ABSTRACT

As the population of a city grows, so does the waste that it generates. Along with industrial and commercial development of a city, waste management systems have to be revised according to the city's needs. Waste management is an important aspect because if not done right, it could lead to contamination and disease. Urban solid waste consists mainly of household waste and commercial waste in either solid or semi-solid form. Waste generated from households is nowadays dominated by plastic and packaging material. Waste from commercial establishments such as restaurants and cafes mainly consist of food waste. Solid waste management is more essential for urban societies as they generate a lot more garbage; the availability of packaged food and other items leads to the accumulation of more trash. The primary goal of the study has been to determine if there is still any unsatisfactory treatment and disposal of USW in and around Bangalore and if so, what are the patterns and causal agents. The specific objective of the study has been to spatially and environmentally locate poor methods of USW deployed in the Varathur and Bannerghatta areas of Bangalore and identify causal factors. This was achieved by breaking up the area into 12 km² grids and carrying out a physical survey of the current USW disposal methods in specific grids. Our results showed that the Varathur area in fact had a large dumping site that did not seem to be government approved and was causing trauma to the surrounding environment. The Bannerghatta area had many small dumps which could be rectified by the authorities once they were notified and a system could be put into place.

1. INTRODUCTION

1.1. Solid waste

Municipal solid waste (MSW), also called urban solid waste, is a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area. They are in either solid or semisolid form and generally exclude industrial hazardous wastes. The term residual waste relates to waste left from household sources containing materials that have not been separated out or sent for reprocessing.

1.2. Bangalore – Garden City to Garbage City

The city of Bangalore has grown from a small Pensioner’s Paradise to a sprawling metropolis within a few decades and the waste management system has not been able to keep up. So, all over town are small and big deposits of trash. The indifference of the citizens also plays a major role in this; they blame the government and turn a blind eye on the fact that they are the ones generating the waste. As the times progressed, more non-biodegradable material has been added to the usual list of things that make up urban solid waste, plastic reigning. As plastic wastes persist even after a decade or two, any dump sites with plastic are permanently littered i.e. if it was organic waste it would degrade over time and become part of the soil.

1.3. Global Positioning System (GPS)

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map.

A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

1.4. Geographical Information System

A geographical information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports and charts. A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared. GIS technology can be integrated into any enterprise information system framework.
1.5. Mavallipura Facility

Bangalore produces roughly 2500 tons of garbage in a day. This garbage, once collected is sent to one among three of the city’s landfills (of which Mavallipura is one). We visited the Mavallipura Solid Waste processing facility on the 8th of August, 2010. We started at 9:00 a.m. in the morning from IISc. and with just a map, GPS and two-wheeler, reached the destination in about an hour. This facility is government leased and run by a private company called RAMKY. Here, the waste is segregated into plastic and organic. The organic waste is then composted. Separation is done with the help of a trommel which is a rotary sieve that sorted the trash according to size. The smaller things are sent for composting while the plastic gets stuck in the mesh and is recycled.

The facility also had a leachate plant which collected all the liquid exudates from the trash in a tank which is subjected to aeration. In the roofed part of the facility were more trommels, a big sieve and an electrical control room. A trommel (from the German word for drum, "Trommel") is a screened cylinder used to separate materials by size - for example, separating the biodegradable fraction of mixed municipal waste or separating different sizes of crushed stone.

The compost is treated for 21 days with bacteria and the result is a bag of fine compost which is hot due to the composting process. The fine compost is sold as Godavari Gold organic manure. The un-composted garbage which is piled in heaps outside is covered during monsoon. Once the leachate is processed, a part of it is used as inoculum in processing further amounts lechate. But, the facilities are currently not running. There are three leachate collecting reservoirs in the facility.

2. AIM

Bangalore has been the home of the first effort to change policy on solid waste management and therefore has been the key to various society driven experiments to ameliorate the environmental and societal impacts of USW management in cities. Today there are serious efforts at various levels within Bangalore city to identify operational problems of its waste management systems. Thus while the collection of USW has generally improved, its disposal is still inadequate in many ways. The primary goal of this study has been to determine if there is still any unsatisfactory treatment and disposal of USW in and around Bangalore and if so, what are the patterns and causal agents.
3. STUDY AREA

Figure 1: Grids covered in the study are indicated in yellow. Line in Blue indicates the outer Ring Road, in red the arterial roads and the boundary in Black.

Table 1: GPS positions of the grid studied

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Grid Nos</th>
<th>Upper left Position</th>
<th>Bottom right position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Latitude</td>
<td>Longitude</td>
</tr>
<tr>
<td>1</td>
<td>213 and 214</td>
<td>12°56′35.50″</td>
<td>77°44′52.75″</td>
</tr>
<tr>
<td>2</td>
<td>215 and 216</td>
<td>12°57′3.58″</td>
<td>77°48′4.99″</td>
</tr>
<tr>
<td>3</td>
<td>302 and 303</td>
<td>12°49′54.67″</td>
<td>77°34′30.49″</td>
</tr>
<tr>
<td>4</td>
<td>304 and 305</td>
<td>12°49′26.66″</td>
<td>77°37′31.68″</td>
</tr>
</tbody>
</table>

3.1. Description of the study area

3.1.1. The Varathur – Sarjapur area is located to the east of Bangalore, slightly south, bordering Kolar district.
Grids 213 and 214
About 40% of the area was residential; the frequency and size of the settlements decreased as we moved further east. 60% of the area appeared to be agricultural with cultivated fields of various dimensions. Right in the middle of this area, we discovered a huge dumping site where the garbage appeared to be burnt. There was a lot of garbage distributed in mounds all over this large barren area. The borders of this area were raised mounds of mud which seemed to purposefully block the view of the dumpsite from the road. There was an average frequency of small roadside dumpsites.

Grids 215 and 216
In the left most extreme of this grid flowed a river on either side of which were active agricultural lands. To the right extreme was the national highway 207 which crossed over the river as the Mugaluru bridge. This bridge is to the south of the grids and cannot be seen on the map. The south west part of the area had two large barren areas which were relatively clean and only had minor garbage dumping which appeared to have been burnt.

3.1.2. The Bannerghatta – Jigni area is located to the south of Bangalore, bordering the National Park area.

Grids 302 and 303
70% of this grid was covered by residential and commercial zones. The proximity to the zoo led to settlements along the Bannerghatta road which are part of Bangalore city’s sprawl. These residential areas are very basic, but further into the grid, many layouts have cropped up. These layouts are self sufficient and even have their own SWM systems. Some of the layouts in this area include Nisarga and Nandanavana by the Nirman group and Vatika by the Pride group.

Grids 304 and 305
55% of this area (to the left) is agricultural while the other 45% is the Jigni industrial area. The one village along the Begur – Koppa road is small and seemed to be clean. This residential area seems to be converted agricultural area. The Jigni industrial area has industries like Biocon and Max (fabrics and clothing). There was a recycling area where they seemed to be sorting various grades of plastic.

4. Material and Method

1. Break up the area around Bangalore into grids measuring about 12 km² so as to enable easy physical verification
2. The GPS number and grid number were noted down.
3. On reaching the start of the grid, the GPS was switched on and tracking was started.
4. Landmarks were noted down and observations were made for each waypoint.
   a. The area was described.
b. The composition of the dumping site - whether from any restaurant or house - was determined and pictures of the same were taken.
c. The area of private (illegal) dumping sites was concentrated on.
d. Any lakes or barren lands in the given area were also noted as potential dump sites.
e. Previously observed barren lands in the area were visited and their level of development was noted.
f. The presence of quarries was given special importance as they generally serve as major dumping sites.
g. Burning of waste if any was noted.
h. Frequency of dumping was determined by interacting with the locals as well as by observation of the site itself.
i. The age of the dumping site was determined by observing the state of vegetation and the degree of decomposition.
j. The approximate area of the site was noted.
k. The type of waste - debris/plastic/mixed/organic/medical - was observed.
l. To ascertain the presence of door-to-door collection, it was noted whether the waste was present loosely or in plastic bags.
m. The presence and direction of leachate if any was noted.
n. If possible the vehicle which dumps the waste was found out - auto/truck.
o. The presence of any water source in proximity to a dump was noted.

The levels of pollution in it were noted. The levels were judged based on comparing field observations with reference pictures studied during the introductory seminar given at IISc.

A Garmin GPS and a Nikon Coolpix camera were used to record the work.

5. OBSERVATIONS

5.1. Date and period of study

5.1.1. First Trip
Date: 21.08.2010 and 22.08.2010
Grid No.: 213, 214, 215 and 216
Team: Aparna Arun and Shashank Shrishrimal
Weather: Cold and rainy on the 21st during the afternoon, pleasant on the 22nd

5.1.2. Second Trip
Date: 29.08.2010
Grid No.: 302, 303, 304 and 305
Team: Aparna Arun and Shashank Shrishrimal
Weather: Pleasant
Figure 2: Places visited in the grids 213 & 214 and waypoints recorded

Figure 3: Places visited in the grids 215 & 216 and waypoints recorded
<table>
<thead>
<tr>
<th>Way point No.</th>
<th>Salient Feature of this way point</th>
<th>Approx. age of the dump</th>
<th>Impact on environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>66, 67 &amp; 68</td>
<td>Small dumpsite, signs claiming to de-silt the lake bed and re-do the road</td>
<td>7 – 28 days</td>
<td>De-silting is beneficial as it will check the overflowing of the lake</td>
</tr>
<tr>
<td>74</td>
<td>Small dumpsites near settlements and household waste</td>
<td>7 – 28 days</td>
<td>Degrading, mostly degrading organic waste and a little plastic</td>
</tr>
<tr>
<td>75</td>
<td>Small dumpsite in a pit on the way</td>
<td>Within 7 days</td>
<td>Plastic may cause asphyxiation in the animals that consume it</td>
</tr>
<tr>
<td>76</td>
<td>Little accumulation at the roadside</td>
<td>More than a week</td>
<td>Plastic will persist because its non-biodegradable and cause soil degradation</td>
</tr>
<tr>
<td>77</td>
<td>Plastic waste, roadside</td>
<td>More than 28 days</td>
<td>May spread to the surrounding areas</td>
</tr>
<tr>
<td>78</td>
<td>Huge dumpsite with burnt garbage dispersed all over the area, the borders of the dumpsite were raised which seemed to keep it hidden from the road</td>
<td>More than 28 days, regularly burnt</td>
<td>Release of toxic gases due to the burning of the garbage, degradation and choking of the soil, burning of plastic along with organic waste, destruction of habitat, loss of greenery</td>
</tr>
<tr>
<td>79</td>
<td>Plastic dispersed in a plantation area (outside the map)</td>
<td>More than 28 days</td>
<td>Disrupting the aesthetics, plastic waste is choking the soil, causing degradation</td>
</tr>
<tr>
<td>80</td>
<td>Chikka Tirupati</td>
<td>Within 7 days</td>
<td>Malodor (based on the number of animals)</td>
</tr>
<tr>
<td>81</td>
<td>Barren Land</td>
<td>No trash</td>
<td>-</td>
</tr>
<tr>
<td>82</td>
<td>Barren Land</td>
<td>More than 28 days</td>
<td>Dumping of garbage into water body</td>
</tr>
</tbody>
</table>

Table 2: Salient features for observations made in grids 213 - 216
<table>
<thead>
<tr>
<th>Way point No.</th>
<th>Salient Feature of this way point</th>
<th>Approx. age of the dump</th>
<th>Impact on environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>002</td>
<td>Off Bannerghatta main road to the left – construction site</td>
<td>7 – 28 days</td>
<td>Habitation loss</td>
</tr>
<tr>
<td>003</td>
<td>Dustbin with trash outside it</td>
<td>7 – 28 days</td>
<td>Lack of civic sense</td>
</tr>
<tr>
<td>004</td>
<td>On the way to the zoo, roadside dump (mostly plastic)</td>
<td>Within 7 days</td>
<td>Lots of plastic, harmful for the environment</td>
</tr>
<tr>
<td>005</td>
<td>Roadside trash</td>
<td>7 – 28 days</td>
<td>Chokes the growth of plants and is polluting the environment</td>
</tr>
<tr>
<td>006</td>
<td>Dustbin with trash outside it</td>
<td>Within 7 days</td>
<td>Lack of civic sense</td>
</tr>
<tr>
<td>007</td>
<td>Off the road, to the left in an empty plot on the way back from the zoo. Many pipelines were present. Garbage spread around</td>
<td>More than 28 days</td>
<td>Malodor, unhygienic, may breed vectors, soil degradation</td>
</tr>
<tr>
<td>008</td>
<td>Construction debris, no garbage</td>
<td>More than 28 days</td>
<td>Hindrance to plant growth</td>
</tr>
<tr>
<td>009</td>
<td>Dustbin with a lot of trash outside it</td>
<td>Within 7 days</td>
<td>Lack of civic sense, will be spread by cows, dogs and wild animals</td>
</tr>
<tr>
<td>010</td>
<td>On the Bannerghatta – Anekal road. Small garbage dump between houses of a settlement</td>
<td>Within 7 days</td>
<td>Pollution of the empty site, may cause choking of animals if they ingest as it is mainly plastic waste</td>
</tr>
<tr>
<td>011</td>
<td>Looked like a sorting area for plastic waste</td>
<td>Ongoing process</td>
<td>No plant growth</td>
</tr>
<tr>
<td>012 - 014</td>
<td>Old dumpsites both sides of the road. Garbage was mixed up and covered in mud</td>
<td>More than 28 days</td>
<td>Seems to have stopped plant growth may have increased toxicity of the soil</td>
</tr>
<tr>
<td>015</td>
<td>Recycling/sorting unit in the industrial area</td>
<td>Ongoing process</td>
<td>Beneficial</td>
</tr>
</tbody>
</table>

Table 3: Salient features for the observations made in grids 302 – 305
Figure 4: Places visited in the grids 302 & 302 and waypoints recorded

Figure 5: Places recorded in the grids 304 & 305 and waypoints recorded
6. DISCUSSION

Bangalore produces about 3600 tons per day of municipal solid wastes. The extent of wastes collected ranges from 75-90% of the total waste generated. It is also important that a decentralized and economically viable processing and management system is required for fermentable components of the MSW in order to be sustainable in the long run. In Bangalore, the informal sector does not participate in collection, processing or recycling of organic waste components as reported for many other urban or peri urban cities of Karnataka. It has been reported that till recently, about 60% of the MSW collected was dumped at about 60 known and unknown (unrecorded) dumping sites around Bangalore. Further, among these more than 35 sites received a mixture of domestic and industrial waste. As Bangalore is rapidly complying with the MSW (H&M) 2000 rules, a large fraction of the MSW is reaching designated “integrated processing and landfill sites” around Bangalore.

With a population of 21800, Varathur is slowly extending into the agricultural area around it. And as this expansion doesn’t appear to be BBMP-compliant, there seems to be no solid waste management system in place. When asked, the villagers admitted that every two to three houses just dug a common pit and buried all their trash there. Once it filled up they would cover it and dig a new pit. This may have worked a few decades ago, but now with the amount of plastic and other non-biodegradable material, this can be a hazardous practice. The plastic remains un-degraded in the soil for an immeasurable period of time, choking the soil and the plants that grow in it. As more and more pits are created, the phenomenon will spread creating large areas of fallow land. If a proper waste management system is set up in this outskirt area, it would go a long way in protecting the soil and the environment.

In the Bannerghatta area, it is only lack of civic sense that is causing the mess. Large dustbins have been provided, yet people walk all the way up to it only to throw the trash just outside the bin. Only awareness can change the state of the solid waste management in this area. Further, into the Jigni area, layouts like Nisarga have their own incinerators and burn their trash, which would lead to air pollution. If BBMP stepped in and set up a system, this air pollution can be avoided. The industrial area seems to be setting a good example with their sorting and recycling units.

7. CONCLUSION

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In the Varathur area, the levels of solid wastes dumped was significant (5 heaps generally over 100 m$^2$ each) in the beginning. But, as the population shifted from urban to rural i.e. as we went further east, the dumps became less frequent but the size was larger as the villagers dug a common pit which they all used and then covered with mud once full. Also, there was a large amount of burnt waste in the urban areas while the rural areas had mainly organic waste which was probably the reason for a higher faunal population. The plastic content was higher in Grids 213 and 214 (mostly urban) as compared to Grids 215 and 216 (mostly rural). The garbage seemed unsorted as there was a mixture of all types of wastes and no plastic had been recovered in the first two grids. Also, in these two grids, the metal content of the wastes was 1-4%. The reason why such high metal content was found was probably because of the absence of continuous recycling processes happening at the site and burning of organic material. The area poses a health risk to all animals due to the presence of plastic carry bags.

In the Bannerghatta area, most of the dumps were more a case of lack of civic sense; there were dustbins in most of the sighted areas but the trash seemed to be spread for at least 2 feet in all directions around the bin. Moving into the second two grids, the levels of garbage was sparse. One reason for this could be the drastic drop in population between the two sets of grids. The first set of grids was mainly along Bannerghatta road where there were many shops – convenience and others while the second set of grids was along the Bannerghatta-Anekal road which has not yet been fully populated. The populations were reflected in the trash; the first set of grids had mainly residential and domestic garbage. At the extreme end of the second set of grids, the Jigani industrial area begins. This area seemed to be relatively well maintained with respect to garbage. There were what seemed to be plastic segregating areas in more than one place in the industrial area. The amount of plastic was higher in the first few grids as the population was higher and use of packaged goods will be more.

In both these localities, a decentralized system such as the one proposed by Chanakya et al. in ‘Small-scale decentralized and sustainable municipal solid waste management potential for Bangalore anchored around total recycle and biomethanation plants’ may be implemented successfully.

Setting up of small vermin-compost plants is also a viable option in these areas since most of the waste is organic. Most common practices of waste processing are uncontrolled dumping which causes mainly water and soil pollution. Besides dumping or sanitary land filling, the final disposal of solid waste can be carried out by other methods like composting. Earthworm farming (vermiculture) is another bio-technique for converting the solid organic waste into compost.$^6$ An innovative discipline of vermiculture biotechnology, the breeding and propagation of earthworms and the use of its castings has become an important tool of waste recycling the world over. Essentially, the vermiculture provides for the use of earthworms as natural bioreactors for cost effective and environmentally sound waste

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management. Mysore city has been successful in using a vermin composting facility as part of their solid waste management.\

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