RECOVERING CLEAN ENERGY FROM HOUSEHOLD WASTE: THE CASE OF DOUALA IV MUNICIPALITY, LITTORAL REGION, CAMEROON

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ABSTRACT

Solid waste management (SWM) is one thing every city government provides for its residents. However, low collection coverage, operational inefficiencies, lack of suitable disposal and treatment facilities are responsible for unsatisfactory SWM. Consequently, communities faced with improper hygiene and energy inefficiencies have resorted to recovered energy from waste. This study used the institutional analysis and development framework on the waste recovery approach to review the model for achieving energy sufficiency from household solid waste in the Douala IV Municipality, Littoral Region of Cameroon. It specifically analysed waste and energy benefits alongside the potentials of municipal SWM. The study, (i) identified and classified household waste generation; (ii) assessed household energy supply sources; (iii) analysed benefits derived from biogas generation, and (iv) assessed environmental status based on environmental hygiene and sanitation. Households were randomly selected, participatory rural appraisal (PRA) tool and registers from health centres were employed to obtain relevant data, and this was complemented by field observation. Collected data were analysed using descriptive statistics of simple percentages presented in tables and figures and inferential statistics of student's t-test. The result indicated that energy recovered from household waste, improved clean energy supplies; generated employment; increased income; created waste recovery value chain; clean environment, regeneration of wetland; reduction in mosquitoes and water borne diseases. Student t-test revealed a significant difference ($t = -3.08$, $P = 0.006$) of household energy supply before and after recovering energy from household waste. Engaging in municipal SWM has enabled 8.5% of communities to improve their livelihood, enhance energy efficiency, good health and decent environment. The study recommends municipal authorities to involve communities in the management of solid waste.

Keywords: waste recovery, household solid waste management, clean energy, biogas, livelihood diversification, disease eradication.

1 INTRODUCTION

Growing economy has led to rapid population growth with a corresponding increase in solid waste generation and municipal solid waste management is one of the global challenges that the world is facing today as countries make strides towards the sustainable development goals [1]. The overriding problems of solid waste management in Cameroon include no properly formulated legislation, inefficient collection and poor recovery and disposal practice [2]. There is little to no sorting of waste at source and illegal waste dumping is the norm. The rate of generation therefore, far exceeds the capacity of local municipalities to deal with it due to inadequate financial resources, organizational capacity and technical expertise [3]. For decades, wastes have been growing at an increasing rate with a corresponding growth of world population so have the problems associated with its growth but current systems in Cameroon cannot still cope with the volumes of waste generated by an increasing urban population, and the impacts on the environment and public health [4] despite government, HYSACAM (hygiene and health in Cameroon), and individual measures put in place. The challenges and barriers are significant, but so are the opportunities. This study therefore sought to identify the sources and categorization of household solid waste, examine the

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challenges faced by the municipality in managing their solid waste, while examining the suitability of homemade bio-digester as recommendation and a measure of solid waste management at household level in the municipality of Douala IV district. The specific objectives are the following: identify the sources and categorization of household solid waste in Douala IV district; examine the challenges faced by the municipality in solid waste management in Douala IV district; proposing a suitable recovery method as recommendation and a measure of improving municipal solid waste management at house hold level in Douala IV district.

2 LITERATURE REVIEW

2.1 Study area

The study was carried out in Cameroon, at the Douala IV municipality. Cameroon, a perfect example of low-income country, is an African country where waste management has developed very slowly over the past decade. The world 53rd largest country, Cameroon covers a surface area of 475,442 km^2, 60% of which can be used to grow crops [5]. Located on a peninsula facing the other districts of Douala and connected to the eastern districts by a double bridge over the river, Bonaberi extends on the right bank of the Wouri estuary between the districts of Bonassama on the southern tip of the peninsula and the borders of the Moungo department in the Bonjongo, Ndobo and Bonendale districts (Fig. 1).

Bonabéri is a port in the Littoral Region of Cameroon. It is located on the western side of the harbour across the Wouri River from the larger port of Douala. Bonabéri, merges with

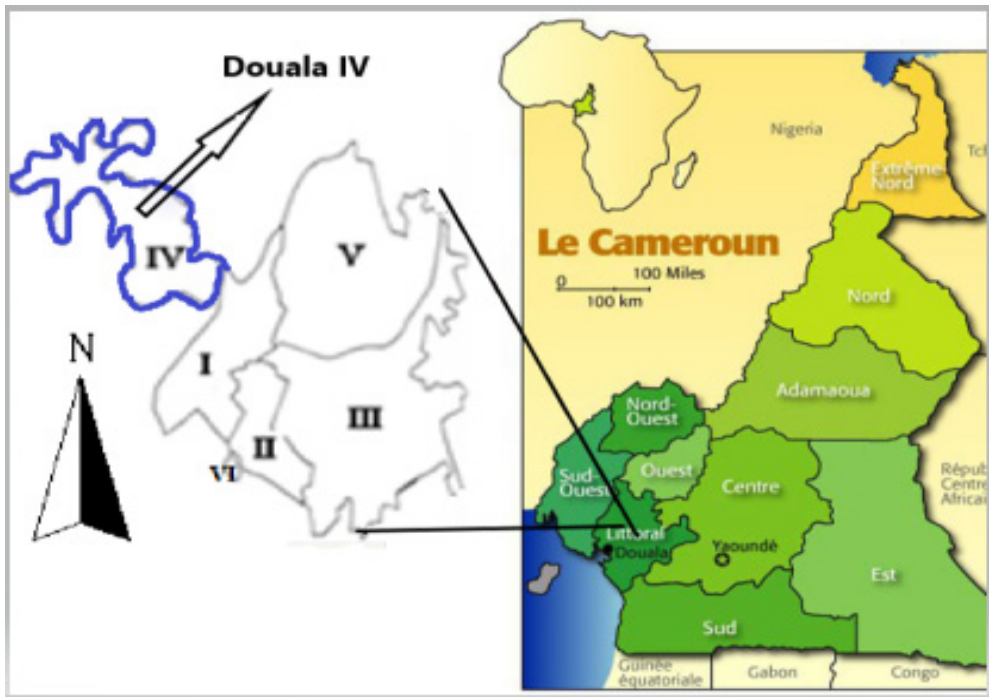

Figure 1: Map of Africa and Cameroon showing the city of Douala with its municipalities [6].

the commune of district of Douala IV, subdivision of the city of Douala. The municipal council is based in the Bonassama district. It is a mixed district with industrial zone, residential districts and spontaneous housing. Bonaberi has ten districts; Bojongo; Bonamatoumbe; Bonamikano; Bonassama; Bonendale I; Bonendale II; Djebale I; Djebale II; Mambanda; Nkomba. The site is completely saturated and has recently been claimed to be too overcrowded: 'Bassa and Bonaberi are suffocating' – indeed these two zones host 47% of the city 340 firms. Industry covers a wide range of activities (agro-industrial, manufacturing, processing etc.)

2.2 Conceptual framework

This typical theory framework is from Schübeler [7], UNDP/UNCHS (Habitat)/World Bank/SDC collaborative programme on municipal solid waste management (MSWM) in low-income countries, urban management and infrastructure. With the overall aim of establishing sustainable MSWM systems which meet the needs of all citizens, including the poor, it has the following goals: to promote the health and wellbeing of the entire urban population; to protect the quality and sustainability of the urban environment; to promote the efficiency and productivity of the urban economy, and to generate employment and income. Despite the government efforts in improving MSWM, the situation is still critical. Existing MSWM practices are not efficient as the practice constitutes issues in the environmental protection and sustainable development debate that are still wanting of deserved attention. Besides, there is also the lack of required legal framework to enforce existing bylaws on waste disposal, and to check the poor waste-handling attitude of the population as well as the inability to enforce standards on land use and shelter development within the city.

2.3 Solid waste management in Cameroon

In Cameroon as in many other Sub-Saharan African countries, massive population growth and urbanization are driving an exponential increase in the production of household waste. The waste amount is being projected to be about 15,000 tons/day in 2020 (Cameroon government, 2019). Approximately 78% of the waste produced is collected and landfilled without prior sorting. The waste composition has a very high organic waste content, estimated at around 84% with low levels of recyclable materials such as paper (4%), plastics (3%), glass (1%), textiles and leather (2%) and miscellaneous materials (5%). The predominant waste treatment practice is open dumps, no biological treatment, or formal recycling. The formal waste management sector is governed by a contract between municipality and the Hygiene and Sanitary Provider of Cameroon (HYSACAM). Challenges in managing solid waste include: cultural norms; climatologic, geographic, and topographic conditions; limited or lack of communications with relevant stakeholders; difficult working conditions; limited or lack of vertical and horizontal government coordination; lack of planning and evaluation; limited staff capacity; political turnover; limited technical expertise and awareness of best practices; limited access to and technical knowledge of equipment; limited financial resources and capacity. Inadequate solid waste management can impact cities and their residents in myriad ways. These impacts can generally be categorized into three categories: human health, environment and socioeconomics, in compliance with the United States Environmental Protection Agency Office of Resource Conservation and Recovery [8] and sustainability pillars.

3 METHODOLOGY OF THE STUDY

3.1 Study design

This study adopted a design of descriptive nature to help answer the question of who, what, when, where, and how associated with the improvement of the municipal solid waste management system in Douala IV. Specifically, the descriptive study design was used to obtain information concerning the current status of the Douala IV MSWMs and the various types of waste-to-energy (WTE) technology, employing key informal interviews, questionnaires, observations and archives reviews. Moreover, an exploratory design was used in this study. This was used to establish an understanding of how best to proceed in studying the various possibilities of WTE transformation and what procedures would effectively apply to gathering information about it. The exploratory research design was intended to provide a well-grounded picture of the situation being developed and determination about whether our study is feasible in the future, while directing future research and techniques to be developed.

3.2 Sources of data

Primary data were obtained with the help of self-administer questionnaires, completed by 150 households in Bonassama, Bonendale I, Djebale II villages according to the ratio 50:50:50. Also, five households were selected with respect to their accessibility, and willingness from which we could deeply characterised their waste. Similarly, interview guided by an interview guide, and field work guided by a practical guide.

Secondary data provided information collected from archives, books, articles websites, masters and PhD theses, policies and manuals.

3.3 Study population and sample size

The specific population of this study was the community of Douala IV district in the Littoral region of Cameroon, specifically, in the villages. As a result, we had a total population size of 170 households from the approximate 65,922 households (Douala IV municipal council, 2019), distributed in the ten villages (Table 1). In addition to that, participants such as the municipal council of Douala IV and HYSACAM were involved (waste management coordinators: three in the municipality council and two at HYSACAM) and interviewed with

Table 1: Population size. *(Source: Douala IV Municipal Council, 2019.)*

Villages	Population size (households)
Bojongo	19
Bonamatoumbe	21
Bonamikano	17
Bonassama	25
Bonendale I	20
Bonendale II	17
Djebale I	16
Djebale II	15
Mambanda	11
Nkomba	9

help of an interview guide. For this study, we adopted different types of sampling techniques: stratified random sampling and convenient sampling. The samples were selected from strata corresponding to the different villages in Bonaberi. This use a convenience sampling.

3.4 Data collection instruments

3.4.1 Objective 1: Identify the sources and categorization of household solid waste in Douala IV district

The questionnaires were administered to a total of 170 households distributed in the villages. This enabled us to get an overview of the demographic distribution of the respondents (sex, age, and educational level), the average number of people in the household and various types of waste produced by these communities. Also, from five households, we separated and physically sorted the waste as represented in Table 2, using weigh balance to weigh the quantity of each sorted waste in kg units. Prior to categorization, waste collection bags were distributed to the different house to separate the organic from inorganic wastes for a duration of five weeks. This sorting technique is a modified version to that used by Mbue et al. [6]. This information was completed by interviews and archives on waste categories and composition from the Cameroon waste management company HYSACAM on waste characterization. The interview was directed using the tool 5W and H (what, who, where, when, how, why) and the first point on the interview guide.

Table 2: Average waste produced by households for 5 weeks. *(Source: Field survey, 2022.)*

Average waste produced by households for 5 weeks (kg)							
No	Waste category	Waste composition	Household				
			A	B	C	D	E
1	Organic	Leaves, branches, grass, manure, food waste	10.34	7.44	10.5	11.6	9.68
2	Plastic	Plastics containers, plastic bag, PETE and HDPE containers	0.3	0.12	0.24	0.44	0.2
3	Electronic	Computer, TVs, radio, etc.	0.04	0.02	0.13	–	–
4	Paper	Office papers, newspapers, wrapping paper, and cardboard paper	0.24	0.07	0.1	0.17	0.13
5	Metal		0.42	–	–	–	–
6	Glass	Brown, clear, green, black	0.12	–	–	–	–
7	Other organics	Rubber, clothes, synthetic, cables, wood	1.6	1.18	1.04	0.7	1.22
8	Other waste	Textile, carpet, ash, sand, rocks, concretes, tyres, batteries	0.1	0.36	0.88	1.06	1.24

3.4.2 Objective 2: Examine the challenges faced by municipality in solid waste management

Through the elaborated questionnaires, the waste management responsibility was assessed from the perspective of the community, how they disposed of their waste the rate of waste collection by HYSACAM, any known effect of poor MSWM, and finally the possible challenges faced in waste management. In addition to this, using the interview guide, an examination of challenges faced by the municipality in solid waste management at the level

of the municipal council and HYSACAM was carried out to know the challenges faced by the organization in charge management of waste, the possible cause of inadequate waste management and the possible solutions to the problems faced. Analyses of the challenges faced by municipality and waste management companies were carried out using the method of 5M where all the causes of inadequate management will be classified in families of corresponding M and the result was represented in a fishbone diagram. Having the cause and effect diagram, we proceeded in classifying each cause in each group of Ms in the 5M methodology; this was done to better trace the problem and get the prominent target group cause of the problem so as to implement corrective actions from there. Using this method, we demonstrated that factors affecting each 'M' are more or less causes of a challenge (effect). So, method + management + material + milieu + man power = effect (challenge).

After reciting these causes by the improved Ishikawa family, we prioritized them using the 80/20 method called the Pareto method. The formula used is:

$$\text{Percentage} = (\text{number of causes for family X} \div \text{total number of causes}) \times 100\%,$$

where X= any family of cause. The root-cause diagram will then be displayed to depict the root causes of the challenges faced by municipality and solid waste management company.

3.4.3 Objective 3: Proposing a suitable recovery method as recommendation and a measure of improving municipal solid waste management at household level

A reconnaissance study was carried out in this study, as a guide to propose a recovery method as means of an improvement in managing waste. This was done through observation, surveys and open-ended questions, associated with the result of waste characterization to propose a waste recovery framework that best suites the community based approach associated with an objective literature review.

4 RESULT AND CONCLUSION

4.1 Objective 1: Identify the sources and categorization of household solid waste in Douala IV district

Data was obtained from self-administer questionnaires, completed by 150 respondents in the villages. A total of 170 questionnaires, administered and filled by 150 respondents, were used during the study. Of the remaining questionnaires, some were incomplete (10), other respondents did not live in the district (7) and the rest refused to answer (3). The information obtained is shown in Table 2. Additionally, from our interview guide, we obtained additional data on types of wastes generated from houses and the composition of these wastes. The findings of objective one of this study reveals that more that more than 60% of the population have four or more than four inhabitants in their households. Also all respondents produced waste and particularly organic waste which is of our interest. We also have plastic, metals, electronic, and others in relatively small quantities. Waste produced by this community is 80% made from organic waste. This implies that, reducing this organic waste will drastically reduce the total waste quantity, which is beneficial for the government, the individual and the waste management company.

4.2 Objective 2: examine the challenges faced by the municipality in solid waste management

Despite the fact that the waste management responsibilities from the perspectives of the community was high, 69 (46%) respondents, the greater portion, affirmed it is the responsibility of both the government and community (Table 3). The respondents still disposed of their wastes using archaic methods such as open burning, disposal in gutters and rivers, by road sides etc., which are not environmental sound practices. Although the level of awareness on the health and environment was determined and revealed, the greatest portion (74%) of the respondents were aware of the health effect and environment degradation as a result of waste management; of the respondents disposing off their waste at a HYSACAM collection point, only 26% of them (the greater percentage), disposed once a month. From our questionnaire, the following points were pertinent as possible challenges faced by the waste management sector from the respondents' perspective. With respect to limited or absence of waste collection points as a possible challenge, we had 47 (31%) respondent who strongly agreed, and 62 (41%) who agreed, whose high percentage of agreement is explained by the presence of little or no waste collection point in these quarters. Regarding inaccessibility to waste collection point as a result of inadequate roads, 23 (15.3%) respondents strongly agreed, and 57 (38%) agreed; where this accessibility is governed by few well-constructed roads with their degradation increasing with seasons and harsh atmospheric conditions and traffic congestion, making the roads inaccessible. Concerning loaded waste collection point, 71 (47.3%) respondents strongly agreed, and 52 (34.6%) respondent agreed, explaining the constant presence of waste by the roads and at collection point associated with the ineffectiveness of HYSACAM collection trucks. We also had mixed waste difficult to sort, irregularity/low frequency collection rate by the management company, and climatologic, geographic, and topographic conditions, explaining respectively, difficulties in sorting by management company and rapid diseases when poorly managed, the respondents' little or no knowledge on waste management best practices, and the swampy area of some quarters where the situation gets worse in the raining seasons with heavy rains rendering the poorly constructed road inaccessible.

Similarly, challenges faced by the organisation in charge of management of waste (HYSACAM) were identified and presented as follows according to the interview guide: management and methods not followed up; topographic conditions; unawareness and low educational level of the community; inaccessibility to household; hard working conditions; socio-political situation of the country; inadequate or limited financial resources; unavailability of roads, and waste not sorted. After the elaboration of the root cause tree diagram, we can identify the root causes of a poor waste management in Cameroon to be: management and methods not followed up; unawareness and low educational level of the community; inaccessibility to household; unavailability of roads; and waste not sorted.

These results come as a complement, demonstrating that the management method used by the municipalities and HYSACAM are not effective and are the main cause of waste management problems encountered in this area.

Finally, here are the possible solutions to the problems faced by the waste management sector and any interested party may be subsidised and supervised by the government for their effective implementation: sensitisation programs, teaching the population on how to keep and manage their waste and or before disposing it properly, associated with the health and environmental effects of inadequate waste management. Waste sorting at the source can be practiced by segregating waste into at least organic and inorganic. This can be sorted in waste

Table 3: Possible challenges faced by the municipality in solid waste management. *(Source: Field survey, 2022.)*

Possible challenges	**SA**	**%**	**A**	**%**	**N**	**%**	**D**	**%**	**SD**	**%**
Limited or absence of waste collection points	47	31.3	62	41.3	8	5.3	16	10.6	17	11.3
Inaccessibility to waste collection point as a result of inadequate roads	23	15.3	57	38	22	14.6	33	22	15	10
Limited access to and technical knowledge of equipment	17	11.3	34	22.6	73	48.6	14	9.3	12	8
Long distance separating households and collection point	16	10.6	48	32	26	17.3	31	20.6	29	19.3
Non respect of collection procedures by community	23	15.3	19	12.6	71	47.3	26	17.3	11	7.3
Waste collection point loaded	71	47.3	52	34.6	7	4.6	11	7.3	9	6
Mixed waste difficult to sort	41	27.3	75	50	11	7.3	16	10.6	7	4.6
Limited technical expertise and awareness of best practices	17	11.3	14	9.3	66	44	35	23.3	18	12
Irregularity/low frequency collection rate by management company	52	34.6	73	48.6	8	5.3	11	7.3	5	3.3
Limited or lack of communications with relevant stakeholders	13	8.6	15	10	29	19.3	50	33.3	43	28.6
Limited available land	9	6	23	15.3	14	9.3	58	38.6	46	30.6
Climatologic, geographic, and topographic conditions	30	20	49	32.6	9	6	37	24.6	25	16.6
Cultural norms	6	4	3	2	34	22.6	48	32	59	36.3

Key: SA: Strongly agree; A: Agree; N: Neutral; D: Disagree; SD: Strongly disagree.

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bags at household and waste containers at collection points. These will facilitate transportation, and disposal, and treatment while limiting health and environmental contamination. Waste reduction at the source can be a solution as some of the waste can be reuse and recycle for further purposes. Furthermore, introduction of simple and practical method to the communities on ways to reduce their waste such as composting, biogas manufacturing, etc., may reduce the waste at the source. Improvements can be done on the legislations and policies with emphasis on implementing the laws with adequate assessment tools. More finances allocated to the waste management sector and adequately managed may greatly improve the management in this this sector.

4.3 Objective 3: Proposing a suitable recovery method as recommendation and a measure of improving municipal solid waste management at household level

From the questionnaire, 41 respondents out of 150 had a very basic understanding of biogas, (27%), and 110 had no idea of what biogas is all about (73%). Also from our questionnaires of the 27% of the respondents which knew about biogas production, it was revealed that, the respondents classified as beginners, knew partially about biogas and is production (69%), and only 1% of respondents had already used biogas and were classified as experienced. Moreover, of the 150 respondent, 117 of them (78%) were ready to introduce a bio-digester in their house while 33 (22% of the respondents) were not ready for the introduction of a bio-digester in their homes after a brief explanation of what the biogas was all about. This 22% was as a result of the following reasons: not enough space, fear of explosion risk, fear of novelty, not enough finances and lack of management time.

Besides, of the 150 respondents, 117 (78% of them) where interested in the introduction of a bio-digester in their homes, though only 41 respondents, making a 27%, had information on biogas production. Of the 27% with awareness of biogas production, 69%, the greatest portion, had just basic knowledge of biogas production. Considering the study population as a relatively medium population with low standards of living and no major agricultural activities carried out, all respondents used fire wood (or partly) as a source of cooking energy fuel, and a mixture of charcoal, domestic gas, sawdust or/and kerosene. With the highest population number of cooking hour in the range 1–2 hours (59%), this community largely engages in commercial activities at home (corn, yams and plantains roasting etc.), of which the resulted waste generated are also considered as their household waste.

Now, though composting is the best and most used waste management recovery method [9], it could not work in this community as little or no agricultural activities, where the composting could be used, is carried out. On the other hand, the introduction of a homemade bio-digester in their homes was the ideal solution. This was confirmed by the positive response of 78% interested in biogas production although only 27% new what it was all about. Acknowledging the fact that the greater portion of waste produced at household level was of organic source, we selected biogas production as the best recovery waste system.

Using International Renewable Energy Agency (IRENA) as tool for measuring small scale biogas capacity, the amount of energy which can be produced from a biogas plant was quantified: 0.17 m^3/day, representing 0.68 kg of firewood, 0.3 kg of charcoal, 0.1 litre of kerosene, 0.16 litre of domestic gas, and 0.08 kg of domestic gas. The implementation was carried out through training sessions, from the introduction of bio-digester to the construction before assessing its acceptability.

Now, in other to assess the acceptability a performance of the bio digester, we used indicators and questionnaires administered to seven participants. From the administered

questionnaires to the participants, all participants gave a positive response to the functioning of their bio-digester with six out of seven participants satisfied with their device. From the questionnaires still, the three set up are currently actively producing biogas. Abnormalities encountered such as gas leaks; low gas production; poor construction; low amount of waste available; not enough waste/water; blocked inlet/outlet, but all were resolved with the exception of the presence of some impurities in the gas.

5 CONCLUSION

The problems of municipal solid waste management date as far back as the industrial revolution. The situation has been amplified by rapid urbanization, economic development and population growth resulting in high waste production. This waste production has been increasing at a continuous rate and more significantly in towns, as well as its management. Acknowledging the fact that the inadequate management of these MSWs affect both our health and environment, we ought to manage it. All the same, several works have been carried out in the domain by several researchers but still we witness a constant presence of waste in our environment. This study sought to improve the municipal solid waste management at household level. This was done through an identification of the waste types and characterization, an examination of the challenges faces by the municipality in managing waste, and finally an examination of the suitability of a home-made bio-digester as a measure of solid waste management at household level.

The study revealed that the waste produced by the study population is mostly organic (80%) with a mixture of plastic, metals, electronic and others with more than 60% of the population having four or more than four inhabitants in their households. Even though the waste responsibility burdens are on both the government and the community, and their awareness of the impact of poor waste management on their health and environment in general, the study population still disposed of their waste using archaic methods which are not environmentally sound (open burning, random dumping in rivers and gutters, etc.). Challenges faced by the waste management sector were examined and assessed to be mainly as a result of the methods and management procedure as per both the respondents and municipality council. Besides, we also have limited finances, limited/absence of waste collection points, community awareness of the effect and impact of the poor waste management, the hard working condition of the waste managers, the socio-political situation of the country, unavailable, inaccessible and/or poorly constructed roads etc. as the root causes of the various challenges.

Bio-digester has been proven to be the most appropriate, beneficial and most environmental sound waste recovery method for this community in managing their household waste. Despite the community's little or no knowledge on bio-digester as a means of waste management, a high percentage of the population were willing to have one in their homes. Using International Renewable Energy Agency (IRENA) as tool for measuring small scale biogas capacity to quantify the amount of energy which can be produced from our ideal biogas plant, the amount 0.17 m^3/day was found, representing 0.68 kg of firewood, 0.3 kg of charcoal, 0.1 litre of kerosene, 0.16 litre of domestic gas, and 0.08 kg of domestic gas. After implementation through several training sessions, the implemented bio-digesters are effective till to date with a positive return and a greater decrease in the quantity of household waste.

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REFERENCES

[1] Amougou, J., Patrick, F., Michel, N., Joel, S., Barthelemy, X.E. & Irene, N., Economic assessment of the impact of climate change on food crop yields in the centre, east, far north and south west regions of Cameroon, Yaounde, center. Observatoire National sur les Changements Climatiques, ONACC, p. 57, 2019.

[2] Manga, V., Forton, O. & Read, A., Waste management in Cameroon: A new policy perspective? *Resources, Conservation and Recycling,* pp. 592–600, 2008.

[3] Mckay, J., Turban, E. & Kim, D., *Electronic Commerce: A Managerial Perspective*, 8th ed., Springer*,* pp. 11–27, 2015.

[4] Gutberlet, J., Kain, J.-H., Nyakinya, B., Oloko, M., Apata, P., María José, M. & Campos, Z., Bridging weak links of solid waste management in informal settlements. *The Journal of Environment and Development,* 2016.

[5] U.S. Agency for International Development, Annual Freedom of Information Act report. U.S. Agency for International Development, Washington, DC, 2019.

[6] Mbue, I., Azibo, R. & Bitondo, D., Municipal solid waste generation, composition, and management in the Douala municipality, Cameroon. *Journal of Environment and Waste Management, 1936–8798*, pp. 91–101, 2015.

[7] Schübeler, P., *Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries*, SKAT (Swiss Centre for Development Cooperation in Technology and Management), Vadianstrasse, 1996.

[8] Environmental Protection Agency, The waste hierarchy. Environmental Protection Agency, 2017.

[9] The International Renewable Energy Agency (IRENA), Renewable Energy Statistics 2016, IRENA, Abu Dhabi, 2016.