A review of municipal solid waste data for Harare, Zimbabwe

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ABSTRACT: Municipal solid waste (MSW) data sources in Harare metropolitan province show significantly varying data with regards to generation and composition. The sources of variations include data lumping; exclusion of MSW managed outside the formal system and remain uncollected, lack of a clear definition of what constitutes MSW within the Zimbabwean context as well as temporal variations. It is therefore important for waste generation and characterisation studies to be undertaken building upon the already existing datasets to ensure the accuracy and reliability needed for data credibility for use in MSW management planning.

1 INTRODUCTION

Reliable and accurate municipal solid waste (MSW) data both on generation rate and characteristics (composition, moisture content, density and calorific value) for a given temporal and spatial scale is critical in deciding and planning the most appropriate and sustainable MSW management strategies (Aleluia and Ferrão, 2016, Palanivel and Sulaiman, 2014, Suthar and Singh, 2015, Dangi et al., 2011, Zaman and Lehmann, 2013, Hanc et al., 2011, EMA, 2014). The lack of universally agreed definition of MSW and methods to estimate MSW per capita generation rates and composition bring challenges in comparing and or benchmarking the reliability and accuracy of MSW data from various sources and different geographical areas of varying lifestyles. Different MSW definitions exist with the Intergovernmental Panel on Climate Change (IPCC) (2006), United Nations Department of Economic and Social Affairs (UN DESA) (2008) and Hester and Harrison (2002) defined MSW as those waste streams generated in urban environments that are managed by or on behalf of municipalities or other urban local authorities. This MSW constitutes food, park and garden, cardboard and paper, wood, disposable diapers, textiles, leather and rubber, metals, plastics, glass, pottery and chinaware, ash, dust, soil, dirt and electronic waste usually excluding demolition and construction derived wastes. This definition is relatively universal though variations exist amongst jurisdictions.

There are significant environmental impacts and additional costs consequences that arise from under and or overestimation of MSW generation (Beigl et al., 2003). Accurate MSW data thus allows for the prioritization of materials and energy recovery opportunities, attraction of investors in MSW management, baseline development for continuous long-term monitoring and evaluation and the formulation of informed MSW management policies. Worryingly reliable accurate MSW data is lacking in developing countries (Buenrostro et al., 2001, Kawai and Tasaki, 2016). Available MSW data is inconsistent as it comes from different sources difficult to validate and not scientifically measured but assumption based (IPCC, 2006, Couth and Trois, 2011, Miezah et al., 2015). This is despite the existing enormous MSW management challenges and the economic opportunities that are possible from materials and energy recovery in the MSW management sector.

Zimbabwe is no exception in regard to the deficiency of reliable and accurate MSW data associated challenges. National and sub national level statistics on MSW generation and characteristics is generally lacking as there has not been any holistically and systematically conducted studies on waste generation and composition. MSW data for Harare metropolitan province of Zimbabwe covering the Capital City, Chitungwiza and Epworth comes from various database sources and studies whose reliability and accuracy has not been ascertained. Therefore, this study seeks to establish whether the MSW data for Harare was systematically obtained or not to ensure reliability and accuracy for its use as baseline data for sustainable MSW management planning.

2 MATERIALS AND METHODS

2.1 *Description of the study area*

Harare metropolitan province comprises of Harare, the Capital City of Zimbabwe and its 2 dormitory towns of Chitungwiza and Epworth with a total population of just over 2 million (Zimstat, 2013). The uniqueness of Harare metropolitan province is its location upstream in the catchment of its potable water sources. The mismanagement of MSW generated in Harare metropolitan province is contributing to the eutrophic status of Lake Chivero. At present, slightly over 400 thousand tons of municipal solid waste is generated in Harare metropolitan province (Makarichi et al., 2019) with reported collection falling from 52% in 2011 to 48.7% in 2016 (EMA, 2016) indicating that almost half of the MSW generated remaining uncollected. Solid waste generated in Harare metropolitan province is being indiscriminately collected and dumped at the three official poorly managed dumpsites which are unprotected without leachate infiltration into groundwater prevention mechanisms namely Pomona for Harare, Chitungwiza for Chitungwiza and Golden Quarry for Epworth. Pomona covers an area of 100 hectares and has been operational since 1985 (Chijarira, 2013). The City of Harare Management records of 2010 indicate that the disposal capacity of Pomona dumpsite is expected to be exhausted by 2020. This calls for the need to redesign and define future integrated and sustainable municipal solid waste management strategies. Such future management strategies can only be feasible if reliable and accurate MSW data on generation, composition, characteristics and properties is available. Hence need to assess the accuracy and reliability of the available data which is the purpose of this study.

2.2 *Review of few selected MSW generation and characterisation methodologies*

MSW constitutes household waste generally reported to constitute between 55 to 80% with markets and or commercials areas constituting between 10 to 30% and varying contributions from institutions, streets and industries (Nabegu, 2010, Okot-Okumu, 2012). Therefore, MSW data from these sources need to be accounted for in any MSW data to ensure its reliability and accuracy. Estimating MSW data should involve the collection of MSW from where it is generated (households, restaurants, streets, supermarkets, offices) according to the criteria established by Tchobanoglous and Kreith (2002) as well as ensuring that MSW managed outside the official management system is also incorporated as argued by Abel (2007).

Temporal variations on a seasonal, monthly and week day scale (Tchobanoglous et al., 1993, Vesilind et al., 2002, Hanc et al., 2011, Gómez et al., 2009, Denafas et al., 2014) and geospatial variations (Miezah et al., 2015) exist in the quantity and composition of MSW generated depending on the prevailing socio economic situation. Estimation of MSW generation and characterisation data therefore need to consider all the MSW streams, temporal and spatial variations and the socio economic or demographic profiling (low density or high income, high density or low income and medium density or medium income of households).

Palanivel and Sulaiman (2014) randomly collected three 20kgs samples of MSW being disposed at a landfill per fortnight in winter and summer thereby considering seasonal variations and assumed 100% MSW collection efficiency which is rarely the case as there is also MSW that remains uncollected and managed outside the official systems. Suthar and Singh (2015) selected a sample of 144 households from 11 systematically identified blocks of varying socio economic status in Dehradun city of India. MSW generated from restaurants, supermarkets, hotels, schools, offices and streets was considered with no seasonal variations bringing some limitations regarding accuracy and reliability of the MSW data. Dali et al (2011) used three-stage stratified cluster sampling technique to analyse solid waste generated from 336 households that represented four socio-economic strata of Kathmandu Metropolitan City in Nepal considering MSW generated from restaurants, hotels, schools and streets as well and assuming the negligibility of temporal scale variations. Miezah et al (2015) considered three socio economic classes where households were determined using stratified, purposive and direct sampling technique in all the Capital Cities of the ten regions in Ghana without considering alternative MSW streams and temporal variations.

2.3 *Available MSW data for Harare metropolitan province*

Three sources of MSW data in Harare metropolitan province were obtained and analysed (Zimstat, 2016, EMA, 2014, Makarichi et al., 2019). The Ministry of Environment, Water and Climate (MEWC) in 2011 contracted the Institute of Environmental Studies (IES) of the University of Zimbabwe to undertake a baseline assessment of waste generation and management systems that characterised Zimbabwe in 2011 whose outcome facilitated the development of the national integrated solid waste management plan. The national biennial urban waste data collected by Zimstat (2016) is used by the United Nations Statistics Division (UNSD) and United Nations Environment Programme in the development of the UNSD International Environment Statistics Database. Makarichi (2019) estimated waste composition and generation to assess the suitability of MSW generated in Harare metropolitan province for thermochemical waste to energy conversion. The accuracy and reliability of these MSW data sources together with the appropriateness of the methodology used for data collection and estimation is vital in that the national integrated solid waste management plan was developed based on the EMA data, and also the UNSD International Environment Statistics Database is a source of data used by various stakeholders for decision making, research , and as well as thermochemical waste to energy conversion options in Harare.

3 RESULTS AND DISCUSSIONS

Tables 1 – 6 show the national, Harare metropolitan province and city specific MSW generation and composition for the three data sources.

Table 1. MSW generation in Zimbabwean urban environments (Zimstat, 2016, EMA, 2014)

Waste stream	Zimstat, 2016		EMA, 2014*****
	2014	2015	2011
		1,000 tons	
Commercial activities	-	-	485,72
Academic activities	-	-	72,03
Medical activities	-	-	34,14
Industrial activities	-	-	442,84
Other economic activities	100.53*	126.16***	-
Residential areas or households	291.64**	293.18 ****	614.84
Total	392.16	419.34	1649.57

*Data refer to Bindura, Bulawayo, Chitungwiza, Epworth and Mvurwi only

**Data refer to Bindura, Bulawayo, Chitungwiza, Epworth, Kariba, Kwekwe, Masvingo, Mutare, Mvurwi, Norton, Nyanga and Plumtree only

***Data refer to Beitbridge, Bindura, Bulawayo, Chitungwiza, Epworth and Mvurwi only

****Data refer to Beitbridge, Bindura, Bulawayo, Chitungwiza, Epworth, Kariba, Kwekwe, Masvingo, Mutare, Mvurwi, Norton, Nyanga and Plumtree only

***** Data refer to Harare, Bulawayo, Chitungwiza, Mutare, Gweru, Masvingo, Chinhoyi, Chegutu, Ruwa, Epworth, Domboshava and Murehwa

Table 1 shows that the national MSW generation data possesses discrepancies possibly emanating from a number of factors. The Zimstat datasets only considers MSW collected and managed within the official systems of urban environments leading to underestimation. What constitutes MSW differs in both datasets with Zimstat datasets considering other sources apart from households waste namely waste generated from ISIC divisions 36, 37, 39 and 45 to 99 while excluding waste from ISIC 38 activities associated with waste collection, treatment and disposal and materials recovery. The EMA data includes all solid waste from households or residential areas including other solids that does not constitute MSW with annual solid waste figures from commercial, academic, medical institutions and industry also being lumped inclusive of MSW constituents as shown in Table 3. The lumping associated with the EMA dataset therefore brings along with challenges in extracting accurate and reliable MSW data. Both datasets in Table 1 are not for the same urban environments and do not cover all the national urban environments resulting in underestimation and distortions.

Table 2. Harare metropolitan province MSW generation data (Zimstat, 2016)

Category	**Unit**	**2014**	**2015**
Total population of the Province	1,000 inhabitants	2,067.50	2,123.11
Average percentage population served by MW collection	%	61.40*	67.45*
Total amount of municipal waste generated		-	-
Municipal waste collected from households		239.12	181.98
Municipal waste collected from other origins		87.72	76.36
Total amount of municipal waste collected (=4+5)		326.84	258.34
Amounts going to recycling		17.27	23.39
Amounts going to Composting	1,000 tons	3.84	3.84
Amounts going to Incineration		0.26	14.65
Incineration with energy recovery		-	-
Amount going to landfilling		-	-
Landfilling with energy recovery and leachate treatment		-	-
Disposed at dumpsites		305.48	216.46

* Simple average for Harare and Chitungwiza only as Epworth population contribution to the metropolitan province is significantly low hence the 5% percentage served by municipal is negligible and would result in distortions

Makarichi et al (2019) reported a MSW generation for Harare metropolitan of 421,757 tons per annum with Tirivanhu and Feresu (2013) reporting a per capita daily generation rate of 0.361kg at household level translating to 279,751 tons per annum. This annual generation data from Tirivanhu and Feresu (2013) is expectedly lower as it projects a 33.6% increase in annual MSW generation in Harare from 2013 to 2017 considering an annual population growth of 2.2 reported by Zimstat (2013). This low estimation is because other waste streams such as supermarkets, restaurants, offices, streets etc were not segregated at a city level. Instead they were lumped at a national level in the commercial, academic, industry and medical categories without extracting per capita data from these streams at a city regional or provincial level. The MSW generation data for Harare metropolitan province like other Zimbabwean urban environments reported to the United Nations Statistics Division and UNEP by Zimstat (2016) is silent on the total amount of municipal waste generated. This data is based on the municipal waste collected from households and other sources leaving out the municipal waste that remains uncollected and managed outside the official system. With almost 50% of municipal waste collection efficiency as reported by EMA (2016) it therefore means there is significant underestimation in the Zimstat datasets. Municipalities need monitoring to ensure accuracy of data they provide to Zimstat as they might be tempted to report false coverage of population served by MW collection to improve their image.

Table 3. Contribution of the waste streams to the national mean composition of solid waste generated in Zimbabwe from the EMA dataset (EMA, 2014, Tirivanhu and Feresu, 2013)

Waste stream	Composition by mass (tons/year)									
	Biowaste	Paper	Plastic	Textile	Metal	Glass	E-waste	Medical	Rubble	Other
Residential	345,809	62,197	80,985	31,997	39,406	23,542	2,851	26,713		1,341
Commercial	76,411	181,233	127,643	24,490	29,775	9,080	12,915	15,798		8,371
Academic	12,801	27,892	20,344	94	10,270	313				313
Medical	3,775	6,540	3,329		365	254		18,980		893
Industrial	91,951	129,346	70,739	44,284	28,808		7,842		39,794	30,076
Grant total	530,746	407,207	303,040	100,865	108,624	33,188	23,607	61,491	39,794	40,995
Mean % composition	32	25	18	6	7	2	1	4	2	2

National average compositions of biowaste for the EMA datasets in relation to solid waste generated in 2011 shown in Table 3 and those reported to United Nations Statistics Division and UNEP for the years 2012 to 2016 in Table 4 with a minimum difference of 13.13% observed in

2012 indicating presence of inconsistences with regards to the datasets. Such inconsistences are a major cause for concern considering the importance of such data sets. The EMA dataset was used as baseline for the development of the national integrated solid waste management plan while the Zimstat dataset reported to UNSD and UNICEF are used for research and other planning purposes at national, regional and international levels in light of global concern on biodegradable waste landfilling. The same discrepancies are observed on the composition of paper with 25% recorded in the EMA dataset for 2011 in Table 1 and a maximum of 14.96% in the 2014 reported data by Zmstat to UNSD and UNEP in Table 3.

Table 4. Composition of solid waste collected from Zimbabwean urban environments for years 2012 to 2016 reported to the United Nations Statistics Division and UNEP (Zimstat, 2016)

Waste type	2012*	2013**	2014***	2015****	2016*****
	% weight				
Paper, paperboard	12.88	10.26	14.96	14.44	12.50
Textiles	1.13	2.88	3.40	2.72	1.24
Plastics	20.75	16.00	15.50	13.25	22.50
Glass	4.33	3.81	5.28	5.62	6.00
Metals	6.10	4.69	5.06	7.08	3.50
Other inorganic material	9.70	12.48	10.66	8.03	5.52
Organic material	45.13	49.89	45.16	48.85	48.75
TOTAL	100	100	100	100	100

*Simple average of Harare, Epworth, Kwekwe and Kariba

**Simple average of Bulawayo, Chinhoyi, Chitungwiza, Epworth, Kariba, Kwekwe, Norton and Plumtree

*** Simple average of Bindura, Bulawayo, Chitungwiza, Epworth, Gweru, Kariba, Kwekwe, Masvingo and Plumtree

****Simple average of Beitbridge, Bindura, Bulawayo, Chitungwiza, Epworth, Gweru, Kariba, Kwekwe, Masvingo, Mutare and Plumtree.

*****Simple average of Beitbridge and Gutu

Table 5. Percentage composition of MSW in Harare metropolitan province wet and dry basis (Makarichi et al., 2019)

Waste type	Harare	Chitungwiza	Epworth	Harare	Chitungwiza	Epworth
	% weight (wet basis) original composition			% weight (dry basis)after reconstitution		
Food	28.00	40.00	46.40	14.50	27.30	40.60
Paper	13.00	4.00	3.30	18.20	7.60	7.70
Yard	12.00	11.00	2.30	12.20	17.60	5.00
Other fines	1.00	2.00	0.90	1.20	3.70	1.90
Plastics	23.00	10.00	12.40	38.70	23.00	33.20
Textiles	10.00	11.00	5.10	13.50	20.80	11.30
Rubber	1.00	-	0.10	1.70	-	0.30
Glass	4.00	3.00	4.00	-	-	-
Metals	4.00	1.00	1.90	-	-	-
Rubble	4.00	18.00	23.60	-	-	-

Discrepancies do exist as well with regards to Harare metropolitan province waste composition data obtained by Makarichi et al (2019) and that observed under the EMA dataset shown in Tables 5 and 6 respectively.

Table 6. The mean composition of household solid waste in Harare metropolitan province (Tirivanhu and Feresu, 2013, EMA, 2014)

Urban area	% weight (wet basis)								
	Biowaste	Paper	Plastic	Metal	Glass	Textile	E-waste	Sanitary	Other
Harare	62	10	11	5	4	4	2	4	0
Chitungwiza	71	7	9	3	1	4	0	5	1
Epworth	42	12	14	15	6	8	1	2	0
Mean	58	10	11	8	4	5	1	4	0

With regards to biowaste these discrepancies are pronounced with only data for Epworth exhibiting some near similarities. Even after considering yard waste under biowaste the differences remain pronounced.

4 CONCLUSION

The MSW data review revealed that the available MSW data sources in Harare metropolitan province show significantly varying data with regards to MSW generation and composition. All sources of significant variations in the datasets need to be eliminated to ensure reliability and accuracy of the data for use in the planning and designing of sustainable future MSW management options for Harare. Such sources of variations include data lumping; exclusion of MSW managed outside the formal system and remains uncollected, lack of a clear definition of what constitutes MSW within the Zimbabwean context as well as temporal variations. However it is interesting to note that Tirivanhu and Feresu (2013) considered temporal variations as they collected data from January to November 2011considering all the annual seasonal variations. It is therefore important for waste generation and characterisation studies to be undertaken building upon the already existing datasets to ensure the accuracy and reliability needed for data credibility for MSW management planning.

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