in 2009 (Deccan Herald, 2009). This focus on plastic waste reduction is important given that the growth rate of plastic consumption in India in 2006 was a high 16% per annum (Muthaa et al., 2006). The state government continued to tackle this issue by banning all non-biodegradable plastic cups and plates in 2011 (Daily News & Analysis, 2011). If these trends continue, waste composition in the region will begin to lean heavily into the biodegradable sphere. However, at the current moment significant amounts of biodegradable and non-biodegradable waste continue to accumulate in the region.

2.2 Stakeholders

The following Table 1 lists some of the major stakeholders in the region.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>Prevalence of waste poses health risks to locals.</td>
</tr>
<tr>
<td>Shopkeepers</td>
<td>Waste buildup can deter shoppers and tourists</td>
</tr>
<tr>
<td>Medical facilities</td>
<td>Hazardous medical waste must be handled safely</td>
</tr>
<tr>
<td>Municipality</td>
<td>Local government involvement improves sustainability</td>
</tr>
<tr>
<td>State regulators</td>
<td>State Pollution Control Board oversees waste management policy</td>
</tr>
<tr>
<td>Waste corporations</td>
<td>Financially invested in any waste management system</td>
</tr>
<tr>
<td>Sweepers</td>
<td>Future system should not negatively impact their livelihood</td>
</tr>
</tbody>
</table>
2.3: Logistics and infrastructure for waste management

The lifecycle of waste can be broken down into four major stages: waste generation, collection, separation, and disposal. In the following sections a number of systems for performing each of these tasks is discussed.

2.3.1: Generation

In the Mandi district’s rural regions the main source of waste is agricultural, while in the urban areas the majority of waste is produced by residents and transient populations (Ascenso Envio Private Limited, 2008).

There have been no statewide waste audits conducted for Himachal Pradesh. However, it is known that, despite the statewide ban on plastic bags, there is still a substantial quantity of plastic packaging waste present (Directorate of Urban Development, 2015, Panwar et al., 2014). The unregulated mixing of plastic waste with organic waste makes the waste unfit for recycling. A waste audit would, therefore, allow waste management officials to make decisions targeted to the region’s waste composition.

2.3.2: Collection

When a formalized waste system is present, the collection of waste is the first necessary step. There are two forms of waste collection: primary collection and secondary collection. Primary collection, which is common in Mandi town, involves an individual paying an organization for the removal of waste from their property (Panwar et al. 2014). Secondary collection is a large scale government organized waste collection system. Unfortunately, such a system is expensive, and might not be feasible in the local villages of Mandi district (Wilson, 2012). A third option, utilized for example in Nakuru, Kenya, involves the combination of the two collection strategies mentioned above. This town suffered from waste disposal issues similar to those faced in the Mandi district, but managed to increase their waste collection from 20% to 64% over 16 years by changing the governmental role from operation to oversight of private waste management firms (Mwanzia, 2013). Such a system might be worth investigating for use in the Mandi district.

Waste pickup in Mandi and the surrounding villages is very sporadic and does not operate on a set schedule.

Approximately 38% of Mandi residents receive collection services at their place of residence, the rest dispose of their own waste (Nexus, 2015). In the villages waste collection is often non-existent or informal. Therefore, as Wilson (2012) argues, to ensure success any formal waste collection system should work to incorporate the informal sector by organizing local rag pickers under government oversight or hiring them directly.

The collection of waste from public spaces such as campus grounds or a city park provides some unique challenges. Such collection is usually coordinated using public waste bins. The placement of these waste bins is a major consideration when designing the collection strategy. Trash bins and recycling bins are likely to be most effective when installed in areas that generate high volumes of waste. Ensuring waste bins are easily accessible and in high enough numbers also improves waste collection effectiveness (O’Connor, 2010).

The usage of public recycling bins, or a similar system, to facilitate source separation of waste can save waste management facilities the equivalent of millions of dollars (Rinkesh, 2009).
When considering source based separation, bin location is an important consideration. Bins should be located within 12m (40ft) of any waste source to ensure proper usage (Environmental Protection Agency of Australia, 2005). With sufficient infrastructure, a source separation based system is preferable, if the local population accepts and implements the process.

2.3.3: Waste disposal strategies and challenges

Once waste has been sorted it must be disposed of in a safe and environmentally friendly manner. Where waste management procedures are not in place, the most common practice is to dump the waste in a local non-engineered landfill or river. Burning waste heaps when they become too large is also a common practice (Hodzic et al., 2012). Both strategies will cause the environment to become contaminated and full of dangerous substances called leachates (Melnyk et al., 2014).

A better alternative waste disposal strategy, for non-biodegradable waste, would be the use of engineered landfills. These prevent leachates from entering the soil and contaminating the environment. For biodegradable waste, another method is composting, which converts the waste into nutrient rich soil. Both of these methods can be used to generate biogas for energy generation (Ali et al., 2014, Ndegwa et al., 2001).

Furthermore, a method commonly used is incineration, where waste is burned at high temperatures in order to generate energy. However, the health implications of incineration are still debated (Candela et al., 2015, Protano et al., 2015).

2.4: Considerations

As evidenced by the numerous topics discussed above, development of waste management systems requires an understanding of numerous topics from logistics to human behavior. The recommendations we developed for the Mandi region needed to take all of these into consideration. By conducting sufficient research into the needs of all key stake holder groups it was possible to develop recommendations that used the most appropriate processes to improve waste management in the region.
Chapter 3: Methodology: Gauging Waste Metrics and System Effectiveness

The goal of this project was to develop models for waste management on the IIT-Mandi campus and the nearby villages of Katindhi, Kataula, and Navlay. A map of these locations can be seen in Figure 3, on the right.

To meet our goal, at each location, we:

1. Documented local solid waste metrics.
2. Identified and assessed waste collection programs and infrastructure.
3. Gauged perceptions and preferences with regards to waste management.
4. Developed a set of recommendations for improved waste management systems in the IIT-Mandi campus and the village of Kataula.

3.1: Document municipal solid waste metrics

To gain an understanding of the waste that is generated at each location, we conducted a detailed site assessment and interviews. We also conducted waste audits on the IIT-Mandi campus and in the village of Kataula. This data was used to gauge the scope of the problem with regards to composition and quantity of waste, as well as the effectiveness of the current systems. The methods used are outlined in Table 2. The interview guide for this step can be found in Appendix B.

Table 2: The three methods used to collect waste metrics

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Purpose</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site assessments</td>
<td>Gauge scope of problem</td>
<td>Map dumpsters and landfills assisted by local knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify areas of need</td>
</tr>
<tr>
<td>Interviews</td>
<td>Understand waste sources</td>
<td>Semi-structured</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sample of convenience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 local participants</td>
</tr>
<tr>
<td>Waste audits</td>
<td>Obtain quantitative data on waste composition</td>
<td>Approximate waste composition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approximate waste quantity</td>
</tr>
</tbody>
</table>
3.2: Evaluation of waste collection programs and infrastructure

In order to evaluate existing waste management systems, we identified the staff and organizations responsible for collection and transportation of waste. Semi-structured interviews were conducted with collectors and managing organizations directly associated with the transportation of waste. See Appendix B for the interview guides used throughout the project.

3.3: Gauging perceptions and preferences

The waste disposal practices of both villagers and IIT stakeholders and their preferences with regards to potential changes were evaluated in order to determine feasible alternatives. During the site assessments mentioned above, we observed and documented the waste disposal habits of locals. A series of semi-structured interviews were administered in an effort to reveal the current practices and attitudes, of both locals and professionals, with regards to waste management. A photo of one such interview is shown in Figure 5. This understanding was needed before the waste management strategies could be evaluated. Furthermore, it allowed us to determine the subjects’ attitudes towards their own waste disposal habits. This information allowed for the identification of the driving factors behind these practices such as local norms, preference, or lack of options and resources. Finally, the purpose of conducting semi-structured interviews was to obtain information from individuals who might be reluctant to criticize the waste management practices of their community. See Appendix B for the interview guide.

3.4: Development of recommendations

To develop a set of actionable recommendations to improve the waste management systems at each location, the collected data was analyzed and synthesized. The team modeled the flow of waste during standard disposal at the campus and a village. This model was used to help conduct a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. This was used to develop effective recommendations utilizing each systems’ strengths to address its weaknesses. A diagram of this overall process can be seen in Figure 4, on right.
Chapter 4: Results and Discussion

This chapter outlines and discusses our on-site research findings by objective. Our research focused on three villages, Kataula, Katindhi, and Navlay, and the IIT campus.

4.1: Documentation of municipal solid waste metrics

This section covers our observations and site assessments of the area, as well as metrics, collected from the IIT campus and three surrounding villages.

The team conducted a site assessment of the IIT-Mandi campus. Waste quantity, litter prevalence, dumpster and waste bin locations and trash sorting effectiveness were all investigated. First, we found that the majority of the campus had small amounts of litter. Our team found 10 multi-colored trash bins and 9 dumpsters. The multi-colored bins are meant to separate waste, however, they often contain unseparated waste. The locations of bins and dumpsters were mapped as shown in Appendix A: Figure 22.

During interviews with the manager and employees of the two campus mess halls, we determined that 300 kg of food is wasted between both mess halls. A bar graph of the mess hall waste can be seen in Figure 6.

Through an audit of the waste bins located in the B6 Student Hostel, we identified recyclables as the primary form of waste generation in student housing. A bar graph of our data can be seen in Figure 7.

Our team visited the local village of Kataula to evaluate the waste disposal practices of its residents. Solid waste pollution was more apparent in Kataula than on the IIT Campus. Moderate trash was found in gutters lining the road. The majority of inorganic waste appeared to be food packaging and empty drink containers. Large amounts of solid waste was dumped off a cliff along the river. Our team observed some burnt trash piles as well. Finally, we were unable to find public waste bins in Kataula. To understand the local waste composition, household waste was sampled over a two day period, the results are shown in Figure 8.

![Figure 6: Waste generated from each mess hall on daily basis](image6.png)

![Figure 7: Results of B6 Hostel waste audit](image7.png)

![Figure 8: Waste generated per person per day in Kataula](image8.png)
After conducting a rapid site assessment, it became clear that Katindhi was much less polluted than Kataula. We observed some trash on the side of the road, however, trash did not line the entire street. Katindhi also lacked public waste bins. Unique to Katindhi, we found numerous piles of burnt trash; significantly more than what was observed in Kataula.

While conducting a site assessment in Navlay the team noticed a lack of solid waste pollution. We were able to locate a few small waste burning piles, but could not find a local dumping site. In addition, there were composting piles in almost every field but public waste bins were nonexistent.

4.2: Waste collection programs and infrastructure

This section describes the team’s analysis of the current waste management systems and infrastructure on campus and in the surrounding villages. It is important to note that none of the villages have any sort of official collection or management system. In contrast the campus has a formalized system that is capable of handling the current population, but needs to be expanded to accommodate the incoming increased student count.

4.2.1: IIT campus

The IIT campus has a coordinated system of waste disposal which utilizes waste bins and dumpsters around campus to collect waste from campus residents and visitors. This waste is ultimately taken to Mandi’s municipal landfill. Through our interviews with Colonel Naik, the campus superintendent, waste employees, and students, as well as our own observations, we developed a model that shows the waste flow on campus. This is described by the flow chart seen in Figure 9, on right.

As can be seen in the flow chart, there is generally one condition that determines the flow of waste post disposal: the user’s location. The location of the user on campus determines which type of waste bin is available. There are three main categories of waste bins on campus: indoor bins, multi-colored outdoor bins, and mess hall bins for food waste. An example of each of these can be seen in Figure 10.

Figure 9: Flow chart of the waste flow on campus from the individual.

Figure 10: Multi-colored waste separation bins (left) unseparated indoor waste bin (middle), mess hall food waste bin (right)
The multi-colored bins found on the campus grounds are meant to facilitate source separation of the waste. While color-coded, many of the bin labels have fallen off; this makes it difficult for users to separate waste. Furthermore, a contractor empties all bins into the communal dumpsters on a daily basis seen in Figure 11. This removes the environmental benefit from source separation.

Unlike the multi-colored bins, indoor waste bins are utilized to collect all forms of trash in the same bin. These bins are located in the hostels and academic buildings on campus. They are deposited each day in one of the communal dumpsters by the same contractor mentioned above. These dumpsters are ultimately picked up by a second contractor who takes them to the Mandi municipal landfill.

The mess hall bins have a different destination from the previous two bin types. At every mess hall meal, food waste is deposited into these bins. Once a day, this waste is deposited into a vermicomposting pit. This composting pit can be seen in Figure 12, on right. The compost created here will ultimately be used as fertilizer in the IIT-Mandi medical garden.

Figure 11: Contractor depositing an indoor waste bin into a communal dumpster

Figure 12: The vermicomposting pit for food waste on campus. It was constructed in December 2015.
4.2.2 Villages

The waste management practices used in each village in the region are unique to that village; however, there are common themes that the team has identified. This has allowed us to create a flowchart of the common movement of waste within an average village in the area. This flowchart can be seen in Figure 13, on right.

From interviews and observations, our team determined three common waste disposal habits: burning, unregulated dumping or tossing, and composting. The prevalence of each of these methods can be seen in Figure 14, on right. Kataula seemed to be the most polluted village, and 54% of locals reported dumping as their primary method of waste disposal. Katindhi was significantly less polluted than Kataula. In Katindhi, 63% of locals reported burning waste as their primary method of disposal. Many of the shop owners informed us that locals sell glass and certain plastics to recycling vendors once a month. Navlay, showed the least amount of solid waste pollution; according to locals, the majority of waste is either burned or composted.

Figure 13: Flowchart of the waste movement within an average village of the Mandi district

Figure 14: Pie charts of villager waste disposal practices
4.3: Gauging perceptions and preferences

4.3.1: IIT Campus

The team spent several days evaluating the waste disposal habits of IIT students. We determined that most students understand the purpose of having multicolored waste bins. However, as shown in Figure 15, only 27.8% of students consistently separate their waste. The students were asked why they neglected to follow the separation system. The most common answer was that inadequate labeling made it difficult to determine the appropriate bin to use. This coincides with the fact that 78% of students do not know which type of waste goes in which colored bin.

The team also evaluated the perceptions of IIT students with regards to the current waste management system on campus. Seventy eight percent of students recognized that the current system needs to be improved (see Figure 15), however, the responses varied with regards to the root of the problem. Some students blamed their colleagues for not separating waste upon disposal, while others blamed the institution for not implementing an effective system.

4.3.2: Villages

To identify the amount of local support for waste management change, villagers were asked about their desire for improvements. The majority of villagers interviewed displayed a disinterest or opposition to any change being made to the current informal system. As shown in Figure 16, Kataula was the only village where locals consistently seemed receptive to implementing a better waste management system.

Figure 15: Pie charts of student interview responses

Figure 16: Pie charts of villager support for changes to status quo
4.5: Discussion

4.5.1: IIT Campus Discussion

The team’s findings for the IIT-Mandi campus were used to conduct a SWOT analysis, shown in Figure 17. This analysis is focused on the capacity of the campuses existing system to handle waste. As shown in this analysis, the campus does a decent job of handling day-to-day waste. The vermicomposting of food waste is a particular strength. However, the success of waste separation on campus has been minimal at best. The campus residents do not separate their waste in the appropriate bins, and even when they do, that waste is mixed in the communal dumpsters before being taken to Mandi. Fortunately, students and faculty are receptive to change, so any incentives to improve the system should be able to garner the necessary support.

![SWOT Analysis Diagram]

*Figure 17: Diagram of SWOT analysis for the waste management system on the IIT-Mandi campus.*
4.5.2: Villages Discussion

The team’s findings in the local villages were used to conduct a SWOT analysis of the common systems as seen in Figure 18. This analysis focuses on the villages’ ability to handle waste in an environmentally sustainable manner. As shown in the analysis, the villages primarily struggle with the handling of plastics and packaging. Most organic waste, which makes up the majority of waste in villages, is composted regularly. Unfortunately, the other forms of waste are either burned or dumped in unregulated sites. Although this removes them from sight in most situations, it fails to address environmental and health concerns. The villagers are often either not aware or not concerned with these effects. This means apathy or a lack of awareness is a threat to any future waste system. Fortunately, Kataula in particular seemed receptive to change and would be a good starting location to test an improved system.

Figure 18: Diagram of the SWOT analysis for the waste systems found in the local villages
Chapter 5: Project Outcomes

This section describes the actions taken by the team to attempt improvement of the waste management systems of the IIT-Mandi campus and the village of Kataula.

5.1: Recommendations for the IIT-Mandi campus

The team analyzed the IIT-Mandi waste management system using a SWOT analysis and identified waste separation as a major area of weakness. The influx of students from the opening of the North campus in August 2016 also posed a major threat to the current system. To address these, and other concerns, we developed a suggestion packet called the “IIT-Mandi Solid Waste Management Improvement Guide 2016”. This guide outlines a timeline for improving waste management on campus. The full packet can be found in Appendix E.

Part of this plan required that the campus update their existing separation bins with new engineered lids and permanent labels. These lids would limit the types of waste that can be easily discarded in a bin. According to Duffy (2009) such a system can increase plastic bottle recycling by over 30%. The team created prototypes of these improvements. These can be seen in Figure 19. These prototypes were tested over a three day period. Each day the contents of each bin was evaluated for accuracy. As shown in Figure 20, there was an average of 11% improvement in separation. Unfortunately, the food waste bin saw a 9% drop in correct contents. However, this could be due to the limited sample size available from that bin which was nearly empty on all three days. Still, the overall success of the prototypes suggests the campus should pursue such improvements further.

Additional suggestions in the plan included the marking of communal dumpsters for recycling, creation of informative posters, and expansion of the current campus Earth day event. Prototypes of informative poster designs were included in the plan and can be found in Figure 21, on right.

The team met with the campus superintendent to discuss our recommendations. He was very supportive of suggestions and planned to move forward with many of them.
5.2: Recommendations for Kataula

After conducting a thorough analysis of Kataula’s current waste management practices, our team identified two major problems: a lack of public awareness with regards to solid waste pollution and inadequate waste management infrastructure. In an effort to combat these problems, our team developed both an educational guide and an infrastructure improvement packet. Both of these can be seen in Appendix E.

To improve local awareness, the team decided to utilize the influence of the primary school. We created an education packet which contained suggestions for environmental curriculums, waste management project ideas, proper practices the school can follow, and suggestions for the implementation of an earth day similar to the IIT’s. The guide was presented to the school principal who expressed approval of the ideas. With these ideas implemented, an environmental consciousness will begin to spread into the community through their children.

To capitalize on increasing environmental awareness, Kataula will need to create a more formalized waste management system. To assist in this effort we created a packet of suggestions. One major suggestion is the collection of recyclables by a third party. The local hospital which plans to soon triple its patient capacity has employed a recycling contractor to collect their recyclable waste on a regular basis. This contractor will begin collection in two months. The town can utilize this system by having shop owners save their recyclables until the contractor’s regular visits.

We interviewed 7 local shop owners about this idea and found 71% willing to save recyclables. Of these 20% said they would do it only with payment from the contractor similar to the system used in Katindhi. Many of the shop owners would also prefer dust bins be provided to them or communal dumpsters be used for storing recyclables. These hurdles are fortunately not insurmountable and the high percentage of participation means such a system could be implemented effectively.

Chapter 6: Conclusions

After analyzing waste management at the IIT campus and three villages, our team was able to collect various forms of data. We collected waste metrics, assessed waste management infrastructure, gauged common waste disposal practices, and determined local perceptions regarding change. Through our research, we determined that the IIT and the three villages need to improve both solid waste management infrastructure and environmental awareness. Finally, we presented both the IIT campus and the village of Kataula with a set of actionable recommendations to improve the current waste management systems.
Works Cited


References


Bodh, A. (2013). Beas river turning into dumping site for hotels and others. The Times of India


Mandi District: Census 2011 data.


The Tribune of India. (2016). Shimla, Solan under Hepatitis-E threat, all water samples fail test.


Waste Management Inc. (2010). Case Study: Manhattan Beach USD.
Appendix A: Campus Map

Figure 22: Map of bin and dumpster locations on campus.
Appendix B: Interview Guides

Basic interview
1. Do you hold a waste management related position?
2. What kind of waste do you generate?
3. How often do you dispose of household waste?
4. How do you dispose of household waste?
5. Why do you dispose of it in this manner?
6. How do you dispose of non-household trash? For example, if you buy a candy bar, how do you dispose of its wrapper?
7. Why do you dispose of non-household waste in this manner?
8. What is your profession and how do you dispose of trash while working?
9. Why do you dispose of work related trash in this manner?
10. What are your current views on the waste disposal practices in (insert region)?
11. Are there any changes you would recommend for the current waste management system in (insert region)?

Student interview
1. Do they know what the waste bins are for?
2. Why the waste are bins different colors?
3. Do you separate your waste into these bins? (Special attention given to why or why not)
4. Do you know how littering effects the environment?
5. What are your views on campus waste management?

Waste management employee interview
1. What is your role when it comes to the location and transportation of waste?
2. During your years of experience in the branch, would you say that the location and transportation methods used are developing, evolving or even change?
3. What are the most common problems you are facing in the workplace?
4. What are some changes you think would improve the current procedures?
5. What are your opinions about the current waste collection and transportation?
Appendix C: Supporting Pictures

IIT-Mandi Campus

Figure 23: Installing engineered lids on IIT-Mandi campus outside the D1 mess hall

Figure 24: Contractor emptying communal dumpster on IIT-Mandi campus
Figure 25: Biodegradable waste bin near the campus canteen. Waste has not been properly sorted.

Figure 26: Team recording dumpster dimensions.
Figure 27: Shop owner interview

Figure 28: Burnt pile of waste on side of road
Figure 29: Katindhi’s main street with very little litter
Figure 30: Waste pollution along river bank

Figure 31: Unregulated waste dump above river
**Figure 13: Interview with Kataula villagers**

**Figure 32: Interview with Kataula hospital director**
Figure 34: Interview local shop owner
Navlay

Figure 35: Clean bridge and path

Figure 36: Village of Navlay
Figure 37: Compost pile in local field
Appendix D: Final Presentation Poster

Evaluating Waste Management Systems: Kataula and IIT-Mandi Campus

- BACKGROUND -

Abstract

Mandi District in Himachal Pradesh, India is experiencing increased waste generation due to economic growth and the expansion of the Indian Institute of Technology-Mandi campus. This project's goal was to develop recommendations to improve solid waste management at the IIT Mandi campus and village of Kataula. Data on local practices, waste composition, and student preferences were collected using waste audits and interviews. Findings indicated a need for better separation techniques on campus and a waste collection system in Kataula.

Goal

Develop recommendations to improve solid waste management at the IIT-Mandi campus and the village of Kataula.

The Necessity for Change

IT campus map

IT waste management program initiatives

Increasing population

Increased waste generation

IT Campus waste is not properly recycled

Human health hazards and environmental damage

Methodology

IIT-Mandi

Site assessment

Student interviews

Waste audit of public bins

Kataula

Site assessment

Resident/store owner interviews

Waste audit of household bins

- RESULTS -

Kataula

Primary waste disposal habits in Kataula (%)

- OUTCOMES -

IIT-Mandi

Campus Improvement Guide

Long Term Plan

2 Months

4 Months - 2 Years

5 Years

Educational Poster Design

Student competition for educational posters

Updating Waste Separation Bins

Hospital Utensils

Permanent Preventative Labels

Future Projections (IIT-Mandi)

- ENTRANCE TO HOSPITAL
- 10,000
- 10,000
- 10,000
- 10,000
- 10,000
- 10,000
- 10,000
- 10,000

Kataula

Environmental Educational Guide

Kataula Recycling Plan

Implement after hospital expansion in 2 months

- Environmental curriculum
- Earth day
- Waste matrix recording

Hospital contracts with local bulk collection companies

Shop keepers used in awareness for company hospital van

Company passes are distributed to 2000 people
Appendix E: Deliverables

The following pages contain our team’s waste management guides developed for the IIT-Mandi campus, the village of Kataula, and the Kataula primary school.
Introduction

This guide presents a set of recommendations for how to improve the IIT-Mandi campus waste management system. The recommendations were developed based on data collected over a seven week academic term, and are presented in the form of a timeline. This timeline is presented chronologically. Recommendations located earlier in the timeline can be implemented quickly and inexpensively. Longer term recommendations are targeted to help the campus prepare for the incoming influx of new students, and often have an increased cost as well. If the campus is able to implement these recommendations, its waste management system will be more environmentally friendly, and serve as a model for the surrounding communities.
Section 1: Waste Management Overview and Timeline

Waste metrics should be routinely recorded on campus. This will allow future improvements to the campus waste management system to be tailored to the current campus waste composition. The data will also inform as to the effectiveness of any such improvements. All waste contractors and relevant employees should be provided with an accurate scale which can be used to collect waste weight metrics every day upon collection. This data should be recorded and provided to the head of campus waste management on at least a weekly basis.

Section 2: Two Month Timeframe

Recording of waste metrics

Waste metrics should be routinely recorded on campus. This will allow future improvements to the campus waste management system to be tailored to the current campus waste composition. The data will also inform as to the effectiveness of any such improvements. All waste contractors and relevant employees should be provided with an accurate scale which can be used to collect waste weight metrics every day upon collection. This data should be recorded and provided to the head of campus waste management on at least a weekly basis.

Updating separation bins

In public spaces on campus, source separation is encouraged through the use of multi-colored bins. However, these bins have been largely ineffective. This is primarily due to poor labeling and awareness among students. The bins should be updated to address these concerns according to the methods shown in Figure 2. The high quality images of our prototype designs can be found in Appendices A and B.

Figure 1: A set of recommendations grouped with their corresponding time

Waste management on the IIT-Mandi campus has been progressing since its inception, but still has room for major improvement. A number of suggested improvements are presented in Figure 1 above. These are organized by the recommended time frame for implementation. The specific recommendations are discussed in detail in the following sections.

Bin Improvements

Engineered Lids
- Prevents disposal of improper waste types
- Tested prototypes with 11% improvement
- Can be attached to current lids

Graphic Labels
- Quickly signals user of waste type
- Painted on to prevent label loss

Figure 2: Outline of suggested bin waste separation bin improvements.
Maintaining separation post collection

Using only outdoor separation bins has proved inadequate to maintain separation throughout the campus waste management system. Separation must also be encouraged within hostels and maintained upon disposal in communal dumpsters. A suggested process for how to achieve this can be seen in Figure 3.

- Designate 1 bin for each type of waste (Organic, Recyclable, General) on every hostel floor.
- Apply the same improved labels used on the source separation bins.
- Inform students of new policy using posters and electronic media.

- Two or three dumpsters should be labeled for recyclables.
- These dumpsters should be painted differently for easy identification.
- If these dumpsters are too far away, dividers such as those shown in Appendix C can be used as an alternative to maintain separation.

- Waste contractors should be informed that they are expected to dump waste in the appropriate section of the dumpsters and all organic waste should be deposited in the vermicomposting pit.
- Waste contractors should be informed that recyclables can be dropped off near the Mandi landfill.

Figure 3: A three step process for maintaining waste separation post collection.

Section 3: Four Month Timeframe

Updating infrastructure to meet population demands

With the construction of the IIT-Mandi North campus, the student population will be reaching upwards of 3,000 students. Once the campus is complete the total population will be closer to 10,000 residents. To prepare for this, the amount of waste management infrastructure must be dramatically expanded. To handle this expansion the system should be expanded according to the specifications in Figure 4.

Infrastructure Updates Per 700 Additional Students

<table>
<thead>
<tr>
<th>Source Separation Bins</th>
<th>Dumpsters</th>
<th>Compost Pits</th>
<th>Collection Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Implement 10 sets of the 3 multi-colored bins</strong></td>
<td><strong>Implement 5 communal dumpsters</strong></td>
<td><strong>Construct 1 compost pit with 6 sections</strong></td>
<td><strong>Hire additional staff equivalent in number as those employed in 2016</strong></td>
</tr>
<tr>
<td>Projected Cost: Rs 82,500</td>
<td>Projected Cost: Rs 200,000</td>
<td>Projected Cost: Rs 60,000</td>
<td>Projected Cost: Rs 3,500</td>
</tr>
</tbody>
</table>

Figure 4: Suggested updates to the campus waste management infrastructure per every additional 600 students.
Improving waste management awareness and education

In order to sustain the various waste management improvements described in this guide, the environmental awareness and conscientiousness must be increased among the student and faculty bodies. This can be achieved using a combination of educational advertisement, engaging activities, and mandatory education. Each of these concepts is expanded upon in Figure 5 below.

**Educational Advertisement**
- Informative posters or billboards should be displayed on campus during the opening of the North campus to promote awareness among new students.
- Recommended topics
  - Danger of littering to wildlife and the environment
  - Benefits of recycling
  - Instructions on how to use the current separation system.
- A example poster design has been included in Appendix D.

**Activities for Increasing Student Engagement**
- The campus’s current Earth Day events should be expanded. Some suggestions include
  - Competition with monetary award for best waste separation during volunteer litter collection event.
  - Informative seminars on the environment and waste management
  - A review of current sustainability initiatives being pursued by the IIT.
- System to allow student suggestions for improvement
- Environmental clubs on campus should be encouraged and established.

**Mandatory Waste Management Education**
- All students should be required to complete a short online education session before the start of their 1st year. Such a session would include
  - Watching videos on the dangers of littering and the importance of recycling
  - Learning about the campus waste system
  - Taking a brief quiz to confirm that the session was completed. The quiz need not have an grading significance.

*Figure 5: The suggestions for how to improve student environmental involvement and awareness on campus.*

**Section 4: Five Year Timeframe**

**Reducing collection frequency**

As the campus population increases, daily collection of waste may become more cumbersome and difficult to manage. If the school is able to reduce the daily removal of waste from its ground to a weekly removal, the cost of waste management could be reduced. Additionally, this would free up the waste contractors to service other areas of the community. This would potentially improve the entire region. However, reducing the collection frequency could introduce new unexpected hazards into the current system and should be approached with caution. Should the administration wish to proceed, there are some possible routes to success. Firstly, the use of biodegradable trash bags in trash cans will allow waste to be stored for longer periods of time without generating an undesirable smell. Secondly, trash compaction can be used as an effective means to increase the capacity of the current waste system. This will allow for reduced collection frequency. To condense waste, solar powered trash compacting waste bins can be purchased and emptied on a weekly basis. The transportation of this increase waste mass and volume may require the use of larger collection vehicles. This should be taken into consideration when considering this form of improvement.
Waste to energy system on campus

The location of the IIT-Mandi campus makes the collection and disposal of waste near the Mandi landfill a very energy intensive process. The carbon footprint left by this system and the campus could be dramatically reduced if a waste to energy system was implemented on campus. Such a system could be used to generate electricity which could power any number of facilities on campus. There are two primary waste to energy systems that could be implemented on campus. These are high temperature waste incinerators and bio-gas generators. Incinerators, which generate energy from the combustion of waste, do create some air pollution and might set a bad example to locals that the burning of waste is acceptable. Therefore it is recommended that the campus investigate the construction of a biogas reactor instead. Biogas reactors work by converting the methane and other gases produced by decomposing biodegradable waste into usable fuel or electricity. An example of a Biogas reactor constructed at University of Agricultural Sciences-Bangalore can be seen in Figure 6 below.

![Figure 6: A biogas reactor at the University of Agricultural Sciences-Bangalore. The system provides 25% of the campus’s power requirements each day. photo: Sampath Kumar G.P.](image)

The system shown above cost that campus Rs. 40 lakh. Such a system at the IIT-Mandi campus would likely cost more given the difficult terrain that would need to be overcome for materials transportation. However, if the school deems such a system financially viable, it would be a major step forward for long term environmental sustainability on campus.
Appendix A: Multi-colored separation bin label designs

PLASTIC / PAPER

RECYCLING
FOOD
COMPOST
GENERAL WASTE LANDFILL
Appendix B: Multi-colored separation bin lid designs

General waste bin lid
Recycling bin lid
Appendix C: Communal dumpster divider designs

Smaller dumpster type

The dividers are attached using drawer sliders. The dimensions should be adjusted to accommodate the selected slider. Additionally, a common bolt can be attached to allow the system to lock after fully expanding.
Large dumpster type

The divers are attached using drawer sliders. The dimensions should be adjusted to accommodate the selected slider. Additionally, a common bolt can be attached to allow the system to lock after fully expanding.
Appendix D: Environmental awareness poster designs

Recycling poster

**Recycling: Do Your Part**

**Facts:**

- Recycling plastics reduces air pollution from manufacturing by 20%.
- Recycling 1 glass bottle can power a 100-watt light bulb for 4 hours.
- Recycling plastic bottles requires only $\frac{1}{2}$ the amount of energy to incinerate.
Waste Separation poster

Disposable plates and utensils
Packaging

Other non-recyclable waste
Blue Bin = General Waste

Glass and paper
Plastic bottles and containers

Other recyclable waste
Yellow Bin = Recyclable waste

Vegetable peels
Food scraps

Other bio-degradable waste
Green Bin = organic waste

Always be sure to separate out organics and recyclables.

Packaging and other non-recyclable waste should be tossed in designated bin.

Do your part: Placing plastics and glass in designated bin allows them to be recycled, which reduces air pollution from manufacturing by 50%.

Recycling Bin

Organic Bin

General Bin
Pollution Kills
KATAULA SOLID WASTE
MANAGEMENT
IMPROVEMENT GUIDE 2016

BY: CAMERON DISPIRITO, YASHU MADAAN,
MICHAEL MCCONNELL, AIMILIOS TACHIAOS, AMAR YADAV
ADVISERS: DR. INGRID SHOCKEY, DR. STEPHEN MCCAULEY,
DR. PAUL BHAVENDER, DR. ATUL DHAR
Introduction

This guide presents a set of recommendations for how to improve the Kataula waste management system. The recommendations were developed based on data collected over a seven week academic term. The recommendations are presented in steps. Each step must be accomplished before the next can be pursued; this will help ensure that the environmental consciousness necessary for each step has already been developed in the community. As the village completes each step it will move closer to environmental sustainability, and provide examples of systems that could function in other local villages as well.
Step 1: Begin Implementation of recycling infrastructure

Recycling is a very crucial part of modern and ecofriendly waste management. It is also the most accessible form of waste management for the village. The beginning phase of this system can be coordinated through the local hospital. By July 2016 the hospital plans to contact with a company for recycling collection. This contract could be expanded to the include the shops around the area. See Figure 1.

1. Install two dumpsters for recycling on the main street.

   ![Example of waste dumpster](image1)

2. Contact recycling company utilized by local hospital and arrange for pick up dates as seen fit

   ![Recycling calendar](image2)

3. Encourage nearby shop owners to deposit their recyclables in the new dumpsters.

   ![Team with local shop owner](image3)

Figure 1: Steps for implementation of recycling infrastructure
**Step 2: Implementation of waste collection infrastructure**

Once recycling infrastructure has been introduced to Kataula, implementing waste collection infrastructure should be the next step. However, before implementation the local authorities should ensure maintenance of this infrastructure is ensured. Our suggested infrastructure additions are shown in Figure 2.

- Install differently colored dumpsters for collection of non-recyclable waste
  - Recommended number: 5
  - Clearly labeled for public dumping of inorganic waste only
  - Residents should be encouraged to compost organic waste
  - This will also reduce the amount of waste in the dumpsters
  - This will help keep smell levels to a minimum
  - Easily accessible area to both residents and waste collectors
  - Placed in an empty lot to limit smell

- Establish a waste disposal system
  - Hire contractor to remove waste from Kataula’s dumpsters once or twice a week (keeping the organic waste out of the dumpsters allows pickup times to be spread further apart)
  - Waste is to be taken directly to Mandi municipal dump

**Step 3: Encourage residents to utilize new waste management infrastructure**

(to be enacted simultaneously with step 1)

For a new waste management system to be implemented, community outreach is required. The residents of the village must be motivated towards adopting new behaviors to effectively utilize the new infrastructure. In Figure 3 below, we present some suggestions for Kataula to motivate its residents.

1. Community leaders, such as local schools and other local organizations, should be used to communicate with residents
2. These leaders should encourage residents to utilize the new infrastructure.
3. Hold town meetings on the subject of waste management in the village to gain local support

**Figure 2: Implementing waste collection infrastructure**

**Figure 3: Suggestions for encouragement of the residents**
Step 4: Continue implementation of waste management infrastructure

(finished one year after step 1 is completed)

One of Kataula’s main objectives should be to reach a point where all waste is handled and there is no more littering. In Figure 4 below, the suggested steps to achieve this goal are noted.

1. Install public waste bins
   A) Place in areas with high volumes of human traffic
   B) Clearly labeled for public disposal of inorganic waste

2. Hire workers to empty bins into dumpsters once a day

Figure 4: Suggested steps for waste management infrastructure implementation

Figure 5: Example of a public waste bin. Taken at the IIT-Mandi campus.
Step 5: Continue implementation of waste management infrastructure
(one year after step 3 is completed)

Once the first steps are made towards a successful waste management system, the village of Kataula should continue implementing waste management infrastructure. Our recommended steps are shown below, in Figure 6.

1. Routinely evaluate dumpster effectiveness and add more dumpsters if needed
2. Install a second bin for recyclables next to public waste bins
   A) Clearly labeled for recyclable goods (paper, plastics and glass)
3. Hire workers to empty bins into dumpsters once a day
4. Continue selling these additional recyclables to the recycling company from section 1 (this money could be used to help fund future endeavors)

Figure 6: Steps for the continuation on implementing waste management infrastructure

Figure 7: Example of how a waste contractor might deposit contents of a waste bin in a dumpster
Step 6: Finish implementation of waste management infrastructure

After everything mentioned above has been implemented and the residents have started adapting to the new waste management system, evaluation of the methods used should take place. In Figure 8 below, recommended steps for the improvement of the system are shown, as well as concepts of expansion towards the near villages.

1. Consistently evaluate methods for improving Kataula’s current system
   A) Determine if more recycling and waste bins are needed
   B) Determine if more dumpsters are needed
   C) Determine if more workers are needed
   D) Evaluate feasibility of funding compost bins and other forms of infrastructure

2. Once an effective waste management system has been established in Kataula, it is important to convince other towns to follow suite.

Figure 8: Steps for evaluating, improving and expanding the system
IMPROVING WASTE MANAGEMENT EDUCATION IN KATAULA’S PRIMARY SCHOOL

BY: CAMERON DI SPIRITO, YASHU MADAAN, MICHAEL MCCONNELL, AIMILIOS TACHIAOS, AMAR YADAV
ADVISERS: DR. INGRID SHOCKEY, DR. STEPHEN MCCAULEY, DR. PAUL BHAVENDER, DR. ATUL DHAR
Introduction

Please note that the following content contains several suggestions which may help to improve the Kataula Primary School’s waste management education program. The activities have been designed to respond to the solid waste management needs of the school and the community. The future of the town’s surrounding ecosystems may well be in your hands. Improving the school’s current waste management practices and ensuring the proper education of students in this subject may prove to be the start of a waste management revolution in Kataula!
Updating Curriculum

In order to improve Kataula’s current waste management system, proper waste disposal practices must be instilled in future generations. As seen in Figure 1, the recommended subjects to be included in the curriculum are very general; specific topics are to be chosen by the instructor as seen fit.

1. Importance of the environment to our existence on earth
2. Side effects of littering on the environment and surrounding human population
3. Importance of proper waste disposal
4. Importance of separating waste
5. Importance of recycling

Figure 1: Suggested topics to include in school curriculum.

Earth Day Activity

As previously mentioned, students need to be educated about proper waste management in the classroom, however, the learning does not stop here. It may prove helpful to educate students through extra projects and activities. Earth day occurs annually on the 22nd of April. On this day, people from all around the world collect solid waste to help clean the environment. Announce to students and faculty that the school will be holding an earth day competition. Give students waste containers and explain the rules as seen in Figure 2. Rules are subject to change at the discretion of the school.

Figure 2: Guidelines for earth day
A crucial aspect of proper waste management is keeping track of waste output. Such information is important for several reasons. First, it allows the school to determine its most prevalent form of waste, which is useful when searching for ways to improve the current system. Consistently recording waste metrics will allow the school to identify changes in waste composition and deal with them accordingly. Finally, conducting waste audits on a regular basis will set an example of proper waste management for the rest of the Kataula community. The school needs to start doing this as soon as possible; conveniently, it could be a designed as a class project (to be conducted by high school students) as shown in Figure 3.

**Waste Audit Project**

- **Weigh each kind of waste (recyclables, organics, and general waste) on a daily basis.**
  - Use scale
  - Weigh student with empty bin
  - Weigh student with full bin
  - \((\text{student with full bin}) - (\text{student with empty bin}) = (\text{weight of contents})\)

- **Analyze the data over the course of the semester.**
  - Look for:
    - Changes in waste composition
    - Changes in overall amount of waste
    - Changes in waste during different times of the year (analyze past students data in conjunction with new data)

- **Report nuances in data to school officials on a regular basis.**
  - Students should be required to form hypotheses about said nuances.
  - For example, what caused waste composition to change during the winter months?

- **Engineer ways to improve the school’s waste management system and expand/improve the ideas presented in this booklet.**
  - Use collected data and data from past students in an attempt to better the current system
  - This is an important step because it not only teaches students about waste management, but it also gives them the opportunity to be the ones enacting change.

*Figure 3: Waste audit project.*
At Home Waste Management Project

In an effort to foster exemplary waste disposal habits in students and the surrounding community, the school could assign a waste management project to be completed at home. The students could be instructed to analyze the waste management system at their home. This can be done by tracking the quantity of waste generated on a daily basis and their families methods of disposal. This project will not only further the students understanding of waste management, it will also help to diffuse the concept of proper waste management practices in the surrounding community. Figure 4 outlines some guidelines for a potential project.

I.) Over an extended period of time (to be determined by the school) have students document the following:
   A.) Waste content
   B.) Quantity of waste generated on daily basis (measure by weight in terms of waste category)
II.) Recyclables and organics should be separated from non-recyclable waste
III.) Recyclables should be stored outdoors and sold to vendor
IV.) Amount earned per purchase should be documented along with the amount of material sold
V.) Organics should be composted or tossed in woods
VI.) Have students analyze the following:
   A.) Average amount of waste generated on daily and monthly basis
   B.) How waste content varies with the season
   C.) Why their waste content is the way it is
VII.) Using the data obtained above, the final part of the project could require students to determine ways to improve waste disposal habits at home in order to be more environmentally friendly
VIII.) A follow up project could require students to implement potential improvements to their homes’ current system
   A.) Students could then analyze the effectiveness of their solutions over a period of time
   B.) Students could also be required to use the knowledge they have learned to propose solutions to Kataula’s waste management system

Figure 4: At home waste management project for students.

Rewarding students for environmentally conscious behavior

It’s extremely important that students are recognized and honored for being environmentally friendly. In order to encourage environmentally friendly habits, and perhaps to motivate students, an award could be given once a month to the student who consistently acts in an environmentally conscious manner. The award should be accompanied by a prize to elicit the interest of students and reward them for their efforts. The qualities associated with acting in an environmentally friendly manner are to be determined by the school.
Take initiative to combat solid waste pollution in the community

In order to effectively improve the waste disposal habits of residents, the school needs to set the example, for children, parents, and store owners alike. If the school decides to improve its current waste management system, then surrounding stores and residents may follow suit. At the very least, setting an example for the rest of the community will increase awareness with regards to waste management; even this would be a step in the right direction for Kataula. In order to set the example in Kataula, follow the points illustrated in Figure 5.

- Consistently perform daily waste audits
- Do not dump waste in unregulated areas
- Always separate waste into three categories before disposal: Bio-degradable, recyclable, and non-biodegradable waste
- Recycle as much waste as possible (if stored and sold to vendors the money can be used to help fund events)
- Encourage students to pass on information about waste management to friends and family

Figure 5: Waste management guidelines for the school.

Conclusion

By updating the curriculum, setting the example, and encouraging students to be environmentally friendly, the school has the potential to affect true change in both its own system and the village of Kataula. Educating todays children about proper waste management practices will ensure the integrity of tomorrows environment.