



# Assessment of the Aesthetic Quality in a Rural Community in Cameroon: Using Litter Survey Technique

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## Abstract

The issue of poor waste management in rural communities is still a challenge and whose practices are still elementary in developing countries. This paper evaluates and assesses the solid waste management in rural communities using litter survey technique, Muyuka, Cameroon. The objectives were; to assess visible litter along the roadway and main road in Muyuka town, to determine the litter rate within the study area, and to estimate the most littered item and lastly to evaluate the effects of the most littered item on the environment. Litter survey check listing was developed and done with site reconnaissance survey and with a GPS. Purposive data collections along four roadways, four main roads and from seven different grids were also collected and analyzed using SPSS. Results show that roadways were twice heavily littered (22,294) than main road (10,204) because of lack of local storage facilities, poor follow up, and sensitization campaign. Also 08.46 litter items/metre were visible at a detectability function of 85% (*i.e.* items greater than 1 m<sup>2</sup> in surface area) with at least 04.94 plastics litter/metre of which 03.50 plastics littered was LDPE plastic type coupling with the low decay rate of plastics ( $\lambda = 0.0014$ ) on the environment, due to resins. Total visible litter in Grid 1 and 7 were 1544 and 8394 respectively. Conclusively, the level of SWM was too poor within the town. Along roads, roadway is twice heavily littered whereas in grids, Grid 1 is the cleanest. As recommendation this work should serve as a standard baseline litter survey manual for further research assessment in rural council with single used plastics discouraged with sanctions.

## Subject Areas

Plastic Pollution Control, Ecotoxicology and Safety

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## Keywords

Disposal, Litter Item, Litter Survey, Plastics, Solid Waste, and Solid Waste Management

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## 1. Introduction

Litter generally refers to waste in the wrong place. The presence of litter can either result from a personal behavioral attitude where waste is deliberately thrown into the environment—especially on the go or a spillover from inadequate solid waste management where waste at collection sites/receptacles is spatially redistributed ([1] [2]). Litter can accumulate almost anywhere in the urban environment, including private, commercial, industrial and public spaces. Public spaces, including parks, green areas, and areas next to roads, railways, and waterways, are also common areas for litter to be present. Uncollected litter, if not cleaned up, can remain in place; continue to accumulate; or be transported by water, wind, animals, or human activities [3]. The predominance of litter and heaps of solid waste is one of the most visible signs of improper solid waste management in many African countries. Although limited in number, a few studies have been carried out on the problematics of littering in Africa ([4]-[6]).

Litter is comprised of any solid or liquid waste generated from residential, commercial or institutional sources and items can include paper (small pieces and packaging paper), drink bottles (both plastic and metal), glass, metal, cigarette butts, fabric, plastic wrappers, bottle caps, other bottles, plastic straws, wood, food, abandoned vehicles, abandoned vehicle parts, construction or demolition material, garden remnants and clippings, and soil sand or rocks. Similarly, any other material, substance or thing deposited in a place if its size, shape, nature or volume makes the place where it is deposited disorderly or detrimentally affects the proper use of that place, whether or not it has any value when or after being deposited, is considered to be litter ([7]-[9]). This form of pollution of roads, public transport facilities, markets, schools, playing grounds and other public or semipublic spaces is unpleasant from the viewpoint of city hygiene and increases the financial costs associated with the cleanup of these places [10].

[11], identify five negative impacts associated with litter which includes, aesthetic blight, health hazard impact, blocked drainage and flooding, increased costs associated with refuse collection and crime. Litter is a physical “symbol of disorder” or “incivility” along with vandalism, dilapidated or abandoned housing, and dirty vacant lots [12]. More importantly, unmanaged litter challenges civic order by representing the absence of management ([13] [14]). As such, it is often synonymous with environmental and social problems related to garbage ([15] [16]). The latter can seriously damage the attractiveness of the neighborhood, heighten safety concerns, and have negative impacts on visitors and businesses.

The direct cost of litter control can be enormous and can significantly increase

the cost of solid waste management. Local cleanup campaigns and manual sweeping are measures employed in certain parts of the city to address this issue. However, it is highly inefficient since the element of redistribution of these items move them to places that are inaccessible and difficult to reach, such as gutters, streams, soil, green spaces and forests. The consequence is that heaps of waste are found scattered and littered around the communities. These items provide habitat to disease vectors such as flies, rodent and mosquitoes, facilitating the transmission of common diseases like malaria, cholera, dysentery etc. [17] report an association between solid waste accumulation and urban vector-borne diseases, especially mosquito-borne diseases, and urban zoonosis. Common litter items that are containers, such as plastic bottles, and tin cans account for between 7 and 15 percent of the breeding habitats for the mosquitoes that carry Dengue [18]. Disease transmission by these vectors is more effective in this situation because of the limited range of movement, in densely populated areas—areas that also produce large amounts of waste [19]. Litter can also serve as a health threat to animals, particularly in many rural African communities, where animals kept in a free ranging style commonly feed off litter, thus exposing them to diseases.

To effectively devise strategies to reduce littering it is important to investigate the spatial distribution of littering. Knowledge relating to litter can be useful in planning solid waste collection strategies and community environmental awareness programs. The spatial distribution of litter can be applied in devising strategies to reduce littering. Monitoring and diagnosing litter generation and litter volumes in public spaces is useful in view of assessing their impact, and in determining the environmental load of the waste and its potential costs of removal [11]. A “cleanliness” parameter based on the abundance and distribution of litter can be used evaluating environmental degradation of neighborhoods and in monitoring the performance of SWM systems. Street “cleanliness” has been used extensively in developed countries to assess the efforts of local municipalities in addressing the “cleanliness gap” [20], and evaluate changes in the amount and composition of litter over time.

The aim of this study is to investigate the litter distribution in the rural township of Muyuka (Cameroon), using the litter survey technique. The following specific objectives are to:

- 1) assess the quantity and quality of visible litter, 2) determine spatial distribution of litter within the study area, 3) estimate the litter rate and 4) determine the effect of the most littered item on the natural environment.

## **2. Materials and Methods**

### **2.1. Study Area**

This study was carried out in Muyuka town, a typical and fast-growing rural community within the Fako Division in the Southwest Region of Cameroon. Administratively, Muyuka classified as a Rural Council as it is comprised of several villages. The Council is comprised of four (4) zones; Muyuka town, Ekona, Yoke and

Malende with a total population of 118,470 individuals (with approximate population of 25,000 inhabitants in Muyuka town) over a surface area of 820,000 Km<sup>2</sup>. It is located between Longitude 9°64'E and Latitude 4°72'N about 31km from Buea with rainfall of 2509 mm per annum, average temperature of 26.82°C and average humidity of 80.1% [21]. The town is principally drained by a stream, popularly called “Balong Water” which has numerous tributaries most especially from the Mountain spring.

The main activities carried out are agriculture and commerce. Agriculture is enabled by the rich volcanic soils of the Mount Fako. The main crop cultivated includes food crops (such as plantains, cassava, and cocoyam) and cash crops which includes cocoa, coffee, oil palm and rubber. Small scale processing is carried out using rudimentary methods, particularly in the transformation of cassava and milling of oil palm. Commerce is dominated by petit trading in small stores and hawking of diverse goods. The town is a nexus of commercial activities as it is the main town serving highly agricultural productive areas of Bafia, etc.

The Council is highly under-funded making it incapable of providing some vital public services like solid waste management. The waste management activity practiced by the Council is still rudimentary, and it depends on keep clean campaigns days. During official cleanup days, the Council cleanliness is limited to the Muyuka Main Market including other small markets and important culverts allocated around its jurisdiction. These areas are cleared, swept, inseparable wastes gathered and burnt at various packed heaps indiscriminately; often wastes gathered around those markets especially the Muyuka Main Market is dumped and sometimes burned behind enclosed market, a small valley, at its base a running stream. On that same day, some chosen groups and youth meetings are selected and appointed to cleanup around the premises of administrative offices and buildings. Meanwhile individual households, cleared if possible, sweep, gather their waste for immediate disposal if distant from local dumpsite is near, however they are often burnt in their yards.

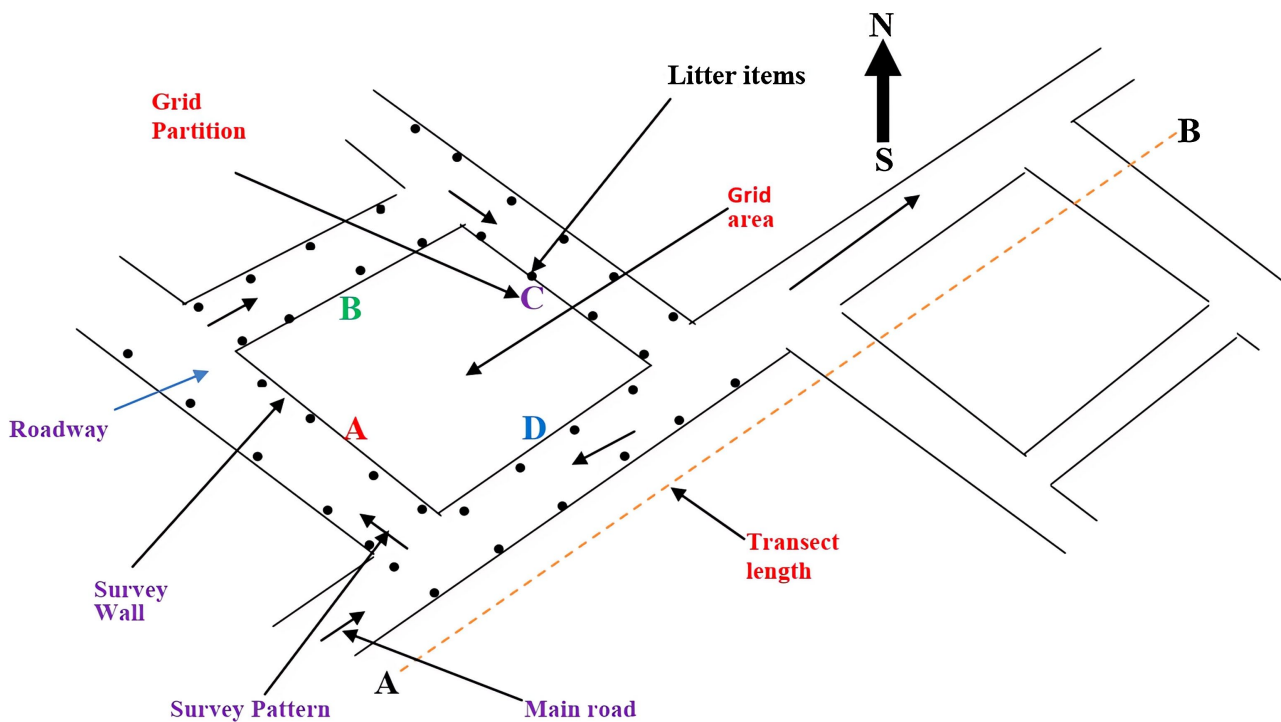
Apart from the official cleanup days, the different residential areas carryout cleanup campaigns, organized and led by Quarter-head. Some appointed groups of persons usually cleanup gutters and public access ways while households do the same around their premises. The wastes collected following these activities is usually burnt indiscriminately.

## 2.2. Sampling Method

Data was collected for a period of seven weeks using the visible litter survey assessment checklist. The survey sites were established as near as possible to the point determined in the site selection process. To ensure finding the site during repeat surveys, the sites were started at permanent fixed features such as mile posts, utility poles, bridge abutment, main street entrances, important buildings, etc by using a simple walk through the main street while also noting the major site street. In addition, the transect length was also determined by a single method

using Garmin GPS N60 to records GPS location of water ways, open dumps on the main street (road) on both side to show littering along the path on the map of the sample area.

Sampling was conducted in Muyuka, a small town characterized by a decentralized commercial structure along its main road. The town has 14 major streets, with 8 on the left and 6 on the right side of the main road. The selected streets were further divided into blocks, which were used for the survey. Seven blocks (also called grids) were selected from the main street transect for the litter survey count. Four of these grids were in the northern direction, while three were in the southern direction. Sampling began at the first main street, with every alternate street skipped, following this pattern on both sides of the road. The litter survey commenced after the site selection process, during which grid or street locations were identified and designated. A checklist for the survey was developed based on the composition of litter, as adopted from reference [22], and observations gathered during a slow but steady reconnaissance survey conducted at the beginning.



**Figure 1.** Litter survey grid layout and transect mapping.

After developing a representative sample litter survey (see **Figure 1**) checklist and adopting a stratified street sampling technique, the count begins at a particular street chosen by walking at a steady pace along the side of the street and road, visualizing and counting each visible litter items to the eyes (those larger than 1 m<sup>2</sup> in surface area). This walk was over a predetermined distance in the form of a rectangle block designs into four (4) site sections *i.e.* for the first street, name one (1) a rectangular block was drawn and labeled as 1A, 1B, 1C and 1D and so on.

Visible litter items were counted and noted slowly through this street path, walls, poles or bill (boards) and empty spaces on the developed checklist. At the end, both the total visible litter items and transect length were computed into the formulae below to get the litter/m for the study area [23] since the visible litter survey grids was assumed as a transect path.

### 2.3. Classification of Litter

Visible litter surveyed was classified based on the physical nature and content independently of the sizes but of visibility size of 1 m<sup>2</sup> and above. Particular litter subcategories were as well grouped into a major litter item, such as bill posting, cardboard, carton, cement paper, tissues, and others were counted individual and grouped under paper waste, and so on done for glass, plastics, metal, rubber, leather, clothes, wood, waste dump and miscellaneous wastes as well. And it is from this litter classification clue that the litter survey checklisting was developed, designed, and modified after the site visitation, as mentioned in the sampling method.

### 2.4. Data Analysis

The data collected daily with the use of a designed litter survey check listing from each grid were separately analyzed and later grouped and further analyzed using the formulas below.

1. Estimate of the rate of littering

$$LR = \frac{TVLI}{TL \times Df} \quad (1)$$

where;

LR = Litter rate (/m)

TVLI = Total number of visible litter items

TL = Transect length

Df = Detectability function (0.85%/m<sup>2</sup>) [23]

2. The amount of the most visible littered item during the survey

$$MLI = \frac{TMVLI}{TVLI} \times LR \quad (2)$$

where;

MLI = Most littered items (/m)

TMVLI = Total number of the most visible litter items

TVLI = Total visible litter items

LR = Litter rate

3. The amount of the most visible litter type

$$MLT = \frac{TMVLT}{TMLI} \times MLI \quad (3)$$

where;

MLT = Most litter type (/m)

TMVLT = Total number of the most visible litter type

TMLI = Total number of most litter items

MLI = Most littered item

Hence, litter rate = amount of visible litter/m which signifies level of cleanliness implies that zero waste/m meant area is clean ([24] [25])

Estimate the rate of decay of the most visible litter type

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}} \quad (4)$$

where;

$\lambda$  = Decay rate

$\ln 2$  = Decay constant

$t_{\frac{1}{2}}$  = Half life

4. The amount of the actual decay after certain period of time

$$N_t = N_0^{-\lambda t} \quad (5)$$

where;

$N_t$  = Actual amount remaining by the most littered items after littering

$N_0$  = Total amount of the most littered items (g)

$\lambda$  = Decay rate

$t$  = Decay at a certain time ( $t$  can be day, month, year)

Assumptions:

The following assumptions were made in various calculations carried out in the study.

- An average of three (3) persons was taken to estimate the population per grid.
- Detectability was taken to be 85% meaning litter visible item of size in 1 m<sup>2</sup>
- Estimated surface area for Muyuka town was obtained by dividing the total surface area of Muyuka Municipal area (820,000 m<sup>2</sup>) by the four (4) zones.
- Estimated population for Muyuka town was obtained by dividing the total population of Muyuka Municipal area (118,470 inhabitants) by the four (4) zones.
- Estimated total length within grid was taken to be the perimeter of the grid calculated using the Garmin N60 GPS.
- Average half life for all plastics was taken to be 480 years.
- Average weight by mass (in gram) were taken to be 12.36 g since the weight/plastic ranged from 0.92 - 23.8 g
- Total transect length was taken to be the main road length using Garmin GPS.
- Four roads as main road (road that link one city to another) and four roads as roadway (road that link one quarter to another) were selected within a distance of 150 m from the main street entrance

### 3. Results and Discussion

#### 3.1. Characteristic of the Studied Grids

**Table 1** is a summary of the characteristics of the studied Grids. Grid 5 has the

**Table 1.** Community litter survey and management assessment table.

Description of area (Litter survey)	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5	Grid 6	Grid 7
House Type	Clapboard houses	Unfenced block houses	Unfenced block houses	Unfenced block houses	Unfenced block houses	Unfenced block houses	Unfenced block houses
Number of Houses	30	35	65	120	150	64	38
Estimated population	90	105	195	360	450	192	114
Surface Area, m <sup>2</sup>	700	250	800	850	1250	755	526
Activity/land use	Small road business,	Commercial center, institutions	Medium road business	Student residential area, institution	Agricultural center	Small road business	Medium road business, institutions
Settlement nature	Linear	Clustered	Clustered	Clustered	Scattered	Clustered	Clustered
Road type	Un-tarred but sandy	Un-tarred but graded	Un-tarred but with potholes	Tarred and graded	Un-tarred but sandy	Un-tarred but sandy	Un-tarred but muddy
Drainage nature	Only along the main road	30 cm width along two side of the Gird	Only along the main road	60 cm width along three side of the Gird	Only along the main road	Only along the main road	Only along the main road
Resident waste practices along the grid	Dumping in valley in the vicinity	Storage in plastics bag (50 Kg)	Waste dumped in swampy land	Stored in plastics or rubber container (15 L = 15 Kg)	Illegal dumping vacant plot	Open burning in premises	Dump in open around premises
Availability of dumping site	None	Local dump close to an Office	None	None	None	None	None
Waste bin available along the grid	None	None	None	None	None	None	None
Total visible littered items per grid	1544	2343	2961	6147	6933	3471	8394
<b>Litter age group</b>	Less than 15	10 - 25	15 - 35	15 - 30	25 and above	15 - 60	15 - 60
Litter rate along grid in m <sup>2</sup> (≈)	2	8	3	6	5	4	14
Level of cleanliness along grid	1	6	2	5	4	3	7

highest surface area (1250 m<sup>2</sup>), number of houses (150) and population (450), followed by Grids 4 and 3 with surface area of 850 m<sup>2</sup> and 800 m<sup>2</sup> respectively. Grid 2 has the least surface area of 250 m<sup>2</sup>. There are no public waste collection bins in the entire study area. There is a multiplicity of activities with all the grids, besides serving as residential areas. Small commercial businesses, institutions (schools)

and offices are the common activities. Grids 7, 4 and 2 are typical in terms of diversity of activities. [26] investigated littering rates in urban areas based on landuse/activity and reported low pollution rates in administrative and recreational land uses.

### 3.2. Overall Abundance and Litter Composition

**Table 2** is a summary of the total number of visible litters on the highway and the main streets. Over thirty thousand (32,498) items were counted over the study period. The total amount of highway visible litters (10,204 items) is smaller than that along the side streets (22,294). This is due to the absence of public waste collection bins in the town. This is because there is no effective, organized and sustained waste management system. The comparable lower levels of visible litter along the highway may be due to the fact that most commercial services found here provide trash can for waste storage which is either dispose-off daily or weekly. However, a major source of litter found along the highway is from moving cars, buses, bikes, pedestrians etc. Plastic litter was the highest in both highway and side streets. Plastics accounted for 5139 items (58%) while paper accounted for 5139 items (15.8%). These two items should be considered as very important environmental and public issue as they comprise 73.8% of the total litter survey. This implies that any measures to reduce or recover these two items will drastically reduce the presence of litter.

**Table 2.** Total number of visible litter items along roadway and main road.

Waste items	Total	Major street	%	Highway	%
Paper	5139 (15.8 %)	3140	14.1	1999	19.4
Glass	808 (2.5%)	518	2.3	290	2.8
Plastics	18,854 (57.8%)	12,928	58	5926	57.6
Metal	1627 (5%)	1128	5.1	499	4.8
Rubber	1724(5.3%)	1384	6.2	340	3.3
Leather	432 (1.3%)	345	1.5	87	0.8
Clothes	1607 (4.9%)	1229	5.5	378	3.7
Wood	911 (2.8%)	592	2.7	319	3.1
Waste heaps	311 (1.0%)	185	0.8	126	1.2
Miscellaneous	1185 (3.6%)	845	3.8	340	3.3
<b>TOTAL</b>	<b>32,598</b>	<b>22,294</b>	<b>100</b>	<b>10,304</b>	<b>100</b>

The predominance of plastics and paper is similar to those of previous studies which identified cigarette butts-paper-plastics as the dominant litter in cities in of the Northern Hemisphere [27] and [28], The exception being firstly that cigarette butts were not considered as a separate item in our study and secondly, plastics accounted for more litter items compared to paper in our study. **Table 3** is a

summary of the results of the spatial distribution of the components of the visible litter survey.

**Table 3.** Litter composition in the different grids in the study area.

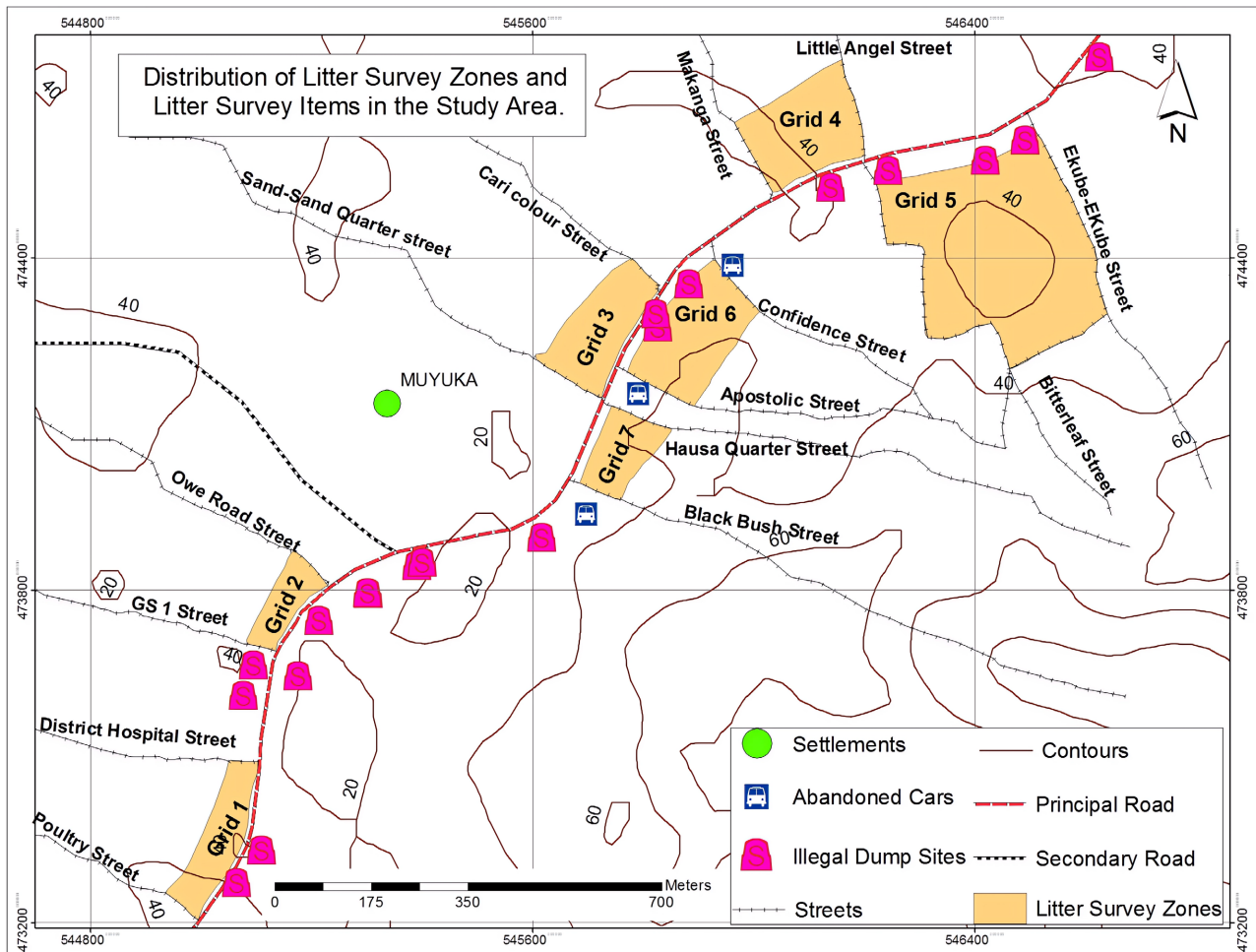
Waste items	Sub-waste item	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5	Grid 6	Grid 7
Paper	Bill posting	50	175	95	115	90	70	80
	Cardboard	70	145	220	545	365	190	695
	Carton	25	160	35	76	45	40	130
	Cement Paper	20	85	36	145	155	90	270
	Tissues	10	25	25	135	65	35	145
	Other paper materials	30	38	29	50	25	30	20
	<b>Sub total</b>		<b>205</b>	<b>628</b>	<b>440</b>	<b>1066</b>	<b>745</b>	<b>455</b>
Glass	Glass Bottle	20	30	20	20	50	30	55
	Glass Plate	20	19	14	11	20	10	55
	Glass Mirror	30	6	12	13	35	8	30
	Ceramics	5	8	9	11	21	18	25
	Other glass materials	25	30	26	42	27	32	21
<b>Sub total</b>		<b>100</b>	<b>93</b>	<b>81</b>	<b>97</b>	<b>153</b>	<b>98</b>	<b>186</b>
Plastics	Transparent Bottle	225	250	300	520	470	500	730
	Plastics Packaging	480	610	1300	3060	3545	1310	2865
	Plastics Bag	35	95	27	65	95	35	55
	Furniture	5	21	2	7	11	2	23
	Plastics Can	30	45	40	100	100	40	260
	Plastics Container	15	40	50	125	180	70	300
	Other plastics Materials	40	43	30	30	50	48	290
<b>Sub total</b>		<b>830</b>	<b>1104</b>	<b>1749</b>	<b>3907</b>	<b>4451</b>	<b>2005</b>	<b>4523</b>
Metal	Metallic tin	65	90	118	180	285	150	140
	Iron Scraps	10	15	45	70	53	51	125
	Other metal materials	20	22	14	27	25	37	85
<b>Sub total</b>		<b>95</b>	<b>127</b>	<b>177</b>	<b>277</b>	<b>363</b>	<b>238</b>	<b>350</b>
Rubber	Tires	40	17	7	11	0	6	40
	Rubber shoes	10	39	20	30	85	30	55
	Rubber Container	20	5	100	85	160	80	370
	Other rubber materials	20	18	25	45	100	96	210
<b>Sub total</b>		<b>90</b>	<b>79</b>	<b>152</b>	<b>171</b>	<b>345</b>	<b>212</b>	<b>675</b>
Leather	Leather Shoes	5	25	28	25	45	25	70

## Continued

	Leather Bag	7	6	2	6	13	10	20
	Other leather materials	3	2	4	8	28	20	80
	<b>Sub total</b>	<b>15</b>	<b>33</b>	<b>34</b>	<b>39</b>	<b>86</b>	<b>55</b>	<b>170</b>
Clothes	Clothing Fabrics	40	75	85	155	285	115	275
	Non clothing fabrics	20	8	42	40	37	45	270
	<b>Sub total</b>	<b>60</b>	<b>83</b>	<b>127</b>	<b>195</b>	<b>322</b>	<b>160</b>	<b>545</b>
Wood	Wood Scraps	35	60	65	205	165	95	225
	Wood Basket	3	3	14	10	25	0	0
	Plywood	3	0	3	0	0	0	0
	<b>Sub Total</b>	<b>41</b>	<b>63</b>	<b>82</b>	<b>215</b>	<b>190</b>	<b>95</b>	<b>225</b>
Waste dump	Small size dumpsite	30	47	26	40	60	40	37
	Medium size dumpsite	6	2	1	1	6	11	2
	Large size dumpsite	0	0	0	0	0	0	2
	<b>Sub Total</b>	<b>36</b>	<b>49</b>	<b>27</b>	<b>41</b>	<b>66</b>	<b>51</b>	<b>41</b>
Misc.	Yard trimming	15	20	23	32	95	10	40
	Drainage Channel	10	5	3	5	10	0	5
	Battery	5	5	1	15	18	14	8
	White good	0	5	11	16	0	6	0
	Human hair	6	4	5	15	9	5	1
	Food Scraps	30	45	49	56	80	67	285
	Diapers	6	0	0	0	0	0	0
	<b>Sub total</b>	<b>72</b>	<b>84</b>	<b>92</b>	<b>139</b>	<b>212</b>	<b>102</b>	<b>339</b>
	<b>TOTAL</b>	<b>1544</b>	<b>2343</b>	<b>2961</b>	<b>6147</b>	<b>6933</b>	<b>3471</b>	<b>8394</b>

It can be seen that the distribution of the dominant components (*i.e.* plastics and paper) showed some variability. Overall Grid 7 has the highest number of litter items and Grid 1, the least with 8394 and 1544 respectively. The seemingly lower levels in Grid 1 could be as a result of the existence of an illegal dump (a valley), which is not the case with the other grids. The valley site is not allocated by the municipal authorities concerned but for purposes of land reclamation, the owner has offered his plot where the valley is situated, for waste disposal options.

Plastic abundance was highest in Grids 7 and 4 and least in Grids 1 and two. Paper visible litters were most abundant in Grid 7, followed by Grid 4 and least in Grid 1. This implies higher littering intensities in Grids 7 and 4. The high litter count in Grid 7 can be due to the absence of local dumping grounds, the high rate of institutions (particularly schools) and medium size businesses. Grid 2 has the highest number of illegal dump sites along the Highway transect path, followed by Grid 6 and the least from Grid 3 (See **Figure 2**).



**Figure 2.** Map showing the distributions of litter survey zones and litter survey items along transect path of the study area.

There are a high number of auto repair shops in Grids 2 and 6 located in the commercial center of the town. Previous studies have associated auto repair shops with poor environmental performance, ranging from pollution of noise, temperature, exhaust gas, waste water, and trash [29]. [30], have described the vicinities of garages as the recipients of all sorts of waste generated from onsite activities; the wastes are littered on the premises with no attempt of waste collection of any sort. [30], ascribes poor environmental practices in auto repair garages to low knowledge, education and training on how to manage and treat waste auto repair, and the low awareness of people around the workshop on the importance of cleanliness of the environment. The role of education as an important factor explaining street littering habit also reported by [4] positing that the lower the level of education of subjects the more they littered the streets. Measures to address the issue of poor waste management should therefore include anti-littering and improved waste collection focused in Grids 7 and 4. Besides, providing waste collection bins, prohibition of littering, education and awareness, monitoring, arresting, and fining of individuals who litter, are among other measures to consider. These initiatives require a lot of community participation and this can only be effective if

some kind power is given to quarter-head by Municipal Council to fine/sanction violators independently after every keep clean campaign days.

**Table 4.** Litter survey assessment for different plastics waste type.

Waste item	Plastics type based on use	Plastic SPI name	Plastic SPI symbol	Plastic code	Grid Tot. / type	Av.Tot./ type	%Grid Tot. / type
	Transparent bottle	Polyethylene terephthalate	PET	1	2995	427.9	16.1
	Plastic packaging	Low-density polyethylene	LDPE	4	13,170	1881.4	70.9
	Plastic bag	High-density polyethylene	HDPE	2	407	58.1	2.2
Plastics	Plastics can	Polystyrene (Styrofoam)	PS	6	615	87.9	.3.3
	Plastics container	Polypropylene	PP	5	780	111.4	4.2
	Furniture	Polyvinyl chloride	PVC	3	71	10.1	0.4
	Other plastics material	Polycarbonate	PC	7	531	75.9	2.9
<b>TOTAL</b>					<b>18,569</b>	<b>2652.7</b>	<b>100</b>

**Table 4** is a summary of the types of plastics counted among the visible litter. Plastic packaging comprised of LDPE is the most dominant items (13,170), over two magnitudes higher than other resin types. Next in line is PET in the form of plastic bottles (2995). The government of Cameroon banned the use and commercialization of single use plastic bags (of thickness less than 60 microns) in 2014, however this item is still very much in use according to many consumers, its consumption has even increased. Implant believes that the lack of a suitable alternative for local businesses and tourism users has significantly contributed to the increased littering rate.

Results on **Table 3** as well shows that the level of cleanliness per Grid varies as a result of the nature of activities; surface area (m<sup>2</sup>), settlement pattern, population, settlement and house type and the amount of visible littered items surveyed during the research time thus this cleanliness is classified in descending orders as follows; Grid 1 > Grid 3 > Grid 6 > Grid 5 > Grid 4 > Grid 2 > Grid 7. Grid 1 was the cleanest. Reason being that, they have a valley where 95% of resident dispose of their wastes in the cases there is lack of land for pit digging. The other 05% used pits dug behind their house as dumping site for various purpose based on the individuals, in accordance to [31] “limited land areas and land tenure issues due to rapid increase in waste generation”. This is also because the litter rate considered only included litter found on bare ground, as well as on walls, poles, etc.

Grid 7 was also noted as the dirtiest in terms of cleanliness even though the grid surface area is the smallest (14,816 m<sup>2</sup>). As a result, illegal dumping behind house is ramped and during windy days, these wastes (since they are made mostly of plastics) are easily carried off to causes littering randomly. This is due to lack of awareness and legislation among public according to [31]. Surprisingly, this quarter has a special day for Keep Quarter Clean Campaign apart of the normal Keep Muyuka clean day. This quarter though, lacks a special site for waste disposal and

thus solid waste management is difficult.

This variation in plastics packaging is because it is made of low-density polyethylene, LDPE plastics material type with thickness of  $\leq 60$  micros thus they are called single used plastics meaning disposed of once use though there are possibility that some might be coming from local industries, commercial activities, or consumer behavior too due to lack of local/streets bins. The transparent bottles though, are made of PET plastics material type, they are  $\geq 60$  micros in thickness and therefore they have the potentials to be reuse like water storage containers, groundnut oil and palm oil retailing uses etc as also cited by [32]

From **Table 3** and **Figure 2**, above the rate of littering is 08.46 littered items/m ( $\approx 9$  littered items/m) plastics seen as the most littered item. the number of LDPE plastics littered/m is 03.50 ( $\approx 4$ ). According to [33]-[36], plastics especially LDPE plastic takes atleast 50 years to decompose of eventhough some traces would still be seen on the top-soil and sub-soil with consequence resulting to heavy contamination.

From [23], calculation, it was realized there exist a positive correlation between the rates of littering ( $\approx 9$  littered items/m), the most littered visible item ( $\approx 5$  plastics littered/m) with (4 LDPE plastic littered) and the decay rate (0.00014) of the most littered item in respect to level of cleanliness since for every littering/m. The amount of plastics littered is highest coupling since the types of plastics mostly littered, is the LDPE (which has a minima decomposing rate/month of 220,072.9. This low decay rate is due the presence of resins, which are the most important constituent of plastics (**Table 5**).

**Table 5.** Decay rate and decomposition trend for littered plastics on the environment.

Variables	Decay rate (formula (iv))	Actual amount after 30 days (formula (v))	Actual amount after 365 days (formula (v))	Actual amount after 50 years (formula (v))
Half life for all plastics, $t_{\frac{1}{2}} = 480$ years				
Actual amount of plastics = 229,512.9	0.0014	220,072.9	137,687.7	0.0000018 ( $1.8 \times 10^{-6}$ )
Decay constant = $\ln 2$				

In accordance with [23], the higher the rate of littering, the poorer the level of cleanliness, indicating that if care is not taken or if the ban of single used plastics and the supervision by the municipal authorities through the quarters committee is not intensified then there is a likelihood that after 50 years the environment would be contaminated or plastics will be found littering the top-soil of the municipality which are normally case noticed within the study areas as of now ([37]-[40]).

Comparing the litter rate of our study, (08.46) to similar studies carried out in USA like the New Jersey, 0.87 [24], Georgia, 0.96 (Litter report, 2006) [41], Pomona,

California 0.81 [42], while Frankfurt, Germany [43], and Sierra Leone [44], equally showed low rate hence, we realized that the rate of littering of the study is orders of magnitude higher. In addition, the most littered item shown from the various report were still plastics but of the PC (Polycarbonate) which therefore means that miscellaneous plastics type like compact disc, drug casing etc are the most littered items in USA.

#### 4. Conclusions

From the forgoing it was discovered that the rate of littering in Muyuka town is too high coupled with the fact that the decay rate for plastics on the environment is too slow *i.e.* in each metre surface area there are 08.46 visible litter and in that same area there are also 04.94 visible plastic litter of which 03.46 plastics littered was LDPE plastic type. The rate of littering in the grids varies not depending on the surface area but on the number of visible littered seen and for which Grid 1 with littered items and litter rate of 1544 and 0.054/m respectively is the cleanest compared to Grid 7 with littered items and litter rate of 8394 and 0.481/m as well is the dirtiest.

The sustainability of any solid waste management system depends on numerous factors; however, the most important factor is the will of the people to change the existing system and develop something better. People in the Muyuka Municipal area in general are willing to contribute positively and participate. It is recommended that this work should serve as a baseline study to assess the level of cleanliness of the town (particularly along the main road, roadways, parks, beaches, railways, bus station etc) after official keep town clean day set at side by the government. This can also be used to evaluate the degree of participation of individual household at the quarter in Committee labour.

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#### Conflicts of Interest

The authors declare no conflicts of interest.

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## Appendix A

Date: \_\_\_\_\_

### Litter Survey Checklist

Street Name: \_\_\_\_\_

Survey Block No.: \_\_\_\_\_

Waste items	Sub-waste item	Litter quantity (in number)
Paper	Bill Posting	
	Cardboard	
	Carton	
	Cement	
	Tissues	
	Other paper materials	
Glass	Glass bottle	
	Glass Plate	
	Glass mirror	
	Other glass materials	
Plastics	Transparent bottle	
	Plastics packaging	
	Plastic bag (>60 micros)	
	Plastics tin	
	Plastic containers	
	Ceramics	
Metal	Other plastic materials	
	Metal container (tin)	
	Iron scraps	
Rubber	Other metallic materials	
	Tyres	
	Rubber shoes	
	Rubber container	
Leather	Other rubber materials	
	Leather shoes	
	Leather bag	
Clothes	Other leather materials	
	Clothing fabrics	
	Non-clothing fabrics	

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**Continued**

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Wood	Wood scraps
	Wood baskets
	Ply wood
Waste dump	Small waste dump
	Medium waste dump
	Large waste dump
Miscellaneous	Yard trimming
	Drainage channel
	Battery
	White goods
	Human hair
	Food scraps
	Diapers

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