

Situation Based Solid Wastes Source Characterization: The Kibuye Market and Other Peri-urban Ward Units - Kisumu City (Kenya)

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Abstract- Solid Wastes management (SWs) characterization and 3Rs benefit is lacking and an integral problem of Kisumu city today, at best a scavenging level effort *that needs a shift*. The study characterized and quantified SWs streams because of the varied reported estimates. Also, it was for finding a cheap and sustainable participatory approach of characterizing the daily generation. The study area choice was then based on existence of waste pickers for a fee and the organic matter at Kibuye market. Data was collected by pre-trained waste actors and market representatives. Generation rates (2010 to 2015) by researchers averaged 200 to 450 tons daily, against 135 to 400 tons daily from present and a previous study, at a base population of 500,000. 400 tons daily also has been quoted and used, as Kisumu city strategy paper up to 2025 suggests 210 tons daily. These points to need for a comprehensive re-check of the values. Organizing waste management today require understanding of its *dispersed* nature, *material characteristics, unit associations, enforcement of weighing, the law and Service Centers* for data collection for planning, as there is little to show from Kisumu today.

Keywords - Solid Waste, Characterization, Waste Pickers, Participatory Approach, Service Centers.

I. INTRODUCTION

Kibuye market and other unit generation areas (Manyatta/others and Obunga settlements) discussed are within Kisumu city which lies between latitude 00°02'N; 00°11'S and longitude 34°35'E and 34°55'E, standing at an elevation of 1,131 meters above sea level (Atieno *et al.*, 2017). The location and origin of Kisumu city within Kisumu county is also variously explained by Aguko *et al.*, 2018; Munala and Moirongo, 2011. Kibuye market is next to Jaramogi Oginga Odinga referral hospital, bordering the Kisumu – Kakamega road, on a 12 ha land with a population of 30,000 – 35,000 persons daily and

60,000 to 70,000 on Sundays (market days). The market was started in the 1950's and later became a solid waste dumping site until the activity was rejected by locals and moved to the present Kachok dump site (Aguko *et al.*).

The net effect of Kibuye today is; it's the largest open-air market in East Africa and a daily solid waste (SWs) generating city unit. Other City generating units are; households, businesses (Central Business District), Industry ('Jua Kali') and other markets (Kiboswa, Nyamasaria, Otonglo and Mamboleo) that are as a result of goods and services that flow in and out of the city as waste (SWs, waste water and sewage). Water and sewage have the compelling demands to flow respectively due to dire need and odor inclusive of clumsiness. The two flows are further assisted by force of gravity (slope effect) in pipe systems and even in the pit latrines. This is unlike the SWs.

The SWs volume per unit time depends on generation rate and may be bearable for some time but finally inflicts demand that must be handled and disposed of. Water flow starts at a place to dispersed units while SWs and fecal matter is the reverse. As such, SWs flow needs lifting and deposition as use of slope factor in transport is minimal. These processes thus require forms of technology and management; and are the point of departure in cities, cultures, and communities. The proper starting point especially for SWs management would be characterization. This is the first integral problem of Kisumu city today, as there is minimal attempt in this direction.

There are activities on SWs management chain that would benefit from characterization, for example the 3Rs which in Kisumu at best can be graded at scavenging level efforts. The whole scenario is an issue of interactions with entities, sensitivity to environment, the technologies and the policy but the question remains; which way is the SWs

flow in Kisumu City from the status quo. The aim was to characterize and quantify solid wastes streams in light of the wide range of the volumes/quantities so far reported for the city. This was to assist in proposing a sustainable and participatory approach that is cheap and embodies science in determining on a regular basis the amount of solid waste that is generated in the city. This entailed a review of aspects of SWs flow from generation to position of imbedding characterization as an incentive (3Rs) and ingredient before the dumpsite. Focus was also on challenges to the SWs flow system operation to the current SWs management structure.

A. Governing Waste Management

Solid wastes understandably arise from a dispersed geographical area and are required to be dealt with at a concentration point, the dumpsites in most African cities. This is opposite in water and sewage flow. A city like Kisumu therefore needs an organized structure of SWs from generation to disposal. There must therefore be laws and bylaws or norms to deal with the issue of SWs management in its entirety. In Kenya, apart from Local Government Act CAP 265, the other two useful legislations are the Public Health Act CAP 242 and the Environmental Management and Co-ordination Act (EMCA) No. 8 of 1999 within the prevailing culture and practice. Thus, the city bylaw is derived from these.

The key skeleton needs of a solid waste management should encompass (i) bylaws (ii) health and safety (iii) promoting education and awareness (iv) Monitoring, evaluation (v) and largely effective engagement of the generators; where necessary; associations, businesses in which forms of permits may be given to participants. It should be noted that this chain is not water or sewage pipe that is pre-conditioned, but should be interactive. The waste management bylaws for Kisumu were revised in 2008, but implementation is still low due to capacity level of awareness. Kisumu Waste Management Association (KIWAN), as a voluntary association of waste pickers is just but a sign of low capacity, though very essential as data collection for this study was done with involvement of KIWAN.

II. METHODOLOGY

A. Data Collection

General information regarding solid waste management, generation and its composition for the 14 administrative Wards in Kisumu City were gathered from research publications and the Kisumu town management discussions. The existing waste characterization practice/methods were reviewed vis-à-vis the available materials, human resources, area conditions and time constraints. The categories of the SWs in addition to the socio-economic factors were thus taken into account.

The existing methods as listed in Dahlen & Lagerkvist (2007) were reviewed but were by no means compulsory. Adopting a standard waste determination method would not have been absolute. The Kisumu waste management structure was fluid (from discussions) and varied with Wards or units. The option was a situation choice of interest and for an output of value. Kibuye market in Kaloleni-Shaurimoyo ward, Manyatta in Kondele ward and Obunga informal settlement in Kondele ward comprised the situation of interest for the case studies, where data were collected for 14 consecutive days except on Sundays (market day) for Kibuye. Sunday is the market day and wastes collection is not easy due to lack of space. Data for Manyatta/others was also collected for 14 consecutive days. Data from Obunga informal settlement in Kondele ward was collected for seven consecutive days.

Data was collected by help of research assistants (waste actors and market representatives) who were trained before engagement. The assistants were duly compensated but under an overall supervisor and the researchers. The wastes collection activity was done from households except for Kibuye where it was undertaken in the designated market sections. These were transported by vans, handcarts, and wheelbarrows as was appropriate to the temporary open deposition point or at skip designated places (service center). These were spread at these points, segregated and weighed according to the waste streams. The data collection activities were captured by photographs, data sheets as the weighing was by a spring weighing scale.

B. Selection of Study Area

Kibuye market in KaloleniShauri-Moyo Ward is among the many waste generating units under the Kisumu city, the 3rd largest city in Kenya that is located in Kisumu Sub-County among others. It is the County's headquarter and the principal city in Western Kenya. The city has over the years become one of the leading communications and trading junction for the Great Lakes region (Tanzania, Uganda, Rwanda and Burundi) and one of the fastest growing cities in the Country. The city serves 14 administrative wards as is listed in with 310 Sub Wards and varying population (2009 census) for every ward.

Kibuye Market was selected for the study owing to its unique size as the largest open air market and probably one of the highest generators of organic wastes on a daily basis in Kisumu. The nearby areas within Kondele and Railways Wards have mixed households (high, middle and low income) which previous studies considered wholly as Low/Middle income category. This may not be true. Obunga in Railways ward however is a low income household area with occasional middle and high income households. The waste generating areas within the three administrative Wards (Kondele, Railways and KaloleniShauri-Moyo) are neighboring administrative wards and at best can be described to be generators of mixed wastes with varying percentages.

C. Situation in Generating Areas

Documents review and discussions with Kisumu city management was fundamental in understanding how a characterization exercise for a particular area needed to be approached (E-cueassociates (2015), CGK (2015), CGK SWs Bill (2014).The Kisumu Integrated Solid Waste Management Strategy (2015-2025) though recommended options for source separation to include the 3-colour system bins, curbside and House-to-house/door-to-door collection. It was noted that little had been done except for the Central Business District (CBD) where the three colour system was introduced but has not been appropriately utilized. It was also eminent that instituting source separation in line with literature (European Commission, 2004) recommendations for any research objective within the prevailing conditions would require a lot more resources. Thus, the approach was to review the existing situation and utilize it where it would have value (Kibuye, Obunga and Manyatta/other areas).

The 14 administrative wards with the Sub Wards were also noted to have challenges and variability that required different approaches to implementation of source separation. Sampling as a procedure of selecting the wards or sub wards for source separation was also not advantageous guided by knowledge and challenges of the solid waste management practice in those wards or sub wards. Kibuye market in Kaloleni sub-ward of KololeniShauri-Moyo Ward was thus chosen because of the volume of organic matter. Obunga in Nyawitasubward of Railways Ward and Manyatta in Manyatta B sub-ward of Kondele Ward were selected because of proximity to Kibuye in addition to them having some mixed distinct level dwellings.

The method adopted for SWs source separation at Kibuye, Obunga and Manyatta/other areas consequently arose from the discussions with the private solid waste pickers (KIWAN) and the City' management responsible for the wards. It sounded easier and cheaper to use the private waste picker;asa way of undertaking the source separation. The second approach depended on the today Kibuye Market management arrangement as is instituted by the city. It has a structure (Table 1) of two market masters and deputies responsible for part of Kibuye market namely whole sale and retail sides. Their responsibility mainly covers planning for the market, revenue collection and cleanliness of the market.

D. Kibuye

Kibuye is divided into 14 sections (Table 1) which in order covers; Vegetables, Fruits, Cereals, Green maize, Carpentry, Textile, 'Mtumba' (2nd hand clothes), Hotel, Ready-made clothes, Second hand shoes and bags, Onions and Tomatoes. Apart from the market masters and security, each section is manned by a volunteer representative. Cleaning or sweeping is also done by volunteer employees, notably four in number who are paid or taken care of by the combined traders from the sections. It takes over one month to clean the market with this arrangement and always not done adequately. A lot would remain unattended; a situation that ends up attracting illegal depositions within the market empty spaces. The city management hence provided none centrally stationed three skips (service center) within Kibuye market. The skips are picked daily as is appropriate and taken to the Kachok dumpsite by the city management; with none source solid wastes separation. This situation assisted in building up the conditional method of source separation of the SWs before transportation to the Kachok dumpsite.

During the study period, the number of the volunteer section sweepers (VSS) was added to 9 people. Apart from sweeping and taking the wastes to the skip, the other responsibility was separation of the SWs into the categories before deposition into the skips. One of the VSS was given the responsibility of ensuring all sections targeted for the day's work were done well. A team at the skips with an overall supervisor, a record clerk and other two who were specially undertaking the source separation, checking quality, weighing by categories and transferred the wastes to the skips. The SWs to the skips could next be mixed and tractor towed to the dumpsite. The frequency depended on time to fill and tractor availability. The Sweeping arrangement was as in Table 1 for the days of the study.

E. None Market Areas

Obunga and Manyatta/other areas were different as private SWs pickers were allowed to operate. One skip was at Obunga below a city road bypass. In manyatta/other areas, there were neither skips nor temporary waste deposition center nor arrangement by City management for the SWs removal. A temporary center (service center) was hence established in consultation with the local administration by a road for purposes of the study. The SWs pickers in Obunga and Manyatta/other areas, on their own efforts identified households that required their services. The City management in both areas had no arrangement for door to door SWs collection or a waste source separation. The waste pickers hence made their own arrangements for a monthly fee, between waste pickers (WPs) and the waste generators (WGs).

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Table 1: Kibuye Solid Waste Section Collections by the Day

Day	Section Attendance	Contents of Section	Day	Section Attendance	Contents of Section
1	a) Vegetable	a) Tomatoes, Onion	2	a) Vegetable	a) Vegetables, tomatoes,
	b) Fruits	b) pineapple, Oranges,		b) Fruits	b) Onions, Pineapple's, Oranges and passions
	c) Carpentry	c) mangoes, melon, sawdust and		c) Textile	c) used Pieces of materials, cloths
	d) Textile	d) banana material pieces		d) Mtumba	d) soles
3	a) Vegetable	a) Cabbages, tomatoes, onions,	4	e) Second hand shoes	e) Ashes, Food remains
	b) Fruits	b) mangoes, pineapple, Oranges, melons, avocado,		a) Hotel	a) Vegetable, onions, carrots tomatoes
	c) Maize	c) maize cobs & leafs		b) Vegetable	b) Sawdust.
	d) New cloths	d) Papers/ cartons		c) Carpentry	
	e) Hardware	e) Glasses and blanket waste			
5	a) Carpentry	a) Sawdust	6	a) Vegetable	a) Cereals, vegetable and onions
	b) Secondhand bags	b) Used bags and belts Nb; Vegetable and some fruits was brought by traders themselves		b) Fruits	b) Mangoes, avocado and oranges
				c) Ready-made cloths	c) Clothes tags boxes/paper
7	a) Vegetable	Vegetable, carrots, tomatoes, onions	8	d) Second hand shoes	d) Soles and Shoe straps
	b) Hardware	- Glasses and blanket waste		e) 2 nd hand item	e) Used clothes and storage bags
9	a) Vegetable	a) Cabbage, tomatoes, onions, carrots and cereals	10	a) Vegetable	a) Vegetable, carrots, tomatoes, onion
	b) Fruits	b) Mango, passion, melon and orange		b) Fruits	b) Melons, mango, pineapples, sugarcane, avocado
	c) Maize	c) Maize cobs and leafs		c) Carpentry	c) Sawdust
	d) Hardware's	d) Paper (boxes) glasses and Blanket waste		d) Second hand shoes	d) Soles and covers
				e) Ready-made clothes	f) Boxes and polyethene
11	a) Vegetable	a) Vegetable, spinach, cabbage, onion, carrots.	12	a) Vegetable	a. Vegetable, tomatoes, onion fish rejects and Irish potatoes
	b) Carpentry	b) Saw dusts		b) Fruit	b. Mango, avocado, melon and passion
13	a) Vegetable	a) Cabbages, carrots, kales, spinach and Irish potatoes	14	c) Carpentry	c. Saw dust
	b) Fruits	b) Orange, mango,		d) Hardware's	d. Hash and food remains
	c) Hotel	c) bone and banana		e) Hotels	b) Boxes
	d) New clothes	d) outer covers		a) Vegetable	a) a)Tomatoes, cabbages, onions
				b) Fruits	b) Sugarcane, pawpaw, melon and avocado
		c) Maize	c) Maize cobs and leaves		
		d) Hotel	d) Tomatoes, kales and ugali (Maize Meal Bread)		
			a) Vegetable	a) Cabbage, kales, spinach	
			b) Fruits	b) Pawpaw, melon, mango and oranges	
			c) Hardware	c) Glasses,	
			d) Cereals	d) Maize, beans and rice	
			e) 2 nd hand Cloths	e) boxes and blanket wastes	

The waste pickers in their perception also identified the households within their jurisdiction as Low, middle and high income for SWs collection. The original number of WPs team was then beefed up after discussion on how to handle the daily SWs. The front runner team moved to the generators homes to source for the SWs. The second team of the WPs loaded the SWs at site, downloaded and re-loaded at the appointed temporary center on either a hand cart or pick up to the dumpsite. The third team was at the collection center where they did separation according to the decided criteria (categories). The activity of separation was thenceforth undertaken, weighed and shoveled back to the means of transport and taken to the Kachok dumpsite. The number of people who undertook separation depended on the load at hand.

III. RESULTS

A. *Quantity of Solid wastes and Characterization*

An in-depth understanding of the SWs generation (waste stream) in particular area was observed to be a real need for planning such as pampers that were a special challenge of all the wastes due to its characteristics. Different wards/transfer points can host different solid waste enterprises depending on the waste streams. The Kisumu County Government therefore has a challenge to organize regular forums with the residents to enable interaction for a better understanding of how to manage waste for the different population cadre's areas. This should be followed by development and application of policies that specifically governs waste disposal in the informal settlements and an oversight on illegal disposals/dumping. Details of variability are as covered under the ward units of the study (Kibuye, Manyatta/other areas and Obunga).

B.

The area units discussed indicates variation of quantity and types of solid waste generated in the Kisumu city. This is summarized as situation in the wards. Also, the units illustrate sustainable, cheap, participatory (co-production) and scientific methodological approach that can be employed by like Cities to regularly collect data on wastes management.

C. *Kibuye Market*

The cleaning/sweeping of the 14 sections were carried out as in Table 1. Averagely, four sections of the market were cleaned everyday by the 15 man team apart from heaps that existed before exercise. Three of the team members were already working within the market cleaning system. Table 2 indicates that cleaning or sweeping of the vegetable and fruit sections were more frequent, almost on a daily basis. Second hand items were the third most common sweeps. The hotel (local) picks were low as the remains were also purchased for dogs or kept for sale the following day.

The cleaning study activity started on 11th Sep. 2018 and ended on 26th Sep 2018 for the Kibuye market. The constituted cleaning team did the work smoothly with a lot of questions from the traders. Keen interest was on why weigh and separate the wastes. The team informed the traders of an organization (KLIP) who wanted to know the volume and components of waste generated in Kibuye market on a daily basis for city planning. The team found that, many sections for a long time had not been cleaned; the wastes were decayed and could neither be sorted at source nor at the temporary collection center.

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Table 2: Kibuye Market Solid Waste Generation and Separation – Weight by Day

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	Kg/Day
Vegetable	615	875	1,231.50	855	862	1,892.50	1,293.50	1,804.50	2,107	1,383	851	1,487	1,513	1,082	16990	1213.6
Fruits	398	266	512	242	492	646.5	213	1,208	488.5	330.5	295	757.5	361.5	467.5	6677.5	477.0
Saw Dust	181	84.5	272.5	421.5	626.5	145	157.5	300.5	281.5	260	674	98	180	199	3881.6	277.3
Maize	66.5	70	183.5	178.5	362.5	160.5	200.5	78.5	369	64.5	152	198	59.5	57	2200.5	157.2
Paper	112	76.5	119	97.5	74	361.5	160.5	291.75	167	122.5	59.5	143.5	101	118.5	2004.8	143.2
Plastics	8	3.25	110	1.5	3	16	10	4.25	0	3.75	9.5	44	4.5	2.5	220.25	15.7
Ash	7	17	20.5	8.5	19.5	32	7	18.5	57.5	11.5	27	17	38	15	296	21.1
Others	777	1,855	1,379	896.5	1,075	1,423.50	873	1,766	1,233	1,020	592	897	1,290	1,142	16217	1158.4
G. Total	2163	3247	3828	2701	3515	4677.5	2914.5	5472	3842	3195.75	2659.5	3641.5	3547.5	3084	48,488	3463.4

Other variability's noted during clean-up period were; (i) Market days (Sundays) were congested and cleaning operations could not proceed. Always, for this particular market there is an influx of traders from other counties within the western region, some come from as far (\approx 400 Km) as capital City of Nairobi. The volume of sweeps thus was high on Mondays through to Thursday and lean on Friday and Saturdays. (ii) One time the tractor broke down, the Skip could not be towed and this caused work stoppage (iii) the period of the study coincided with the tomatoes season in some counties and thus the frequency and volume of vegetables, as a lot also perished by the day. Some traders felt they could be paid for the waste. (iv) Plastics may not have been as many and frequent, as "street boys" also collected these at the market for sale elsewhere (v) The variability on type of wastes was instituted by the specific days that were allocated for none frequent services areas, such as timber area where sawdust was the main item (vi) On sunny days, organic wastes were being collected by local farmers from the peri-urban areas to feed cows and pigs; these were mainly vegetables, waste tomatoes and avocado. The weight of wastes on these days were lighter compared to rain days (vii) The column of other waste as in Table 2 comprised mainly of; bone's from the butchery, pieces of shoe soles, pieces of materials (cloths), blankets pieces, used sacks, pamper pieces, pieces of glasses, used matt pieces, saloon/Berber shop wastes and electronics. A total of

48,524.09kg (nearly 5 tons) was collected in a period of two weeks as in Table 2. This would amount to 1,265.1tons in a year, which is useful for planning purposes especially the last column of the kg/day.

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Table 3: Manyatta Area/Others

Class	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	Total	LIA	LIA	LIA	LIA	LIA	LIA	Total	HIA	HIA	HIA	Totals
	1 trips Kon Hotels	1 trip Oga Area	1 trip Kon Hotels	1 trip Mig Area	1 trip Tunl	1 trip Sky Way	2 Trips Gud	1 st trip -Gud	2 nd trip Gud	MIA	1st Trip umo	2 nd trip corner legio	3rd Trip Kay Area	1 st Trip ;KonH seHol ds	2 nd Trip Meta Meta Area	1 trip ges	LIA	1 trip Wig Hotel	1 trip Riat	1 Trip Mam	HIA
WARDS	Kon	Kol	Kon	Mig	Kon	Kon	Man	Man	Man		Kon	Kon	Man	Kon	Kon	Man		Kaj	Kaj	Kaj	
Hh	5	18	5	30	60	48	75			241	10	60	15	32	32	32	181	1	18	90	109
Organic	244	206	86	167	122	97.5	239	117	226	1505	65	138	77	151	161	85	677	78	124	233	435
Plastics and Pet	18	7.5	4.5	31	15	25.5	16	14	22	154	2.5	9	8	33	3.5	49	105	41	7	93	141
Polythene	4	16	11	15	7.5	5	15	20	9.5	103	4	5.5	4	20	1.5	4.5	39.5	14	4	19	37
Paper	9	22.5	7	11	16	20.5	32	11	35	164	10	12	13	22.5	3	9.5	70	23.5	11	41	75
Pampers	7	49	0	33	25	16	6	77	23	236	12	10	7	16	24	26	95	41	22.5	96	159.5
Shoes	0	0.25	4	0	4.5	8	4	8.5	0.5	29.8	3	2	0	4.5	0	1.5	11	11.5	4	1	16.5
Bones	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	9	19.5	11	53	83
Bottles	12	7	7.5	6	8	9	0	2	12.5	64	0	0	5	3	0	9	17	5	13	5	23
Metal	0	0	0	0	0	0	5.5	0	0	5.5	0	2		1.5	0	1	4.5	0	0	11	11
Glass	0	0	0	0	1	0	2	2.5	4.5	10	0	4		6	0	0	10	0	0	0	0
Others	24	13	22	8.5	18	24.5	73	31	38.5	253	18	31	5	58	47	24	183	6.5	15	34	55.5
Totals	318	321	142	272	217	206	393	283	371.5	2523	115	223	119	315.5	240	209.5	1221	240	211.5	585	1037
Avg/Hh Unit	64	18	28	9	4	4	5	4	5	10	11	4	8	10	8	7	7	240	12	7	10
Avg/Hh/ Capita	12.7	3.6	5.7	1.8	0.7	0.9	1.0	0.8	1.0	2.1	2.3	0.7	1.6	2.0	1.5	1.3	1.3	48.0	2.4	1.3	1.9
RP	1.6	0.4	0.7	0.2	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.1	0.2	0.2	0.2	0.2	0.2	6.0	0.3	0.2	0.2

5 people per Hh; (RP)Return Period of Waste Collection ; Kon (Kondele, Oga (Ogango), Tun (Tunnel),Gud (Gudka), Umo (Umoja), Kay (kayego), Ges (Gesoko), (Wigot), Man (Manyatta), Kaj (Kajulu), Mam (Mamboleo), Hh (Household)

Table 4: LIA, MIA, HIA and LMH

Categories	LIA	LIA/ Day	MIA	MIA/ Day	HIA	HIA/ Day	LMH- Total	LMH/ Day
Organic	677.0	37.6	1504.0	83.6	435.0	24.2	2616.0	327
Plastics and Pet	105.0	5.8	153.0	8.5	141.0	7.8	399.0	49.9
Polythene	39.5	2.2	103.0	5.7	37.0	2.1	179.5	22.4
Paper	69.5	3.9	163.0	9.1	75.0	4.2	307.5	38.4
Pampers	95.0	5.3	235.0	13.1	159.5	8.9	489.5	61.2
Shoes	11.0	0.6	29.8	1.7	16.5	0.9	57.3	7.2
Bones	9.0	0.5	0.0	0.0	83.0	4.6	92.0	11.5
Bottles	17.0	0.9	64.0	3.6	23.0	1.3	104.0	13
Metal	4.5	0.3	5.5	0.3	11.0	0.6	21.0	2.6
Glass	10.0	0.6	10.0	0.6	0.0	0.0	20.0	2.5
Others	182.0	10.1	252.0	14.0	55.5	3.1	489.5	61.2
Totals	1219.5	67.8	2519.3	140.0	1036.5	57.6	4775.3	596.9

Low income Areas (LIA), Middle income Areas (MIA), High income Areas (HIA), Low, Medium and high income areas (LMH).

D. Manyatta/other Areas Settlements

- i. The following were noted by observation and from Tables 3 and 4 for Manyatta/others area settlements;
- ii. A total of 520 Hh were sampled (181 LIA, 231 MIA and 108 HIA). Respectively 10 and 1 hotels were included in Kondele and Kajulu wards. It means that a total of 2,600 (905 LIA, 1,155 MIA and 540 HIA including 10 middle class and 1 high class hotels) people were covered if there are 5 people per Hh.
- iii. Paper and polythene were more by volume as at the middle and high income areas. This could be attributed to shopping patterns which is common in the supermarkets and they had interest in paying for waste collection.
- iv. Pampers were notably less in solid wastes for the low class. Old newspapers probably were used and thrown into pit latrines. This could be observed in relation to densities of pit latrines and presence of piped water to households or distance to the water source. This class mainly shopped at the nearby local shops and stalls and as such the young ones was handled differently.
- v. There were also disparities in behavior with the solid wastes among the low class. At Kondele (showed exposer) compared to Manyatta as many households

were willing to pay for the waste services and some simply dumped their wastes by the road at night.

- vi. At Gesoko, a low class with a high population, many local brew bottles were recovered in addition to presence of flying toilets (waste paper used as such and thrown away).
- vii. Bones were hard to come by at the hotels as many collected them for their dogs, except from Wigot hotel which could be due to restrictions as it is a high standard hotel.
- viii. The increased waste generation at the high and middle class areas was due to; easily found food leftovers, used shoes, cloths and sandals that were dumped while in good conditions. The house helps and security guards though assisted by selling plastics and papers to the dealers.
- ix. Gudka was a mixed area but from Table 3; average generation of wastes per category was higher in the high class followed by middle class and least in the low class areas. This is with respect to the number of households (or units) that were sampled per category. What was peculiar was the high quantity of Bio degradable wastes in the low class as compared to the absence of bones and glass from the middle and high classes.

E. Obunga Area

Obunga area comprised Sega sega, Kamakowa, Nyawita and Obunga as a unit. Three groups dealt in waste collection and especially households. They christened themselves as waste champions. Their main aspiration was to be trained in making compost manure from organic wastes and especially from the Kibuye team who were already practicing composting. In this area, organic wastes included fish bones and intestines which arose from petty trade in Nile perch remains from the nearby fish dealers by the Lake Victoria, within the industrial area. Re-use or circulation of waste is a petty trade that is already taking place within this area. Apart from fish remains, the teams were already separating wastes at source for plastics and bottles for sale to the dealers from the many local pubs and local brewers within the area. There was even a request for a paper bailing machine identified by the teams as a hope for enhanced potential in sale of paper.

It can be observed that Obunga and its environs had fewer categories of wastes and where there is coincidence between Table 5 for Obunga and Table 3 for Manyatta/other areas, the rate of generation differed. Notable, is the paper and bottles which are higher in Obunga (Table 5) compared to Manyatta/other areas (Table 3) based on the number of households sampled and thus the prompt for business in the same at Obunga.

Table 5: The Obunga Situation

Area	Obunga	Riat	Nyawita/ Kamakowa/ Sega sega	Kamak owa	Total	Avg
Types/ days	1	2	3	4	Total	Avg
H/h	16	36	69	24	145	Picks
Paper	55.5	36.05	73	22.5	187.05	46.8
Plastic & Pet	87	16	75	16.5	194.5	48.6
Bottles	92.5	41.5	112	0	246	61.5
Organic	676.75	354.5	463.5	157	1651.8	413
Pampers	31	77	86	23	217	54.3
Others	188.5	37	424.5	130	780	195
Iron	3	4	8	0	15	3.75
Total	1134.25	566.05	1242	349	3291.3	822.8
Per –Hh	70.89	15.72	18.00	14.54	119.15	29.8
Day/Hh	10.13	2.25	2.57	2.08	17.03	4.3
Per Capita	2.03	0.4	0.51	0.4	3.34	0.84
Avg/Per Capita	0.29	0.06	0.07	0.06	0.48	0.12

F. The Wards Situation

Among the three wards compared in Table 6 (Kondele, Railways and Kaloleni - Shaurimoyo) derived from Tables 2, 4 and 5; where waste source separation was done with regard to the existing conditions especially the SWs flow; the notable variations were that organic matter was higher in Kibuye than Obunga and Manyatta/other areas combined. Pampers were absent in Kibuye. Plastics in general were higher for Manyatta/other areas and Obunga compared to Kibuye in Kaloleni-Shaurimoyo ward. Bottles and metal were present in Manyatta/other areas and Obunga though not significant for metals. Other wastes were higher in Kibuye compared to the other two wards put together. This is an indicator that there are variability's in SWs types in all the wards within Kisumu city. Consequently,

for purposes of planning each ward there is need for a detailed understanding of the waste types. The behavior on solid wastes management in each ward may then require different treatment and especially the structure for the SWs flow (Table 6). Obunga in Railways ward (Table 6) had higher rate of wastes per day for a smaller sample compared to Kondele Ward with a larger sample.

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Table 6: The Wards Summary

Ward	Kondele	Railways	Kaloleni/Shauri-Moyo
Categories	Gudkaetc	Obunga	Kibuye
Organic	327	413	0
Plastics/Pet	49.9	48.6	15.7
Polythene	22.4	0	0
Paper	38.4	46.8	143.2
Pampers	61.2	54.3	0
Shoes	7.2	0	0
Bones	11.5	0	0
Bottles	13	61.5	0
Metal	2.6	3.75	0
Glass	2.5	0	0
Vegetables	0	0	1213.6
Fruits	0	0	477
Saw Dust	0	0	277.3
Maize	0	0	157.2
Ash	0	0	21.1
Others	61.2	195	1158.4
Per –Day	265.4	822.8	3463.5

Nb- Kibuye is primarily distributed Organic

G. Present Variation and Previous Situations.

There is need for a re-assessment of the quantity of wastes generated in Kisumu city. The variation of data is large and raises questions on how they were determined. The range is so great to be scientific and especially where waste management lacks a coherent hierarchy from generation to dumping for every corner of the city.

The scenario by KISWM (2015) and Atieno *et al* (2017) in Kisumu isolates rates for Milimani, Kenya Re, Migosi, Nyalenda and Manyatta respectively as in Table 7 for high, middle and low income areas and is accordingly compared to Obunga, Manyatta/other areas and Kibuye (Tables 2, 3&4). The generation per day per person as from Table 4 covering Manyatta/other areas and Obunga shows rates that are almost similar to sources 1 and 2 for HISG, MSIG and LSIG. In Kibuye (Table 6) the generation rate is an average of 0.049 and 0.115 (0.082kg/person/day) with reference to market population of between 70,000 and 30,000. What is unique in Table 7 is the average/total differences between the periods of the survey, which if extended for the total population is an under estimate. Using the totals from the Table 7 (source 1, 2 and 3) and populations

(500,000) the range for the City output is 400to 630 tons/day; from which the average is 135 to 210 tons/day. This can be summed to an average range of 267.5 to 420 tons/day. The 400 tons/day consistently used for the city planning today thus may not be accurate. The variability in each cluster by weight needs confirmation. Source 2 in Table 7 is out of range in the cases of HISG and MSIG and was done in 2015. ObungaLSIG is also surprisingly low. Manyatta and Migosi for MISG and LSIG are comparable for Table 3 and Table 7.

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Table 7: Previous Data Compared to Present

Socio-	Source 1	Source 2	Source 3	Source 4
Economic Group	Atieno <i>et al</i> (2017)	KSWM (2015)	Data of the study (2018)	Data of the study (2018)
HISG	0.36 (Milimani)	0.54 (Milimani)	0.4 Manyatta/Others	Nil
MSIG	0.24 (Migosi)	0.45 Kenya Re	0.2 Manyatta/Others	Nil
LSIG	0.21 (Obunga)	0.27 Nyalenda/Manyatta	0.2 Manyatta/Others	Obunga (0.12)
				<i>Kibuye (0.082) high population</i>
Average (Total)	0.27 (0.81)	0.42 (1.26)	0.27 (0.8)	Nil

Atieno *et al* also modeled HSW (House hold Solid Wastes) generation using socio-economic and demographic data in Kisumu urban estates (Table 7) for High Income (Milimani), Middle Income (Migosi), Low Income (Obunga) which was selected through multi-stage simple random sampling. They used questionnaires and direct waste weighing (Gomez *et al* (2008), Dieu *et al* (2014), Aisa (2013)) to obtain primary data for the household characterization. Their Multiple linear regressions concluded that socio-economic and demographic data were appropriate in modeling HSW generation and that knowledge on household solid waste quantity is essential for planning solid waste management in a city. The house hold was assumed to have an average of five persons. From the Table 7, the HSW generated showed an increasing trend from the LSIG to HISG. The inherent difficulty in applying their model is the dependency on direct weighing and knowing the ever-variable socio-economic parameters of communities. The data from that study shows a reduced rate for the MSIG based on the approach that was used but comparable to the present study.

In terms of figures for Kisumu, there has been a variation. Munala and Moirongo (2011) states that about 20% of the 400 tonnes (in doubt now) of solid waste in Kisumu is generated/collected and transported to the dumpsite daily. Agong and Otom 2015; Gutberlet *et al.*, 2017; Magezi 2015; NEMA 2015) says the generation rate is estimated between 200 and 450 daily, varying (different) with the average range in this study of 270 to

420 tons/day. Gutberlet *et al.*, 2017 estimates organic wastes to be between 62.5 to 67% by weight. Kisumu Integrated Solid Waste Management Strategy (2015-2025) however puts the total domestic waste generation rate for Kisumu city at 210 tons/day (or 0.42Kgs/Person/Day) and with an average overall household size at five (5) persons. 385 tons of waste per day is also mentioned in the same document and that only 25% is effectively collected. The rest ends in the backstreets, markets, road sides and open spaces more so in the informal settlement. Based on Table 7, 0.42 Kg/day/person is higher than the other two studies of 0.27 kg/day/person as the average for HSIG, MSIG and LSIG. Using the totals (Table 7), it is the present study Source 3 and 1 that estimates 400 tons/day (0.8 multiply by population of 500,000) as upper limit. These figures vary sharply hence need verification study for planning and contemplation of 3Rs. Table 6 is generated as a template view needed for planning if all units in the City were to be properly documented.

KISWM baseline survey of 2015, Agong/Otom (2015), Okot/Okumu (2012) in Table 8 summarizes the Kisumu solid waste stream by types/categories/quantities/generation rates. The wastes by sectors by tonnage are also reflected in the same table. The total tons per day are 373 which are towards the upper limit of this study and source 1 in Table 7.

Table 8: Wastes Data, 2012 and 2015

Waste Composition	Tons/Day	% Wastes	Annual (tons)	% wastes Agong /Otom (2015)	% Wastes Okot/Okumu (2012)	Sectors KISWM (2015)	Daily Tons
Organic Waste	235	63.1	85,850	65 -70	63	Industries	6.5
Paper	46	12.3	16,735	5 -9%	12.2	Markets	145
Plastics	38	10.2	13,877	6 -12%	10.2	Hospitals	12.5
Glass	12	3.2	4,354	0.7 – 4	3.2	Others	11.25
Metals	5	1.3	1,769	0.3 -3	1.3		
Others	37	9.9	13,469	0.4 – 1	9.5		
Total	373	100	136,054	77.4 – 99	99.4		

Of importance from Table 8 is the organic waste which is over 60%, plastics and paper which are within 12% range and the rest are below 5%. It is worth noting that the others are below 10% and variable. This summary has a sharp difference of what is presented for Railway (Obunga), Kondele (Manyatta/Other areas) and Kaloleni-Shaurimoyo (Kibuye). Percent estimates in this respect means very little with respect to total weights for different clusters. (Table 6 and also Table 8). The percentages can be same for high or low weights. It means, for all the wards there will be variations of figures by weight but percentages could be within the same range. Estimates for further planning should therefore be focused by region, clusters or area and purpose of the data and by weight. The key question is to understand and nature the issues (Munala and Moirongo (2011)) that could transform the Kisumu SWs management system to one that need no stir up, but self-moving.

At Kachok, the final Dump for the wastes in Kisumu, Agukoet *al* (2018) on an earlier finding indicated it was not properly sited and was at 10% or lower deposition rate of the city's wastes since the 1970's. The heap could not justify the deposition rates advertised in literature for Kisumu, for example 200 to 450 tons/per day. This is even if settlement rate was taken into account.

The average dump composition in the order of plastics, glasses and organic matter was 34.7, 13.8 and 51.8% and weight per volume that varied by depth/age with an estimated volume of 6853m³. Table 6 for the Wards to date indicates the organic matter to be over 50% with Kibuye as a special case with over 60% organic matter. Plastics and glass though present in the wards but were lower than 10% in all the cases. The dumpsite (Kachok – now being removed) could have been different due to accumulation of scavenging and recirculation that has been going on to date. The figures in percentage are not far apart in distribution from past to present with respect to the organic matter, though weight changes might have occurred. The rate at Kachok indicated need for improved planning, regulation and enforcement for the city and the Kisumu County. This is true even for the present study.

Munala and Moirongo (2011) captured the spirit of waste management as is in Kisumu today. They identified core issues in waste management to include review of the commercial viability of wastes, appreciating its potential as a raw material, appropriate technology in its handling and thus a need for proper infrastructure for a flow delivery till destination that maintains quantity and quality within the living environment. Kisumu city management should thus stir the system to react and drive it away from 'business-as-usual' attitude.

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They emphasized that; already many technologies to facilitate some of these processes (for example the 5Rs) are in existence. It's only a matter of socio-cultural behavioral change at the household level and creation of an acceptable chain in the waste management where populations are willing to participate. The composition of waste in a city depends on the existing sectors, public consumption patterns, lifestyles, income and cultural traditions but is on the increase. Residents at the moment do not separate waste at household level and burning is a common mode of disposal. This literature emphasizes reorganization on waste management and thus the need for use of home-grown solutions such as the suggested data collection through private waste pickers.

Elsewhere in the Philippines NSWMC reports of 2015 also concurs with Munala and Moirongo (2011) generally that, waste characteristics comprises; composition, rate of generation and categorized into biodegradable and non-biodegradable wastes. The report established that waste generation rates varied (just as in this study- Table 6) with regions in the Philippines. That the city generation rate was highest at 0.79 kg/capita/day and other parts were as low as 0.10 kg/capita/day (appreciated in Table 5). That these depended on income level, economic activity, and waste policies etcetera that relates to GDP with an average generation rate for the Philippines at 0.40 kg/capita/day (Kisumu is between 0.27 to 0.42kg/day/person – Table 7 and needs confirmation). Their reports of between 2008-2013 suggests that typical waste composition is dominated by biodegradable wastes at 52.31% and can vary from 30% to 78%. The same report estimates that 86.2% of organic waste is mostly from food residue and the rest are leaves and twigs. Also, the recyclable wastes comprised about 27.78% of municipal solid wastes (MSW) and a range of 4.1% to 53.3%. The plastic packaging wastes accounted for 38% of recyclable wastes, paper and cardboard comprised around 31% that includes metals, glass, textile, leather and rubber. Special wastes (hazardous materials) constituted 1.93%, but varied from negligible to 9.2%. The residuals constituted a share of 17.98%, a mix of disposable wastes and inert materials. This means cluster variations should be taken into account for waste estimates. Kisumu may consider this aspect though the idea is within those in the horizon for the city.

IV. CONCLUSIONS AND RECOMMENDATIONS

The key aspects of the solid waste management that concern Kisumu are the *dispersed* nature of the SWs, the *material characteristic* for an entrenched 3Rs businesses, element of *unit associations*, *weighing* SWs material and *the law* within the space of the people's attitudes. Last is the principle of reaching all corners of the wards by *Service Centers* that is; to help build a pyramid of the material flow from the generators to the dumpsite, of cause with emphasis on the inner consumption by the 5Rs (Reduce, Recycle, Re-Use, Re-Think and Re-sale). All these should culminate to an integrated SWM approach that is advanced by many writers (Lund, 1984; EPA, 1989, Kootatep, 1995; Ogawa, 1997, Kibwage, 2002). Planning for a proper dumpsite should also be enhanced as the current is being removed.

SWs is a (*dispersed*) material that needs everybody. It cannot be conditioned to a behavior as it is characteristically variable with time and space. The Kisumu city handlers are too few for a large area with inherent constraints (financing, technology and the society), hence inadequacy. It's not as simple as supervising a sewer or water pipeline. The Kenya government has an administrative system called "MjiKumi" or Ten Houses. It was evolved to make administration be closer to people at minimum cost. Presumably the city can enforce close voluntary associations (as the evolving Obunga Associations) to take care of SWs at a Unit levels and also contemplate introduction of space and place everywhere in the city for the SWs. This could be escalated to city planning standards, dwellings, industries, petty trades and other commercial ventures. Every space in the city is 'owned' and it would be fine for owners to be responsible for the space sweeps, vigilance and depositions. Let the city demarcate equitable deposition spaces and enforce the same to be at owners' spaces. The flow from temporary deposition space should be the responsibly of the city or contacted private providers. It's at this point where separation (or scavenging) should be arranged to happen before transfer to the landfills.

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The dominant **Material** waste types in households (Obunga, Manyatta/others/ Kibuye, all Tables) and the Kachok dumpsite are organic, paper and plastics at their respective percentages. This is confirmed elsewhere by NSWMC report of 2015. This particular report is confined to what the waste pickers deal with, inclusive of the households they serve but a lot of many type households were not covered. However, the trend revealed is also comparable to what is in the Kisumu previous reports and elsewhere but with weight variability.

KIWAN (Association of waste pickers) is an example of a need created for the solid waste management. They are basically waste pickers at a fee. The associations modality could be relied on in the meantime until arrangement for own picks and pickers including modality benefits from reuse, recycling and delivery to a designated temporary center are done. Significantly; in Manyatta/others there are no city designated SWs deposition centers. The city should create these and it is from where the SWs are picked and towed to the dumpsite. This is an evident practice in Kibuye where traders by own arrangement does the sweeps and deposits at Skips (the designated temporary center). The city only undertakes the towing and supervision of the market activities for revenue including SWs.

Weighing (tool of source separation) is a key element in data collection for solid wastes or its segregation. There should be an area manned by the association or individual for segregation (the temporary center). The proceeds from the re-use or recycling could be property of the association, funds from which they manage the area and the SWs. The flow of the 3R's benefits could be an agreement between the generators and their associations or the individual responsible for the center. The city could also specially introduce an incentive to the associations or individuals for the purpose. This can be a periodic affair like annually, though monetary but based on specific parameters of monitoring and evaluation. It would be a base planning tool.

The Law is for the people and as such should be developed from the people. The basic laws for SWs management are (or should be) hinged on the Kenyan national laws (Local Government Act CAP 265, Health Act CAP 242, and the Environmental Management and Co-ordination Act (EMCA) No. 8 of 1999). The city bylaw is guided by these but should adopt existing practices or borrow relevant successes from elsewhere. The three model examples are; the Kibuye Sellers, Manyatta/others (Waste Pickers) and Obunga association waste dealers where there is respectively own arrangement for sweeps and waste picks/the city providing the skip services. Manyatta/others is own arrangement for waste picking and delivery to the Kachok dump site. The administrative wards/sub wards could be utilized for planning for the temporary centers with involvement of the space owners (generators) into appropriate and manageable unit organizations and thus a pyramid to the dumpsite.

The **Skip Service Centers (Service Centers)** if appropriately placed may be the main arteries for data, segregation for the 3Rs, management and environmental control. These to be evolved into a flow structure or a body like the Kisumu water and sewerage company (KIWASCO) with its leadership and an interaction role with the generators known by space (digitized). The study therefore adopted **skip service centers** and own arrangement to dumpsite for the SWs source segregation or separation. Own arrangement model depended on the actors or waste pickers knowing waste generators in their social settings. This existing flow model was preferred because household weighing level arrangement required additional time, labour and cost.

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