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The Role of Sub-Saharan Africa Countries' Households Waste Charges on Sustainable Cities Development

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Abstract

The increasing use of rare earths elements (REEs) in a number of recent technological innovations led to a rapid increase (>50% in the last decade) in their applications. Europe is one of the most important regions of consumption of these substances. In this context, Europe in its 'Raw materials' strategy puts the recycling at the center of its concerns to provide a part of securing its supplies in REEs. Recycling of these substances, on an industrial scale, remains somewhat developed while it presents numerous advantages over the exploitation of primary resources. This paper will present some results obtained from characterization study of permanent magnets (PMs) present in WEEEs. Three components containing PMs are identified: hard disk drives, small electric motors and speakers. The representative sample of these components has been dismantled manually to recover the PMs contained and to quantify their amount. The results show that the weight percentage of the PMs varies from 4 to 6% in the speakers, 2.5 to 2.8% in the hard disks, and between 0.8 and 2% in some electric motors.

The results of the thermal treatment of the Nd-Fe-B PMs of the investigated samples show that the majority of these PMs lose their magnetic property upon reaching Curie temperature (300-400°C) in 15-20 min. Scanning Electronic Microscopy reveals the morphological aspects of the PM which consist in crystals shaped tetrahedral phase $Nd_2Fe_{14}B$ sintered in the presence of the interphase rich in Nd, Dy and Pr. The PM are layer coated with 20 µm thick, consisting of Ni, Zn or metals alloys.

Keywords: Wastes; Households; Equipment; Recycling

Introduction

Solid waste generation is an increasing global environmental and public health problem particularly in developing countries [1]. In urban areas of the developing countries, the totality of solid waste generated is not properly managed [2]. Most of the generated solid waste in developing countries is haphazardly thrown in streets, road sides, river banks and open spaces which have escalated environmental and health challenges to the people [3]. Most of the developing countries cities often lack financial resources to provide required municipal infrastructures for adequate solid waste management, despite their citizens' demand for waste management services [4]. Most these municipalities spend between 20 and 40% of their revenues on the collection, transport, and disposal of solid waste. However, this budget is often unable to keep pace with the scope of the problem of solid waste that is generated [5]. Furthermore, most attempts to improve Solid Waste Management (SWM) in cities of developing countries like Tanzania have focused on the technical aspects of different means of collection and disposal little has been done to investigate the demand side perspectives on solid waste management [6].

In Tanzania, the local government authorities have been responsible for providing solid waste management services to their citizens. However, the increased human population overwhelmed the capacity of local government authorities to provide SWM services to the growing urban population [7,8]. Like other developing countries, local government authorities in Tanzania lack enough financial resources to provide needed SWM services to their citizens. Most attempts to improve solid waste management in the country like privatization of solid waste management services and introduction of waste charges have concentrated on the supply side of the problem; the demand side is often not considered [7,9]. This has negatively impacted on the success of solid waste management in most urban areas of the country, for instance only 41% of the generated solid wastes in Kinondoni municipality are collected and disposed off the dumpsite while the rest are not attended [3]. Little has been done in the country to study the extent in which households can support their Municipalities financially to manage the escalated solid waste volumes, including how much households are willing to pay to ensure provision of solid waste management services; How much can be raised from household' payments of solid waste charges; Which solid waste management equipment can be purchased from the collected household' solid waste charges; How will the purchased solid waste equipment improve solid waste management in respective areas and what solid waste recovery alternatives can be put in place to manage solid waste. It is against this background the current study was conducted in Kinondoni municipality to estimate the amount which can be collected from households to support provision of solid waste management services, how the collected amount can be used to improve SWM in the area and to identify solid waste recovery alternatives which can add value to the generated solid waste.

Methodology

The study area

The study was conducted in Kinondoni Municipality (KM) which is a fastest growing Municipality in Dar es Salaam region, Tanzania. According to the National Population and Housing Census of 2012, KM covers about 531 km^2 and has a population of 1 775 049 with an

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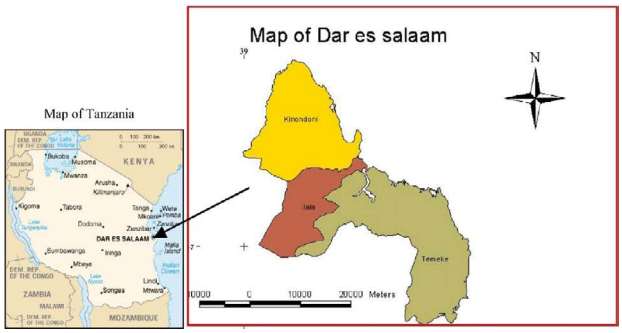

Figure 1: A map of Dar es Salaam region, showing Kinondoni, Ilala and Temeke municipalities [9].

annual growth rate of 4.1% and 446 504 households. KM covers a wide range of informal settlements, where solid waste is a great threat (Figure 1). KM generates the highest volume of solid waste in the region (2026 tonnes/day), and about 60% of the generated solid waste per day in the Municipality is not attended [3]. This necessitates the need to establish effective strategies for improving the availability and delivery of SWM services in the KM. It is also imperative to find out alternative ways of turning volumes of generated solid waste in KM into useful resources.

Sample size and sampling procedures

Stratified sampling method was used to stratify wards in Kinondoni municipality into two strata based on the amount of solid waste generated in each ward per day. Mwananyamala Ward was randomly selected from wards generation below 50 tonnes/day while, Kawe Ward was randomly selected from wards generating 50 tones and above/ day. Simple random sampling was used to select 4 *mitaa*/streets from each ward, making a total of 8 mitaa, namely, Msisiri A, Kopa, Kambangwa, Mwinjuma, Ukwamani, Mzimuni, Mbezi Beach A and Mbezi Beach B. Again, simple random sampling was used to select 30 households from each *mtaa*/street, making a total of 240 households used in this study. Purposive sampling was employed to select key informants. The key informants included local government officials and local organized groups dealing with wastes collection.

Data collection

The main data collection tools used were focus group discussions, semi structured questionnaire, checklists and direct measurements on the amount of solid waste generated in each household per day. The value perceived for the Willingness to Pay (WT) was determined through Choice Experiment (CE), the details of the experiment is in [10]. Conditional Logit Model was used to estimate of perceived value of SWM attributes from the respondents.

Data analysis

Both quantitative and qualitative methods were used to analyse the collected data. Quantitative data were analyzed using STATA and SPSS software. STATA was used to analyse CE while SPSS was used to run the normal descriptive statistics. Microsoft excel was also employed for data entry for variables analyzed using STATA software. Qualitative data were analyzed using content analysis method.

CE model specification: The conditional logit (CL) model was used

$$Vi = ASC + \beta 1Z1 + \beta 2Z2 + \beta 3Z3 + \ldots \beta n\, Zn \ldots\ldots\ldots (1)$$

Where;

Vi is the utility of individual for option i;

Z1 –Zn SWM service attributes such as covered trucks for transporting solid waste, provisional of polythene bags for storing of solid waste, frequency of solid waste collection and payment of SWM services per month;

β1 – βn Coefficient parameters for SWM service attributes;

ASP Alternative specific constant.

Estimation of implicit prices: The implicit prices were calculated using the coefficient parameters from results of CL model in equation 1. The implicit price/ marginal WTP for each SWM service attribute was estimated by:

$$MarginalWTP = -\frac{(\beta attribute)}{monetary} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where;

(β attribute) is the estimated coefficient on the non-market attribute (SWM service attribute) such as covered trucks for transporting solid waste, provision of polythene bags for storing solid waste and frequency of solid waste collection. (β monetary) is the estimated coefficient on the cost attribute (cost of SWM service per month).

Results and Discussion

Household willingness to pay for solid waste management services

The household's willingness to pay (WTP) for solid waste management services were estimated for low income households in KM was TZS 7192.944 per month whereas, the WTP per month for high income households was TZS 16 313.682. The attributes of importance in the solid waste management services were; use of vehicles with covering materials such as nets to minimize littering of waste on road and improvements in frequency of solid waste collection from households to disposal sites. Low income households included households earning below TZS 500 000 per month while high income households included households earning TZS 500 000 and above. The households were categorized into 2 income groups so as to get better estimates of households' WTP for solid waste services.

Equipment	Available	Required
Tipper trucks	10	10
Compactor trucks	0	10
Skip containers	0	250
Skip loaders	0	25
Tractors	2	4
Trailers	38	20
Wheel loaders	0	1
Semi- trailers	0	4

Table 1: Existing and required solid waste management equipment in Kinondoni municipality.

Equipment	Quantity available
Tipper	12
Compactor trucks	4
Skip containers	0
Skip loaders	0
Tractors	2

Table 2: Solid waste management equipments owned by contractors in Kinondoni municipality.

Household category	No. of households	Household's WTP per month in TZS	Amount collected from households per month in TZS
Low income	299, 158	7192.944	2 151 828 741.152
High income	147,346	16 313.682	2 403 755 787.972
Total Amount Collected from all households per month			**4 555 582 529. 124**

Note: 1 USD=2140.65 TZS

Table 3: Solid waste collections from households in Kinondoni Municipality in a month.

Equipment	Price in TZS	Quantity which can be purchased	Cost in TZS
Open Truck (18 tonnes)	135 000 000	12	1 620 000 000
Covering material	100 000	36	3 600 000
Skip container	1 500 000	100	150 000 000
Skip loader	35 000 000	12	420 000 000
Other costs			
Fuel	2500 @ litre	12 960	32 400 000
Salaries	1 000 000 @ driver	20	20 000 000
	600 000 @ waste collector	36 (3 @ truck)	21 600 000
Landfill charges	5000 @ trip	1080 trips @ month	5 400 000
Maintenance services			40 000 000
Total Costs per month			**2 295 000 000**

Table 4: Solid waste management equipments and other operational costs that can be supported from the collected solid waste charges.

The findings revealed that KM has inadequate solid waste management equipment as shown in Tables 1 and 2 above. The available solid waste equipment cannot afford to manage properly all the generated solid waste in the Municipality. Moreover, the few available Municipal solid waste management equipment are used to collect solid waste from public places such as markets, roadsides, commercial centers and few households located along the roads, hence households are required to find their own means of managing their solid waste. Budgetary, constraints was cited by respondents to constrain the Municipality to purchase enough solid waste management equipment. Besides, the existing solid waste contractors do not have adequate facilities for managing solid waste as portrayed in Table 2. This activates the need to find sustainable ways of rising finances to support the purchasing of required solid waste management equipment.

Households' financial supports for solid waste management

From the study it was found out that a total of TZS 4 555 582 529. 124 can be collected per month from all households in KM to support provision of solid waste management services (Table 3). This tells that a significant amount of income can be contributed from the households to support solid waste management in KM. The monthly solid waste charges can be given to solid waste contractors who deliver SWM services to households as the municipality necessitates the need for each ward to find its own solid waste contractor. Contrary to this, the monthly solid waste charges can be paid direct to the municipality and the municipality will be required to find ways of delivering SWM services to households.

Households' collections and their implication to the solid waste management

The results of the study suggests that a total of 12 solid waste collection trucks, 36 covering materials (tarpaulin and nets), 100 skip containers and 12 skip loaders can be purchased from the households' monthly collections of solid waste charges in KM (Table 4). These equipments can be used to deliver SWM services in the municipality. According to the Tanzania Population and Housing Census 2012, KM has thirty four wards, this imply that as a start if the Municipality for example opt to use the estimated collection to purchase the proposed number (12 trucks) of collection trucks, each solid waste collection truck will provide services in three wards, but later on as solid waste charges will be collected every month, more solid waste collection trucks will be purchased and given to wards. From the study we learn that preferably, each ward should have its own solid waste collection truck.

The skip containers can be distributed to respective streets, and they should mainly be used to encourage communal collection of solid waste prior to waste collection exercise especially in areas which cannot be easily accessed by roads. Use of skip containers encourages collection and transportation of solid waste to disposal site [11]. The skip loaders will help in off- loading waste from the skip containers to collection trucks. Again, depending on the nature of the area, providers of SWM services can also opt to use wheel barrows to collect solid waste from houses which are not easily accessible by roads.

Furthermore, a total of 56 persons will be employed to work as drivers and waste collectors/assistants who will help in the collection of solid waste from households and transportation of the collected waste to a disposal place. Their number will keep on increasing as more waste collection trucks will be purchased from the households' monthly collections of solid waste charges.

Solid wastes equipment and improvement of solid waste management in urban areas

Solid waste generation rate: The study findings ascertained that the amount of solid waste generated by each household per day is 4.030 kg/household. On average, the per capita solid waste generation rate was estimated to be 0.804 kg/person/day in which the amount of solid waste generated per person per day in Mwananyamala ward was estimated to be 0.675 kg/person/day whilst in Kawe ward was 0.932 kg/person/day. The difference might be attributed due to the difference in income levels between the two wards, where the former is categorized as medium income area while the latter is categorized as high income area. This is regarded to be, since it was hypothesized in this study that income influences consumption and generation of solid waste. The

Street/*Mtaa*	Solid waste generated per household per day in kg (kg/household/day)	Solid waste generated per person per day in kg (kg/capita/day)
Kambangwa	4.336	0.808
Msisiri A	2.751	0.554
Mwinjuma	3.402	0.638
Kopa	3.978	0.702
Mzimuni	3.105	0.601
Ukwamani	2.47	0.570
Mbezi Beach A	5.609	1.185
Mbezi Beach B	6.595	1.374
AVERAGE	**4.030**	**0.804**

Note: 1 USD=2140.65 TZS, (2015)

Table 5: Daily solid waste generation in the study area.

No. of households	Solid waste generated per household per day	Total amount of solid waste generated by households per day	Total amount of solid waste generated by households per month
446 506	4.030 kg	1799 tonnes	53 970 tonnes

Table 6: Amount of solid waste generated by households in Kinondoni municipality.

Carriage capacity of each truck per trip	No. of trips made by each truck per day	Amount of solid waste collected by each truck per day	Total amount of solid waste collected by 12 trucks per day	Total amount of solid waste collected by 12 trucks per month
18 tonnes	3	54 tonnes	648 tonnes	19 440 tonnes

Table 7: Amount of solid waste that can be collected from purchased solid waste collection trucks.

results are quite in line with that of [3] who indicated that the amount of solid waste generated per person per day in Dar es Salaam City was 0.8 kg/person/day.

Additionally Kasozi and Blottnitz [12] reported that the per capita solid waste generation in middle income settlements in Nairobi was 0.82 kg/capita/day. However, the study finding on solid waste generation rate exceeds the World Bank standards for developing countries which ranges from 0.4-0.6 kg/person/day, this justifies that solid waste generation is among the key environmental problems in KM. Community interventions are highly needed to support the collection, transportation and disposal of the generated solid waste. Table 5 below summarizes daily solid waste generation rate in the study area.

Improvement of solid wastes management: The findings of this study reveal that on average each household in KM generates 4.030 kg of solid waste per day (Table 5). This implies that a total of 1799 tons of solid waste are generated per day from 446 506 households present in the Municipality. On the other hand, it is anticipated that each solid waste collection truck will carry 3 trips per day to the disposal site. Considering this estimation then in each trip, 18 tons of solid waste will be carried, so each truck will carry 54 tons of solid waste per day to the disposal site. A total of 648 tons of solid waste will be collected daily to the disposal site by the proposed 12 solid waste collection trucks which will be used to collect solid waste from households. This implies that if the Municipality will consider purchasing solid waste equipment, the equipment will help to carry 648 tons out of the total 1799 tons of solid waste generated daily by households in KM. This will significantly improve SWM as about 36% of the generated solid waste will be collected and transported to the disposal site. Since the collections will continue, it means the percent will keep on increasing as more waste collection trucks will be purchased and given to each ward. Tables 6 and 7 illustrate the explanations above.

Solid waste recovery alternatives: There are other alternatives of managing household solid waste apart from disposing them in the landfill. Options such as re use, recycling, composting and energy generation turn household solid waste into useful resources thereby adding value to the discarded solid waste [9]. Table 8 shows the physical composition of household solid waste in KM. Regarding the physical composition of the generated solid waste various solid waste recovery options can be thought of.

Results on the physical composition of household solid waste in Kinondoni municipality (Table 8) agree with those of Oberlin [13,14] who reported that food waste constitute a larger proportion (64.4%, 74.1% respectively) in households' solid waste stream. This may be as a result of cooking which is done in almost every household. Cooking normally is associated with high generation of food waste from food peelings and food remains. Besides, the findings show a high percentage of plastic material waste such as polythene bags and plastic bottles; this could be due to the fact that nowadays, there is an escalating use of polythene bags as packaging materials in shops, supermarkets and market places. Moreover, many industries are using plastic containers such as food containers, water, soft drinks and drugs bottles which have increased the quantity of plastic waste in households. The presence of ashes in solid waste stream signifies that some households in KM are using firewood and charcoal as their energy source especially in cooking. The findings are in line with Oberlin [14] who indicated that households' overdependence on firewood and charcoal has increased ashes in a solid waste stream in KM.

Recycling option

Recycling of solid waste could help to turn a volume of solid waste into useful resources which can be used in other production activities. Regarding the study findings in Table 8, about 24.82% of solid waste can be recycled; this constitutes plastic materials, papers and metal wastes. As households in KM generate 1799 tons of solid waste in a day (Table 6), about 447 tons (24.82%) of the generated solid waste can be recycled. A total of 13 395 tons of solid waste can be recycled from a total amount of solid waste generated by households in a month (53 970 tones).

Recycling option would help to turn these waste into useful materials

Waste category/component	Percentage
Food waste	67.23
Plastic materials	18.63
Paper waste	3.65
Garden waste	2.83
Metals	2.54
Other waste	5.12

Table 8: Physical composition of household solid waste.

to be used in production activities, meanwhile it will also save the space needed to dispose them at the landfill. Apart from creating space in landfills, recycling of solid waste into useful resources will reduce the volume of solid waste which is transported to disposal places, more so it reduces the demand of virgin resources needed to manufacture new products such as plastic bottles and polythene bags. Besides, it increases the economic value of waste and saves energy [15]. Poor development of recycling programs in the Municipality has negatively impacted on solid waste management in the area, as volumes of useful solid waste are taken to disposal places; others are thrown haphazardly in streets as most people do not recognize the economic value of discarded solid waste. Moreover, improvements in recycling programs will attract establishments of recycling industries which will create employment opportunities to people who will be serving in those industries. In addition, more recyclable solid waste can be generated from other areas which were not considered in this study such as industries, hotels, commercial centers and other institutions.

Further, recycling programs will also have a financial motivation to households as they will be selling recyclable materials such as plastic bottles, polythenes, aluminium among others to people engaging with recycling activities. In doing this households can recover some money from the generated solid waste which they can in turn use for payments of solid waste charges at the end of the month.

Compositing and energy generation options: Biodegradable solid waste can be used for composting and generation of bio fuels. Mbuligwe and Kassenga [16] reported that composting can avail a reduction in landfill space exhaustion rate by more than 50%. Since 70.06% of household solid waste in KM comprised compostable waste such as food and garden waste (Table 6), this can be considered significant enough to warrant further planning of composting and bio fuel generation options rather than disposing in the landfill or dumpsite. Composting of biodegradable solid waste will result in generation of green manure which can be used by farmers in crop production. However, composting programs will require a large portion of land for composting the waste, given the congestion in the KM there might be limited space to establish composting programs as most of the available land is allocated for residential uses; the reduced volume to be dumped into landfills can provide such space for compositing. On the other hand, biodegradable waste can be used to generate bio fuels such as bio gas [17]. Generation of bio fuels will help to reduce the volume of solid waste disposed to the landfill creating more space to be used for composting. Given the increased demand of energy especially in urban areas, bio fuel generation will supplement on the availability of energy. Bio fuel generation will also attract establishment of bio fuel industries thereby creating employment opportunities to people specifically youths. For all these options to be pragmatic action research is needed to learn on the practical outcomes.

Conclusion

This study investigated on the extent in which households in developing countries especially those in Sub-Saharan Africa can support their Municipalities in ensuring sustainable solid waste management. This is because most Municipalities lack financial resources to invest in solid waste management. The findings reveal that a total of TZS 4 555 582 529. 124 can be collected per month from households in KM to support delivery of solid waste management services suggesting that, the Municipalities can well support in sustaining their growing cities in SWM. The collections from the households can be used in several beneficial ways including purchase of solid waste equipment. The purchased equipment would help to collect about 36% of the solid waste generated per day to the disposal place considering the situation of KM which is revealed to have high rate of waste generation when compared to the average rate suggested by the World Bank. Besides, recycling programs would help to turn 25% of the solid waste generated per day into useful resources whereas composting and bio fuel generation would turn 70.06% of the solid waste generated per day into other useful products thereby saving landfill space needed to dispose biodegradable waste. Policy and decision makers in developing countries specifically those with similar settings to that of KM should use the findings of this study in establishing sustainable ways of managing solid waste in their respective urban areas. The findings of this study agree that households can have a significant impact toward sustainable solid waste management in urban areas once they are being involved in planning of SWM services. Recycling, composting and bio fuels generation programs can have huge impacts toward sustainable solid waste management in most urban areas of the region.

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