WASTE TYRE MANAGEMENT PROBLEMS IN SOUTH AFRICA AND THE POSSIBLE OPPORTUNITIES THAT CAN BE CREATED THROUGH THE RECYCLING THEREOF.

by

MPANYANA LUCAS MAHLANGU

Submitted in fulfillment of the requirements for the degree of

MASTER OF ARTS

In the subject

ENVIRONMENTAL MANAGEMENT

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF O R AWOFOLU

APRIL / MAY 2009

LETTER OF DECLARATION

I, Mpanyana Lucas Mahlangu, hereby declare that the work contained in this thesis, is of my own originality and have not been previously in its entirety or part thereof submitted to any institution of higher learning in South Africa or abroad for the purposes of a degree.

The work is submitted for the first time to the University of South Africa for the purpose of study towards a Masters degree in Environmental Management.

SIGNED: ……………………

DATED:……../…………/…………..

ACKNOWLEDGEMENTS

I wish to express my profound gratitude to my substantive supervisor Professor O R Awofolu, who despite his busy schedule was able to guide me through this research until the final write up.

I acknowledge my indebtedness to my wife Nomsa, my son Siyabonga and daughter Khanyile for the support and understanding they afforded me during trying times when I conducted the research.

Finally, I thank the almighty God for bringing me this far and for always been with me.

SUMMARY

The research work critically analyzed the factors responsible for imprudent waste tyre management in South Africa. As an approach to determine the complexity of the problem, questionnaires were sent to one hundred and sixty (160) respondents in conjunction with interviews. Perusal of literature and interaction with industry involved in waste tyre processing to further gain knowledge of the problem and possible solutions that can be solicited to address the problem. Findings revealed that, lack of clear, focused legislation that guide the handling, disposal and processing of waste tyres remain the challenge. It is also deduced that recycling of waste tyres can provide economic benefits and opportunities. It is recommended that South Africa develop appropriate legislation that deals with handling, treatment and disposal of waste tyres, develop an incentive programme to set up initiatives as well as developing skilled and capacitated enforcement agency.

***Key words**: Waste Tyres, Legislation, Recycling, Management, South Africa*

LIST OF CONTENTS

HEADING **PAGE No.**

CHAPTER 1

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

CHAPTER 1

1. INTRODUCTION

Wastes generally are inevitable products that are generated by every living organism. This extends from the simple unicellular organism such as *Amoeba proteus* to the complex multi-cellular organism such as man. The volume of waste generated by various organisms is related to their size or complexity. Before the industrial era, anthropogenic wastes include but not limited to those from physiological process, ashes from burning of wood, agricultural and animal wastes which are buried in the ground. However, with increase in population, the volume of wastes generated also increases. The industrial era brought about tremendous improvement in the standard of living of man. This was also accompanied by the introduction of different kinds of waste materials, some of which are detrimental to our lives and the environment. These wastes are in the form of solid wastes e.g. waste tyres, broken glasses, spent nuclear fuels, plastics; liquid wastes e.g. leachates, general chemical and gaseous wastes such as methane emitted from landfills, carbon-monoxide etc. Waste tyres has been classified or defined as tyres that are bald and worn down to the tread belt or have bulges or sidewall damage and are not suitable to be re-treaded as a result of long use (Adhikari and Maiti, 2000).

Waste tyres are bulky and difficult to dispose. Their nature does not allow compression or folding in order to reduce the space occupied during disposal at landfills and they also do not degrade easily (Adhikari and Maiti, 2000; Weng and Chang, 2001). In addition, when whole waste tyres are land filled, they trap air in their curvatures with possibility of migrating to the top of the landfill, hence breaking the sanitary cap and creating further problems (van Beukering and Jassen, 2001).

Shredding of the waste tyres before disposal has been suggested and tried for size reduction before disposal. The high operational costs of this process made it an unattractive option. Subsequently, many landfills around the world stopped accepting waste tyres due to the aforementioned problem of size among others where the land becomes filled quickly (ANZECC,1994 and ASTMC, 1994). This situation eventually leads to waste tyres becoming litters in the environment (EN, 2006).

According to a survey, 160,000 tons of scrap tyres are generated in South Africa each year and about 28 million used tyres are dumped illegally or burnt to recover the steel wire annually, which is sold as scrap metal (SATRP, 2008). This amount is thought to increase by 9,3 million annually (SATMC, 2005). Indiscriminate and illegally discarding of waste tyres in the environment also exacerbates the problem. The tyres become reservoir of rain water hence providing breeding space for mosquitoes and other vectors of diseases like malaria, denge and yellow fever (Jang and Yoo, 1998). They are also burnt by people in slums for heat generation especially during the winter period, the practice of which introduces many noxious gases such as dioxins, carbon monoxides etc into the environment. Depending on design and purpose of use, tyres contain some amount of hazardous compounds like copper compounds, cadmium, acids in solid forms and zinc compounds (UNEP, 1999). The practice has also been found to be responsible for many fire hazards. In developed countries such as the United States, Canada, Germany, United Kingdom, and Japan, waste tyres have been used as a supplemental fuel for the cement kilns (Prisciandaro, et al., 2003) and in the paper mills (Barlaz, et al., 1993).

The purpose of the study is to investigate the problems of inadequate waste tyre management in the country as well as opportunities that are available through recycling processes. This is particularly important in view of the high level of unemployment in the country.

1.1 Background information of the Study

In recent years, South Africa is experiencing an increase in socio-economic activities involving large scale production, consumption and ultimately waste generation. These has resulted in a wide range of environmental problems. The primary cause of such problems is the failure to incorporate the cost of using the environment (environmental cost) in the mechanism of market economy. In South Africa and other developing countries, the cost of production does not involve or take into account the environmental costs, in terms of the damage / exploitation caused to the environment as a resource that is utilized. In developed economies however, environmental cost is paid for future restorations to the damaged environment, e.g. restoring polluted lakes, damaged ozone layer, polluted soils, etc. In developing countries like South Africa, protection of the environment is solely left in the hands of the state. Principle 16 of Earth Agenda 21 of Earth Summit in support of environmental costing states that “National authorities should endeavour to promote the internationalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment” (UNCED, 1992).

The degradation of the ozone layer through the greenhouse gases continues unabated, and pollution standards are exceeded (Wenzel, 1998). This is due to lack of awareness against the cost to society for taking advantage of the environment in socio-economic terms. The problem of dealing with waste continue to increase in both quantity and complexity. This situation requires an increased capacity in terms of technology and utilization. The orthodox legal approach has been to confront these problems by adopting the traditional command and control where administrative and criminal sanctions are applied when there is non-compliance. This approach is encountering a number of challenges and difficulties in monitoring, compliance, enforcement of laws and directives on different waste types entering the three environmental strata. The new approach of enforcing legislation promotes co-operative governance in a sense that it encourages industry to regulate and audit itself, so that enforcement of legislation is symbiotic in application. A win-win situation is favoured. For example, an industry will undertake an environmental audit through an independent audit company and submit an audited report to the state/authorities and the authorities review and recommend corrective actions where non compliance is envisaged.

In South Africa eleven million tyres are scrapped every year and only six percent are recycled (Human, 2006). Less than 20 percent of the waste tyres are recycled to manufacture products such as floor-mats, floor linings (rubberize), insulators, gumboots, feeding and drinking troughs for animals while the rest are dumped in the veld (DACST, 2004). Developed countries, like the United States of America generates about 290 million waste tyres per annum and only 2% of that waste goes to the landfill and the rest are utilized for various uses like Tyre Derived Fuel, Civil Engineering, ground rubber applications, making new products and some are exported (Goodyear, 1995).

According to the United Kingdom Environmental Agency (UKEA, 2004), United Kingdom generated about 475,232 tons of waste tyres during the year 2004. Thirty four percent (34%) thereof was recycled, twenty six percent (26%) reused, fifteen percent (15%) combusted as fuel, seven percent (7%) exported and six percent (6%) used in land fill engineering applications. Twelve percent (12%) of the total waste generated after all other applications were land filled. Under the European Union landfill ban (EU, 1999), whole waste tyres are not allowed to be disposed in landfills. After July 2006 the ban extended also to the shredded waste tyres (EU, 2007).

Developing countries like South Africa, is faced with the ever increasing pile of waste tyres that are hardly used for any other application. The pile is further increased by importation of new and used tyres from the developed countries such as Germany, the United States of America, Japan, United Kingdom, China and Australia for use on vehicles and for re-treading purposes. Most of the used tyres (over 60 %) that are imported for re-treading purpose are sold as second hand tyres (SAMTC, 2005).

Interestingly, the minimum tread depth of a tyre in South Africa is legally fixed at 1, 0 mm by the Council of the South African Bureau of Standards (CSABS, 2005). That of the EU, Japan and the United States of America is currently 1.6 mm (USDT, 2001). This mean that waste tyres from those countries are useable in South Africa and tyres imported from those countries for re-treading purposes in many cases instead of being re-treaded as intended are sold as second hand tyres with a life span of between two to three months. These further compound the stockpile of waste tyres (SATMC, 2005).

The Tyre Retreaders Association of South Africa argues that they will continue to import casings (used tyres), because used tyres in South Africa are utilized until there are no more threads left and re-treading such tyres is posing danger to the users of said tyres in vehicles (SATRP, 2008). There is potential for waste tyres to generate wealth. For example, in Wadeville, South Africa, there is a plant that granulates waste tyres into rubber crumbs which are exported to Europe where they are mixed with asphalt in tarred road making or resurfacing. Another example is the manufacturing of carbon black from waste tyres that is further sold to countries like Botswana, Zambia, Swaziland, Lesotho, and Namibia. Carbon black is used to refill printer and photocopier cartridges. These few examples can be used as models and what is required is for the government to create enabling environment for more local entrepreneurs to join the effort.

Currently in South Africa, there is a provision for the Minister of Environmental Affairs and Tourism to identify waste tyre as a special waste in terms of the Environment Conservation Act (Act No. 79 of 1989), section 24 (c) which state that " Minister may make regulations with regard to waste management, concerning the classification of different types of waste, handling, storage, transportation and disposal of such wastes". However, local governments, whose responsibility is the provision of waste management services in terms of the Constitution of the Republic of South Africa (Constitution of RSA, 1996) continue to refuse to accept waste tyres at their disposal sites. The main reason is that, disposing whole tyres create problems that lead to the development of air pockets within a tyre when land filled. That situation will enable waste tyres to float to the surface of the landfill due to earth's movements and thereby spoil the landscape that would have been expensively developed as required by the Disposal Permit Conditions once the lifespan of the site has been exhausted (DWAF, 1998). Furthermore, shredding waste tyres into shanks is expensive and waste generators are not prepared to pay for the service. The option of shredding waste tyres into small chunks for disposal into the landfills is feasible, but due to lack of incentives, policy directives and enforceable legislation, there is no institution that is prepared to go that route because it is expensive to cut a rubber like tyre. Waste rubber shredding merchants estimate cost of shredding a passenger motor vehicle tyre at about R10-00. Subsequently, illegal dumping is the cheap route, hence waste tyres are dumped illegally in the open and perpetrators are not followed (SATMC, 2005).

Also at the helm of waste tyre management problem is the uncontrolled burning of waste tyres in order to recover the steel strap (SATRP, 2008). Although, this could be regarded as a wealth creation route for waste tyre utilization, the manner in which the process is carried out negates the created wealth. In the process, waste tyres are burnt in open veld with the release of toxic and other ozone depletion gases into the atmosphere. The Air Quality Management Act No. 39 of 2004 is not enforced sufficiently to curb the situation. The uncontrolled burning at low temperatures usually below 200 degrees Celsius results in the generation of dioxins, excessive carbon dioxide, sulphur dioxide, furans, nitrogen oxide, etc. Usually, huge black smog is created which is unsightly and can impair visibility of motorists.

In the City of Cape Town in South Africa, a committee tasked to combat indiscriminate burning of tyres has been established due to many reported cases of waste tyre burning. Municipalities are expecting the National Government to enact a legislation that will deal specifically with waste tyres. Adding to the complexity of waste tyre management, disturbing findings are that increasing number of waste tyres are re grooved and re-introduced into the supply stream. These tyres do not have the required thread depth as required by law in terms of the South African Bureau of Standards (CSABS, 2005), but are made to appear legal by re grooving.

The National Department of Environmental Affairs and Tourism (DEAT) is in the process of developing Waste Tyre Regulations that would be expected to:

- Control the stockpiling
- Control illegal dumping
- Regulate storage
- Provide guideline for the management of waste tyre facilities, e.g. waste tyre storage sites, waste tyre recycling sites, etc.

In the absence of proper regulation, waste tyres continue to pose environmental, health and transport risks to man.

Lessons can be drawn from developed countries such as the US, UK, Japan, Sweden, Finland, Denmark, Germany, Australia and Switzerland on the applications of used or waste tyres. Waste tyres can be utilized to yield many uses and create other products like energy, rubber, fuel and so on. However environmental policies and legislations must be sound, applicable, provide for development and be enforceable such that the processes employed do not degrade the environment. South Africa has developed a White Paper Policy on Integrated Pollution and Waste

Management (DEAT, 2000) that can be implemented given the required economical and political support. Subsequently a Waste Management Strategy intended to deliver on the policy was developed by Danish consultants through Danida funding. The strategy could be said to be hypothetical and lack reflection of the realities of South Africa. The Strategy is seen by many as technology transferred without adaptation to the existing realities. South Africa is a developing country with policy and legislative challenges regarding waste management. The integrated implementation of the strategy could be very costly and unachievable; hence implementation is not sequential and coordinated. The environment and the economy are inseparable elements and sustainable development is founded on economic growth and the protection of the environment. Waste tyres have many uses that can create jobs and stimulate economic growth in developing countries. It is important to note that polymeric materials do not decompose easily and as such poses the most challenge in terms of disposal when they are waste (Sieve, 1996).

1.2 Waste Tyres

A tyre is a continuous pneumatic covering encircling a wheel, made of natural rubber or synthetic rubber or a combination of natural and synthetic rubber, whether new, used or re-treaded. It is made of the following compounds which are rubber, carbon black, silica, metal, textile, zinc oxide, sulphur, copper compounds, cadmium, lead and lead compounds, organic halogen compounds and some additives like solvents, age resistors, vulcanizing agents, softeners, fillers and processing aids in varying proportions depending on whether it is a car or truck tyre (UNEP, 1998). According to Basel Convention (UNEP, 1999), a waste tyre is considered a hazardous material and is included in Annexure 1 of the hazardous material, because it contains about 1.5% by weight of hazardous substances.

Table 1: Some hazardous substances found in Tyres

Chemical Name	**Remarks**	**Content (% weight)**	**Content* (Kg)**
Copper compounds	Alloying constituent of the metallic reinforcing material (steel cord)	Approx. 0.02%	Approx. 0.14g
Zinc compounds	Zinc Oxide, retained in the rubber matrix	Approx. 1%	Approx. 70g
Cadmium	On trace levels, as Cadmium compounds attendant substance of the Zinc Oxide	Max. 0.001%	Max. 0.07g
Lead and Lead compounds	On trace levels, as attendant substance of the Zinc Oxide	Max. 0.005%	Max. 0.35g
Acidic solutions or acids in solid form	Stearic acids in solid form	Approx. 0.3%	Approx. 21g
Organo-halogen compounds other than substances in Annex to the Basel Convention	Haloge GroupWise.lnk n butyl rubber	Content of halogen Max. 0.10 %	Content of halogens Max. 7g

***Estimated for a 7 kg car tyre. Source: (UNEP, 1999).**

Hazardous waste by definition is a special type of waste that requires specific management procedures (DEFRA, 2005). South Africa, though is a signatory to Basel Convention is not managing waste tyres as hazardous waste, hence a need to research into the problems of waste tyre management in the country.

Table 2: Materials Used in the Manufacture of Tyres

Natural Rubber	Natural rubber is predominantly obtained from the sap of the *Hevea brasilensi* tree	Natural rubber accounts for about 30 – 40% of a car tyre and about 60 – 70% of a truck tyre
Synthetic rubber	All synthetic rubber are made from petrochemicals	Synthetic rubber account for about 60 – 70% of a car tyre and 30 – 40% of a truck tyre
Steel cord and beading including the coating materials and activators, copper/tin/zinc/chromium	The steel is premium grade and is only manufactured in a few plants around the world due to its high quality requirements	Steel is used to provide rigidity and strength to the tyres. It accounts for 15% of the weight of a car tyre.
Other reinforcing fabrics	Predominantly derived from petrochemicals	Used for structural strength and rigidity. It accounts for 5% of a radial tyre.
Carbon Black	Derived from petroleum stock	It provides durability and resistance against tear and wear. It accounts for about 28% of a car tyre.
Zinc Oxide	A mineral	Zinc is added to provide resistance against UV degradation and vulcanization control. Zinc Oxide accounts for about 1.2 % of a passenger tyre.
Sulphur (including compounds)	Sulphur is used to vulcanize the rubber	Makes up about 1% of a passenger tyre
Other additives and solvents, age resistors,	The other additives are used in the various rubber	The additives make up about 8% by weight of a

processing aids, accelerators, vulcanizing agents, softeners and fillers	compounds to modify handling, manufacturing and end products properties	passenger tyre.
Recycled rubber	Recovered from used tyres or other rubber products	Used in some rubber compounds in the manufacturing of new rubber products and retread materials

Source: Adapted from (DEWHA, 2001).

1.2 Problem statements

Presently, waste tyres in the country could be regarded as constituting a menace to human and environmental health (Human, 2005). They are found in illegal dumpsites across the country which habour storm or rain water and thus constitute breeding haven for mosquitoes. They are burn for the generation of heat by people in rural areas, low income residential areas and informal settlements. It is widely known that such action will lead to the release of noxious gases such as the NOx, SOx, COx, dioxins etc into the atmosphere causing the atmospheric pollution.

It is estimated that about eleven million tyres are scrapped every year in South Africa. Unutilized or improper disposal of these substances present a major ecological hazard since they are not biodegradable and disposal is a serious challenge since most landfills do not accept them. As a consequence, waste tyres litter the countryside and are often burnt to recover the steel strap by poor and unemployed people. This situation is compounded due to the absence of effective legislation to guide, control and regulate the disposal, storage, utilization and recycling of this “waste” in the country.

These problems can be ameliorated and possible turned into human and environmentally beneficial products through appropriate societal and governmental intervention. Hence, it becomes imperative to investigate root cause of these problems and deduce ways by which they can be mitigated.

1.3 Research Motivation

Waste tyres, when neglected or injudiciously managed can have serious social impacts to communities. The impacts of waste tyres on social well - being of communities ranges from being a nuisance, unsightly, cause health problems when ignited and the fire generated is difficult and costly to extinguish. Socially communities do not see waste tyres as their responsibility and as such are not willing to interfere with them. Unscrupulous traders sell waste tyres as second hand tyres and the results are fatal accidents and deaths. Some community members burn the waste tyres to warm themselves during winter months and care less about the problems that result from their actions due to ignorance.

On the contrary, waste tyre is a resource that has multi-uses that are not well researched and accorded the benefits they can provide in South Africa. Coal, which is widely used in South Africa, is highly contributing to the Global Warming due to its high carbon content that creates carbon dioxide and carbon monoxide (CO) in chemical reaction and that is a major contributor to the green house effect. Major industries are emitting more than they are supposed to in terms of Air Quality Management Act, No. 39 of 2004. It is important that utilization of coal, which is one of the main culprits as a source of greenhouse gases and ozone layer depleting substance is minimized in South Africa. Waste tyres are successfully used by developed countries in various applications and viable industries have developed therefrom, however their use in South Africa is very minimal. It therefore becomes imperative to find out why South Africa is not deriving the benefits from the waste tyres as the developed countries. It is equally important to investigate the possibility of generating new uses for waste tyres, which are peculiar or indigent to South Africa.

Coal that is widely used in South Africa contains twice the fixed carbon that is in the Tyre Derived Fuel. Furthermore, coal is a finite natural resource that is being depleted. The rubber crumbs from tyres will also replace quarried gravel materials that are also finite, difficult to find and also expensive to quarry and transport. The resultant benefit of rubber crumbs will be the likely reduction in road noise through absorption of sound by the rubber layer. Rubber crumbs derived from recycled tyres are also used as additives to the bitumen to increase the durability of the surface layers of roads and pavements structures. Rubber crumbs also increase the braking and gripping efficiency of motor tyres when used on roads. Job creation from waste tyre collection, transportation, recycling and applications of the recycled products will positively improve the economic activities in South Africa. It is very critical that the benefits of waste tyres are thoroughly researched and all the valuable information brought to the fore for public information that will assist in business decisions while also addressing environmental and social problems posed by waste tyres.

1.4 Aims and Objectives of the Research

The aims and objectives of the research project are:

- To critically identify environmental, socio-economic and legal factors that contribute to the failure by the markets or institutions to develop or support the sustainable management of waste tyres for use in recycling and for energy generation purposes.
- In the process attempt to develop a “Model” that will stimulate waste tyre management in developing countries.
- To identify opportunities for job creation from waste tyres.

The most important aspects to consider in this objective are:

(a) The impacts of waste tyre management problems on the environment. Emphasis will be based on the studies, interviews, observation and existing findings. The environmental impacts play a very critical role especially on the World Trade Organization (WTO) as South Africa is a signatory. Participating countries are required to adhere to stringent environmental standards like the Rio Declaration and the Earth Summit, also the commitments of World Summit on Sustainable Development held in South Africa, Kyoto Protocol and the ISO 14000. This pertains to products that will be developed from the waste tyres.

(b) Economics of the waste tyres. A waste tyre has no economic or commercial value attached to it currently in South Africa while it has economic value in developed countries. For a waste tyre to have value its economic or commercial use must be developed through stimulation of the market forces. There are several ways to stimulate the economic value and create the markets. One of the ways is the subsidies to waste tyre disposal companies to create the markets. For example, in the United States, companies that are recycling waste tyres are provided with a grant to commission sustainable plants like electricity generation from waste tyres and tyre derived fuels (TDF) and that create markets for waste tyres. The second way is the disposal fee paid by the generator of waste tyres. The other way is the taxation of waste generation when enforcement is not practically executed. A portion of the levies collected either by disposal fee or taxation is used to promote the technologies that address waste tyres and as such markets for waste tyres are being developed and expanded. In South Africa, an example can be cited from the plastic bag levy that is intended to fund and promote plastic recycling.

(c) Legal implication of waste tyres. In terms of legal capacity in developing countries to enforce compliance of waste management where poverty is the order of the day pose a very serious challenge. South Africa, like many developing countries is confronted by many challenges ranging from health, food security, education, industry development (technology), housing, water, sanitation, etc. and least attention is however given to the environment. There are no environmental courts where environmental violations are tried. Waste tyre is a special type of waste and requires a special management procedure for example storage and handling of waste tyres to be considerate of fire hazard management, have sufficient drainage so that it does not provide a breeding ground for mosquitoes. This procedure should be backed by enforcement and supported by legislative imperatives.

- Provide long lasting potential opportunities in the waste tyre recycling industry. Potential opportunities that could arise from the recycling of waste tyres will be looked into and the findings made available to potential investors. Products that could be made from the recycled waste tyres will be researched. The important consideration in this case will be sustainable use in the recycling industry. Research will focus on why the usage of waste tyres in the recycling industry is not sustainable.
- Provide information on the possible use of waste tyre for business (medium and large scale) development.
- Usage of waste tyres in an environmental, economic and socially friendly manner will be investigated and the findings made known.
- Highlight the pollution problems posed by indiscriminate and illegal dumped waste tyres in the country.
- It is the most important anticipation that solutions discovered or researched will result in the approach that address pollution from waste tyres that plague our country.
- To suggest ways by which waste tyres could be turned into valuable resources.

1.5 Research Hypothesis

The approach to waste tyre management in South Africa should be to encourage the development of an innovative tyre recycling industry that creates a demand for waste tyres, give them value and develop sustainable markets. In commercial perspective, the ultimate objective of South African strategy should be to develop a strong diversified industry capable of using all waste tyres generated in the country from various applications. At the moment however, there are no economic incentives for collectors and recyclers of waste tyres, hence a failure in the process industry to access waste tyres to develop products. In essence, appropriate Waste Tyre Management in the country should involve a high percentage of waste tyres being recycled and or used as energy source.

Hence it is hypothesized that:

(a) Socio economic factors contribute to the problems of waste tyre management in South Africa.

(b) Environmental and legal factors also contribute to waste tyre management problems in South Africa.

(c) Waste tyre utilization and recycling will reduce environmental pollution as well as create wealth and economic development.

CHAPTER 2

2.1 Review of Literature

The starting point to the understanding of the complexity and challenges of waste tyre management is by providing a general overview of the past and existing information with regards to waste tyre utilization both nationally and internationally. This will show or indicate the gaps that exist so that possible solutions and recommendations can be provided. Generally, research work into the menace of waste tyres has largely focused on the economics and Law of Disposal of Solid Waste (Stedge, 1996). Stedge (1996, p43); cited paper by Fullereton and Kinnaman (1995) that where enforcement is assumed to be non-feasible for municipal waste disposal, a subsidy than tax as an economic instrument for disposal companies where illegal disposal is a possibility, is found to be more efficient and effective. Dinan (1992), cited by Stedge (1996) discusses the potential effects of a disposal tax and reuse subsidy. Under this policy, producers will be taxed according to the cost of disposing the waste emanating from the goods they produce. In South Africa, disposal companies are costing disposal of waste based on the distance to the disposal site and the cost of landfill operation. However, hazardous waste disposal is additionally charged for the hazard rate and the treatment method used .

In relation to tax, companies that use recycled material receive a subsidy. This programme can be expensive to implement for all products, hence may be used to target specific problematic waste streams like waste tyres (Rudolph, 1995). In South Africa, there are no tax incentives for using recycled material (DEAT, 2008). At the moment, discussions are on-going between the government and the private sector regarding the tax incentive for the use of recycled material; however legislative reform has taken effect to a certain level. A reference is made specifically to the amendment of Environment Conservation Act, 73 of 1989 (Amendment of section 24 i.e. insertion of section 24(i)). The section give effect to the imposition of compulsory charging, deposit or related financial measures on waste streams or specified items in waste streams by Minister of Environmental Affairs with the concurrence of the Minister of Finance. It is important to note that demand for recycled products is dependent on:

(a) **Price**: In most cases recycled products are more expensive than virgin products. For example, the 1993 price of recycled paper in Central Pennsylvania was $10.35 more per cartoon than paper produced from virgin pulp (Stedge, 1996). In reality, the opposite is expected to hold.

(b) **Environmental conscience:** In countries where awareness on environmental issues is high, people tend to take convictions to support initiatives that persuade environmental cause like recycling. People feel that it is through their actions and activities that the future generations will inherit the environment that is habitable.

(c) **Perception associated with recycled products:** There is a perception, especially in developing countries such as South Africa that recycled products like recycled paper, plastics and glass are of poor quality. This could be true in some cases, because some recycling companies do not perform quality assurance checks on the recycled products and thus are assumed to be of lower quality. There is a need for recycling industry and standardization institutions to change this perception and ensure transparency with respect to quality checks that are carried out on recycled products.

2.2 Recycling of Waste Tyres

Recycling of waste tyres is a business like any production process where economic efficiency is central to sustainability (Sharma, et al., 2000). Environmental consideration is another integral factor, although it is not the sole driver of the initiative. Energy or resource economics might be the determinants of resource recycling. In the interest of the environment, governments are putting measures to integrate environmental management into the production process of all business initiatives (Scott, 1998). As a result, reuse and recycling of resources is not by choice but in the interest of environmental protection. Consequently, recycling of any material in a sustainable manner requires the critical consideration of:

(1) Economic growth and

(2) Environmental protection

It is crucial that a balanced between these considerations is attained. The use of cost – benefit analysis in environmental policy can be used to strike a balance between the economic growth and environmental management. International trends show renew use of cost benefit analysis (Rudolph, 1995). Whenever a government choose a method of recycling, economic efficiency is key in the decision. Economic efficiency is categorized as follows:

(a) **Allocative efficiency**: Companies produce products where marginal social cost of production equals the marginal social benefits. Allocative efficiency is at the equilibrium price where suppliers of commodities like recycled waste tyre products are enticed to just supply enough to get the market cleared as the products are being sold. The supply balances the demand hence; there is no noticeable surplus or shortage.

Critical economic considerations in this efficiency are surplus and shortage. These are the most poorly understood and misused terms. Surplus exists only when the price of a commodity is too high to clear the market. That means the commodity suppliers are willing to sell at that price which exceeds the quantity demanded at the price. Shortage exists when there is an excess demand for a commodity in a market. Excess demand can be caused by either the price of the commodity being too low or positive change in consumption pattern for a commodity. Positive change may include the diminishing of substitutes in the market place, health choice consciousness, and sudden economic improvement of the communities.

Surplus and shortage can be eliminated when the price of recycled products is accordingly adjusted as follows:

Surplus can be eliminated when the price of recycled products is reduced to a market clearing level and the shortage addressed when the price of recycled products is increased to the market clearing level. In these circumstances, equilibrium will be achieved when available commodities will be distributed to the available capable buyers. In essence, the price determines the resource allocation function. This is illustrated in Figure 1 as shown below.

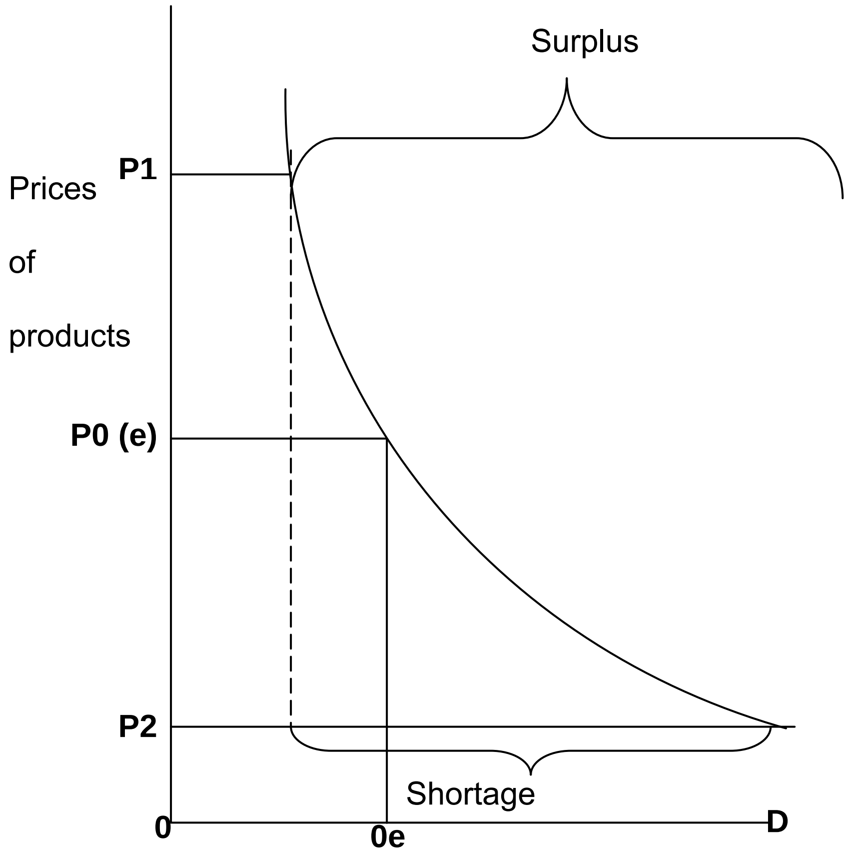

Figure 1: Surplus and Shortage vs the price of products

(P= price; P(e) = price at equilibrium (no shortage or surplus at that price); D= demand at varying prices)

Whenever the price exceed P_0, as shown by P_1, there will be surplus and consequential when the price fall below P_0, as shown by P_2 there will be shortage

(b). **Cost efficiency**: Companies produce at the lowest possible point of production given the environmental considerations. In production economics, cost efficiency is relative to allocative efficiency in the sense that when the cost of production is high, suppliers of products would like to sell just at that high price and as a result will tend to produce just more products to be cleared at the market. The indication of the scenario is most likely to represent the surplus of products, because high cost will deter demand, hence surplus products. Economic efficiency theory inform us that companies always want to maximize return on income, meaning that less cost effective approach will always be sought and put into practice, so as to produce more products at that least price. Illustrated in Figure 2

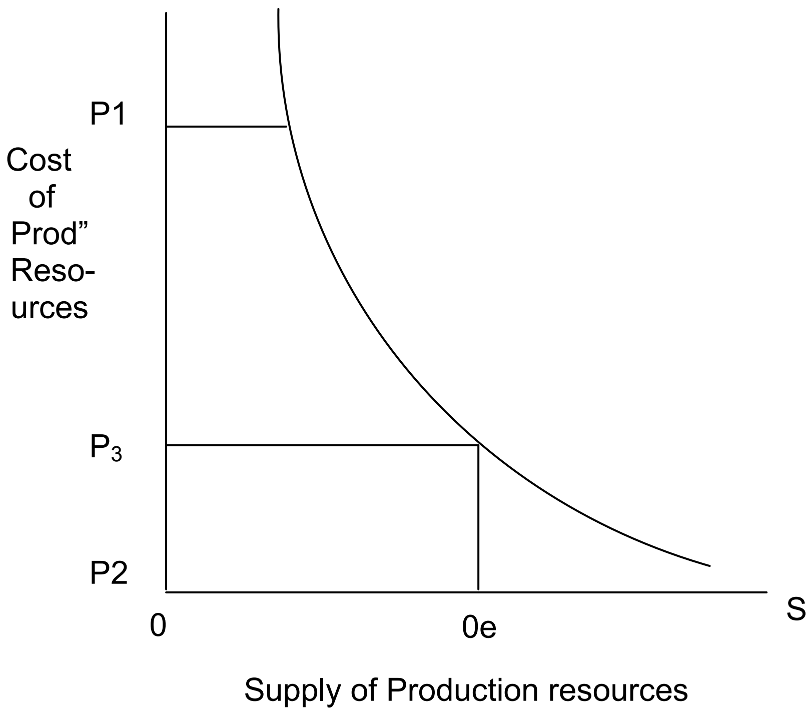

Figure 2: Allocative efficiency of Production Resources

(*P = varying prices; Supply of production resources at varying costs)*

When the cost of production exceed P_0, as shown by P_1 companies try to use the least cost combination of production resources until the maximum marginal cost and then either increase the price of the product or reduce production accordingly to sustain the business.

(c) Technological efficiency: Companies use the cheapest possible technology and at times not the cleanest technology. Efficient production is about maximizing utilization of resources to yield maximum desirable products. Whereby, any method of production that will maximize output and minimize costs using the best possible technology is seen to be technologically efficient. Cleaner production methods that yield benefits over time and are environmental sensitive are most often seen as the expensive technologies. For a technology to be efficient, it must be weighed in terms of economics and environmental management. Developed countries such as Denmark, Finland, Sweden, Japan, United Kingdom and the United States of America are developing more technologies that are efficient in both economics and environmental terms. Technologies such as “scrappers” (entrapping of particulates, compounds e.g. furans and SO_2 from incineration of waste tyres in cement kilns are seen to be cleaner technologies in terms of environmental protection.

There is no legislation in South Africa that encourage recycling; hence recycling of waste is voluntary and non–mandatory. Waste Tyre Regulation state that any person who undertakes an activity involving the re-use, recycling or recovery of waste tyres must, before undertaking that activity, ensure that the re-use, recycling or recovery of waste tyres to the extent that it is possible, is less harmful to the environment than the disposal of such waste tyres (DEAT, 2008). As a consequence, waste tyres stock piles continue to rise unabated. There are no systems in place to entice or compel the industry to recycle waste tyres, neither to look into the product designs so that they can be recycled. However, there are discussions taking place between the industry and the government to regulate stockpiling and the disposal of the waste tyres. Recycling of waste tyres is in the centre of the discussions. The main issue is that, if the industry does not realize benefits from recycling waste tyres, they will be reluctant to participate in the programme of recycling (Liaskos, 1994). Hence, it is crucial that government take the lead in creating conducive conditions for the creation of the markets for the recycled tyre products. Creating conducive conditions will require developing appropriate policies for example green procurement policy that encourage the use of recycled goods, legislative support and incentives to encourage participation by business. Incentives may include tax breaks for using recycled tyres, subsidies to encourage use of waste tyres and also preferential treatment for recycling waste tyres. The industry is also required to commit to social responsibility to ensure that the products they produce/ manufacture do not compromise the environment and impact negatively on the social being of the communities. The developed countries such as the United States of America recycle waste tyre to derive various products that are value adding. Some of these processes are as follows:

(i) Civil Engineering Applications

One of the fastest growing markets in the United States is the use of waste tyres in civil engineering applications (STMR, 1994). The process can be called physical application because the waste tyre does not undergo any chemical process where the structure (thermosetting materials) is broken down.

The waste tyre can be used whole or chipped in the following applications:

- Clean fill, gravel and sand. (Waste tyres are used as they are without physical or chemical processing). In this regard, waste tyres are used as light weight back fill, as road embankment fill, as leachate collection system and as septic field drainage material. Others include:
- Artificial reefs
- Floating Breakwaters
- Erosion control

- Silage production. Here tyres are used to hold plastic sheeting
- Landscaping. There is some use of waste tyres as a base for landscaping in raised garden beds and cascading rock gardens.
- As alternative landfill daily cover
- As thermal insulator along housing foundations

(ii) Ground Rubber Applications

Waste tyres can be processed into products known as ground rubber or alternatively called rubber crumbs. The crumbs can vary from particle size of about 18 mm to 150 microns. The use thereof would be a function of size and shape (Edwards and Smith, 1997). Large materials (12.5 mm to 18 mm) are used as cover material for play grounds, as soil conditioner and as synthetic turf. Larger size rubber particles (4- 16 mesh) are used in asphalt binding which is the largest market for ground rubber. Ground rubber in the 20 – 80 mesh sizes is incorporated into a wide range of manufactured products, including but not limited to mats and carpet backing. The ultra fine mesh e.g. 100 mesh and below is used in tyre manufacturing. This is the second largest market application for ground rubber. The following are notable applications for ground rubber:

- Road surfacing
- Rubberized bitumen and asphalt
- Incorporation into rubber and plastic products
- Molded and Extruded rubber products
- Synthetic turf
- Protecting coatings
- Industrial flooring

- Building materials
- Traffic guide posts
- Soil conditioner
- Production of new tyres

(iii) Chemical process applications

One of the serious challenges facing the environment globally is the disposal of rubber waste. Rubber, due to its chemical composition, does not decompose easily. A waste rubber need very long time (over 10 years) for natural degradation due to cross-linked structure and the presence of stabilizers and other additives such as fire retardants, colorants and plasticizers that are added to enhance product properties and performance (Adhikari et al., 2000).

The well documented and researched method of chemical processing of waste tyres is the Cryogenic process (Aldhikari et al., 2000). The rubber chips are placed into the liquid nitrogen for a specified period depending on the required particle size. The particle size of cryogenically ground powder varies between 30 to 100 mesh for most products (Adhikari et al., 2000). It has been found that up to 10 percent of cryogenically crumb rubber in the passenger and truck tyre compounds during manufacturing show some economic benefit. The economic benefit for the modest usage (5%) in passenger and truck tyres has been estimated at approximately $0.10 and $0.54 per tyre, respectively (Adhikari et al., 2000). At the 10% usage, the benefit almost doubles as shown in Table 3.

Table 3: Cost saving per tyre using cryogenically ground rubber

Percentage used	Cost saving ($)	
	Passenger tyre	Truck tyre
5	0.0980	0.5424
10	0.1861	1.0310

Source (Aldhikari et al., 2000)

Advantages of using Cryogenic process

- The cost of equipment is lower
- The cost of operation are lower due to lower capital outlay
- Not labour intensive
- The product has better flow characteristics due to its powdery nature than the ordinary ground rubber.

Other chemical reclamation of natural and synthetic rubber will involve diphenyl disulfide, dibenzyl disulfide, diamyl disulfide, butyl mercaptans, thiophenols, and disulfides. Most of the processes are patented. Chemicals used are both organic and inorganic in their characteristics.

2.3 Thermal technologies (applications) of treating waste tyres

2.3.1 Incineration

Incineration is a thermal waste treatment technology, because it involves combustion of waste at high controlled temperatures. Incineration of waste materials including tyres converts waste into heat that can be used to generate electricity, emit gases from the resultant combustion into the atmosphere as well as ashes residue. There are various general public concerns regarding the health consequences of incineration of waste. The major concern revolves around the emissions of toxic compounds such as dioxins, mercury, cadmium, nitrous oxide, hydrogen chloride, sulfuric acid, fluorides and particulates that can be inhaled and magnify or stay permanently in our lungs. They can cause an array of diseases like asthma and cancer. Incineration of waste in conventional terms means that when you burn something it goes away. Scientifically in physical law, we know that matter does not go away but change its state of matter. It is known that heavy metals like arsenic, lead, mercury, chromium and organic chemicals such as polycyclic aromatic hydrocarbons, dioxins and furans; radioactive materials are not destroyed by incineration.

They are however; vapourized and released through the smoke stack into the environment or alongside the ash coming out as waste causing the resultant ash to be toxic. The volume of waste is sometimes reduced but the material still remain hazardous. Incinerators in South Africa, like any developing countries are not yet compliant to the International Standards such as Directive 2000/76/EC of the European Parliament. There have been many non compliant cases investigated by Air Quality Management Inspectors of South Africa. In developing countries like South Africa, Botswana, and Swaziland cement kilns are not yet using scrubber process to address the toxic emissions into the atmosphere.

Waste tyres are not yet used in the cement kilns in the country although the industry is challenging the government to give them the opportunity to tap into the cheap waste. This will however, exacerbated the situation with a lot more toxic emissions into the atmosphere. The current situation is the use of low grade coal in the cement kilns. Gases such as dioxins, furans, sulphur-dioxide, nitrogen oxide, hydrogen chloride and carbon dioxide are emitted unabated into the atmosphere.

2.4 Incineration emission limit in South Africa

The emission limits from incinerators in South Africa is as presented in Table 4 below:

Table 4: Incineration Emission Limit (IEL) for some chemical compounds

Chemical Name	Emission limit	O_2 (%)	H_2O (%)
Average Dioxins and Furans concentration	80 ng/m³	No figure provided	No figure provided
Particulate emissions	180 mg/m³	11	0

Source: DEAT, 2004)

Furthermore, all emissions to the air other than steam or water vapour should be odourless and free from mist, fume or droplets. All pollutant concentrations should be expressed at 0º C and 101, 3 kPa, dry gas and 11% oxygen. Finally the capacity of smoke should not exceed 20%.

However the modern incinerators used in developed countries such as UK, USA and France have been synonymous with waste to energy technology in the sense that they are different from the older or earlier incinerators. They burn waste in modern boiler furnaces, capture the resultant heat to produce steam and electricity. They are also capable of reducing the volume of waste by 90%, depending on the use of the output and the waste composition. Modern incinerators have continuous emission monitors and air pollution control mechanisms and able to handle clinical and hazardous wastes where pathogens and toxins are destroyed by high temperatures.

Table 5: Emissions Limits set by the EC Directive on Waste Incineration

Compounds	Sampled periods	Daily permitted Average Values
Total Dust		10 mg/cubic meter
Total Organic Carbons		10 mg/cubic meter
Hydrogen Chloride		10 mg/cubic meter
Hydrogen Fluoride		10 mg/cubic meter
Sulphur dioxide		50 mg/cubic meter
NO2 (New or Large incinerators		200 mg/cubic meter
NO 2 Existing smaller incinerators		400 mg/cubic meter
Average values over sampled period	**30 minutes**	**8 minutes**
Cadmium and Thallium compounds (total)	0.05 mg/cubic meter	0.1 mg/cubic meter
Mercury compounds	0.05 mg/cubic meter	0.1 mg/cubic meter
Other Metalloid compounds (total)	0.5 mg/cubic meter	1 mg/cubic meter
Average values measured over 6-8 hours Dioxins and furans (in toxic equivalents)		0.1 ng/cubic meter

Source: EC Directive 2000/76

The directive required new incineration plants within the EU to comply by 28 December 2002 and existing plants by 28 December 2005. Incinerators are very popular in countries like Japan where land is very scarce as well as countries such as Sweden and Denmark which incinerates waste to generate energy for heat and power facilities to support district heating schemes.

Waste tyres are incinerated to yield the following by-products:

- Scrap metal and gypsum resulting from the control of sulphur dioxide emissions through the chemical process known as the scrubbers that ensures the chemical bonding (reaction) with escaping pollutants during the incineration process. Scrap metal is sold to industries in the steel business and gypsum to fertilizer industries to condition alkaline soils.

- Fly ash will be used by reclaiming companies to recover zinc sulphate, lead and cadmium for various applications like motor car batteries.
- The bottom part of the fly ash contains significant quantities of iron oxide that could be sold to cement kilns.
- The steam that can produce up to 11.5 megawatts per hour can also be sold to the local power generator or can be used for local heating systems.

Table 6: Concentration limits of some pollutants present in tyres

Chemical name	Max. concentration measured in the chimney
Cadmium and compounds (Cd)	0.05 mg/m³
Mercury (Hg)	0.05 mg/m³
Thallium (TI)	0.05 mg/m³
Chromium (Cr)	0.5 mg/m³
Beryllium (Be)	0.5 mg/m³
Arsenic (As)	0.5 mg/m³
Antimony (Sb)	0.5 mg/m³
Barium (Ba)	0.5 mg/m³
Lead (Pb)	0.5 mg/m³
Silver (Ag)	0.5 mg/m³
Cobalt (Co)	0.5 mg/m³
Copper (Cu)	0.5 mg/m³
Manganese (Mn)	0.5 mg/m³
Tin (Sn)	0.5 mg/m³
Vanadium (V)	0.5 mg/m³
Nickel (Ni)	0.5 mg/m³

Source: (UNEP, 1999).

The environmental activists (green movements) throughout the world are against the commissioning and operation of incinerators despite scientific findings that support the efficient and beneficial use of incineration in many cases. However, incineration is not always a perfect process, because toxic gases in many cases are emitted where operation is not appropriate.

Discussions in favour of incineration are enumerated below:

- The concerns over health effects of dioxins and furan emissions have been significantly reduced by advances in technology and stringent air emissions control.
- Modern incinerators generate electricity and heat that can be sold to electricity grid and can sell to district heating system or industrial customers.
- The post incineration ash residue has been found to be non hazardous and can be safely reused or land filled.
- In densely populated areas it is difficult to find land for a land fill.
- Incineration of clinical waste result in sterile and non hazardous ash.
- Countries like Germany, Sweden, Switzerland and Denmark rely on incineration to dispose of their post recycling waste**.**

Discussions against incineration are as follows:

- Modern incineration facilities cause environmental harm of similar magnitude to a modern engineered land fill.
- It is expensive to develop and operate a modern incinerator.
- Incinerators also emit heavy metal such as mercury, cadmium and lead that are toxic at very minute level.
- The end product of incineration must still be safely disposed of.
- There are still concerns by many about the health effects of dioxins and furans in the environment.
- Incinerator workers risk to pathogens and toxins in developing countries due to poor maintenance of the equipments.

2.5 Pyrolysis

This is a thermal technology process of degrading /combusting waste material at higher temperatures without the addition of oxygen or gases. It is an anaerobic process that can be optimized for the production of fuel liquids (pyrolyses). It produces fewer gases unlike other thermal processes where gases are produced in large numbers. It is a suitable process for tyre derived fuel if tyre burning is intended to yield fuel. A number of processes directly combust pyrolysis oils, gases and char. During the combustion of waste tyres by incineration, pyrolysis and gasification toxic substances like dioxins and furans are released while toxic metals are such as cadmium, chromium, beryllium, vanadium, zinc, manganese, nickel, selenium, tin and mercury are volatized. Other halogenated organic compounds e.g. carbon monoxide, hydrogen chloride, sulfur dioxide are also released into the air. Pyrolysis process produces both gas and liquid products. At lower temperature, it produces more liquid products while at higher temperatures, more gases are generated. The products from pyrolysis are usually burnt to produce energy. In some instances or through some technologies, the resources are converted directly to electricity while others create liquid or gaseous fuels.

2.6 Gasification

Gasification system involves heating/combusting materials with some addition of air, oxygen, hydrogen or some combination of these reactants. The composition of products of pyrolysis and gasification systems can be altered by the temperature, the speed of the process, the rate of heat transfer and the pressure. Products from gasification can be converted directly to electricity.

2.7 Geoplasma and Plasma Arc

A plasma arc operates on a principle similar to an arc welding machine in that an electrical arc is struck between two electrodes. The high energy arc creates a high temperature, highly ionized gas. The plasma arc is enclosed in a chamber. Waste material is fed into the chamber and the intense heat of the plasma breaks down organic molecules like oil, solvents and paint into their elemental atoms. In a carefully controlled process, these atoms recombine into harmless gases such as carbon dioxide. Solids such as glass and metals are melted to form material like lava in which toxic metals are encapsulated. The plasma arc technology does not involve burning or incineration or formation of ash. There are two plasma arc technologies: Plasma Arc smelter and Plasma Arc torch. Plasma arc melters have very high destruction efficiency. They can treat any type of waste with minimal or no pretreatment and they produce stable waste form.

The high temperatures produced by the arc convert organic waste into light organics and primary elements. Combustible gas is cleaned in the off gas system and oxidized to CO_2 and H_2O in ceramic bed oxidizers. The potential for air pollution is low due to the use of electrical heating in the absence of free oxygen. The Plasma Arc Torch has an arc struck between copper electrode and either bath of molten slag or another electrode of opposite polarity. The only difference with the latter is that the organic portion of the waste is retained in a stable leach resistant slag and the Air Pollution Control system is larger than other plasma arc systems due to the need to stabilize torch gases.

The major concern about the plasma arc technology is the reliability of the plasma torch technology and ensuring that gaseous emissions are kept to a minimum and cleaned before being released into the environment. However, plasma arc is a fairly new technology that is being researched and has not being applied to full scale. The technology use the heat generated by plasma arc to gasify, pyrolysis or combust the material depending on the amount of oxygen or hydrogen fed into the reactor. The process melts the inorganic part of waste and destroy the organic portion. Plasma arc is used to destroy hazardous waste and in the process renders the waste to non hazardous and beneficially reduce the volume of waste drastically between 67 – 99 % depending on the composition of waste stream (U.S SEAR, 2000). The technology has better safety benefits when compared to other conventional incinerators. This is due to the following reasons:

- It uses less air for combustion.
- Water cooled chambers allow better sealing, which reduces the risk of uncontrolled release of noxious fumes.
- Water cooling reduces the exterior surface temperature, which reduce burn and fire hazards.
- It also allows for faster shut down and a significant thermal capacitance for responding to unusual events.
- Rapid cooling and capture of the reaction products in the slag or in the off gas treatment systems reduce the opportunities for operator contact with hazardous material.
- It offers a single treatment for a number of different waste streams.
- Requires minimal pre waste treatment.

Disadvantages:

- It is still in research stage.
- It requires substantial initial investment in equipment and staff training.
- It requires air and water permits.

2.8 Legislative Review

2.8.1 South Africa

Environmental legislative development in South Africa, like in many developing countries in Africa and part of Asia are still at infancy that is being articulated. In the past, Environmental legislation focused more on nature conservation than waste management. Waste management in South Africa relied on the Environment Conservation Act of 1989 (DEAT, 1989). The Act addressed waste in a fragmented manner, in that some sections like section 20 of ECA, 1989 that addresses waste disposal facilities was being dealt with by the Department of Water Affairs and Forestry. The turning point was in 2000 when a white paper policy on Integrated Pollution and Waste Management (DEAT, 2000) was developed, through a consultative process called, Consultative National Environment Policy Process (CONNEP). The policy afforded the Minister of Environmental Affairs and Tourism, the latitude to further develop legislative instruments on waste management and pollution in South Africa (DEAT, 2000).

During the year 2004, DEAT published the Air Quality Management Act, No. 39 of 2004 which replaced the outdated Air Pollution Prevention Act No. 65 of 1965. The legislation list scheduled processes and set standards on emissions. Burning of tyres in an open space is prohibited, however the problem continues unabated due to the laxity and insufficient enforcement. In the year 2005, a new unit was established to reinforce compliance of waste and pollution directives. Training of enforcement personnel was carried out through the year 2005, 2006, and 2007 with assistance from the United Kingdom and the United States Environmental Protection Agencies (UKEA and USEPA) respectively.

In 2005, Environment Conservation Act of 1989, despite other amendments was amended with the insertion of section 24(I). The section give effect to the imposition of compulsory charging, deposit or related financial measures on waste streams or specified items in waste streams by the Minister of Environmental Affairs with the concurrence of the Minister of Finance (DEAT, 2005). This amendment is very important in the management of special wastes that may include waste tyres. South Africa, like the rest of the developed world may use the section to introduce waste tyre management fee. Until now in the year 2008, there was no promulgated legislation that addresses the management of waste tyres. In 2007, DEAT published waste tyre regulations (DEAT, 2007) for public comments. The regulations were published with a 30 days comment period ending 30 March 2007. The purpose of the regulations is to regulate the management of waste tyres by:

- Providing requirements for transportation, treatment and disposal of waste tyres.
- Providing requirements for the storage of waste tyres
- Providing for the regulatory mechanism for dealers handling waste tyres.

2.8.2 European Union

The European Union landfill directive, 1999/31/EC which outlawed land-filling of waste tyres from July 2006 from member states has played a significant role in ensuring that national waste management policies are developed. Member states are allowed the laxity to implement the directive in different ways. From the enactment of the directive, 10 member states in 2004 successfully recovered 90 % or more of their annual arising, 15 states recovered an average of 85% and the remaining 2 member states recovered an average of 80% (Fleck, 2006). The EU member states use the three legal instruments provided for in the directive to manage waste tyres. These legal instruments are as follows:

- Tax system
- Free market system and the
- Producer responsibility

- **Tax system**

The system under this legal instrument allow the state to levy the production of tyres, the levy then gets collected from the end user (customers). In simpler terms, the producer of tyres pay tax to the state and the tax is recovered from the clients or tyre users. The tax or levy is used in the organization of the waste tyre collection system and remunerate the operators in the waste tyre recovery chain (Fleck, 2006)

- **Free market system**

In this system, the state set legislation, objectives and targets to be met; however it does not designate who is responsible. As a result, all players in the recovery of waste tyres chain oblige to the conditions of the free market within the objectives and the requirements of the law. Cooperative agreements may strengthen compliance and enhance performance. Countries such as Germany, UK and Austria apply this system (Fleck, 2006).

- **Producer responsibility**

The principle allows the state to place the responsibility of addressing waste tyres on the tyre industry. The tyre industry should develop a transparent strategy and reporting mechanism to the designated authorities. Under the EC, tyre industry has formed an association known as the European Tyre and Rubber Manufacturers Association (ETRMA,2006). It is reported that fourteen (14) European countries operate under the system (Fleck, 2006). In this system, a cradle to grave principle is upheld wherein the manufacturer/producer of a product is responsible for it until it is finally disposed of.

2.8.3 United States of America

In the United States, a levy system is applied in all states. However the collection process differs from state to state. Tyre levy also differ from state to state which is shown in Table 7 below:

Table 7: Levies/fees charged on tyre production in selected US states

State	Fee charged	
- Alabama	No fee	tyre dealer pay county fee
Arizona	2%sales tax(max. $2)	tyre dealer collects
California	$0.25 per tyre	tyre dealer collects
Iowa	Part of $5 vehicle title fee	state collect
Minnesota	$4 on vehicle title transfer	state collect
Ohio	$0.50 per tyre	collected at wholesale level
North Dakota	New vehicle sales fee	state collect
Hawaii	$1.00 per tyre	importer pays

Source: (STMC, 2005)

Federal Assembly Bill 1843 established waste tyre programme in 1990. Amongst some provisions is the protection of public health, safety, and the environment by establishing technical standards and a permitting programme for waste tyre facilities which handle scrap tyres for storage and disposal. A Senate Bill 744 of 1993 established a waste tyre Hauler registration that became effective on 9 May 1996. The waste tyre Hauler registration is based on the manifest system where transporters of waste tyres have to get permit and report back on the quantity of waste tyre they are transporting and where they will be treated or disposed. The recipient of waste tyres must also indicate and report on how many scrap tyres were received, so that waste tyres cannot be dumped illegally during transportation.

CHAPTER 3

3.1 Environmental and Health Problems Associated with Waste Tyres

In South Africa, eleven million tyres are scrapped every year and only six percent are recycled (Human, 2006). Less than 20 percent of the waste tyres are used for mats, gumboots, feeding and drinking troughs for animals while the rest are dumped in the veldt (DACST, 2004). Developed countries, for an example United States of America generates about 290 million waste tyres per annum and only 2% of that waste goes to the landfill and the rest goes for various uses like Tyre Derived Fuel, Civil Engineering, ground rubber applications, making new products and some are exported (Goodyear, 1995).

According to (UKEA, 2004), an amount of about 475,232 tons of waste tyres was generated in UK annually. Thirty four percent (34%) thereof was recycled, twenty six percent (26%) reused, fifteen percent (15%) combusted as fuel, seven percent (7%) exported and six percent (6%) used in land fill engineering applications. Twelve percent (12%) of the total waste generated after all other applications was land filled. Under European Union (EU) whole waste tyres are not allowed to be disposed in landfills. After July 2006, the ban also extended to the shredded waste tyres (EU Directive,2000/76/EC)

3.2 Waste Tyre Problems

The following are problems that might be caused by waste tyres:

(a) Human health problems

Waste tyres can harbor disease carrying pests such as rats and mosquitoes. Mosquitoes can also breed in the stagnant water that collects inside waste tyres. In Southern Africa, the deadly disease likely to be transmitted by the mosquito is malaria while dengue and yellow fever that afflict millions of people in tropical regions like in South America is also transmitted by the mosquitoes (UNEP, 1998). The composition of tyres include hazardous chemicals like cadmium, lead and chromium which poses further risk to human health and the environment when disposed of inappropriately into the environment. This occur when the waste tyres are indiscriminately combusted.

(b) Fire hazard

Deliberate or unintentional fire problems emanating from tyre can be very difficult to extinguish especially when the pile is very huge involving about ten million waste tyres. Examples are those stored in the Meyerton area of Gauteng. Fire engines of Emfuleni District municipality on their own will not be able to contain the fire that might arise. As shown in the pictures taken in 2003 (see Fig 1), fire engines that assisted to put under control the flames of burning tyres came from City of Johannesburg, Vanderbijl Park, Vereeniging, Meyerton and Parys in the Free State. Most of South African municipalities, on many occasions do not have contingency plans to contain emergencies from tyre fire. When piles of tyres ignite, various environmental, health and social problems occur. Significant pollution such as thick, black, foul smelling smog from the burning rubber result. The smog from the burning tyres can cause a number of environmental problems such as:

Air Pollution: Complete combustion of a tyre, will produce carbon dioxide that contribute to greenhouse effects water vapour and inert residues that may contain sulphur dioxide. Incomplete combustion release dioxins and noxious gases (Hoddinott, 1997). Furthermore, the following substances: volatile organic compounds and hazardous air pollutants such as polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs), arsenic, cadmium, nickel, mercury, zinc, chromium and vanadium are released into the atmosphere.

Figure 3: Burning of waste tyres creating air and soil pollution; (Photograph by Researcher, 2003)

Water Pollution: Tyre combustion causes pyrolysis of the rubber, resulting in oily decomposition waste (Reisman, 1997). The oily discharge can flow into nearby streams, ditches and waterways or can leach into the ground water. In cases where water is used to put out the fire, chemical compounds like aromatic liquids and paraffin may be carried by the water. Then the used water needs to be treated, before it is disposed of, which does not often happen in practice (Hoddinott, 1997). The situation can pollute nearby streams or may seep into the ground water.

Soil Pollution: Residues that remain on the soil after a fire can have an impact on the environment in two ways:

- Immediate pollution resulting from decomposing liquid products penetrating the soil.
- Gradual pollution caused by leaching of ash and unburned residues (UK, Chemical Hazard Report, 2003).

Gradual leaching of oily discharge can occur and the toxic residues of the burnt tyre such as zinc salts can cause harm to fauna and flora (Humphrey et al., 1997). As shown in Figure 4 below, it will take some time for the contaminated soil to recover unless remediation and or rehabilitation measures are taken.

Figure 4: An example of polluted soil from waste tyre burning; (Photograph by Researcher, 2006)

3.3 POSSIBLE OPPORTUNITIES THAT CAN CREATE WEALTH AND JOBS FROM WASTE TYRES.

Given the favourable economic conditions in South Africa, that can be supported and facilitated through appropriate legislative frameworks, and the commitment through collaboration between the tyre industry and government, it is firmly believed that waste tyres have an inherent value that can be enhanced commercially to yield viable products and by products. Reviewed in detail, the recycling of waste tyre is considered in terms of economics and the hierarchy of environmental management alternatives which is Reduce, re-use, recycle and recover. However markets are key to the success and sustainability of waste tyre industry. The main markets for waste tyre are:

- **Cement Kilns**

Due to the better caloritic value of tyres compared to the low grade coal used in the cement industry, waste tyres are preferred. The metal strap in tyres adds iron that is required in the cement kilns which coal does not provide. This is another advantage of a waste tyre than coal.

- **Electricity Generating Utilities**

Waste tyres can also replace finite resource like coal. They have a better burning efficiency and heat value than coal. So they can be used in the power generating plants provided their collection is coordinated and there is a constant supply.

- **Paper and Pulp mills**

In the United States of America, Waste Tyre Fuels (Tyre Derived Fuels or TDF) are the most preferred fuel enhancement. North Carolina in the U.S is used as a case study where 5.4 million waste tyres would be used as supplemental fuel in pulp and paper mill boilers and cement kilns (Barlaz, et al., 1993).

- **Waste Tyre to Energy Recovery Plants**

The largest use of waste tyre is in the energy recovery, where the TDF is the main objective of waste tyre processing. U.S is leading the developed countries on energy generation from waste tyres (Sharma, et al., 2000).

- **Brick Making**

In brick making, waste tyres are utilized in the furnaces to create heat used to dry the bricks, so that more bricks are ready for use in shorter periods.

- **Boiler systems**

In the mining sector, where warm water is continuously used, waste tyre could be put in better use to heat water than the continued use of electricity which is in short supply in South Africa.

- **Road construction industry**

In South Africa, it is still a limited market, because waste tyre collection is not coordinated for continous market supply. Furthermore, there is no legislation that compels tyre centres to accept waste tyres, hence, are dumped illegally in the veld.

- **Miscellaneous industry**

Waste tyres are used in various applications such as under floor carpet, sport fields tracks, rubber turf, mats, drainage systems, shoe soles making, wheel burrow wheels, knee caps for mines, reclaimed rubber to replace virgin rubber in new tyre making, buffer rubber to retreat tyres. Pictoral representation of some applications of waste tyres are as follows:

Fig 5: Floor mat and turf made from waste tyres; (Source: picture taken from a local company, 2008)

Fig. 6: Rubber mats made from waste tyres; (Source: picture taken from a local company, 2008)

Fig. 7: Wheel burrows wheel from waste tyres; (Source: picture taken from a local company, 2008)

Fig. 8: Waste bins made from waste tyres; (Source: picture taken from a local company, 2008)

Fig. 9: Various products made from waste tyres; (Source: picture taken from a local company, 2008)

In South Africa critical factors that will stimulate/unlock entrepreneurship for waste tyres utilization include:

(a). Coordinated collection of waste tyres to ensure their availability whenever they are required.

(b). Sustainable markets of products made from waste tyres supported by demand and supply.

(c). Legislative support that will ensure that waste tyres are not used in polluting applications.

(d). Industry and government support to guide and enhance the initiative like in developed countries, where there is a levy system.

3.4 OTHER PRODUCTS THAT CAN BE PRODUCED FROM WASTE TYRES

There are over two hundred products that can be manufactured from waste tyres. The important ones can be enumerated as follows:

- Fabricated products

  Examples in this category are mat compounds, boots, shoe soles, rubber crumbs in road construction, dock bumpers, carbon black, reclaimed rubber for use in new tyre making, buffer products for use in reconditioned tyres, knee caps for use in mines, mine blasting bags, belts, gaskets, waste bins, wheel-burrow wheels and washers.

- Civil Engineering

  Examples of products in this category include road fills, landfill leachate collection systems, landfill cell daily covers, septic systems leach fields and crumbs mixed with asphalt in roads enhancement and construction.

- Agriculture

  In this category the following are examples Animals feeding and drinking troughs, farm dam walls and as fill in horse stables to create mat finish.

- Miscellaneous

  Other examples of applications are backyard swings, flower pots, tyre walls, race track crush barriers.

CHAPTER 4

4.1 RESEARCH DESIGN AND METHODOLOGY

4.1.1 Survey area

Sampling areas where the survey was conducted are Johannesburg, Ekurhuleni, Emfuleni and Tshwane municipalities within Gauteng Province. The latter is referred to as the commercial heartland of South Africa with the highest investment; population density as well as number of automobiles hence could be regarded as the most appropriate sampling sites for the investigation. These areas were carefully studied and selected as a result of the complexity and the magnitude of the problem. The standard practice in dealing with waste tyres was evaluated including waste tyres that are illegally dumped, stock piled and thrown into the veldt. Figure 11a illustrate the map of South Africa and the nine provinces that constitute the country while Figure 11b show the survey area within Gauteng province.

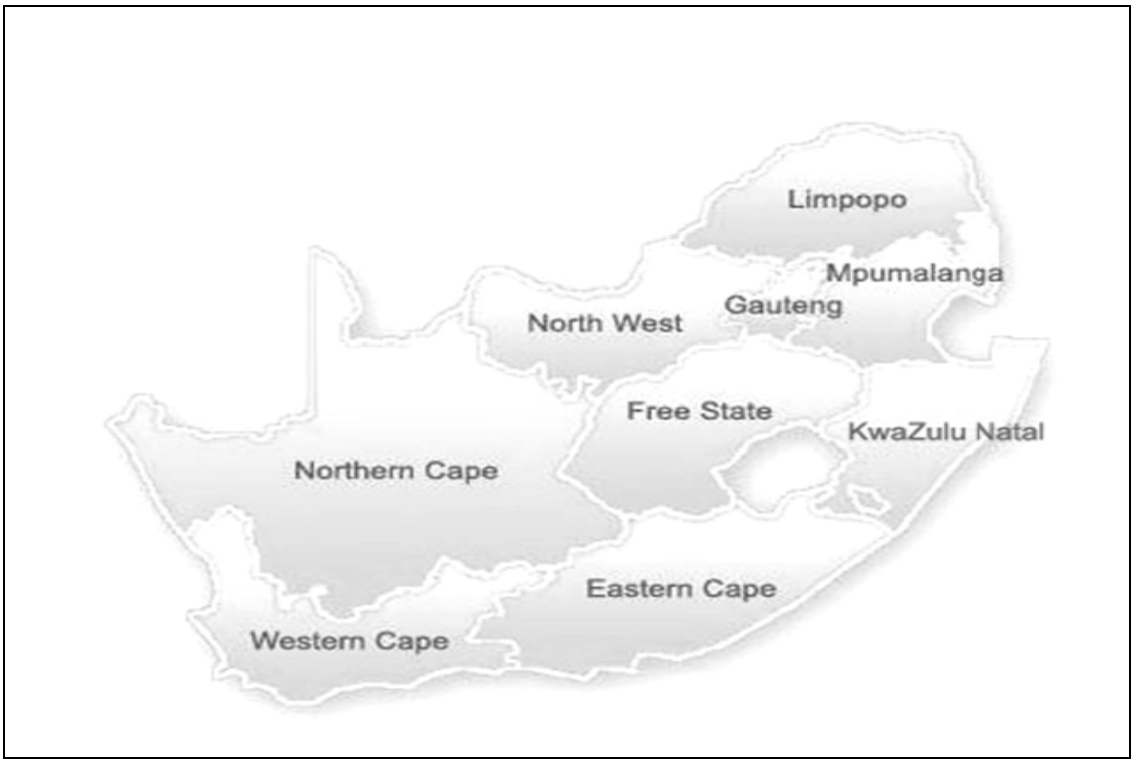

Figure 11a: Map of South Africa and the nine provinces

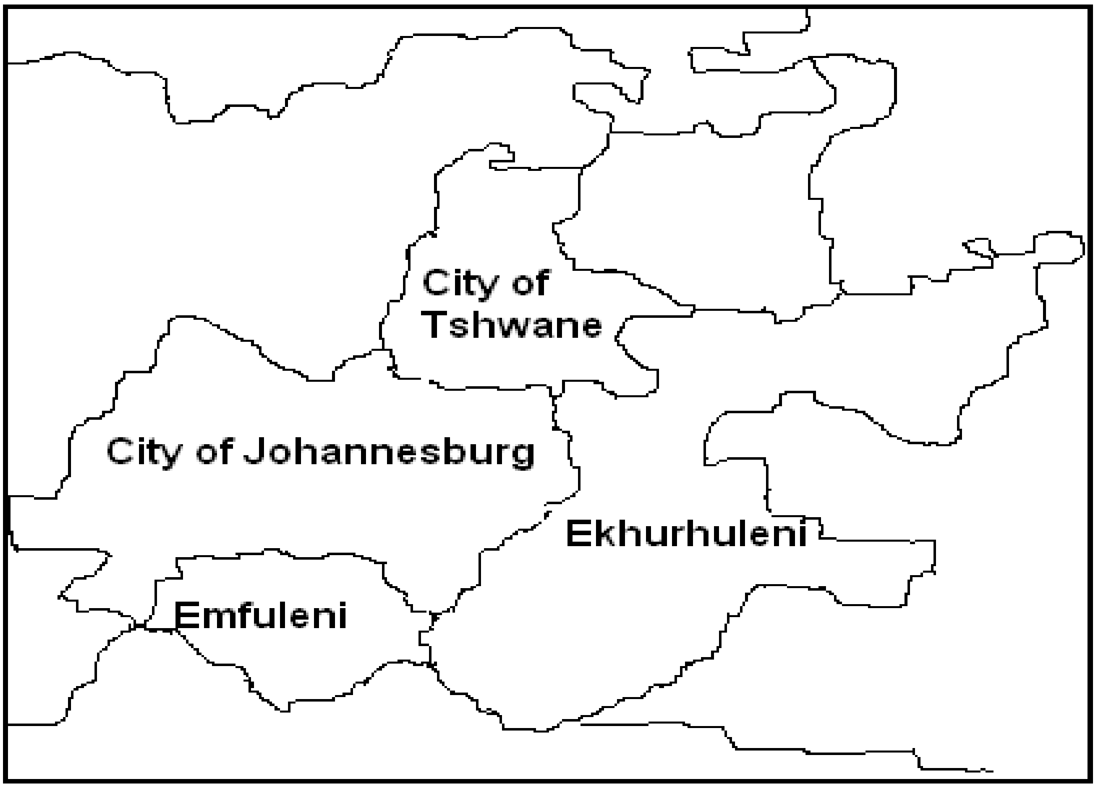

Figure 11b: Map of the survey area within Gauteng Province.

4.1.2 Research methods

Comprehensive research methodology approach involving visitation to selected areas in order to survey the complexity of the problems was used. This involves pictorial representation, interviews and the use of structured and validated questionnaire by a curriculum and learning expert. Questions that addressed waste tyre management issues and other indicators required to deduce and evaluate the problems were posed to one hundred and sixty (160) respondents that cut across four relevant groups. These include officials of relevant government departments e.g. Department of Environmental Affairs and Tourism (DEAT), community members, non-governmental organizations, reclaimers at selected landfills, private waste collection companies and workers association from the selected research areas. All questionnaires were personally collected from respondents.

4.1.3 Design of Questionnaire

The design of the survey questionnaire has been done in principle as follows:

A: The type of information that is required from the respondents was determined in relation to the objectives of the research study. An intuitive approach was used in terms of how the respondents should provide the answers. For example, single or multiple responses could be provided where the respondent gives one or more answers for a single question (see Appendix 1).

B: Questions were phrased in simple sentences and as simple as possible for adequate understanding by respondents. It is believed that understanding of the questions and the intention of the research are very vital to achieving the aims of the study. Technical and ambiguous words and phrases were avoided so that ordinary person can read and understand the questions.

C: Questions were arranged in a logical manner that allows sequential flow of questions and the intention of the researcher with respect to the aims of the study. Ideally, questions that are posed to respondents should be meaningful and relevant in such a way that the purpose of the questions and how they are linked to each other are revealed. In doing this, the direction of the study would be clear and allow the respondent to be at ease when answering and filling the questionnaire.

D: The questions have to be specific and unambiguous. The respondent should not guess as to what the researcher wants but has to understand the questions explicitly. It is however, important that after the questionnaire is designed and before distribution to the sampled group of sectors of respondents, it is weighed against the hypothesis being verified.

4.14 Validation of the questionnaire

It is very important for questionnaire to be used in a study of this magnitude to undergo validation. This ensured the acceptability and applicability of the research instrument. It also ensured the validity and correctness of the result obtained from the use of the tool. Subsequently, the questionnaire was sent to qualified personnel at the Institute of Curriculum and Learning Development (ICLD) of the University of South Africa. This was adequately scrutinize, corrected and validated for use as research instrument for the intended study.

4.1.5 Sampling

Sampling is a technique in interpolation used to rationalize the collection of information whereby an acceptable approach is chosen to collect the actual information. The instances or institutions where information was obtained are those that have frequent dealings with waste tyres. Not many institutions in South Africa deal with waste tyres. According to Leedy (1997), sampling is the process of choosing from a much larger population, a group which researchers wish to make a generalized statement so that the selected part will represent the whole group. The sample was therefore responsibly and sensitively selected so that a group of people being researched / studied is faithfully and truthfully relevant. It is critical that the selections of the groups in the sample are done correctly. It does not matter how best the collection of the data is, as long as the sampling is not correctly done, the generalization will not be accurate.

4.1.6 Data Collection

As mentioned earlier, the empirical instrument used for this quantitative research to gather the required data was the questionnaire. This was complemented with visual field observations and interviews by the researcher. One hundred and sixty (160) questionnaires were distributed to respondents in the identified research areas during October 2007. Collection and return of questionnaires spaned a period of 4-5 months (November 2007- March 2008) in order to allow for sufficient follow up time for receipt of completed questionnaires. Twenty (20) questionnaires were distributed to people and individuals representing the following categories or organizations:

1. Relevant government environment departments involved in waste management at national, provincial and local level.
2. South African Tyre Recycling Process company (SATRP) consisting of waste tyre recyclers, tyre retreaders, tyre dealers association, tyre manufacturers association, informal tyre dealers and cementious association of South Africa representing cement kilns.
3. Community members residing in the following municipalities: Emfuleni, Tshwane Metropolitan, Ekurhuleni Metropolitan as well as Johannesburg Metropolitan of Gauteng province.
4. Four Environmental Centers of non-governmental organizations in Ekurhuleni, Johannesburg, Tshwane and Emfuleni municipalities of Gauteng province.
5. Reclaimers at the landfills in Tshwane, Johannesburg, Emfuleni and Ekurhuleni municipalities of Gauteng province.
6. Private waste collection companies in Emfuleni, Tshwane, Johannesburg and Ekurhuleni municipalities of Gauteng province.

Respondents were visited one by one at their workstations, questionnaires fully explained including the purpose and their willingness to participate in the research. In order to ensure maximum follow-up and collection of completed questionnaire, collection of completed questionnaires was carried out physically by the researcher.

CHAPTER 5

5.1 RESULTS AND DISCUSSION

5.1.1 Data analysis

Out of the 160 questionnaires that were distributed to respondents, a total of 140 i.e. 87.5 % were duly completed and used for data analysis; hence 20 questionnaire could not be retrieved due to logistic reasons. Analysis of data were manually carried out and graphical representations was based on Microsoft excel.

Table 8: Distribution pattern of respondents from sampled areas

Sampling site	Frequency	Percentage (%)
Ekurhuleni	31	22.1
Emfuleni	24	17.1
Jo'burg	38	27.1
Tshwane	47	33.6

Table 8 showed the distribution of respondents across the sampled areas. It could be seen that Tshwane municipality recorded the highest frequency which was an indication of higher representation of this municipality within the sample size but not necessarily the size. Emfuleni municipality recorded the lowest frequency.

Table 9 below shows the frequency and participation by various sampled groups in the study. The frequency is an indication of the number of times a particular group of respondents featured in the sampling. It further indicates the size of participation by a group within the sample size which has a potential to influence the outcome of queries in the study. For example, the Table showed that respondents from waste collection companies, government departments, Tyre Dealers and recyclers recorded higher frequencies of participation in the sampled areas.

Table 9: Frequency and percentage participation by various groups

No.	**Sampled groups**	**Frequency**	**%**
1	Government	29	20.7
2	Community members & NGOs	29	20.7
3	Recyclers, retreaders & reclaimers	26	18.5
4	Tyre dealers	26	18.6
5	Waste companies	30	21.4
	Total	140	100

5.2 Waste tyres as nuisance to communities

From the result obtain in Figure 12 below, 126 respondents out of 140, representing 90 % concur that waste tyres are of great nuisance to the community while only 14 respondents which represent 10 % of the total did not agree with the assertion. Although, the 10 % could be regarded as small or marginal, it does signify the view of a group of people who perhaps are unemployed and thus benefit from the waste tyre through burning and recovering the inner metal for income purposes. It is pertinent to mention that respondents from the government (34.5 %) are of the opinion that waste tyres do not constitute nuisance to the public.

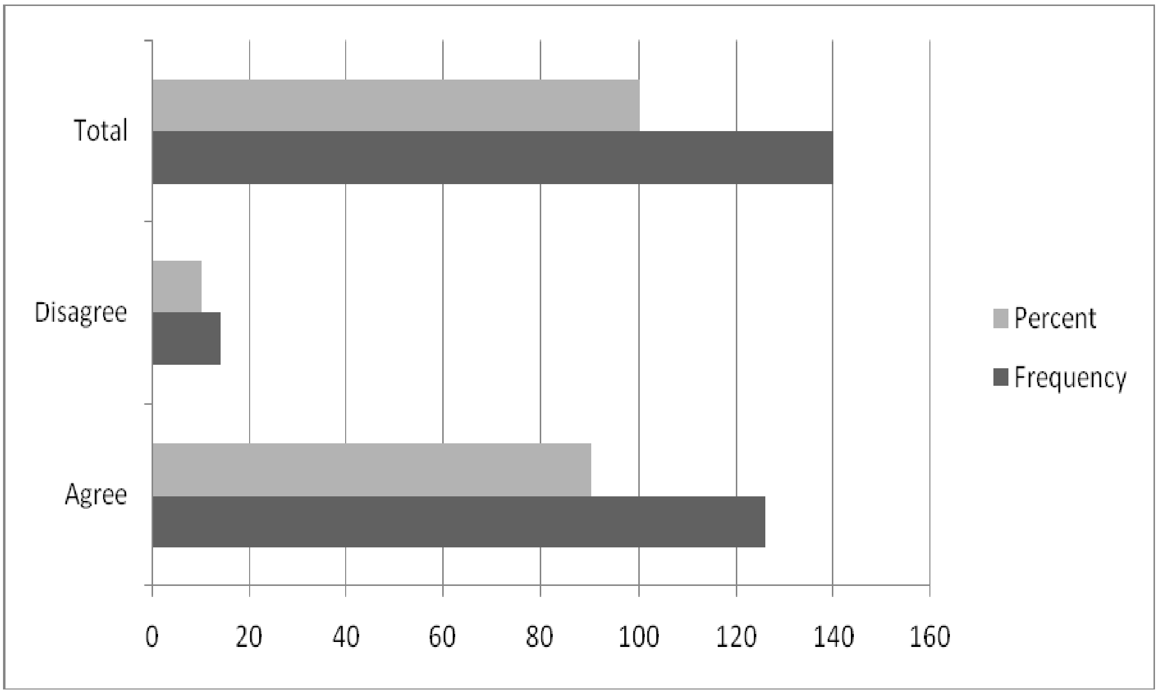

Figure 12: Distribution of responses on nuisance of waste tyres

Table 10 shown below illustrates varied responses by different sampled groups on the nuisance posed by waste tyres to their communities.

Table 10: Percentage (%) response on nuisance of waste tyres

	Group Type					
	National, Provincial & Local Governments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Agree	65.5	89.6	100	96.2	100	
Disagree	34.5	10.4	0	3.8	0	
Total	29 100.0% 20.7%	29 100.0% 20.7%	26 100.0% 18.6%	26 100.0% 18.6%	30 100.0% 21.4%	140 100.0% 100.0%

Most noticeable is the 34% which is higher compared to all other groups by a big margin considering that the lowest percentage is 0. It is interesting to note that only the surveyed group from government is of the opinion that waste tyres are not much of significant nuisance. However, considering all other responses from other groups in the sample, it is deduced that 90% of responses view waste tyres as nuisance to the environment. Only 9.7% of the overall responses believe waste tyres are not posing nuisance to the environment. Table 10 above illustrate percentage responses regarding whether waste tyres are a nuisance or not to the environment.

5.3 Severity of waste tyre problems in poor communities

The issue of uncontrolled and unregulated dumping of waste tyres is of great concern. This is due to the impact this will have on human and environmental health especially in poor and disadvantaged communities in South Africa. In Figure 13, an overwhelming 97.7% of the respondents acceded to the severity of the problems of waste tyres in poor communities while only 2.3 % of respondents disagree. Analysis also revealed general support of this assertion by the various sampled groups i.e. the tyre dealers (100 %), communities including NGOs (93.1 %) as well as the government (96.6 %).

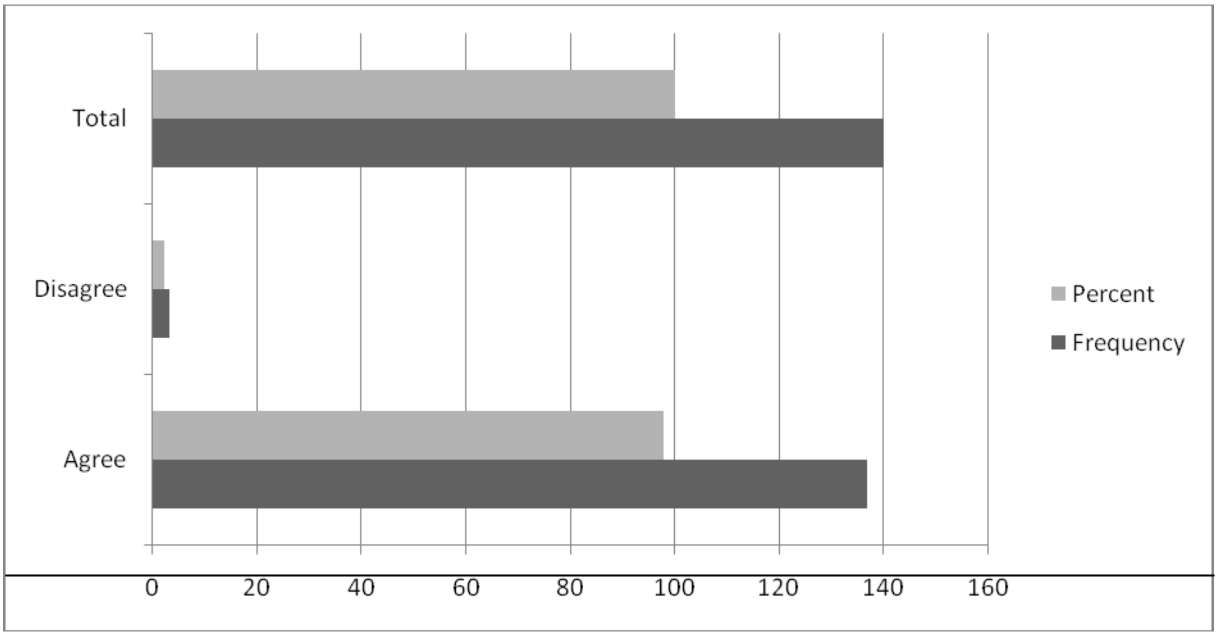

Figure 13: Responses on severe of waste tyre problems in poor communities

All groups in the sample overwhelmingly in excess of 93% agree with the assertion that waste tyre problems are severe in poor communities especially in areas where waste removal is erratic or non-existent. The problem is worse in informal settlement where waste management is a challenge. Views on the severity of waste tyre management in poor communities are illustrated in Table 11 below:

Table 11: Percentage (%) response on severity of waste tyre problems in poor communities

	Group Type					
	National, Provincial & Local Governments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Agree	96.6	93.1	100	100	100	
Disagree	4.5	6.9	0	0	0	
Total	29	29	26	26	30	140
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

5.4 Waste tyre as contributor to environmental pollution

The issue of climate change and global warming is very topical worldwide. Governments all over the world, who are also signatories to climate protection treaties such as Kyoto Protocol, are trying to prevent factors that might exacerbate the problem of global warming. It is generally recognized that several noxious gases such as dioxins, SOx, NOx etc are released into the atmosphere when tyres are burnt. Analysis of the results revealed that 88.6 % of the respondents are aware of the environmental pollution caused by poor waste tyre management through burning while 11.4 % of respondents are not aware. It was also found that most people within this 11.4 % are from the poor, historically disenfranchised communities. Visitation to some dump sites showed constant burning of waste tyres in order to recover the scrap metals which are to be sold for some income (see Fig. 3). The response is graphically represented in Figure 14 below.

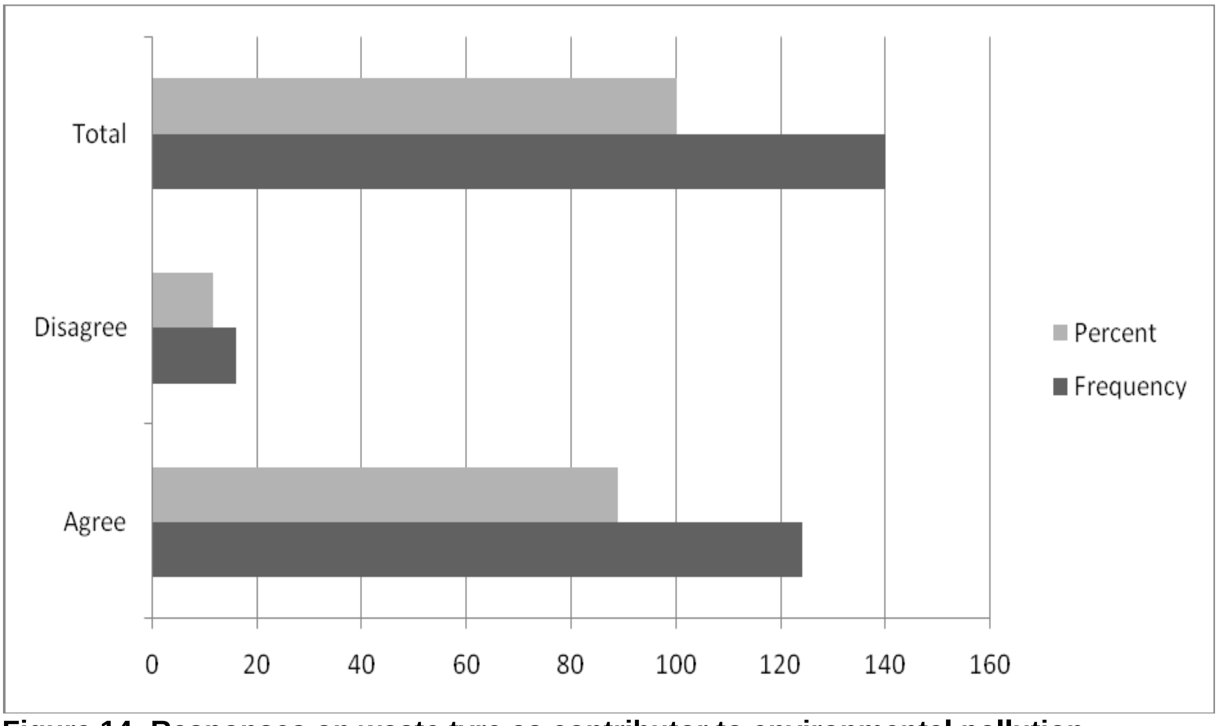

Figure 14: Responses on waste tyre as contributor to environmental pollution

On average all groups agree to the assertion that waste tyre is a contributor to environmental pollution. Government group, however believe that contribution to environmental pollution by waste tyres is not alarming when compared to energy generating facilities like power plants and petrochemical industry. Table 12 below illustrates percentage responses to the assertion of whether waste tyre is a contributor to environmental pollution or not.

Table 12: Percentage (%) response to waste tyre as contributor to environmental pollution

	Group Type					
	National, Provincial & Local Governments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Agree	65.5%	86.2%	96.1%	96.2%	100%	
Disagree	34.5%	13.8%	3.9%	3.8%	0	
Total	29	29	26	26	30	140
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

5.5 Legislation or legal framework governing the management of waste tyres

Societies are legally maintained through legislations, without which possibility of chaotic situation might arise. In this view, 90 % of respondents are unaware of any legislation or legal frameworks that address the issue of waste tyre management. The legislative awareness query with respect to this study was based on finding out if any of the groups are aware of any legislation that governs waste tyre management. Results obtained showed that 10.3 % of people in the communities and NGOs, 17.2 % from government departments and 19.2% of tyre dealers are unaware of any legislation regulating waste tyre management. It is pertinent to note that as at the time of this study, there was no specific legislative framework for waste tyres in existence but an Environment Conservation Act No. 79 of 1989 that generally address waste management. Figure 15 shows the responses with regard to legal framework governing the management of waste tyres.

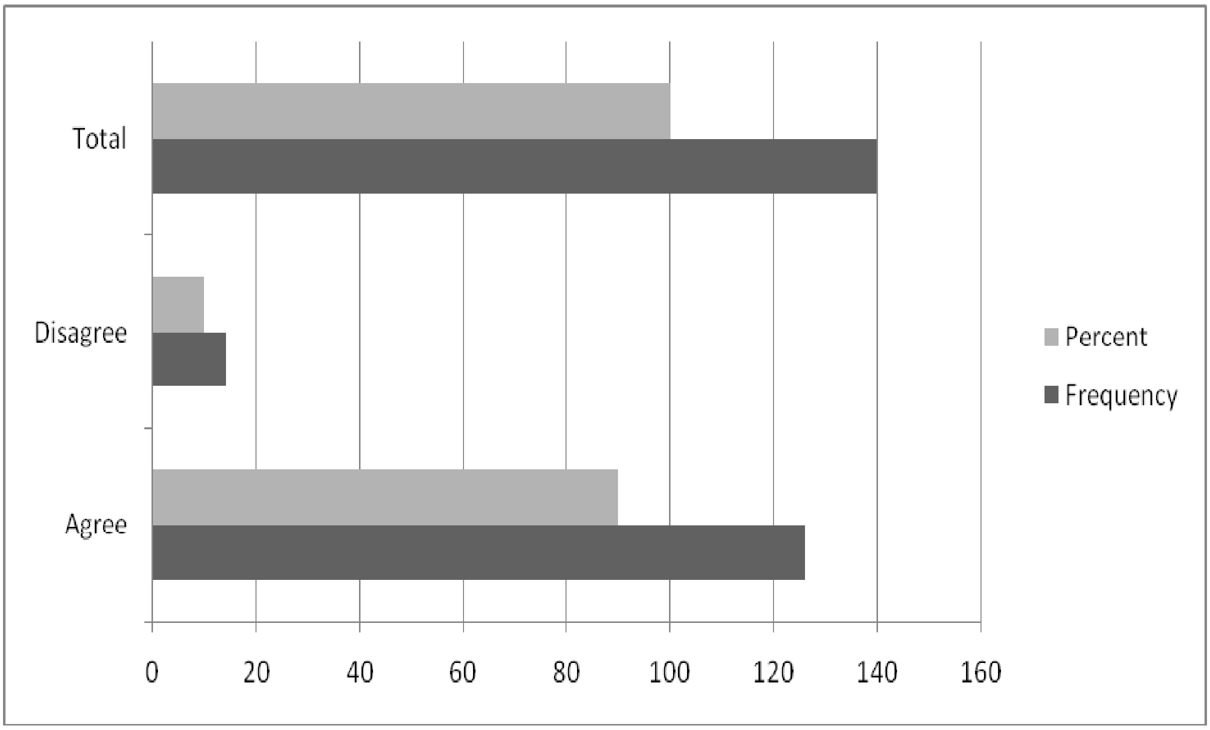

Figure 15: Spread of responses on legal framework of waste tyre management

It is interesting to note that 90% of respondents are not aware of any legislation that regulate management of waste tyres which include collection, treatment and final disposal thereof. Currently there is no specific guideline that direct the management of waste tyres. Table 13 below illustrate responses regarding whether communities are aware of legal framework on waste tyre management.

Table 13: Percentage (%) response on legal framework for waste tyre management

	Group Type						
	National, Provincial & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total	∑%/5
Agree	17.2%	10.3%	0.0%	19.2%	3.3%		10%
Disagree	82.8%	89.7%	100%	80.8%	96.7%		90%
Total	29.0	29.0	26.0	26.0	30.0	140.0	
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%	

5.6 Existence of government or community programme on waste tyre management

The intention of this query was to highlight the importance of the existence and participation of the private and government sector e.g. tyre industries including the retreaders, recyclers and importers in waste tyre management with the support of the government from the results obtained, Ninety two point nine percent (92.9 %) of respondents are not aware of any programmes that are either community, private or government based which sought to address the issue of waste tyre management in the country. Figure 16 reflect the responses.

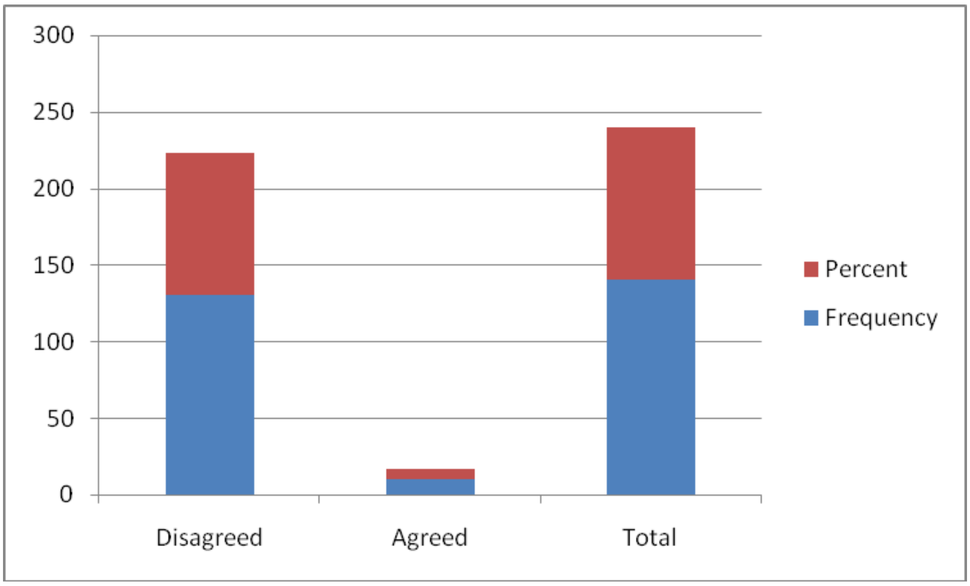

Figure 16: Range of responses on government or community programme on waste tyre management

Over 93% of responses believe that community or government driven programmes to address management of waste tyres do not exist. Of importance, government group overwhelmingly with 93% does not agree that there are government or community programmes to support management of waste tyres. Table 14 below illustrates percentage response to the statement.

Table 14: Percentage (%) response to government or community programme on waste tyre management

	Group Type						
	National, Provincial & Local Governments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total	∑%/5
Agree	6.8%	17.2%	.0%	7.7%	3.3%		7%
Disagree	93.2%	82.8%	100%	92.3%	96.7%		92.8%
Total	29	29	26	26	30	140	
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%	

5.7 Environmental pollution reduction through waste tyre utilization and recycling

Recycling and indeed the '3Rs' concept has become a global issue that is being encouraged by all nations. Recycling and generation of other beneficial products from waste tyres will definitely contribute to the reduction of global environmental pollution. Results obtained from respondents revealed that 93.6 % are in support of this concept. It is believed that this positive result was based on the concern of the pollution to the atmosphere caused by the burning of tyres and the charred remain that litter the environment. Respondents from government department, tyre dealers and the community members all supported the issue of recycling in the following order 96.6 %, 92.3 % and 96.6 % respectively.

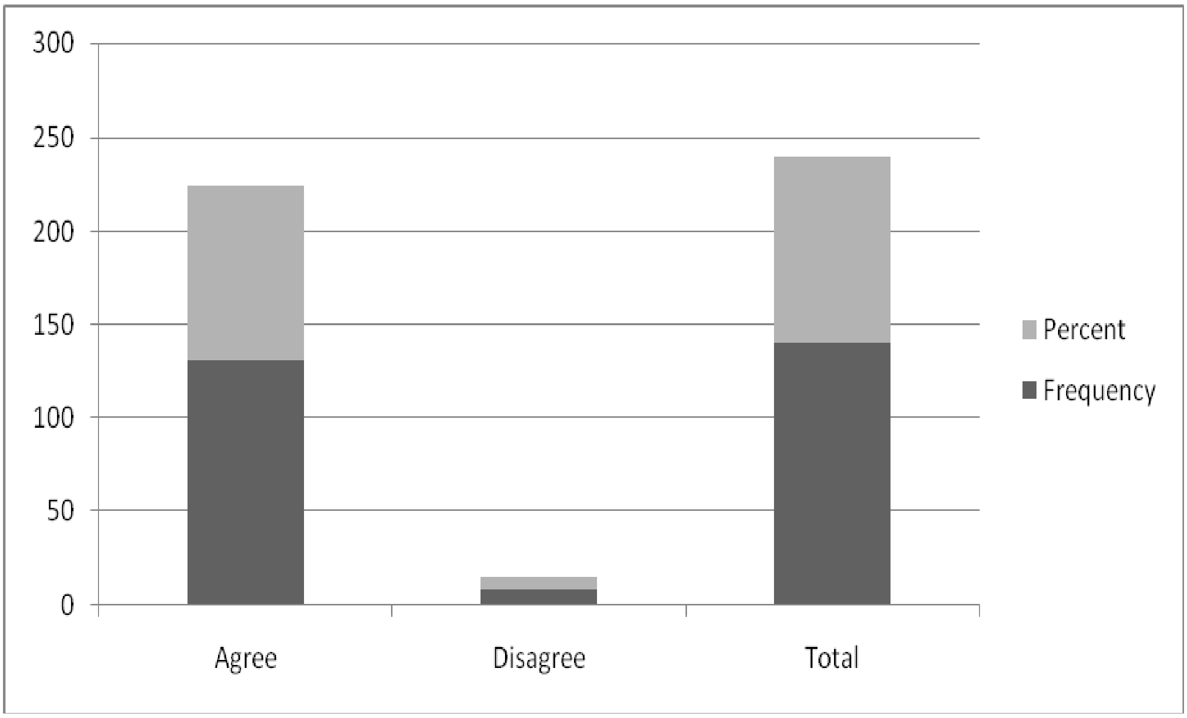

Figure 17: Responses on pollution reduction through waste tyre utilization and recycling

The question expected some understanding of the uses of waste tyres that are environmentally sound which could be used as options to reduce pollution emanating from waste tyres. All respondents from various sampled groups overwhelmingly agreed that waste tyre utilization and recycling would reduce pollution from waste tyres. Table 15 further illustrates this percentage.

Table 15: Percentage (%) response on pollution reduction through waste tyre utilization and recycling

	Group Type						
	National, Provincial & Local Governments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total	∑%/5
Agree	96.5%	96.5%	80.7%	92.3%	100%		93.2%
Disagree	3.5%	3.5%	19.3%	7.7%	0%		6.8%
Total	29 100.0% 20.7%	29 100.0% 20.7%	26 100.0% 18.6%	26 100.0% 18.6%	30 100.0% 21.4%	140 100.0% 100.0%	

5.8 Processes or applications that utilize waste tyres

There are some industrial processes that could utilize waste tyres as source of energy. The main markets for waste tyre include cement kilns, electricity generating utilities that can replace finite resource like coal, small to medium scale enterprises that can create floor carpet, mats, shoe soles etc as by-products from waste tyres. These applications and processes might contribute to the solution of the problem. From Figure 18, the result showed that 64.3 % of respondents believed that efficient processes that make use of waste tyres will be beneficial to the economy and the society. Table 16 also shows the distribution of views people within the surveyed groups relevant to the study with respect to utilization of this waste resource. The

Recyclers, Retreaders and Reclaimers group are in strong support of this notion with 69.2% agreement while the National, Provincial & Local Government group disagree with 58.7 % that waste tyres could be beneficially utilized as a resource.

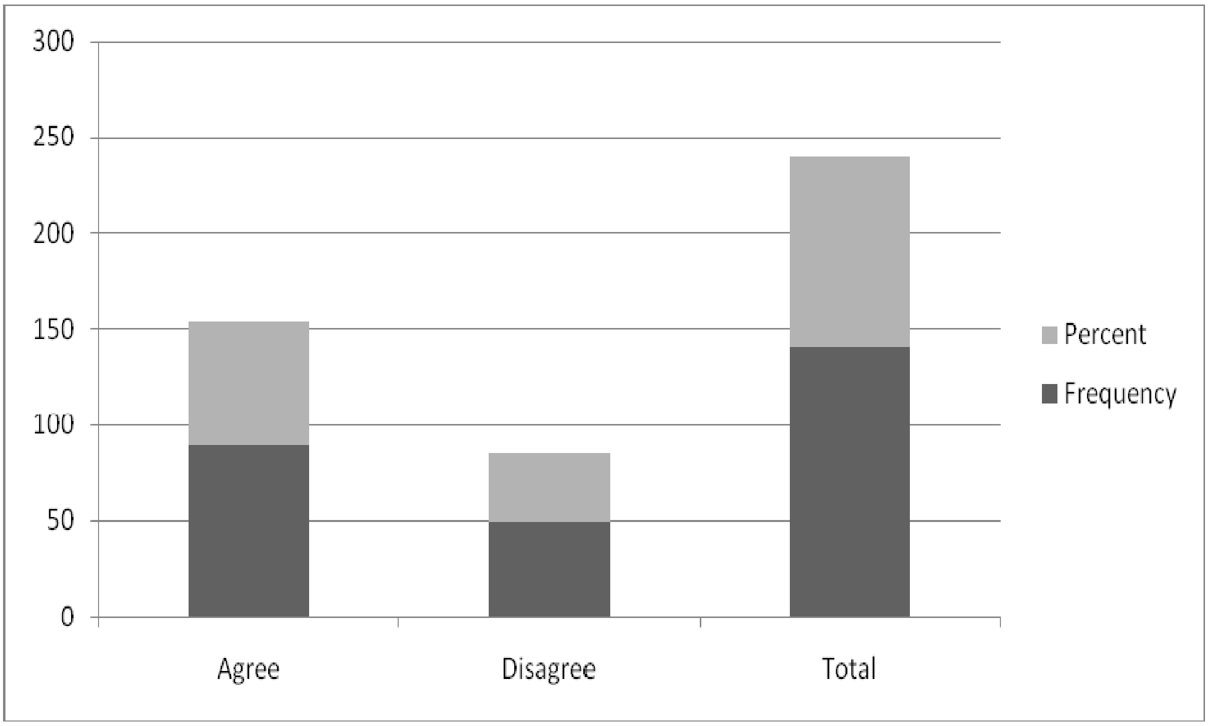

Figure 18: Spread of responses on applications that utilize waste tyres

Of interest to note is that tyre dealers and traders do not believe, (with 53.9%) that there are many applications for waste tyres. They were of the opinion that once a tyre is declared as waste, very little can be done with it. Waste collection companies firmly agree that waste tyres can be used for other applications. They are better exposed, because they collect waste from various institutions that also use waste tyres. Table 16 confirms the responses by various sector on the application of waste tyres.

Table 16: Percentage (%) responses on applications that utilize waste tyres

	Group Type						
	National, Provincial & Local Governments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total	∑%/5
Agree	41.3%	68.9%	69.2%	46.1%	93.4%		63.8%
Disagree	58.7%	31.1%	30.8%	53.9%	6.6%		36.2%
Total	29	29	26	26	30	140	
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%	

5.9 Creation of wealth and jobs through utilization and recycling of waste tyres

A total of one hundred and one (111) respondents (79.3 %) across the sampled group acquiesce to the fact that wealth and job opportunities can be created through products development from waste tyre reuse (Figure 19). This assertion is an indication that the concept of reuse should be encouraged by the government. Twenty point seven percent (20.7 %) of the respondents disagree with the concept. Fabricated products such as mat, boots, shoe soles, asphalt, dock bumpers, carbon black, buffer products, waste bins, wheel burrow wheels, rubber washers etc can be created. All the sampled groups were also in support of the view that wealth and jobs could be created and harnessed through waste tyres utilization and recycling.

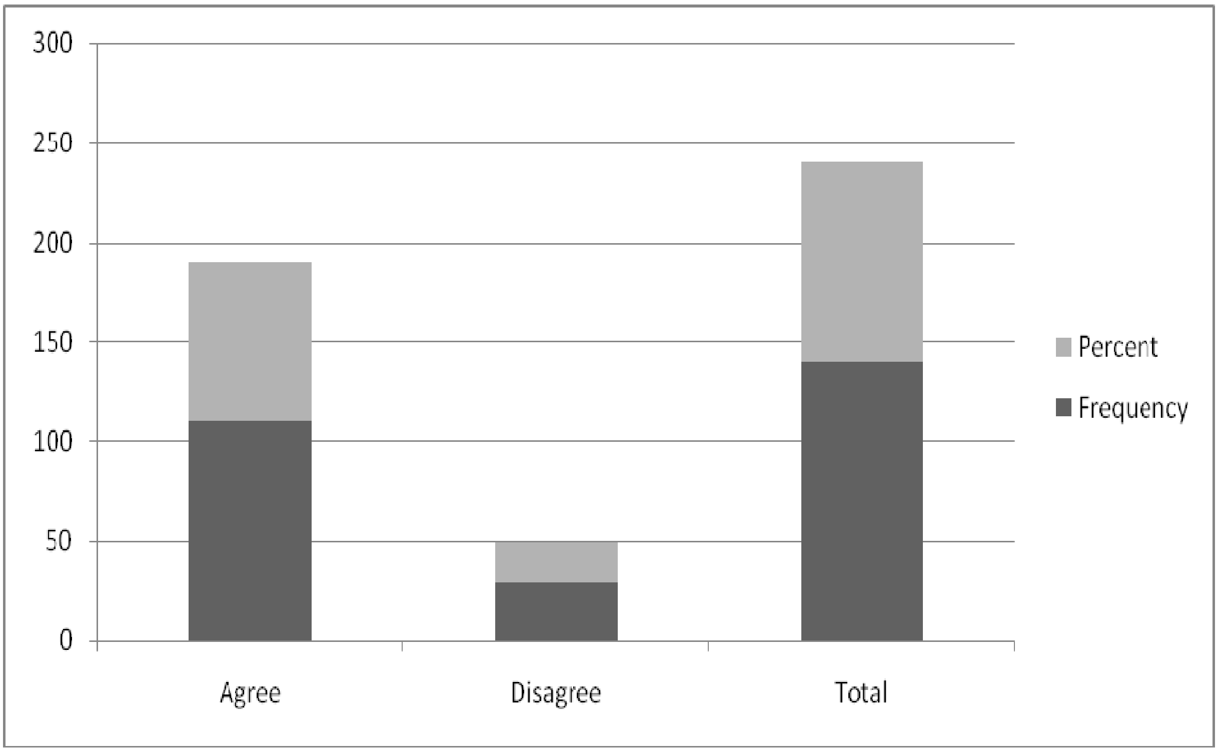

Figure 19: Responses on wealth & job creation through waste tyre utilization and recycling

On average 78.8 % of respondents are optimistic that waste tyre utilization will create wealth and jobs. A caution from waste tyre recyclers is that waste tyre utilization will take place provided that government devise support programmes like incentive schemes and further create conducive conditions for the markets to develop. Others include promoting recycled material markets and facilitate the collection of waste tyres through the levy or tax systems. Developed countries facilitated collection of waste tyres through incentive schemes that facilitate easy access to waste tyres. Table 17 below illustrate the percentage response by all groups within the sample

Table 17: Percentage (%) response on wealth and job creation through waste tyre utilization

	Group Type						
	National, Provincial & Local Governments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total	∑%/5
Agree	86.2%	86.2%	61.5%	76.9%	83.4%		78.8%
Disagree	13.8%	13.8%	38.5%	23.1%	16.6%		21.2%
Total	29	29	26	26	30	140	
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%	

Views by various groups in the sample represent varied opinions which could not be predicted. Of interest is the 34.4% from the government group that do not agree that waste tyre is a contributor to environmental pollution. This assertion could not be ignored on the premise that other activities like power generation were cited as notable contributors to pollution. However, all other groups especially communities, waste collection companies, tyre recyclers and tyre dealers all agreed that waste tyres is a contributor to environmental pollution. Overall responses by all groups in the sample are represented by Table 18 below.

Table 18: Overall responses by all the surveyed groups

Question No.	% Agree	% Disagree	Total %
1	90	10	100
2	97.9	2.1	100
3	88.6	11.4	100
4	10	90	100
5	7.1	92.9	100
6	93.6	6.4	100
7	64.3	35.7	100
8	79.3	20.7	100

RECOMMENDATIONS

Development and use of appropriate applicable framework / model for effective and efficient management of waste tyres by countries is essential. Characteristics that can make the proposed waste tyre management model to be implemented in waste management systems are:

- Consumers or general public must be well informed about waste management matters including applicable legislations. These characteristic enable the consumers to actively participate and support existing waste tyre and other waste management systems. The consumers play an import part in the management of waste and thus become whistle blowers for non complying companies that are menacing the environment and can challenge such companies in the courts of law.

- Appropriate legislation

  The legislation must be specific and not ambiguous; address waste tyres in an integrated manner such that generation, collection, transportation, treatment and final disposal are monitored through the Waste Information System. The legislation must give guidance on storage, handling and treatment / processing. Tyre manufacturers are an important player and are leading the technology development to enhance compliance with the existing legislations.

- Economic instruments

  Most of the developed countries use economic instruments, like tax incentives, tax charges or in some instances the levy system to address environmental impacts associated with waste tyres. For example, economic instrument assist companies to set up recycling plants, give tax incentives to companies that recycle waste tyres.

- Free market system

  Countries such as the United Kingdom with stringent enforcement agent do not attach any form of levy to waste tyres. However, once a legislation is passed or enacted, the environmental agency will make sure that the industry complies and if not, stringent fines will be imposed as stipulated by the law. The command and control sanction is favoured. The tyre industries created an association and regulate their activities.

- Law enforcement agencies

  A country need to have effective and functional agencies that are well equipped with capacity and supported by the environmental courts.

Short comings of developing countries on waste management

Developing countries have waste management systems that are not compatible with socio economic development in many cases. Some countries are thriving with defective policies, legislations and some have insufficient capacities. Interestingly, in South Africa environment including waste management is not prioritized. Consumers are not sufficiently up dated about developments in waste management. Consumers do not see themselves as part of the solution for waste management problems. There are no environmental courts, which is the biggest challenge. It is however recommended that vigorous public awareness programmes on environmental issues especially waste management should be carried out. Furthermore, appropriate legislation for integrated waste management should be enacted. Enforcement agencies are developed, capacitated and equipped with the necessary skills, legal power and dedicated unit that can coordinate and work with other agencies to streamline the function in teamwork approach. Most importantly, environmental courts should be developed. Below is the formulated model on waste tyre management, see Fig. 10 below.

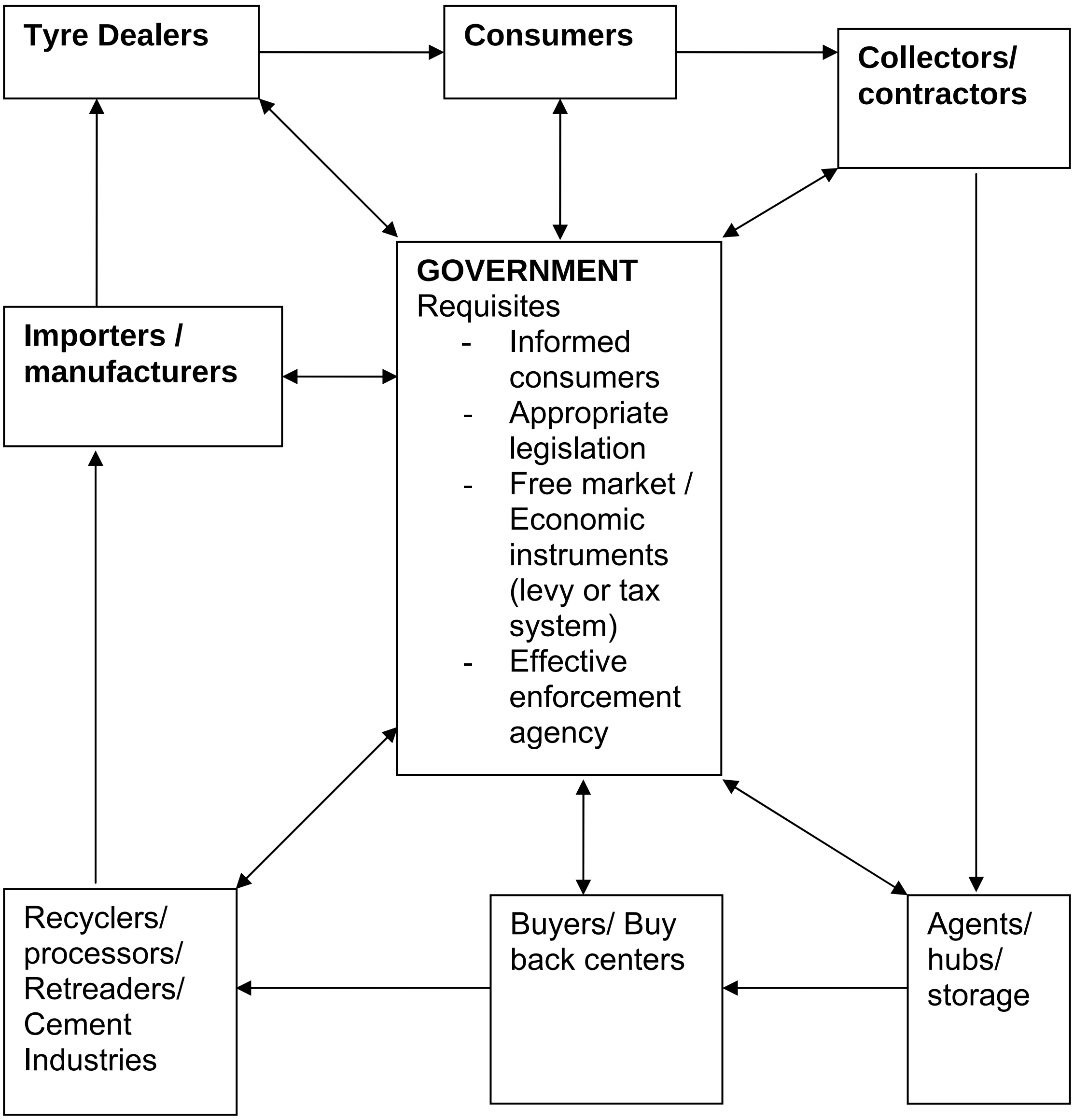

Fig. 10: Waste Tyre Model (source: Formulated by the researcher).

CONCLUSIONS

The diverse range of views and opinions obtained in this study revealed the independence of opinion within the sampled groups. Results showed that opportunities and potential job creation from waste tyre recycle are not harnessed by the government. Hence, there is a need for leadership through focused legislation that will regulate the handling, disposal and recycling of waste tyres in the country which the tyre industries are eagerly awaiting. The absence of adequate legislation created many waste tyre illegal dumps sites especially in less developed areas where unemployed people use them for various purposes. The current state of unregulated disposal poses serious threat to human, environment and health. The results also revealed that the community is unaware of the role of the government with respect to waste tyre management. In addition, it could be inferred that the low socio-economic level of people, presented by high unemployment rate in the country contributes to the problem of waste tyre management. People living in informal settlements tend to burn waste tyres for heat generation, especially during winter season and to recover the steel strap for some income. This act can contribute to the national, regional and possibly global atmospheric pollution. The government is required to provide leadership in this direction through appropriate legislation, enforcement and control.

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APPENDIXES

Appendix 1: Copy of the questionnaire administered for responses.

1. Do you see / consider waste tyres or the management thereof, a problem in your community? 1 **Strongly agree**☐ 2 **Agree**☐ 3 **Not agree** ☐ **4 Strongly disagree** ☐

   ____

   ____

2. In your opinion, impacts of waste tyre management problems are severe in poorly resourced communities or in highly resourced communities or impacts are equally the same?

   1 **Strongly Agree** ☐ 2 **Agree** ☐ 3 **Not agree** ☐ 4 **Strongly disagree** ☐

   ____

   ____

3. Are you aware of environmental pollution caused by injudicious management of waste tyres? 1

   Strongly Agree ☐ 2 **Agree** ☐ 3 **Not Agree**☐ 4 **Strongly disagree** ☐

   ____

   ____

4. Do you know any legislation or legal framework governing the management of waste tyres? 1 **Strongly Agree**☐ 2 **Agree** ☐ 3 **Not Agree** ☐ 4 **Strongly disagree** ☐

   ____

   ____

5 Are you aware of government or community programme (s) if any that is / are to address waste tyre management problems?

1 **Strongly Agree** ☐ 2 **Agree** ☐ 3 **Not Agree** ☐ **4 Strongly disagree** ☐

____

____

6. In your opinion, do you think waste tyre utilization and recycling will reduce environmental pollution?

1 **Strongly Agree** ☐ 2 **Agree** ☐ 3 **Not agree** ☐ 4 **Strongly disagree** ☐

____

____

7. Are there efficient processes or applications that use waste tyres ?

1 **Strongly agree** ☐ 2 **Agree** ☐3 **Not Agree** ☐4 **Strongly disagree**☐

____

____

8. Do you think waste tyre utilization and recycling can create wealth and jobs Opportunities? 1 **Strongly Agree**☐ 2 **Agree**☐3 **Not Agree**☐4 **Strongly Disagree** ☐

____

____

Appendix 2: List of Tables

Appendix 3: List of Figures

(xxi) Figure 19: Response on wealth and job creation through waste tyre utilization and recycling.

Appendix 4: List of Acronyms

APPA	**Air Pollution Prevention Act**
CAPCO	**Chief Air Pollution Control Officer**
CSABS	**Council of the South African Bureau of Standards**
DACST	**Department of Arts, Culture, Science and Technology**
DEAT	**Department of Environmental Affairs and Tourism**
DEFRA	**Department of Environment, Food and Rural Affairs**
DEWHA	**Department of Environment, Water, Heritage and Arts**
DWAF	**Department of Water Affairs and Forestry**
ECA	**Environment Conservation Act**
EN	**Engineering News**
EPAQ	**Environment Protection Agency of Queensland**
ETRMA	**European Tyre and Rubber Manufacturers Association**
EU	**European Union**
IPWM	**Integrated Pollution and Waste Management**
ODNR	**Ohio Department of Natural Rsources**
SABS	**South African Bureau of Standards**
SATMC	**South African Tyre Manufacturers Conference**
SATRP	**South African Tyre Recycling Process Company**
STMR	**Scrap Tyre Market Report**
TDF	**Tyre Derived Fuel**
UKEA	**United Kingdom Environmental Agency**
UNCED	**United Nations Conference on Development and Environment**
UNEP	**United Nations Environment Programme**
USDT	**United States Department of Transport**

USEPA	**United States Environment Protection Agency**
US SEAR	**United States Secretary of Energy Advisory Report**
WTO	**World Trade Organisation**
WTR	**Waste Tyre Regulations**

LETTER OF INTRODUCTION

UNISA university of south africa

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES
DEPARTMENT OF ENVIROMENTAL SCIENCES

TO WHOM IT MAY CONCERN

DATE: 2007.09.25

LETTER OF INTRODUCTION OF MR LUCAS MAHLANGU

This is to introduce and attest that the above named person is a registered Masters Degree student in the Department of Environmental Science, College of Agriculture and Environmental Sciences, University of South Africa.

He is carrying out a research into the Waste Tyre Management Problems in South Africa and any form assistance that would positively impact and contribute to the success of his endeavour would be highly appreciated.

Sincerely,

Prof. O.R Awofolu

Supervisor
Department of Environmental Sciences, CAES
Tel: 0123524059

Appendix 6: Computer Analysis of Data obtained from the research

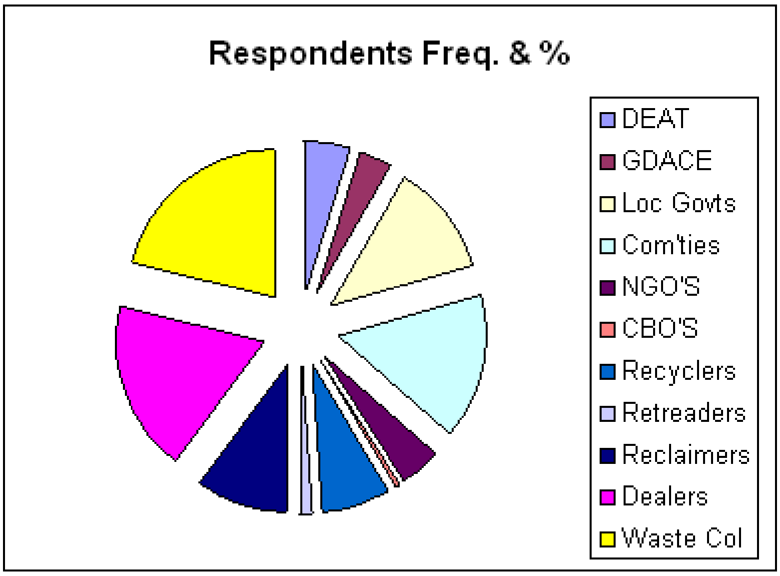
Waste Tyre Management Problems in SA: Mr Lucas Mahlangu
Computer Analysis: OV Kilpert
23 May 2008

Frequency Table of Research Groups

Groups

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	National department	7	5.0	5.0	5.0
	Provincial department	5	3.6	3.6	8.6
	Local governments	17	12.1	12.1	20.7
	Communities	22	15.7	15.7	36.4
	NGOs	6	4.3	4.3	40.7
	CBOs	1	.7	.7	41.4
	Recyclers	10	7.1	7.1	48.6
	Retreaders	2	1.4	1.4	50.0
	Reclaimers	14	10.0	10.0	60.0
	Dealers	26	18.6	18.6	78.6
	Waste collection companies	30	21.4	21.4	100.0
	Total	140	100.0	100.0	

Chart representation of frequency and percentage for all groups

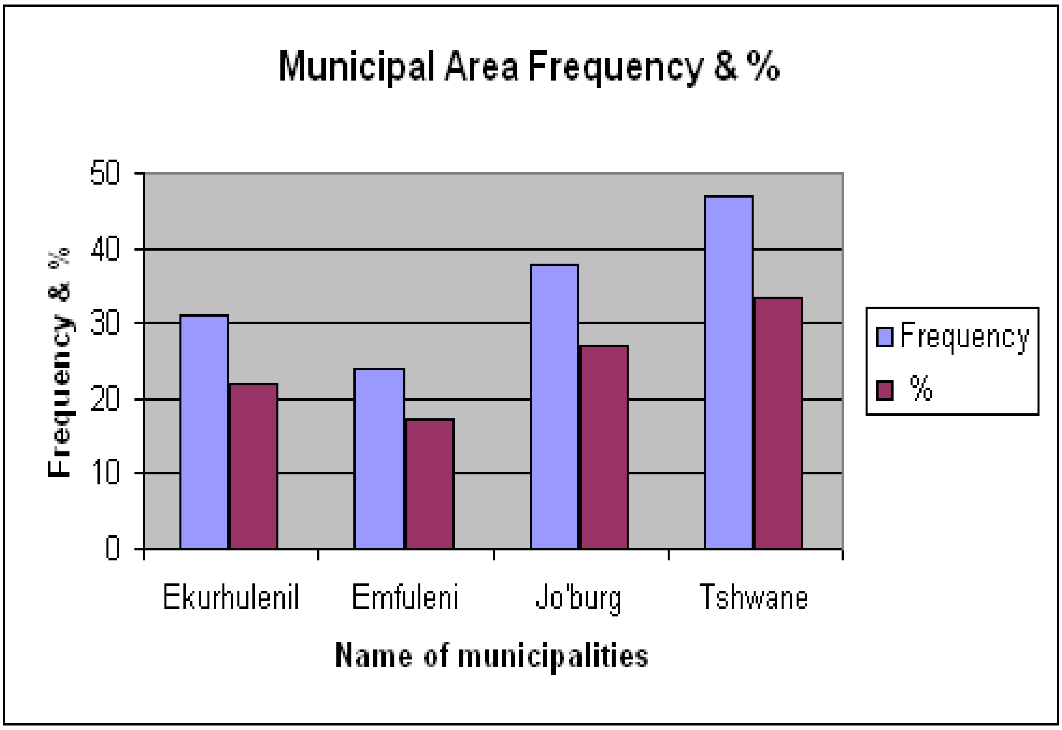


Municipal areas frequency and percent table within the Sample

Municipal areas

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ekurhul	31	22.1	22.1	22.1
	Emfulen	24	17.1	17.1	39.3
	Jo'burg	38	27.1	27.1	66.4
	Tshwane	47	33.6	33.6	100.0
	Total	140	100.0	100.0	

Graphical representation of municipal areas frequency and percentage



Responses by all Groups to the questions (From Q 1 – Q 8 in the questionnaire)

Q1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	49	35.0	35.0	35.0
	Agree	77	55.0	55.0	90.0
	Disagree	14	10.0	10.0	100.0
	Total	140	100.0	100.0	

Q2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	36	25.7	25.7	25.7
	Agree	101	72.1	72.1	97.9
	Disagree	2	1.4	1.4	99.3
	Strongly disagree	1	.7	.7	100.0
	Total	140	100.0	100.0	

Q3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	27	19.3	19.3	19.3
	Agree	97	69.3	69.3	88.6
	Disagree	13	9.3	9.3	97.9
	Strongly disagree	3	2.1	2.1	100.0
	Total	140	100.0	100.0	

Q4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	2	1.4	1.4	1.4
	Agree	12	8.6	8.6	10.0
	Disagree	86	61.4	61.4	71.4
	Strongly disagree	40	28.6	28.6	100.0
	Total	140	100.0	100.0	

Q5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	2	1.4	1.4	1.4
	Agree	8	5.7	5.7	7.1
	Disagree	30	21.4	21.4	28.6
	Strongly disagree	100	71.4	71.4	100.0
	Total	140	100.0	100.0	

Q6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	28	20.0	20.0	20.0
	Agree	103	73.6	73.6	93.6
	Disagree	8	5.7	5.7	99.3
	Strongly disagree	1	.7	.7	100.0
	Total	140	100.0	100.0	

Q7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	7	5.0	5.0	5.0
	Agree	83	59.3	59.3	64.3
	Disagree	43	30.7	30.7	95.0
	Strongly disagree	7	5.0	5.0	100.0
	Total	140	100.0	100.0	

Q8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	67	47.9	47.9	47.9
	Agree	44	31.4	31.4	79.3
	Disagree	10	7.1	7.1	86.4
	Strongly disagree	19	13.6	13.6	100.0
	Total	140	100.0	100.0	

Reliability of Samples (Statistical reliability testing of sample)

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	140	100.0
	Excluded[a]	0	.0
	Total	140	100.0

a. List wise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.570	8

Cross tabulation of municipal areas response per question

1 * Municipal Areas Cross tabulation

			Municipality				
			Ekurhul	Emfulen	Jo'burg	Tshwane	Total
Q1	Strongly agree	Count	13	7	11	18	49
		% within municipal area	41.9%	29.2%	28.9%	38.3%	35.0%
		% of Total	9.3%	5.0%	7.9%	12.9%	35.0%
	Agree	Count	18	13	23	23	77
		% within municipal areay	58.1%	54.2%	60.5%	48.9%	55.0%
		% of Total	12.9%	9.3%	16.4%	16.4%	55.0%
	Disagree	Count	0	4	4	6	14
		% within municipal area	.0%	16.7%	10.5%	12.8%	10.0%
		% of Total	.0%	2.9%	2.9%	4.3%	10.0%
	Total	Count	31	24	38	47	140
		% within municipal area	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.1%	17.1%	27.1%	33.6%	100.0%

Q2 * Municipal Areas Cross tabulation

			Municipality				
			Ekurhul	Emfulen	Jo'burg	Tshwane	Total
Q2	Strongly agree	Count	5	6	9	16	36
		% within municipal area	16.1%	25.0%	23.7%	34.0%	25.7%
		% of Total	3.6%	4.3%	6.4%	11.4%	25.7%
	Agree	Count	26	18	28	29	101
		% within municipal area	83.9%	75.0%	73.7%	61.7%	72.1%
		% of Total	18.6%	12.9%	20.0%	20.7%	72.1%
	Disagree	Count	0	0	1	1	2
		% within municipal area	.0%	.0%	2.6%	2.1%	1.4%
		% of Total	.0%	.0%	.7%	.7%	1.4%
	Strongly disagree	Count	0	0	0	1	1
		% within municipal area	.0%	.0%	.0%	2.1%	.7%
		% of Total	.0%	.0%	.0%	.7%	.7%
	Total	Count	31	24	38	47	140
		% within municipal area	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.1%	17.1%	27.1%	33.6%	100.0%

Q3 * Municapal Areas Cross tabulation

			Municipality				
			Ekurhul	Emfulen	Jo'burg	Tshwane	Total
Q3	Strongly agree	Count	7	3	4	13	27
		% within municipal area	22.6%	12.5%	10.5%	27.7%	19.3%
		% of Total	5.0%	2.1%	2.9%	9.3%	19.3%
	Agree	Count	24	17	30	26	97
		% within municipal area	77.4%	70.8%	78.9%	55.3%	69.3%
		% of Total	17.1%	12.1%	21.4%	18.6%	69.3%
	Disagree	Count	0	4	3	6	13
		% within municipal area	.0%	16.7%	7.9%	12.8%	9.3%
		% of Total	.0%	2.9%	2.1%	4.3%	9.3%
	Strongly disagree	Count	0	0	1	2	3
		% within municipal area	.0%	.0%	2.6%	4.3%	2.1%
		% of Total	.0%	.0%	.7%	1.4%	2.1%
	Total	Count	31	24	38	47	140
		% within municipal area	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.1%	17.1%	27.1%	33.6%	100.0%

Q4 * Municipal Areas Cross tabulation

			Municipality				
			Ekurhul	Emfulen	Jo'burg	Tshwane	Total
Q4	Strongly agree	Count	1	0	1	0	2
		% within municipal area	3.2%	.0%	2.6%	.0%	1.4%
		% of Total	.7%	.0%	.7%	.0%	1.4%
	Agree	Count	1	1	1	9	12
		% within municipal area	3.2%	4.2%	2.6%	19.1%	8.6%
		% of Total	.7%	.7%	.7%	6.4%	8.6%
	Disagree	Count	22	14	25	25	86
		% within municipal area	71.0%	58.3%	65.8%	53.2%	61.4%
		% of Total	15.7%	10.0%	17.9%	17.9%	61.4%
	Strongly disagree	Count	7	9	11	13	40
		% within municipality	22.6%	37.5%	28.9%	27.7%	28.6%
		% of Total	5.0%	6.4%	7.9%	9.3%	28.6%
	Total	Count	31	24	38	47	140
		% within municipality	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.1%	17.1%	27.1%	33.6%	100.0%

Q5 * Munucipal Areas Cross tabulation

			Municipality				
			Ekurhul	Emfulen	Jo'burg	Tshwane	Total
Q5	Strongly agree	Count	0	0	1	1	2
		% within municipal area	.0%	.0%	2.6%	2.1%	1.4%
		% of Total	.0%	.0%	.7%	.7%	1.4%
	Agree	Count	1	0	3	4	8
		% within municipal area	3.2%	.0%	7.9%	8.5%	5.7%
		% of Total	.7%	.0%	2.1%	2.9%	5.7%
	Disagree	Count	7	3	7	13	30
		% within municipal area	22.6%	12.5%	18.4%	27.7%	21.4%
		% of Total	5.0%	2.1%	5.0%	9.3%	21.4%
	Strongly disagree	Count	23	21	27	29	100
		% within municipal area	74.2%	87.5%	71.1%	61.7%	71.4%
		% of Total	16.4%	15.0%	19.3%	20.7%	71.4%
	Total	Count	31	24	38	47	140
		% within municipal area	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.1%	17.1%	27.1%	33.6%	100.0%

Q6 * Municipal Areas Cross tabulation

			City				
			Ekurhul	Emfulen	Jo'burg	Tshwane	Total
Q6	Strongly agree	Count	3	6	8	11	28
		% within municipal area	9.7%	25.0%	21.1%	23.4%	20.0%
		% of Total	2.1%	4.3%	5.7%	7.9%	20.0%
	Agree	Count	27	18	28	30	103
		% within municipal area	87.1%	75.0%	73.7%	63.8%	73.6%
		% of Total	19.3%	12.9%	20.0%	21.4%	73.6%
	Disagree	Count	1	0	2	5	8
		% within municipal area	3.2%	.0%	5.3%	10.6%	5.7%
		% of Total	.7%	.0%	1.4%	3.6%	5.7%
	Strongly disagree	Count	0	0	0	1	1
		% within municipal area	.0%	.0%	.0%	2.1%	.7%
		% of Total	.0%	.0%	.0%	.7%	.7%
	Total	Count	31	24	38	47	140
		% within municipal area	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.1%	17.1%	27.1%	33.6%	100.0%

Q7 * Municipal Areas Cross tabulation

			Municipality				
			Ekurhul	Emfulen	Jo'burg	Tshwane	Total
Q7	Strongly agree	Count	1	0	2	4	7
		% within municipal area	3.2%	.0%	5.3%	8.5%	5.0%
		% of Total	.7%	.0%	1.4%	2.9%	5.0%
	Agree	Count	25	18	22	18	83
		% within municipal area	80.6%	75.0%	57.9%	38.3%	59.3%
		% of Total	17.9%	12.9%	15.7%	12.9%	59.3%
	Disagree	Count	5	4	13	21	43
		% within municipal area	16.1%	16.7%	34.2%	44.7%	30.7%
		% of Total	3.6%	2.9%	9.3%	15.0%	30.7%
	Strongly disagree	Count	0	2	1	4	7
		% within municipal area	.0%	8.3%	2.6%	8.5%	5.0%
		% of Total	.0%	1.4%	.7%	2.9%	5.0%
	Total	Count	31	24	38	47	140
		% within municipal area	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.1%	17.1%	27.1%	33.6%	100.0%

Q8 * Municipal Areas Cross tabulation

			Municipality				
			Ekurhul	Emfulen	Jo'burg	Tshwane	Total
Q8	Strongly agree	Count	11	13	19	24	67
		% within municipal area	35.5%	54.2%	50.0%	51.1%	47.9%
		% of Total	7.9%	9.3%	13.6%	17.1%	47.9%
	Agree	Count	11	8	13	12	44
		% within municipal area	35.5%	33.3%	34.2%	25.5%	31.4%
		% of Total	7.9%	5.7%	9.3%	8.6%	31.4%
	Disagree	Count	1	1	1	7	10
		% within municipal area	3.2%	4.2%	2.6%	14.9%	7.1%
		% of Total	.7%	.7%	.7%	5.0%	7.1%
	Strongly disagree	Count	8	2	5	4	19
		% within municipal area	25.8%	8.3%	13.2%	8.5%	13.6%
		% of Total	5.7%	1.4%	3.6%	2.9%	13.6%
	Total	Count	31	24	38	47	140
		% within municipal area	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	22.1%	17.1%	27.1%	33.6%	100.0%

Frequency tables of sampled respondents and sector groupings within the whole sample.

Group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	National department	7	5.0	5.0	5.0
	Provincial department	5	3.6	3.6	8.6
	Local governments	17	12.1	12.1	20.7
	Communities	22	15.7	15.7	36.4
	NGOs	6	4.3	4.3	40.7
	CBOs	1	.7	.7	41.4
	Recyclers	10	7.1	7.1	48.6
	Retreaders	2	1.4	1.4	50.0
	Reclaimers	14	10.0	10.0	60.0
	Dealers	26	18.6	18.6	78.6
	Waste collection companies	30	21.4	21.4	100.0
	Total	140	100.0	100.0	

Sector Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Nat, Prov & Local Goverments	29	20.7	20.7	20.7
	Communities, NGOs & CBOs	29	20.7	20.7	41.4
	Recyclers, Retreaders & Reclaimers	26	18.6	18.6	60.0
	Dealers & Traders	26	18.6	18.6	78.6
	Waste collection companies	30	21.4	21.4	100.0
	Total	140	100.0	100.0	

Cross tabulation of questions per sector groups

Q1 * Sector Type Cross Tabulation

			GroupType					
			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q1	Strongly agree	Count	5	11	10	13	10	49
		% within GroupType	17.2%	37.9%	38.5%	50.0%	33.3%	35.0%
		% of Total	3.6%	7.9%	7.1%	9.3%	7.1%	35.0%
	Agree	Count	14	15	16	12	20	77
		% within GroupType	48.3%	51.7%	61.5%	46.2%	66.7%	55.0%
		% of Total	10.0%	10.7%	11.4%	8.6%	14.3%	55.0%
	Disagree	Count	10	3	0	1	0	14
		% within GroupType	34.5%	10.3%	.0%	3.8%	.0%	10.0%
		% of Total	7.1%	2.1%	.0%	.7%	.0%	10.0%
	Total	Count	29	29	26	26	30	140
		% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

Q2 * Sector Type Cross Tabulation

			GroupType					
			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q2	Strongly agree	Count	6	9	5	12	4	36
		% within GroupType	20.7%	31.0%	19.2%	46.2%	13.3%	25.7%
		% of Total	4.3%	6.4%	3.6%	8.6%	2.9%	25.7%
	Agree	Count	22	18	21	14	26	101
		% within GroupType	75.9%	62.1%	80.8%	53.8%	86.7%	72.1%
		% of Total	15.7%	12.9%	15.0%	10.0%	18.6%	72.1%
	Disagree	Count	0	2	0	0	0	2
		% within GroupType	.0%	6.9%	.0%	.0%	.0%	1.4%
		% of Total	.0%	1.4%	.0%	.0%	.0%	1.4%
	Strongly disagree	Count	1	0	0	0	0	1
		% within GroupType	3.4%	.0%	.0%	.0%	.0%	.7%
		% of Total	.7%	.0%	.0%	.0%	.0%	.7%
	Total	Count	29	29	26	26	30	140
		% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

Q3 * Sector Type Cross Tabulation

			GroupType					
			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q3	Strongly agree	Count	3	8	3	10	3	27
		% within GroupType	10.3%	27.6%	11.5%	38.5%	10.0%	19.3%
		% of Total	2.1%	5.7%	2.1%	7.1%	2.1%	19.3%
	Agree	Count	16	17	22	15	27	97
		% within GroupType	55.2%	58.6%	84.6%	57.7%	90.0%	69.3%
		% of Total	11.4%	12.1%	15.7%	10.7%	19.3%	69.3%
	Disagree	Count	9	2	1	1	0	13
		% within GroupType	31.0%	6.9%	3.8%	3.8%	.0%	9.3%
		% of Total	6.4%	1.4%	.7%	.7%	.0%	9.3%
	Strongly disagree	Count	1	2	0	0	0	3
		% within GroupType	3.4%	6.9%	.0%	.0%	.0%	2.1%
		% of Total	.7%	1.4%	.0%	.0%	.0%	2.1%
	Total	Count	29	29	26	26	30	140

		% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

Q4 * Sector Type Cross Tabulation

			GroupType					
			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q4	Strongly agree	Count	1	0	0	0	1	2
		% within GroupType	3.4%	.0%	.0%	.0%	3.3%	1.4%
		% of Total	.7%	.0%	.0%	.0%	.7%	1.4%
	Agree	Count	4	3	0	5	0	12
		% within GroupType	13.8%	10.3%	.0%	19.2%	.0%	8.6%
		% of Total	2.9%	2.1%	.0%	3.6%	.0%	8.6%
	Disagree	Count	10	14	21	14	27	86
		% within GroupType	34.5%	48.3%	80.8%	53.8%	90.0%	61.4%

		% of Total	7.1%	10.0%	15.0%	10.0%	19.3%	61.4%
	Strongly disagree	Count	14	12	5	7	2	40
		% within GroupType	48.3%	41.4%	19.2%	26.9%	6.7%	28.6%
		% of Total	10.0%	8.6%	3.6%	5.0%	1.4%	28.6%
Total		Count	29	29	26	26	30	140
		% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

Q5 * Sector Type Cross Tabulation

			GroupType					
			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q5	Strongly agree	Count	1	1	0	0	0	2
		% within GroupType	3.4%	3.4%	.0%	.0%	.0%	1.4%
		% of Total	.7%	.7%	.0%	.0%	.0%	1.4%
	Agree	Count	1	4	0	2	1	8

		% within GroupType	3.4%	13.8%	.0%	7.7%	3.3%	5.7%
		% of Total	.7%	2.9%	.0%	1.4%	.7%	5.7%
	Disagree	Count	11	2	2	10	5	30
		% within GroupType	37.9%	6.9%	7.7%	38.5%	16.7%	21.4%
		% of Total	7.9%	1.4%	1.4%	7.1%	3.6%	21.4%
	Strongly disagree	Count	16	22	24	14	24	100
		% within GroupType	55.2%	75.9%	92.3%	53.8%	80.0%	71.4%
		% of Total	11.4%	15.7%	17.1%	10.0%	17.1%	71.4%
	Total	Count	29	29	26	26	30	140
		% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

Q6 * Sector Type Cross Tabulation

	GroupType

			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q6	Strongly agree	Count	11	7	3	5	2	28
		% within GroupType	37.9%	24.1%	11.5%	19.2%	6.7%	20.0%
		% of Total	7.9%	5.0%	2.1%	3.6%	1.4%	20.0%
	Agree	Count	17	21	18	19	28	103
		% within GroupType	58.6%	72.4%	69.2%	73.1%	93.3%	73.6%
		% of Total	12.1%	15.0%	12.9%	13.6%	20.0%	73.6%
	Disagree	Count	1	0	5	2	0	8
		% within GroupType	3.4%	.0%	19.2%	7.7%	.0%	5.7%
		% of Total	.7%	.0%	3.6%	1.4%	.0%	5.7%
	Strongly disagree	Count	0	1	0	0	0	1
		% within GroupType	.0%	3.4%	.0%	.0%	.0%	.7%
		% of Total	.0%	.7%	.0%	.0%	.0%	.7%
	Total	Count	29	29	26	26	30	140
		% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

Q7 * Sector Type Cross Tabulation

			GroupType					
			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q7	Strongly agree	Count	1	3	0	1	2	7
		% within GroupType	3.4%	10.3%	.0%	3.8%	6.7%	5.0%
		% of Total	.7%	2.1%	.0%	.7%	1.4%	5.0%
	Agree	Count	11	17	18	11	26	83
		% within GroupType	37.9%	58.6%	69.2%	42.3%	86.7%	59.3%
		% of Total	7.9%	12.1%	12.9%	7.9%	18.6%	59.3%
	Disagree	Count	15	6	8	12	2	43
		% within GroupType	51.7%	20.7%	30.8%	46.2%	6.7%	30.7%
		% of Total	10.7%	4.3%	5.7%	8.6%	1.4%	30.7%
	Strongly disagree	Count	2	3	0	2	0	7
		% within GroupType	6.9%	10.3%	.0%	7.7%	.0%	5.0%
		% of Total	1.4%	2.1%	.0%	1.4%	.0%	5.0%
	Total	Count	29	29	26	26	30	140
		% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Q7 * Sector Type Cross Tabulation

			GroupType					
			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q7	Strongly agree	Count	1	3	0	1	2	7
		% within GroupType	3.4%	10.3%	.0%	3.8%	6.7%	5.0%
		% of Total	.7%	2.1%	.0%	.7%	1.4%	5.0%
	Agree	Count	11	17	18	11	26	83
		% within GroupType	37.9%	58.6%	69.2%	42.3%	86.7%	59.3%
		% of Total	7.9%	12.1%	12.9%	7.9%	18.6%	59.3%
	Disagree	Count	15	6	8	12	2	43
		% within GroupType	51.7%	20.7%	30.8%	46.2%	6.7%	30.7%
		% of Total	10.7%	4.3%	5.7%	8.6%	1.4%	30.7%
	Strongly disagree	Count	2	3	0	2	0	7
		% within GroupType	6.9%	10.3%	.0%	7.7%	.0%	5.0%
		% of Total	1.4%	2.1%	.0%	1.4%	.0%	5.0%
	Total	Count	29	29	26	26	30	140
		% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

Q8 * Sector Type Cross Tabulation

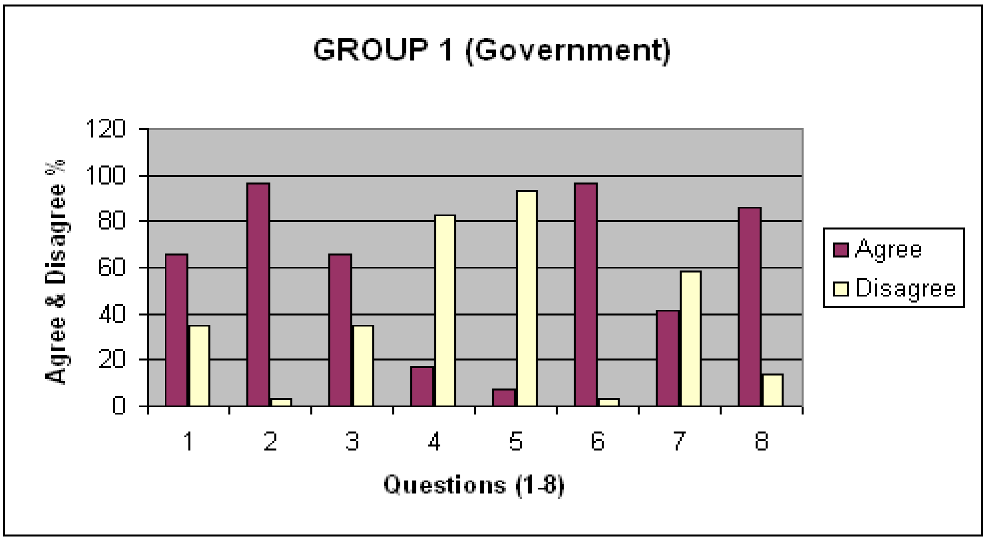
			GroupType					
			Nat, Prov & Local Goverments	Communities, NGOs & CBOs	Recyclers, Retreaders & Reclaimers	Dealers & Traders	Waste collection companies	Total
Q8	Strongly agree	Count	17	14	11	11	14	67
		% within GroupType	58.6%	48.3%	42.3%	42.3%	46.7%	47.9%
		% of Total	12.1%	10.0%	7.9%	7.9%	10.0%	47.9%
	Agree	Count	8	11	5	9	11	44
		% within GroupType	27.6%	37.9%	19.2%	34.6%	36.7%	31.4%
		% of Total	5.7%	7.9%	3.6%	6.4%	7.9%	31.4%
	Disagree	Count	2	3	1	2	2	10
		% within GroupType	6.9%	10.3%	3.8%	7.7%	6.7%	7.1%
		% of Total	1.4%	2.1%	.7%	1.4%	1.4%	7.1%
	Strongly disagree	Count	2	1	9	4	3	19
		% within GroupType	6.9%	3.4%	34.6%	15.4%	10.0%	13.6%
		% of Total	1.4%	.7%	6.4%	2.9%	2.1%	13.6%
	Total	Count	29	29	26	26	30	140

	% within GroupType	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	20.7%	20.7%	18.6%	18.6%	21.4%	100.0%

Percentage (%) responses for Group 1 to all questions 1- 8

Group	Question	Agree	Disagree
1	1	65.5	34.5
	2	96.6	3.4
	3	65.5	34.5
	4	17.2	82.8
	5	6.9	93.1
	6	96.6	3.4
	7	41.4	58.6
	8	86.2	13.8

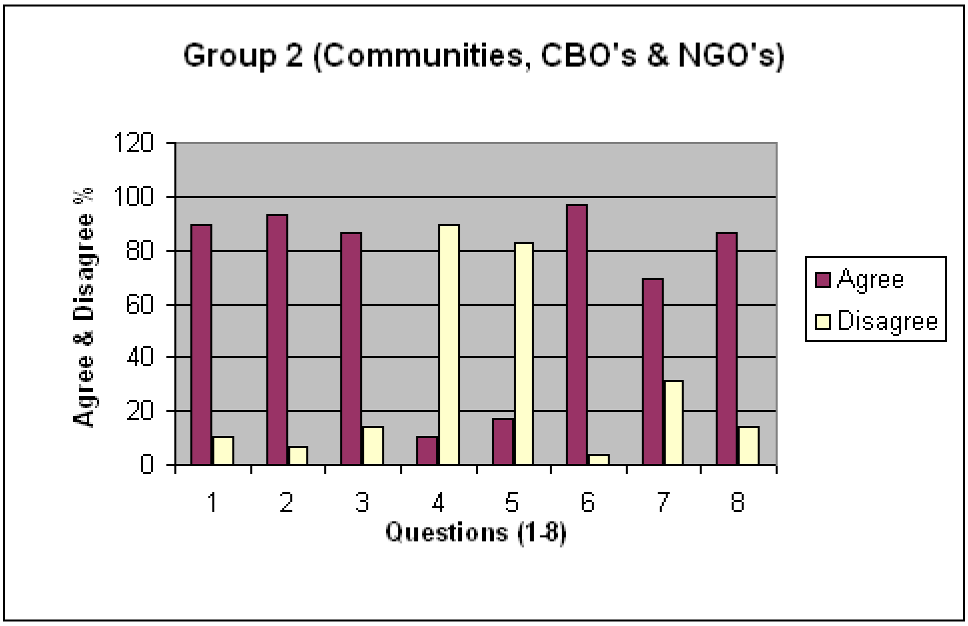
Graphical percentage representation of Group 1 to all questions from 1 - 8



Percentage (%) responses for Group 2 to all questions 1- 8

Groups	Question	Agree	Disagree
2	1	89.7	10.3
	2	93.1	6.9
	3	86.2	13.8
	4	10.3	89.7
	5	17.2	82.8
	6	96.6	3.4
	7	69.0	31.0
	8	86.2	13.8

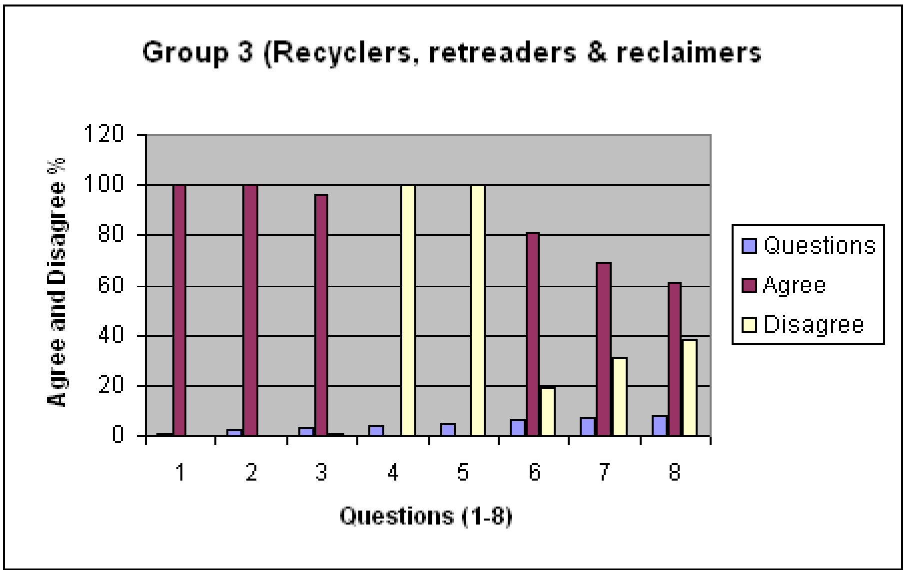
Graphical representation of Group 2 to all questions from 1 - 8



Percentage (%) responses for Group 3 to all questions 1- 8

Group	Question	Agree	Disagree
3	1	100.0	0.0
	2	100.0	0.0
	3	96.2	0.7
	4	0.0	100.0
	5	0.0	100.0
	6	80.8	19.2
	7	69.2	30.8
	8	61.5	38.5

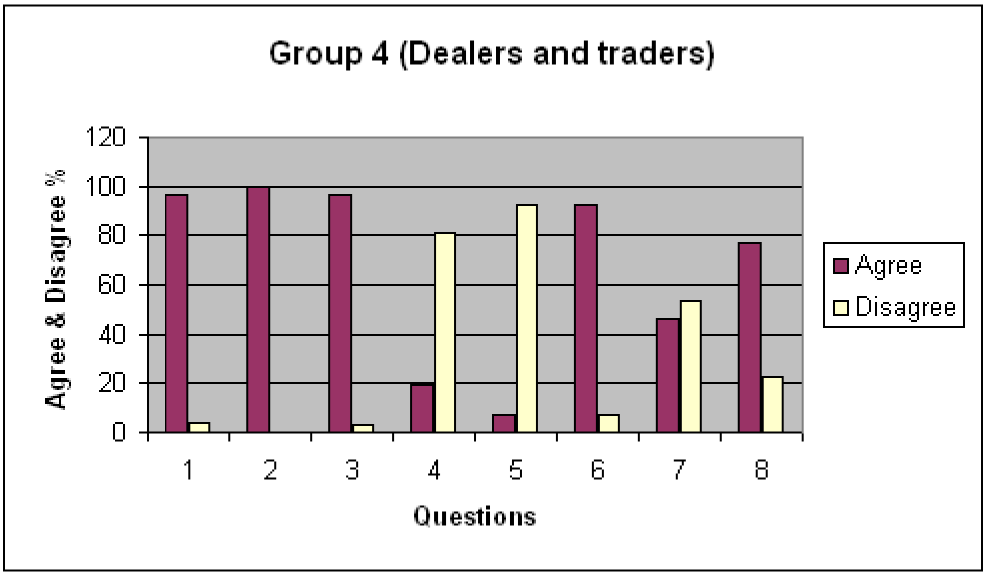
Graphical representation of Group 3 to all questions from 1 – 8



Percentage (%) responses for Group 4 to all questions 1- 8

Group	Question	Agree	Disagree
4	1	96.2	3.8
	2	100.0	0.0
	3	96.2	3.3
	4	19.2	80.8
	5	7.7	92.3
	6	92.3	7.7
	7	46.2	53.8
	8	76.9	23.1

Graphical representation of Group 4 to all questions from 1 - 8



Percentage (%) responses for Group 5 to all questions 1- 8

Group	Question	Agree	Disagree
5	1	100.0	0.0
	2	100.0	0.0
	3	100.0	0.0
	4	3.3	96.7
	5	3.3	96.7
	6	100.0	0.0
	7	93.3	6.7
	8	83.3	16.7

Graphical representation of Group 5 to all questions from 1 - 8

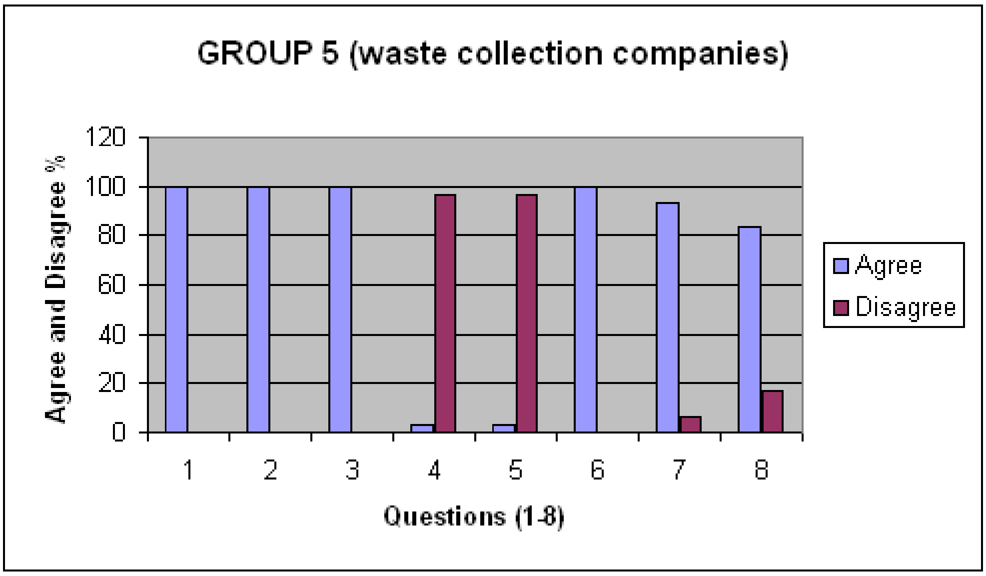


Table representation of responses for all Groups to all questions from 1 - 8

All Groups	Question	Agree	Disagree
	1	126	14
	2	137	3
	3	124	16
	4	14	126
	5	10	130
	6	131	9
	7	90	50
	8	111	29

Graphical representation of responses for all Groups to all questions from 1 - 8

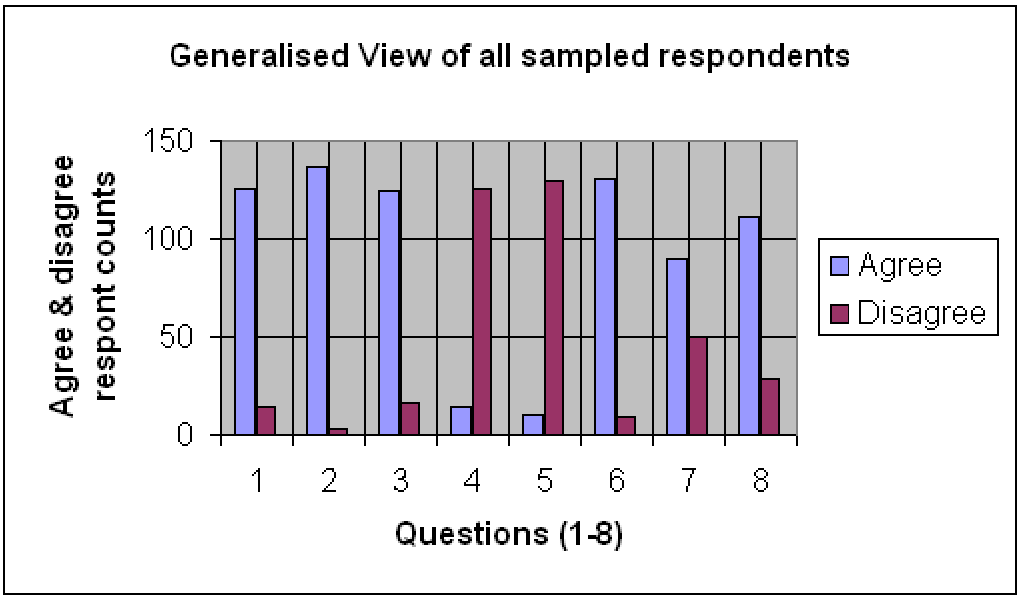


Table of percentage (%) responses for all Groups to all questions from 1 - 8

All Groups	Questions	% Agree	% Disagree
	1	90.0	10.0
	2	97.9	2.1
	3	88.6	11.4
	4	10.0	90.0
	5	7.1	92.9
	6	93.6	6.4
	7	64.3	35.7
	8	79.3	20.7

Graphical percentage (%) responses for all Groups to all questions from 1 - 8