Photo: Zoomlion Web

Analysis of Waste Management in Accra, Ghana and Recommendations for further Improvements

Earth Engineering Center, Columbia University

Photo: Seth

WTERT Waste-to-Energy Research and Technology Council
Advancing Sustainable Waste Management

Analysis of Waste Management in Accra, Ghana and Recommendations for further Improvements

by

Ranjith Annepu and Nickolas J. Themelis

Earth Engineering Center, Columbia University

March 24, 2013

Study sponsored by

Zoomlion Ghana Ltd.

COLUMBIA UNIVERSITY
EARTH ENGINEERING CENTER
Advancing Sustainable Waste Management

ZOOMLION
Waste Management Experts

JLM Support Services LLC

EXECUTIVE SUMMARY

Objectives of study

After meeting with Prof. Nicolas Themelis, Director of the Earth Engineering Center (EEC) at Columbia University, Mr. Japhet Aryiku of JLM Support Services LLC arranged for Mr. Ranjith Annepu, EEC Research Associate, to spend a week in Accra, Ghana where he visited waste management facilities and met senior personnel of Zoomlion Ghana Limited and The Institute of Sanitation and Waste Management (TISWM) (www.tiswm.com) in Accra, Ghana. This Institute is the first of its kind in Africa and was created by Zoomlion, the largest (88,000 employees) waste management company in Ghana who has constructed the new Tema sanitary landfill and the 600-TPD recycling and composting facility (ACARP) described in this report. The objectives of this visit were to:

a) Study the current state of waste management in Accra;
b) Study the Zoomlion waste management current activities and future plans;
c) Examine the possibility of TISWM becoming a sister organization of EEC's Waste-to-Energy Research and Technology Council;
d) Use the above information to make recommendations for improvements and, also, to inform U.S. waste management companies who may provide training and technology assistance.

Summary of waste management picture in Accra

Accra is the capital city of Ghana. Its population of 3.9 million generates about 2,000 tons per day (TPD) of municipal solid waste (MSW), of which over 75% is collected and transported to the Achimota dumpsite at a cost of US$ 3.45 million per year (GHS 6.7 million). The non-collected waste is openly burnt or dumped in storm water and sewage water drains. Open burning of waste is common even in high income communities.

In 2008, the Accra Metropolitan Authority (AMA) spent 82% of its funds on solid waste management. Most of this funding was spent on collection and transportation. Waste is collected using different types of vehicles ranging from tricycles, and donkey carts, to small trucks equipped with compactors, to large trucks with or without compactors. The major reasons for partial waste collection coverage are inadequate or late payment of operational funds and lack of a system for monitoring the performance of private contractors. Among other attempts to increase collection coverage, there is a current AMA and Zoomlion project to provide plastic waste containers to individual households for free.

Over the last ten years, AMA has used at least seven temporary dumping grounds within the city perimeter to dispose the city's solid waste, thus impacting public health and the environment. This has led to public outrage and resulted in AMA and Ghana's Environmental Protection Agency (EPA) closing the last in-city landfill of Achimota. The city is now served by the new Tema sanitary landfill, located at Kpone, 30 kilometers from the city center. This facility was constructed and is operated by Zoomlion Ghana.

Currently, nearly all recycling in Ghana is carried out by the informal recycling sector. Waste pickers collect recyclables by sorting through mixed waste on the streets or at the dumpsites. Some informal

recyclers also collect waste by going home to home and by offering incentives to the households. At several locations, the informal waste sector, AMA, EPA and private companies are collaborating. For example, the new Tema landfill provides a special shed for informal waste recyclers to sort out recyclables. Also, the new Accra Composting and Recycling Plant (ACARP) of Zoomlion has a nominal capacity of 600 tons per day (TPD) and is currently accepting 300 TPD of mixed waste.

Conclusions and Recommendations

Ghana reached middle income level in 2010 and, since then, the city of Accra has made much progress towards sustainable waste management. It closed the last waste dump within the city, constructed a new sanitary landfill, started operations at the new material recovery and composting facility, and is encouraging the informal waste recycling sector. The City should now strive for 100% collection of MSW, increase public awareness and participation in reducing littering, and stopping the open burning of waste, that constitutes a major threat to public health through dioxin and particulate emissions.

Recommendations to the City

- Develop and follow waste collection schedules and routes for various parts of the city so that the public knows when to put out the solid wastes.
- The Waste Management Department should employ independent reviewers to monitor and ensure adequate service delivery by the various contractors to all parts of the City.
- Increase the size of the shed provided for informal waste recyclers at the Tema landfill based on the space requirements at Achimota dumpsite.
- The best way to increase recycling is by asking citizens to help the city and the environment by separating their waste into two parts: a) Materials designated by the City as recyclables (paper, metals, certain types of plastics; generally, called the “dry” stream); b) the non-recyclable trash to be landfilled. This source-separation of recyclables can be started at some of the more affluent parts of the city and slowly expanded to cover the entire city. Small posters should be provided to households and businesses with pictures of the items to be recycled and a slogan explaining that this effort by the citizens is beneficial to the City and the environment. The recyclables set out by households and businesses can be collected by informal recyclers and private collectors and brought to a Materials Recovery Facility, where they are manually sorted and then baled to marketable commodities. Dealing with the “dry” stream is much easier and productive than allowing the recyclables to be mixed with food and other trash and <u>then</u> trying to separate them.

Recommendations to Zoomlion regarding Tema and ACARP facilities

- The new sanitary landfill of Zoomlion is infinitely better for the environment that the waste dumps used by Accra in the past. However, sanitary landfills are more costly to construct and operate. In order to maintain and operate the Tema landfill properly and economically, Zoomlion needs to secure a continuous revenue stream from gate fees charged per ton of waste deposited at the Tema landfill. The EEC experience with several developing and developed

nations has shown that the necessary gate fee for sanitary landfills ranges from a low of $15/ton in Latin America to $70/ton in the U.S. Because of lower cost of living, the gate fee in Accra will be somewhere between $5-15/ton. In the absence of an adequate gate fee, sanitary landfills are not maintained properly and in effect become non-sanitary waste dumps that can contaminate water and air.

- Generally, sanitary landfills can charge a much higher fee for industrial wastes that are deposited at the landfill; a very high fee is charged for medical wastes.
- Separate collection of recyclables, as described under Recommendations to City above, and transporting them to the existing ACARP will greatly increase its productivity and working conditions. Trying to sort out recyclables from mixed "dirty" wastes is very difficult and, experience has shown, results in low yield of products.
- When the above system of source separation of recyclables is instituted fully, the composting section of the ACARP should be used mainly for the composting of "green" wastes, such as grass, leaves, market wastes, and food processing wastes.
- Involve and utilize the informal waste sector, e.g., via the collection of "dry" recyclables as discussed above and providing a mechanism for informal recyclers to use the ACARP facilities for recyclable materials they collect.
- Starting to plan for one waste-to-energy facility to serve the city of Accra and also serve as a prototype for other cities in Ghana and West Africa to emulate.

Recommendations to Zoomlion and Institute of Waste Management

To fulfill the vision behind the creation of The Institute of Sanitation and Waste Management (TISWM), the Institute should focus on:

- Increasing human resources at the institute and exposing them to state-of-the-art waste management practice; for example EEC invited Zoomlion and TISWM to participate in the 2nd Workshop on Waste Management organized by WTERT-India (February 2013) but it could not be arranged on time. There is another opportunity for TISWM and Zoomlion representatives to attend the one-week intensive course on waste management, organized by GWC and Azerbaijan Waste Management company in Baku (June 17-21, 2013).
- Considering of organizing and hosting the WTERT-Ghana organization. The responsibilities and benefits of such an organization are described in Appendix 2 (Charter of the Global WTERT Council). One of the things that could be done by WTERT-Ghana is to organize, in 2014, a waste management training session for facility operators, private companies, academia, decision makers and others from Ghana and other West African nations, to take place sometime in 2014.

Background

Zoomlion Company

Zoomlion Ghana Limited (ZL) is an 88,000 employee (85,000 field + 3,000 administrative) organization set up in 2006 in Ghana as a solid waste collection company. Since then it has quickly expanded into other related services like composting and recycling services (Accra Composting and Recycling Plant, ACARP), sewage treatment, janitorial services (Zoom Janitorial Services Ltd.), landscaping and beautification services, mobile toilet services (Zoom Cabin Ltd.), oil waste treatment (Zoil Services Ltd.).

Figure 1: From left to right: Flags of Ghana, Zoomlion Company, Angola, Togo, Liberia, and Zambia

It is currently operating in 216 different localities around Ghana and has expanded to other West African countries like Angola, Togo, Liberia and Zambia. Apart from handling 70% of the solid waste in Ghana, it also provides waste transportation sub-contract services to competitors through its Zoom Alliance.

The Institute of Sanitation and Waste Management (TISWM)

The Institute of Sanitation and Waste Management (TISWM) is an initiative of ZL to provide training to its employees and encourage applied research on sanitation and waste management in the country and in Africa. TISWM is accredited by Kwame Nkrumah University of Science and Technology (KNUST) and will commence degree granting courses in August, 2013.

Figure 2: Campus of The Institute of Sanitation and Waste Management (TISWM) has finished construction and is currently building the interiors, labs and classrooms.

Rapid urbanization is increasing the pressure on the limited waste and sanitation infrastructure in cities of the developing world. The rate of urbanization in today's world, driven mainly by these cities is unprecedented and therefore the challenges it presents are much larger in scale and different in scope compared to those experienced in the past by developed countries. To be able to address these challenges, we need new research which can use latest technological tools in understanding changing life styles, public expectations and infrastructural needs, and also to design innovative solutions. (1) In this context, the Global WTERT Council was impressed to know about TISWM, set-up for research and training in solely in waste management and sanitation. Commitment of the institute's management and its vision, and the infrastructure that the institute is providing for future researchers is also impressive.

It is important to note that TISWM is one of a handful of organizations around the world which will be able to provide degree and certificate courses in waste management and sanitation. This reason along with the potential the institute has in addressing waste management and sanitation problems in Ghana, West Africa and the entire developing world makes the institute visionary and necessary.

Trip Agenda

Developing an understanding of the dynamic changes occurring in waste management and the government in Ghana and the rapid expansion of ZL would have been difficult remotely. Therefore, the 6 days trip was useful in understanding the situation in Ghana and in providing the opportunity to EEC to document it for the rest of the world.

Days	**Agenda**
Monday, 01/07/2013.	Inauguration of Ghana's new President John D. Mahama

Tuesdays, 01/08/2013.	1. Meeting and tour of ZL headquarters and TISWM; 2. Tour of Accra Municipal Assembly (AMA) dumpsite in Achimota; 3. Tour of Tema landfill.
Wednesday, 01/09/2013.	1. Tour of Accra Composting and Recycling Plant (Adjen Kotoku); 2. Tour of Ga west (Amasaman) Assembly; 3. Tour of Ga South Assembly.
Thursday, 01/10/2013	1. Lavender Hill and Mudor; 2. Agbogloshie slum on Odaw basin.
Friday, 01/11/2013	1. Final meeting at ZL headquarters with a presentation by Ranjith Annepu and discussing further steps; 2. Meeting Accra's Mayor and ZL's Chairman.

Figure 3: Map of important field visits during WTERT Research trip to Accra, Ghana

Introduction to Waste Management in Accra

Ghana is categorized by the World Bank as a middle income country with a gross national income per capita of US$ 1,820 (GHS 3,466 @ 0.525 US$/GHS). Accra is the largest city in Ghana with a population of 3.9 million (2). Accra is also the capital city of Ghana and one of the fastest growing cities in Africa in terms of population and economy. Changes in material consumption patterns and life style which follow economic growth coupled with increase in population results in increased waste generation levels.

In 2008, AMA spent 82% of its funds on solid waste management (3). Almost all funds spent on solid waste management were on waste collection and transportation. It is a common observation in cities of developing nations worldwide that they are unable to achieve satisfactory results despite spending most of the municipal funds on waste management. AMA pays US$ 5.25 (GHS 10) per ton of waste collected,

transported and dumped, but is able to collect only 20% of beneficiary revenue from households which receive solid waste collection service (3).

Cities in developing countries generally suffer from a lack of infrastructure to handle increases in waste generation, resulting in incomplete waste collection. However, that is not the reason hindering the progress towards achieving complete waste collection coverage in Accra. The major reasons for partial waste collection coverage in Accra are a lack of or late payment of operational funds and a mechanism to monitor the performance of private contractors.

Over the last ten years, AMA has used at least seven temporary dumping grounds to dispose the city's solid waste. Some of these dumpsites were used for as less as two months, while others like the Oblogo controlled dumpsite were used for as long as five years (3). All of the above dumpsites were located inside the city and severely impacted public health, the environment and quality of life. Accra city has a history of public confronting authorities to oppose the disposal of wastes in their neighborhood. Such confrontations have led AMA and EPA to close the current Achimota disposal site. After the closure of Achimota dumpsite, Accra's waste will be transported to the new Accra Composting and Recycling Plant (ACARP) located in Adjen-Kotoku and to the new Tema sanitary landfill located in Kpone, Tema.

Waste Collection and Transportation

Waste collection in Accra is divided into two parts: 80% of the city's waste collection is handled by private contractors, whereas the other 20% is handled by AMA's WMD (4). In 1992, soon after the start of economic liberalization in Ghana, a pilot project initiated by World Bank started privatization of waste management in Accra (4). The percentage of private waste collection has since increased from nearly 11% to the current level of 80% of all waste generated. Simultaneously, the waste collection coverage in Accra has increased from 51% to the current level of 75% – 90% during the same time period (4). The Waste Management Department (WMD) under AMA is unable to fulfill its obligation of collecting 20% of the city's waste.

Waste is collected using different types of vehicles ranging from manually driven tricycles, donkey carts, small trucks equipped with compactors, large trucks and large trucks equipped with compactors. The company ZL has been using tricycles to access areas with narrow lanes and small trucks to access hilly regions with narrow lanes. Large trucks equipped with compactors are being used in places like vegetable markets and corporate areas which generate large quantities of waste every day.

The city of Accra generates about 2,000 tons per day (TPD) of solid waste, out of which 75- 90% is collected and transported to Achimota dumpsite at a cost of US$ 3.45 million per year (GHS 6.7 million) (12 km by road from the city centre) (The dumpsite is about to be closed in response to public agitation) (3). Uncollected waste is openly burnt or dumped in storm water and sewage water drains. Open burning of waste is common even in high income communities.

Figure 4: Waste collection tricycles assembly unit inside Zoomlion facilities.

Waste Collection Service to Urban Poor

The urban poor living in slums in Accra are vulnerable to public health impacts of improper waste management. The poor always tend to be the most adversely affected by public health impacts due to improper waste management, due to a lack of access to health services to get treatment and due to the lack of means to avoid their every day proximity to waste management related problems. This situation is prevalent in Accra too. High income households who can buy door-to-door waste collection services get a special plastic bin for waste, but low income communities have to use large metallic centralized collection containers (CCC). Various studies comparing these two methods of waste collection found that the door-to-door plastic bin system had a higher quality service as opposed to the low quality service at CCCs.

There have been numerous attempts to solve this problem of service delivery to Accra's low income communities. AMA and Zoomlion are undertaking a project to provide plastic containers for waste collection to individual households for free. The freely distributed plastic containers were being used for water storage or other alternative uses as opposed to waste collection. To discourage such alternative uses like water storage, the authorities provided free metal wire containers, which were later stolen or sold as metal for money. The situation can be improved by increasing the number of CCCs, the waste

collection frequency and continuously imparting public awareness. By doing so, the government can ensure quality service delivery to the poor.

Solid Waste Treatment

Recycling

Currently, the only recycling in Ghana is conducted by the informal recycling sector. A material recovery facility (MRF) called the Accra Composting and Recycling Plant (ACARP) has started separating recyclables from mixed waste that arrives at the tipping floor, but is still in search of long term markets for the recyclables, and is yet to start full scale operations. Waste pickers involved in the informal recycling sector collect recyclables by sorting through mixed waste on the streets or at the dumpsites. Some also collect waste by going home to home and by offering incentives to the households.

The actual number of waste pickers or the amount of material they recycle in Accra is unknown. However, an estimate is that informal recycling could be over 100 TPD of recyclables, which is around 5% of waste that is generated in Accra (5). The average daily income of a waste picker ranges between US$ 7 – 17 and is well above the Millennium Development Goals' target of US$ 1 per day (6). Waste picking in Accra is not organized into groups and is mostly carried on at an individual or family level. Most of the waste pickers are male due to the social stigma attached to waste management (6).

Figure 5: recyclers sorting metal near Achimota landfill (in the background)

Figure 6: A shed for waste pickers provided at the new Tema landfill

As opposed to many cities in transitional countries, government authorities in Accra and private companies perceive the presence of the informal waste sector as complementary to their work. Waste pickers are provided space to separate and store their recyclables at the old Achimota dumpsite and also a separate shed at the new Tema Landfill.

Composting

Accra has two composting facilities, the first composting facility was built in 1976 and stopped operations in 2001; the second composting facility called the Accra Composting and Recycling Plant

(ACARP) has started operations in September, 2012 and is currently optimizing its operations to operate full scale.

The Accra Composting and Recycling Plant (ACARP), built by ZL in partnership with the Government of Ghana and the United Nations Framework Convention on Climate Change (UNFCCC) is designed to handle 600 TPD of mixed waste. It is located 38 km away from the city and is the only waste processing facility in operation in Accra. As of January 9th, 2013, the plant is receiving 300 TPD of mixed waste. The plant is a project of ZL and has started operations in September, 2012. Since then, the plant has been accepting small quantities of waste in an attempt to optimize its operations.

Figure 7: Tipping floor of the Accra Composting and Recycling Plant (ACARP)

The ACARP facility is separated into two different units, one is a material recovery facility and the other is the composting facility. A conveyor transports rejects from the material recovery facility to the composting facility, where they are subjected to windrow composting for up to 8 weeks. Details about the sales of the compost were not available at the time of this visit.

Figure 8: Primary Handsorting unit inside ACARP

Figure 9: Separated recyclables sorted in the Primary Handsorting unit of ACARP

Final Disposal

Open dumping in dumpsites

Over the last decade, AMA has used at least seven temporary dumping grounds to dispose the city's solid waste. Some of these dumpsites were used for less than two months, while others like the Oblogo controlled dumpsite were used for as long as five years. All of the above dumpsites were located inside the city and severely impacted public health, the environment and quality of life. Until January 8th, 2013, all the waste that was collected from Accra has been transported to Achimota dumpsite, which is also inside the city, 12 km away from city centre. The dump is surrounded by residential areas, a primary school and is in close proximity to surface water sources. However, due to recent public agitation, the dumpsite is about to be closed soon.

AMA and Ghana's Environmental Protection Agency are planning to turn Achimota dumpsite into a transfer station, from which the waste will be transferred to either ACARP or the new Tema landfill. The new Tema sanitary landfill is located in Kpone, Tema city. It is about 35 km from the centre of Accra city and 34 km from the Achimota dumpsite. Ghana's EPA mandates a 50 m buffer gap between the landfill and residential premises (7). The nearest residential area to the landfill is the Kpone Township, which is 2.5 km to the south east; and Kpone's light industrial area is 1 km south east from the site. Thus, the landfill siting considerations were fulfilled with respect to distance from residential or industrial premises. The new landfill site was once a stone quarry. People displaced from the stone quarry due to the construction of this landfill were provided another site to continue their operations (7).

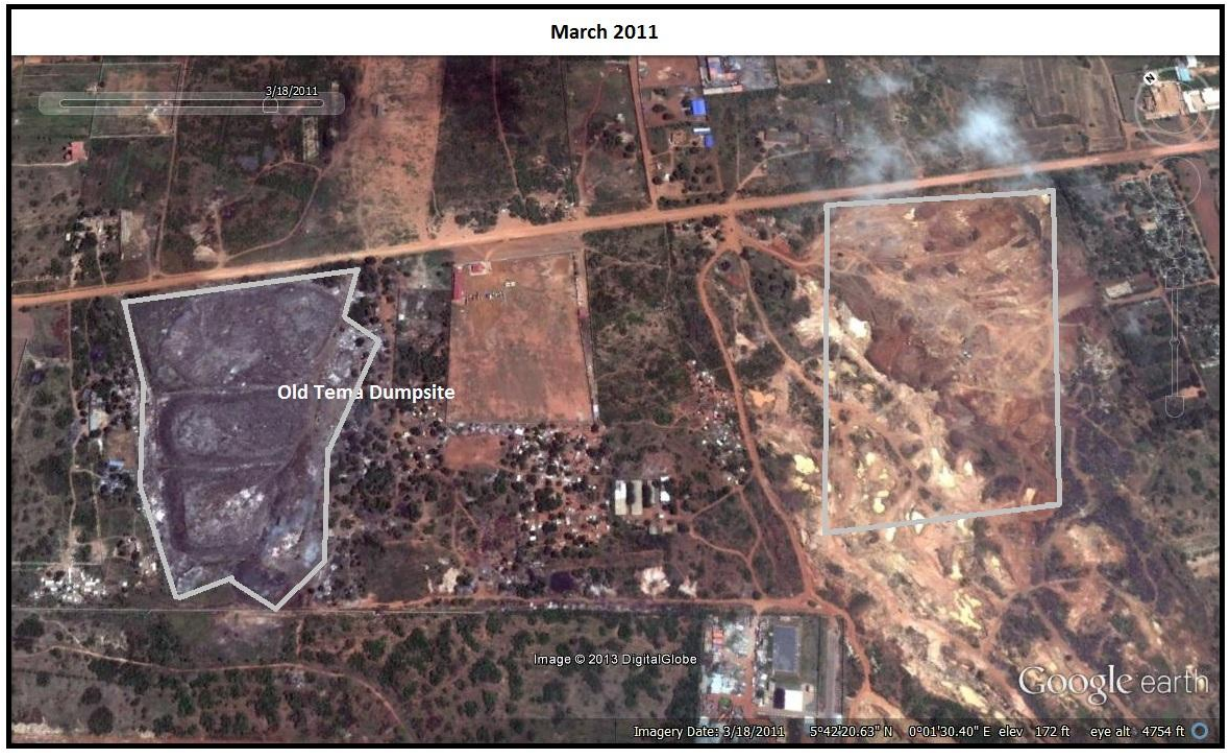
Stones from the quarry and from around the area were used in the construction of the new Tema landfill. This facility is equipped with leachate collection and treatment systems, gas collection and flaring systems, HDPE liner and fencing (8). The facility also has a separate shed for informal recyclers to collect and sort their recyclables.

Figure 10: The Achimota dumpsite with a primary school in the background.

Figure 11: Leachate collection ponds at the Tema landfill

Figure 12: A leachate pumping system installed in Tema landfill.

The new Tema landfill is built besides an older dumpsite which was capped in 2011 after more than 15 years of operation. Capping of the Tema dumpsite and the construction of the Tema landfill were both financed by a World Bank project approved in 2004 and called “Ghana Second Urban Environmental Sanitation Project” (7).



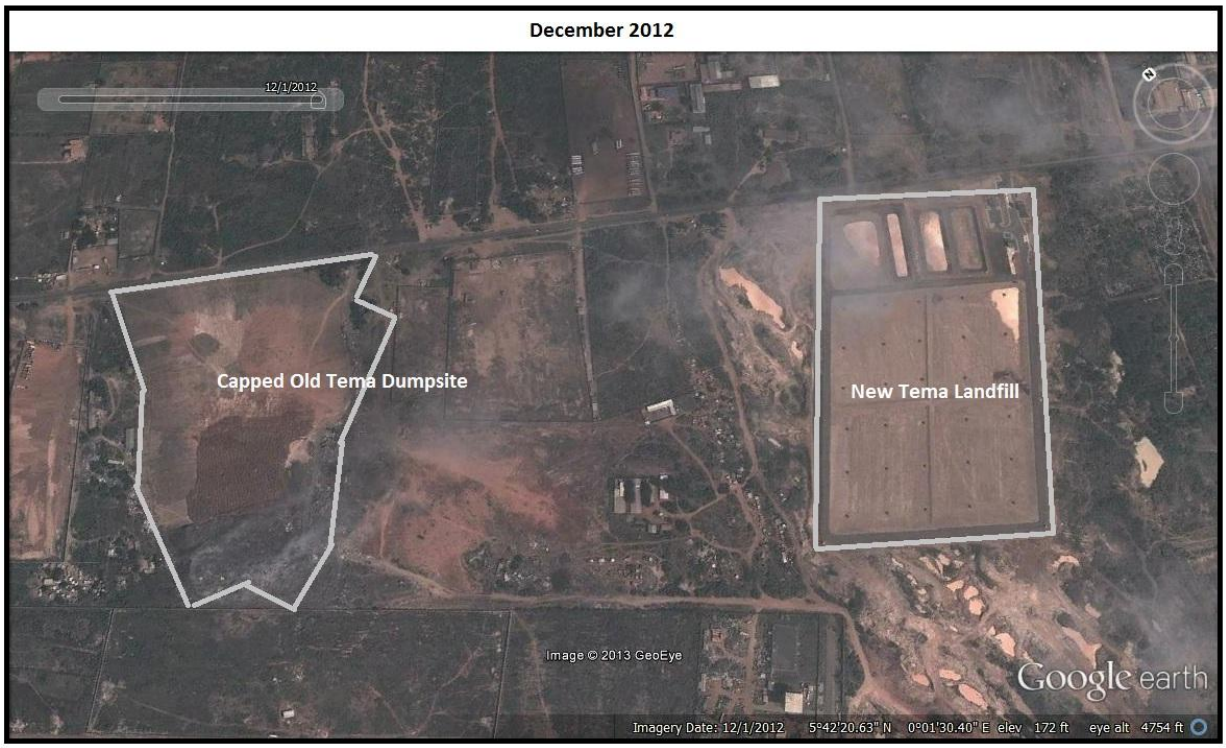


Figure 13: Comparison of the sites before and after the Tema dumpsite capping and Tema landfill construction.

Conclusions and Recommendations

Ghana reached middle income level in 2010 and, since then, the city of Accra has made much progress towards sustainable waste management. It closed the last waste dump within the city, constructed a new sanitary landfill, started operations at the new material recovery and composting facility, and is encouraging the informal waste recycling sector. The City should now strive for 100% collection of MSW, increase public awareness and participation in reducing littering, and stopping the open burning of waste, that constitutes a major threat to public health through dioxin and particulate emissions.

Recommendations to the City

- Develop and follow waste collection schedules and routes for various parts of the city so that the public knows when to put out the solid wastes.
- The Waste Management Department should employ independent reviewers to monitor and ensure adequate service delivery by the various contractors to all parts of the City.
- Increase the size of the shed provided for informal waste recyclers at the Tema landfill based on the space requirements at Achimota dumpsite.
- The best way to increase recycling is by asking citizens to help the city and the environment by separating their waste into two parts: a) Materials designated by the City as recyclables (paper, metals, certain types of plastics; generally, called the "dry" stream); b) the non-recyclable trash to be landfilled. This source-separation of recyclables can be started at some of the more affluent parts of the city and slowly expanded to cover the entire city. Small posters should be provided to households and businesses with pictures of the items to be recycled and a slogan explaining that this effort by the citizens is beneficial to the City and the environment. The recyclables set out by households and businesses can be collected by informal recyclers and private collectors and brought to a Materials Recovery Facility, where they are manually sorted and then baled to marketable commodities. Dealing with the "dry" stream is much easier and productive than allowing the recyclables to be mixed with food and other trash and <u>then</u> trying to separate them.

Recommendations to Zoomlion re Tema and ACARP facilities

- The new sanitary landfill of Zoomlion is infinitely better for the environment that the waste dumps used by Accra in the past. However, sanitary landfills are more costly to construct and operate. In order to maintain and operate the Tema landfill properly and economically, Zoomlion needs to secure a continuous revenue stream from gate fees charged per ton of waste deposited at the Tema landfill. The EEC experience with several developing and developed nations has shown that the necessary gate fee for sanitary landfills ranges from a low of $15/ton in Latin America to $70/ton in the U.S. Because of lower cost of living, the gate fee in Accra will be somewhere between $5-15/ton. In the absence of an adequate gate fee, sanitary landfills are not maintained properly and in effect become non-sanitary waste dumps that can contaminate water and air.

- Generally, sanitary landfills can charge a much higher fee for industrial wastes that are deposited at the landfill; a very high fee is charged for medical wastes.
- Separate collection of recyclables, as described under Recommendations to City above, and transporting them to the existing ACARP will greatly increase its productivity and working conditions. Trying to sort out recyclables from mixed "dirty" wastes is very difficult and, experience has shown, results in low yield of products.
- When the above system of source separation of recyclables is institute fully, the composting section of the ACARP should be used mainly for the composting of "green" wastes, such as grass, leaves, market wastes, and food processing wastes.
- Involve and utilize the informal waste sector, e.g., via the collection of "dry" recyclables as discussed above and providing a mechanism for informal recyclers to use the ACARP facilities for recyclable materials they collect.
- Starting to plan for one waste-to-energy facility to serve the city of Accra and also serve as a prototype for other cities in Ghana and West Africa to follow.

Recommendations to Zoomlion re Institute of Waste Management

To fulfill the vision behind the creation of The Institute of Sanitation and Waste Management (TISWM), the Institute should focus on:

- Increasing human resources at the institute and exposing them to state-of-the-art waste management practice; for example EEC invited Zoomlion and TISWM to participate in the 2nd Workshop on Waste Management organized by WTERT-India (February 2013) but it could not be arranged on time. There is another opportunity for TISWM and Zoomlion representatives to attend the one-week intensive course on waste management, organized by GWC and Azerbaijan Waste Management company in Baku (June 17-21, 2013).
- Considering of organizing and hosting the WTERT-Ghana organization. The responsibilities and benefits of such an organization are described in Appendix 2 (Charter of the Global WTERT Council). One of the things that could be done by WTERT-Ghana is to organize, in 2014, a waste management training session for facility operators, private companies, academia, decision makers and others from Ghana and other West African nations, to take place sometime in 2014.

APPENDIX 1 Data Sheet on Waste Management in City of Accra

*The information presented below is as of January, 2013.

Name of the City	Accra Greater
Population of city Ghana per capita GDP (PPP)	3.9 million $3,300 (2012 est.)
Waste Generation (*Tons per year*)	730,000
Waste Composition (9)	Organic 60% Paper & Cardboard 8% Plastics & Rubber 8% Glass 2% Metal 3% Textile 2% Inerts 11% Miscellaneous 2%
Waste collection coverage (*%*)	75-90%
Means of waste collection and transportation (*list them*)	1. Manually driven tricycles, 2. Donkey carts, 3. Small trucks equipped with compactors, 4. Large trucks, and 5. Large trucks equipped with compactors
Percentage of waste recycled	5% by informal waste recyclers. Details about formal waste recycling by ACARP were unavailable*.
Solid Waste Transfer stations	None*. There are plans to convert Achimota dumpsite into a transfer station.
Material Recovery Facilities	A 600 TPD combined recyclables recovery and windrow composting facility called Accra Composting and Recycling Plant (ACARP) is operating at half of its design capacity*. Details of material balance could not be retrieved.
Composting facilities	See above
Sanitary Landfills	Tema landfill received its first load of waste on January 9th, 2013
Open dumpsites	1. Abokobi 2. Ashaiman-Presby 3. Kokroko 4. Kwashiebu 5. Mallam SCC 6. Oblogo 7. Tema-Kpone (old)
Prevalence of open burning of waste?	Common
Prevalence of open dumping of waste?	Common
Prevalence of solid waste clogging sewers, storm water drains and other water handling	Common.

infrastructure?	
Extent of surface water contamination by waste	Solid waste, waste water and e-waste disposal have severely contaminated surface water sources in Accra in the last 20-30 years.
Prevalence of vector borne diseases	Malaria is one of the most common causes for death in Ghana. Specific details for Accra could not be found.
Complaints from residents near waste handling facilities and from citizens of Accra or tourists in general	Protests by local residents around Achimota dumpsite led to its closure. Residents still complain about open burning, open dumping (stench), and about the contaminated surface water sources

APPENDIX 2 Charter of Global WTERT Council

COLUMBIA UNIVERSITY
EARTH ENGINEERING CENTER

CHARTER OF THE GLOBAL WTERT COUNCIL (GWC; MARCH 20, 2013)

Introduction

Since the end of the last century, the Earth Engineering Center (EEC)) of Columbia University (www.columbia.edu/cu/earth) has conducted research on the generation and disposition of used materials and products in the U.S. and globally. Economic development has resulted in the generation of billions of tons of used materials that represent a considerable resource but, when not managed properly, result in a major environmental problem for cities in both the developed and developing world. The goal of EEC has been to identify and help develop the most suitable means for managing various solid wastes, and disseminate this information to policymakers and the public. EEC has also collaborated with BioCycle journal in carrying out a bi-annual survey of generation and disposition of MSW in the U.S. that is now being used by USEPA in estimating greenhouse emissions from waste management.

This research has engaged many M.S. and doctoral students on all aspects of waste management. EEC has produced over thirty M.S. and Ph.D. theses and published over one hundred technical papers. In 2002, EEC co-founded, with the U.S. Energy Recovery Council (ERC; www.wte.org) of the U.S., the Waste-to-Energy Research and Technology Council (WTERT), which is by now the foremost research organization on the recovery of energy and metals from solid wastes in the U.S.

In the course of its studies, EEC established that over one billion tons of urban solid wastes are landfilled each year and that nearly 80% of the world's landfills are not equipped to capture landfill gas (LFG) and protect surface and ground waters from contamination. Therefore, in 2008 EEC proposed the expanded Hierarchy of Waste Management (Figure 1) that differentiates between traditional and sanitary landfills.

In recent years, sister organizations with similar objectives to EEC and WTERT-US. were created in several nations, such as Brazil, China, France, Germany, Greece, Italy and India. In order to encourage interaction between these organizations and help form new ones, the "Global WTERT Council" (GWC) was formed in December 2011 and is registered as a non-profit corporation in the State of New York. The first draft of the GWC Charter was reviewed by the GWC members in December 2011. Newer and older members of the WTERT Council can suggest revisions to this second draft of the Charter that serves to explain the operations of the Council a) to other national groups who may wish to become members and b) to prospective industrial and government sponsors of the various WTERT national groups.

The Name of the WTERT Council

The principal tool for disseminating information by the WTERT national groups is the internet. The web addresses used (www.wtert.org, www.wtert.eu, www.wtert.gr, etc.) all include the acronym WTERT. This has the advantage that when one types "WTERT" in Google or other search engine, one can see the web links to WTERT organizations in various countries. "WTERT" has become a valuable brand name and can be very helpful to people seeking information on waste management in a particular country by using the acronym WTERT and then the name of the country (e.g., Greece") or letters representing it (e.g., "gr"). It is therefore necessary for member nations to register and use the "wtert" web address (e.g. www.wtert.gr) as well as whatever other name and web address they wish. For example, the sister organization in Greece chose the name "SYNERGIA" so one can find their web either by going to www.wtert.gr or by using the SYNERGIA address. The same is true for our sister organization in Italy, MatER. (www.wtert.it).

In summary, each national, or regional, member can choose whatever word or words are most suitable to express the mission of their organization in their national language; and also use the second name "WTERT-Greece", "WTERT-Italy", etc. to express the fact that they are also a member of the Global WTERT Council.

Mission of Members of WTERT Council

The mission of the member organizations of the Global WTERT Council is to identify the best available technologies for the treatment of various waste materials in their country or region, conduct or sponsor academic research on waste management, and disseminate credible information by means of the national WTERT web pages, publications, and presentations in technical and public meetings. In particular, WTERT strives to increase the global recovery of materials and energy from discarded solids, by means of recycling, composting, waste-to-energy, and sanitary landfilling with landfill gas (LFG) utilization. The guiding principle is that responsible management of wastes must be based on science

and best available technology in a particular region and not what seems to be inexpensive now but can be very costly in the future.

Figure 1 shows the general rule of the accepted "hierarchy of waste management". However, WTERT understands that for practical or economic reasons it may be not be possible to follow this hierarchy at all times and at all locations. For example, waste-to-energy requires a larger initial investment than a sanitary landfill and therefore may not be feasible at a certain stage of economic development of a community; in such a case, a sanitary landfill with LFG recovery would be the next preferable option. As another example, an EEC study has shown that use of yard wastes as Alternative Daily Cover in sanitary landfills, in place of soil, is environmentally advantageous to windrow composting of the yard wastes.

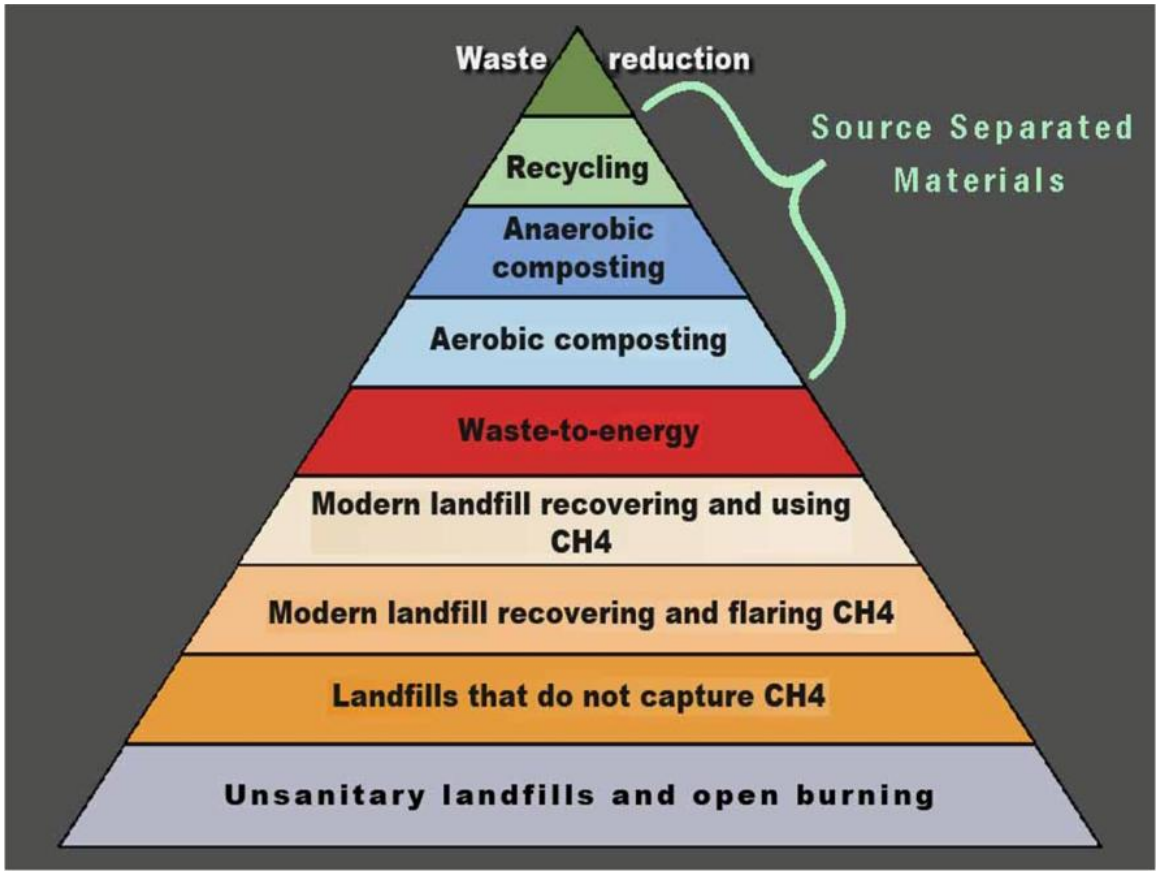


Figure 1: The EEC hierarchy of waste management

Scope of Operations of Global WTERT Council

The Managing Committee of the Global WTERT Council consists of representatives designated by each national WTERT organization. The Chair of the Managing Committee of GWC is elected by majority vote of all members for a tenure period of two years. The present, and first, Chair of GWC (December 2011-December 2013) is Prof. Nickolas Themelis, founder of GWC.

The Managing Committee reviews and votes on the WTERT Charter and subsequent actions affecting the operations and Charter of the Global WTERT Council. Most communications are by e-mail or

telephone conferences. However, occasional meetings of the Managing Committee are arranged, preferably to be held in conjunction with international meetings on waste management.

The Global WTERT Council realizes that waste management solutions vary from region to region. It is hoped that through the new and powerful tool of the internet, publications, and presentations, we can collectively create a global platform for sharing of experience, expertise and information that will advance the goals of sustainable waste management world-wide.

Scope of Operations of Each National WTERT Organization

The objectives of each WTERT national organization are:

1. To develop and maintain a WTERT web page that describes the mission and scope of the organization and links as many as possible academic and industrial research groups working on various aspects of waste management, within the nation. Preferably, this web page will be hosted at a major university that is conducting research on resource recovery from wastes. Most of the material in this web page will be in the national language so as to inform the general public and policymakers as well as academia and industry. However, the front web page should also provide for English language translation of part of the content, as discussed in (2) below.

2. To identify the most suitable technologies for the treatment of various waste materials in the nation, encourage additional academic research as required, disseminate this information within the nation, and provide an English language window for the outside world to learn about problems and opportunities for advancing waste management in their respective nation.

3. Once the organization platform described in (a) and (b) has been created, the national WTERT can seek sponsorship and funding by industry and government organizations concerned with advancing waste management in the nation. This model of operation has been successful with some of the existing WTERT national members who are willing to advise and assist new members.

4. To propose to the Managing Committee of GWC the adoption of measures and means that will advance the mission of the Global WTERT Council.

Current WTERT national members (in chronological order of joining the WTERT Council); March, 2013

WTERT-US (www.wtert.org)
Earth Engineering Center - Columbia University, New York

WTERT-Canada (www.wtert.ca)
Canadian Energy from Waste Coalition (CEFWC), Toronto

WTERT-Greece (www.wtert.gr)

WTERT-China
Zhejiang University (wtert.zju.edu.cn)

ChongQing University of Science and Technology (wwwwtert.cn)

WTERT-Germany (www.wtert.eu}
Technical University of Munich

RWTH-Aachen, Aachen

WTERT-Japan (www.WTERT.jp)
Tokyo Institute of Technology

WTERT-Brazil (www.WTERT.com.br) >

University of Brazil, Rio de Janeiro (UFRJ)

WTERT-France (www.WTERT.fr)
Ecole des Mines d'Albi-Carmaux, Albi

WTERT-U.K. (www.wtert.co.uk)
Imperial College, London

University of Leads

WTERT-Italy (www.wtert.it)
Politecnico di Milano, Piacenza

WTERT-India (ww.wtert.in)
National Environmental Engineering Research Institute (NEERI), Kolkata

WTERT-Mexico (www.wtertuane.com.mx)
Universidad Autonoma del Noreste (UANE), Saltillo

WTERT-Korea (www.wtert.kr; under construction)
Yonsei University, Wonju,

KSWM (Korea Society of Waste Management)

KAWET (Korea Association of Waste to Energy Technology)

WTERT-Singapore
Nanyang Technological University

Bibliography

1. **Annepu, Ranjith Kharvel.** Research Requirements in Solid Waste Management in Transitional Countries. *Blog - Sustainable Solid Waste Management in India.* [Online] 2013 February.

2. **Ghana Statistical Service.** 2010 Population and Housing Census - Provisional Results: Summary of Findings. *Government of Ghana.* [Online] 2011 February.

3. Performance Audit Report of the Auditor-General on Solid Waste Management by Accra Metropolitan Assembly (AMA). *Ghana Audit Service.* [Online] February 2011.

4. **Fobil, Julius Najah.** Municipal Wastes Collection and Urban Environmental Management in Accra, Ghana. *Proceedings of International Symposium on Environmental Pollution Control and Waste Management (EPCOWM'2002).* [Online] January 2002.

5. **Kodwo, Miezah.** The Waste Management Situation in Accra-Ghana: The Challenges and Prospects. *D-Waste.* [Online] 2012.

6. **Rockson, George N.K, et al.** Activities of Scavengers and Itinerant Buyers in Greater Accra, Ghana. *Sciendirect.* [Online] 2013 July.

7. **Ministry of Local Government and Rural Development, Government of the Republic of Ghana.** Resettlement Action Plan, Tema Metropolitan Assembly Sanitation Landfill Facility Project, Urban Environmental Sanitation Project Phase II (2). *The World Bank - Documents & Reports.* [Online] December 2009.

8. **ADMIR Technologies (ADMIR Ghana).** Lining and Drainage of the Tema Landfill, Ghana. *ADMIR Technologies.* [Online] 2012.

9. **Fobil, Julius Najah, Carboo, Derick and Armah, Nathaniel A.** Evaluation of Municipal Solid Wastes (MSW) for Utilisation in Energy Production in Developing Countries. *environmental-expert.com.* [Online] 2005.