REPORT

ON

THE OPTIONS FOR THE EFFECTIVE MANAGEMENT OF PLASTIC WASTE IN GHANA

BY

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1.0 INTRODUCTION

1.1 Purpose of this report

Sekondi-Takoradi Agona Sachet Water Producers Association (STASWAPA) is a network of sachet water producers in the Sekondi-Takoradi Metropolis and Ahanta West District in the Western Region of Ghana. The main objectives of STASWAPA include;

- To promote, encourage and educate members to produce good quality drinking water.
- To provide safe treated drinking water.
- To promote and maintain one united front, solidarity and cooperation among members.
- To work to uplift the treated water industry.
- To share information and network with like – minded organizations from other geographical locations in Ghana.

Despite the significance of sachet water production to Ghana's economy, its contribution to plastic waste generation and management problems in the country has resulted in threats by some MMDAs and Central Government to impose levies on its production or ban its production completely. These threats if carried out will increase the cost of production of sachet water and/or worsen the unemployment situation in the country.

It is against this background that STASWPA with support from BUSAC Fund undertook this research to investigate a range of options and solutions for the effective management of plastic waste in the country that will used by STWASPA for its advocacy.

This report provides the findings of the study. The report discusses the legal and regulatory frameworks for solid waste management in Ghana. It also highlights the amount and sources of plastic waste in Ghana and discusses the options for sustainable plastic waste management in Ghana.

1.2 Objectives of the Study

The objectives of this study are three fold.

- To investigate the actual situation of plastic waste management in Sekondi-Takoradi Metropolis.
- To investigate various ways of handling plastic waste the Sekondi-Takoradi Metropolis.
- To identify and propose sustainable plastic waste management in the Sekondi-Takoradi Metropolis.

The output of this study will also serve as a working document for STWASPA advocacy activities, as well as provide information for policy makers as an exemplarily way of transforming plastic waste into wealth (money) and therefore providing jobs to the urban poor. It is hoped that this document shall be useful to other MMDAs where plastic waste is engulfing all the major cities and causing all sorts of environmental problems.

1.3 Scope of the Study

- Collect data on the source of plastic waste in the country.
- Identify the different types and compositions of plastic waste in the country.
- Identify the volume of plastic waste that is generated in the country.

- Provide technical and non-technical recommendations for the effective management of plastic waste in the country.

1.4 Methodology

Literature information for this study was gathered from diverse sources. These include information gleaned through the internet from different sources such as journals, technical reports on international research work on plastic waste recycling, press releases on recycling and findings of research centers and pilot projects. Other sources of information included key informant interviews and field visits.

2.0 PLASTIC MATERIALS AND PRODUCTION

2.1 The History of Plastics

From a historical viewpoint, the development of plastics can be regarded as one of the most important technical achievements of the twentieth century. In just 50 years plastics have permeated virtually every aspect of daily life, paving the way for new inventions, and replacing materials in existing products. The success of these materials has been based on their properties of resilience, resistance to moisture, chemicals and photo- and biodegradation, their stability, and the fact that they can be molded into any desired form (Lardinois and Van de Klundert, 1995).

The original breakthrough for the first semi- synthetic plastics material, cellulose nitrate, occurred in the late 1850s and involved the modification of cellulose fibres with nitric acid. Cellulose nitrate had many false starts following its invention by a Briton, Alexander Parkes, who exhibited it as the world's first plastics in 1862.

The world's first plastics were produced at the turn of the twentieth century, and were based mainly on natural raw materials. Only in 1930 were thermoplastics, made from the basic materials styrene, vinyl chlorine and ethylene, introduced onto the market. But the main growth of the plastics industry did not take place before the 1960s, reaching a peak in 1973, when production reached over 40 million tons per year (Saechtling, 1987). Following a temporary drop in production during the oil crises and the economic recession in the beginning of the 1980s, the world production of plastics continued to increase to approximately 77 million tonnes in 1986 (Saechtling, 1987), and 86 million tons in 1990(Schouten and Van der Vegt, 1991). Figure 3 shows the rapid development of plastics production worldwide which now far exceeds the combined production of non-ferrous metals such as aluminum, zinc, lead and copper.

2.2 What are Plastics?

Plastics are man-made organic materials that are produced from oil and natural gas as raw materials. Plastics consist of large molecules (macromolecules), the building blocks of all materials. The molecular weights of plastics may vary from about 20, 000 to 100,000 mg/L. Plastics can be regarded as long chains of beads in which the so-called monomers such as ethylene, propylene, styrene and vinyl chloride are linked together to form a chain called a polymer. Polymers such as polyethylene (PE), polystyrene (PS) and polyvinyl chloride (PVC) are the end products of the process of polymerization, in which the monomers are joined together. In many cases only one type of monomer is used to make the material, sometimes two or more. A wide range of products can be made by melting the basic plastic material in the form of pellets or powder (Warmer Fact Sheet, 1992).

Plastics can be either thermoplastics or thermosets. Materials that repeatedly soften on heating and harden on cooling are known as thermoplastics. They can be melted down and made into new plastic end products. Thermoplastics are similar to paraffin wax. They are dense and hard at room temperature, become soft and moldable when heated, dense and hard again and retain new shapes when cooled. This process can be repeated numerous times and the chemical characteristics of the material do not change.

Thermosets, on the other hand are not suitable for repeated heat treatments because of their complex molecular structures. The structure of thermosetting materials resembles a kind of thinly meshed network that is formed during the initial production phase. Such materials cannot be reprocessed into new products unlike thermoplastics. Thermosets are widely used in electronics and automotive products.

The properties of plastics can be modified by a number of substances known as additives.

2.3 Types of Plastics

In industrialized countries, literally hundreds of plastic materials are available commercially. In economically less developed countries however, fewer types of plastics tend to be used. In both economically less developed and industrialized countries, the four types of plastics that are most commonly reprocessed or recycled are polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). Each of these can be subdivided according to their density, the type of process involved in their manufacture, and the additives they contain. These four types are briefly described below.

2.3.1 Polyethylene (PE)

The two main types of polyethylene are low-density polyethylene (LDPE) and high-density polyethylene (HDPE). LDPE is soft, flexible and easy to cut, with the feel of candle wax. When very thin it is transparent, when thick it is milky white, unless a pigment is added. LDPE is used in the manufacture of film bags, sacks and sheeting, blow-molded bottles, food boxes, flexible piping and hosepipes, household articles such as buckets and bowls, toys, telephone cable sheaths, etc. HDPE is tougher and stiffer than LDPE, and is always milky white in colour, even when very thin. It used for bags and industrial wrappings, soft drinks bottles, detergents and cosmetics containers, toys, jerry cans, crates, dustbins, and other household articles.

2.3.2 Polypropylene (PP)

Polypropylene is more rigid than PE, and can be bent sharply without breaking. It is used for stools and chairs, high-quality home ware, strong moldings such as car battery housings, domestic appliances, suitcases, wine barrels, crates, pipes, fittings, rope, woven sacking, carpet backing netting surgical instruments, nursing bottles, food containers, etc.

2.3.3 Polystyrene (PS)

In its unprocessed form, polystyrene is brittle and usually transparent. It is often blended (copolymerized) with other materials to obtain the desired properties. High-impact polystyrene (HIPS) is made by adding rubber. Polystyrene foam is often produced by incorporating a blowing agent during the polymerization process. PS is used for cheap, transparent kitchen ware, light fittings, bottles, toys, food containers, etc.

2.3.4 Polyvinyl chloride (PCV).

Polyvinyl chloride is a hard, rigid material, unless plasticizers are added. Common applications for PCV include bottles, thin sheeting, transparent packaging materials, water and irrigation pipes, gutters, window frames, building panels, etc. If plasticizers are added, the product is known as plasticized polyvinyl chloride (PPVC), which is soft, flexible and rather weak, and is used to make inflatable articles such as footballs, as well as hosepipes and cable coverings, shoes, flooring, raincoats, shower curtains, furniture coverings, automobile linings, bottles, etc.

Other types of plastics include polycarbonate (PC), polyethylene terephthalate (PET), polyurethane (PU) and nylon or polyamide (PA).

2.4 Identifying the types of Plastics

When recycling plastics it is essential that the materials are correctly identified. If not, this can create severe problems during reprocessing, leading to products with a poor appearance and impaired mechanical properties. It is usually difficult to tell exactly which type of plastic is present solely from the type of product. Many different types of plastics may look identical, or one type of plastic may appear to have several physical and chemical characteristics depending on the type of additive that has been used. Detailed chemical tests, such as infrared analysis, may be needed to make a definite identification of a polymer.

However, experience in this field can be gained with practice, and in case of doubt, testing is the only option. Some simple tests using basic equipment can provide adequate information for identification. In Istanbul, for example, some re-processors claim to be able to distinguish plastics by touch (Konings, 1989), but when in doubt, they apply the "burning test" or the "flotation test.

1. To make a general distinction between thermoplastics and thermosets, heat a piece of wire just below red hot and press it into the material. If it penetrates the material, it is a thermoplastic; if it does not, it is a thermoset.
2. The type of plastic can be identified by scratching it with a fingernail or from the flexibility of the material. However, these tests are not always reliable. For example, PE that has been exposed to all kinds of weather conditions may have become rigid and brittle, and cannot be scratched. Also, very thin material made of any polymer may seem flexible, very thick may seem rigid (Vogler, 1984).
3. Flotation test. This test can be used to disentangle larger quantities of mixed or shredded polymers, as well as to separate them from non-plastics. The test is also useful for making the complicated distinction between PP and HDPE, and between HDPE and LDPE. When placed in a tube of water and alcohol in certain proportions (this can be tested using a "hydrometer", with arrange of 0.9-1.0) the materials will separate according to their density; one material will sink and the other will float. For example, in a mixture with an exact density of 0.925, the PP will float and HDPE will

sink; in one with a density of 0.93, LDPE will float and HDPE will sink. Note, however, that the flotation test is not exact enough to distinguish between PP and LDPE, since their densities can overlap. In this case the fingernail test and the visual appearance of the material may be more conclusive indicators.

Another flotation test using pure water and salt can be used to distinguish between PS and PVC, both of which sink in pure water. When a specific amount of salt is added to the water, the PS will float to the surface, while the PVC and dirt will remain on the bottom of the container. The amount of salt need not be measured, but may be determined by experience.

4. Burning test. This test is carried out as follows (Vogler, 1984). Cut a 5 cm long sliver of the plastic material, 1 cm wide at one end, and tapering to a point at the other. Hold the sample over a sink or stone, and light the tapered end. The colour and smell of the flame can be used to tell the type of polymer. PVC can be confirmed by touching the sample with a red hot copper wire and returning the wire to the flame; it should burn with a green flame. Burn of all residues before repeating the test with the same wire.

Caution: When conducting this test, be sure to hold the sample at a safe distance from the body and clothing, since the melted material may drip and burn if it falls directly from the flame. Do not breathe in the smoke, since it may contain dangerous substances.

In economically less developed countries, particularly in the informal sector, polymers are usually identified by manual/visual inspection, whereas in industrialized countries, mechanical separation techniques are used.

Technology is also becoming available to sort plastics using instrumental analytical methods, such as infrared spectroscopy and thermal analysis. Even in Europe and North America, the recovery of household plastics is burdened with several problems, including the high costs of separation and the general low level of purity of the waste materials. The packaging industry, for example, uses more than 60 different kinds of plastics. These are often mixtures or combinations of plastics and other materials, which preclude the melting option, as uncontrolled mixing of different kinds of plastics leads to inferior properties of the resulting material. The plastics may also be contaminated with residues of the packaged product, particularly food, or other packaging material (paper, aluminum).

Even elaborate sorting and cleaning procedures cannot resolve these problems satisfactorily. A number of measures have been proposed to reduce the number of different kinds of plastics, combined with the introduction of an effective system for coding such plastics during their manufacture. These measures, which would certainly make identification easier, are now gaining general acceptance and changes in the packaging of some products, for example using less material or only one type of material, are slowly becoming apparent (Halbekath, 1989). To facilitate identification, in the United States, the Society of Plastics Industry (SPI) has developed a model coding system (using numbers combined with the abbreviations PE, PP, etc.), which is now also being introduced in Europe. This coding system is especially suitable for moulded products where the coding can be engraved onto the moulds. In this way, households will be able to identify and separate the various types of plastics before disposal.

2.7 Hazardous effects of Plastics

2.7.1 Polluting Substances

In terms of environmental and health effects it is important to differentiate between the various types of plastics. Most plastics are considered nontoxic (PVC is an important exception). Polyethylene (PE) and polypropylene (PP), for example, are inert materials (Mewis, 1983), but it should be realized that plastics are not completely stable. Under the influence of light, heat or mechanical pressure they can decompose and release hazardous substances. For example, the monomers from which polymers are made may be released and may affect human health. Both styrene (which is used to make polystyrene, PS) and vinyl chloride (used to make PVC) are known to be toxic, and ethylene and propylene may also cause problems (Beumer, 1991).

The environmental effects of plastics also differ according to the type and quantity of additives that have been used. Some flame retardants may pollute the environment (e.g. bromine emissions) .Pigments or colorants may contain heavy metals that are highly toxic to humans, such as chromium (Cr), copper (Cu), cobalt (Co), selenium (Se), lead (Pb) and cadmium (Cd) are often used to produce brightly coloured plastics. Cadmium is used in red, yellow and orange pigments. In most industrialized countries these pigments have been banned by law. The additives used as heat stabilizers (i.e. chemical compounds that raise the temperature at which decomposition occurs), frequently contain heavy metals such as barium (Ba), tin (Sn), lead and cadmium, sometimes in combination (Nagelhout, 1989).

From the heavy metals mentioned, lead and cadmium are the most serious environmental pollutants, and have different effects on human health, depending on their concentrations. When present at or above specific concentrations, they interfere with processes in plant and animal tissues, and in the soil. Plastics such as PVC may also have serious impacts on the environment because they contain a number of hazardous substances. For example, PVC contains chlorine which can be released during heating as hydrochloric acid (HCl). Other potentially hazardous substances in PVC include the relatively large quantities of additives such as plasticizers (up to 60%) and heat stabilizers (sometimes up to 3%) (Nagelhou, 1989). In the opinion of some environmental and consumer organizations in Western Europe, the use of PVC and other plastics containing chlorine (or bromine), especially for packaging, should be halted entirely.

Apart from the aforementioned effects of waste plastics, the waste plastic water sachets are discarded randomly after usage. These then scatter around the city, choking drains, threatening small animals, damaging the soil and polluting beaches. Plastic waste has had a terrible impact on tourism, particularly on beaches where rain water carries the waste. Almost all the major gutters in major cities are currently choked with plastic waste and this has resulted in floods, loss of property and in Ghana recording high rate of malaria and cholera.

2.7.2 Air pollution

Taking into consideration the process of plastic recycling, the most important environmental problem caused by the (afore mentioned) polluting substances is air pollution, either within the reprocessing units or in the open air. During the extrusion process several substances such as additives, may be released. Since PE and PP do not contain large amounts of additives, potential problems with PE and PP are far less than with PVC. While extruding PVC additives may be released, but also vinyl chloride and HCl. It is very common to see plastic waste being burnt in Ghana. However, unless the combustion is complete, burning plastics release considerable quantities of polluting substances. The incomplete combustion of PE, PP, PS and PVC can cause further problems, as CO and smoke may be produced. As a result of incomplete combustion of PVC also dioxins and other hazardous substances may be formed. The burning of plastics release CO_2 which is a major contributor to the global warming problem.

3.0 Overview of past and present environmental policies and regulatory framework in Ghana.

Even though Ghana is claimed to be the first country in the world to formulate a Long Term Development Plan (the 1919-1926 Guggisberg Plan), there had not been any comprehensive legislative framework on the environment until recently. What was happening was that certain laws on the exploitation of natural resources sometimes had specific aspect of the environment. Even then it is on record that issues such as industrial effluents and waste were virtually not covered.

Ghana created the Environmental Protection Council (EPC) in 1973 which became the main governmental body that decided whether or not an environmental impact certificate or permit should be issued to potential contractors (Japan International Cooperation Agency, 1999: 10). The EPC was criticized for adopting foreign environmental strategies that were not adaptive to the Ghanaian situation. The Peoples National Defense Council (PNDC) law 207 of 1988 was enacted which made the District Assemblies responsible for human settlements and the environment in the districts (Japan International Cooperation Agency, 1999: 10).

The most comprehensive environmental policy in Ghana was the National Environmental Policy and National Environment Action Plan enacted in 1991. The Policy seeks to improve living conditions and the quality of life of the entire citizenry and to harmonize economic development with natural resources conservation. The Action Plan was the first comprehensive plan for environmental protection for Ghana in which the following activities are spelled out:

Investment related to the environmental protection institutional building commitment of the government to policy making, legislation and management of land resources, forest and wildlife, water, marine and coastal ecosystem, human settlements and pollution control (ibid: 11).

In the early 1990s, the National Development Planning Commission (NDPC) was constituted to initiate the process of preparing a National Development Policy Framework (NDPF) to provide a consistent framework for comprehensive development planning over the long-term with the main goal of transforming Ghana from a poor, underdeveloped low-income country into a vibrant, prosperous middle-income country within a generation, by the year 2020. It was envisaged that the long-term objectives would be implemented through successive five-year rolling plans. Although the NDPC was not set out to prepare a vision document, the long-term orientation of the NDPF enabled the Government to refer to it as Vision 2020.

Consequently, the Government directed the NDPC to initiate the process of preparing the Medium-Term Plans that would constitute the first step in the implementation of Vision 2020. The Ghana-Vision 2020 is regarded as the overarching framework for strategy work in Ghana. It provides the framework for several of the current strategic processes while at the same time incorporating many of the other strategic processes within its framework.

3.3 Regulatory framework

There had been no comprehensive legislation on environment in Ghana until the late 1990s. What was happening was that a number of laws that concerned exploitation of natural resources sometimes had specific aspects of the environment. Even then, issues such as industrial effluents and waste were virtually left uncovered. The Environmental Protection Agency (EPA) was established in 1994, under parliament Act 490 which replaced the EPC. The EPA is empowered to besides advise the Minister of the Environment, enforce, monitor, and control environmental standards and regulations including the following means: coordinates the activities of bodies concerned with the technical or practical aspects of the environment and serves as a channel of communication between such bodies and the Ministry; secure in collaboration with such persons as it may determine the control and prevention of discharge of waste into the environment and the protection and improvement of the quality of the environment; issues environmental permits and pollution abatement notices for controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or other sources of pollutants and of substances which are hazardous or potentially dangerous to the quality of the environment or any segment of the environment; issues notices in the form of directives, procedures or warnings to such bodies as it may determine for the purpose of controlling the volume, intensity and quality of noise in the environment; prescribes standards and guidelines relating to the pollution of air, water, land and other forms of environmental pollution including the discharge of wastes and the control of toxic substances.

3.4 Policies and regulations on solid waste management

Solid waste regulations in Ghana are normally coming from the Ministry of Local Government and Rural Development, the Ministry of the Environment, and the EPA. In 1999, the Ministry of Local Government and Rural Development came up with the National Environmental Sanitation Plan that seeks to develop and maintain a clean, safe and pleasant physical environment for human settlements. Along this policy, local governments have been enjoined to develop Strategic Environmental Plans to implement the programmes proposed in the policy.

The EPA has designed solid waste management guidelines for Municipalities, and has equally established standards for design, construction and management of waste disposal system to protect health and the environment. The purpose of the guidelines is to assist the District Assemblies and other relevant stakeholders in the planning and management of waste.

The EPA makes sure the District Waste Management Plan (DWMP) addresses all aspects of solid waste management in the district namely:

- Health care waste,
- Hazardous waste (including industrial waste)
- Public cleansing,
- Promotion of re-cycling, re-use, and waste minimization strategies,
- Promotion of composting

• Acquisition, development, operation, maintenance and after-care of treatment and disposal sites.

4.0 Plastic Waste Situation in Ghana

4.1 Amount of Plastic Waste Generated

The daily waste generation of solid waste in Ghana varies from Districts by District. For example in Sekondi- Takoradi Metropolis generates about **268 tons** of which plastic waste constitute about 30%. The yearly generation of solid waste is **98,820** tons. Out of this number the STMA is able to collect 70% of the solid waste that is generated (WMD Annual Report, 2010). In Accra, about 2,000 metric tons of solid waste is produced and plastic waste of which AMA is able to collect 60%. In Kumasi, an estimated 1,200 metric tons of solid waste is generated of which KMA is able to collect about 65%.

4.2 Types of plastic waste generated

Basically, there are two types of plastic waste that is generated in Ghana namely primary and secondary waste.

The primary plastic wastes are mostly generated from plastic producing and goods manufacturing industries. A characteristic of primary waste is that, the quality of plastics recovered for reprocessing is almost as high as that of virgin plastics. The waste is pure and suitable for reprocessing with standard equipment into the same kind of products manufactured from virgin materials. The processing of primary waste into products with characteristics similar to those of the original products is called primary recycling (Ehrig, 1992). Primary plastic waste is usually homogeneous and therefore its recycling is comparatively economical and easier.

The term “secondary waste” refers to waste plastics from sources other than the industrial ones. This type of plastic waste is predominant in Ghana, due to the consumption and littering habits of the inhabitants. These plastic wastes are impure, i.e. they may be contaminated and often consist of mixtures of various types of plastics. The direct reprocessing of such mixed plastics /supplies is called secondary recycling and results in products with poor mechanical properties because of the different characteristics of the plastics they contain. The potential for marketing these materials is relatively low.

4.3 Sources of plastic wastes

The main sources of plastic waste in Ghana can be classified as follows: industrial, commercial and municipal.

4.3.1 Industrial waste

Industrial plastic wastes are obtained from the plastics processing, manufacturing and packaging industries. Most of this waste material has relatively good physical characteristics, i.e. it is sufficiently clean, since it is not mixed with other materials. They are exposed to high temperatures during the manufacturing process which may have decreased its characteristics, but it has not been used in any product applications. Many industries discard polyethylene film wrapping that has been used to protect goods delivered to the factory. This is an excellent material for reprocessing, because it is usually relatively thick, free from impurities and in ample supply. Many industries may provide useful supplies of primary waste plastics:

- The automotive industries: spare-parts for cars, such as fan blades, seat coverings, battery containers and front grills.
- Construction and demolition companies: e.g. PVC pipes and fittings, tiles and sheets.
- Electrical and electronics industries: e.g. switch boxes, cable sheaths, cassette boxes, TV screens, etc.

This type of plastic waste is not common in Ghana. Plastics processing industries in Ghana sometimes recycle the waste they generate, but this is relatively very low. Considerable amounts of waste plastics generated by many industries remain uncollected or end up at the municipal dump. Industries are often willing to cooperate with private collecting or reprocessing units.

4.3.2 Commercial waste

Workshops, craftsmen, shops, supermarkets and wholesalers may be able to provide reasonable quantities of waste plastics for recovery. A great deal of such waste is likely to be in the form of packaging material made of PE, either clean or contaminated. Hotels and restaurants are often sources of contaminated PE material.

4.3.3 Municipal waste

Waste plastics can be collected from residential areas (domestic or household waste), streets, parks, collection depots and waste dumps. In Ghana, considerable amounts of plastic waste can be found within the Municipal Solid Waste stream due to the littering habit of the people. The most common type of plastic waste within the municipal waste stream is the “sachet” water film bags that are discarded indiscriminately soon after consuming its contents. In Asian countries in particular, the collection of this type of waste is widespread. However, unless they are bought directly from households, before they have been mixed with other waste materials, such waste plastics are likely to be dirty and contaminated. Sometimes the plastics can be separated and cleaned quite easily, but contamination with hazardous waste is not always visible and may be more difficult to remove. Litter that has been waiting for collection for some time may have been degraded by sunlight. This is mainly a superficial effect, however, and does

5.0 Options for sustainable plastic waste management in Ghana

5.1 Public awareness and education

Both formal and informal education is urgently needed to raise Ghanaians' awareness of the negative impact of irresponsible waste disposal in general and plastic waste in particular. Education must also be used to forge a positive change in our attitude to plastic waste management. Information materials such as bill boards, posters, fliers, leaflets etc. should be distributed among the general public.

5.2 Recycling of plastics through environmentally sound manner

Recycling, in simple terms, is defined as the conversion of used materials (waste) into new products. The purpose of recycling is to:

- Prevent waste of potentially useful materials,
- Reduce the consumption of fresh raw materials,
- Reduce energy usage,
- Reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to virgin production.

According to a feasibility study on plastics waste by Centre for Scientific and Industrial Research (CSIR), GHC 1,200,000 can be generated in the country every a month, if plastics waste go through various stages towards recycling. Recycling therefore provide opportunities for effective management of plastics waste management, as well as income generation. However, though some plastic wastes recycling plants have been established in the country, the menace still persists. Funding and capacity have been identified as the major problems hindering recycling of waste. It is therefore proposed that:

- A plastic waste management fund should be created to support recycling and upgrading of plastic waste infrastructure to promote private-public partnerships in the development and management of plastic waste infrastructure. The fund should be resourced with voluntary contributions from industry, Government and other donors; and these contributions are tax exempt.
- Setting up of differential power and water tariffs to increase the level of recycling.
- Zero- rating of recycled products to create a vibrant market for recycled products.
- Supporting the development of biodegradable bags that are more durable, reusable and recyclable
- Preferential tax treatment to the private sector for the construction of plastics waste treatment plants.
- A voluntary code of practice for retailers, consumers and manufacturers aiming at rationalizing the issuance of plastics, increasing the usage of plastic bags made from recycled material, creation of convenient and accessible recycling stations to customers, and setting up of better standards for imported packaging plastics

5.3 Plastics waste disposal through Plasma Pyrolysis Technology (PPT)

Plasma Pyrolysis is a state of the art technology, which integrates the thermochemical properties of plasma with the pyrolysis process. The intense and versatile heat generation capabilities of PPT enable it to dispose off all types of plastic wastes including polymeric, biomedical and hazardous waste in a safe and reliable manner.

5.3.1 Plasma Pyrolysis Technology

In plasma pyrolysis, firstly the plastics waste is fed into the primary chamber at 8500C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbons etc. Induced draft fan drains the pyrolysis gases as well as plastics waste into the secondary chamber, where these gases are combusted in the presence of excess air. The inflammable gases are ignited with high voltage spark. The secondary chamber temperature is maintained at around $10500^{o}C$. The hydrocarbon, carbon monoxide and hydrogen are combusted into safe carbon dioxide and water. The process conditions are maintained so that it eliminates the possibility of formation of toxic dioxins and furans molecules (in case of chlorinated waste). The conversion of organic waste into non-toxic gases (CO_2, H_2O) is more than 99%.

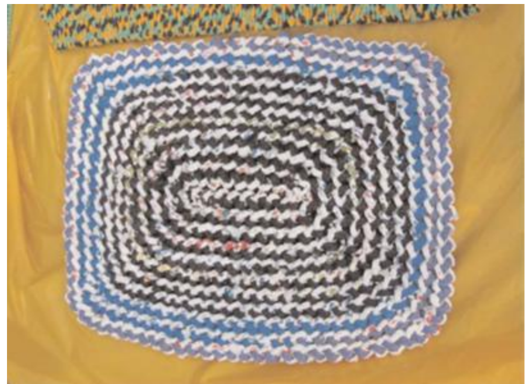
5.4 Establishment of a Waste Stock Exchange (WSE)

One of the emerging systems that is increasingly assuming a pivotal role in the achievement of recycling and resource recovery is an on-line waste stock exchange. This system will serve as an on-line Waste Exchange Network available for all companies in the country, to increase business profitability by promoting waste trading and recycling. This system will streamline co-operation between waste producers, re-users and business advisers making transactions quicker and easier to achieve. This web-based mechanism will serve as secondary raw materials market that solves logistical and qualitative problems for all public and private entities that could potentially use some kind of waste in their production cycles, or that implement recycling and recovery programs. It is an innovative and efficient instrument, if introduced in a solid legal and economic context, as is typical of a free and competitive market will promote the reuse and recycling of industry by-products and wastes. The WSE system could be implemented on a pilot basis in one of the Metropolitan areas of Ghana.

5.5 Conversion of plastics waste into artifacts

Another option for sustainable plastic wastes management is conversion into artifacts such beads, bags, door mats and hats. This option should be promoted in basic and secondary schools.

Hats made of plastic waste



Doormats made of plastic waste

5.6 Encourage the use bio-based and biodegradable plastics

Bio-based and biodegradable plastics are on the rise: Numerous new products have been developed, achievable properties are much more diverse and possible applications for these materials are much more versatile than they were just a few years ago. With regard to the end-of-life phase, biodegradable and compostable plastics offer additional recovery options, like composting or anaerobic digestion. Biodegradability is a special feature which is particularly attractive when economic and/or ecological benefits can be gained by leaving plastic products in the soil or biowaste stream. For example, used as biowaste bags, biodegradable plastics support a clean separation and collection of organic waste: divert from landfill towards high-quality compost production. Composting is important for areas when soil erosion is a serious problem.

5.7 Impose levies on plastic shopping bags

One practical option to reduce the rate of generation of plastic waste is by discouraging overuse or misuse of plastic wrappers and carrier bags.

The "abuse" of plastic shopping bags is a serious and visible environmental problem in Ghana. To address the "abuse" of plastic shopping bags at source, it is proposed that Government impose an environmental levy on plastic shopping bags, with the first phase covering chain and large supermarkets, convenience stores and personal health and beauty stores. Aside from reduction at source through the environmental levy, Government should also encourage the reuse, recovery and recycling of plastic shopping bags, through source separation of waste programme and community campaigns.

In some countries, whereas alternative paper wrappers/bags are free in shops, plastic wrappers/bags carry a fee that is used to subsidize the more expensive production of paper wrappers/bags. The reason is that paper waste decays, so it does not endanger the environment. However, concerns about cutting trees for paper production and its negative impact on the environment must be borne in mind. Re-use of plastic carrier bags should be vigorously encouraged and practiced by all Ghanaians to minimize plastic waste generation.

5.8 Increment in the thickness of plastic films

There is also need to consider increasing the thickness of the plastic film used in manufacturing carrier bags from the current 9-11 micrometers to a minimum of 30 micrometers. This indeed is the situation in countries such as India. The increased thickness of plastic film is expected to reduce excessive contamination of plastic waste (that increases recycling costs), and makes discarded carrier bags difficult for the wind to blow around. It is proposed however, that any increase in thickness of plastic film must be accompanied by adoption of a technology that provides a line of weakness on water sachets and other plastic containers that need to have one end torn before their contents can be used.

5.9 Household segregation, re-use and recycling

Waste should be regarded as a great economic resource. The segregation, re-use and recycling of waste at the household levels or point of generation should be encouraged. Paper, plastics, organic matter, metals and glass could all be recycled or converted to usable materials.

In order to make user charges effective, there is the need to tailor such charges to the level of environmental consciousness of residents, and their ability to pay. Very serious consideration must be given to how more money could be generated to improve the delivery of the service. The District Assemblies in the long-term should consider adopting and modifying the use of other economic instruments such as:

• Institution of solid waste pricing systems that will provide continuous incentives for households to reduce waste generation (e.g. pay-per-volume of waste);

• Disposal charges levied on dumping of industrial and municipal waste at landfill sites. Rate of charges should depend on type of waste and method of treatment before dumping;

• Incentive schemes such as subsidies, concessional loans and tax incentives to encourage District Assemblies and private investors in research, training, and demonstration projects for energy resource recovery as well as for planning for solid waste disposal;

• Linking charges to other utility services within the district

• Charging for dumping at landfill sites

• Adding charges to property rates so as to unify payment;

• Indirect charges through the sale of polythene bags for waste disposal

5.10 Energy Recovery

Plastics are almost all derived from oil wastes which are of a high calorific value. Energy recovered from plastic waste can make a major contribution to energy production. Plastics can be co-incinerated with other wastes or used as alternative fuel (e.g. coal) in several industry processes (cement kilns). The energy content of plastic waste can be recovered in other thermal and chemical processes such as pyrolisis. As plastic waste is continuously being recycled, they loss their physical and chemical properties at their end- of-life cycle. Continuous recycling could lead to substandard and low quality products. Hence it would no longer be economically profitable to recycle any longer. Incineration with energy recovery would be the economically preferred option at this stage.

6.0 CONCLUSION/RECOMMENDATIONS

The successful implementation of the options of plastic waste management discussed above will be critically dependent on the ability of stakeholders to initiate changes at policy, managerial, and technical levels with a view to changing consumptions patterns.

Specific recommendations need to address the following:

- Policy formulation and implementation for plastic waste management should consider the needs of all levels of the community. The social responsibility for plastic waste management should be initiated at all levels of our education system, right from the primary school level upwards. The role of communities (church, youth and women groups) in plastic waste management should be strengthened.
- The need to develop indigenous and homegrown technologies for plastic waste management is paramount as it is essential for effective plastic waste management.
- Primary collection and involvement of informal waste recyclers (scavengers) is of prime importance in plastic waste management, as it will help reduce costs and also enable the collection of waste from inaccessible areas.
- Government should provide adequate budgetary support. Coordination and networks should be formalized between ministries so as to create appropriate policies with the aim of increasing benefits from the recycling industry.
- There is need to encourage the minimization, reuse and recycling of plastic wastes by all solid waste producers. Alternative uses for recycled goods should be developed and brought to the attention of the community and manufacturers. There is need for source segregation of waste. Manufacturers should be encouraged to use recyclable/reusable items as raw materials for their production processes. There is therefore need for more information on simple, on-site recycling activities and technologies that are environmentally safe and cost-effective. Incentives such as tax rebates and/or soft loans for all scales of plastic recycling should be made available.
- There is need to develop quality standards and have them implemented for all plastic recycled products.
- There is need for constant information exchange on best available practices and technologies.
- An enhanced and sustained market for recycled plastic products will ensure better prices using preferential government purchase, better conditions for informal recyclers (scavengers) and also stimulate all levels of plastic waste recycling.
- MMDAs should coordinate and champion plastic recycling and re-use strategies with the support of stakeholders.
- Local communities should be made aware of the health and safety aspects of all levels of plastic waste recycling.
- There is need for political will, enthusiasm and top commitment on the side of the Government, MMDAs, NGOs and the City Council of Nairobi so as to assure adequate allocation of resources.
- Bye-laws on plastic waste management should be enforced.

- Innovative ways of fund raising for plastic waste management that prioritizes community involvement need to be developed.
- There is need for capacity building and strengthening of solid waste management infrastructure at the district level.
- The Government should create an enabling environment for plastic waste recycling by reducing electrical/water tariffs and if possible waive 17.5% VAT on recycled plastic products (differential power and water tariffs/ zero-rating of recycled products).
- Promotion of a voluntary national code of practice for retailers, consumers and manufacturers on environmental sound ways of managing plastic wastes.