Characterisation of Kitchen Solid Waste at Senior High Schools in Tarkwa

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Abstract

Solid Waste Management has become a predicament in most developing countries across the globe of which Ghana is no exception. Solid waste if remains unattended leads to numerous environmental nuisances such as aesthetic degradation, offensive odour, breeding ground for vermin and a waste of resources. Presently, Kitchen Solid Waste (KSW) management in Senior High Schools (SHS) within the Municipality is attained chiefly by incineration or landfilling, a method that has caused untimely deterioration of incinerators due to the high moisture content of the kitchen waste, leachate production and uncontrolled release of greenhouse gases. This study aimed at characterising and quantifying solid waste generated in the kitchen of selected SHS in the Tarkwa-Nsuaem Municipality. The effectiveness and willingness of waste segregation assessed at source and production of primary data for forecasting to enhance waste management would be ascertained. Well-lined waste bins coupled with other materials, enabled sorting and segregation of the KSW at source. Also, well-structured questionnaires and in-depth interviews with relevant stakeholders were undertaken for the purpose of data acquisition over a two-week period. The outcome of the study revealed a per capita waste generation rate of 0.0920 kg/cap/day at Tarkwa SHS (Tarsco) with a biodegradable and non-biodegradable generation rates of 0.0896 kg/cap/day and 0.0024 kg/cap/day. Also, the willingness of segregation was 94.44 % while its effectiveness was 50 %. Fiaseman SHS (Fiassec) on the other hand recorded per capita KSW generation rate of 0.0477 kg/cap/day, with a biodegradable and non-biodegradable generation rates of 0.0440 kg/cap/day and 0.0036 kg/cap/day. Also, the willingness of segregation was 100 % while its effectiveness was 26.67 %. Conclusively, the per capita KSW generation rate at Tarsco outweighs Fiassec hence it is envisaged that biogas and compost would be readily produced at Tarsco due to the availability of more resources while ensuring environmental sustainability.

Keywords: Kitchen solid waste, Segregation, Biodegradables, Environmental sustainability, Waste hierarchy

1 Introduction

Solid waste is a solid or semisolid, non-soluble material generated by human activities. Solid waste classification includes agricultural refuse, domestic waste, demolition waste, industrial waste, mining residues, commercial waste and sewage sludge (Hagerty *et al*., 1973). Annually, developed nations such as Australia, and United Kingdom, record an average food waste generation of 7.0 (WRAP, 2013) and 4.4 (National Waste Report, 2010) million tonnes respectively. It has been estimated that beyond a third of food is wasted annually via processing, distribution, consumption and disposal worldwide (FAO, 2013; Vandermeersch *et al*., 2014; Slorach *et al*., 2019). In developing countries, the quantities of waste generated on daily basis is very alarming of which Ghana is no exception. According to Seo *et al*. (2004), the life style, population growth, consumer habit and increase in the use of packaging materials are major contributing factors to high quantity waste generated in developing countries. Poor management of the waste has been attributed to the unavailability of facilities to contain the generated waste and lack of primary data (Ogwuleka, 2009). Eriksson *et al*., (2015) and Karmee (2016) on the other hand attributed food waste disposal challenges primarily to its high moisture, heterogenous nature and oil content.

Despite the global technological advancement, wastes still pose detrimental challenges to the environment of most communities of developing countries. Zurbrugg (2003) revealed that in developing countries, one to two-thirds of the solid waste generated lacks routine collection. Additionally, the inability to segregate these wastes to recover valuables before being disposed of marks a major contributor to the short life span of several landfill sites. According to Periathamby *et al*. (2008) most developing countries including Ghana has most her SHS primarily resorting to either dumping or incineration of their kitchen solid waste (KSW) as the ultimate but ineffective waste treatment option. However, dumping has detrimental impacts such as breeding of flies, offensive odour, attraction of rodents and an

unsightly scene whereas the higher moisture contents of these biodegradables results in low combustion, production of excessive particulate matter, ash residue during incineration and wastewater discharge into the environment (Ali *et al*., 2015; Othman *et al*., 2012). Regardless of reduction method being the most preferred management option in the waste hierarchy (Papargyropoulou *et al*., 2014), advanced measures are not in place to retrieve valuables which may serve as raw materials for biogas production and compost for the agricultural sector.

1.1 Present situation in these schools

Tarkwa-Nsuaem Municipality has two public funded SHS namely Tarkwa Senior High (Tarsco) and Fiaseman Senior High Schools (Fiassec) respectively. Kitchen solid wastes (KSW) generated in these institutions face ineffective waste collection and treatment. This therefore has the potential to create serious health issues for the workers at the kitchen, students and waste handlers. The waste is usually composed of kitchen leftover, food waste, empty cans, plastics, bones, wood, rubbers, etc. All these wastes are usually dumped in the same bin without any proper segregation. These institutions lack reliable data on the level of waste generated for a given time period, the respective component of the kitchen waste to aid proper management plans and to curb the difficulty encountered routinely by waste handlers and the appropriate KSW treatment option. This research seeks to characterise and quantify solid waste generated at the kitchen of some selected SHS, produce primary data and to establish an optimal KSW management option.

2 Materials and Methods Used

2.1 Study Area

The study was conducted at some selected Senior High Schools (SHS) in the Tarkwa-Nsuaem Municipality which are situated in the Western Region. Geographically, the municipality is located with coordinates of 05°18'00" N and 01°59'00" W. Averagely, a rainfall expectancy of 1500 mm with a doubling maximum effect is experienced usually from the period of March to September seasonally. Also, it has been marked as one of the areas with high rainfall recordings in the country. Temperature recordings usually range from 26 °C to 30 °C in August and March.

The research targeted the publicly funded Senior High Schools (SHS) in the municipality. These publicly funded institutions are the Tarkwa Senior High School and Fiaseman Senior High School.

Fiaseman Senior High School (Fiassec), is a second cycle institution in the Tarkwa-Nsuaem Municipality. The school has a population of 1735 students excluding the second-year students due to the present changes in the educational system. It has infrastructural facilities to accommodate a sect of students as boarders while the remaining sect of students are non-resident (day). The institution is a mixed sex school. The school is located in the southern part of Tarkwa. It has a dining hall spacious enough to house over 1056 students. The dining hall has been architecturally merged with the school's kitchen for easy accessibility.

The Tarkwa Senior High School (Tarsco), is a mixed sex institution with a population of 1537 students excluding the second-year students due to the present changes in the educational system. The school has enough infrastructural facilities for achieving academic excellence. Tarsco is located along the Tarkwa-Takoradi stretch. The dining hall has the capacity to house over 1400 students. The hall has an annex, which is made available in extreme conditions. Also, the school's kitchen has been architecturally merged with the dining hall to enhance access to the hall.

2.2 Research Structure Implementation

The study was conducted through the acquisition of relevant data. The research gathered data from both primary and secondary sources. Primary data acquisition was achieved through reconnaissance or field survey, in-depth interviews, and a questionnaire administration. A reconnaissance was made at both schools' kitchen, which sought to familiarise with the environment and to engage the matrons and the kitchen staff by explaining to them, the relevance of the survey. An in-depth interview was carried out to solicit for information from the heads in charge of the kitchen (matron) of the respective institutions. Questionnaires were administered to respondents in the various institutions to aid in gathering data on their willingness to segregate waste, attitude and knowledge on kitchen solid waste management. Secondary data was acquired via sources including articles, journal review, reports, internet resources and books that had relevant information pertaining to kitchen solid waste management.

2.3 Segregation of KSW Generated

The kitchen staff of both institutions were sensitized on how to segregate their kitchen solid waste generated on daily basis throughout the entire period of data collection. The method employed in this exercise sought to classify the KSW generated based on its biodegradability or non-biodegradability from the selected sites. A green and blue rubber container with legible

inscriptions were provided to enhance the exercise at Fiassec and Tarsco to facilitate the segregation. Also, each container had polythene bags as inner liners, for easy handling of the waste. The KSW was accessed and handled neatly from the segregation containers. The respondents were also given packs of polythene bags which were to be used in lining the segregation containers each day, throughout the study. All biodegradable solid food waste were dumped in a green container while the non-biodegradable solid food waste were deposited into a blue container. The segregation exercise spanned from the 11th to 27th February, 2019 but was very representative of the sample size. Participants were also, made to understand and appreciate the significance of this activity. Room was given for questions to ensure a thorough understanding of the process. The KSW segregated at the various sites were analysed to determine the percentage composition by the formula:

Percentage Composition of Segregated KSW =

$$\frac{\text{Weight of segregated waste}}{\text{Total weight of KSW generated}} \times 100\ \%$$

2.3.1 Sorting of Generated KSW

KSW generated on a daily basis in both institutions were further sorted irrespective of the initial clue the food menu provided. Sorting was carried out in a spacious and serene environment close to the kitchen premises. Different components of the non-biodegradables were sorted out on a clean polythene sheet. The biodegradable composition reflected a specific meal on the menu served that particular day. The non-biodegradables included cans, rubbers and plastic bottles. Personal protective equipment and other specified materials that enhanced the sorting process included; nose mask, gloves, safety boot, polythene sheet and bags.

2.3.2 Quantification and Per Capita Waste Generation

The solid waste stream generated from the selected sites were weighed daily using a spring balance having a span of 0 – 150 kg. The biodegradables and non-biodegradables generated after characterisation were recorded daily from both institutions. For proper record keeping, a notebook and pen were used in gathering the field data. The characterised waste stream at the sites were weighed and quantities recorded differed significantly among these institutions.

The per capita waste generation (PCG) was determined for both schools. This was done by determining the total weight of each characterised waste and expressing the output in kilogram Miezah *et al*., (2015). Mathematically, PCG was obtained by this formula;

Per Capita Waste Generation =

$$\frac{\text{Weight of waste generated at household}}{\text{Total number of persons in the household x Total number of generation days}}$$

3 Results and Discussion

3.1 Knowledge on some Environmental Management Options

The study depicts an overall staff size of 41 that manage the kitchen of the two publicly funded second cycle institutions in the municipality. An overall respondent size of 33 were reached with male to female ratios of 5:13 at Tarsco and 3:12 (1:4) at Fiassec respectively.

The study revealed that, 94.44 % respondents at Tarkwa SHS were willing to segregate the KSW generated, hence a high segregation likelihood. On the effectiveness of segregation, it was realised to be higher after sensitising the respondents on how and the need to segregate their waste. Also, 88.89 % of respondents admitted that value such as manure and biogas production can be added to the KSW after segregation while 11.11 % were not in support. On the management issues of the environment, a 100 % respondent feedback was attained. They had either read or heard an issue on waste management. 22.22 % of respondents disclosed that they acquired information on television only, while the radio furnished 33.33 % such information. Other respondents (38.89 %) attributed the source of their information to both television and radio while other source of information recorded 5.56 %. 100 % of respondents revealed that, KSW mismanagement can be catastrophic to the environment.

At Fiaseman SHS, the study revealed that, 100 % of respondents were willing to segregation the KSW generated hence a high likelihood of segregation while on the effectiveness of segregation, it was realised to be low after sensitising the respondents on how and the need to segregate their waste for week one. Nevertheless, there was appreciable increment in weight quantified during the second week. Also, 66.67 % of respondents admitted that KSW segregation enables retrieval of valuable materials that can add value such as biogas and compost production to the waste while 33.33 % were not in support. On the management issues of the environment, a 94.44 % respondent feedback was attained. They had either read or heard an issue on waste management. 26.67 % of respondents disclosed that, they acquired information on television only, while the radio furnished 26.67 % such information. Other

respondents (26.67 %) attributed the source of their information to both television and radio. Other sources of information recorded 13.33 %. A 100 % respondent revealed that, KSW mismanagement can be catastrophic to the environment.

3.2 Composition of KSW

The results from the two-week KSW characterisation in Tarsco and Fiassec due to the variations in the numbers enrolled (Gold and Green Sect of students) demonstrated that the waste stream had several compositions. As illustrated in Table 1, the daily KSW composition was dependent on the meal served from the schools' respective menu. It comprised chiefly of biodegradables (carbohydrates, proteins, green leaves, etc.) and a few non-biodegradables (cans, plastics, rubber, etc.). The components of the waste stream significantly project a fore knowledge of the opportunities available to industries that use such waste as resource or raw material and also to predict their respective flaring abilities when used for biogas production. The composition also assists decision makers in arriving at better decisions.

Table 1 KSW Composition

Item	NAME OF INSTITUTION			
	Tarkwa SHS		Fiaseman SHS	
	Biodegradables	Non-Biodegradables	Biodegradables	Non-Biodegradables
Monday	Corn dough, bread, kenkey, rice, bones	Cans (tomato, milk), sachet	Millet, bread, rice, kenkey, fish bones	Cans (tomato, sardine)
Tuesday	Millet, bread, gari, beans, rice	Cans (tomato, milk), sachet	Bread, gari, beans, rice	Tomato cans
Wednesday	Bread, rice, beans, egg shells, kenkey	Cans (tomato, sardine), rubber	Millet, bread, kenkey, fish bones	Tomato cans, sachet
Thursday	Bread, gari, beans, rice, fish bones	Cans (tomato, milk)	Rice, Fante kenkey, fish bones	Tomato cans
Friday	Millet, bread, rice, kenkey, egg shells	Cans (tomato, mackerel)	Bread, gari, beans, rice	Tomato cans
Saturday	Rice, bread, beans, kenkey, fish bones	Cans (tomato, milk)	Millet, bread, rice, kenkey, husk	Cans (tomato, sardine)
Sunday	Bread, gari, beans, rice	Tomato cans. Rubbers	Gari, beans, rice	Cans (milk, tomato)

3.3 Quantification of KSW

Presented in Figures 1 to 4 are charts depicting the quantities of KSW recorded at the study sites with blue and brown bars representing biodegradables and non-biodegradables respectively.

The study therefore ascertained the quantity of waste generated on daily basis at the respective sites. This aimed at knowing the waste generation trends, fluctuations and what the causes are. The KSW generated by these institutions were in kilograms for the study period. Comparatively, Tarsco recorded relatively higher values of KSW generated by weight to that of Fiassec on daily basis throughout the study. Figure 1 shows both the trend and fluctuations of the KSW from Tarsco for the first week of the study. At Fiassec (Figure 2),

the KSW was comparatively lower to the results from Tarsco. Nevertheless, the biodegradables recorded extremely greater values than the non-biodegradables on daily basis. Subsequent data gathered from the respective institutions reflected similar trend, having the biodegradables outweighing the non-biodegradables at Tarsco (Figure 3) and that of Fiassec (Figure 4).

The overall waste generated from the two study sites by weight was 2300 kg. Tarsco contributed a quota of 1757 kg biodegradables and 46.5 kg of non-biodegradables for the study period. Also, Fiassec contributed 458.5 kg of biodegradables while the non-biodegradables were 38 kg adding to the grand total recorded. The higher values of biodegradables recorded can be attributed to purchasing of unprocessed food ingredients to be cooked for students at the respective sites of study as it is for most developing countries (Seshie, 2015).

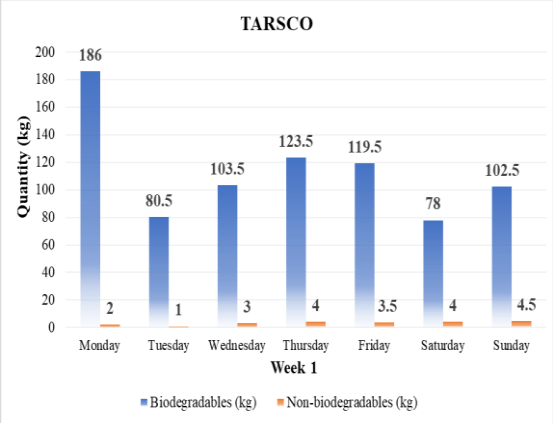

Figure 1 Quantification of KSW at Tarsco for Week One

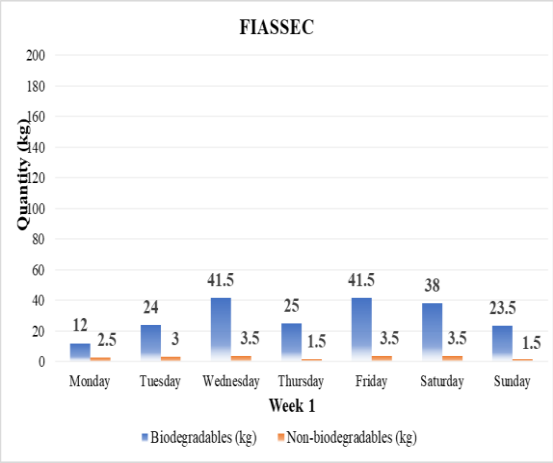

Figure 2 Quantification of KSW at Fiassec for Week One

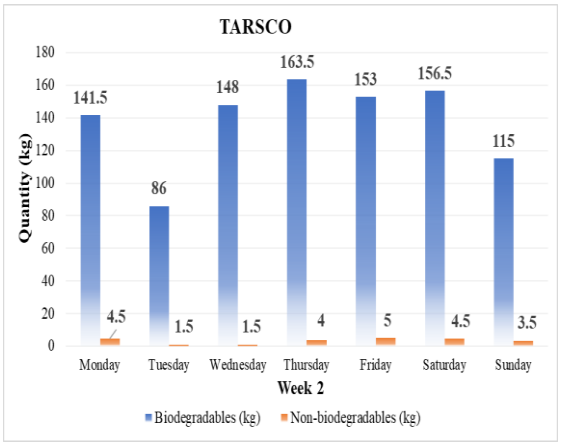

Figure 3 Quantification of KSW at Tarsco for Week Two

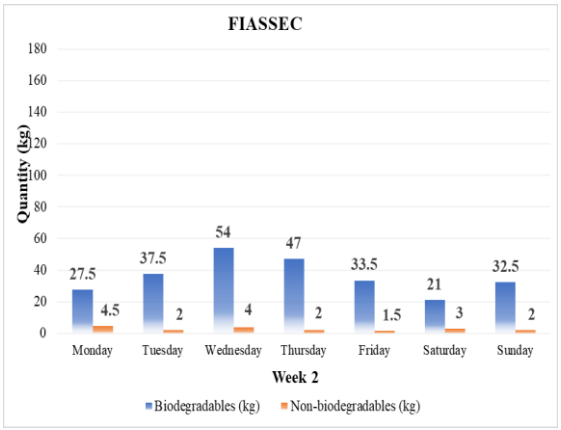

Figure 4 Quantification of KSW at Fiassec for Week Two

3.4 Per Capita Waste Generation

Presented in Figure 5 is a chart depicting the per capita waste generation for both institutions.
The study revealed a total of 1803 kg KSW generation from Tarsco. From Figure 5, the average daily KSW generation per person was 0.09 kg/cap/day with a negligible quantity of non-biodegradable waste resulting in a close fit record of 0.09 kg/cap/day biodegradables. On the other hand, Fiassec with an overall KSW production of 458.5 kg recorded an average daily KSW generation of 0.05 kg/cap/day, while biodegradables alone had 0.04 kg/cap/day. Comparatively, Tarkwa SHS had greater per capita KSW generation than Fiaseman SHS. This can be attributed to the population size. At Tarkwa SHS, a higher number of tables (100) were served daily with 14 students per table while Fiassec served only 62 tables with 12 students at each table. Regional factors such as policy restrictions of the respective institutions also contributed to that vast differences in the per capita waste generation. The level of enforcement of these laws at the dining halls influenced the values recorded at the

respective sites. Other reasons could be reluctance on the part of the students to go for the meal hence contributing to higher values recorded.
According to Guangyu (2009), the average daily solid waste generation per capita in low income countries is 0.3-0.6 kg/cap/day. In Ghana, precisely Tarkwa-Nsuaem, an average daily waste generation of 0.92 kg/cap/day has been recorded to be generated by households (Ansah, 2014). The study discloses lesser values of 0.09 kg/cap/day and 0.05 kg/cap/day at Tarsco and Fiassec respectively as compared to findings from the entire municipality. This can be attributed to a more narrowed area of search, with a smaller population influence affecting the results. Also, regional and social factors such as school (dining hall) policy enforcement and attitudinal lifestyle of the students, were some other reasons accounting for the vast deviation in records. This baseline data has the tendency to be the first of its kind in these publicly funded institutions in the municipality. Investors can rely on this information to forecast and make critical decisions regarding KSW as a resource from these institutions. The authorities of the respective institutions can also fall on the information for advanced planning, even as the population increases.

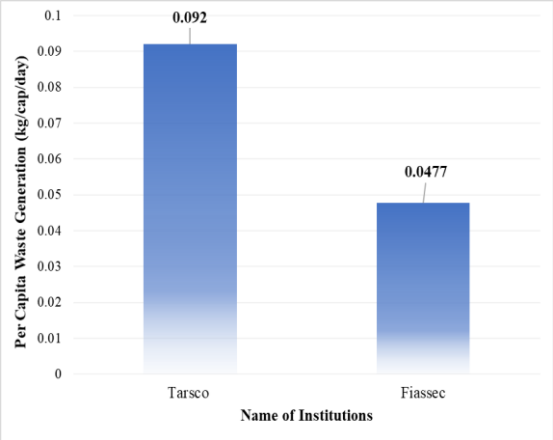

Figure 5 Per Capita Waste Generation

3.5 Willingness and Effectiveness of KSW Segregation

Figure 6 presents a graphical representation on the willingness to segregate KSW at the respective study sites.

The survey conducted during the study revealed that, respondents at the respective site were zealous and willing to segregate their KSW primarily into biodegradables and non-biodegradables which was subject to the availability segregating materials at their disposal. Figure 6 shows the willingness of respondents at Tarsco and Fiassec to segregate their KSW. The likelihood of respondents to segregate their KSW at Tarkwa SHS was very good with a percentage marking of 94.44 %. Fiaseman Senior High School recorded 100 % willingness to segregate their KSW. On the other hand, responses on the effectiveness of KSW segregation was not encouraging at the initial stages as respondents from Fiaseman Senior High School found it challenging segregating their KSW after the sensitisation. This can be reason for the lower quantities of KSW recorded during the first week of quantification. The effectiveness of KSW segregation was on the rise at the Tarkwa Senior High School after the awareness creation, hence reflecting in the quantities of KSW recorded for the two-week period.

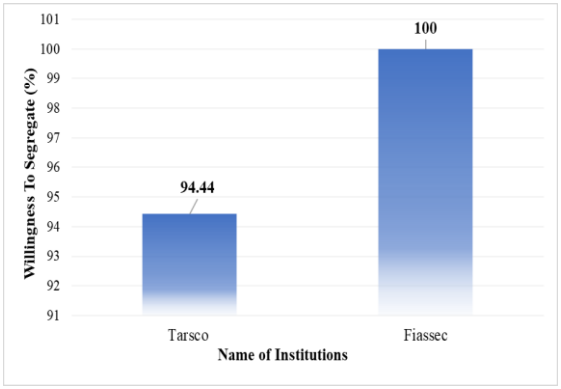

Figure 6 Willingness to Segregate

4 Conclusions and Recommendations

4.1 Conclusions

From the available data and result discussions, it can be concluded that;

At Tarkwa SHS, the overall biodegradable KSW by weight recorded was 1757 kg, accounting for 97.42 % of all solid waste generated at the kitchen. The non-biodegradables constituted 2.58 % of the total KSW generated, having a quantity of 46.5 kg by weight. The per capita waste generation for biodegradables was 0.0896 kg/cap/day. Also, the willingness of segregation was 94.44 % while its effectiveness was realised to be higher after sensitising the respondents on how and the need to segregate their waste.
Fiaseman SHS, recorded a notable amount of KSW. A 458.5 kg of biodegradables and 38 kg of non-biodegradables were recorded with a percentage by weight of 92.35 % and 7.65 % respectively. The per capita waste generation for biodegradables was 0.044 kg/cap/day. The willingness to segregate was 100 % while the effectiveness of segregation was realised to be lower after sensitising the respondents on how and the need to segregate their waste. There was an

appreciable increment in weight quantified during the second week.

4.2 Recommendations

The institutions should channel their KSW (biodegradables) into other beneficial products such biogas or organic manure.

More data should be acquired over a period of time to establish the waste generation trends.

The institutions should make available to the kitchen staffs, colour-coded bins to enhance segregation buttressed with periodic sensitisation programs.

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