KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

KUMASI, GHANA

COMPOSTING AS A TOOL FOR SOLID WASTE MANAGEMENT AND FOR PROMOTION OF ORGANIC FARMING:

A CASE STUDY OF SENIOR HIGH SCHOOLS IN EJURA-SEKYEDUMASE DISTRICT. GHANA.

BY

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CERTIFICATION

I hereby declare that this submission is my own work towards the MSc. degree award and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

The existing landfill (not engineered) in Ejura-Sekyedumase district is reaching full capacity. Senior High Schools in the district contribute significantly to the quantity of solid waste generated in the district and adopting the nearest environment for dumping these wastes has been the easiest means of managing them. In addressing the task of properly disposing solid waste, it has become eminent to look for an alternative treatment option beyond land filling to reduce the increasing volume of waste in these schools. The rejection of landfill sitting by communities will lead to difficulty in acquiring land for land filling. This, together with the large investment cost in landfill construction has therefore necessitated the need for this research to divert part of the increasing volume of waste generated in these schools from going to the landfill. To establish the basis for waste diversion from landfill, this study was conducted to examine the possibility of using composting to manage solid waste generated in Senior High Schools in the district. Out of the two Senior High Schools in the district, one of them, Ejuraman Anglican Senior High School was used as a case study. Using a structured self-administered questionnaire, 246 students were surveyed from the school. Using specified tools, the quantity of solid waste generated in a day and its composition were determined. Compost was prepared from the organic waste fraction of the solid waste generated. Samples of the raw organic solid waste and the finished compost were taken to the laboratory for analysis. Data collected were subjected to graphical interpretations, percentage, mean, t-test and chi-x^2. The findings revealed that the students in the school were knowledgeable about composting and acknowledged the need for it, but stayed in a school environment that has unsatisfactory solid waste management practices. The mean volume of solid waste generated in a day was 133.7 Kg. The wastes were sorted into three fractions of which the organic waste accounted for the highest proportion (81%) on the average. Though the C:N ratio of the organic waste (47:1) did not favour the effective composting of the organic solid waste in the school, the composting process reduced the organic solid waste by 49.3% and by extension 40.1% of the total solid waste generated in the school in a day leaving 59.9% of the waste to be sent to the landfill or disposed of. The study could not confirm the relatively appreciable level of nitrogen, phosphorus and potassium in the compost as has been reported by other researchers. The nitrogen, phosphorus and potassium content of the compost were 0.36%, 0.04% and 0.09% respectively. The prepared compost seemed not effective for the growth of maize. The school can reduce the increasing volume of waste that is disposed off through composting, but the compost prepared may not be able to support plant growth.

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CHAPTER ONE

INTRODUCTION

1.1 Background

Solid waste comprises of all unwanted or discarded materials arising from both human and animal activities that have insufficient liquid content to be free flowing (Rhyner *et al*., 1995). Problems of solid waste, however, have existed globally ever since humans made the transition from hunting and gathering societies to settle in communities characterized by industrialization. The problem of solid waste management has intensified, practically, in all communities of the world today. Growing population, changes in habits and life style and greater production and consumption of new products are acting in concert to increase both the quantity and complexity of solid waste being generated. Since solid waste is an inevitable by-product in a society, its effective management is a huge challenge in Ghana as well. Though technological solutions such as sanitary land filling, recycling, incineration and bioreactor treatment have been suggested to handle the type and quantity of waste generated in Ghana, their contribution to the effective management of waste has been insignificant and of little help (Agyemang *et al*., 2004).

Ejura-Sekyedumase District is one of the twenty-seven districts in the Ashanti Region of Ghana and the problem of solid waste management in the district, especially the densely populated district capital, is not anything different. The inability of the district to pursue the use of high technologies to handle the solid waste generated, coupled with poor enforcement or non-existence of waste management by-laws have resulted in the dependence on primitive disposal methods such as land filling (not engineered) and discharge into forests (Sintim, 2010).

Senior High Schools in the district contribute significantly to the quantity of solid waste generated in the district and adopting the nearby environment for dumping these wastes has also been the easiest means of managing them. In addressing the task of properly disposing solid waste, it has become eminent to look for an alternative treatment option beyond land filling to reduce the increasing volume of solid waste in these institutions. The rejection of landfill sitting by communities will lead to difficulty in getting land for land filling, this together with the large investment cost in landfill construction has therefore necessitated the need to divert part of the increasing volume of waste generated in these institutions from going to the landfill. No known study has considered the option of 'Composting' in addressing the waste management problems in educational institutions in the district, especially the views and knowledge level of students with regards to composting.

To establish the basis for waste diversion from landfill, this study was conducted to examine the possibility of using composting to manage solid waste generated in Senior High Schools in the district in order to protect the environment. On the agricultural front, a lot of concerns have been raised about the effect of chemical fertilizers on human health and the environment coupled with its high price, pollution of water bodies, its residual effect on crops and on non-target microorganisms in the soil. These challenges associated with the use of chemical fertilizer are not in the "books" of compost when it is used as fertilizer to promote organic farming.

1.2 Problem statement

In one of the twenty seven districts in the Ashanti Region of Ghana, Ejura-Sekyedumase District, only one sanitary landfill exists to accommodate the increasing amount of solid waste generated in the district. Second cycle institutions in the district contribute large amount of solid waste daily, which also ends up in the landfill. Due to the large volume of waste that goes to the landfill, it is reaching full capacity, and all components of our environment, air, water, as well as open spaces are increasingly threatened. Part of the waste generated in these schools are dumped indiscriminately in the school environment, creating nuisance, filth, bad odor and threatening the health of students. Farm lands of these institutions are being destroyed due to the over reliance on agrochemicals.

The large investment cost involved in constructing a new landfill as well as the cost incurred by the schools in disposing of the waste coupled with its environmental and health implications have therefore made it prudent to look for alternative treatment options beyond the land filling to handle solid waste generated in these schools. The present study seeks to investigate the use of composting to reduce and divert most of the solid waste generated in these schools from going to the landfill and investigate its use for crop production.

1.3 Aim of the Study

To demonstrate the feasibility of using composting to manage solid waste in Senior High Schools and to determine its suitability for organic farming.

1.4 Specific Objectives of the Study

The specific objectives of the study were to:

i. estimate the percentage composition of organic solid waste (solid waste that can decay or decompose) among the waste generated in the schools

ii. demonstrate the possibility of composting organic wastes in the schools

iii. estimate the potassium, phosphorous and nitrogen content of the prepared compost

iv. determine the level of knowledge / awareness of students on composting and their responses on waste management practices in the schools.

v. determine the suitability of the compost for growing maize as a short-term crop.

1.5 Justification of the Study

The management of solid waste is a critical problem today in Ejura-Sekyedumase District. Due to the large volume of waste generated in the district the existing landfill in the district is reaching full capacity, hence the components of our environment, such as air and water bodies are increasingly threatened. Schools in the district are major contributors to this quantity of waste. The involvement of students in the science of composting or the introduction of composting as part a waste management program into these schools will help divert a significant amount of solid waste going to the landfill, conserve space, maximize the use of the existing landfill and hence protect the environment. Besides, schools can use the compost prepared to grow crops which will reduce the cost of crop production and reduce the negative impact of inorganic fertilizer on the environment. Apart from providing facts that will help reduce the quantity of solid waste meant for the landfill, the outcome will contribute in creating well-informed citizens of tomorrow who will take on the responsibility of safeguarding the environment. Finally, the findings of this research will serve as a spring board for other researchers who intend to work in this area.

1.6 Scope of the study

The area selected for the study is Ejura, the district capital. Due to the lack of logistics and funds, the study was limited to one out of the two Senior High Schools in the district. Four main forms of data were collected from the school. The first data was on students' knowledge on composting and their responses on solid waste management practices in the school. The second was on the quantity and percentage composition of solid waste generated in the school daily, the solid wastes collected were sorted into organic waste, plastic waste and other solid waste such as used clothes, cans etc. The third data was on the chemical characteristics of the organic solid waste to be composted (feed stock) and the prepared compost. The chemical characteristics comprised: the total organic carbon, total nitrogen, C:N ratio, potassium and phosphorus.

Data was also collected on the effect of the prepared compost on the growth of maize.Growth parameters of maize plants that were considered were; height of plant, width of stem, length of root, fresh root weight, fresh shoot weight and dry shoot weight.

1.7 Limitation

The total solid waste collected did not include used toilet papers in the two places of convenience because they were contaminated with liquid waste (faeces). Due to circumstances beyond the researcher's control solid wastes from the offices of the Headmaster, Assistant Headmaster and the Senior Housemistress could not be collected. The results cannot be generalized for other schools in the district due to the peculiar nature of solid waste in the school.

1.8 Organization of report

This report is made up of six chapters. Chapter one begins with an introduction which consists of the background, problem statement, the aim, specific objectives, justification of the study and the scope of the study. Chapter two presents a review of available literature. Chapter three describes the study area and the research methodology. Chapter four presents the results, the fifth chapter outlines the discussion while the sixth chapter presents the conclusions and the recommendations made.

CHAPTER TWO

LITERATURE REVIEW

2.1 Solid waste

Solid waste is defined as discarded materials and objects which originate from domestic, business and industrial sources, which are typically disposed of in landfills, but does not include industrial hazardous or special wastes (W.H.O., 1996). Tchbanoglous *et al*. (1993) also defines solid waste as all the waste arising from human and animal activities that are normally solid and are discarded as useless or unwanted. Besides, the U.S Environmental Protection Agency regards solid waste as any garbage, refuse , sludge from waste treatment plant, water supply treatment plant or air pollution control facility and other discarded material including solid, semi-solid, liquid or contained gaseous material resulting from industrial and commercial operations or from community.

In this study, however, solid waste is considered as all unwanted or discarded materials arising from both human and animal activities that have insufficient liquid to be free flowing (Rhyner *et al.*, 1995).

2.1.1 Solid waste composition

Solid waste composition describes the individual elements that make up the solid waste stream and their relative distribution, usually based on percentage by weight and that it depends on the environment in which the waste is generated (Bolaane and Ali, 2004). Yousuf (2005) in his work on Sustainable and Replication of Community-based Composting in Bangladesh, classified the components of solid waste as plastics, glass, wood, textile, metals/cans, cardboards and miscellaneous (ash, sand etc.). According to Makende (2007), the understanding of what materials are in a solid waste stream helps in the identification of, to some degree, the valuable natural resources being thrown away rather than reused, recycled or recovered to create other products, materials or energy. Waste composition information helps develop waste minimisation programmes such as composting (for solid waste with significant percentage of organics), material recovery and recycling schemes (Cointreau, 1999). Tables 2.1, 2.2 and 2.3 show the various solid waste composition analysis on both local and global fronts.

Table 2.1 Comparison of solid waste composition in Ghana, India, Britain and U.S.A

Components	**Ghana**	**India**	**Britain**	**U.S.A**
Garbage (food waste)	89.5	67	13	5
Paper	2.4	8.75	30	54.4
Glass	0.8	1	6	9.1
Plastics	0.3	7.3	3	2.6
Rags	1.3	0.7	_	1.7
Bones	0.1	_	_	_
Tins/cans etc.	3.6	15.3	28	27

Source: (Kotoka, 2001 as cited by Mensah, 2010).

Table 2.2 Composition of solid waste in Accra.

Components	Weight (%)
Organic waste	65
Paper	4.2
Plastics	3.5
Metal	1.8
Inert Materials	22.5
Glass	1.9
Miscellaneous	1.1

Source: Waste Management Department – Accra Metropolitan Assembly (AMA).

Table 2.3 Comparison of solid waste composition in Kumasi

Components	Solid waste composition in some low income areas in Kumasi (% dry wt)	solid waste composition in some High income areas in Kumasi (% dry wt)
Greens/Vegetables/Fruits	44	43.87
Plastics	3.52	1.145
Fabrics/Textiles	3.2	0.505
Paper/Cardboard	3.1	2.275
Bottles	0.64	1.165
Metals	0.64	0.565
Rubber	0.3	0.35
Miscellaneous(including ash, sand etc.)	44.6	50.31

Source: Kotoka, 2001 as cited in Mensah, 2010

2.1.2 Solid waste composition in schools

According to the City of Los Angeles Bureau of Sanitation, U.S.A, waste composition determination means finding how much of the different composition of waste is discarded in a quantity of waste. This involves collection, sorting and weighing waste generated in schools and district facilities. Waste characterization helps in planning how to reduce waste set up recycling programmes and conserve money and other resources (City of Los Angeles Bureau of Sanitation, 2007). The Waste Disposal Characterization Data developed from 10 sample High Schools in three different Waste Characterization Studies in Southern California is indicated in Table 2.4.

Table 2.4 Solid waste composition in 10 High Schools in Southern Califonia

Waste Composition	**% (by weight)**
Construction/demolition	2
Glass	2
Metals	5
Organics	36
Paper	47
Plastics	12
Special solid waste	< 1
Mixed Residue	< 1

Source: Baker (1998). (Result is exclusive of waste recycled)

A similar study by Ifegbesan (2008) in six Secondary Schools in Ogun state revealed that a large percentage (62%) is made up of organic waste consisting of food remains, fruits, vegetables etc. with less paper waste. A waste composition study was conducted in North Carolina in January 2008 to evaluate the composition of solid waste disposed by the Wake County Public School System (WCPSS) which comprises of the Elementary, Middle and the High Schools. The findings of the study was meant to be used as an indicator of the effectiveness of the County's recycling programme in schools. The findings of the study are presented in Table 2.5.

Table 2.5 Solid Waste Composition Analysis in 9 Wake County Public Schools in North Carolina

Waste Fractions	**% by weight**
Organic waste	33.8
Plastics	5.7
Electronics	0.5
Glass containers	0.8
Scrap Metals	2.5
Aseptic Containers	0.8
Films	4.7
Construction/Demolition debris	1.3
Other recyclable trash	49.9

Source: Kessler Consulting Inc. (2008). U.S A.

A key variable influencing options for schools' composting programme is the assumed quantity of the compostable waste among the waste generated (Walling *et al*., 2004). Based on this, Global Action Plan, an independent environmental charity, presented a comprehensive data on the quantity of compostable solid waste generated in 13 Schools in London over a two-year period. According to the findings, the 13 Secondary Schools constituting about 6004 students, annually generated 36.4 tones of food waste (which is approximately 99.7Kg daily).

2.2 Solid waste management

Waste management is the control of the generation, storage, collection, transfer and transport, processing, reusing, recovery and disposal of solid waste in a manner that is in accordance with the best principles of public health, economics, engineering, conservation of nature, aesthetics, and environmental considerations in general and that is also responsive to public attitude (Bilitewski *et al*., 1994 as cited by Fei-Baffoe, 2009). The management of solid waste includes administrative, financial, legal, planning, social, scientific and engineering functions involved in solutions to all problems of solid waste. (Bilitewski *et al*., 1994 as cited by Fei-Baffoe, 2009) Similarly, McDougall *et al*. (2001) as cited by Zeng (2005) defines solid waste management as the collection, transport, processing, recycling or disposal and monitoring of waste materials and is usually pursued to reduce their effect on health, environment and aesthetics. According to Zeng (2005) waste management differs from developed to developing nations, for urban and rural areas and for residential and industrial producers. Waste minimization or prevention, then reuse, recycling, recovery and disposal is the favoured waste management hierarchy if waste management will be effective. The main objective of this 'path' of waste management is to reduce the amount of solid waste that is disposed of in a landfill or a disposal site (Tchbanoglous *et al*., 1993).

2.2.1 Waste Prevention

Waste prevention or minimization is given the highest priority in integrated waste management (Tchobanoglous *et al.*, 1993). By optimizing production processes, producers and manufacturers can reduce waste or even allow it to be reused by another manufacturer; this is a preventive action whose objective aims at reducing the amount of waste that individuals, businesses and other organizations generate (Zurbrugg, 2003 as cited by Wakjira, 2007). Waste prevention prevents emissions of many greenhouse gases, reduces pollutants, saves energy, conserves resources, and reduces the need for new landfills and combustors (Medina, 1999).

2.2.2 Reuse

Reuse occurs when something that has already fulfilled its original function is used for another purpose without the waste being processed or transformed into another item (Bagchi, 2004). Waste that cannot be prevented or reduced can be put into a newly developed use. Reuse, according to Tchbanoglous *et al.* (1993) comprises the recovery of items to be used again, perhaps after some cleaning and refurbishing. Reusing materials and products saves energy and water, reduces pollution and minimizes society's consumption of natural resources. Reuse of 'waste' is regarded as more socially desirable than recycling the same material (Hui *et al*., 2006).

2.2.3 Recycling

Recycling represents the reprocessing of waste into new products by breaking the material down to its main components (Adara, 1997). It is most common for valuable materials that are costlier if produced from virgin raw materials. However, Onibokun and Kumuyi (2003) regard recycling as the recovery of materials for melting and reincorporating them as raw materials. Waste materials that are organic in nature can be recycled using biological composting and digestion processes to produce compost for agricultural and landscaping purposes. It is technically feasible to recycle a large amount of materials, such as plastics, wood, metals, glass, textiles, paper, cardboard, rubber, ceramics, and leather (Holmes, 1981). In many African countries, artisans also constitute a significant source of demand for waste materials (Onibokun and Kumuyi, 2003).

2.2.4 Recovery

When waste cannot be prevented, reused or recycled, then we need to pursue strategies aimed at reducing volumes or toxicity before ultimate disposal (Fei-Baffoe, 2009). Recovery, according to Adara (1997) relates mainly to energy recovered from waste and that the appropriateness of the recovery strategies depends on the composition and the caloric value of the waste. Material recovery also aims at treating waste using effective and efficient methods such as incineration, while minimizing energy usage and the creation of new waste streams (Fei-Baffoe, 2009).

2.2.5 Disposal

At the lowest level of waste management hierarchy is final disposal where remaining waste or residue from previous waste management processes must be stored in such a manner that its negative impact does not affect man and his environment (Agunwamba *et al*., 1998). According to Pichtel (2005) as cited by Fei-Baffoe (2009) waste that cannot be recycled or treated need to be disposed of in the most environmentally safe manner possible and in compliance with all applicable regulation. A sanitary landfill is a facility designed specifically for the final disposal of wastes, which minimizes the risks to human health and the environment associated with solid wastes. Sanitary landfill, as the final disposal site for solid waste, is given the least priority in an Integrated Waste Management approach (Tchobanoglous *et al*., 1993). Waste arriving at the landfill is compacted and then covered with a layer of earth, usually every day. This prevents animals from having access to the organic matter to feed on. Proper management of landfill sites is of a major concern because landfills might cause environmental impacts, such as bad odor in the neighborhood, leachate leakage, and ground water contamination (Wakjira, 2007). Due to financial constraints and lack of technical knowhow most institutions, towns and cities in African countries have resorted to open dumping instead of sanitary land filling (Medina, 1999).

2.3 Solid Waste management practices in schools

The attitude of schools towards waste management has been a topic of interest among researchers for years. Many studies in the last two decades on socio-demographic variables, environmental perceptions and waste management have helped in understanding students' views and thinking about the environment (Ifegbesan, 2008). Gender is a variable that has received consistent attention among researchers. Raudsepp (2001) found that female students were significantly more likely than males to be concerned with environmental problems. Females have been consistently shown to have higher environmentally conscious attitudes than men. However, in other studies such as that of Van-Liere and Dunlap (1981) gender was not a significant predictor of environmental concerns and attitudes as other socio-demographic variables. Kellert (1995) also found no gender difference in this attitude for U.S. children in the 2nd grade.

Muffitt (1990) in a study of Canadian students in 6th, 7th, and 8th grade, found no attitude differences between the sexes.

Environmental knowledge in the school sector is known to provide opportunities for students and authorities to engage in actions and behavior that impact positively towards achieving a more sustainable school environment (Diamontopoulos *et al*., 2003). There are studies that have examined public and students' views on the attitudes of their schools towards waste management. Bassey *et al*. (2006) used both qualitative and quantitative methods to examine the types of waste disposal techniques employed in the management of solid wastes in five selected public schools in the Federal Capital Territory, Abuja and reported that more than half (55.8%) of the students expressed dissatisfaction in the way waste are disposed of within their schools. In his study to examine the level of understanding and practices of Secondary School Students in Ogun State with regards to waste management, Ifegbesan (2008) revealed that Secondary School students from the sampled zones, independent of their sex, were aware of waste problems on their school compounds , but possessed poor waste management practices differ by sex, class and age of students. Duan and Fortner (2005) found that students possessed high environmental awareness and knowledge of local environmental issues than global environmental issues. Other researchers have also studied how solid waste is handled and managed in High Schools in Ghana. In a study on how waste is generated, treated or managed at Armed Forces Technical Secondary School in Kumasi, Agyemang *et al*.(2004) identified the school farm, the compound, residences of staff, the kitchen and the sewage as the sources of waste generation in the school. As part of the school's waste management programme, plantain peels which form a significant percentage of the garbage is collected and handed over to a local soap manufacturing company which is used for the production of a local soap called 'Alata samina'. The quantity and the complexity of solid waste generated in High Schools is drawing increasing attention as garbage normally lie uncollected on campuses causing inconveniences, environmental pollution and a risk to public health (Ifegbesan, 2008).

Due to the waste management problems in schools experts have done some work in the field of waste disposal in schools in an attempt to correct the situation. Presenting a fact sheet about waste management in schools, Horeder (2004) investigated the possibility of implementing waste stations on the campus of Saint Peter's in central Newcastle, U.S.A. Research by Waranusantikule (2003) gave birth to a waste management model at Maneeya Kindergarten School, Thailand. The model centered on waste separation practice along with a "garbage bank" that combines to provide environmental education for the students. According to Waranusantikule (2003), a strong commitment from staff and students is extremely critical if a waste management model is to succeed, thus it is essential that an appropriate awareness raising scheme be put in place. Furthermore, waste separation and garbage bank practices can only be done successfully when the government's central waste collection and management systems for separated wastes are available (Waranusantikule, 2003).

2.4 The concept of composting

Composting is the controlled aerobic or anaerobic degradation of organic materials (Kone *et al.*, 2007). The final product of composting is called "compost". Kone *et al.* (2007) in their study on dewatering and co-composting of faecal sludge in tropical climates came out with the two most important purposes for composting organic wastes as; to decrease the amounts of usable organic materials that are being deposited in landfills and to conserve the nutrient or fertilizer values of the organic materials. According to Surahet (2005) the feasibility of adopting composting as a waste management option to manage solid waste in a community depends on its acceptance by the people, the quantity of organic solid waste among the waste stream and the ability of the finished compost to support plant growth which is mainly defined by the C:N ratio of the organic waste composted.

2.4.1 Factors affecting composting

Many researchers including Zurbrugg (2003) have shown that decomposition of organic material in the compost pile depends on maintaining microbial activity and that any factor which slows or halts microbial growth also impedes the composting process. Most researches have noted that efficient aerobic decomposition mainly depends on aeration (oxygen level), moisture, particle size of composting material, temperature and a sufficient source of carbon and nitrogen (C:N ratio).

Carbon and nitrogen are essential to microorganisms that break down organic material. In the process of breaking down organic material, microorganisms utilize the carbon as a source of energy and the nitrogen as the building block for protein synthesis (Hoitink *et al*., 1997). A nutritional requirement for microorganisms is that the C:N ratio of organic material must be at a level for optimum decomposition efficiency (Adholeya and Prakash, 2004). Many studies on the quality of compost have revealed that C:N ratio is an important parameter that can be used to determine if a compost is nitrogen stable or not. In a study of the nutrient content of composted organic materials in the sub-Saharan climatic conditions, Madar (2002) revealed that woody plants or lignin-rich materials such as news papers, sawdust, wood, straw, dry leaves and corn stalks have relatively high carbon content but low in potassium, phosphorus and nitrogen whiles others such as food wastes and animal waste are low in carbon but rich in nitrogen. According to Mamo *et al.* (2002) as cited by Mensah (2010) the limiting C:N ratio for most microbial organisms ranges from 25:1 to 30:1 (i.e., 25–30 parts carbon to 1 part nitrogen). When the C:N ratio of the organic material exceeds 30:1, the organisms become deficient in nitrogen and the process of decomposition is slowed down (Mamo *et al*., 2002 as cited by Mensah, 2010). However, other researchers including Diaz (1999) have shown that in general, a C:N ratio of 35:1 or lower is preferred if the material is to be nitrogen stabilized. The C:N ratio is a critical factor in composting since it could prevent nitrogen robbing from the soil and ensure the conservation of maximum nitrogen in the compost (Hoitink *et al*., 1997).

Reporting on the composting potential of waste generated from different income group areas in Kumasi, Mensah (2010) indicated that the C:N ratios of waste in low, middle, high income groups were 26.6:1, 24.7:1 and 25.0:1 respectively. However, a good compost can be prepared from hard plant materials, with high C:N ratio, by mixing lime in a ratio of 5 kg per 1000 kg of waste material (Mahimairaja *et al*., 2008). The addition of lime neutralizes some of the organic acids released during decomposition, maintains a desirable acidity range, and reduces the loss of nitrogen gas. It also enhances the process of decomposition of hard plant materials by weakening the lignin structure (Mahimairaja *et al*., 2008).

According to Hirano *et al.* (1991) when oxygenation is inadequate, aerobic bacteria die off and anaerobic bacteria take over the decomposition which slows significantly.

Temperature is a function of the biological activity within the composting system, and, to some extent, its exposure to the sun (Jiang and Doyle, 2003). In their view, Jiang and Doyle (2003) observed that when microbes flourish, they raise the pile temperature through their metabolism, reproduction, and conversion of composting materials to energy. The main reason, according to Jiang and Doyle (2003) for one to be concerned about pile temperature is that maintaining a minimum pile temperature of 131°F (61.7^{o}C) for a week is desirable to destroy weed seeds or plant pathogens.

According to Zurbrugg (2003) the ideal moisture level for a composting system is between 40 and 60 percent (the compost should feel damp but not soggy)

The conditions for efficient biological decomposition of organic waste depend on optimum temperatures (61.3^{o}C–70.8^{o}C), moisture (46–56%), oxygen (15–21%), pH (6.0–7.5) (Mamo *et al.*, 2002 as cited by Mensah, 2010).

2.5 Agricultural value of compost

The content of nitrogen, phosphorus and potassium influences the quality of compost the most (Follet, 1999). Nitrogen, phosphorus and potassium are the three most important macronutrients needed for plant growth. The addition of phosphorus has been found to stimulate root growth in a phosphate-fertilized soil as compared to root growth in the unfertilized soil; the degree of root growth stimulation depends on the level of available phosphorus in a fertilized soil (Stanley and Peterson, 1995). Nitrogen is generally known to promote rapid shoot growth, increase seed and fruit production and improve the quality of leaf and forage crops. When a plant is deficient in nitrogen or phosphorus, it apparently diverts relatively more photosynthate to the roots and thus obtains greater root length which in turn aids the plant in obtaining more nitrogen or phosphorus (Stanley and peterson, 1995). Of the major nutrients, nitrogen conservation is the most important since it is more difficult to conserve in the compost pile than phosphorus and potash. Nitrogen may be lost by leaching, but the major loss of nitrogen in the compost pile comes from the escape of ammonia or other volatile nitrogenous gases from the compost material to the atmosphere (Bassey *et al*., 2006).

Table 2.6 shows the ranges of values, on a dry basis, in which the chemical characteristics of most finished composts generally lie.

Table 2.6 Ranges of values of the chemical characteristics of most finished compost

Chemical substances	**% (by weight)**
Organic matter	25.0-50.0
Carbon	8.0-50.0
Nitrogen (as N)	0.4-3.5
Phosphorus (as P_2O_5)	0.3-3.5
Potassium (as K_2O)	0.5-1.8
Calcium (as CaO)	1.5-7.0

Source: Whatcom County Extension (2007). Washington State University, U.S.A.

Since the nutrient content of compost is low compared to synthetic fertilizer products, Bassey *et al*. (2006) reported that compost is usually applied at greater rates in order to make its contribution to the nutrient content of soil very significant. The nutrient content from composts and other sources of organic fertilizer can be quite variable depending on the composition of the raw material used for the composting, nevertheless they are at least as effective as chemical fertilizers over longer periods of use Bremner (2000). A good quality compost which is ready for use has smell that is earthy (not sour, putrid or like ammonia), dark, it's crumbly, and doesn't have identifiable food items, leaves or grass (Yousuf, 2005). According to Yitayal (2005) the C:N ratio of most finished compost ranges from 10:1 to 20:1. Table 2.7 shows the comparison of compost nutrient concentration as determined by some investigators.

Table 2.7 Concentration of nutrients in compost as determined by some investigators

Authors	Feed stock	N(%drywt)	P(%drywt)	K(%drywt)	pH
Gouin, (2001)	Clover straw	0.01	0.02	__	7.1
Zarina *et al*. (2010)	__	1.64	0.49	2.45	8.00
Mahimairaja *et al*. (2008)	Farm yard manure	0.92	0.46	5.32	8.1
Hoitink *et al*. (1997)	Cattle dung	0.34	0.14	0.21	7.4
Mahimairaja *et al*. (2008)	Poultry litter	2.1	2.48	2.6	7.3

2.6 Effect of compost on the environment

It is believed that compost is more environment-friendly and better maintains soil organic matter levels than inorganic fertilizers. Compost provides increased physical and biological storage mechanisms to soils, thus lessens the risk of over-fertilization (Adholeya and Prakash, 2004). Organic nutrients increase the abundance of soil organisms by contributing micronutrients for organisms such as fungi and can drastically reduce external inputs of pesticides, energy and fertilizer, at the cost of decreased yield (Paramanathan, 2000). Wong *et al*. (1993) classifies organic fertilizers as 'slow-release' fertilizers, and therefore cannot cause nitrogen burn. Composting about 40 % of solid waste in North Carolina, Shelton (2007) reported that the composting process reduced the volume of organic materials by approximately 50 percent and concentrated the basic elements nitrogen, phosphorus, potassium, calcium, and magnesium. Using compost application as a strategic tool, Cottenie (1996) as cited by Paramanathan (2000) revealed that compost application improves soil quality and facilitates soil moisture retention, and thus the capability of reducing the impact of drought when it is used as mulch or a conditioner. The use of compost, according to Coleman *et al*. (2002) facilitates reforestation, wetlands restoration and habitat revitalization efforts by amending contaminated, compacted, and marginal soils. According to the Basel Convention (1997) compost cost-effectively remediates soils contaminated by hazardous waste and removes solids, oil, grease and heavy metals from storm water runoff. Many conventional farmers rely on concentrated chemical fertilizers that are rapidly absorbed by plants, which produce quick growth but at the same time may pollute water bodies with toxic residues of leached nitrogen and kill important soil organisms, such as earthworms and bacteria (DeCeuster *et al.,* 1999). For consumers, the most obvious benefit of the use of organic fertilizer is that the food produced has little or no pesticide residue (Paramanathan, 2000).

However, other researchers have revealed some limitations associated with the use organic fertilizers to promote organic farming. According to the US Environmental Protection Agency compost cannot be used immediately by plants and requires some sort of action by the micro life (bacteria, earthworm, fungi) which need to break down the matter and convert them to the form, which can be used by plants. Apart from containing less nutrients, the solubility and nutrient release rate of compost are all lower than that of inorganic fertilizers (Hoitink, 1997). Yousuf (2005) revealed that plot treated with 100% inorganic fertilizer produced the greatest yield in terms of dry weight and cob production as compared to maize plant treated with only compost. In general, the nutrients in organic fertilizer are both more dilute and also much less readily available to plants (Adholeya and Prakash, 2004). According to Edris *et al*. (2003) the use of compost, which is very bulky, is more labor-intensive and require more management skills. One important factor which discourages small scale farmers in Syantu (a small community in Bangladesh) from using compost on their land is the long duration of the decomposition process, which is between two and three months (Popkins, 1995).

2.7 Effect of compost on plant growth

Gouin (2001) measured the germination and growth of Norway spruce and white pine in response to three levels of screened and unscreened compost compared to an inorganic fertilizer in Maryland. Soils amended with screened compost produced taller seedlings than those treated with unscreened compost. Organic fertilizers are better used for sustaining continuous cropping for 2-3 years than inorganic fertilizers (Marschner, 1995). In a separate study by Hoitink (1997), three mixtures of compost (10, 15, and 20 percent v/v) were applied to seven different species of nursery plants. Results showed that at all locations, most plants treated with the compost grew significantly faster ($P<0.05$) than the control mixture. Phosphorus is generally present in soils as insoluble compounds of calcium such as di-calcium phosphate and tri-calcium phosphate with little or no solubility (Rahmatulah *et al.*, 1994). Soil moisture demand by maize crop is minimal at seedling and crop maturity phases and optimal at crop establishment to grain filling phase (Dim *et al.*, 2003).

Using maize and rice as bio-test indicator plants for measuring fertility of a range of soils, Boonchan and Chantaprasarn (2004) reported that maize growth indicators, height and rate of growth, were significantly higher than that from the negative control. The details of the growth parameters are indicated in Table 2.8 below.

Table 2.8 The heights and growth rate of maize and rice under different treatments

Type of soil	**Height at 25 days (cm)**		**growth rate(cm/day)**	
	Maize	**Rice**	**Maize**	**Rice**
Sand **(**negative control)	30.2^{a}	13.2^{a}	1.2^{a}	0.5^{a}
Clay soil	34.3^{a}	36.3^{ab}	1.4^{a}	1.5^{b}
Loam with compost	74.3^{b}	33.8^{ab}	3.0^{b}	1.4^{ab}
Compost (positive control)	71.3^{b}	26.5^{ab}	2.9b	1.1ab

^{a,b} *= Value within the same column without superscript in common differ at P<0.05*

Source: Boonchan and Chantaprasarn (2004). Available at: http://www.mekarn.org.

Tariq *et al*. (2001) observed substantial improvement in root and shoot fresh and dry weights of maize plants, 42 days after planting in a soil treated with organic manure.

There are studies that have also examined the effect of complimentary use of organic and inorganic fertilizer on plant growth. In a study to investigate the influence of different NP-fertilizers and compost on maize plant growth Zarina *et al*. (2010) reported that fertilizer formulations, diammonium phosphate + Compost at 50 ppm and diammonium phosphate + Compost at 100 ppm performed better in boosting the maize growth parameters about root and shoot. It was concluded that fertilizer formulations could provide significant positive enhancement to maize growth as compared to sole inorganic fertilizer application. Similarly, the results of a field experiments carried at the Federal College of Agriculture, Ibadan revealed that maize yields from sole organic fertilizer application are significantly lower than yields from either sole inorganic fertilizer or a combined application of organic and inorganic fertilizers. Yields from a combined application of organic and inorganic fertilizers were not significantly lower than yields from sole inorganic fertilizer application. Maize plants from the unfertilized plots were only comparable with plants fertilized with sole organic fertilizer (Sobulo and Babalola,1992).

Makende (2007) has attempted to ascertain the effect of complementary organic and inorganic fertilizer application on growth and yield of maize and cassava. His results showed that maize performed best in terms of growth and yield with complementary application of inorganic and organic fertilizers. In their attempt to indentify the effect of organic (poultry manure) and inorganic fertilizer on yield and chlorophyll content of maize (*Zea mays* L.), Amujoyegbe *et al*. (2007) reported that grain yield was highest in sorghum (3.55 kg/ha) and maize (2.89 kg/ha) under complementary use of inorganic fertilizer and poultry manure followed by sole use of inorganic fertilizer.

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 Study area

3.1.1 Location and size

Ejura-Sekyedumase District is one of the 27 districts in the Ashanti Region of Ghana. It is located within Longitudes 1° 5'W and 1° 39'W and Latitude 7° 9'N and 7° 36'N. Located in the northern part of the Ashanti Region, it shares borders with Atebubu-Amantin District in the north-west, Mampong Municipality in the east, Sekyere South District in the south and Offinso Municipality in the west. It has a large land size of about 1782.2 sq.Km (690.781sq.miles) and is the fifth largest district in the region. Its land size constitutes about 7.3% of the region's total land area with about one-third of its land area lying in the Afram plains. Out of the 130 settlements in the districts only three (Ejura, Sekyedumase and Ayinasu) are urban areas with the rest being rural settlements , thus giving the district a rural status (Office of the District Engineer (2011), Ejura- Sekyedumase District).

3.1.2 Climate

The District is located within the transitional zone of Ghana, characterized by both the forest and savannah climatic conditions. It is marked by two rainfall patterns; the bi-modal pattern in the south and unimodal in the north. The main rainy season in the district is between April and November, annual rainfall varies between 1200 mm and 1500 mm. The district is dissected and well drained by a number of rivers and streams among which are rivers Afram, Akobaa and Bresua. Relative humidity is very high during the rainy season, recording 90% in its peak in June and 55% in February. The climatic conditions of the district together with the topographical layout are favorable for the cultivation of food crops, especially, maize (it is the largest maize-producing district in the Ashanti region).

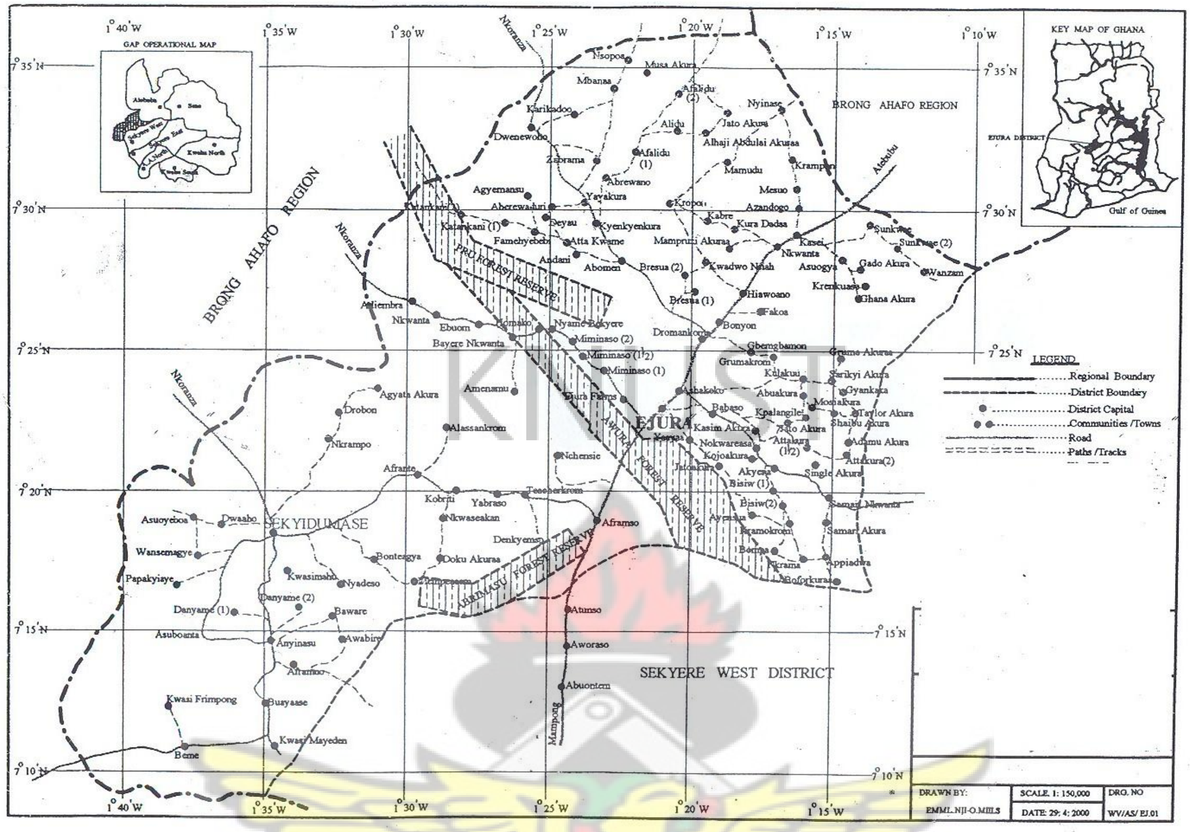

Figure 3.1 Map of Ejura-Sekyedumase District, indicating the study area.

Source: Office of the District Engineer (2011). Ejura- Sekyedumase District.

3.1.3 Population

According to the 2000 population census, Ejura-Sekyedumase District has an evenly distributed population of 88,753, with males constituting 58.7%. About 53% of the people fall within the economic active group and 40% are within the school-going age. Most of the natives are farmers. Based on its current annual population growth rate of 1.8, the District Assembly's current population projection stands at 90,350 inhabitants, which is made up of approximately equal number of Muslims and Christians.

3.1.4 Senior High Schools in the district

The district can boast of two Senior High Schools ; namely Sekyedumase Senior High School, in Sekyedumase and Ejuraman Anglican Senior High School, in Ejura, the district capital. However, due to inadequate logistics, conveniences, cost and time constraints one of the schools Ejuraman Anglican Senior High School, was used for the study. The selection of one school was also based on the assumption that all the three schools have similar waste management practices and generate similar quantity and composition of solid waste.

3.1.5 Ejuraman Anglican Senior High School (EASHS)

EASHS is a mixed public second cycle institution located in the outskirts of Ejura. The student population stands at 821; being 464 males (56.5%) and 357 (43.5%) females (Office of the

Assistant Headmaster, EASHS). As at the end of the 2009/2010 academic year 474 (57.7%) of the students were day students with the remaining 347(42.3%) being boarders. The total land size of the school is about 262 acres though its facilities occupy only about 20% of the total land area. The school has nine unit classroom blocks, a dining hall, kitchen, canteen, staff common room, boys dormitories, girls dormitories, physics, chemistry and biology laboratories. The various programmes run by the school are General Arts, Business, Visual Arts, Home Economics, Agric Science and General Science. The school's workforce stands at 49 permanent teaching staff and about 50 non-teaching staff. The school was officially commissioned on the 12th of May, 1993

3.2 Ethical consideration

Permission was officially sought from the authorities of the school three weeks before the start of the study. The school authorities provided the assistance of the students and a small piece of land for sorting and composting activities. The management of Zoomlion, Ejura district was consulted for the provision of sorting equipments (nose mask, hand gloves, etc.). The Deputy Director of the Ejura Crop Research Institute was also contacted for a balance and other turning equipment such as hand fork. Teachers of the school were personally consulted for their support during questionnaire administration.

3.3 Target population

The targeted population for the study consisted of students of the school. That is, students in S.H.S 2, S.H.S 3 and S.H.S 4 (S.H.S 1 students were not in school at the beginning of the study).

3.4 Students' knowledge on composting and waste management practices in the school

3.4.1 Sample size selection

According to Kennan (2009) sample size selection depends on the confidence interval or error permitted in the data (α), the confidence level which is written as a Z-score and the predicted percentage of expected responses the study will generate (p). Based on the above, a sample size (N) of 246 students was selected using the formulae:

$$N = \underline{Z^2 \times P(1 - P)}$$

α^2 where Z is the Z-score representing the confidence level (95%)

α is the confidence interval (0.05)

P is the estimated proportion of student (80%)

N is the sample size.

Based on the male-female ratio (1.3: 1) of the total student population, 139 males and 107 females were sampled. The 246 students were randomly selected from students of all programmes from S.H.S.2 to S.H.S 4.

3.4.2 Instrument for data collection

Questionnaire was used to collect the data from the students. Based on reviewed literature, the questionnaire was designed on students' knowledge and practices of waste management in the school. It was made up of three parts. The first part consisted of three items (questions) which were meant to categorize the students according to sex, age and programme of study. The second part, which is the knowledge component consisted of six items on a 3-point Likert scale of "Yes", "No", "Not Sure", while the practices of waste management on campus also consisted of six items, with the following options: "Yes", "No", "Not Sure", "Adequate", "Inadequate", and "Open burning", "Open dumping" , "Composting".

3.4.3 Reliability and validity of questionnaires

The questionnaire was validated with the assistance of an expert in the environmental Health and Sanitation Department of the District. It was pilot-tested using 10 students in the school who were not part of the sample size. Coefficient of internal consistency (ε) of the questionnaire was calculated using the Kudar-Richerson formulae:

$$\varepsilon = \frac{K}{K - 1} \times \frac{(1 - M(K - M))}{K\mu^2}$$

Where M is the mean of the Scores (2.25)

K is the number of items in the questionnaire (12) and

μ^2 is the variance (8.3)

Using the above formulae, the reliability coefficient of the questionnaire obtained was 0.80

3.4.4 Questionnaire Administration

After the rationale of the study was explained to students, the questionnaires were administered to the randomly selected students in each of the classes. Since all the students could read and understand the items its administration was not as difficult as expected. The questionnaires were completed and collected in the presence of the researcher after little guidance was given to the students.

3.4.5 Data Handling

194 of the returned questionnaires (78.9%) were found to be properly completed. The items and

their responses were coded and were carefully placed in a spreadsheet grid for storage. Responses to the items were pooled and scored (weighted) by assigning nominal values to the items according to scales. Responses to items on knowledge had an assigned score from 1 to 3 for “Not sure”, “No” and “Yes” respectively; or “Not sure”, “Not important” and “Important” respectively. The responses on waste management practices were scored as follows: 1- “Not sure”, 2 – “No” and 3 – “Yes” or 1 – “Not sure”, 2 – “Inadequate” and 3 – “Adequate”. The scoring of the responses was based on the appropriateness (how positive) of the response. That is, the more acceptable or positive the response is, the greater the score.

3.5 Quantity and percentage composition of solid waste

3.5.1 Sources of solid waste for the study

The solid waste used for the study were collected from the Staff common room, laboratories, canteen, dining hall, boys dormitories, girls dormitories, class rooms, offices and the school kitchen.

3.5.2 Solid waste collection

Five large wooden waste bins and five smaller litter bins were used for the exercise. The purpose of the exercise was explained to students during one of the school’s current affairs programs. The exercise was carried out by selected students under the direct supervision of the researcher.

Waste collection was done on Monday and Friday during the first week of November, 1st – 5th 2010. The collection of waste in two days was done to allow for variation in waste generation over the week. Each of the bins was assigned to each of the sources of solid waste in the school at 5:00 AM on each of the selected days. The solid waste generated in the classrooms, compound, staff common room, laboratories and canteen were collected and transported to the sorting and weighing site at 4:00 PM (after school had closed) on each of the days. Waste from the dormitories, kitchen and the dining hall, however, were collected at 4:00 AM the next day for each of the two days. This made it possible for the researcher to collect waste generated from these sources in the evenings and at nights.

Plate 3.1 Waste collection bins positioned at vantage points to collect waste in the school

Plate 3.2 Students carrying solid waste to the sorting and weighing site

3.5.3 Sorting and weighing of waste

Hand gloves, nose mask (to ensure safety), a rectangular wooden container and a weighing balance were used to carry out the exercise. With the assistance of two students, the sorting and weighing were done by the researcher. The activities took place on a small plot behind the boys dormitories, during the week of waste collection. Waste collected from all the sources except those from the dormitories, kitchen and the dining hall, were sorted and weighed in the evenings of the days they were collected. Waste from each source was then transferred on wooden platform and manually sorted into organic solid wastes, plastic wastes and other solid wastes such as rags, cans etc. After sorting the waste from a particular source into the three components, the rectangular wooden container was weighed and recorded. The individual components from a particular source were placed in the container and weighed. The weight of the empty container was subtracted from the weights to obtain a net weight of each material component from a specific source. The actual weights of the waste fractions from each source on each of the two days were recorded. The quantity of solid waste generated in a day was determined by adding the total weight of all the components from all sources on each of the two days (Monday and Friday) and divided by two.

Plate 3.3 Sorting and separation of waste fractions

Plate 3.4 Weighing (L) and recording (R) of weights of organic solid waste

3.6 Composting of organic waste

The pile method of aerobic composting, described by Edris *et al.* (2003) was the method used to compost the organic portion of the waste. The organic materials used for the preparation of the compost were a mixture of mainly mango leaves and some few left over foods. A fence of 1.5m × 0.6m × 1.5m was erected on the composting site with perforated racks placed at the bottom of it to improve drainage. The fencing was done to restrict the access of chicken and life stock to the compost pile. To help speed up the decomposition process, the size of some of the waste materials such as the dry mango leaves were reduced by cutting them into smaller pieces with a knife. The mixed organic material was piled into the erected fence in a layer as thick as about 9 inches. A 2 cm layer of good quality soil was placed on the heap. After preparing a layer of compost a little water was added to it. The introduction of the soil was meant to introduce microorganisms into the heaps to facilitate the decomposition process. The sprinkling of water in between the piles was also meant to create conducive environment for microorganisms in the organic material. Following the above procedure, four layers of the piles were made up to a height of about four feet. The organic waste was composted for ninety-two days.

Plate 3.5 Piling and heaping of organic waste into the fence

3.7 Laboratory analysis of organic waste and compost

The laboratory analysis was done to determine the nitrogen, potassium, phosphorus and carbon content of the compost prepared and the raw organic materials used. The potassium, phosphorus and carbon content were determined by using the dry ashing method. However, the proportion of nitrogen was determined by using the Kjeldhal procedure, as described by Sadasivam and Manickam (1991).

3.8 Growing maize with prepared compost

The experiment was carried out on the site where the school used to farm, which is about 10 m from the boys’ dormitory. The nature of the soil at the site was a sandy-clay type of soil which could not effectively support the growth of maize without fertilizer application. Table 4.7

indicates the chemical properties of the soil in question. The study was carried out from the 8th of February, 2011 to the 17th of March, 2011. The treatments that were being tested were :

(i) Application of the prepared compost (T_1)

(ii) No fertilization / no compost application (Control) (T_2)

The experimental site was cleared and ploughed with a pickaxe and a hoe, after which four (4) 1.2 m x 0.7 m beds were prepared (two beds in each block). The experimental design was a randomized complete block design with 2 replications. This design was adopted to account for any significant variation in the field. 0.035 m^3 (0.15 m x 0.4 m x 0.5 m) of the compost was evenly spread and slightly worked into each of the beds labeled T_1 in each block.

School Farm

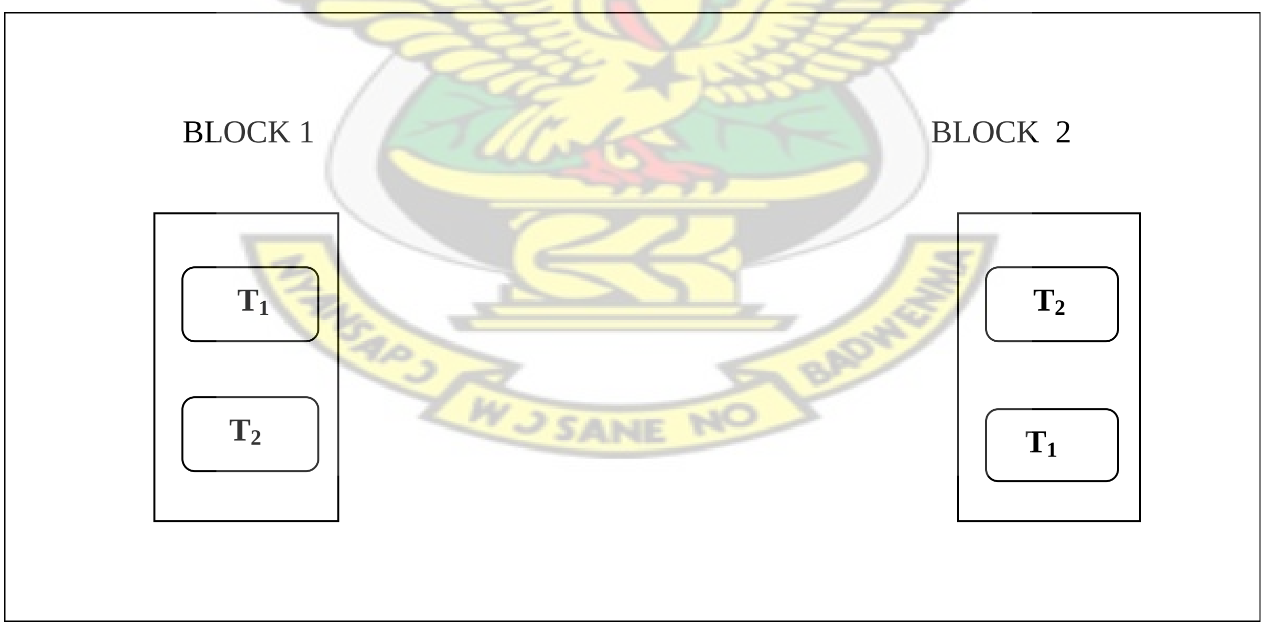

Figure 3.2 Plan of the experimental design

A week after, the maize seeds (*Zea Mays* L.) were planted at a rate of 3 seeds per hole in all the four beds. 30 maize plants were expected from each bed. The planting distance was 30 cm within plants and 60 cm between rows. Manual watering (irrigation) was done in the mornings and in the evenings since the planting was done in the later part of the dry season. Seven days after emergence, plants were thinned to have five plants per bed. Three (3) maize plants with average, representative appearances were selected per bed to assess the growth parameters of the plants. Plant heights were measured with a meter rule from the ground level to the topmost part of the tallest leaf and were taken every five days.

Growth parameters such as root length (cm), shoot length (cm), diameter of stem (cm), fresh shoot weight (g), dry shoot weight (cm) and fresh root weight (g) were measured and recorded 30 days after planting. The growth parameters were assessed on the 30th day because maize plant, based on literature, is most likely to show the most significant growth defect on nutrient-deficient soil during that period.

Plate 3.6 Maize plants grown with compost; 18 days after planting.

Plate 3.7 Maize plants grown without compost (control); 18 days after planting

Plate 3.8 Measurement of the height of a maize plant, 18 days after planting

3.9 Data Analysis

In order to determine the weight (score) for a particular response of the questionnaire its score was multiplied by the number of students who chose that response. The total score for a question was calculated by adding the scores of all the responses of that question. Those calculations were based on the assumption that all the questions were equally important. The level of knowledge on composting and practices of waste management on campus were determined by using binary partitions (Low/ High). The partitioning value was determined by finding the average of the nominal values. Thus, the partition value of knowledge and practices was put at 2.0. The expected maximum score per question was put at 3.0. For purposes of data interpretation mean values of 2.0 and above were deemed to indicate that the number of students knowledgeable about composting, with respect to that question, was high while those that fell below 2.0 were regarded as low.

The statistical method used in this research consisted of descriptive statistics of frequency count, percentage, and mean. On the solid waste generated, the percentage by weight of each component was calculated and used to generate a graph with the excel statistical tool park. Treatment means were compared by Tukey's test at $P \leq 0.05$ using the Statistical Package for Social Sciences. Significant relationship between students' knowledge on composting, sex and age was tested using the Chi- square.

CHAPTER FOUR

RESULTS

4.1 Students' knowledge on composting

Table 4.1 represents the percentage of students who are knowledgeable about composting and the mean scores of their responses to the questions. It shows that the mean scores of all the questions fell above the partition value (2.0), indicating that the number of students who were knowledgeable about composting was very high.

Table 4.1 Mean scores and percentage analysis of students' knowledge on composting

Questions	**Responses**			**Mean scores**
	Yes	No	Not sure	
Have you ever had any education on solid waste disposal / management?	162 (83.5%)	32 (16.5%)	0 (0%)	2.84
	Yes	No	Not sure	
Do you know what organic solid waste is?	158 (81.4%)	36 (18.6%)	0 (0%)	2.81
	Yes	No	Not sure	
Do you understand the term composting?	102 (52.6%)	92 (47.4%)	0 (0%)	2.53
	Yes	No	Not sure	
Is it important that your school compost its organic waste ?	155 (79.9%)	39 (20.1%)	0 (0%)	2.79
	Yes	No	Not sure	
Will you support it if your school decides to compost its organic waste and use it on the school farm?	146 (75.3%)	48 (24.7%)	0 (0%)	2.75
	Organic	Plastics	Others	
What type of solid waste do you think is generated in largest quantities in your school?	63 (32.5%)	102 (52.6%)	29 (14.9%)	2.18

The percentage of male students who were knowledgeable about composting and the mean scores of their responses to the questions are represented by Table 4.2. It shows that the mean scores of all the questions fell above the partition value (2.0), indicating that the number of male students who were knowledgeable about composting was very high.

Table 4.2 Mean scores and percentage analysis of male students' level of knowledge on composting

Questions	Responses			Mean scores
	Yes	No	Not sure	
Have you ever had any education on solid waste disposal / management?	102 (92.7%)	8 (7.3%)	0 (0%)	2.93
	Yes	No	Not sure	
Do you know what organic solid waste is?	93 (84.5%)	17 (18.6%)	0 (0%)	2.85
	Yes	No	Not sure	
Do you understand the term composting?	69 (62.7%)	41 (37.3%)	0 (0%)	2.65
	Yes	No	Not sure	
Is it important that your school compost its organic waste ?	89 (80.9%)	21 (19.1%)	0 (0%)	2.81
	Yes	No	Not sure	
Will you support it if your school decides to compost its organic waste and use it on the school farm.	75 (68.2%)	35 (31.8%)	0 (0%)	2.68
	Organic	Plastics	Others	
What type of solid waste do you think is generated in largest quantities in your school?	42 (38.2%)	49 (44.5%)	19 (17.3%)	2.21

The percentage of female students who were knowledgeable about composting and the mean scores of the questions are represented by Table 4.3. The table shows that the mean scores of their responses to all the questions fell above the partition value (2.0), indicating that the number of female students who were knowledgeable about composting was very high.

Table 4.3 Mean scores and percentage analysis of female students' level of knowledge on composting

Questions	**Responses**			**Mean scores**
	Yes	No	Not sure	
Have you ever had any education on solid waste disposal / management?	60 (71.4%)	24 (28.6%)	0 (0%)	2.71
	Yes	No	Not sure	
Do you know what Organic solid waste is?	65 (77.4%)	19 (22.6%)	0 (0%)	2.77
	Yes	No	Not sure	
Do you understand the term composting?	33 (39.3%)	51 (60.7%)	0 (0%)	2.40
	Yes	No	Not sure	
Is it important that your school compost its organic waste ?	66 (78.6%)	18 (21.4%)	0 (0%)	2.79
	Yes	No	Not sure	
Will you support it if your school decides to compost its organic waste and use it on the school farm?	71 (84.5%)	13 (15.5%)	0 (0%)	2.85
	Organic	Plastics	Others	
What type of solid waste do you think is generated in largest quantities in your school?	21 (25%)	53 (63.1%)	10 (11.9%)	2.13

4.2 Solid waste management practices in the school

Table 4.4 represents the percentage of students who expressed their views on the waste management practices in the school and the mean scores of their responses. According the table, most (four out of six) of the mean scores fell below the partition value (2.0), indicating that waste management practices in the school was not satisfactory.

Table 4.4 Mean scores and percentage analysis of responses on waste management practices in the school

Questions	Responses			Mean scores
	Yes	No	Not sure	
Is waste disposal a major problem in your school?	161 (82.9%)	32 (16.6%)	1 (0.5%)	2.16
	Yes	No	Not sure	
Do you have adequate waste collection bins in your school?	13 (6.7%)	162 (83.5%)	19 (9.8%)	1.96
	Yes	No	Not sure	
Do students patronize the bins, if any?	1 (0.5%)	174 (89.7%)	19 (9.8%)	1.91
	Composting	Open burning	Open dumping	
What is the most common method of managing solid waste in your school?	0 (0%)	33 (17%)	161 (82.9%)	1.17
	Yes	No	Not sure	
Are you comfortable with the location of the open dump, if any?	2 (1%)	176 (90.7%)	16 (8.2%)	1.93
	Adequate	Inadequate	Not sure	
What do you think about the current waste management practices in your school?	3 (1.5%)	191 (98.5%)	0 (0%)	2.02

4.3 Composition of solid waste in the school

Figure 4.1 shows the percentage composition of solid waste generated in the school. While the organic waste dominated (81%) the total waste generated, other solid wastes such as bottles, cans etc. were the least(5 %) among the waste stream.

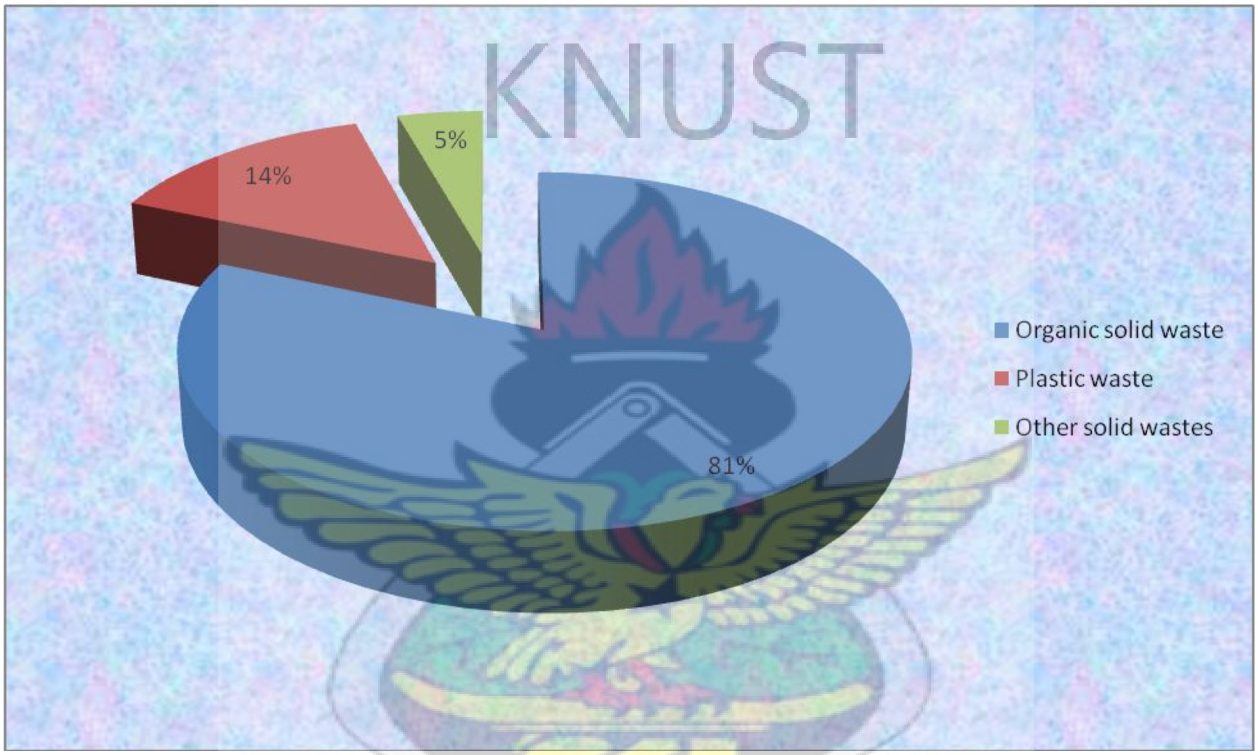

Figure 4.1 Percentage composition of solid waste

Plate 4.1 The dominance of dry mango leaves among the waste stream in the school

Figure 4.2 shows the percentage composition of solid waste, from different sources, generated in the school. It indicates that the dining hall / kitchen is the single source that generated the largest (48.9%) proportion of the organic waste in the school. The source could be targeted as a primary source of feedstock if composting is adopted as a waste management tool in the school. The kitchen and the dining hall, however, recorded the least amount of plastic waste and other solid waste (cans, bottles etc) among the various sources of waste generation.

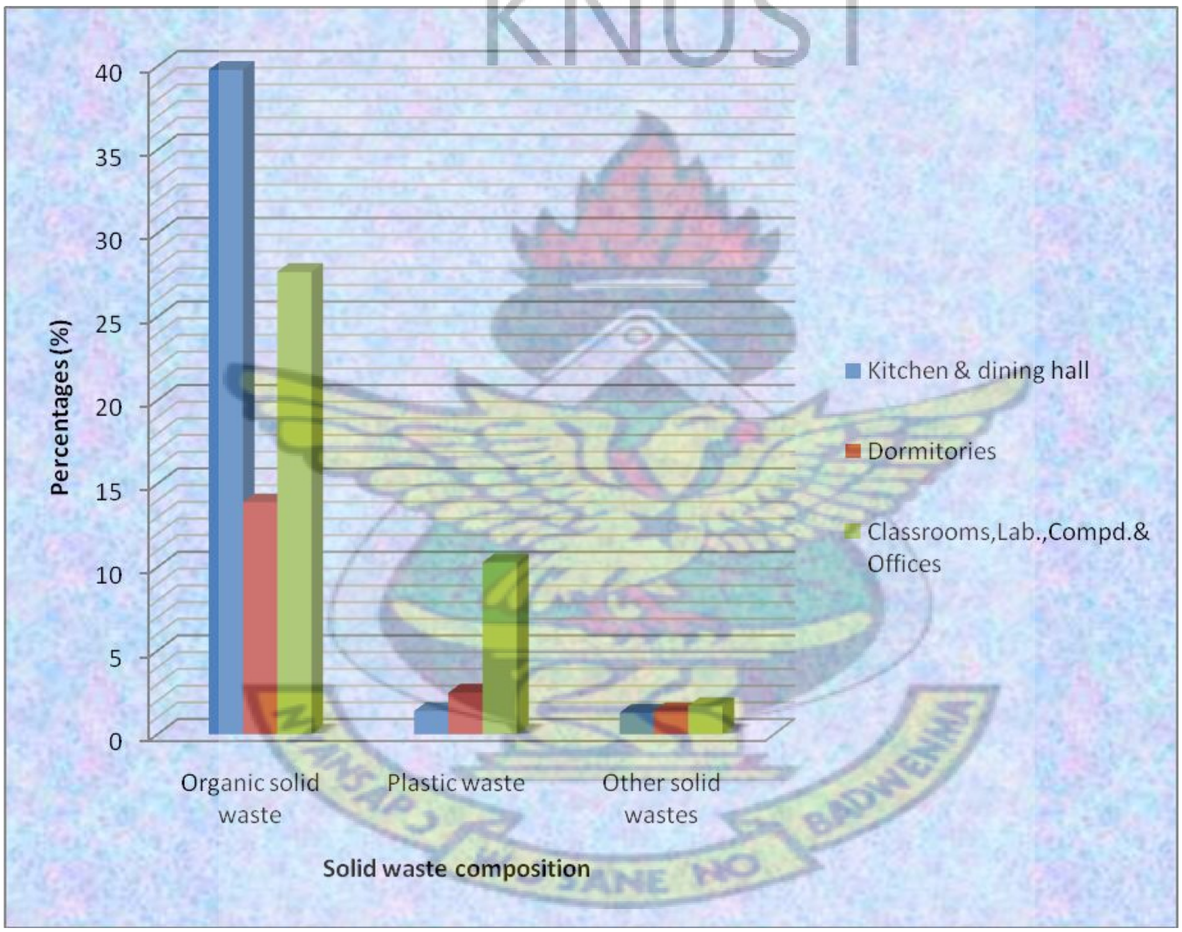

Figure 4.2 Percentage composition of solid waste from different sources

4.4 Chemical Analysis

Table 4.5 shows the chemical characteristics, especially the C:N ratio, of the organic solid waste generated in the school. The table shows that the C:N ratio of the feedstock (47:1) fell far beyond the ideal range (25:1 to 30:1), a range that is considered favorable for composting.

Table 4.5 Chemical characteristics of organic solid waste

Nutrient	**Composition (% dry wt)**	**Composition (% dry wt)**	**Average (% dry wt)**
Organic matter	86.28	86.30	86.29
Nitrogen	1.07	1.05	1.06
Carbon	50.04	50.05	50.04
C : N ratio	46.7 :1	47.7 : 1	47 : 1

The chemical characteristics of the prepared compost are represented by Table 4.6. The table shows that the percentage composition of nitrogen (0.36 %), phosphorus (0.04 %) and potassium (0.09 %) were not appreciable as compared to that of most finished compost indicated in Table 2.6. The pH of the compost (8.06), however, was quite high depicting a compost material that is basic in nature.

Table 4.6 Chemical characteristics of compost

Nutrients	Composition (% dry wt)	Composition (% dry wt)	Average (% dry wt)
Organic matter	6.92	6.90	6.91
Nitrogen	0.35	0.36	0.36
Phosphorus	0.03	0.04	0.04
Potassium	0.09	0.09	0.09
Carbon	4.01	4.00	4.00
C:N ratio	11.5:1	11.1:1	11.3:1
pH	8.05	8.06	8.06

Table 4.7 shows the chemical characteristics of the soil (control) at the experimental site. The table shows that the percentage composition of nitrogen (0.18%), phosphorus (0.04 %) and potassium (0.07 %) were not appreciable, indicating that indeed, the fertility of the soil was very low.

Table 4.7 Chemical characteristics of the soil

Nutrients	Composition (% dry wt)	Composition (% dry wt)	Average(%dry wt)
Organic matter	3.44	3.40	3.42
Carbon	1.82	1.97	1.89
Nitrogen	0.19	0.17	0.18
Potassium	0.07	0.07	0.07
Phosphorus	0.05	0.03	0.04

Table 4.8 shows the quantity of organic waste, compost and the effect of composting on the quantity of waste meant for disposal. According to the data, composting the total organic solid waste in the school (108.8 Kg), produced 55.2 Kg of compost and by extension reduced the total solid waste meant for disposal by 40.1 %.

Table 4.8 Percentage quantities of organic waste, compost and waste lost

Materials	**Quantity (Kg)**	**% (organic waste)**	**% (total waste)**
Organic waste	108.8	100.0	81.4
Compost	55.2	50.7	41.3
Waste material lost	53.6	49.3	40.1

4.5 Effect of compost on the growth of maize plant

The effect of the prepared compost on the growth rate of maize plant is represented by Figure 4.3. The figure shows that the rate of growth of the maize plant on the composted bed (1.03 cm/day), within the first five days after planting, was lower than that of the control (1.12 cm / day). However, the growth rate of the maize on the composted bed (2.97 cm/ day) overtook that of the control (2.82 cm / day) after the fifteenth day after planting.

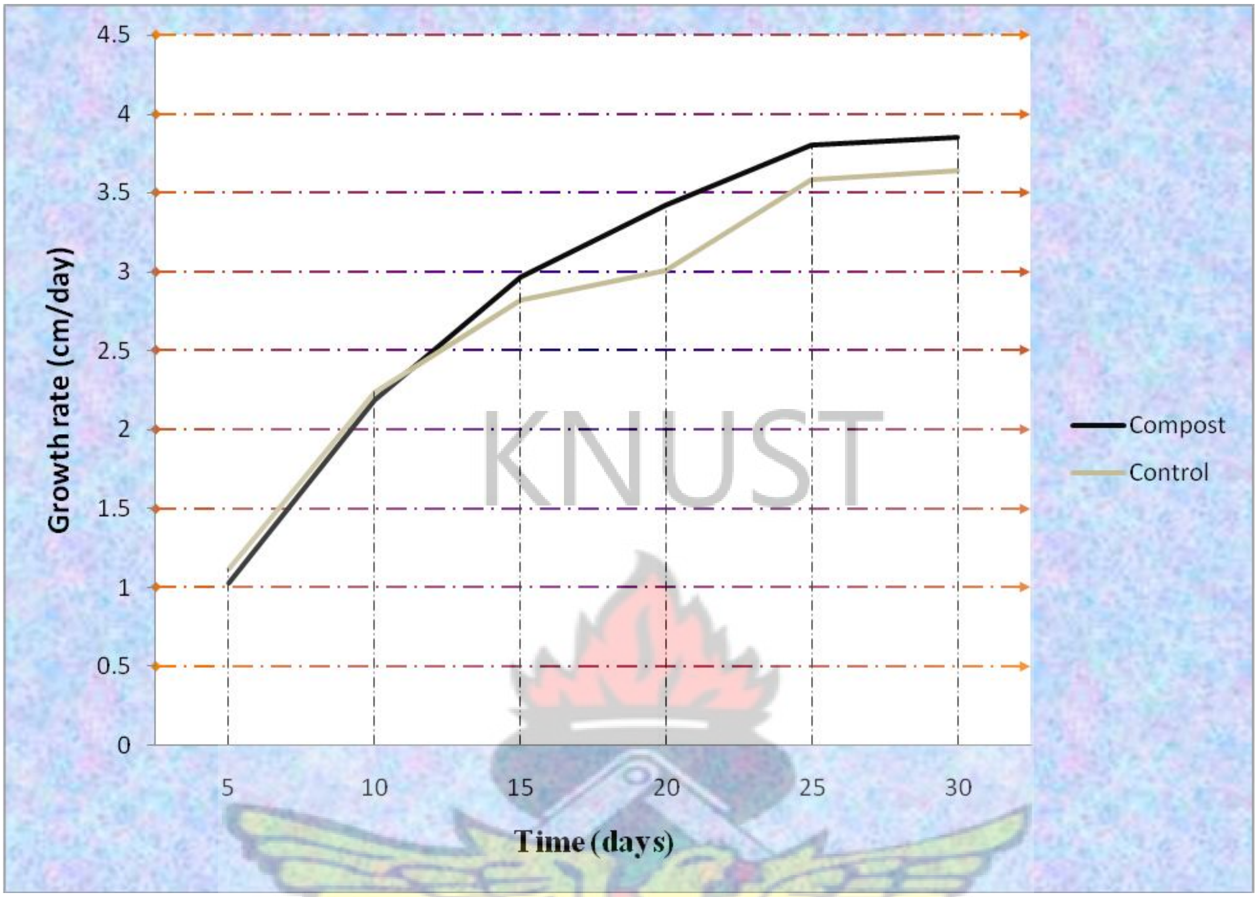

Figure 4.3 Growth rate of maize in height under different treatments within 30 days after planting

Figure 4. 4 compares the effect of compost on the heights of maize plant on composted bed with that of the control (without compost). According to the figure, the average height of maize plants on the soil with compost was lesser than that of the control within the first five days after planting. After the fifteenth day, the average height of maize plants on the experimental site overtook that of the control. Though not statistically significant, the average height of maize plants on the composted bed, 30 days after planting, was higher than that of the control.

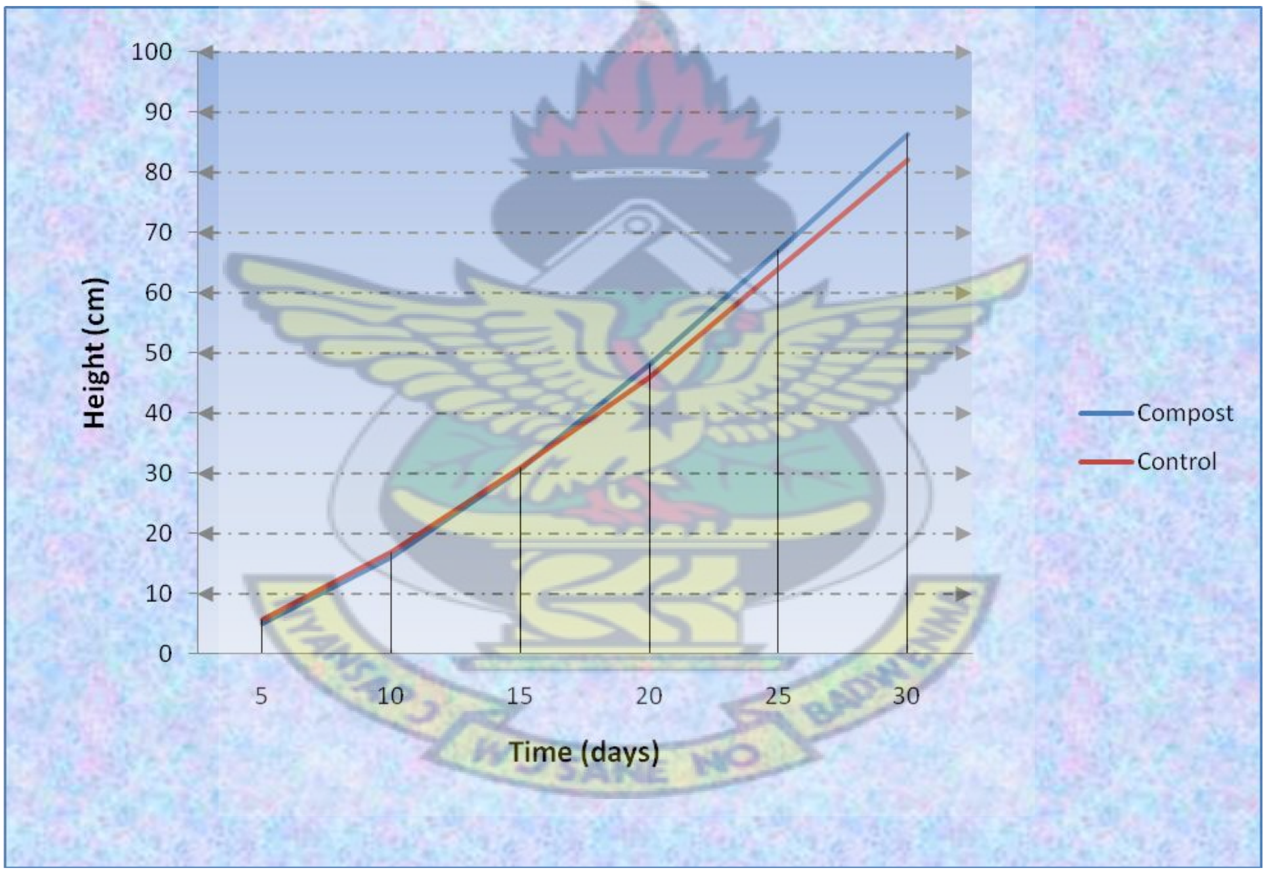

Figure 4.4 Height of maize plant under different treatments 30 days after planting

CHAPTER FIVE

DISCUSSION

5.1 Students' knowledge on composting

High awareness or knowledge on environmental issues normally leads to positive attitude towards environmental protection and its management. Environmental knowledge in the school sector is known to provide opportunities for students and authorities to engage in actions and behaviours that impact positively towards achieving a more sustainable school environment (Diamontopoulos *et al*., 2003).

Establishing a baseline of descriptive information on students' knowledge and practices concerning waste management in the school, the findings of the present study have made it clear that a high number of the students were knowledgeable about waste management and were aware of composting, as an effective solid waste management tool. This observation agrees with the findings of Duan and Fortner (2005) who found that students possess high environmental awareness and knowledge of local environmental issues. The high awareness about composting among the students might have been influenced by a number factors. One of which is the current structure of the educational curriculum in Ghana. Right from Lower Primary students are exposed to sanitation and other environmental-related issues through the study of Natural Science as a subject. The method and significance of composting have also been addressed in Soil Conservation, as a topic, in the Integrated Science Syllabus for Senior High Schools. Secondly, the school organizes current affairs programme every Thursday morning during which environmental and other educational issues are 'preached' to the students. These exposures might have influenced their awareness on composting.

The significance of this observation is directly related to the acceptability of composting as a waste management tool. The feasibility of using composting to manage solid waste in the school depends on, among other factors, the acceptability of it to the students. Its acceptability also depends on the level of awareness and how knowledgeable the students are as far as composting is concern. Hence, since most of the students are aware of the need for composting, its introduction to the school may receive the cooperation and support of the school community. This may also enhance the sustainability and culture of composting in the school.

Significant relationship (sig.< 0.05) was observed between gender and the number of students who were knowledgeable about composting. This outcome, however, is inconsistent with previous research (Van Liere & Dunlap, 1981; Kellert, 1995; Muffitt, 1990). According to Van Liere and Dunlap (1981), gender is not a significant predictor of environmental concerns and attitudes as other socio-demographic variables. Kellert (1985) found no gender difference in this attitude for U.S. children in the 2nd grade. Muffitt (1990), in a study of Canadian students in 6th, 7th and 8th grades, found no attitude differences between the sexes. The common reason that could account for the gender differences is probably the different socialization patterns between boys and girls. The result also showed that there was no significant relationship between age and knowledge on composting. This might suggest that access to information on composting or waste management as a whole by students in the school was not influenced by their different ages.

5.2 Practices of waste management in the school

The solid waste management practices in the school were not satisfactory since the mean scores of more than half of the questions (Table 4.4) were below the 2.0 mark set, which is the partition value. This confirms the observation made by Ifegbesan (2008) whose findings revealed that Secondary School Students from sampled zones in Ogun State, independent of their sex, possessed poor waste management practices. Bassey *et al*. (2006) also reported that more than half (55.8%) of the students in five selected public schools in Abuja expressed dissatisfaction in the way waste were disposed in their schools. The data, may therefore suggest that high knowledge on waste management among students does not necessarily culminate in positive waste management practices in schools and that this trend according to literature, is not restricted to Ejuraman Anglican Senior High School.

This observation could be attributed to a number of factors including lack of financial commitment from the school authority to pursue the right waste management option such as composting or recycling or any of the waste management tools. Another factor that could contribute to this problem was probably poor attitude of members of the school community towards solid waste generation and its management. This attitudinal problem, therefore, may explain the adoption of open dumping as the commonest waste disposal method in the school as shown in Table 4.4. Due to financial constraint and lack of technical knowhow most institutions, towns and cities in African countries have resorted to open dumping, instead of sanitary land filling (Medina, 1999). The findings from this study have great implications for waste management practices in Secondary Schools in the district. It has revealed the need for behavioural and attitudinal change which is essential for effective participation in solid waste management.

5.3 Percentage composition of solid waste

According to Zeng *et al*. (2005), waste management strategy differs from developed to developing nations, urban to rural areas and residential to industrial producers. This is based on the observation that the appropriateness of the strategy for waste management depends on the composition and the quantity of the waste. Considering the solid waste composition as shown in Figure 4.1, organic solid waste dominates (81%) the total daily solid waste generated in the school. This result is not in agreement with that published by Baker *et al*. (1998) and Kessler Consulting Inc. (2008). According to Baker *et al*. (1998) paper constituted the largest fraction (47%) of the solid waste, followed by organic waste (36%), generated in 10 High Schools in Califonia. Kessler Consulting Inc. (2008), also reported that other recyclable trash such as discarded clothes, pads etc. constituted the largest portion (49%) of the daily solid waste in 9 Wake County Public Schools in North Carolina. However, the 81% of organic solid waste obtained in the present study compared with the outcome of the work of Efebgesan (2008) except that the value obtained in this study was on the high side which probably could be due to the higher amount of waste generated in the school. The result is also a reflection of the proportion of organic solid waste generated in Ghana (89.5%) as a whole and Accra (65%) as indicated in Table 2.1 and 2.2 respectively.

It is a general knowledge that the type and nature of resources available at a particular environment determines directly or indirectly the composition of waste generated in that environment. The school environment has quite a number of mango trees which shed dry leaves on daily bases. This might have contributed to the large percentage of organic waste generated in the school. It is also worth mentioning that most students in the school fall within the low income group with less purchasing power which might have made them unable to buy a greater variety of products packaged in non-biodegradable materials such as bottles, plastics and glass containers. A key variable influencing options for schools' composting programme is the assumed quantity of the compostable waste among the waste generated (Walling *et al*., 2004). Hence the large percentage of organic waste in the waste stream supports the composting potential of the solid waste generated in the school and may imply that about 81% of the solid waste could be diverted from being deposited in a landfill or openly dumped. This will significantly reduce the cost of disposing of the solid waste generated in the school and by extension reduce the negative impact of open dumping on the environment.

The kitchen and the dining hall, according to Figure 4.2, generated most of the organic solid waste. The result also showed that the source also generated the least (1.4%) proportion of plastic waste in the school. These observations could be due to the fact that the kitchen basically deals with the handling and preparation of food items which are organic materials. Besides, items used in the kitchen were mostly bought in large quantities at a time, hence non-biodegradable materials such as polythene bags and other smaller plastic bags that could have been used to carry those items in bits were limited in quantity. Since the kitchen and the dining hall are the only sources that generated the largest proportion of organic waste they could be targeted as a primary source of organic waste if composting is adopted as a waste management tool in the school.

5.4 Chemical characteristics

5.4.1 Chemical characteristics of organic solid waste

Apart from the need for organic waste to constitutes a large percentage of the total solid wastes, the composting potential of solid waste also depends on the C:N ratio of the organic materials. During composting microorganisms utilize the carbon as a source of energy and the nitrogen as the building block for protein synthesis (Hoitink *et al*., 1997). A nutritional requirement for microorganisms is that the C:N ratio of organic material must be at a level for optimum decomposition efficiency (Adholelya and Prakash, 2004). When the C:N ratio of the organic material exceeds 30:1, the organisms become deficient in nitrogen and the process of decomposition is slowed (Mamo *et al.*, 2002 as cited by Mensah, 2010). However, other researchers including Diaz *et al*. (1999) have shown that in general, a C:N ratio of 35:1 or lower is preferred if the material is to be nitrogen stabilized.

In the present work, the C:N ratio of organic materials used for the preparation of the compost (47:1) was quite high (Table 4.5). This result is not comparable with that reported by Mensah, (2010) for waste generated by low, middle and high income groups in Kumasi (26.6:1, 24.7:1 and 25.0:1 respectively). The ratio fell far beyond the ideal C:N ratio of 25:1 to 30:1, a range that is considered favorable for composting without any further balancing or proportioning. Woody plants or materials such as sawdust, wood, straw, dry leaves, corn stalks etc. have relatively high carbon content but low in nitrogen whereas others such as food wastes, vegetable trimmings, animal waste etc. are low in carbon (Madar, 2002). A very significant proportion of the organic materials generated in the school and used for the preparation of the compost were dry mango leaves as indicated in Plate 3.3 and this might have contributed to the high C:N ratio of the feed stock.

The high C:N ratio of the organic waste has a lot of negative implications for the composting potential of the organic materials generated in the school. That is, the amount of carbon in the compost pile to be oxidized for the generation of energy to reach a stabilized condition may be very high. Besides a significant proportion of the carbon may be in a form of cellulose and lignin which are resistant to microbial attack. To add to this, high carbon content implies that the microorganisms in the pile will have to recycle the little nitrogen available through many generations in order to break down the large carbon-containing organic materials in the pile. These bio-chemical activities will require more time which may prolong the composting period of the organic waste if composting is adopted as a waste management tool in the school. Secondly, if compost is prepared from this feedstock it may have a lot of identifiable parts of organic materials due to the fact that the decomposition process may not be complete.

Compost prepared from this waste may not support the growth of plants when used as a fertilizer. This is because the nutrient availability (mineralization) from organic source, such as compost, partly depends on the biochemical activities of microorganisms in the soil. Since the compost is likely to be deficient in nitrogen, the microbial cells may draw any available soil nitrogen, in the proper proportion, to make use of the available carbon in the compost in order to continue the decomposition. This is known as "robbing" the soil of nitrogen, and may delay the availability of nitrogen in the soil. However, if the unavailable carbon happens to be very high in the organic materials and hence in its finished compost, then the carbon may be so slowly available that nitrogen robbery will not be significant. This suggests that the organic materials in the school will need to be proportioned or co-composted with nitrogen-rich organic material, such as rotten vegetables or animal waste. This may provide a near optimum C:N ratio in order to conserve an appreciable amount of nitrogen to support plant growth effectively. Besides proportioning, reducing the sizes of the organic waste could help increase the surface area of the feedstock thereby facilitating the decomposition process. According to Mahimairaja *et al*. (2008), the mixing of 5 kg of lime and 1000 kg of hard plant materials could produce a good compost. This technology could help produce good compost from the type of waste generated in the school. However, it is necessary to be mindful of the economic implication since this may raise the cost of compost production in the school.

5.4.2 Chemical characteristics of compost

One of the important purposes of compost preparation is the conservation of nutrients and the fertilizer-value of the organic waste. A quality compost product is characterized, among other features, by a significant level of nutrients notably, nitrogen, phosphorus and potassium (NPK). Nitrogen conservation during the decomposition process is the most important because the shortage of nitrogen limits microbial activity and hence the cessation of decomposition during composting (Follet, 1999).

In the present work, the data in Table 4.6 shows that the nitrogen conserved in the prepared compost is not appreciable. Though the level of nitrogen in the compost is higher than that reported by Gouin (2001), all the three macronutrients (NPK) fell far below the range of values for nutrients in most finished compost, as reported by the Whatcom County Extension of Whatcom University (2007). Since the C:N ratio of the feedstock (47:1) depicts a far lower nitrogen content, very little amount of the nitrogen in the organic materials was conserved in the finished compost. The low concentration of nitrogen in the compost can also be attributed to the escape of nitrogen, through denitrification (conversion of nitrate to free nitrogen by microorganisms), into the atmosphere. It is also worth mentioning that water serves as solvent or diluents for ammonia, hence the higher the moisture content in the compost pile the lower the volatilization of the nitrogen, as ammonia, into the atmosphere. Since the composting of waste was carried out during the dry season the high temperatures might have reduced the moisture content of the unfinished compost leading to the loss of a significant amount of nitrogen from the compost. Though both phosphorus and potassium are non-volatile nutrients, their concentrations in the compost were quite low.

The compost, according to Table 4.6 has a very high p^H value (8.06), depicting a compost material that is basic in nature. This high p^H value of the compost corroborates with that reported by Zarina *et al*. (2010) and Mahimairaja *et al*. (2008). Ash normally contains more alkali metals such as potassium and sodium. In the presence of moisture, these metals react violently with water to form hydrogen gas and hydroxides, the hydroxides then react with the metals to form strong bases such as sodium hydroxide or potassium hydroxide. Hence the high p^H value of the compost may probably be a reflection of the fact that the organic materials contained higher amount of ash or alkali metals. This property of the compost could enhance its ability to remediate highly acidic soils for crop production.

5.4.3 Chemical characteristics of the soil

Organic materials constitute an essential component of soils. These materials mostly come from the residue of plant parts such as the remains of plant roots or leaves and dead animals. They become part of a cycle of decomposition that provides important nutrients such as nitrogen, phosphorus and potassium to improve the nutrition and health of the soil. Hence, in general, soil fertility depends mainly on high content of organic materials.

The nitrogen, potassium, phosphorus and the organic matter contents of the soil at the school farm (control), according to Table 4.7, were very low indicating that the soil was poor indeed. The state of the soil could be attributed to a number of factors. Continuous growing of crops on a land without any fallow periods erodes and uses up most of the soil nutrients. This practice which is common in Ejura and for that matter the school might have created the poor state of the soil at the school farm. Erosion and its consequent run-offs of water over the surface of the soil could also contribute to the loss of nutrients from the soil. The condition of the soil has very serious implications for life in the soil. That is, since the nutrient content of the soil is not appreciable it may encourage the continuous application of inorganic fertilizers on the land. This may create unfavourable environmental conditions for living organisms which may cause their disappearance from the soil. This can worsen the situation because loss of living organisms will mean loss of organic matter and the consequent loss of nutrients from the soil. It is worth mentioning that the excessive application of chemical fertilizer on the soil could also increase the amount of chemical leachate in the nearby river that flows some few meters behind the boys' dormitories.

Though the percentage of potassium and phosphorus in both the compost and the soil were relatively similar, the organic matter and the nitrogen contents in the compost were significantly higher than that of the soil, as indicated in Table 4.6 and 4.7. It is important to mention that if the prepared compost will be deemed effective in promoting the growth of a particular plant, the difference between the growth parameters of the experimental setup (composted plot) and the control (unfertilized plot) should be significant. Hence, if the soil of the unfertilized plot happened to have an appreciable amount of nutrients the difference in growth parameters between the control and the composted bed may not be significant and vice versa. If the above inference is something to go by, then the consideration of the compost as being effective, as compared to the control, may be easier since the nutrient content of the soil was very low.

5.5 Effect of composting on the quantity of waste meant for disposal

One of the most important rationales for composting solid waste is to significantly reduce the volume of waste meant for disposal and the cost involved. Table 4.8 indicates that the composting process reduced the organic solid waste used as feed stock by 49.3% and by extension 40.1% of the total solid waste generated in the school. This figure is relatively comparable with that reported by Shelton (2007) who reported that composting the solid waste in North Carolina reduced the volume of organic solid waste by 50%.

Carbon generally constitutes the largest portion, followed by nitrogen, of organic materials. This large reduction in volume could be attributed to the fact that microorganisms utilized the carbon and the nitrogen components of the feed stock as a source of energy (it is respired as carbon dioxide into the atmosphere) and for protein synthesis respectively, hence bringing about a significant reduction in the volume of the solid waste. Comparing the C:N ratios of both the feedstock and the compost, as indicated in Table 4.5 and 4.6, it is clear that the feedstock has lost far more carbon than nitrogen after the decomposition period. Generally, mesophilic microorganisms that carry out active decomposition require carbon for two main purposes; it is respired as carbon dioxide to provide energy and it's also combined with nitrogen to form the structure of the protoplasm of the microbial cells. This then may explain the fact that microorganisms make use of more carbon than nitrogen during the decomposition of organic materials.

5.6 Effect of compost on growth parameters of maize

Several field research reports have indicated that high and sustainable crop growth and yield are only possible when the soils on which they grow are of high quality. Application of organic materials such as animal waste and compost as fertilizers has been known to provide growth-regulating substances and improves the physical, chemical and microbial properties of the soil.

The data generated in this study indicated that, the proportions of root length, root weight, shoot weight, shoot length and width of stem of maize plants did not differ significantly between the plots fertilized with compost and the control ($P>0.05$). This does not corroborate with that reported by Tariq, *et al*. (2001) who observed substantial improvement in root and shoot fresh and dry weights, 42 days after the application of organic manure. Maize plant on composted bed gave higher (though not significant) heights than that of the control. This result does not support the result reported by Boonchan and Chantaprasarn, (2004) who reported that maize plant height was significantly higher on composted soil than that from the negative control 25 days after planting. The result, however, was comparable with that reported by Sobulo and Babalola

(1992) who noticed that maize plant heights from unfertilized plots were only comparable with plants fertilized with sole organic fertilizer. This suggests that the compost seemed not to have any significant effect on the maize plants. This may be attributed to the low concentration of nutrients in the compost. Compost is at least as effective as chemical fertilizers over longer periods of use (Bremner, 2000). The observed ineffectiveness of the compost to promote the growth of biomass (shoot weight) and other growth parameters supports the observation that organic fertilizers could better be used for sustaining the growth of plants over longer period of use.

According to Dim *et al.* (2003) soil moisture demand by maize crop is minimal at seedling phase and optimal at crop establishment phase. Figure 4.3 shows that the compost began influencing the growth rate of the maize plants from between the 10th and the 15th day after planting. This period which is the period of establishment in the life cycle of the maize plant might have optimized the extraction of water and nutrients from the soil, thereby initiating an appreciable increment in the growth rate of the plant. This observation could also be attributed to the thought that the release of inorganic nutrients and the mineralization of the organic nutrients from the compost might have been effected some few days before or within that period. This result may imply that compost prepared from organic waste generated in the school need to be applied at least three weeks before sowing, so that the mineralization of the organic nitrogen in the compost could begin before the plants get established in the soil for optimum growth. In this case, the effect of the compost on the plants may be manifested earlier. The generally low performance of the compost in supporting the growth of maize 30 days after planting may be attributed to the obviously low nutrient content of the compost as compared to that published by the Whatcom County Extension of Washington State University (2007).

In general, compost is often considered as a low nutrient organic fertilizer but a good conditioner. More recent reports published by different field researchers including Zarina *et al*. (2010) ; Makinde (2007) and Amujoyegbe *et al*. (2007) have confirmed that the sole use of organic fertilizers to sustain the cropping of maize has proved inadequate as macronutrients are less concentrated in it. Complementary application of organic and inorganic fertilizer has proved to be as effective as the sole use of inorganic fertilizers (Yussuf *et al*., 2007). Complementary use of both organic and inorganic fertilizer is important not only for enhancing the efficiency of the fertilizers, but also in reducing environmental problems that may arise from their individual use. Hence in the present circumstance, apart from the need to co-compost the organic waste in the school with nitrogen-rich materials, fortifying the finished compost with inorganic fertilizer will therefore raise its nutrient content to significantly improve the growth, and for that matter the yield of maize grown in the school.

Compost, apart from its ability to support plant growth, has soil-amending properties that could be tapped. Cottenie (1980) as cited by Paramanathan (2000) revealed that compost application facilitates soil moisture retention and thus the capability of reducing the impact of drought when it is used as mulch or a conditioner . The use of compost, according to Coleman *et al*. (2002) facilitates reforestation, wetlands restoration and habitat revitalization efforts by improving soil aeration, controlling soil erosion and amending contaminated, compacted and marginal soils . It is therefore clear from the above schools of thought that though the compost could not effectively support the growth of maize it could be used as mulch or any other form to improve the physical properties of the soil. Therefore, if the aforementioned environmental benefit of the compost is anything to go by then 81% of the total solid waste generated in the school daily could be diverted from being dumped in a sanitary landfill or being dumped openly in the school community and used to promote organic farming.

According to Surahet (2005) the feasibility of adopting composting as a waste management option to manage solid waste in a community depends on its acceptance by the people, the quantity of organic solid waste among the waste stream and the ability of the finished compost to support plant growth. These concerns may imply that the full benefits of composting organic waste cannot be achieved if it is not able to significantly reduce the amount of waste that need to be disposed of and also support plant growth. The present study has revealed that though composting the organic waste in the school could significantly reduce the total solid waste meant for disposal the support of the compost to the growth of maize plant could not be confirmed.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

i. The findings of the present study reveal that students in Ejuraman Anglican Senior High were knowledgeable about composting and have acknowledged the need for it, but stayed in a school environment that has unsatisfactory solid waste management practices.

ii. The largest proportion of solid waste generated in the school was the organic waste (81%), which consisted mainly of dry mango leaves

iii. The C: N ratio of the organic materials was not satisfactory (47:1) in relation to what is considered the optimum range for composting organic waste.

iv. The composting process reduced the total daily solid waste meant for disposal by 40.1%.

v. The contents of nitrogen (0.36%), phosphorus (0.04%) and potassium (0.09%) in the compost were not appreciable suggesting that it may not be possible to obtain good quality compost from the solid waste generated in the school.

vi. The prepared compost seemed not effective in promoting the growth of maize (organic farming) due to its low nutrient content.

6.2 Recommendations

Based on the study findings and relevant conclusions the following recommendations have been made:

i. Efforts should be made by government and school management to organize seminars and workshops for students, teachers and administrators to sensitize them to waste problems and their consequences on the students. This will make members of the school community able to promote environment-friendly practices.

ii. The segregation of solid waste at source is highly recommended so that clean source of raw materials could be obtained for the various waste treatment or disposal options.

iii. The school can reduce the quantity of solid waste meant for disposal through composting, but the nutrient content of the compost may not support the growth of maize.

iv. In preparing compost in the school, the organic waste materials should be cut or shredded into small pieces and mixed with high nitrogen materials such as poultry droppings etc. before composting to improve the nutrient content of the prepared compost to support crop production.

v. In the future, an extended study could be conducted to cover the rest of the Senior High Schools to give a more representative picture of the composting potential of solid waste generated in the schools in the district.

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APPENDICES

Appendix: A

Table A: 1 Test of significant relationship between students' level of knowledge on composting, sex and age

Knowledge on composting			
Background Variables	x^2	df	sig. value(2-sided)
Sex	196.005*	1	0.000
Age	5.430*	2	0.066

* Significant at 0.05

Appendix B

Table A: 2. Volumes of different fractions of solid waste generated in the school daily

Components	Waste from kitchen & dining hall	Waste from dormitories	Waste from classrooms, laboratories, compound & offices	Total
Organic solid waste (kg)	53.2	18.5	37.1	108.8
Plastic waste (kg)	1.9	3.4	13.7	19.0
Other solid waste (cans, rags etc.) (kg)	1.7	1.9	2.3	5.9
Total	56.8	23.8	53.1	133.7

Appendix C

Table A : 3. Average values for growth parameters of maize 30 days after planting.

Growth parameters	Plants (Plt.) on composted soil (T_1)							Plants (Plt.) on unfertilized soil (control) (T_2)						
	Plt.1	Plt.2	Plt.3	Plt.4	Plt.5	Plt.6	Average	Plt.1	Plt.2	Plt.3	Plt.4	Plt.5	Plt.6	Average
Shoot length (cm)	84.3	98.6	91.1	80.3	73.4	87.3	86.30	85.3	84.6	83.1	77.0	80.4	80.9	82.07
Root length (cm)	15.2	14.0	17.6	15.1	13.5	14.2	14.93	16.2	14.6	15.4	13.2	13.8	16.6	14.97
Thickness of stem (cm)	1.3	1.6	1.6	1.4	1.4	1.5	1.47	1.3	1.6	1.5	1.4	1.4	1.5	1.45
Fresh shoot weight (g)	39.4	50.1	45.7	34.2	39.0	41.2	41.60	36.0	39.4	41.6	47.2	51.6	30.1	40.98
Fresh root weight (g)	0.4	0.3	0.3	0.9	0.7	0.3	0.48	0.6	0.4	0.3	0.4	0.5	0.9	0.51
Dry shoot weight (g)	4.3	6.0	5.5	4.2	4.6	4.8	4.90	4.4	4.6	4.9	5.5	6.1	3.5	4.83

Appendix : D

Table A : 4. Mean height and growth rate of six maize plants, under each treatments, within 30 days after planting

	Plants on composted soil (T_1)								Plants on unfertilized soil (T_2)							
Days after planting (DAP)	Height (cm)						Mean Height	Growth rate (cm/day)	Height (cm)						Mean Height	Growth rate (cm/day)
5 DAP	5.1	5.0	5.2	5.6	5.4	4.6	5.15	1.03	5.6	5.5	5.4	5.2	5.3	6.7	5.62	1.12
10 DAP	14.8	15.0	17.5	18.2	16.0	15.1	16.10	2.19	17.4	17.1	16.8	15.2	16.1	18.3	16.82	2.24
15 DAP	20.8	30.6	34.5	35.0	35	29.8	30.95	2.97	34.6	35.0	33.9	30.0	32.7	36.2	30.92	2.82
20 DAP	43.7	45.2	44.8	53.6	50.6	43.4	48.05	3.42	48.1	47.8	46.9	38.1	44.8	49.6	45.97	3.01
25 DAP	68.3	61.3	71.3	77.8	71.7	54.6	67.05	3.80	66.4	64.8	65.8	56.3	62.3	66.5	63.87	3.58
30 DAP	84.3	80.2	87.3	98.6	91.1	73.4	86.30	3.85	85.3	84.6	83.1	77.0	70.4	90.9	82.07	3.64

Appendix : E

Table A. 5. Test of significant difference in plants' fresh shoot weight, dry shoot weight and fresh root weight

	Fresh shoot weight			Dry shoot weight			Fresh root weight		
Treatments	Mean	t	P-value	Mean	t	p-value	Mean	t	P-value
Compost	41.60	0.139	0.447*	4.90	1.121	0.2110*	0.48	0.2190	0.4175*
Control	40.98			4.83			0.52		

* Significant at 0.05

Table A. 6. Test of significant difference in plant's height, root length and width of stem

	Height(cm)			Root length(cm)			Width of stem(cm)		
Treatments	Mean	t	P-value	Mean	t	P-value	Mean	t	P-value alue
Compost	85.820	0.636	0.276*	14.930	0.046	0.412*	1.470	1.010	0.182*
Control	81.88			14.97			1.45		

* Significant at 0.05