LUMES 2001/2002

LUND UNIVERSITY

**International master's program in environmental science-LUMES**

# Environmentally based treatment of solid waste in urban and semi urban areas of Cameroon


**By**

**Tapong Sylvester**

Email: tapongsylvester@yahoo.co.uk

**Supervisor**

**Dr. Torleif Bramryd**

**Associate professor of urban ecology. Department of Ecology, Lund University, Ecology Building, 223 62 Lund, Sweden. Telephone:046/2229293**

**Email: Torleif.Bramryd@planteco.lu.se**


**An M.Sc. thesis Submitted in partial fulfilment, for the award of a Master's degree in environmental science, from University of Lund, Sweden.**

**Acknowledgements**

The process of writing this Master's thesis has led me to incur debts to many friends and family members. Many of these debts have arisen not just in the writing of this specific work, but in the willingness of many to spend time talking with me about this subject matter, providing a supportive community of scholars.

I will first of like to sincerely thank my mother; Akwi Tapong Lydia, My sister; Mrs. Irene Chungag, and her husband; Dr. Goddy Chungag all of Detroit, U.S.A., for supplying me with the necessary finances during my stay in Sweden.

Special thanks goes to

- Mr. and Mrs. Nfor of King Williams Square Hotel Limbe for all they did to enable me travel to Sweden in August 2001.
- My supervisor, Dr. Torleif Bramryd of the department of ecology, University of Lund, Sweden for guiding me through the tough process of writing this master's thesis.
- Sister Ayuk Mary Asi-Tim of the department of Zoology, University of Buea and Dr. Matute Martin of the department of Biology, Illinois Wesleyan University-U.S.A. for all the useful advice they use to give me.
- Miss. Irene Neng of London for all her moral and financial support during my stay in Sweden.
- Åsa Grunning of LUMES, for all the efforts she made to enable me travel to Sweden.
- Mr. Mathias Mbinto of the "The Cure Books Series" Gardens, Limbe, Mr. Lekunze Ransom, Miss. Demgne Honorie and Miss. Abey Lilian all of Lund, Sweden for their constant encouragement.

Mr. and Mrs. Emoh of legal department Buea, Mr. Ketchem Richard of Baptist High School Buea, Mr. John Mokake of Roskilde, Denmark; Mr. Divine Atelefack of Wuppertal, Germany; Mr. Nyindem Ernest of Buea, Miss. Chi Adeline of Buea, Miss. Mengot Susan of Göteborg University, Sweden and Miss. Epolleh Valerie of the University of Buea have all turned up trumps as the best of friends and deserve thanks simply for that. That they are all so competent and knowledgeable in their various academic and policy work, which has often overlapped with mine, is an added bonus.

It is said that "If you pray to God and receive, also pray to God and give thanks", so above all I will like to thank the almighty God for giving me the courage, knowledge, health and time to attend the LUMES programme, and also for guiding me through the harsh Swedish winter and the burning summer.

## Abstract

Rapid urbanisation of many towns in Cameroon and the associated growth of industry and services are key features of economic development. The population of Cameroon has risen drastically over the past few years. Such a rapid population growth with uncontrolled development can seriously degrade the urban environment, placing enormous strain on the natural resources and sustainable development.

One of the most important environmental consequences of the process of urbanisation in Cameroonian towns is the immense and ever growing amounts of solid wastes, most of which remain uncollected and are dumped on vacant land or into gutters, from where the waste is washed into water bodies, resulting to a negative impact on the environment. The poor quality of the services provided in terms of solid waste collection and disposal is the issues of concern.

If an efficient solid waste collection management is to be achieved, then waste reduction, reuse, waste recycling, biological treatment and grass root education/sensitisation of the community would be essential components of a sustainable urban waste management system, both in terms of job creation and an improved environment. If recycling and reuse are to flourish and generate employment especially in the informal sector, while protecting the environment, then there is need to enhance the technical and management capacity of both the local councils and the ministry of urban affairs. The active participation of the community will also be very crucial.


Keywords: solid waste, management, reduction, recycling, population, community, resources, environment, sustainable, Cameroon.

# 1. INTRODUCTION

## 1.1 Problem

With the increasing population in urban areas of Cameroon, due high birth rate and rural exodus, where young people move from the villages to the cities to look for white-collar jobs, there has been a corresponding increase in urban decay, championed by an increase in the production of wastes in the cities. The effect of urbanisation, which primarily involves poor people, has resulted in informal settlements and a considerable increase in backyard shacks. The informal settlements have in turn resulted in the increase in the quantity of waste generated.

Because the poor often live in such overcrowded and unhealthy areas, they are often prone to hazards derived from disease vectors that are forested by unsanitary surroundings. For instance, the sand fly (Phlebotomus), that transmit leishmaniasis[1] breeds in piles of refuse or in pit latrines, and the mosquito Culex quinquefasciatus, a vector for bancroftian filariasis (or elephantiasis)[2] breeds in open or cracked septic tanks. Mosquitoes of the genus Anopheles, which act as the vector for malaria often breed in empty tins that hold water. Such tins are often numerous in these waste heaps located in the vicinity of these squatter settlements. This has led to a significant increase in the incidence of malaria, which is still the number one killer disease in Africa. The stacks of waste also serve as a breeding ground for rats, which are vectors of several diseases affecting man e.g. leptospirosis[3] caused by the bacterium Leptospira icterohaemorrhagiae. The disease is passed to humans through water contaminated by rat's urine. Leachate[4] from decomposing organic matter in the garbage heap contaminates water sources leading to pollution. The effect of this is greatly felt mostly in areas with a high dependence on well water, of which most of the wells are located in the vicinity of these waste heaps.

Indeed, many of the diseases passed on by insect vectors that were once predominantly rural are now threatening urban areas. The poor are also exposed to toxic and radioactive waste, when for instance; their economic desperation forces them to scavenge through landfill sites. Given that labour is the only economic asset for the majority of the poor, any injury, disability, or loss of life resulting from such vulnerability results in a major loss in economic power. A sick farmer for example will not only spend money in treating himself, but will also lose precious time that would have been used to plough his farm. This also affects the welfare of his/her family.

Apart from the increase in the urban population, another factor that has been responsible for the increase in solid waste in urban areas has been a change in lifestyle. Initially the majority of the waste was made up of biodegradable material, which gradually decomposed with time. With the gradual westernisation of Cameroonians, largely due to our being exposed to western cultures through the media (radio and television), our consumption patterns have changed. Many people can now afford western-like products, which are often in non-biodegradable containers. Unfortunately, the westerners from whom we are trying to copy

[1] A disease characterised by cutaneous lesions, caused by a parasitic protozoan of the genus leishmania and transmitted through the bite of the sand fly. It is common in tropical and subtropical regions of the world.
[2] A disease caused by a parasitic round worm called *Wuchereria bancrofti*, which blocks the lymph glands of the legs making them to swell thereby assuming elephantine proportions, hence the name of the disease.
[3] A disease characterised by headache, fever and jaundice, and it is caused by a "bacterium" called Leptospira.
[4] Rainwater contaminated as it percolates through solid waste.

their consumption pattern have developed efficient methods of managing their waste. A good example of a change in consumption pattern is the case of mineral water, Coca Cola and pamplemousee beverages in plastic containers.

Until quite recently, there was no mineral water being sold in Cameroon. Babies were being given water that has been disinfected by boiling and later on left to cool. With the coming of Supermont and Tangui[5], this method is no longer practised, as babies can now be given pure natural mineral water. The mineral water is being sold in non-returnable, non-reusable and non-recyclable plastic bottles. This has led to the accumulation of these containers in the environment. The same holds true for Coca-Cola and Pamplemousee bottles. A random survey carried out in five widely displaced houses in Buea, Cameroon showed each household has at least five of these plastic bottles.

The predominant method of waste disposal in many African countries, and some countries in South America and Asia is uncontrolled dumping in open in unsanitary landfills. A lot of problems are associated with this method: The release of methane and carbondioxide, which are green house gases, bad odours, serve as a breeding ground for vermin[6], contamination of ground water by leachate from decomposition waste, lack of space due to increase population etc. In many developed countries, sanitary landfills have replaced the old unsanitary types, and useful materials like methane gas is being extracted and sold. The top of landfill is also covered to prevent escape of bad odour and breeding of vermin, and the bottom is also sealed with an impervious material to prevent contamination of ground water by leachate.

## 1.2 Objectives and scope

The aim of this research work is to seek ways and means through which Cameroonians in urban areas can best manage their solid waste, with the easiest and cheapest means. Owing to the fact the majority of Cameroonians are poor and uneducated, the methods proposed will not involve minimal expenditure by the common man.

The present methods of waste management in Cameroon are chiefly dominated by disposal in unsanitary landfill, or at times around the living areas. This is very typical of the big cities like Douala and Yaounde. Composting is carried at a small scale, mostly by farmers in the rural areas. Recycling is very minimal, while reuse is common to a certain extent, but is limited to beer bottles. This can be expanded to involve other products. Other advanced methods like the construction of sanitary landfills will hardly be achieved at the moment, due to lack of funds and expertise.

## 1.3 Methodology

Information for most part of the work was gathered from books on solid waste management, the Internet and personal discussion with my supervisor. For the section about Cameroon, I made a personal trip to Cameroon to better access the situation. Since nothing really as been done in the area of waste management, all the ideas in this work about Cameroon is all mine. This information was gathered through on the spot assessment, personal interviews with

[5] Two mineral water companies in Cameroon.
[6] Small animals and insects that can be harmful and which are difficult to control when they appear in large numbers. Flies, rats, lice cockroaches can all be described as vermin.

people, particularly those living in the vicinity of waste piles, questionnaires to students and adults.

A causal loop diagram is used to show the effects of the present situation of waste management in Cameroon, and also to show the possible benefits if the manner in which solid waste is handled is improved.

## 1.4 Hypothesis

By developing adequate means for better management of solid wastes, a lot can be achieved by Cameroonians; manure from composting will help to increase agricultural yield. Though food shortage has never been a problem in Cameroon, the excess food harvested can be marketed, and the extra income used for other purposes.

Recycling and reuse will increase job opportunities for many jobless Cameroonians; this may help reduce the crime rate, which at the moment is very high because of unemployment. There will be a significant drop in vector borne diseases like malaria. The population of vermin e.g. rats will also drop as lack of garbage piles will also mean shortage of food for them. There will be a decrease in insect borne diseases because these insects will not have a breeding ground, reduction in pollution and limiting resource use through reuse and recycling.

# 2. BASIC CONCEPTS OF SUSTAINABLE WASTE MANAGEMENT

## 2.1 Definition of waste

"Waste" invariably refers to lack of use or value, or "useless remains". Waste is a by-product of human activity. Physically, it contains the same material as are found in the useful product; it only differs from useful products by its lack of value. A basic way to deal with waste therefore is to restore value to it, at which point it will cease to be waste (White et al., 1999).

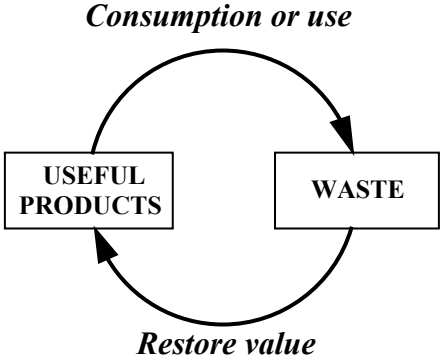



**Figure 1: The relationship between waste and value**

Alternatively, waste can be defined as a set of "mobile things-----of which their owners want to, will or must dispose (Ziehmann, 2001). The lack of value in many cases can be related to the mixed, and in many cases, unknown composition of the waste. Separating the material in waste will generally increase their value if uses are available for these secondary materials. This inverse relationship between degree of mixing and value is an important property of waste.

## 2.2 Classification of waste

Waste can be classified by a multitude of schemes: by physical state (solid, liquid, gaseous) and then within solid waste by original use (packaging waste, food waste, etc.); by physical properties (combustible, compostable, recyclable); by material (glass, paper, etc.); by origin (domestic, commercial, agricultural, industrial etc.) (White et al, 1999).

## 2.3 The waste stream

This is a term that describes the steady flow of varied wastes that we all produce, from domestic garbage and yard wastes to industrial, commercial and refuse from construction sites. Many of the materials in our waste stream will be valuable resources if they were not mixed with other garbage. Unfortunately, our collecting and dumping process mix and crush everything together, making separation an expensive and sometimes impossible task. In a dump or an incinerator, much of the value of recyclable material is lost.

Another problem with refuse mixing is that hazardous materials in the waste stream get dispersed through thousands of tonnes of miscellaneous garbage. The mixing makes the disposal or burning of what might have been rather innocuous stuff a difficult, expensive, and risky business. Spray paint cans, pesticides, batteries, cleaning solvents, radioactive materials, and plastics that produce dioxins[7] and PCBs[8] when burned are mixed with paper and other non-toxic materials (Cunningham, 1997).

## 2.4 The waste management hierarchy

Policy debate around the world on reducing waste to landfill has in recent years been reduced to simplistic arguments like this. The waste Management Hierarchy states (quite logically) we should practice (in priority order):

- Waste avoidance.
- Waste reduction.
- Waste reuse.
- Waste recycling.
- Waste treatment and waste disposal.

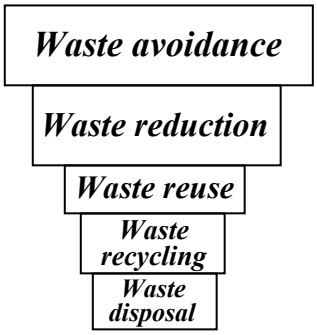



**Figure 2: The waste management hierarchy**

[7] A highly toxic compound produced as a by-product in some manufacturing processes, notably herbicide production and paper bleaching. It is a serious and persistent environmental pollutant.

[8] Polychlorinated biphenyls: any class of toxic aromatic compounds, often formed as waste in industrial processes, whose molecule contains two benzene rings in which hydrogen atoms have been replaced by chlorine atoms.

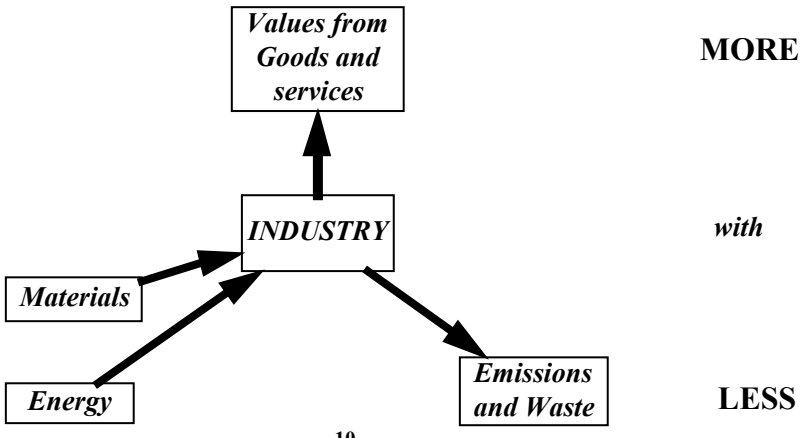
The hierarchy makes good environmental sense. Any set of policies, which promote or encourage the implementation of the hierarchy also makes sense. Legislation, which prevents waste generators from going further down the hierarchy before exhausting higher options, is also a good public policy (Wallace and Sutton, 2001). A logical definition of "waste disposal" surely means the disposal or containment of those wastes, which cannot be sustainably managed higher up the Waste Management Hierarchy. Therefore by definition, wastes should only go to disposal as an absolute last resort. To put it simply landfill is the option of last resort (Fox-lane et al., 2001).

## 2.5 Environmental concerns

Historically, health and safety have been the major concerns in waste management. These still apply; waste must be managed in a way that minimises risks to human health. Today, society demands more than this; as well as being safe, waste management also needs to look at its wider effect on the environment. Environmental concerns about the management and disposal of waste can be divided into two major areas: conservation of resources and pollution of the environment.

### 2.5.1 Conservation of resources

In 1972, the best-selling book Limits to growth was published. It argued that the usage rates (in 1972) of the earth's finite resources and energy resources could not continue indefinitely. Now, thirty years on, the sequel[9], beyond the limits, tells the same story, but with increased urgency; raw materials are being used at a faster rate than they are being replaced, or alternatives are being found. As a result of such reports, it is now becoming clear that the future of the planet lies in the concept of sustainable development. This is defined in the Brundtland report "Our Common Future" as "development that meets the needs of the present generation without compromising the ability of future generations of meeting their own needs". Sustainability requires that natural resources be efficiently managed, and where possible conserved.




**(a)**[10]

[9] A published, broadcast, or recorded work that continues the story or develops the theme of an earlier one.

[10] Sustainable development. The Brundtland Report on Sustainable Development (WCED, 1987) introduced the concept of "more with less", i.e. the need to produce more value from goods and services with less raw material and energy consumption, and less waste and emission production.

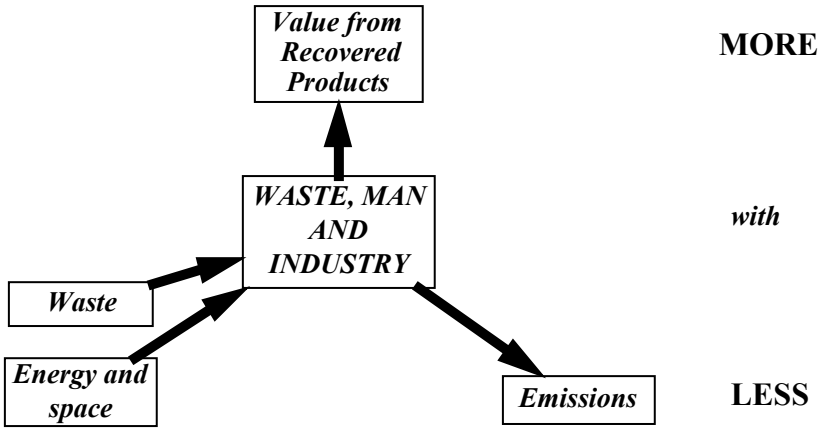



**Figure 3: "More with less" and sustainability**

## 2.5.2 Pollution

Potential or actual pollution is the basis for most current environmental concern over waste management. Historically, the environment has been considered as a sink for all wastes produced by human activities. Materials have been released into the atmosphere or watercourses, or dumped into landfills and allowed to "dilute and disperse". At low levels of emissions, natural biological and geochemical processes are able to deal with such flows without resulting changes in environmental conditions. However, as the levels of emissions have increased with exponential rise in human population and activity, natural processes do not have sufficient turnover to prevent changes in environmental conditions (such as the level of atmospheric carbondioxide). In extreme cases of overloading (such as gross sewage pollution in rivers), natural processes may break down completely, leading to drastic changes in environmental quality (White et al., 1999).

## 2.6 General environment and waste strategies

Increasing attention is given to international cooperation. The UN conference in Rio de Janeiro in 1992, confirmed that it is no longer possible to consume non-renewable resources at such a rapid rate, and discard the products as waste. To attain long-term sustainable development more efficient conservation of resources is necessary, including a changeover to cyclical handling of materials. The recycling society strives for the greater saving of resources, reduced load on the environment, and the preservation of biological diversity. Efforts towards a closed cycle oriented society should be implemented close to the population. The Rio conference, Agenda 21, describes how this work should be carried out (Hogland, 1997).

[11] Sustainable waste management. This also calls for "more with less", i.e. more valuable products recovered from the waste with less energy and space consumption and less emissions.

# 3. SUSTAINABLE AND INTEGRATED WASTE MANAGEMENT TECHNIQUES AND ENVIRONMENTAL EVALUATION OF EACH

## 3.1 Definition of sustainable and integrated waste management

It is important to understand the terms sustainability and integrated when referring to waste issues, and the context in which it is used. The terms mean different things depending on the context in which they are used.
Sustainability: "existing and solving today's problems in a responsible environmentally-friendly manner thereby not prejudicing the ability of future generations to exist to solve their own problems".
Integrated waste management: "the consideration of all components which make up the waste management hierarchy and the selection of the appropriate components in consideration with each other cradle to grave approach" (Novella, 2001).

Solid waste management is the integration of suitable techniques, technologies, and management programs to achieve waste management objectives. Of the many components of solid waste management, solid waste collection is one of the most complex and costly to plan and implement. Thus, it is one of the most beneficial to modernise. Though the many aspects of modernisation are case specific, the use of conventional solid waste containers and collection trucks is a general practice that can greatly increase the efficiency of solid waste collection by decreasing the time required at individual collection sites. In addition, modernisation of solid waste collection practices improves the aesthetics[12] and reduces the number of vectors attracted to the collection locations.

Solid waste management planning includes all aspects of solid waste collection, transport, processing and disposal. Solid waste collection is perhaps the most important of these components. A solid waste collection system must be convenient, efficient, economical, and dependable and must protect human health and the environment. Solid waste collection systems vary between countries. Political considerations, public acceptance, public health, economics, and environmental and historical conditions are a few of the many factors affecting solid waste collection plans.

## 3.2 Frequency of collection

The frequency of collection is an important factor in the solid waste management program due to the cost involved in personnel and equipment requirements. The optimal collection frequency is decided by the quantity of solid waste generated, the climate, the cost involved in collection, and public demand or consumer service expectations. The following summarises some of the factors involved in determining the frequency of solid waste collection:

- Costs, where a lower collection frequency corresponds to fewer trucks, employees, and mileage put onto the collection vehicles.
- Storage space, where more storage space is needed at the collection point having less frequent collection (the frequency of collection should be less than the time in which the amount of solid waste that is generated no longer fits into the storage container); and
- Sanitation, where more frequent collection reduces health, safety, and nuisance concerns associated with stored solid waste (the frequency of collection should be less

[12] The appreciation of beauty.

than the time it takes for vectors, e.g. flies, to complete a breeding cycle, and less than the time it takes for solid waste to develop an odour problem) (Wallace et al., 2001).

## 3.3 Present waste management techniques

### 3.3.1 The SYSAV[13] model for waste handling and treatment

Regional waste management is based on an ecocycling philosophy. Waste products can be (1) reused as products for the same purpose or for a new purpose (e.g. returnable bottles), (2) recycled as raw materials in the production of new products (e.g. waste-paper), (3) used as energy resource, thus reducing the need for fossil fuels such as oil, coal and gas, (4) biologically stabilised through composting or digestion and then returned to the environment. During digestion, energy can be generated in the form of biogas. (5) Final deposition with long-term environmental protection. (6) Materials classified as hazardous waste is removed from the waste flow and handled separately (SEPA[14], 1999).

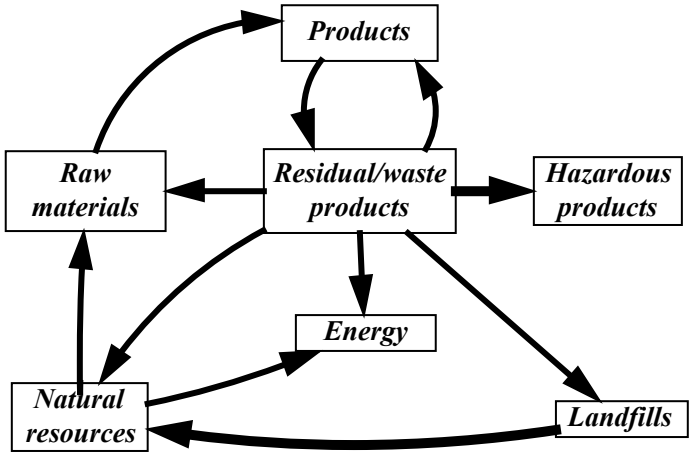



*Figure 4: SYSAV model for waste handling and treatment*

### 3.3.2 Producing less waste/source reduction

In general, waste prevention has a high priority in integrated waste management concepts. European Waste laws clearly define, that waste prevention is the first option to solve waste problems. This hierarchy is also found in the European community strategy, where prevention represents the first priority, followed by recovery in the forms of recycling and energy recovery, and in the last instance by waste disposal (Salhofer et al., 2001).

Source reduction, is the reduction in the amount and/or toxicity of materials entering the waste stream prior to recycling, treatment or disposal. Source reduction applies to municipal solid waste and to waste resulting from a products life's cycle, including raw materials extraction, processing and distribution (Saphire, 1998). For many companies, this involves eliminating waste that would go into their own dumpsters, as well as materials that would become waste for their customers (EPA[15], 1993). The Brundtland report of the United Nations

[13] A solid waste company in southwest Scania, Sweden.
[14] Swedish environmental protection agency.
[15] United States environmental protection agency.

"Our Common Future" (WCED[16], 1987) clearly spelled out that sustainable development would only be achieved if society in general, and industry in particular, learned to produce "more with less"; more goods and services with less use of the world's resources (including energy) and less pollution and waste. What is even better than reusing materials? Generating less waste in the first place. Industry can play an important role in reducing the quantity of waste from source.

Excess packaging of food and consumer products is one of our greatest sources of unnecessary waste. Paper, plastic, glass, and metal packaging material make up 50% of our domestic trash by volume. Much of that packaging is primarily for marketing and has very little to do with product protection. Manufacturers and retailers might be persuaded to reduce these wasteful practices. Canada's National Packaging Protocol (NPP) recommends that packaging minimise depletion of virgin resources and production of toxins in manufacturing. The preferred hierarchy is

- No packaging.
- Minimal packaging.
- Reusable packaging and
- Recyclable packaging.

This plan sets a target of 50% reduction in excess packaging by December 31st 2000.
Where disposable packaging is necessary, we still can reduce the volume of waste in our landfills by using biodegradable materials. Usually this means no plastics. Recently, however, plastics have become available that do breakdown in the environment under ideal circumstances. Photodegradable plastics breakdown in the environment when exposed to ultra violet radiation. Biodegradable plastics incorporate such materials as cornstarch that can be decomposed by microorganisms. Each individual can contribute towards waste minimisation by:

- Buying foods that come with less packaging; shop at farmers' market using your own container.
- When you have a choice at a grocery store between plastic, glass, or metal containers for the same food, buy the reusable or easier-to-recycle glass or metal.
- When buying plastics, pay a bit extra for environmentally degradable varieties.
- Separate your cans, bottles, papers and plastics for recycling.
- Wash and reuse bottles, aluminium foils, plastic bags, etc. for personal use.
- Compost grass and garden waste, leaves and grass clippings (Cunningham, 1997).

Source reduction differs from recycling, which diverts materials that have entered the waste stream and uses them in place of virgin materials to make other products. Source reduction instead prevents materials from becoming part of the waste stream. Materials that are discarded, whether recycled or not, require costly and time consuming collection, handling, and processing. Source reduction reduces or eliminates the need for this effort.

Besides preventing waste, source reduction conserves resources, reduces the use of raw materials, avoids the need for energy to manufacture or recycle containers, and reduces pollution arising from the manufacture or recycling of containers.

[16] World conference on environment and development.

### 3.3.3 Reuse

Even better than recycling or composting is cleaning and reusing materials in their present form, thus saving the cost and energy of remaking them into something else. In most cities, glass and plastic bottles are routinely returned to beverage producers for washing and refilling. The reusable, refillable bottle is the most efficient beverage container we have. To encourage use of refillable glass bottles, Ecuador has a refundable beverage container deposit fee that is 50% of the cost of the drink. In Finland, 95% of the soft drink, beer, wine, and spirits containers are refillable, and in Germany, 73% are refillable (Miller, 2002).

In less affluent nations, reuse of all sorts of manufactured goods is an established tradition. Where most manufactured products are expensive and labour is cheap, it pays to salvage, clean, and repair products. Cairo, Manila and Mexico city, and many other cities have large populations of poor people who make a living by scavenging, sorting, and reprocessing scraps from city dumps (Cunningham, 1997).

#### 3.3.3.1 Advantages of reuse e.g. refillable containers

Reuse is a form of waste reduction that

- Extends resource supplies.
- Keeps high-quality matter resources from being reduced to low-matter-quality waste.
- Reduces energy use.

Unlike throwaway and recyclable cans and bottles, refillable beverage bottles create local jobs related to their collection and refilling. Moreover, studies by Coca- Cola and Pepsi companies of Canada show that their soft drinks in 0.5litre throwaway bottles cost one-third less in refillable containers (Miller, 2002).

### 3.3.4 Recycling

This is the recovering of waste from one process and reusing it in the same process or in another process in an environmentally safe manner (EPA, 1993). Recycling involves collecting and processing a resource into new products. Such valuables are sorted or selected from the refuse and are later crushed or melted to produce new ones. For example, glass bottles can be crushed and melted to make new bottles or other glass items. Large scale recycling can be accomplished by collecting mixed urban waste and transporting them to centralised material recycling facilities (MRFs). There, machines shred and automatically separate the mixed waste to recover valuable materials for sale to manufacturers as raw materials. The remaining paper, plastics and other combustible wastes are recycled or burnt to produce steam or electricity to run the recovery plant or to sell to nearby industries or home (Miller, 2002).

Recycling is a three-step process. First, materials are collected. Secondly, the collected mater -ials are purchased by manufacturers for use in making new products. And thirdly, the new products are sold to consumers for re-use. Each step needs to happen for true recycling to occur.

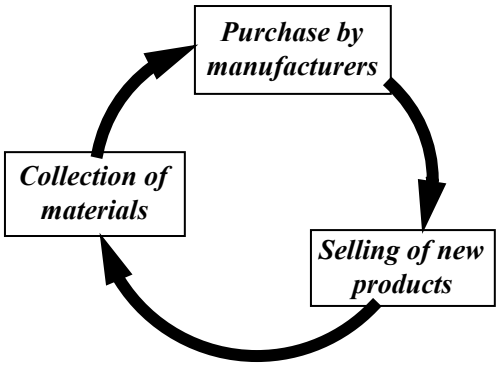



**Fig.4. Stages of recycling**

### 3.3.4.1 Types of recycling

There are two types of recycling for materials such as glass, metals, paper, and plastics:
Primary, or closed loop, recycling, in which waste discarded by consumers are recycled to produce new products of the same type. (Such as newspaper into newspaper and aluminium cans into aluminium cans).

Secondary, or open loop, recycling, in which waste materials are converted into different and usually low-quality products. Primary recycling reduces the amount of virgin materials in a product by 20-90%, whereas secondary recycling reduces virgin material by 25% at most.

Studies show that one of the best ways to encourage recycling is a pay- as- you throw program that bases garbage collection charges on the amount of waste a household generates for disposal; materials sorted out for recycling are hauled away free (Miller, 2002). Segregating organic matter from garbage can be handled in several ways. Separate collection of organic and non-organic garbage is one option for city governments, with the city assuming responsibility for composting the organic waste.

A more innovative and decentralised approach is city sponsorship of educational programs that equip residents to compost their own food and garden wastes (Brown et al, 1998). Many Solid waste experts argue that it makes more sense economically and environmentally for household and business to separate trash into recyclable and reusable categories (such as glass, paper, metals, certain types of plastics, and materials that can be composted). Then compartmentalised city collection truck, private haulers or volunteer recycling organisations pick up the segregated waste and sell them to scrap dealers, compost plants and manufacturers.

Another alternative (especially in less populated areas) is to establish a network of drop-off centres, buyback centres, and deposit refund programs in which people deliver and either sell or donate their separated recyclable material (Cunningham, 1997). Industries can save money by collecting different categories of waste separately and local communities can install bottle banks and waste paper collection system (Thomas and Croft, 1990). Japan has the most successful recycling program in the world. Half of all household and commercial waste in Japan are recycled while the rest is incinerated or landfilled. Japanese families diligently separate waste into as many as seven categories, each picked up on a different day (Cunningham, 1997). Germany Sweden, Holland, Belgium and Austria also have a well-developed household waste collection and recycling program (Bramryd, 2002).

### 3.3.4.2 Benefits of recycling

Recycling is usually a better alternative to either dumping or burning waste. It saves money, energy, raw materials, and land space, while also reducing pollution. Recycling also encourages individual awareness and responsibility for the refuse produced. Many recycling programs cover their own expenses with materials sales and may even bring revenue to the community.

Another benefit of recycling is that it could cut our waste volumes drastically and reduce the pressure on disposal systems. Recycling lowers our demand for raw resources. In the United States, two million trees are cut down daily to produce newspaper prints and paper products. Recycling the print run of a single Sunday issue of the New York times would spare 75,000 trees. Recycling one tonne of aluminium saves four tonnes of beauxite ($Al_2O_3$)[17].

Recycling also reduces energy consumption and air pollution. Plastic bottles recycling could save 50-60% of the energy needed to make new ones. Producing aluminium from scrap instead of the beauxite ore cuts energy use by 95%, yet we still throw more than a million tonnes of aluminium every year. If aluminium recovery were doubled world wide, more than a million tonnes of air pollutants would be eliminated every year.

Reducing litter is an important benefit of recycling. Ever since disposable paper, glass, metal, foam, and plastic packaging began to accompany nearly everything we buy, these discarded wrappings have collected on our roadside, in our rivers and oceans. Without incentives to properly dispose of beverage cans, bottles, and papers, it often seems easier to just toss them aside when we have finished using them. Bottle bills or deposits on cans and bottles have reduced littering in many countries.

### 3.3.4.3 Creating incentives for recycling

In many communities, citizens have done such a good job of collecting recyclables that a glut has developed. Mountains of waste materials accumulate in warehouses because there are no markets for them. Too often waste that we carefully separate for recycling end up being mixed together and end up in a landfill or incinerator (Cunningham, 1997).

### 3.3.5 Incineration

In natural ecosystems, waste incineration corresponds to forest fires and natural burning of savannahs or grasslands. In these rather limited numbers of ecosystems, fire is used naturally to mineralise nutrients from litter and other debris and thus promotes regeneration and activation of the ecosystem. The ashes contain easily available nutrients and at the same time they produce an increase in the soil pH[18]. In a system controlled by man, incineration should only be used for by-products that will leave ash with such low concentrations of heavy metals and other pollutants that a recirculation of the ashes to, for example, forests is possible.

If mixed and polluted waste is burnt, the total amount of nutrients is lost in contaminated ash, which must be landfilled, in sealed and carefully controlled monofills[19]. Thus, in a city with

[17] The impure ore from which aluminium is extracted.
[18] The –logarithm of hydrogen ion concentration i.e. $-[\log]^+$.
[19] A landfill with a particular kind of waste.

mass incineration as the main route for waste disposal, almost the whole stream of nutrients that has been transported into the society from agriculture or forestry will be lost in toxic ash. The other main problem with incineration of waste mixed with polluted material is the risk of polluted gas emissions and heavy metals (Bramryd, 1997).

Despite what industry and governments would like people to believe, incineration is not a solution to the world's waste problems, but part of the problem. Incineration of waste is a major contributor to air pollution. Other human activities such as power generation, industrial combustion or emission from traffic are other important sources of air pollution. Incinerators may reduce the volume of solid waste, but they do not dispose of the toxic substances contained in the waste. Incinerators emit a wide range of pollutants in their stack gases, ashes and other residues. The filters used to clean incinerator stack gases produce solid and liquid toxic wastes, which also need to be disposed.

Municipal and biomedical waste incinerators are the largest dioxin sources in industrialised countries, according to the US environmental protection agency. An important contaminant in incinerators is PVC[20]. Although it only accounts for approximately 0.5% of municipal waste by weight, PVC provides over 50% of available chlorine-the element essential to dioxin formation. According to the majority of incineration studies, when all other factors are held constant, there is a correlation between input of PVC and output of dioxin. For this reason, the Danish government policy is to avoid the presence of PVC in incinerators. If all PVC and chlorinated waste were eliminated from the waste stream, incineration will still be a poor solution due to high costs, loss of jobs in the recycling industry, loss of profits from secondary resale and on going contamination from heavy metals, hydrocarbons and other air emissions (Greenpeace, 1993).

The only way to improve the situation is to avoid toxic waste production by improving our products and processes. Public opposition to incineration is growing worldwide. People are recognising that there is no place for the incineration of waste in a sustainable society. Strategies to prevent generating incineratable waste streams currently exist by: Waste reduction and alternative forms of sterilisation in hospitals, and efficient reduction, recycling and compost actions at community level for household waste. Processes to stop the generation of hazardous waste in the first place are needed.
There following are important quality issues in relation to incineration of wastes:

- Incineration is one of the important generating sources for the emission of organic micro pollutants like dioxins and furans.
- Incineration is an important source for the release of volatile metals like mercury and lead, which can be transported over long distances.
- Trace metals, including heavy metals are not destroyed during incineration. The minor part remains in the slag[21] that can be considered as biologically inert materials. However, the slag is not chemically inert .The major part is transferred to the fly ashes. Thus fly ashes cannot be landfilled without pre-treatment. In Europe, the fly ashes are considered as hazardous waste.

[20]Polyvinyl chloride: a tough chemically resistant synthetic resin made by polymerising vinyl chloride and used for a wide variety of products including pipes, flooring and sheeting.

[21]The solid deposit, which remains at the bottom of an incinerator after incineration.

The table below shows some dangerous substances released by waste incineration

| Dangerous substance | Path | Category | Remark |
|---|---|---|---|
| Organic compounds especially dioxins and furans. | Gas, fly ash, residue | Human toxicology | Very important, incineration is major contributor. |
| Volatile heavy metals, e.g., Cadmium, Lead. | Gas, fly ash, residues | Eco-toxicology | Important because of transboundary movement. |
| Hydrogen chloride | Gas | Acidification | Important |
| Metals, e.g. Arsenic, Cadmium. | Gas, fly ash, residues | Human toxicology | Important, carcinogenic[22]. |
| Salt, e.g. chlorides. | Waste water, fly ash, residues | Ecotoxicology | Important, highly soluble, transported to surface water. |

(EEA[23], 1998).

**Table 1: Important dangerous substances released by incineration of waste.**

### 3.3.6 Biological waste treatment techniques

Biological waste treatment can include aerobic composting of mixed or source separated waste, anaerobic fermentation or fermentation in bioreactors constructed in landfills. Each technique is normally appropriate for a given spectrum of wastes. It is thus of great importance to identify the best available options for different types of wastes. The aim of biological or ecological waste treatment is to resemble natural ecological processes as much as possible, and to achieve as closed a system as possible. This will reduce the risks of negative environmental effects like over saturation and spreading of pollutants (Bramryd, 1998).

### 3.3.6.1 Composting

From an ecological point of view, composting can be compared to the natural degradation of organic matter in most aerobic ecosystems. Most of the organic matter is degraded over a longer or shorter time, while, at the same time, the nutrients are mineralised to fractions available for plant uptake (Bramryd, 1998). Composting is a several month long process in which bacteria, worms, or other organism feast on piles of carbon rich matter and digest it, leaving behind humus-a rich, stable medium in which roots thrive. Because it is riddled with pores, humus shelters nutrients and provides extensive surface area to which nutrients can bond; indeed, humus traps three to five times more nutrients, water, and air than other soil matter does (Brown et al., 1998). At home, compost pile is an easy and inexpensive way to dispose of organic waste in an interesting and environmentally friendly way. Home composting is easy, beneficial and educational. It takes very little effort or attention because millions of tiny microorganisms do the work (Cunningham, 1997).

[22] Cancer causing agent.
[23] European environment agency.

Farmers, homeowners, and communities produce compost by pilling up alternating layers of (1) nitrogen rich waste such as grass clippings, weeds, animal manure, and vegetable kitchen scraps, (2) Carbon rich plant wastes (dead leaves, hay, sawdust) and (3) topsoil (Miller, 2002). Too much nitrogen will produce an odour like urine or ammonia gas; it also will make the pile slimy and putrid. To function well, a compost pile shouldn't either be too large or too small. A pile that is too small doesn't retain enough heat for the microorganisms to grow optimally. One to two metres wide and a metre high is about right. Given a good nutrient supply and plenty of air, bacteria and fungi growing in the compost pile will produce a temperature of about 70°C, enough to kill most pathogens and weed seeds. Turning the pile frequently (every week or two) will mix the components and provide enough fresh air to keep the pile working well and to prevent the sour smell of anaerobic (oxygen starved) fermentation.

The other essential ingredient for microorganisms in a compost pile is water. If you leave a rainy climate or put lots of vegetables and grass clippings in your compost pile, you won't need supplemental moisture, but if you use lots of dry leaves or live in a very dry place, you may need to add some water from time to time. The compost should be moist but not saturated (Cunningham, 1997). Decomposition ideally requires a humidity of around 60% in the compost heap. If much lower, the process comes to a standstill because the organisms involved in the process are deprived of water (Esrey et al., 1998). Too much water blocks oxygen penetration. The rate of decomposition depends on the surrounding temperature. In the summer, a few weeks should produce a dark, soft, crumbly material that smells earthy. Composting will even work in winter-but slowly if you live in a cold climate. Branches and large chunks of material decay very slowly. Shredding, chipping, or chopping the starting material into small pieces will speed up the process.

There are certain things that should not be put in a compost pile. They include meat, bones, butter, skin or other animal products. They don't compost well, they tend to smell bad, and they attract pests and vermin. Plants infected with disease should not be added, or insects that could survive the compost pile's heat. Avoid plants that take too long to break down such as pine needles, eucalyptus leaves or bark, or oak leaves. The tannins[24] and acids they contain are natural bactericides[25] and fungicides[26] and inhibit composting. Cat and dog faeces may contain harmful pathogens that can survive composting-especially if the pile doesn't reach optimal temperature. The compost produced may be infectious.

If these materials are avoided, keep pests and vermin out, and maintain a neat well aerated, odour free compost pile, neighbours will not complain of odours coming from the compost, and after a few weeks, you will have a valuable soil amendment to spread on your yard or in your garden, or to use in potted plants kept in the house (Cunningham, 1997).

### 3.3.6.2 Anaerobic technique

The anaerobic techniques include both reactor fermentation and fermentation in bioreactor cells constructed in landfills. Controlled steel-reactor fermentation is normally faster than landfill bioreactor fermentation. On the other hand, the total yield of energy is normally lower with the faster techniques. In the slower landfill bioreactor cell there is enough time for processes such as the hydrolysation of cellulose, which can significantly increase the yield of methane gas. If non-polluted waste is used for the fermentation process, the bio-residue can

[24] A yellowish or brownish bitter-tasting organic substance present in some barks, and other plant tissues.
[25] A chemical that kills bacteria cells.
[26] A chemical that kills fungi.

be used for soil improvement. Because of the content of organic matter, the bio residue has a value as both fertilizer and soil conditioner.
Mixed residual municipal and light industrial wastes, remaining after source separation for recyclable material and/ or fractions for the production of soil improvers, can be fermented in the landfill bioreactor cells (Bramryd, 1998). Fermentation in landfill bioreactor cells is an ecologically based technique, which opens possibility for both bio-energy and nutrient extraction (Binder and Bramryd, 2001). The reactor cell functions like an anaerobic filter, where energy is extracted through the collected biogas, while nutrients are recovered through the leachates. Pollutants, such as the heavy metals, are captured in the fermentation residue and are left in the landfill (Bramryd, 1998).

Landfilling stands alone as the only waste disposal method that can deal with all materials in the solid waste stream. Other options such as biological treatment themselves produce waste residues that subsequently need to be land filled. Consequently, there will always be need for landfilling in any solid waste management system. Landfilling is also considered as the simplest, and in many areas the cheapest, of disposal methods, so has historically been relied on for the majority of solid waste disposal. Not all cases of "landfill" actually involve filling of land.

The concept of landfilling as a final disposal method for solid waste can also be challenged. A landfill is not a "black hole" into which material is deposited and from which it can never leave. Like all other waste options, landfilling is a waste treatment process, rather than a method for final disposal. Solid wastes of various compositions form the majority of the inputs, along with some energy to run the process. The process itself involves the decomposition of part of the landfilled waste. The outputs from the process are the final stabilised solid waste, plus the gaseous and aqueous products of decomposition, which emerge as landfill gas and leachate. As in all processes, process effectiveness and the amounts and quality of the products depends on the process inputs and the way that the process is run and controlled. The same applies to landfilling: what comes out of a landfill depends on the quantity and composition of the waste deposited, and the way the landfill is operated (White et al., 1999).

In a sanitary landfill, trash and garbage are crushed and covered each day with fresh layer of clay or plastic foam to prevent accumulation of vermin and spread of disease (Cunningham, 1997). Modern landfills on geologically suitable sites are lined with clay band plastic before being filled with garbage. The bottom is covered with a second impermeable liner, usually made of several layers of clay, thick plastic, and sand. The liner collects leachate and is intended to prevent its leakage into groundwater (Stegmann, 2001).

The purpose of a sealing system in the landfill is to protect nature from pollution by the hazardous materials produced by landfill processes. A typical final cover for a landfill is from 0.6-2m thick (Tammamagi, 1999). A new advancement in landfill sealing is to smear the surface cover with methane bacteria of the genus pseudomonas. These bacteria break down any methane that leaks from the landfill into carbon dioxide and water. This has been done in Switzerland (Bramryd, 2002). Collected leachate is pumped from the bottom of the landfill, stored in tanks, and sent to a regular sewage treatment plant or an on-site treatment plant. When full, the landfill is covered with clay, sand, gravel, and topsoil to prevent water from seeping in. Several wells are drilled around the landfill to monitor any leakage of leachate into nearby ground water.

Modern landfills are equipped with connected network of vent pipes to collect landfill gas (consisting mostly of two green house gases, methane and carbondioxide), released by underground (anaerobic) decomposition of wastes. The methane is filtered out and burned in small gas turbines to produce steam or electricity for nearby facilities or sold to utilities. However, thousands of older and abandoned landfills do not have such systems and will emit methane and carbondioxide, both potent greenhouse gases, for decades (Miller, 2002). Therefore, the operation of closed landfills has to continue in other to seize remaining emissions and to reduce them to an acceptable minimum. This so-called aftercare phase of closed landfills should, however, be kept as short as possible. The landfill should then remain mainly self-regulatory and only very few measures of control should be necessary. The aftercare phase will last, however for a few decades (Stegmann, 2001).

Although the methane produced by refuse is not poisonous either to plants or animals, it does discourage revegetation of some sites, as its presence in the soil prevents oxygen from penetrating, so that roots are asphyxiated[27]. Burrowing animals are also excluded by the lack of oxygen. The greatest disadvantage of methane is its danger to humans, particularly if houses are erected on a site where it is still being generated. Under such conditions, explosive mixtures, which may contain as little as 5% methane, may be produced. Should this be generated into a house with an unventilated cellar, serious explosions may occur (Mellanby, 1992).

Contamination of ground water and nearby surface water by leachates from unlined and lined older landfills is a serious problem. Modern double lined landfills delay the release of toxic leachate into ground water below landfills but do no prevent it. These landfills are designed to accept waste for 10-40years. However, they could begin to leak after this period, passing the health risks and costs of contamination to future generations. According to G. Fred Lee, an experienced landfill consultant, the best solution to the leachate problem is to apply clean water to the landfill continuously and then collect and treat the resulting leachate in carefully designed and monitored facilities. He contends that after10-20 years of such washing, little potential for ground water pollution should remain. This wetting will also hasten the breakdown of wastes and thus allow old landfills to be dug out and used again (Miller, 2002).

### 3.3.6.2.1 Advantages of sanitary landfill

Probably the biggest advantage of sanitary landfills, when compared to open dumps, is the protection of public health and the environment. The major objectives to sanitary landfills are initial costs for design and construction, public opposition when siting, and increasingly the concern for recovery of material instead of disposal. With regard to public health and environmental protection, a properly designed and operated landfill will offer advantages in the following areas:

Gas and leachate: The green house gases may intensify the greenhouse effect, while the leachate contain heavy metals and can contaminate underground water. Collection of these gases and the sealing of the bottom of the landfill prevent these from happening.

Birds: These can be a nuisance or even cause problems with planes if the landfill is near an airport. Several methods, including use of noisemakers, and nets or wires suspended over the site, have been tried to discourage birds at landfills near airports.

[27] Kill by depriving them of air.

Odours: The daily covering of the surface of the landfill prevents the escape of bad odour from the decomposition of the biodegradable waste in the landfill.

Pests: Flies and mosquitoes are best controlled by daily cover of the solid waste along with the elimination of any open standing water.

Rats: These can be a problem at open dumps, but the use of cover, ensuring that all food wastes are buried, eliminates rat problems at a sanitary landfill.

Scavenging: While recycling may be desirable, the scavenging of materials from a landfill is usually prohibited. Scavenging is the uncontrolled picking through waste to recover useful items, as contrasted to salvaging, which is controlled separation of recoverable materials. Scavengers have been injured, sometimes fatally, while picking through the waste. Scavenging should not be allowed (O'Leary and Walsh, 1993).

### 3.3.6.2.2 The importance of organic matter in landfills

Landfills are major accumulators for organic carbon, comparable with peatlands, marine and limnic sediments. If the emissions of methane, a potential "greenhouse gas," can be controlled through reliable systems for collection and utilisation, like in landfill reactor cells (biocells), landfills have a positive effect for counteracting global warming.

The accumulation of organic carbon, which is resistant to anaerobic decay, e.g. derived from the lignin fraction of the waste, helps to retain water in the fermentation rest and, maintain high moisture content. This will provide for a reliable long-term storage in the fermentation rest of heavy metals bound up as sulphides, which are insoluble under anoxic[28] conditions. Thus in the leachate mainly metals with low atomic weight, as nutrients like sodium, potassium, magnesium and calcium will occur together with nitrogen fractions. Thus long-lived organic matter in landfills e.g. paper and wood products will act as a stabilizer for the landfill and immobilize toxic elements in a rather stable fermentation rest, which is left in the landfill.

Decreased concentrations of organic matter in landfills will thus increase the risk for leaching of toxic elements as heavy metals, as the immobilization processes of long-lived organic matter will be exhausted (Bramryd, 1997).

### 3.3.6.2.3 Restoration

Restoration, which means that closed landfill sites are turned into, for example, recreation sites (SAWM[29], 1998).

### 3.3.6.2.4 Ecological aspects of waste treatment

A major part of waste products from agriculture and forestry is transported into human society. Therefore, it is of paramount importance to achieve an ecocycle, where nutrients especially can be brought back into the producing ecosystems. An increased recovery of by-products as raw materials for new products will reduce the need to exploit new natural

[28] An absence of oxygen
[29] Swedish association of waste management.

resources, like minerals, oil and other materials that have been stored in the ground. However, not only material recovery will save natural resources. Recirculation of nutrients from products in urban society to agriculture and forestry will reduce the need for commercial fertilizers, and thus the use of long term accumulated nutrients from the ground. The energy needed for the fixation or refining of these fertilizers will also be saved. Nutrients can either be recirculated in a solid form as compost, as residues from fermentation or in a liquid form as leachate from landfill bioreactors.

It would be a serious mistake to forget the absolute necessity of accumulating processes in natural ecocycling. As long as new resources are taken from the ground as minerals or as fossil organic matter, it is necessary, from an ecological point of view, to balance the excess of substances that may occur in the ecocycle. Otherwise there is an obvious risk of different types of over saturation effects. A good example is an increased atmospheric carbondioxide concentrations that have arisen since industrialisation began, due to burning of fossil fuel, increased harvesting of forests and new techniques in agriculture with, for example, deeper ploughing and an increased use of nitrogen fertilisers. In other to reduce the risk of climatic effects and other disturbances, it is of great importance to stimulate processes that that withdraw carbondioxide from the atmosphere. (Bramryd, 1997).

### 3.3.6.2.5 Effects of waste treatment of the global carbondioxide balance

As a result of the burning of fossil fuels, extensive exploitation of forests and new agricultural technique, the atmospheric carbondioxide concentration has increased since industrialisation started in 1860s. Natural feedback processes like sedimentation, increased accumulation in soils and increased uptake by oceans can slowly compensate for some of the increases. However, in a sustainable society, man-made systems for balancing the increased carbondioxide concentrations are also strongly needed. As mentioned above, landfilling can be compared to sedimentation and peat-forming processes. It has been estimated that approximately 35-50% of the organic carbon added to landfills is long-lived and will be stored in the fermentation residue. Lignin is especially resistant to degradation under anaerobic conditions and most of this fraction will be left in the fermentation residue in the landfill or the bioreactor.

Landfilling is one of the few available processes for long-term accumulation of organic matter and is thus of great importance as a feedback mechanism for increased atmospheric carbondioxide concentrations. On a global scale, the annual accumulation of organic carbon in landfills is of the same magnitude as the carbon accumulation in the world's peatlands. Landfilling of organic carbon derived from fossil sources, such as in plastics or synthetic rubber, is a way to return this fossil organic matter to long-term storage. Landfilling of non-recyclable plastics thus is an ecologically correct technique (Bramryd, 1997).

## 4. PRESENT SITUATION IN CAMEROON

After returning from Istanbul in 1996, the government of Cameroon undertook wide ranging measures aimed at implementing the resolutions adopted at the City Summit. The focus was on how to take care of the extremely high rate of urban growth faced by the big cities of the country. More critical was the fact that, in practice, the actual growth of cities and towns was taking place outside the official legislative and regulatory framework that was put in place by the government. This was again aggravated by inappropriate urban management approaches, lack of planning tools, as well as the serious deterioration of urban infrastructure services or

the total lack of them (Forgwe, 2000). In many developing countries, it has become evident that population growth imposes stress on infrastructure and the necessity of sharing services have worsened the living conditions of the urban population in those countries (Mwaiselage, 2002).

The economic crisis, which prevails in Cameroon since 1987 had severe repercussions in several sectors. The framework of life in the cities was not saved by it. The phenomenon of urban insalubrities[30] was truly reinforced towards the end of the last decade. It is after 1989 that one started to feel the pressure of the household refuse in big cities like Douala and Yaounde, and in other smaller cities of Cameroon. In the absence of collection, and because of the harmful effects of the household waste, certain townsmen took the practice of setting fire on the waste deposits. Many of other initiatives were taken by the housewives with an aim of facing the rise of the heaps of refuse in their surrounding, but without success.

## 4.1 Poverty as a contributing factor to environmental degradation

UNDP[31] defines human poverty as the denial or deprivation of opportunities and choices that would enable an individual "to lead a long, healthy, creative life and to enjoy a decent standard of living, freedom, dignity self-respect and respect of others". To measure human poverty, UNDP proposes three indices: The first relates to an individual's vulnerability to death at a relatively early age and it is measured by the percentage of the population expected to die before the age of forty years; the second relates to an individual's exclusion from the world of reading and communication and is measured by the percentage of adults who are illiterate; the third index relates to the standard of living and is measured by the percentage of people with access to health services and safe water, and the percentage of malnourished children less than five years old.

The failure of these definitions to relate poverty to the environment reflects a shortcoming in the approach to solving these problems. In an address to the high session of the Economic and Social Council of the United Nations Organisation in June 1993, Dr. Boutros Boutros-Ghali, then UN secretary–general, demonstrated an effort to change this approach when he emphasized that poverty is only one aspect of the generally dehumanising phenomenon of deprivation:

"Deprivation is a multidimensional concept. In the sphere of economics, deprivation manifests itself as poverty; in politics, as marginalisation; in social relations, as discrimination; in culture as rootlessness; in ecology as vulnerability. The different forms of deprivation reinforce one another. Often the same household, the same region and the same country is the victim of all these forms of deprivation. We must attack deprivation in all its forms. None of the other dimensions of deprivation, however, can be tackled unless we address the problem of poverty and unemployment"[32].

A remarkable shift of global population from rural to urban areas has occurred in developed and developing regions of the world. In fact, by 2030, the urban population is expected to be twice the size of the rural population globally. The shift in population distribution from rural to urban areas has been accompanied by a shift in the concentration of the poor. Poverty in urban centres has been increasing rapidly more than in rural areas. According to a United

[30] Not healthy or pleasant.
[31] United Nations development program.
[32] Quoted in the article on poverty and environmental degradation by Akin Mabogounje.

Nations estimate, six hundred million people in urban areas of the developing countries (almost 28% of the developing world's urban population) cannot meet their basic needs for shelter, water, and health. Infact, about half the urban population in poor countries is living below official poverty levels. This number is expected to rise phenomenally in the next few decades. Rapid population growth and urbanisation, coupled with the need to produce for export, has negatively affected the environment in many ways including urban pollution (Mabogounje, 2001).

## 4.2 Effects of garbage proliferation in Cameroonian towns

The proliferation of household refuse in cities is an alarming problem with regard to the effects, which they generate on the environment and health. Such effects can be divided into effects on the environment, and effects on human health.

### 4.2.1 Effects on the environment

Pressure on physical space: The accumulation of the household refuse takes up so much space and cause road obstruction in some cases. This obstructs traffic, and reduces the available land space, which is becoming very scarce due to over population.

Pressure on urban aesthetics[33]: The accumulation of the household refuse causes the degradation of the aesthetic aspect and urban beauty.

Pressure on the layer of ozone: The incineration of the heaps of refuse by the population causes the outbursts of certain gases like nitrogen dioxide, carbondioxide etc., which destroy the ozone layer. Methane, another green house gas is also released from the refuse heaps as the cellulose in the plant material present in the garbage is broken down anaerobically.

Air pollution**:** Pungent odours from decomposing uncollected garbage degrade the air quality.

Ground and water Pollution: Surface waters, which the refuse heaps carry pollutants such as heavy metals from it. These pollutants contaminate ground water as the water infiltrates or percolates, or contaminates water bodies when it drains into them.

### 4.2.2 Effects on human health

a) Outburst of air pollutants: The incineration of refuse heaps in the open-air leads to the release of harmful gases such as sulphur dioxide, and carbon dioxide into the atmosphere. Sulphur dioxide causes bronchitis[34], while carbondioxide is an important green house gas.

b) Presence of the dangerous objects: The household refuse normally contains sharp objects such as broken plates and glasses, syringes, sharp metallic objects etc., which generally wound children who play around such waste piles.

[33] The appreciation of beauty.
[34] Inflammation of the mucous membranes in the bronchial tubes. It typically causes contraction of the bronchus and coughing.

## 4.3 Present rate of waste generation in Cameroon

The rapid population growth with uncontrolled development can seriously degrade the urban environment, placing enormous strain on the natural resources and sustainable development. One of the most important environmental consequences of the process of urbanisation in Cameroonian towns and cities is the immense and ever growing amounts of solid waste, most of which remain uncollected and are dumped on vacant land or into water bodies.

## 4.4 Waste composition in Cameroon

The composition of waste varies from region to region within a particular town or city. In the areas inhabited by low-income earners, the waste mostly consists of biodegradable materials, while the waste generated by the high-income earners contains a significant amount of non-biodegradable materials like plastics. Biodegradable waste materials include: Plantain, cassava and cocoyam peelings, vegetable stumps, food remains etc. The non-biodegradable materials include bottles, tins, old clothes, rubber and plastic articles, paper etc. The effects of unsustainable solid waste management in Cameroon can be shown with a causal loop diagram (CLD)[35].

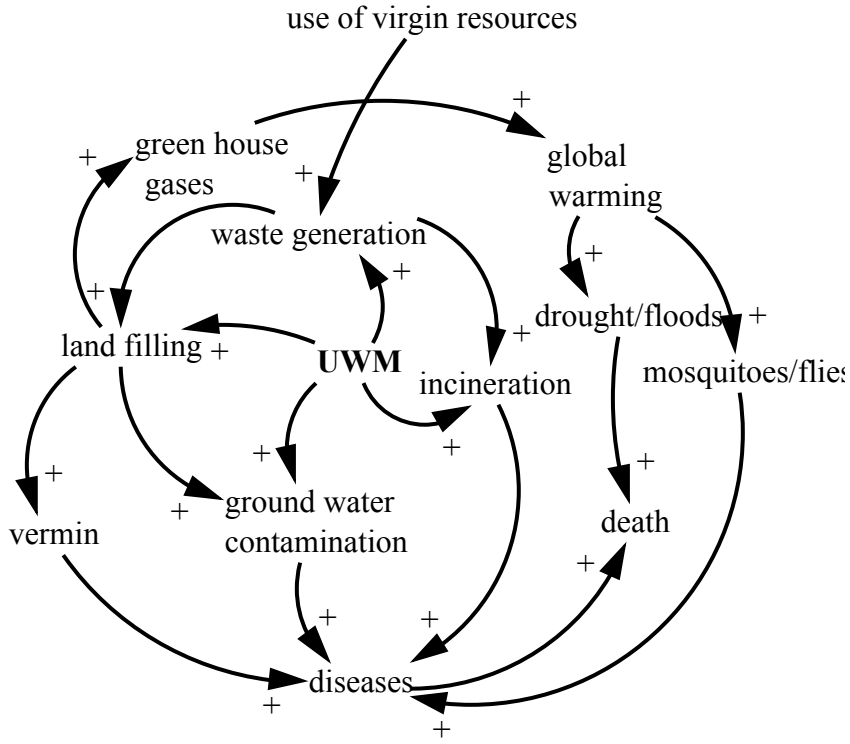



**Figure 5: CLD showing the effects of unsustainable solid waste management (UWM) in Cameroon.**

## 4.5 Waste collection

A waste collection system is completely lacking in some towns e.g. Buea, and in cities where they are present e.g. Douala and Yaounde, it is highly inefficient. In cities with no collection provisions, the inhabitants dispose of their waste in a highly disorganised manner. Some

[35] In a causal loop diagram, an arrow with a + sign denotes that the cause an effect change in the same direction, and a minus sign denotes that they change in opposite direction.

people use their backyard as a waste disposal site, while in some small communities there is usually a place set aside for the waste to be dumped.

## 4.6 Constraints towards the collection of household refuse in Cameroon

- The collection and disposal of household refuse are tasks which cause considerable expenditure e.g. the cost of collection of one tonne of waste by HYSACAM[36] is 15000frs CFA (20US$), for 450 tonnes per day in Yaounde, and 550 tonnes per day with Douala. However today, the municipal budget remains the principal financial resource for the collection and disposal of household waste. The formerly permanent state grant was suspended. On the level of the municipal budget, the only resource for the financing of urban waste remains the tax for the collection of domestic garbage. This tax suffers not only from the narrowness of the rates of the taxpayers, but also of the weakness of the level of covering.
- The collection of domestic waste suffers from an absence of legal texts, which regulate the collection, and the transport of the refuse to the point of disposal. The housewife who throws her refuse in middle of the roadway is not afraid of any penalty.
- HYSACAM, the company contracted by the government to collect and dispose of household waste does not have sufficient vehicles and manpower. This is partly because the amount of funds coming from the government is small.
- Due to the irregular construction of houses, and bad nature of most of the roads, the collection vehicles cannot cover all the areas.
- The collection of the communal containers placed in residential areas for garbage deposition is irregular. If is very common to find an overflowing collection container, with people still dumping their garbage beside the container.
- When full, the container is carried by a collection vehicle that takes it and disposes of the contents. This same container is brought back to the same location later on. People still go ahead to dump their refuse even when the container is not there, and even when the company eventually comes to carry away the filled container, the spilled garbage is more often than not left behind.
- Some people are from the rural areas and cannot relate to the concept of collection on particular days, as it is not the case where they come from.
- The tenant system, whereby people rent houses discourages some tenants from cleaning their surrounding. Some tenants have the wrong feeling that it is the duty of the landlord to clean the surrounding of the house.
- The number of containers allocated for a large community is insufficient, in most case only one for a large population. This takes a few days to get full, of which the collection and disposal is very irregular. At times the container is very far from some houses, and such people who are far away from the container are likely to create illegal dumping sites closer to their homes.

## 4.7 Other initiatives towards garbage collection in towns

In the city of Douala, the city council usually employs youths during the long holidays (summer holidays). These youths are charged with cleaning the town, especially the gutters which are blocked to prevent flooding during periods of heavy rains. This is a very good practice, but the important question is "who then will do the cleaning when these youths have gone back to school?" The city council should instead try to seek ways and means of reducing

[36] A local company contracted for the collection and disposal of household garbage.

the generation of waste, rather than clearing huge quantity of waste released into the environment.
Some small communities have highly efficient and functional waste collection system e.g. the community of the national oil refinery (SONARA) workers in Limbe[37], Cameroon. The service that collects the garbage is called "common services", and it is a small unit within SONARA. The workers of this unit go round every morning with a car and collect garbage from the houses of SONARA workers. All these houses are equipped with modern trashcans with tight fitting lids to prevent the entry of flies and the escape of smells. The waste collected is later land filled. The SONARA community can go a step further, if each household sorts the waste, and the biodegradable waste composted. The compost manure can then be sold to the SONARA workers at a very cheap rate. This compost can be used for small vegetable gardens where there is available land, or for the growing of flowers to further beautify the surrounding.

## 4.8 Present methods of waste management in Cameroon

### 4.8.1 Reuse

Reuse is carried out at a very low rate in Cameroon. Traditionally, only glass beer bottles were reused/returnable. Of recent, glycerine bottles are also being reused but on a very small scale. It is very common to find people going round and buying these bottles.

### 4.8.2 Recycling

An insignificant portion of recyclable waste generated is actually being recycled, notably old rubber slippers and shoes. However, this is being done at a very low scale. Such recyclables include: Plastic Coca- Cola, Sprite, Fanta and Pamplemousee bottles from Brasseries du Cameroon and Union Camerounaise de Brasseries,[38] Supermont and Tangui bottles from Supermont and Tangui companies, Fruit juice containers from Frutas[39]; plastic containers from yoghurt companies e.g. Camlait, plastic vegetable oil containers from Oilio and Diamaor companies[40], Polythene bags from Metropolitan plastics; paper and cardboard, metallic tins etc.

Corrugated aluminium sheets are also being recycled but on a very small scale. Local pot manufacturers, who melt the sheets and then use the liquid aluminium for the manufacturing pots, do this. Such people always scavenge on landfill sites in search of old aluminium sheets, or move around and buy the old sheets.

### 4.8.3 Composting

Composting of biodegradable materials is carried out in a small scale and is restricted to the local areas where people use the compost manure for agriculture, and also where there is available land space. In the urban areas where people rely on the local markets for all their foodstuffs, composting is rare, partly due to the unavailability of land space. Another contributing factor is insufficient land space due to increase in population.

[37] A town in Cameroon.
[38] Brewery companies in Cameroon.
[39] A fruit juice company in Cameroon.
[40] Trademarks for vegetable oil different kinds of vegetable oil sold in Cameroon.

### 4.8.4 Landfilling

This is the most widely practised method of waste disposal in Cameroon. Landfills can be private, used by a particular person, or communal, where a small group of people or a large community use a particular landfill. In most instances, the land fills are usually uninhabited land areas, though it normally turn out to belong to some one, and after sometime you may see a notice such as "No dumping of refuse here". With this, the inhabitants have no choice but to turn to a new temporal site. The local council and the government fail completely in that no particular place has been allocated in most instances for the dumping of refuse by the inhabitants of the area.

The landfills are always in the vicinity of living areas, and this has led to so many problems such as an increase in the incidence of vector borne diseases e.g. malaria and typhoid fever. The landfills serve as a fertile breeding ground for these vectors. Bad odours from decomposing food remain in the garbage heaps. This is normally worsened when the wind blows across the landfill towards living quarters. Pests that live principally on animals can at times be found on the body of man. Such pests include Jigger[41] (Tunga penetrans) and tick from dogs and pigs. This happens because these animals normally come to forage for food on the landfill site, and as such these vectors drop from their bodies. The vectors later crawl and install themselves on humans, especially children who normally play in the vicinity of the landfill.

Getting an appropriate site for the disposal of household waste can at times be a problem in the big cities e.g. In 1985, a garbage landfill site for the city of Yaounde, the capital of Cameroon was created at Nkol Foulou[42]. HYSACAM was supposed to landfill all the collected household waste on this site. The close to 3000 people living there later complained that the garbage disposal was done haphazardly. In addition they asked to be given potable water, as the garbage was to pollute the existing water sources. Tension mounted between the population and the Yaounde urban council, and the site was thus closed in 1990. Other sites were put in use.

The pyramid below shows the extent to which each method of waste disposal is carried out in Cameroon. The area of each rectangle in the pyramid indicates is directly proportional to the rate at which each method is practiced.

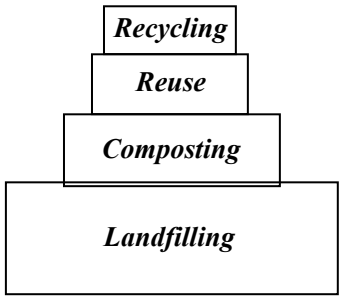



**Figure 6: Pyramid showing the extent to which each method of waste management is carried out in Cameroon.**

[41] A species of flea commonly found in dirty floors and the dirt accumulated in a house. It causes an infection that appears as a swelling under the skin, usually on the foot. The swelling itches intensely, and scratching can cause secondary infections.

[42] A village in the outskirts of Yaounde, the capital of Cameroon.

### 4.9 Proposed strategy for sustainable solid waste management in Cameroon

This strategy identifies three objectives:

- The protection of human health.
- The protection of the environment.
- The protection of natural resources.

The waste management hierarchy is fundamental to the strategy. The waste management hierarchy is an ordered hierarchy of waste priorities as follows:

- Waste reduction.
- Waste reuse and or recycling.
- Waste disposal.

In the absence of any known means to eliminate the production of waste, the hierarchy presents the best means to deal with the problem. The strategy therefore puts a lot of emphasis on the reduction of waste at the initial stage of production. Secondly, it advocates for best use of waste that is produced through reuse or recycling. Lastly, it calls for the critical examination of techniques for final disposal of wastes to prevent harm to the environment.

#### 4.9.1 Reduction

Reduction can be achieved through actions geared towards good house keeping and minimal packaging of products in factories and industries. Products should not be packaged if the packaging is not really necessary e.g. toothpaste (Bramryd, 2002). This will not only lower the cost of production, but the price of the product as well. The introduction of a fee for depositing waste at a landfill will make people to try as much as possible to reduce the waste generated in each household.

#### 4.9.2 Reuse

Although this is being practised in Cameroon at the moment, it is taking place at a very small scale. Reuse of waste should therefore be increased. Companies that produce packages, tins or bottles that cannot be reused or recycled should pay higher taxes. This will urge companies to come out with recyclable or reusable packages.

#### 4.8.3 Recycling

The rate of recycling is even lower than reuse. Just like in the case of reuse, companies that produce non-recyclable packages should pay higher taxes. Deposits for plastic containers should be instituted, as this will compel people to carry their bottles back to the shop. A lot of materials that can be recycled are present in our environment: Supermont and Tangui bottles, Plastic Coca-Cola and Pamplemousee bottles from Brasseries du Cameroon and UCB, plastic plunger and cylinders of disposable syringes, Plastic containers from Frutas, Diamaor, Oilio etc. Polythene bags, broken bottles, broken plates, rubber shoes, slippers and paper. All these when disposed into the environment occupies spaced and decrease the attractiveness of the environment.

In Sweden for example, the average price for a plastic bottle of 1.5litre Coca Cola is 14SEK[43] (1050FRS CFA[44]). The actual price is 10SEK(750FRS CFA), just like in Cameroon. The

[43] Swedish crown: unit of the Swedish currency.

remaining 4SEK(300FRS CFA) is for the container. When buying the Coca Cola, you pay a deposit of 4SEK for the plastic bottle, and when you return the plastic you get back your 4SEK(300FRS CFA). You will hardly find a plastic bottle or an empty can on the street, or even in a trash can because there are people who go round in search of these articles, since they will earn a reasonable sum of money by taking these containers back to the shop. Cameroonian companies will realise much more profits if they engage in large-scale reuse and recycling. This will also mean better working conditions for their worker, higher salaries, drop in cost of production due to reduced cost of reusable or recyclable raw materials, and a consequent drop in price of their products. A drop in the price of the product will eventually increase the demand for the product, meaning more sales for the company.

### 4.9.3.1 Strengthening key players

### 4.8.3.1a Consumers

Community participation is critical to the success of any recycling program. The recovery of large volumes of high quality recyclable depends on citizen involvement. Wastes separation at households would reduce collection time, hence the collection cost. Effective implementation of the separation of waste at source requires continuous efforts from government and non governmental organisation to create effective educational programmes which are able to reach the man on the street, and which stresses not only the importance of recycling, but also the protection and conservation of the environment as a whole.

### 4.9.3.2 Scavengers

For some, scavengers are considered as a nuisance at the disposal sites as they could hinder the effective flow of disposal operation. However, scavengers are infact undertaking separation at no cost to the formal recycling system. This comparative advantage may be utilised by having more systematic scavenging activities i.e. salvaging, such as by allowing only scavengers registered with the authority at the disposal site, equipping scavengers with at least safety boots, gloves, mask, health education and setting up of scavenger's cooperative (Hassan et al., 2001).

The strategy is also based on a fundamental principle of environmental protection: The polluter pays principle. The polluter pays principle states that "who so ever is responsible for the pollution of the environment should pay for the cost of dealing with such pollution" e.g. In 2001, MINEF[45] imposed fines on five manufacturing companies for releasing toxics and other pollutants into nature. Fines for the offences ran from US$3,380-US$6,760. The companies were engaged in brewing, cement manufacture and chemical production. They are all situated in the port city of Douala, Cameroon. They were accused of gathering and releasing waste without prior treatment, and for spilling hydrocarbons into the environment. The cement manufacturer was guilty of gathering huge heap of poisonous iron scrap without pre-determined disposal arrangements, while a brewing company used cooling fluid R502, a substance known to be deleterious to the ozone layer.

[44] Unit of the Cameroonian currency.
[45] Cameroon's ministry of the environment and forest.

The recent fines is the first in the enforcement of new environmental management regulations in Cameroon, and came at a time when the government was being highly criticised for failing to implement and enforce provisions of existing environmental legislation.

### 4.9.4 Export of waste

Wastes like old car tyres, and old body works of cars that cannot be reused or recycled due to lack of appropriate technology should be exported. There are a lot of these items in our environment, and the government can earn a reasonable amount of money if a program is put in place to collect and export these items. Old cars and tyres take up a lot of space that would have been used for other purposes. Old tyres are usually burnt, and the smoke produced is so polluting to the environment.

### 4.9.5 Massive education of the Cameroonian population

As the old Chinese saying goes "If you want to live for one year plant rice, if you want to live for ten years plant trees, and if you want to live forever educate your people". If Cameroonians are to become sustainable in the management of solid waste, then education will be one of the most important tools. "Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues" (UNCED[46], 1992). The public should be enlightened concerning the benefits of a sustainable waste management scheme. This is very crucial as the many Cameroonians, especially those from the rural areas are illiterates, and may not see the reason for some of the actions being taken.

- Youths in primary and secondary schools should be targeted. Posters showing sustainable solid waste management, and its importance should be produced and pasted in all classrooms. As the Spanish professor, Frederico Mayor, a former director of UNESCO, stated at a global forum for environment and development for survival in Moscow in 1990 "Environmental survival, after all, can be a difficult, abstract concept except we are part of nature, and that we must love our trees, rivers, farmlands and forests as we love life itself. The school at the village and neighbourhood level is an extraordinary medium for linking global concerns with local life"[47](Loh, 1994).
- Each classroom should have more than one trashcan; there should be a separate trashcan for paper, biodegradable waste, plastics, bottle etc. Empty cardboard boxes can be used as trashcans. In this way, the students will already have an idea about source separation of waste and recycling.
- Regular quizzes on waste management should be carried out regularly to increase awareness among the pupils, who are definitely the leaders or policy makers of tomorrow. These pupils will grow up with these ideas and will better promote them in the nearest future.
- The media (radio and TV) will also have an important part to play. There should be regular slogans concerning solid waste management over radio and TV.
- Songs should be composed for students to sing daily. The songs should be able to pass on information concerning waste management e.g. malaria is a very bad thing –we must keep mosquitoes away-the first thing to do is to keep our compounds clean etc.

[46] United Nations conference on environment and development.
[47] Quoted in the book titled: A handbook of environmental education for schools and colleges in Cameroon by Loh.

This song use to be common many years ago in primary schools, but is no more being song today.

- The adult population should not be left out. Apart from the media, educators should go to small communities and the shacks and educate these people who may not understand the language used over the media, or who may hardly watch TV, or listen to the radio. They should be made to understand the benefits of proper waste management.

### 4.9.6 Composting

Increased awareness through education will also increase the rate of composting. Composting is very limited in urban areas due to lack awareness, and of land space. A company could be set up in each municipality to deal with biodegradable waste. People living in urban areas can then sell their biodegradable waste to this company. The compost that will be produced by this company can be sold to small and large scale horticulturists, gardeners, small scale farmers, or even to big agricultural cooperation's like Delmonte banana project and Cameroon Development cooperation (CDC), that grow tropical crops like rubber, banana, tea, palm etc. For example nine composting sites have been set up in the vegetable growing areas of Yaounde, the capital of Cameroon, which now counts over 850,000 inhabitants.

A study done in a ward of the city found out that there were 16 valid market gardening sites, which could absorb 8,000 tonnes of garbage per year, i.e. 5 % of all solid waste produced in the city. Increasing composting activities would require a wider market for the use of organic matter, the setting up of transfer sites for pre-collection of solid waste in each neighbourhood and a labour intensive collection system.

### 4.9.7 Landfilling

The open dump approach still remains the predominant waste disposal option in developing countries, creating considerable nuisance and environmental problems. With the accelerated generation of waste caused by an increasing population, urbanisation, and industrialisation, the problem has become even worse. However, landfilling is considered to be the most effective method of solid waste disposal in developing countries if adequate sites are available. The closure, as well as upgrading existing sites is one of the most important steps towards sustainable solid waste management system. The lack of technical knowledge, financial and human resources limit the extent, to which landfills can be built, operated and maintained at minimum standards of sanitary practice (Ranaweera and Tränkler, 2001).

Although landfilling is the most widely method used in disposing waste in Cameroon, the city council in many areas has not done much in facilitating this. There are some areas where there is no assigned landfill, and the dumping of refuse goes on in a disorganised manner. The local council can be partly blamed for the creation of illegal dumping sites in such areas. The government in collaboration with the local council should put in place an effective landfill program. The following can be done.

- Specific landfills should be identified for each quarter or community.
- The landfills should not be near residential areas as this will not be healthy for the people living around that area. Bad odours, stray animals foraging for food, vermin etc. are always associated with landfills and will negatively affect people living near such areas.

- The landfills should not be located near water sources to prevent possible contamination.
- The landfill should be fenced to prevent stray animals from constantly turning over the refuse while in search of food.
- Scavenging in the landfill should be restricted only to registered scavengers, who have protective gloves and boots, as people have been known to sustain serious injuries from sharp objects in the landfill. Such injuries are more often than not infected by the bacterium Clostridium tetani, which gets into the skin through abrasions or cuts. This bacterium causes a disease, called tetanus or lockjaw. The bacterium produces a powerful toxin called tetanospasmin, which causes stiffness of the neck, muscular spasms[48], first in the region of the mouth and neck, then through out the body. Eventually convulsions may be so severe and frequent that the patient dies of exhaustion or lack of oxygen. Children who play around such landfills are the usual victims.
- The land to be used for land filling should preferably be excavated, so that when full it can be sealed with soil and the land used for another purpose.
- People should pay a token for dumping refuse in a landfill. 25frs(0.033$) per bucket for sorted waste, and 50frs(0.066$) for unsorted refuse can be a reasonable and affordable fare. The fare for disposing biodegradable wastes should be higher so that people will be forced to compost the biodegradable waste. At the moment, people are paying for water in many areas. Water was initially being supplied to people who could not afford private taps in their houses; the council paid for the fare. With the onset of the economic crisis in Cameroon, most councils can no longer afford to pay this and people now have to pay a token for water. If such a token is introduced for disposing waste, it won't be new. Besides, it will also make people to learn to generate less waste.
- There should be a caretaker for each landfill.
- The money collected should be used to pay the caretaker, and to make the immediate vicinity of the landfill more attractive.
- The council should employ sanitary inspectors, whose job will be to go round and check for illegal landfills. Anybody staying in the vicinity of such landfills should pay a heavy fine. By this means, everybody will be on guard for those who will try to create illegal landfills. The salary of the sanitary inspectors will come from the token that people pay for dumping refuse.

In the big cities such as Douala, certain parts of the town are usually swept by HYSACAM e.g. the central town. Unfortunately, the place does not remain clean for a long time as people constantly litter the place. To reduce this, each vehicle, especially the passenger vehicles should have trashcans where passengers can drop their rubbish, as most of this litter comes from travellers. The police should check at each checkpoint, to see that the trash can is there, just as it is done for first aid boxes.

To some extent the people who litter the environment cannot be blamed because there are no available public trashcans. To reduce littering, public trash cans should be provided, especially in the central business districts (CBD), motor parks etc. In some instances, these cans do exist e.g. in Buea[49] motor park but people hardly use them. This is the main reason why education will be very central in the proposed sustainable waste management strategy.

[48] Strong muscular contractions.
[49] A town in Cameroon.

### 4.8.8 The law

Legislation has always been a very important instrument in improving and sustaining the quality of the environment. Very hard laws with firm punishments should be devised, especially against littering and dumping of waste in the wrong place. The existence of such laws is not sufficient, but the maximum application is what matters. If the laws are not applied people will normally go back to their old habits.

In Buea, the capital of the South West province of Cameroon for example, the first Wednesday of the month is set aside for cleaning the town, the so called "keep Buea clean". On this day, shops open only after twelve noon, and only few taxi drivers are allowed to work. The rest are expected to clear the bushes by the roadside. Workers are expected to clean their office surroundings, while the inhabitants of Buea are expected to clean their home surroundings. The law stipulates that, anybody who does not clean his/her surrounding will pay a fine or will be jailed for a few days. Unfortunately, this law is hardly applied, and as such people hardly do what is expected of them on this day, but instead use the time for other activities. Besides, cleaning of the surrounding should be a continuous process, and setting aside a day for this will only go a long way to make some people feel that cleaning should only be done once in a while.

## 5. RESULTS AND PROPOSALS FOR IMPROVEMENT

Sustainable management of solid waste in Cameroon will be beneficial to the entire population. The CLD below shows the benefits that would be derived from a sustainable management of solid waste.

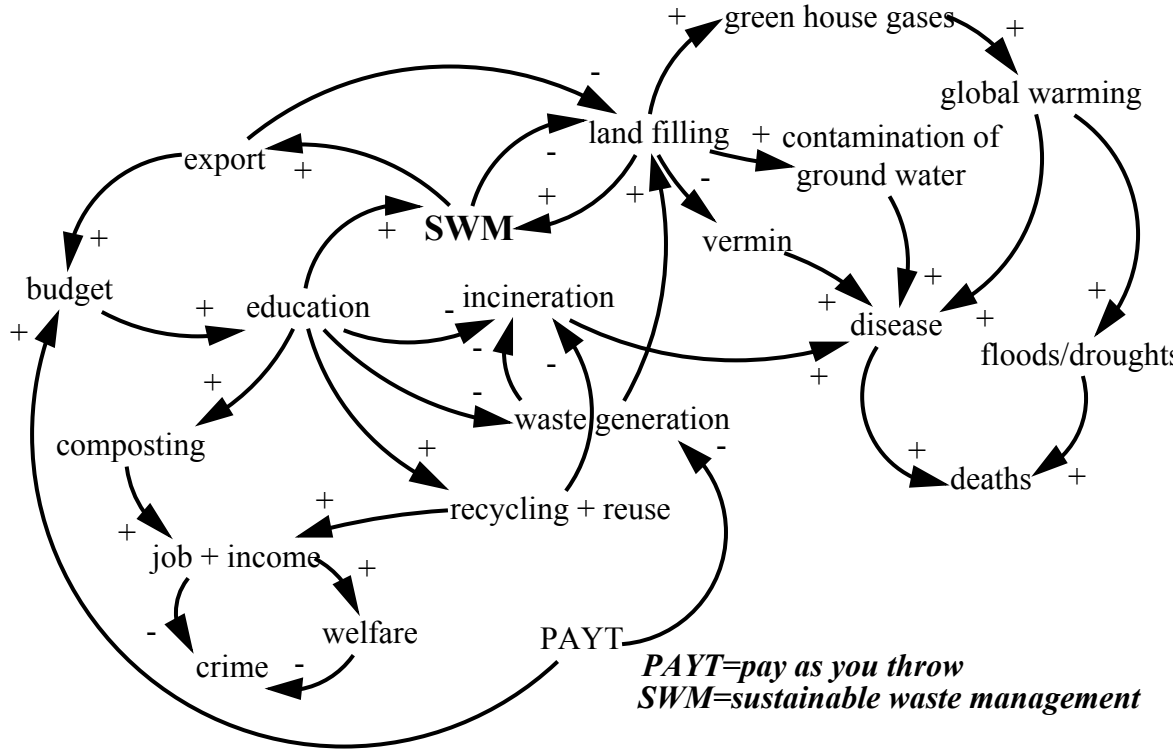



**Figure 7: CLD showing the benefits that would be derived from a sustainable management of solid waste in Cameroon.**

- Recycling and reuse has some environmental benefits. Firstly, waste recycling and reuse will reduce the volume of wastes in Cameroon, with associated benefits-increased lifespan of landfills. Secondly, it will help to save Cameroon's natural resources, and this is a positive way to sustainable development. Economically, it will save costs by making available products at a lower cost than those made from virgin materials. Recycling and reuse will therefore lead to a reduction in the price of products since the cost of production will drop. This will be particularly important as Cameroon is presently suffering from serious economic crises. Socially it will lead to the creation of numerous jobs for millions of jobless Cameroonians. There will be people acting as door-to-door collectors of these materials, street scavengers and normal waste collectors. On top of these, a large number of people will find employment as dealers and traders in waste materials. If companies engage in large-scale recycling or reuse, they will also need to employ many people to take care of this new department. This will lead to a drop in the crime rate, as many of the jobless people take to armed robbery as a means of survival.

- Proper location and management of landfills will help to reduce the proliferation of vermin and the spread of vector borne disease such as Malaria, typhoid fever and the nuisance caused by mosquitoes. Malaria, though very easy to control is still the number one killer disease in Africa. According to the World Health Organisation, one child under the age of five years die of malaria every thirty seconds.
- Increased composting will reduce the volume of wastes going to landfills thereby increasing the lifespan of the landfill. There will also be generation employment and income by many people who will sell their compost or biodegradable wastes to dealers. This extra revenue will help to increase the standard of living for many poor Cameroonians.

- An improvement in the air quality especially in big cities like Yaounde and Douala. The air in the vicinity of the poorly sited landfills has a very bad odour, to the extent that it is not uncommon to find people covering their nostrils with a handkerchief.

- A cheerful and attractive environment.

# 6. DISCUSSION

It can be seen from the study that, Cameroonian will greatly benefit from a program that will enable the solid waste generated to be manage in a sustainable manner. The benefits will not only include a reduction in the death toll as a result of vector borne diseases, but also a clean and cheerful environment should not be under looked.

The measures proposed by this study can work pretty well, if policy makers "deem" it necessary to pay attention to this area, which has been partially or completely neglected in some areas. The aspect of job creation as a result of sustainable waste management scheme will be very crucial to Cameroonians as there are a lot of unemployed qualified graduates roaming the streets. Some of the proposed measures, if implemented might lead to an increase in small-scale theft, but if the law is fully applied on such individuals, this will stop or will be very minimal. This has bean happening as in the case of corrugated aluminium sheets. Second hand zinc is used in making pots in Cameroon, and there has been situations where people have stolen zinc in good conditions just to sell to these pot manufacturers at a give away prize. This will normally happen if wide scale recycling and reuse commences in Cameroon.

Developing countries should spear head measures toward reducing emission of landfill gases as this will eventually lead to global warming. The effects of global warming: droughts, floods and vector borne diseases are worst felt in developing countries which are not well equipped to fight such un foreseen circumstances. If these measures are to work perfectly well, then the common man on the streets, who have never seen the four walls of a school should be made to understand the importance and the benefits of such actions. In this way, each an every Cameroonian will take it as a personal responsibility to properly manage the solid waste generated. If this peaceful approach cannot work, then people should be forcefully compelled to do so.

Furthermore, developing countries like Cameroon rely much on natural resources as a source of income. The exhaustion of such resources will mean a complete breakdown of the economy.

# 7. CONCLUSION

The design and planning of a successful waste management scheme in Cameroon has to involve the community from the beginning, and has to be part of a holistic development program.

- The education of the entire population, with particular focus on youths in primary and secondary school will be very important if this has to succeed. Without this, people will hardly see the reason why they have to suddenly change their behavioural pattern in so far as solid waste management is concerned.

- The government through the local councils should on the other hand play its own part by providing the necessary assistance such as allocation of collection bins, collection vehicles, appropriate landfill sites, etc.

- Deposit system for recyclable and reusable containers should be instituted. This will not only reduce the quantities of waste in our environment and create employment for many jobless people, but will also increase the aesthetics of the environment.

- Proper Landfill sites should be identified, and well situated. The landfills should be well managed to reduce the impact of the landfills on the environment and on human health.

- Poverty and environmental degradation has an old relationship. Poverty alleviation will be a central part of this waste management strategy, as the areas that host these waste piles or landfills are usually inhabited by the poor. If the social status and the income earning of these people can be significantly improved, they will be in a good position to adequately take care of their environment.

With the implementation of all these measures, Cameroon will definitely be on board the "vehicle" for sustainable development.

# 8. REFERENCES

Binder, M., Bramryd T. (2001a). "Environmental impacts of landfill bioreactor cells in comparison to former landfill techniques. Water, Air & Soil Pollution 129 (1/4), 289-303".

Binder M., Bramryd T. (2001b) "Influence of optimisation on bioreactor landfill performance". Sardinia 01. Proc. Eighth International Waste Management and Landfill Symposium, S. Margherita di Pula (Cagliari), Sardinia, Italy, 1-5 Oct 2001.

Bramryd T., Binder M. (2001) "Landfill bioreactor cells as ecofilters for extraction of bio-energy and nutrients from solid wastes". The Environmentalist 21, 297-303.

Bramryd, T. (1997) "An integrated system for energy and nutrient extraction from solid wastes through treatment in landfill reactor cells" Proceedings. Sardina 1997, sixth international landfill symposium. S. Margherita di pula, Cagliari, Italy; 13th -17th October 1997.

Bramryd, T. (1996) "Biological waste treatment techniques from an ecological viewpoint" ISWA yearbook (international solid waste association).

Bramryd, T. (1997) "Landfilling in the perspective of the global $CO_2$ emissions". Proceedings, Sardina 1997, sixth international landfill symposium. S. Margherita di pula, Cagliari, Italy; 13th –17th October 1997.

Bramryd, T. (2001) "Information via personal contacts" Department of ecology, Lund University.

Brown, L.R., Flavin, C., French, H. (1998) "State of the world" London, Earthscan publications Ltd.

Cunningham, W. P. (1997) "Environmental Science; A GLOBAL CONCERN" Chicago, Wm. C. Brown Publishers.

Esrey, S.A., Gough, J., Rapaport, D., Sawyer, R., Simpson-Hebert, M., Vargas, J. (1998) "Ecological sanitation" Stockholm, Swedish environmental protection agency.

European Environment Agency. (1998) "Waste: Annual topic update" Topic report No 6/1999.

Forgwe, G. (2001) "On the road to sustainable development". Cameroon's Ministry of housing and town planning Cameroon. Available online at http://www.unchs.org/unchs/english/hdv7n1/Cameroon_Sustainable_Development.htm. Date accessed (29/05/2002).

Greenpeace (1993) "Incineration" Available online at http://www.greenpeace.org/campaigns/intro? Campaign id=3989). Date accessed: 4/11/2002.

Hassan, M. N., Chong, T. L., Rahman, M., Salleh, M.N., Zakaria, Z., Awang, M. (2001) "Solid waste management in southeast Asian countries with special attention to Malaysia"

Loh, M.A. (1994) "Environmental education, a handbook for schools and colleges" Bamenda, Patron publishing house.

Proceedings Sardina 2001, English International Waste management and Landfill symposium. S. Margherita di pula, Cagliari, Italy; 1st-5th October 2001.

Mwaiselage, A. (2002) "urban Infrastructure and services in developing countries". Architecture and development studies, Lund University.

Fox-lane, B., Hancock, S., Vpela, F (2001) "Sustainable benefits from landfilling, former quarry voids and the dangers of a perspective approach to landfill regulation" Proceedings Sardina 2001, English International Waste management and Landfill symposium. S. Margherita di pula, Cagliari, Italy; 1st -5th October 2001.

Hogland, W. (1997) "Landfilling" Department of water resources engineering, Lund Institute of Technology, Lund University, Sweden.

Miller. T. (2002). "Living in the Environment" Belmont, California, Brooks/ Cole.

Mellanby, K. (1992) "Waste and pollution: The problem for Britain" London, Harper Collins Publishers.

Mabogounje, A. (2001) "Poverty and environmental degradation: challenges within the global economy", Paper presented at the Opening Meeting on Human Dimensions of Global Environmental Challenge Research Community in Rio de Janeiro, Brazil.

Novella, P.H. (2001)"Waste management in metropolitan Cape Town" Proceedings. Sardina 2001, English International Waste management and Landfill symposium. S. Margherita di pula, Cagliari, Italy; 1st -5th October 2001

O'leary, P., Walsh. (1995) "Introduction to solid waste landfills". Available online at http://epd_hp9k.caenn.wisc.edu/~tomo/epd/landfill/A180-01.html. Date accessed (31st October 2002).

Ranaweera, P.M.R.P., Tränkler, J. (2001)"Pre-treatment prior final disposal: A case study for Thailand" Proceedings Sardina 2001, English International Waste management and Landfill symposium. S. Margherita di pula, Cagliari, Italy; 1-5 October 2001.

Stegmann, R. (2001) "Concepts of aftercare of closed landfills" Proceedings Sardina 2001, English International Waste management and Landfill symposium. S. Margherita di pula, Cagliari, Italy; 1-5 October 2001.

Salhofer, M., Graggaber, M., Grassinger, D., Lebersorger, S. (2001) "Prevention of municipal waste and analysis of measure and effects" Proceedings Sardina 2001, English International Waste management and Landfill symposium. S. Margherita di pula, Cagliari, Italy; 1st –5th October 2001.

Tammemagi, H. (1999) " The waste crisis: landfills, incinerators, and the search for a sustainable future. New York, Oxford University Press.

Wallace, R.B., Sutton, I.K. (2001) "Solid waste management and the modernisation of urban waste collection" Proceedings Sardina 2001, English International Waste management and Landfill symposium. S. Margherita di pula, Cagliari, Italy; 1st –5th October 2001.

White, P., Franke, M., Hindle, P. (1999) "Integrated solid waste management: A life cycle inventory" Gaithersburg, Maryland, An Aspen Publication.

Swedish environmental protection agency (1999) "Waste management: the Swedish experience" Ministry of foreign affairs, Stockholm.

Swedish association of waste management (1998) "Swedish waste management" Annual publication of RVF.

Saphire, D. "Delivering the goods: Benefits of reusable shipping containers" Strategies for a better environment.

Thomas, E., Croft, D.R. (1990) "Energy efficiency for engineers and technologists" New York, Wiley.

United States environmental protection agency "Polluter prevention information clearing house: Recycling and waste exchange" Washington, D.C. reference and referral: 202-260-1023.

United States environmental protection agency (1993) "WasteWise: EPA's Voluntary program for reducing business solid waste" Washington, D.C.

Ziehmann, G. (2001)"Mechanical properties of waste in low income countries" Proceedings Sardina 2001, English International Waste management and Landfill symposium. S. Margherita di pula, Cagliari, Italy; 1st –5th October 2001.