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Estimating Unauthorized Dumping of USW around Cities – a case Study of Bangalore

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Abstract

As most cities in India shift to regulated USW collection and centralized processing systems, there is a gradual shift from the earlier haphazard dumping on road sides to an increased level of wastes sent to and processed by waste treatment facilities and landfilling. This slow transition is accompanied by several kinds of leakages and spillages, wherein a certain fraction of total USW is even now dumped at a few of the less visible locations in order to save transportation costs or to cover up delayed arrival at the waste processing site. Good USW management system needs to monitor and minimize this. A simple method to determine and minimize such illegally dumped fraction is required and appropriate measures need to be taken up, identify actors and causal factors in order to prevent them recurring. A simple visual method carried out by motorcycle-borne volunteers has been developed. Data may be collated to affirm the level of this problem and minimize it. Data could be validated by satellite imagery as well. Results show that large unauthorized dumps (more than one truck load) occur for a variety of reasons. USW equivalent to levels between 20-23 days of total annual USW production or 5.5-6% is illegally dumped and can be verified by alternative means. Average deviation in all the three stages of measurement was computed, to check the accuracy of the estimates. The total number of large dumps was 270; classifiable into seven types that include plastics, organics, construction wastes, fresh indeterminate, old waste and non-USW emerging from recycling or industry. Waste quantity is determined based on visual estimation of area and average density of waste. A large part of it appears to be from the recycling units' rejects. A total of about 83557t wastes is scattered around Bangalore of which 71628t is fresh and old USW (non-rejects). Around 10% of locations were measured simultaneously by volunteers, trained expert and with Google Earth for its spread area and both showed an average deviation of 46%.

Key words: unauthorized dumping, waste estimation,

Introduction

Illegal dumping or unauthorized dumping is the disposal of waste at private or public places around the city which is not permitted as per law (Corbyn Lisa, 2008). With the enactment of the MSW2000M&H rules, most cities in India have begun to shift to regulated USW collection and centralized processing systems. Each urban unit has identified at least one site where the USW collected from the city is being landfilled or otherwise processed to compost, recyclables and a certain fraction as landfillable inerts. Earlier a large fraction of USW remained on city streets to be partially dried and partially consumed by stray animals. This partially reduced the weight. Sometimes such partially dry wastes were burnt in the bin or at the dumpsite to make way for fresh wastes to be added. As these practices have been stopped and contracts issued to various garbage contractors to lift such garbage from community bins to designated USW processing sites. As a result there is a gradual shift from the earlier haphazard dumping on road sides to an increased level of wastes sent to and processed by waste treatment facilities and landfilling. Yet this slow transition is still accompanied by several kinds of leakages and spillages, wherein a certain fraction of total USW is even now dumped at a few of the less visible locations in order to save transportation costs or to cover up delayed arrival at the wastes processing site – processing sites close operations at sunset and trucks filled with USW need to wait till 0900 or 1000hrs when the processing sites open their activities in the morning. To overcome such waits, USW is dumped by these transporters in remote locations just outside city limits. Such small and continuously changing dumpsites are sufficiently important because of the plastic and recalcitrant waste components that firstly spread by wind and water and become anaesthetic. Second, wastes attract the next potential dumping instance and more of the wastes are dumped nearby in

the next instance of illegal dumping. Waste materials dumped in this fashion generally include construction and household wastes that can be treated and recycled to be reused as resources.

Everyday Bangalore generates around 3600t of urban waste and 55% of this waste is contributed by residential houses. It is estimated that nearly 90% of the fresh USW generated in Bangalore is fermentable and can have a high C-footprint if not handled adequately (Chanakya and Sharatchandra, 2005). Bangalore city employs a quasi centralized collection system achieving a 75-90% of waste collection efficiency, which is satisfactory and keeps the city clean (Chanakya *et al*., 2009). This means primary collection system functions with reasonable efficiency in terms of time of collection and the extent of collection. The wastes collected are meant to be transported immediately to the designated waste processing sites. However, for example when small tipper autos collect one round of USW from households they are expected to tip the collected wastes to the next larger vehicle or a large bin. In the event such a bin is not free or delayed in its arrival at the designated point, the tipper autos or handcarts dump the collected wastes from the first round at this site and move on to the next round of collection. Such an act renders small waste dumps within the city limits but is ephemeral – they are cleared within a few hours. Yet they constitute small temporary dumps. It is believed that when the system efficiency improves such small dumps would be eliminated. However, the larger and randomly carried out dumps that occur on the outskirts of the city remain for a long time and is the concern of this study.

There are three designated waste treatment and disposal facilities in Bangalore; Mandur, Mavallipura and Karnataka Compost Development Corporation (KCDC). Presently KCDC has been closed and not working. During the early stages, when the city produced about 650tpd (1988), about 100tpd of market wastes were taken back to villages for direct application on land and another 150tpd was handled by KCDC. The rest, comprising a large fraction of decomposable was 'open dumped' along various arterial roads leading out the city (Rajabapaiah, 1988). This trend has continued till about 1999-2000 and the proportion of wastes carried to these arterial roads were approximately same (TIDE, 2000; Chanakya and Sharatchandra, 2005; Lakshmikantha, 2006). There are social and technical limitations which lead to this problem. Primary measures like fine for illegal dumping and transport vehicle with Global Positioning System (GPS) were taken up in 2010 to avoid this kind of dumping, but failed to control it. Finding the location and quantification of unauthorized dumps is still a difficult task because these occur at random and since Bangalore USW has a very large decomposable fraction, much of it would be decomposed in a few weeks leaving behind predominantly the non-decomposable fraction that gradually spreads and becomes unaesthetic. Most often the size of this dump could be that equal the one caused by tipping the contents of a single truck (c.5t) and this cannot be detected easily. However, when more than 2-3 truck loads are tipped, the sizes become cognizable both visually as well as from remote sensing techniques. In few locations in Japan satellite images (Quickbird, 0.61m resolution) were used to find the locations of unauthorized dumping (Yonezawa, 2009). However, most studies have failed to quantify waste which goes for open dumping. As discussed above there are usually two categories of open dumping - one that is temporary, ephemeral and keeps on changing in locations while the other is larger and frequented many times and persists longer. Obviously the one time event type of dumping is difficult to quantify. However, there is potential to quantify the latter

Much of the illegal dumping that is discussed above occurs outside the limits of the city on generally lesser used land (land that is not under cultivation but is left unattended for a long time). Mush of the waste at this stage is carried by trucks that require a motorable road and in addition that can take the kind of weight of a truck. This significantly reduces the points where wastes can be dumped to places along temporary and asphalted roads on the outskirts of the city. Such roads are few in number and therefore the extent of survey to be carried out is also small. This article focuses on the method to find the location and to determine the volume of waste disposed illegally. A second problem of undertaking a conventional survey by a few investigators is the rate of degradation of components of USW which makes it difficult to determine the rate of dumping. In order to overcome this difficulty it is necessary to carry out a large volume survey with a large number of semi-trained volunteers driving motor-cycles and scooters around these poorly motorable roads and tracks. Here, in order to find the locations of dumpsites intense field survey was conducted in all the outer part of the city. The study site, the entire city and its outskirts has been divided city into grids and almost all grids were covered in field survey. This provided the required data to determine the causes of unauthorized dumping in addition to identifying all the dump sites.

Methodology

Unauthorized dumping is happening in both inside as well as outside of the city, while those within city boundaries are generally short lived and act as illegal transfer stations those on the outskirts of the city are generally 'permanent'. In this study we attempt to ignore very small dumps that could be due to various causes which force the truck to abandon

the load such as break-downs, shortage of fuel, delays, etc. We attempted to study dumps larger than 8X8m area (20ft X 20ft – a measure easily identifiable by the student volunteers). The sizes of dumps vary with the location; inside city dumps will be small and waste will be there for around one to two days. However, in the case of those dumps outside city, dumps are generally larger, more frequented and persist longer. Generally the organic wastes are degraded rapidly allowing recyclable materials to be picked up rag pickers. It generally occurs near accessible public and private open land, fallow agricultural land, road sides and at the foot of small hills where land is not owned individually and there is lesser control on the abuse of such common lands.

The methodology developed here requires a relatively short study duration that included two phases: 1) site observation and visual estimation and 2) data verification and measurement. Whole study area is divided into grids of size 2.7 km × 2.7 km and Google earth (GE) images are used to find waste disposal sites in outskirts of the city.

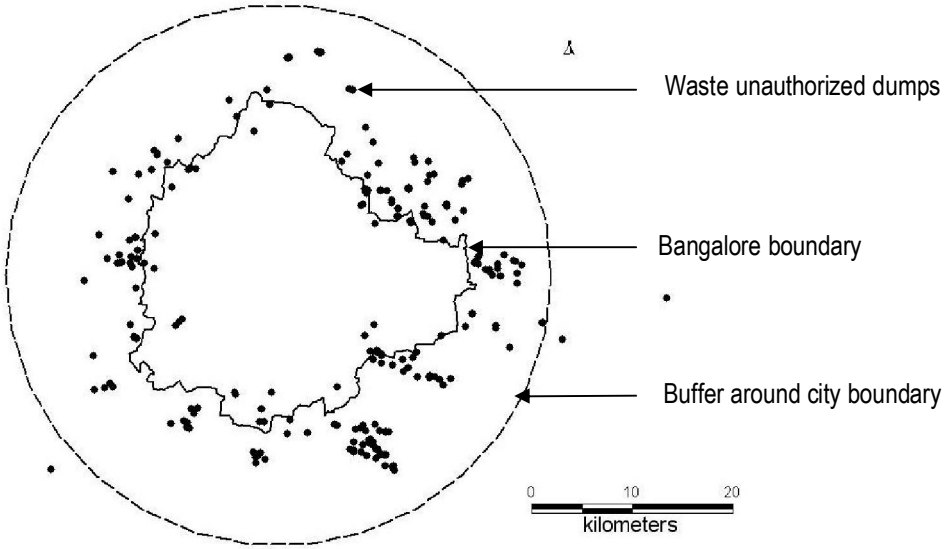

Fig 1: Location of unauthorized dumping around Bangalore city

1) Site observation and visual estimation

The purpose of site observation is to find the locations of waste disposal sites using GPS and to evaluate the size and composition of the waste based on visual observation (Fig 2). A few student volunteers were trained on site to visually estimate composition of USW as well as to determine the GPS locations of the dumpsite while simultaneously photographing the same. In order to ensure that there was a good match among the students a mock assessment was carried out at a dumpsite. These student volunteers rode on motorbikes or scooters in specified grids and determined the locations of illegal dumpsites. Each pair of student volunteer was allocated 2-4 grids to be completed in 2 days of survey time. All observations were recorded on hard copy while the hand held GPS also recorded the track and GPS points. A small camera was used to back up composition estimates by photos. At the end of the survey all data was downloaded on in a pre determined format and estimates of composition were verified by an expert – corrections if any were made at this time. A total of 25 pairs of student volunteers carried out the survey for varying number of grids and submitted their reports and made a presentation of their observation to an expert group. This allowed validation and verification of the data recorded by the volunteers. The area covered in presented in Figure 1. Based on visual observation dumps were classified into different categories – plastic waste, organic waste, construction waste, indeterminate waste, old waste and other waste. Average density of different waste categories and waste volume are used to quantify the unauthorized dumps.

2) Data verification and measurement

Around 10% of total collected locations from the first survey were verified by a co-author – a senior student who has carried out many such surveys. The locations chosen for verification were spread across all the four zones of the city (Figure 1). At each of these locations used for validation the length and breadth were estimated and area determined. The length and breadth of these specific locations were also determined using Google Earth to quantify and minimize errors. Average deviation was computed between the measured and visual estimated area and between Google earth and visual estimated area.

Table 1: Details about waste categories

. No.	categories	Details and Description	
1	Plastic	Waste with more than 60% of plastic. Organic waste must have degraded with time and ultimately waste has left with plastic. It is generally coming from commercial places.	
2	Organic	Waste with more than 60% of fermentable. Waste must be fresh or 15-20 days old, since fermentable get degrade after this duration.	
3	Construction	Waste with more than 60% of construction waste. Organic waste must have degraded and finally left with this.	
4	Indeterminate	Waste where difficult to see its composition.	
5	Other	Waste which is not the part of municipal solid waste. It includes waste generated from specific industries or commercial places.	
6	Old	Waste site must be around six months old. Since all organic waste has degraded and plants have started to grow.	
7	Recycler rejects	Recycling units where they segregate recycling plastic and eventually left with non recyclable materials and organic waste.	

Results and discussion

Various categories of USW dumpsites and their features are presented in Table 1 wherein the dominant form of waste is also listed such as plastic, organic, construction, indeterminate (fresh wastes mixed up making segregation difficult), old (old dumps indicating decomposition of most of the fermentables), other (non-USW wastes often from industry, upholstery, etc.) and recycling rejects (rejects from the recycling processes where other types are rejected and piled including fermentable wastes). These categories are based on the percentage of waste volume at dumpsites. A total of 270 dumpsites were recorded by the study team. Fig 1 shows the spatial distribution of unauthorized dumps at outside the city. These dumps are distributed in all four directions from the city centre. Number of sites is more in North East (NE) and South East (SE) in comparison to South West (SW) and North West (NW) zones. The height of individual dumpsites varied from 10cm to 8m (4 inches to 20ft). Few of the dumps had suffered continuous disposal of waste over the past few years showing clearly distinguishable spots of very old and very fresh dumps of USW. Locations suffering continuously dumped over 2-3 years could be identified in Google Earth maps as well. Identification of newer dumps using Google Earth was however difficult without updated photos and maps. It was also difficult to identify ephemeral dumps which were one off dumping events and occurred over different sites. Wastes have also been dumped on steep hill slopes and quarries and such locations are not identifiable through satellite imagery of Google Earth photos. Such dumps could not be included for comparative studies although their presence and magnitude were manually recorded. The details of the overall dumps are presented in Table 2 where in the number of locations of unauthorized dumping in all four zones of the city surveyed during September to November, 2010 is presented. From the composition of these sites the extent and quantity of various wastes are estimated using earlier determined densities to convert volume measurements to weight. From such estimates we determine that a total of 174,000m^3 of wastes caused by unauthorized dumping around the city. This could be translated to 83557tons by weight.

Wastes are dumped at unauthorized dumping places as well as at recycling units where fermentables or non recyclable wastes lie without any treatment. These non recyclable rejects put out by recycling units are generally called as recycler rejects. At these locations (recycling /recovery units), measurement of area dumped for untreated waste was difficult, so only visual estimation is used to estimate the waste volume. It is clear that recycling units contribute a large fraction (91%) of total waste dumped in these areas. This large percentage of recycler /recovery unit rejects needs to be avoided by adopting safer and cleaner management among these recycling units with planned waste segregation as well as setting up a treatment facility for organic waste nearby. Our estimates show that If such recycler rejects are not allowed to be haphazardly dumped the extent of other dumps would only account for 11923t of haphazardly dumped waste on the periphery of the city.

Table 2: Zone wise unauthorized waste disposal sites based on first survey

Waste categories	Zone wise occurrence of waste disposal sites and waste volume								Total volume (m^3)	Density (ton/m3)	Total quantity (tons)
	NE		SE		SW		NW				
	No.	Volume (m^3)	No.	Volume (m^3)	No.	Volume (m^3)	No.	Volume (m^3)			
Mixed Fresh USW (Indeterminate)	9	108.3	16	2512.1	8	1066.2	4	401.1	4087.7	0.41	1656
Wet Organic	20	451.3	26	34.9	2	1.1	6	121.4	608.7	0.41	247
Debris	28	2305.0	16	1361.1	19	5203.8	13	620.1	9490.0	1.0	9490
Plastic	16	94.5	49	90.4	7	105.7	10	169.7	460.3	0.1	41
Old	1	200.1	1	10.6	0	0.0	2	51	261.6	0.6	157
Other	5	112.7	5	159.8	3	420.3	2	57.3	750.2	0.45	338
Recycling	3	159126	2	48.1	0	0.0	0	0.00	159174.4	0.45	71628
Total	82	162398	114	4217	38	6797	36	1420	174832	Avg: 0.49	83557

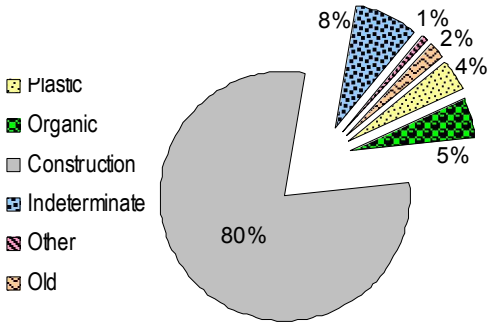

Fig 2: Percentage composition of unauthorized waste excluding recycling units

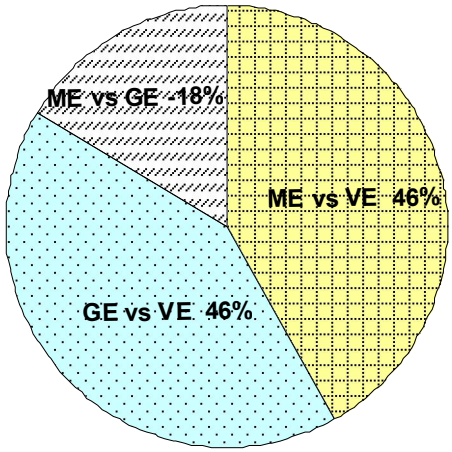

Fig 3: Average percentage deviations in computed area (ME: Manual estimation; VE: Visual estimation; GE: Google Earth estimation. VE<ME<GE)

Among the various locations of illegal dumping on the outskirts of the city, the largest type or contribution came from plastic wastes (82 in number). Construction waste contributes 61% of total waste by volume as well by weight. It is imperative that alternative uses for them needs to be devised considering that the costs of sand today are immense and difficult to find. An understanding of the sizes for these dumps could be had by making an estimate of the average quantity of individual wastes in each category of the dumps studied. Results suggest that the average size of these dumps were as follows - construction waste (124.9t/dump), indeterminate (44.8t/dump) and old waste (39.3t/dump). For organic and plastic waste average waste dumped are 4.6t/dump and 0.5t/dump, respectively suggesting these arise from dumps by a single or two truck loads of USW. It is estimated that Bangalore USW has nearly 72% of fermentable organic wastes (Chanakya *et al*., 2009) and therefore unless observed within a few days after dumping, most of the USW dumps would be bereft of fermentable organic matter. However, not all dumps indicated that the dumped USW were of domestic origin where ultimately dumped waste is left only with non-decomposable constituents like plastic, cloth, glass etc. along with well packed and inaccessible decomposable inputs.

Our survey has estimated a total of 175000m^3 of dumped USW (83557t by weight). This level of dumping is equal to about 20-23d equivalent of daily discharge of Bangalore's wastes or in terms of percent diverted to dumps it ranges between 5.5-6% Among the 270 locations studied and identified, 25 locations were verified simultaneously with field measurements as well as suing Google Earth pictures (GE). These 25 locations all the three type of area estimation was available. Area as measured using length and breadth is presented in Fig 3 where the average deviation for different measurement methods is analyzed. This study needs to be repeated a few times to determine its repeatability and use at other locations. A detailed examination of dumps along with distance for road networks would predict reasons for choice of these locations and possibly evolve methods to dis-incentivize such occurrences.

Conclusion

A simple method to identify the locations of unauthorized dumping is developed that could be used for various cities. The method is based on rapid group based survey and its further verification and validation. Such survey could easily estimate the level of leakage and overall choice of sites for dumping. The single largest cause of their occurrence is the semi-organized recovery units that recover recyclables from freshly collected USW from most likely producers like software firms and their canteens. Over 90% of the wastes dumps located are from this origin and suggests that better and cleaner methods needs to taken up to facilitate this recycling activity. The overall estimates have been verified and validated by three methods and the extent of deviation observed is well within targeted and useful range for such an activity. Therefore this method could provide rapid estimates of unauthorized dumping activities around other Indian cities as well. The total amount of waste disposed in unauthorized dumping is 158645t based on field measurement with average deviation of 46% in comparison to visual estimation.

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