Critical Challenges of Quantifying Solid Waste: The Case Of Ghana

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Abstract:- The quantification or measurement of solid waste as well as the characteristics of the kind of waste is very paramount in managing solid waste. Solid waste generation and its associated problems is a global phenomenon, in which the world battles with as a result of the difficulty in the quantification and measurement of solid waste. The measurement of solid waste in Ghana can be associated with several challenges. Therefore, this study was conducted with an aim of identifying the challenges in the quantification of solid waste taken into consideration Ghana as a geographic location. This research utilizes the technique of data reduction to investigate challenges of quantifying solid waste. A structured survey questionnaire was administered to 112 experts in waste management to elicit the appropriate data and this yielded a significant response rate of 76.79%. Before subjecting the data to principal component analysis, reliability test of the survey was performed, the adequacy of the sample and the population matrix were all tested and satisfied, this led to the identification of six new thematic challenges of quantifying solid waste in Ghana. The findings of the study reveal that the six critical challenges of quantifying solid waste are; difficulties in separation and categorization of solid waste into quantifiable units, technical setbacks faced by waste quantifiers coupled with the lack of innovations; difficulties in method(s) of measuring solid waste; danger to the health of waste quantifiers or measurers; resources and logistics inadequacies; Poor policies and legislature guiding the measurement of solid waste.

Keywords:- *Solid waste, Quantification, Critical, Challenge.*

I. INTRODUCTION

Solid waste management has remained a global phenomenon, that continues to be of a great interest to both developed and developing countries because of the many environmental and societal problems generated by solid waste [1, 2].The amount of waste generated by households, institutions and so on has no limitations [3]. In terms of quantifying solid waste, between 2005 and 2011, literature publications in growing economies suggest that, quantification of waste has less attention and fewer publications [4].Solid waste quantification is essentially vital in the management of waste. The absence of quantified waste data impacts the efficient and sustainable waste management [5].It is difficult to find realistic estimates of the amount of waste generated in Ghana per day, much less the average volumes or percentages of the various components of waste generated periodically in Ghana [6].

Solid waste generation is largely due to the uncontrolled urbanization, industrialization, household population [7, 8, 9], inability of stakeholders and inadequate resources in both human and capital [10]. Actions of humanity contribute significantly to the generation of waste in the community, market place or household [11,5].Waste management institutions and organizations encounter a lot of challenges in various forms in dealing with solid waste[12]. Unfortunately, the attainment of 100% waste-free society is currently not achievable in all areas of production and consumption [13]. That notwithstanding, the evolution of the industrial era has manifested in itself the generation of huge quantities of solid waste, which is more sensitive in developing countries [8]. The disposal of solid waste is problematic in most countries especially in developing and mountainous areas of the world [14].In developed countries municipal solid waste collection costs less than 10% of a municipality's budget, collection rates are usually higher than 90% on average and collection methods tend to be mechanized, efficient, and frequent, while it is the reverse in developing countries [10]. The significant categories of solid waste are paper waste, food waste, plastic waste, metal waste, and glass waste [7].It is a fact that waste disposal is a critical challenge facing many districts in developing countries. It is therefore not surprising to come across waste being disposed of in the open space usually not far from city centre and other unauthorized place, Therefore significant amount of waste generated is not quantified properly [15].

II. MEASUREMENT OR QUANTIFICATION OF SOLID WASTE

The quantity of solid waste from each household is difficult to measure [3]. [16] stipulated that ineffective co-operation among the various stakeholders such as; the inhabitants, government, and NGOs, is a chief obstacle in improving waste situations in countries. According to [17] solid waste quantification is affected by the illegal dumping of solid waste at unauthorized places, Poor institutional experience and the lack of strong legislature and its enforcement. Technically, determining the specific disposal method of solid waste is chiefly identified in the composition of the waste, the separation of solid waste materials at the various sources of generation is significant, especially in reducing treatment cost of waste and ensuring the right quantification the waste generated. Municipalities must enforce strict regulations to prevent illegal dumping of solid waste on riverbanks and in public places[17]. Source separation of solid waste has not been rigorous in communities and municipalities thereby impeding the measurement of the waste as the sources (Separation into plastic waste, paper board waste, food waste, metal waste and also glass waste) [2].Key dimensional elements of solid waste management such as the design of storage facilities, the disposal techniques or methods, the size of the crew, the extent of resources recovery and the type and frequency of waste collection would be effective when substantial knowledge is available about the quantity and composition of solid waste[5]. Proper solid waste management can contribute greatly to the socio-economic value of a country and raise the economic fundamentals of any country [17]. However, these successes or value-adding benefits are opposed by factors in various forms of organizational, technical, cultural, financial and geographical especially in low-income countries, some of which are manageable. There are however, some categories or types of waste that are valuable and has total benefits to both developed and growing economies [18]. The quantification and characteristic of solid waste are very paramount in managing solid waste [5]. The quantification of solid waste in Ghana can be associated with many key constraints [19].

The quantity of solid waste can be determined through the use of numerous methods and techniques. That notwithstanding, the particular method adopted for quantifying the solid waste dictates the level of accuracy of the result. Common methods of quantifying solid waste according to [20] include the following:

Direct weighing or assessing volume: This method involves the quantification of solid waste materials without the need for segregating such waste materials into various types of solid waste such as food waste, industrial waste, household waste, and so on. Assessing volume or direct weighting does not take into consideration waste composition analysis (WCA).Direct weighing of solid waste can be applied at any point of waste generation or the waste materials can be intercepted and quantified during the transfer of such waste.

Waste Composition Analysis: This focuses on the physical separation of solid waste into various components before it is subsequently measured. WCA can be used to determine the total amount of food waste and can also be used to quantify other amounts of different types of solid waste. This technique however establishes the characteristics of each quantified waste component and the amount of materials in each unit. This technique cannot be used to quantifying all types of solid waste but limited to specific categories of solid waste. The moisture content of a particular solid waste content impacts the application of this method in quantifying solid waste and a large sample size is required to use this method.

The use of Records: this method constitutes the use of data collected from previous investigations which can be interpolated to quantify future waste. This method however is suitable for quantifying solid waste from all stages from the generator to the disposal stage. The use of records also involves using a mass balance scale to determine the weight of the solid waste in question. The level of accuracy is dependent on the accuracy of the previous measurements that were undertaken. The use of records to quantify large quantities of solid waste may be inaccurate especially where the previous was juxtaposed from a small quantity of solid waste [20]. The use of existing information for future quantification of solid waste can be problematic but costs less than undertaking new measurements [6].

Inference by calculation: This method is suitable for quantifying solid waste where no direct measurement is undertaken. This method describes the quantity of waste generated by inferring using some form of calculations including the use of the mass balance, modeling and proxy data. The accuracy of this method is dependent on the underlying data.

The mass balance scale: the are several available mass balances that can be used to quantify solid waste. Mass balances of varying sizes and types [20]. The use of large scale to weigh each vehicle and its load at site, the collection of data including the average density of the waste [63].

The quantification of solid waste does not require that an entity use a particular quantification method because the entity's choice of quantification method(s) will be influenced by its particular goals, the scope selected for its waste inventory, and the availability of resources (human, financial). Some quantification methods, such as direct weighing, are straightforward while others, such as a waste composition analysis where solid waste must be separated from other material to be measured can be complex [21].

A. *Importance of Quantifying Solid Waste*

Accurate measurement of waste generation rate is one of the fundamental prerequisites for planning and designing any waste management program and also that is vital to improve solid waste management practices [22].Reliable national data on waste generation and composition that will inform effective planning on waste management in Ghana are absent [23].

The following as factors necessitating the quantification and measurement of solid waste [20]:

Prioritize action: Closely linked to developing an understanding of waste, this may involve identifying the hot spots of waste (where there is a substantial social, environmental or financial impact). This can help in deciding where and how to start tackling the issue (deciding on which commodities, products or sectors to focus. Estimates can be used to guide financial decisions.

Evaluate a solution or initiative: This is the process in which a combination of quantitative information (amounts of waste) and qualitative information (observations) is obtained to understand if a proposed solution is having a positive impact. This may be during the piloting or testing phase of the proposed solution, or during the solution's full-scale deployment. This type of activity goes by many names, including program evaluation and policy evaluation. Also, estimates of waste may be used in a cost-benefit analysis to see if regulatory action would make economic sense.

Monitor targets: This involves repeated quantification of waste of a particular scope to determine trends over time. This information may be used to determine if targets (national, social, environmental, financial) have been met and

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may help in understanding whether all the solutions, initiatives and policies currently deployed have had sufficient effect.

Data can be used to estimate a range of metrics (financial, environmental) to support business case development.

B. Challenges of Measuring Solid Waste

The use of vehicles to transport solid waste to the disposal site and subsequently weighed to determine the weight of the waste are often very absolute and surge the cost of maintenance and operations and decrease the effectiveness of their use [24]. The use of equipment not excluding the weighing scale or the appropriate technology is paramount for waste quantification and management [4].

The measurement of solid waste would be difficult to execute when proper data is not considered especially when the collection and storage are not carried out properly. The storage and collection of solid waste is mostly done adopting the open enclosure storage in most communities. Also, the volume of the storage enclosures should be designed by overestimating the generation of waste, not underestimating it[24].

The absence of sufficient funds for Local governments to execute their mandate of waste collection and subsequently measuring them is a key reason for the involvement of the private sector in the waste industry in Ghana [25]. Taxations within the Local government across District Assemblies in Ghana are inadequate and therefore limited amountof funds are devoted to waste collection, measurement and management [26]. Capital budget expenditures and operational budget expenditures are outsourced to ensure waste management services are implemented. These budget expenditures include infrastructural costs to facilitate the management of waste, cost of operations incurred from the procurement of equipment and machinery and their maintenance as well as labour costs [27]. In quantifying waste, the major constraint companies and organizations face is the finances to acquire the needed tools and equipment. The lack of monetary resources to executive the quantification of waste ranges from the inability to purchase the right tools and equipment through to the inability to properly train or employ workers in the area of waste quantification [28].

A feasible technological advancement that could be used to quantify solid waste by a waste management company relies also on the technical capacity alongside the local environment not only the financial capacity of the company. Data concerning the waste gathering and collection forms the best for quantities but inappropriate to determine the composition and characterization of waste [28].

Also, waste quantification is more challenging especially when the segregation of solid waste is not properly carried out into hazardous and non-hazardous waste substances [29]. The ability to effectively sort out or separate solid waste is a step in the right direction to ensuring the effective quantification and management of the waste. Policymakers and local governments ought to have an interest in the sorting of solid waste. The separation of solid waste is influenced by residents'or the generators' knowledge, availability of waste separation equipment and the incentives. However, households are of the view that sorting out solid waste is complex and difficult, it consumes time and space, and finally, unique facilities need to be designed to aid the sorting of waste. Most households seemingly see sorting of waste as difficulty hinders households' pro-environmental behaviors and hampering the quantification of solid waste using various methods [30].

Separating solid waste into biological or non-biological would aid greatly in measuring or quantifying waste with ease. Waste collection and its subsequent sorting play a vital role in the waste management system because it is a determinant for the feasibilities of recycling and composting. Manual sorting techniques can be used where the plastic components are large enough to justify the time and effort involved, since the method is very labour intensive, has a bad working environment, and is economically unviable. This seriously hampers and distract the quantification process of solid waste. The possibility of human errors should not be neglected [31].

The lack of quantitative data on the volume of waste generated in the Municipality. This situation adversely affects the short-term and long-term planning of waste management in the area, particularly in terms of mobilizing the required financial resources and logistics to ensure the waste management system and efficiency keep pace with the future volumes of the waste stream[32]. Statistic on waste management in low income or developing countries is usually lacking or often misleading since most of the city authorities do not collect or provide an accurate database on solid waste (MSW) [19]. The element of the collection includes not only the gathering of solid waste but also the hauling of waste after collection to the location where the collection vehicle is emptied. Within many assemblies and metropolitans such as the Takoradi metropolis, the collection and disposal of waste is problematic and challenging [28].

The absence of coordination among the relevant government institutions and agencies as a consequence makes the different agencies become the national counterpart to different external support agencies for different solid waste management collaborative projects without being aware of what other national agencies are doing. This leads to duplication of efforts, wasting resources, and unsustainability of overall solid waste management programmes. The lack of effective legislation for solid waste management, which is a norm in most developing countries, is partially responsible for the roles/functions of the relevant organization. Some designated institutions and government agencies are sometimes not clear on the specific roles to play in the management of solid waste, this is more worrisome when there are no any single committees within district assemblies. Government agencies and institutions into waste management most at times do not have well spelt out roles and functions concerning the management of solid waste, this is particularly true in assemblies without designated committees to coordinates waste management activities [26]. The gathering or collection of solid waste in growing economies is predominant within the urban communities. While those within the rural areas do not have access to waste collection schemes [11].

Solid waste management can therefore be described as the gathering or collection as well as transferring and ensuring the gathered waste is disposed-off from households, institutional, construction waste, and other sources of waste. It is a consequence of the day-to-day activity of human kinds that needs to be managed properly [33].

The cost of solid open dumping is difficult to quantify because of a lack of data on construction and tipping fees. However, dumping incurs substantial costs in lost land value and increases the risk of high disaster-related Large scales are usually available at treatment facilities, costs depending on the proximity and density of the local population to the disposal site [27]. Dumpsite closures can also result in significant costs. In addition to the costs of land, disasters, and dump closures, poor waste management using dumping or uncontrolled burning results in environmental costs from air and water pollution and damage to human health No large scales available: Load-count analysis: Count number of loads categorized in terms of the type of vehicle and weight a few of the loads[10]. Lack of an efficient and suitable collection method. The waste collection system of solid waste [9].

III. RESEARCH METHODOLOGY

The study employed a quantitative research method for this research. In the quantitative research method, the study is not dependent on the researcher. As a result, data is used to objectively measure reality. This research developed a construct of questionnaire to help identify the key challenges of quantifying solid waste in Ghana. Quantitative research creates meaning through objectivity uncovered in the collected data [34]. Quantitative research method is adopted to gather data that is pre determined leading to statistical data analysis [35].Quantitative research method makes it possible to collect a substantial quantity of data for further analysis [36]. This research obtained a total of 86 responses which indeed is substantial for the study.

This study employed a quantitative data collection technique. The location considered for the study comprises three regions of Ghana: Greater Accra, Ashanti and Upper West Region. Waste management companies and professionals in the waste management industry were the focal targets. The chain referral or snowball sampling techniques was employed. This is backed by commonly used to locate hidden populations. This method allows a study sample through referral particularly among research subjects who know other subjects that possess characteristics that are of interest to the specific research [37]. Snowball sampling technique takes advantage of the social network that exists within companies or institutions and providing the researcher with requisite data. This study took advantage of gathering data from persons within the waste management companies with the requisite knowledge on quantifying solid waste by adopting the snowball technique due to the sensitive nature of the research. These persons have good level of practice in the area of waste management and quantification.

The research methodology is summarized into fifteen (15) critical challenges. A closed-ended questionnaire was developed to ascertain the perception of waste management employees on these critical difficulties of quantifying waste. The questionnaire responses were eighty-six (86)highly experienced professionals within the Greater Accra Region, Ashanti Region and the upper west Region of Ghana.

Relative Importance Index (RII) was used to analyze the data gathered through questionnaires. The RII indices were used to ascertain the most pressing challenges. The analysis encompassed the challenges encountered by waste management companies within the three stated regions of Ghanain carrying out the quantification of solid waste. Factor analysis was then employed in the classification of the fifteen critical challenges into six major components. Factor Analysis (FA) attempts to simplify complex and diverse relationships that exist among a set of observed variables by uncovering common dimensions or factors that link together the seemingly unrelated variables and consequently provides insight into the significance of underlying structure of the data. Variables are proposed to explain the complex situation and their interconnections and interrelationships. In this regard the few basic variables and propositions central to understanding remain to be determined. It attempts to identify underlying variables or factors that explain the patterns of correlations within a set of observed variables. FA is often used in data reduction to identify a small number of factors that explain most of the variances observed in a much larger number of manifest variables [38].The suitability of the factor analysis led to the adaptation of the Kaiser-Meyer-Olkin (KMO), Bartlett test of sphere city. The appropriateness of factor analysis was confirmed by using the scree plot on the key components of the challenges identified in this study. When applying these techniques, it is important to determine how many factors to retain by using the scree plot. This decision is sometimes based on a visual inspection of the Scree plot [39]. The Kaiser-Meyer-Olkin (KMO) was also adopted in this study in line with the factor analysis to confirm the adequacy of the sample used for the factor analysis. KMO statistic varies between 0 and 1. A KMO value greater than 0.50 is recommended [40].

Piloting of the questionnaire among some industry workers and university lectures was carried out to verify the reliability and validity before distributing to the target population. Respondents were asked to rank the variables using a five-point Likert scale. The rankings were mapped as '1= Not severe' '2= less severe' '3= moderately severe' '4= severe' '5= very severe'. The criticality of the variables was ranked using the relative importance index. This was based on the suggestions that the mean, as well as standard deviation, are statically reliable to evaluate and draw conclusions on [41].

IV. RESULT AND DISCUSSIONS

Statistical package for social sciences (SPSS) was used to code the data gathered from the respondents in the field. Inferential as well as descriptive statistical tools were used in analyzing the data. The relative importance index and factor analysis were used to analysis the fifteen (15) critical challenges that impede the measurements of solid waste.

Code	Challenges	Std. Deviation	RII	Rank
C1	Technological difficulties	0.652	0.763	*1st*
C2	Inadequate separation of solid	0.660	0.763	*2nd*
C3	Financial difficulties	0.841	0.758	*3rd*
C4	Absence of standards of measuring waste	0.817	0.756	*4th*
C5	Insufficient technical resources and capacity	0.631	0.751	*5th*
C6	Composition of solid waste	0.796	0.748	*6th*
C7	Difficulties in gathering or collecting solid waste	0.803	0.746	*7th*
C8	Lack the needed infrastructure	1.001	0.744	*8th*
C9	Absence of waste collection data	0.931	0.742	*9th*
C10	Illegal dumping of solid waste	1.008	0.737	*10th*
C11	Measurement of the weight or volume of waste is completed	0.997	0.721	*11th*
C12	Poor institution experience on solid measuring solid waste	0.899	0.719	*12th*
C13	Time consuming manual process	1.271	0.709	*13th*
C14	Health hazards to waste quantifiers or measurers	1.013	0.705	*14th*
C15	Absence of a compelling legislature	1.011	0.665	*15th*

Table 1: RII ranking of the challenges

Inferring from the above table (Table 1), indicates the responses of the respondents suggesting that inadequate

separation of waste is a key constraint in quantifying solid waste with standard deviation of 0.660 and RII of 0.763. from Table 1 above, it was ranked first (1st). The waste separation is being characterized by inadequate waste bin to store different categories of waste, the lack of space for storage of waste, householders and other generators of waste unwillingly to separate [42]. Waste segregation or separation is a cumbersome process and households complain of not being used to separating waste, and the fear that waste sorted at homes would get mix up later when collected [43]. Respondents further agreed that technological difficulties constitute the second (2nd) key challenges that impedes the quantification of municipal solid waste. It has a standard deviation of 0.652 and RII OF 0.763. Waste. To minimize the volume of the waste, the dump was often binned. Unfortunately, this method is still being used in remote or sparsely populated areas in the world. As better waste-disposal technologies were developed and as values changed, more emphasis was placed on the environment and quality of life. Dumping and open burning of wastes is no longer an acceptable practice from an environmental or health perspective. While the technology of waste disposal has evolved during the past several decades, options are still limited [44]. Financial constraint was ranked fourth (3th). This again is consistent with assessing volume requires physical access to the FLW, costs will be related to ease of access. If multiple sites are included in the scope, then visiting them will add to costs, as will purchasing or renting relevant measuring device. Building up the cost quantifying solid waste comprise of the following: cost of equipment, cost of maintenance, insurance and servicing of equipment, annual cost salaries and other allowances, other costs of operations including office spaces and personal protective equipment (PPE) [20].

V. FACTOR ANALYSIS (FA)

Factor analysis is intimately involved with questions of validity. The critical constraints identified in the study was subject to factor analysis to verify the sampling adequacy. The data subjected to the factor analysis indicted that the sample size was adequate and greater than the 0.50. The KMO value for this analysis is 0.568. A KMO figure not exceeding 0.50 is an indication that the researcher has to increase or reconsider the variables [45]. The Kaiser-Meyer-Olkin Test of Sampling Adequacy (KMO) is a measure of the shared variance in the items [40]. This therefore suggest that the sample for this data is adequate and sufficient. The challenges affecting the quantification of solid waste identified for this study were fifteen in total. Due the large number of the variables prompted the need to reduce them into fewer coherent numbers, hence the use of the rotated component matrix. The importance of adopting the data reduction strategy by subjecting the data to the factor analysis [46] reflecting that the clusters of variables are in common but related factors [47]. To evaluate if this determinant value is statistically different from zero, Bartlett’s Test of Sphericity is used as shown in the table below. The table below shows the KMO and Bartlett’s test where the factor loadings exceeds o.50 [45]. The 0.568 implies the data was sufficient to proceed with the factor analysis [50]. The Bartlett;s test of sphericity shows that the Chi-squared is 351.155, which is a clear manifestations that there is no need for null hypothesis, The null hypothesis of Bartlett's test states that the observed correlation matrix is equal to the identity matrix, suggesting that the observed matrix is not factorable [51], the degree of freedom was 105 which is significant at 0.05 level of significance and all the key strategies identified for this study has being included. All this pointed out factor analysis is necessary for this study and the results are clear manifestation.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.568
Bartlett's Test of Sphericity	Approx. Chi-Square	351.155
	Df	105
	Sig.	.000

Table 2: KMO and Bartlett's Test

The Kaiser-Meyer-Olkin is the measure of sampling adequacy, which varies between 0 and 1. The values closer to 1 are better and the value of 0.5 is the suggested minimum. above. A bare minimum of 0.5 and the value between 0.5 and 0.7 are mediocre [40], value between 0.7 and 0.8 are good, value between 0.8 and 0.9 are great and value between 0.9 and above are superb [64]. To evaluate if this determinant value is statistically different from zero, Bartlett's Test of Sphericity is used [51]. The table below indicates the total variance explained (Eigen values) The components considered are those with Eigen value greater than or one (1). The table suggests that not all the key constraints identified were maintained but was extracted into six (6) components. The initial Eigen values of all the variables used in the factor analysis. The second(2nd) three columns show initial sums of squared loading and the last three columns portraying the rotation sums of squared loadings. The rotated sums of the squared characterizes the various allocations subsequent to the use of the Varimax rotation. The six (6) components retained as shown in the table below is sum up to 70.464%. of all the variance.

Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
2.997	19.983	19.983	2.058	13.721	13.721
2.187	14.579	34.562	2.033	13.553	27.273
1.870	12.468	47.030	1.787	11.911	39.185
1.306	8.704	55.734	1.713	11.423	50.608
1.183	7.889	63.623	1.683	11.218	61.826
1.026	6.841	70.464	1.296	8.639	70.464

Table 3: Initial and Rotated Matrix

The rotation of the squared loading is a representation of various distributions after the varimax with Kaiser normalization. The rotation of the varimax leads to an increase of the variance of each factor [52]. Conventionally, at least two or three variables must load on a factor so it can be given a meaningful interpretation [53].If an item is not significantly correlated to any of the factors (generally considered to be less than 0.30) and does not provide a conceptually vital dimension to the measure, the item should be removed. The secondary loading (or cross-loading) should be no greater than 0.32 [48]. A loading of .50 is enough to be considered strong. Each challenge or constraint that impedes the measurement of solid waste is loaded on a variable exceeding or greater than 0.50. Varimax makes it easy and less difficult to construe of the factor analysis compared to other rotation techniques [49].

Code	Component	Component 1	2	3	4	5	6
Component 1	Difficulties in separation and categorization of solid waste into quantifiable units						
C2	Inadequate separation of solid	**.542**					
C6	Composition of solid waste	**.716**					
C7	Difficulties in gathering or collecting solid waste	**.706**					
C9	Absence of solid waste collection data	**.741**					
Component 2	Technical challenges faced by waste quantifiers coupled with the lack of innovations						
C12	Poor institutional experience on solid measuring solid waste		**.716**				
Component 3	Difficulties in method(s) of measuring solid waste						
C11	Measurement of the weight or volume of waste is complicated			**.739**			
C4	Absence of standards of measuring waste			**.843**			
C13	Time consuming manual process			**.747**			
Component 4	Danger to the health of waste quantifiers or measurers						
C14	Posing health hazards to waste quantifiers or measurers				**.745**		
Component 5	Resources and logistics inadequacies						
C1	Technological difficulties					**.624**	
C3	Financial difficulties					**.797**	
C8	Lack of the needed infrastructure					**.857**	
C5	Insufficient technical resources and capacity					**.838**	
Component 6	Poor policies and legislative guiding the measurement of solid waste						
C15	Absence of a compelling legislature						**.555**
C10	Illegal dumping of solid waste						**.771**

Table 4: Rotated Component Matrix

Extraction method: principal component analysis. Rotation method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations

A. Component 1: Difficulties in separation and categorization of solid waste into quantifiable units

The total variance for this key component sums up to 13.721% of the entire variances. The individual key challenges in this component is collective identified as difficulties in separation and categorization of solid waste into quantifiable units. The research outcome regarding this component is geared towards ascertaining significantly the crucial constraints identified under the component. Inadequate separation of solid has a factor loading of 54.2%, composition of solid waste (71.6%), constraints in gathering or collecting solid waste 70.6% and the absence of waste collection data comprises of 74.1%.Composition of waste entails the component of waste stream as a percentage of the total mass waste generated [54].The findings revealed significant setback in quantifying solid waste to include the inability to segregate solid waste according to the various components within households, institutions and organizations. Quantifying solid waste and determining the composition is problematic. This is more predominantly in rural settlements in developing nations [2].Waste composition differs not just country to country, region to region but also household to household even within the same community [54]. Segregating solid waste into organic, metal, glass, rubber, food, yard waste, plaster paper and textile waste, hazardous waste, leather and so on is demanding, time wasting and challenging as well. The composition and characteristics of solid waste requires stringent and detailed examination [22].Records are data, often collected for other purposes, that can be used to quantify solid waste. Examples include waste transfer receipts and warehouse records. This method has the potential to be used to quantify solid waste. Waste quantification data can be used as part of other approaches or strategies for quantifying solid waste. It may be difficult to assess the accuracy of records in cases where the method used to generate the data is not clear. If records are to be used to quantify solid waste, the method used to obtain the data in the records should be understood, so that the accuracy can be determined. The use of existing information to quantify future waste is one of the most cost-effective methods and therefore should be one of the first avenues explored. It requires appropriate records being available, accessible and well understood by the person using them [20].

B. Component 2:Technical setbacks faced by waste quantifiers coupled with the lack of innovations

The principal component summed up to 13.553% of the total variance. This component was named technical setbacks face by waste quantifiers coupled with the lack of innovations. Technical factors influencing the system are related to lack of technical skills among personnel within municipalities and government authorities in the quantification of solid waste. Lack of resources, poor institutional framework, coupled with the truncated capacity in terms of both human and capital requirement or resources has hampered the quantification and management of solid waste in growing economies in a deprive and deplorable condition [55].The structure of the organization is concerned with the dissemination of roles, functions and the effective training of employees on the processes, methods and the overall capacity of the company in dealing with solid waste. Waste management institutions are confronted with the capacity to carry out capacity building among employees, strategic planning and decentralization responsibilities. While, especially waste management companies in the private sector are faced with competitive bidding, regulatory instruments as well as monitoring and controlling systems [56].

C. Component 3:Difficulties in method(s) of measuring solid waste

This component occupies 11.911% of the total variances. The method and procedure in used in quantifying solid waste poses threat to the quantification of solid waste as shown in the table above. The factor loadings for the individual components are 73.9% for challenges pose by measuring of the weight or volume of waste, the absence of specific standards of quantifying solid waste across board (84.3%) and 74.7% for time consuming manual process usually adopted in quantifying and segregating solid waste. The unique name identified for this component is difficulties in method(s) of measuring solid waste. Sorting out or separation of solid waste requires a more mechanized systems and machines even though other unapproved methods are often adopted, precious time is spent using these crude techniques although sometimes efficient. The use volume as a measure of quantity of waste can be misleading and inaccurate as adopted by some institutions [57]. A cubic meter of loose wastes is a different quantity from a cubic meter of compacted wastes with regards to both collection vehicle and at the landfill site or any other final disposal point[6]. The use of weighing as a method of quantifying solid waste though when compared to the other quantification methods gives a more accurate estimate. The use of the weighing scale, especially when measurement is required at more than one location is cumbersome to carry around. A weighing device must be purchased (or rented) and transported, and solid waste must be sampled and moved to the device. From a practical perspective, weighing is often not feasible. The quantification methods that involves analyzing the composition of waste and its characterization can be complex and complicated requiring specialists to execute [21]. The use regression model to quantify the amount of waste generated by household and solid waste at the municipal level but indicated that this model is complex and complicated as adopted by some waste management professionals [59].

D. Component 4: Danger to the health of waste quantifiers or measurers

Component four is made of health hazards which is posed to waste quantifiers or measurers and people who handled waste in general. The handling of waste poses serious risks and life threaten to people if not properly handled. The factor loading for this component is 74.5%. The principal component sums up to 11.423% of the total variance. [6] indicated waste is hazardous if it poses substantial threat to life and the environment. All individuals exposed to hazardous waste are potentially at risk, including those within health-care establishments that generate hazardous waste, and those outside these sources who either handle such waste or are exposed to it as a consequence of careless handling. Poor efficiencies, undesirable health impacts, environmental problems and social issues (such as informal communities working in unsafe conditions) due to centralized approach to waste management) [58]. Solid waste from all sources including those generated in households and industries have the potential to exhibit characteristics of hazardousness[60].

E. Component 5: Resources and logistics inadequacies

The principle component accounted for 11.218% of the total variance. The factor loading for technological difficulties was 62.4%, financial difficulties 79.7%, lack of the needed infrastructure 85.7%, and insufficient technical resources and capacity is 83.8%. The collective identity for this component is resources and logistics inadequacies. The quantification of solid waste requires different skills, expertise and methods. The use of some methods would even require statisticians' involvements and advice as well as knowledge from other professionals using specific methods to determine the quantity of solid waste [21]. There is the need to use modern technology in the quantification, segregating and characterizing solid waste. Light solid waste materials such as paper and paper bag can easily be sorted out using the machine designed to contain a conveyor belt and fan while the magnetic in built would aid in segregating ferrous and other heavy metals materials [57]. However, these machines were lacking or in total absences in some of the companies visited within the chosen regions of the study. Innovative and technological expediencies ought to be encouraged other than the use of the use of outmoded conventionally method across[58].There is therefore, the need for human resources to be equipped with the needed skills necessary for the measurement solid waste. Promoting public-private partnerships to implement infrastructure projects in different stages of municipal waste and management such as collection, quantification, transport, recycling, composting, waste to energy [61]. The build-up of the cost may will be incurred leading the quantification of solid waste include the cost of the equipment, cost of maintenance, insurance and servicing of equipment, annual

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cost of salaries and other allowances, cost of operations including office space and personal protective equipment. Other costs may include purchasing dustbins, plastic buckets for weighing sorted waste materials, nose masks and gloves.Some respondents did mention the breakdown of the only scale available for weighing and quantifying at the disposal points.

F. Component 6:Poor policies and legislature guiding the measurement of solid waste

The key component accounted for 8.639%. Absence of compelling legislature has a factor loading of 55.5% and illegal dumping of solid waste has a factor loading 77.1%. The lack of an adequate policy and regulatory framework complicates matters even further. Research has proven that command and control approach alone cannot and will not improve waste quantification and management practices. Command and control should be supplemented by market-based instruments with incentives and disincentives so as to stimulate investments and entrepreneurship to transform waste management into an environmentally sound and socially acceptable business. Some countries lack regulations on certain waste streams such as e-waste. Countries that do not have formal infrastructures for recyclables collection, have only recently started legally recognizing the huge numbers of waste pickers who perform such a crucial service for the sector. By doing so, they are not only protecting and empowering the poor, but are also proceeding towards meeting relevant MDGs. Ensures multi-stakeholder participation in decision-making process by involving Non-Governmental Organization (NGOs), Community Based Organization (CBOs), rag pickers, private sector, residential and commercial communities with the government. Brings waste workers into the formal economy and providing them with safe working conditions. Apart from ensuring better living and working conditions for the rag-pickers, the initiative safeguarded the labour rights and successfully addressed the issue of child labour in waste-picking activities [62].

VI. CONCLUSIONS

There are significant challenges impeding the quantification of solid waste directly and indirectly. This is more predominate in the rural communities and within municipalities, institutions or organizations that are unable to engage the services of well-established waste management companies to carry out this mandate of quantifying and managing their waste. Quantitative research technique was used for this study and the snowball or referral method adopted in other to reach the sampled population with the requisite expertise in the quantification of solid waste. Respondents ranked the challenges using a five-point Likert scale. These respondents are stakeholders directly involved in the measurement or quantification of solid waste in the study areas. The application of factor analysis categorized the fifteen identified challenges into six key challenges which are difficulties in separation and categorization of solid waste into quantifiable units, technical challenges face by waste quantifiers coupled with the lack of innovations, difficulties in method(s) of measuring solid waste, inability to meet the health and safety standards, resources and logistics inadequacies and poor policies and legislature guiding the measurement of solid waste. The Cronbach alpha coefficient test showed the reliability of the scale and the KMO and the Bartlett's test of sphere city indicated that the sampling adequacy of this publication.

The research places emphasis on the need to quantify solid waste as it aids in the prioritizing actions on the management of waste, evaluate a solution to the handling of solid waste, repeated quantification of waste to determines the trend of waste generation in specific areas [20]. This publication established fifteen crucial setbacks in quantifying solid waste through the piloted and extensive literature review by previous authors. As population increases, urbanization takes place, institutions and industries grow, waste generated would continuous to exist. The quantification of waste is paramount and the challenges that confront measurement of waste herein identified need to be addressed. Waste management companies, households, local government, industries, NGOs and all other stakeholders need to be involved partial because the generation of waste and its quantification starts from these sources. To achieve proper segregation of waste, it must begin at the generation sources especially in less developed communities where there is no designed machine to segregate waste which would eventually yield effective quantification.

REFERENCES

[1.] Adu-Boahen, K., Atampugre, G., Antwi, K. B., Osman, A., Osei, K. N., Mensah, E. A., &Adu-Boahen, A. O. (2014). Waste management practices in Ghana: challenges and prospect, Jukwa Central Region. International Journal of Development and Sustainability, 3(3), 530-546.

[2.] Taghipour, H., Amjad, Z., Aslani, H., Armanfar, F., &Dehghanzadeh, R. (2016). Characterizing and quantifying solid waste of rural communities. Journal of Material Cycles and Waste Management, 18(4), 790-797.

[3.] Bai, R., &Sutanto, M. (2002). The practice and challenges of solid waste management in Singapore. Waste management, 22(5), 557-567.

[4.] Guerrero, L. A., Maas, G., &Hogland, W. (2013). Solid waste management challenges for cities in developing countries. Waste management, 33(1), 220-232.

[5.] Ejaro, S. P., &Jiya, S. N. (2013). Source Specific Quantification, Characterisation and Management of Solid Waste in Lapai, Niger State, Nigeria. Ethiopian Journal of Environmental Studies and Management, 6(5), 561-569.

[6.] United Nations Environmental Programme, (2009). Developing Integrated Solid Waste Management Plan Training Manual. Volume 1, Washington Dc: United Nation Environmental Programme

[7.] Ying-Chu, C. (2018). Effects of urbanization on municipal solid waste composition. Waste management, 79, 828-836.

[8.] Abdoli, M. A., Rezaei, M., &Hasanian, H. (2016). Integrated solid waste management in megacities. Global Journal of Environmental Science and Management, 2(3), 289-298.

[9.] Hui, Y., Li'ao, W., Fenwei, S., & Gang, H. (2006). Urban solid waste management in Chongqing: Challenges and opportunities. Waste management, 26(9), 1052-1062.

[10.] Hoornweg, D., &Bhada-Tata, P. (2012). What a waste: a global review of solid waste management (Vol. 15, p. 116). World Bank, Washington, DC.

[11.] Zurbrugg, C. (2002). Urban solid waste management in low-income countries of Asia: How to cope with the garbage crisis. Presented for: Scientific Committee on Problems of the Environment (SCOPE) Urban Solid Waste Management Review Session, Durban, South Africa, 1-13.

[12.] Abbas, Ismail I., Jinane K. Chaaban, A. R. Abdel-Rahman Al-Rabaa, and A. Shaar. "Solid Waste Management in Lebanon: Challenges and Recommendations." Journal of Environment and Waste Management 4, no. 2 (2017): 053-063.

[13.] Zaman, A. U. (2015). A comprehensive review of the development of zero waste management: lessons learned and guidelines. Journal of Cleaner Production, 91, 12-25.

[14.] Kuniyal, J. C., Jain, A. P., &Shannigrahi, A. S. (2003). Solid waste management in Indian Himalayan tourists' treks: a case study in and around the Valley of Flowers and Hemkund Sahib. Waste Management, 23(9), 807-816.

[15.] Al-Khatib, I. A., Monou, M., Zahra, A. S. F. A., Shaheen, H. Q., &Kassinos, D. (2010). Solid waste characterization, quantification and management practices in developing countries. A case study: Nablus district–Palestine. Journal of environmental management, 91(5), 1131-1138.

[16.] Zotos, G., Karagiannidis, A., Zampetoglou, S., Malamakis, A., Antonopoulos, I. S., Kontogianni, S., &Tchobanoglous, G. (2009). Developing a holistic strategy for integrated waste management within municipal planning: Challenges, policies, solutions and perspectives for Hellenic municipalities in the zero-waste, low-cost direction. Waste Management, 29(5), 1686-1692.

[17.] Pokhrel, D., &Viraraghavan, T. (2005). Municipal solid waste management in Nepal: practices and challenges. Waste Management, 25(5), 555-562.

[18.] Rubinos, D. A., &Spagnoli, G. (2018). Utilization of waste products as alternative landfill liner and cover materials–A critical review. Critical reviews in environmental science and technology, 48(4), 376-438.

[19.] Kodwo, M., Kwasi, Obiri-Danso., Zsofia, Kadar., Bernard, Fei-Beffoe., and Moses, Y. Mensah (2015). Municipal solid waste, characterization and quantification as a measure towards effective waste management in Ghana. waste management, December, Volume 46, pp. 15-27.

[20.] CEC (2019) Technical Report: Quantifying Food Loss and Waste and Its Impacts. Montreal, Canada: Commission for Environmental Cooperation. 129 pp.

[21.] Hanson, C., Lipinski, B., Robertson, K., Dias, D., Gavilan, I., Gréverath, P., & Lomax, J. (2016). Food loss and waste accounting and reporting standard.

[22.] Dangi, M. B., Pretz, C. R., Urynowicz, M. A., Gerow, K. G., & Reddy, J. M. (2011). Municipal solid waste generation in Kathmandu, Nepal. Journal of environmental management, 92(1), 240-249.

[23.] Miezah, K., Obiri-Danso, K., Kádár, Z., Fei-Baffoe, B., & Mensah, M. Y. (2015). Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. Waste Management, 46, 15-27.

[24.] Hazra, T., &Goel, S. (2009). Solid waste management in Kolkata, India: Practices and challenges. Waste management, 29(1), 470-478.

[25.] Obirih-Opareh, N., & Post, J. (2002). Quality assessment of public and private modes of solid waste collection in Accra, Ghana. Habitat International, 26(1), 95-112.

[26.] Puopiel, F. (2010). Solid waste management in Ghana: the case of Tamale Metropolitan Area (Doctoral dissertation).

[27.] Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a waste 2.0: a global snapshot of solid waste management to 2050. World Bank Publications.

[28.] Fei-Baffoe, B., Nyankson, E. A., &Gorkeh-Miah, J. (2014). Municipal Solid Waste Management in Sekondi-Takoradi Metropolis, Ghana. Journal of Waste Management, 2014.

[29.] Jin, J., Wang, Z., & Ran, S. (2006). Solid waste management in Macao: practices and challenges. Waste management, 26(9), 1045-1051.

[30.] Nguyen, T. T. P., Zhu, D., & Le, N. P. (2015). Factors influencing waste separation intention of residential households in a developing country: Evidence from Hanoi, Vietnam. Habitat International, 48, 169-176.

[31.] Moh, Y. (2017). Solid waste management transformation and future challenges of source separation and recycling practice in Malaysia. Resources, Conservation and Recycling, 116, 1-14.

[32.] Nang, D. B., Abanyie, S. K. &Ampofo, S., 2017. olid Waste Management Challenges in Urban Areas of Ghana: A Case Study of Bawku Municipality. Interational Journal of Geosciences, 08(04), pp. 494-513.

[33.] Farah, M. J. (2019). Challenges of Solid Waste Management and factors influencing its effectiveness: A case study in Burao Municipality.

[34.] Williams, C. (2007). Research methods. Journal of Business & Economics Research (JBER), 5(3).

[35.] Creswell, J. W. (2003). A framework for design. Research design: Qualitative, quantitative, and mixed methods approaches, 9-11.

[36.] Dawson, C., (2009). Introduction to research methods: A practical guide for anyone undertaking a research project. Hachette UK

[37.] Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. Sociological methods & research, 10(2), 141-163.

ISSN No:-2456-2165

[38.] Balasundaram, N. (2009). Factor Analysis: Nature, Mechanism and Uses in Social and Management Science Research. Journal of Cost and Management Accountant, Bangladesh, 37(2), 15-25.
[39.] Ledesma, R. D., Valero-Mora, P., & Macbeth, G. (2015). The scree test and the number of factors: a dynamic graphics approach. The Spanish journal of psychology, 18.
[40.] Kaiser, H. F. (1974). An index of factorial simplicity. Psychometrika, 39(1), 31-36.
[41.] Wan, X., Wang, W., Liu, J., & Tong, T. (2014). Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC medical research methodology, 14(1), 1-13
[42.] Anarfi, K. P. (2013). Source separation, characterization and recycling potential of household solid waste: A case study of Kumasi, Ghana (Doctoral dissertation).
[43.] Zhang, H., & Wen, Z. G. (2014). Residents' household solid waste (HSW) source separation activity: A case study of Suzhou, China. Sustainability, 6(9), 6446-6466.
[44.] Ioana, I. (2010). Clean technology from waste management. In Advances in Waste Management, 4th WSEAS International Conference on Waste Management, Water Pollution, Air Pollution, Indoor climate (WWAI'10) (pp. 155-171).
[45.] Field, A. (2013). Discovering statistics using IBM SPSS statistics. sage.
[46.] Pallant, J. (2020). SPSS survival manual: A step by step guide to data analysis using IBM SPSS. Routledge.
[47.] Degobert, M., &Brangeon, S. (2016). Bringing value to waste in developing countries: Case study of two independent islands (Vanuatu and Haiti). Society and Business Review, 11(1), 2-11.
[48.] Tabachnick, B. G., &Fidell, L. S. (2007). Experimental designs using ANOVA (p. 724). Belmont, CA: Thomson/Brooks/Cole
[49.] Costello, A. B., & Osborne, J. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. Practical assessment, research, and evaluation, 10(1), 7.
[50.] Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2007). Using multivariate statistics (Vol. 5, pp. 481-498). Boston, MA: Pearson.
[51.] Pett, M. A., Lackey, N. R., & Sullivan, J. J. (2003). Making sense of factor analysis: The use of factor analysis for instrument development in health care research. sage.
[52.] De Coster, J. (1998). Overview of factor analysis.
[53.] Henson, R. K., & Roberts, J. K. (2006). Use of exploratory factor analysis in published research: Common errors and some comment on improved practice. Educational and Psychological measurement, 66(3), 393-416.
[54.] Khan, D., Kumar, A., &Samadder, S. R. (2016). Impact of socioeconomic status on municipal solid waste generation rate. Waste Management, 49, 15-25.
[55.] Boadi, K. O., &Kuitunen, M. (2005). Environmental and health impacts of household solid waste handling and disposal practices in third world cities: the case of the Accra Metropolitan Area, Ghana. Journal of environmental health, 68(4).
[56.] Schübeler, P., Christen, J., &Wehrle, K. (1996). Conceptual framework for municipal solid waste management in low-income countries (Vol. 9). St. Gallen: SKAT (Swiss Center for Development Cooperation).
[57.] Ojolo, S. J., Adelaja, A. O., Kilanko, O., &Orisaleye, J. I. (2011). Design and development of waste sorting machine. Journal of Emerging Trends in Engineering and Applied Sciences, 2(4), 576-580.
[58.] ADB, I. (2007). Toward Resource Efficient Economies in Asia and The Pacific: Highlights. Institute for Global Environmental Strategies (IGES), Asian Development Bank (ADB), Online available at http://www. adb. org/Environment/Highlights-TREEAP. asp.
[59.] Lebersorger, S., &Beigl, P. (2011). Municipal solid waste generation in municipalities: Quantifying impacts of household structure, commercial waste and domestic fuel. Waste management, 31(9-10), 1907-1915.
[60.] Rosenfeld, P. E., & Feng, L. (2011). Risks of hazardous wastes. William Andrew.
[61.] Modak, P., Jiemian, Y., Hongyuan, Y., & Mohanty, C. R. (2010). Municipal solid waste management: turning waste into resources. Shanghai manual: a guide for sustainable urban development in the 21st century,
[62.] Manual, S. (2010). A Guide for Sustainable Urban Development in the 21st Century. Shanghai, China.
[63.] Anon, (2005). "Solid Waste Management", Cal Recovery Inc., Vol. 1, California, U.S.A, 49pp.
[64.] Hutcheson, G. D., & Sofroniou, N. (1999). The multivariate social scientist: Introductory statistics using generalized linear models. Sage.