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GENERATION RATE AND PHYSICAL COMPOSITION OF SOLID WASTE IN WOLAITA SODO TOWN, SOUTHERN ETHIOPIA

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Abstract

The ever increasing amount of solid waste generated which is exacerbated by lack of proper waste management system is of growing environmental and public health concern worldwide and in major towns and cities of Ethiopia. The aim of this study was to assess the current solid waste generation rate and compositions in Wolaita Sodo town, Southern Ethiopia. A cross-sectional survey and quantitative methods was used, and a multi-stage sampling method was employed including stratified random sampling, systematic random sampling, and purposive sampling. For house hold survey, sample size was determined using a population proportion formula. Structured and semi-structured questionnaire were used for interview, and direct waste analysis at source was used for waste characterization. A total of 378 household heads and 30 key informants were interviewed. The study showed that solid waste generation rate of Sodo town is 0.47 Kg/cap/day and this is greater than most major towns of Ethiopia. The major sources of municipal solid waste were residential, commercial and institutional sectors. The composition by weight of the households were food (59.5%); ash and dust (25.08%); yard waste (11.6%); plastics and rubber (2.04%); paper and cardboard (1.12%); and textile, wood, glass and metals accounted only 0.1%, 0.16%, 0.2% and 0.2% wastes, respectively. More than 97.6% of solid wastes generated from households and 93.7% of municipal solid waste were biodegradable wastes. The study revealed that the town generates about 18,858,464 Kg of solid waste by wet weight per year. The town municipality must develop an appropriate solid waste management plan and implement to properly manage this huge amount of solid waste.

Key Words: *Wolaita Sodo, Solid waste, generation, composition*

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Introduction

Collecting and managing solid waste is an important challenge for countries across the world (Zerbock, 2003). Ogawa (2000) indicated that many cities and towns in developing countries are not able to manage solid wastes due to institutional, regulatory, financial, technical and public participation shortcomings.

Municipal solid waste management (MSWM) is one of the basic services that are currently receiving wide attention in many towns of Ethiopia. This is mainly because SWs that are generated in most towns of Ethiopia are not appropriately handled and managed (Dereje, 2001; Solomon, 2011; Endalu and Habtom, 2014; Afework, 2015 Mengie *et al.,* 2015; Mohammed, 2015). However, it is possible to minimize and solve these problems through strictly planning and implementing different MSWM components and options.

The first and the most prerequisite step for provision of efficient MSWM is identification of major sources, and determination of generation rate and composition of MSW. This is because these elements are considered as a baseline for the rest of MSWM components. Thus, reliable and accurate data about these elements is very decisive**.** Therefore, the major objective of this study was to assess the household and MSW generation rate and physical composition in Sodo town.

Materials and Methods

Study Area and Population

Wolaita Soddo town, the administrative capital of the Wolaita zone, is located 390 Km South and 167 Km of South West of Addis Ababa and Hawassa, respectively. The town is located $6^0$49" N latitude and $37^0$45'' E longitude. Currently, the total area of the town is about 3,200 hectares and is divided in to three sub town ("Kifle-ketema"), eleven "kebeles" (administrative units) and ninety nine villages ("mender"). Based on the 2010 Census, the town has a total population of 110,660 (male 58,407 and female 52,252) with the projected annual growth rate of the 4.8 % (CSA, 2014).

Study Design, Sampling Procedure and Data Collection Tools

Cross-sectional survey design and quantitative methods was used in the study. The quantitative study method was used to collect data on demographic characteristic of the study participants; quantity and composition of SW generated, and factors contributing to increase in waste generation.

The study employed a multistage sampling method including stratified random sampling, systematic random sampling, and purposive sampling to identify or select the study sites and participants (households, Key Informants (KIs), SW sampling institutions and commercial establishments). From the three sub towns ("Merkato", "Mehal ketema" and "Arada"), a total of five kebeles were randomly selected i.e. two from Merkato (namely, "Merkato Gebeya" and "Fana"); two from Mehal ketema (i.e."Damota" and "Wadu") and one from Arada (i.e. Kidane mihret) that represent each cluster. The study participants HHs were randomly picked from sampling frame using systematic random sampling method. In this study HHs who lived in the town for one year or longer were considered.

For the survey, sample sizes of HHs who participate in the study were determined using the single population proportion formula developed by Cochran (Cochran, 1977) with the desired degree of precision for general population. Therefore, sample size calculation gave a total of 378 HH respondents.

A total of 30 KIs were purposely selected to participate in the study based on their wide exposure to SWM issues, the position they held in the community, their proximity to appreciate the problems of SWM. These included four road SW sweepers; three waste management experts from the town municipality; four private waste collector association members; five Kebele administrators; two town administration officers; three Wolaita University teachers; two Technical and Vocational Education Training (TVET) college teachers; three public health officers and four health extension workers.

To collect data from HHs, a semi-structured questionnaire with closed and open - ended interview questions were used and the interview was carried out by researchers in the house of the HHs. To collect data from KIs, a structured individual questionnaire was used, self-administered to the 30 KIs and collected back by the researcher.

Solid Waste Samples Collection

For SW sample collection, the same five kebeles and house of HHs selected for the survey were also used. Waste sample collection was focused on three types of SWs generated in the town, i.e., HH, institutional, and commercial. A total of seven institutions and twenty commercial establishments were randomly selected. Furthermore, municipal waste samples were collected from the town waste dump site.

Quality Assurance

All the original questionnaires were prepared in English language and were translated into Amharic. To check the accuracy of the translation, a back translation was made. Pre-test of questionnaires was conducted to allow the researcher rehearse before the main study in order to check the clarity of the questions, to eliminate difficulties, and to estimate the length of time a respondent take to complete . Therefore, any problems in the content of the questionnaires were resolved during the pre-test.

Data Analysis

Statistical analysis of data was carried out using SPSS version 20.0 statistical package program. Data were recorded, organized and summarized in simple descriptive statistics methods and mean, percentage, frequencies and range were used to describe the findings.

Ethical Considerations

For the survey, ethical clearance was obtained from the Ethical clearance committee of Hawassa University. Before entering the study area, local authorities and community leaders were briefed about the objective of the study. Respondents participated in the study was voluntary and each respondent was asked to give verbal consent to participate and each HH was assured that the information provided will be kept confidential.

Results and Discussion

Socio-Demographic Characteristics of Study Participants

A total of 378 HHs were participated in the study and among them 211(55.8%)

were males and 167(44.2%) were females. Majority of the respondents (78.0%) were 15-64 years old and 22.0% of them were above age 65 years. Almost half (51.3%) of HH completed secondary school, 32.0% completed primary school and only 8.2% and 6.9% were college/diploma and first degree and above holders, respectively. Majorities (93.4%) of respondents were married and the remaining 3.4% and 3.2% were divorced and widowed, respectively (Table 1).

Considerable proportion (31.5%) of HHs reported being merchants and the other occupations include private employee (24.6%), daily laborers (14.6%), civil servants (11.9%) and others (5.2%). However, about 12.0% of the respondents were unemployed at the time of the survey (Table 1).

Table 1: The Socio-demographic characteristics of household and Key Informants participated in the study

Socio-demographic characteristics		Respondents	
		Households (n =378)	KIs (n =30)
Sex	Female	167(44.2) *	16(53.3)
	Male	211(55.8)	14(46.7)
Age		295(78.0)	27(90.0)
	≥ 65	83(22.0)	3(10.0)
Educational level	Unable to write and read	6(1.6)	-
	Primary school (1-8)	121(32.0)	2(6.7)
	Secondary school (9-12)	194(51.3)	1(3.3)
	College Diploma	26(6.9)	5(16.7)
	First degree and above	31(8.2)	22(73.3)
Income	Low income (≤ 3000 ETB*)	197(52.2)	-
	Middle income (3001-6000 ETB)	161(42.6)	-
	High income (>6001 ETB)	20(5.2)	-
Family size	1-3	13(3.4)	-
	4-8	22459.3	-
	> 8	141(37.3)	-
Marital status	Single	-	-
	Married	353(93.4)	-
	Divorced	13(3.4)	-
	Widow/widower	12(3.2)	-
Occupation	Civil servant	45(11.9)	-
	Private employed	93(24.6)	-
	Traders/merchants	119(31.5)	-
	Daily laborers	55(14.6)	-
	Unemployed	46(12.2)	-
	Others	20(5.2)	-

* Values in parenthesis are percentage of n; ** ETB = Ethiopian Birr

Almost half (52.2%) of the HHs reported having low income and the middle and high income class accounted about 43.0% and 5.0%, respectively. The low income, middle income and high income HHs family size was 5.6, 5.0 and 4.6, respectively and the average for Sodo town was HHs was 5.1 persons. Approximately 59.0% of the respondents had in average six family size and about 37.3% participant had more than eight family members (Table 1).

A total of 30 KIs were participated in the study and among them 16(53.3%) were female and 14(46.7%) males. Almost all KIs (90%) fall within age range of 15-64 years and 10% were above 65 years. The majority of KIs (73.3%) were first degree and above holders. About 16.7% were college diploma holders, 6.7% and 3.3% completed primary and secondary schools, respectively. About a third (33.3%) of KIs were municipality experts, 26.7% were health officers and 16.7% were environmental experts. The others 13.3% and 10% were private association waste collectors and road sweepers, respectively (Table 1).

Solid Waste Generation Rate

The daily SW generation rate of Sodo town for low-income, middle and high-income HHs was 28 kg/capita/day, 0.38 kg/capita/day and 0.76 kg/capita/day, respectively (Table 2). This indicates that the waste generation rate of higher income HHs was about 2.7 times higher than lower income HHs. Consistence with the findings of Wells (1996) and Ngoc and Schnitzer (2009), SW generation in Sodo town has direct relationship with income level. This may be as result of some HHs earning more and have better life standard (i.e., high-income HHs), and consequently use more consumable materials than low income HHs do, and hence the former group had the tendency to generate a larger quantity of SW per day. Similar trends were observed in Arada Sub-City of Addis Ababa (Yitayal, 2005; Solomon, 2006) Adama town (Lema, 2007) and Makurdi inNigeria (Sha'Ato, *et al*., 2007).

Similarly, occupation of respondents showed relationship to waste generation since most of the respondents (about 70.7%) were merchants, employee in non-governmental and private sectors. Therefore; they might have earned more, hence have higher demands for goods to purchase and generate more wastes. Moreover, the marital status of HHs and their family size also showed a direct relationship with SW generation. The present study showed that the majority of study participant HHs were married (93.4%) and the average family size of HHs was about 5.1, which is higher than that of overall family size of urban population of Ethiopia (i.e. 4.6) (CSA, 2001). For instance, married families usually have larger family size, and therefore generate more SWs. The HHs waste generation rate was found to be positively related with family size which means families with more individuals generate a larger quantity of SW per day. Similar trends were observed in Arada Sub-City Addis Ababa (Yitayal, 2005; Solomon, 2006), Adama town (Lema, 2007) and Makurdi-Nigeria (Sha'Ato *et al*., 2007).

The average SW generated in Sodo town is estimated to be 0.47 kg/capita/day; 14.2 Kg/capita/month and 170.4Kg/capita/year. This generation rate is higher when compared with study findings of comparable major Ethiopian

towns, such as the 0.229 kg of Gambella town (Afework, 2015); 0.235 Kg of Debre Markos (Mengie, Venkateswarlu and GopalaKrishna, 2015); 0.41 kg of Hossana (Endalu and Habtom, 2014); 0.157 kg of Jimma (Dagnew *et al*., 2012); 0.231kg of Dessie (Solomon, 2006); 0.21 kg of Gondar (Mohammed, 2015); 0.267 Kg of Adama (Dereje, 2001); 0.277 Kg of Mekelle (Gebretsadkan, 2002). But it is lower than the 0.55 kg of Debre Brihan town (Tyagi *et al.*, 2014).

When compared with available data from some Ethiopian cities, per-capita SW generation of Sodo town is also higher than the 0.25 Kg of Addis Ababa (Nigatu *et* al., 2011); 0.22 Kg of Bahirdar (Gebrie, 2009); 0.231 Kg of Hawassa (Yeballeork, 2014) and 0.233 Kg for East African cities developed by WHO (Birke, 1999; Gebrie, 2009).

The annual SW generation (by weight) for the whole population of the town is estimated to be 18,856,464 Kg or 20,789.9 tons (Table 2). This is higher than the 11,660,392 Kg of Adama town (Lema, 2007); 11 million Kg of Hossana (Endalu and Habtom, 2014); 5,433,025 Kg of Gambella town (Afework, 2015); 4,197,600 Kg of Gondar (Mohammed, 2015); 8,276,375 Kg of Jimma (Melaku, 2008); and 4, 3353,600 Kg of Mekele (Dagnew *et al*., 2012).

Table 2: Solid waste generation rate of HHs in Sodo town (n = 378)

Variables (SW generation rate)	Low income (n = 197)	Middle income (n = 161)	High income (n = 20)	Average
Average family size	5.6	5.0	4.6	5.1
Average Kg/HH/week	10.89 (5.50 - 16.53)	13.36 (9.5 - 32.5)	24.63 (15.0 - 40.50)	16.26
Average Kg/HH/day	1.56	1.91	3.52	2.33
Average Kg/capita/day*	0.28	0.38	0.76	0.47
Kg/capita/month	8.4	11.4	22.8	14.2
Average Kg/capita/year**	100.8	136.8	273.6	170.4

* SW generation (Kg)/capita/day = Kg/HH/day divided by average family size;
******Total population of Wolaita Sodo town was 110,660 (CSA, 2014)

Almost all respondent KIs (Table 3) indicated that rapid population growth, increasing commercial activities, rapid urbanization, poor awareness of residents about environmental sanitation and socio economic status of HHs were the major causes of rapid increase in generation of MSW. About 26.6%, 23.3% and 30% of respondents (Table 3), respectively, also indicated that construction activity, poor town planning and illiteracy, cultural and religious inclinations were also the driving force for increased MSW generation.

Table 3: Factors that contribute to an increase in MSW generation as reported by KIs (n=30)

Causes	**Yes**	**No**
Rapid population growth	30 (100%)	-
Rapid urbanization	30 (100%)	-
Increase in Commercial activities	30 (100%)	-
Increased construction activities	8 (26.6%)	22 (63.4%)
Poor town planning	7 (23.3%)	23 (66.7%)
Improved socio economic status of HHs.	30 (100%)	-
Poor awareness of residents about environmental sanitation	30 (100%)	-
Illiteracy, cultural and religious inclination	9 (30%)	21 (70%)

According to "Yedamot Tsedal" (2004), waste generation rate of Sodo town has increased in the last couple of years. Constant with the current study result (Table 3), the driving forces behind that increase in Sodo town and elsewhere in other developing countries are rapid increase of population size, increased commercial activities, changing consumption patterns, economic development, and changing income (Ngoc and Schnitzer, 2009). Rapid population boom is due to rural-urban migration. The reasons for rapid urbanization and commercial activities seems to be due to good and attractive urban development policy encouraged by the government and the town being a gate way and center of business for all "Woredas" within the zone, special woredas and other zones.

Physical Composition of Solid Wastes

Eighty percent of the KIs ranked SW sources in descending order as: residential, street, hotels, commercial and institutional wastes. This result is almost similar to that (except industrial sources) reported by Tadesse (2004) in Addis Ababa. The major composition of the HH SW were food (59.5%); ash and dust (25.08%); yard waste (11.6%); plastics and rubber (2.04%); paper and cardboard (1.12%); and textile, wood, glass and metals accounted only 0.1%, 0.16%, 0.2% and 0.2% wastes, respectively (Table 4). This result shows that municipal waste is an aggregate of all substances ready for disposal or disposed in the study area. The composition of the solid organic waste was almost homogenous in nature across the study HHs.

In present study, the largest proportion (59.5%) of total HH SW was food (Table 4). Moreover, the proportion of food waste (81.9%) at damp site of the Sodo town (Table 5) was much higher than that reported from Adama (37.8%) (Solomon, 2006) and Debre Berhan (33.0%) (Tyagi *et al.*, 2014).

Tchobanoglous *et al.* (1993) stated that the larger portion of SWs of developing countries is food waste. Likewise, Cointreau and Coad (2000) confirmed that wastes from urban areas in developing countries have a much higher percentage of food waste in their over all waste mix. For example, 36% in Makurdi-Nigeria, (Sha'Ato *et.al.,* 2007), 40.7% in Guadalajara, Mexico (Perez *et al*., 2008). These proportions were lower than that reported in the present study.

Waste generated from offices, academic institutions (schools, university

and colleges) and health care facilities were categorized as institutional wastes. The physical composition analysis of SW revealed that 41.0% of institutional wastes were paper and paper products followed by food wastes (32.0%), plastics (11%), and construction wastes (5.0%). The ash and dusts; yard waste; wood; e-waste; glass; textiles; metals; accounted a small fractions, i.e., 2.5%, 2%, 1.5%, 1.0%, 1.0%, 1.0%, 0.5% and 1.5% , respectively (Table 4).

Results (Table 4) of the present study indicated that fractions of paper and related wastes were higher in institutional SWs followed by commercial wastes. Plastic and rubber wastes were also higher in commercial wastes (12.4%) followed by institutional SWs (11.0%). The amount of above mentioned wastes were relatively lower in municipal disposal site. The possible reasons for this might be the largest fractions of these wastes were burned at sources of generation either at HH, institutes or municipal level. The proportion of plastic and rubber reported in present study (5.0% by weight) is higher than the 4.8% of Hosaina n (Endalu and Habtom, 2014) and the 2.9% of Adama (Lema , 2007).

The average biodegradable SW share of HH, commercial and institutional was found to be 97.6%, 75.2% and 79.0%, respectively. When the average proportion of biodegradable SW share of the three sectors is considered together, the first three highest compositions were food (42.2%), paper and cardboard (22.7%); and ash and dust (10.8%) wastes (Table 4).

Table 4: Physical composition of SW of residential, commercial and institution sectors by proportion of wet weight**.**

SW category	SW composition	Residential **	Commercial	Institutional	Average
		% by Wt* (Kg)	% by Wt * (Kg)	% by Wt* (Kg)	% share
Bio-degradable	Food waste	59.5	35.0	32.0	42.2
	Ash and dust	25.1	4.8	2.5	10.8
	Yard waste	11.6	0.5	2.0	4.7
	Paper and cardboard	1.1	26.1	41.0	22.7
	Wood	0.2	5.2	1.0	2.1
	Textile (Worn out cloth)	0.1	3.6	0.5	1.4
	Total	97.6	75.2	79.0	83.9
Non-biodegradable	Metals	0.2	6.4	1.0	2.5
	Plastic and rubber	2.0	12.4	11.0	8.5
	Glass	0.1	2.2	1.5	1.3
	E-wastes	0.01	1.6	1.0	0.9
	Total	2.4	22.6	14.5	13.2
Others (mixed)		0.03	2.2	6.5	2.9

***** Wt = weight; ****** Residential refers to HH waste

The results (Table 5) of a study on dampe site of Sodo town municipality revealed that the highest proportion (81.9%) was food wastes and plant materials (such as wood, leaves, grass, etc) accounted about 10.0% of the waste. Other type wastes identified included: plastics and rubber (2.3%), paper and cardboards (1.0%),

textile (0.76%), glass (0.62%), and metals (0.4%). Furthermore, the immerging waste like electrical and electronics (e-wastes) account only small fractions (0.6 %) that included CD/VCDs; broken cell phones; parts of computers, television, radio, etc. The total proportion of biodegradable waste at disposal site of Sodo town was 93.7% (Table 5).

The present study also revealed that the combined share of total biodegradable SWs for the three sectors and that identified from damp site of Sodo town were 83.9% (Table 4) and 93.7 % (Table 5), respectively. Such a high proportion has been reported by studies conducted in many different cities of most of the developing and developed countries and in many different cities and town of Ethiopia. For example organic waste constitute of 80.0% in Debre Berhan (Tyagi *et al.*, 2014), 2014), 59.17 % in Addis Ababa (Arada Sub-City) (Yitayal, 2005); 74% in Indonesia (Walhi, 2001) and 52 - 65% in Nigeria (Imam *et al*. 2008).

Table 5: Average physical composition of municipal solid waste sampled from disposal site.

SW category	SW composition	Percent by weight
Bio-degradable	Food waste	81.9
	Wood, leaves, grasses	10.0
	Paper and cardboard	1.0
	Textiles (Worn out cloth)	0.8
	Total	93.7
Non-biodegradable	Plastics and rubber	2.3
	Metals	0.4
	Glass	0.6
	Electronic wastes	0.6
	Total	3.9
Mixed		0.5

Solid waste generated in Sodo town has high content of biodegradable waste (ash, food waste, yard waste, etc.) that can be composite (about 84.0% of HH waste) and recyclables material (plastics, glass, metals, etc.) about 13.0%. These all account for about 97.0% of the total waste generated in the town and if all could be recycled and reused, the municipality would remain with almost 3.0% waste to be disposed. A similar trend was observed in Jimma town (Melaku, 2008) and Gambella towns (Afework, 2015). Moreover, investment in recycling and composting would create job and engage a good number of the unemployed, greatly reducing the quantity of SW to be disposed. Furthermore, recycling will recover raw materials which would otherwise be wasted.

Conclusion

Findings of this study indicated that the biodegradable and recyclables material in the SW generated in the town waste account for about 97.0% of the total. If at source sorting, composting of

the organic waste and recycling should be encouraged and formalized, cost of SWM in the town would be greatly reduced and job will be created. This calls for the town authorities to develop plans, policies, rules and regulations to that effect.

Furthermore, the HHs average SW generation per-capita/day in Sodo town is 0.47 Kg and the town generates more than 18,856,464 Kg of SW (by weight) per year. This huge amount of SW generated in the town requires a good management to protect and bring about a healthy and sustainable environment. Therefore, the town municipality must develop an appropriate SWM plan and promptly implement it. Developing such management plan requires understanding the existing SWM practice in the town. Thus, a detailed further study must be conducted on existing knowledge, attitude and practice of the community in WM; existing WM practices and problems in the town, stalk holder's and public participation in WM, etc.

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