QUANTIFICATION OF SOLID POLLUTANTS ALONG THE HIGHWAY THROUGH MIKUMI NATIONAL PARK

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A Dissertation Submitted in Partial Fulfillment of the requirements for Masters of Degree of Science in Natural Resources Management of the University of Dodoma

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CERTIFICATION

The undersigned certify that he has read and hereby recommend for acceptance by the University of Dodoma Dissertation entitled "*Quantification of solid pollutants along the highway through Mikumi National Park*" in fulfillment of the requirements for the Masters degree of Science in Natural Resources Management of the University of Dodoma.

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Date……..

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I, **Tryphone Nyahinga** declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

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DEDICATION

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ABSTRACT

This study was carried out in Mikumi National Park (MINAPA) to quantify the amount of solid pollutants along the highway through MINAPA. The study adopted longitudinal research design where ten sampling points labeled A to J were established from the western part (Mikumi town) of the highway to the eastern part (Doma village). Waste products were collected, sorted and measured in a daily basis at these sampling points for three weeks. The findings of this study reveals that plastic materials are decreasing as you enter the park from either direction of the highway, tyres and tubes as well as metal wastes are found to be roughly equally distributed throughout the park regardless of the direction of the entrance although the large amount being obtained around the road humps. In addition, the first weeks of data collection, the amount of plastic materials were relatively higher dropping each week to the very low in the third week. The total amount of waste products deposited deliberately or accidentally in the park may have negative impacts to the park ecosystem health which, in some cases may endanger the health of wildlife inhabiting in this valuable ecosystem. Therefore, Tanzania government under the Ministry of Natural Resources and Tourism (MNRT) should adopt effective mitigation measures upon this emerging challenge, and TANAPA should be strictly responsible to ensure these mitigation measures are fully implemented. In addition to that, conservation education should be included in Tanzania education curriculum so that, children may grow with the conservation mentality.

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LIST OF ABREVIATION

MINAPA	Mikumi National Park
MNRT	Ministry of Natural Resources and Tourism
TANAPA	Tanzania National Parks Authority
EMA	Environmental Management Act
NCAA	Ngorongoro Conservation Area Authority
NEMC	National Environmental Management Council
TMA	Tanzania Meteorological Agency
VEC	Village Environmental Committee
KPH	Kilometers Per Hour

CHAPTER ONE

1.1.0 Background of the Study

Mikumi National Park (MINAPA) is among the largest national parks in Tanzania, it is considered to be the biological hot spot just because it consists of the largest number of biodiversity (Hamilton, 2002). Recently, there have been a great debate/ discussion on the issue of highways construction along national parks and the related impacts associated with the highway crossing the parks. Apart from impacts such as road kills and animals discomforted, also there have been big problem of dumping waste materials along the highway by people who are passing through the roads (Andrews, 1990).

Moreover, by tracing the same situation in other national parks, it has been observed that, large amount of waste materials is being collected along the highways across national parks. The most solid wastes collected along the highways are aluminum foil, pieces of tins and soda cans, glass bottles and jars, car tires, water bottles etc which are very detrimental to animals found in the park (Foster, 1995).

Based on estimate in Yellowstone National Park in 1999, about 2000 tourists visit the park per day during dry season (Van, 2008). The same report claimed that, 9180 garbage bags were transported to Dehradun during 2004- 2005 and each bag weighs 4.5 kg on average, then nearly 41,310 kg waste was generated during 2004 season. If 344.25 kg waste was generated per day and 2000 tourists did that in a day, then average generation of waste comes out to 0.172 kg / capita / day compared to the nationwide average of 0.35 kg / capita / day. This data reveals the truth on how

national parks are highly vulnerable to the impacts of unplanned dumping of wastes (Van, 2008).

Kirirom National Park in Cambodia suffers acutely from such poor management of wastes that comes from littering by tourist and other people passing in the park highway (Fahrig, 1996). As the only national park within easy traveling distance from Phnom Penh (85 km), it is a major destination for tourists and local residents. In addition to prolific bird life, Kirirom Park also houses some unique flora, such as Sumatran Pine, the only pine occurring south of the Equator. The Ministry of Environment and the Department of Nature Conservation expressed their desire to address the litter problem, but they lacked the funding needed to organize waste collection and provide public education, hence the problem seems to be a great threat to that ecosystem (Fahrig, 1996).

Furthermore, because of this issue of excessive littering along the highway through national parks and other parts of the parks, Tanzania National Park Authority (TANAPA) has decided to develop some strategies to prevent excessive negative environmental effects that seem to affect the sensitive natural ecosystems in the parks (Hamilton, 2002). Some of the effects that has been identified to be caused by excessive littering along the national parks; wild animals feeding on litter that are scattered around the park may harm them and will also change their behavior. Also visual distortion is a result excessive littering and dumping and Groundwater pollution due to improper depositing of waste (TANAPA, 2009).

However, mentality and regulations fortunately have changed since TANAPA has put a 'trash-in-trash-out' policy in place to prevent excessive littering and dumping. The policy implies that all materials taken into park boundaries should be taken out as well. The policy is also embraced by the Ngorongoro Conservation Area Authority (NCAA). The policy is included in the TANAPA Policy Plan (1994) in the following way;

"TANAPA will promote the use of biodegradable materials, the reuse and recycling of materials, and other appropriate measures to minimize solid waste and conserve natural resource. Every effort will be made to dispose of TANAPA's solid waste outside park lands. Incineration as a means of solid waste disposal will be used only if there is no other feasible alternative. Leases and tour operators will make provisions for the disposal of solid waste in appropriate areas outside the park boundaries" (TANAPA, 2009).

In the past twenty years however, the pressure on popular parks such as Serengeti, Kilimanjaro, Ngorongoro and Mikumi has increased drastically, and mostly in national parks where there is a highway, e.g. MINAPA. As a consequence, waste management is a major concern to park managers as the existing systems are generally insufficient to cope with the high and increasing consumption level (TANAPA, 2005).

In addition, the highway through MINAPA makes accessibility to be much easier especially in connecting the regions, but there are a number of impacts that are experienced due to the presence of this highway, road kills as one of the impact is seriously threatening the free movement of animals crossing the road from one side

to the other side of the park. Animals are dying due to road accidents because of negligent and careless drivers who are driving beyond the speed limit order along the park area (Hamilton, 2002). Furthermore, wastes in the park may cause the deterioration of natural resources which in turn affect the economy of countries where tourism is the most important economic sector. Solid waste and littering can degrade the physical appearance of water bodies and cause deterioration of water quality (Cole *et al*. 1991).

1.2.0 Statement of the Problem and Justification

Currently, the world's wildlife has been facing some big challenges that are caused by man and this has been propagated by the great desire of man to attain much economic development under the expense of environmental resources (Fortune, 1998b). Constructing a highway through the national parks has been a great debate among conservationists and economists, but each side always argue by favoring their own side (Foin, 1977). In real sense, economic development and nature conservation are two things which are antagonistic in nature. The highway through MINAPA is an important road which connects southern part of Tanzania/Africa with the north and eastern part of Tanzania/Africa, through this vitality it has a big contribution to the economic growth of this nation. But the situation of being located through park has made the road itself to be a threat to the park and the wildlife, littering of wastes mainly non-biodegradable materials along the highway such as plastic materials, tyres and iron materials are all challenges that face the park ecosystem (Fahrig, 1996).

In addition, solid wastes dumped by road users are significantly increasing inside the park and can be easily noticed by passengers passing through the park. There is a need of quantifying as well as pinpointing the spatial distribution of solid wastes along the highway for future management of the park. The intention of quantifying waste is to predict the future impact of such wastes as they are likely to affect the wildlife found in MINAPA. Therefore, this study aims at illuminating how these solid pollutants are distributed along the highway through the park as well as quantifying their amounts in weight in daily basis.

We believe that, if the amount and distribution of solid waste along the park's highway will not be known to conservation stakeholders, the park ecosystem health may be interrupted and other ecological functions may be hindered. It is generally known that, solid waste can degrade the physical environment, like water bodies and cause deterioration of water quality. Toxic waste may kill animals by directly poisoning them, affecting their reproductive ability, and causing teratogenic impact (deforming their offspring). Therefore, there is a need to provide answers to how these pollutants are distributed, categorizing them e.g. plastic materials, metals, tyres and tubes etc, and quantifying them so as the concerned authorities can take immediate measures to rescue the park from the impacts that are caused by solid wastes pollutants.

1.3.0 Objectives of the Study

1.3.1 Main objective

The overall objective of this research is to quantify the solid pollutant materials along the highway through MINAPA.

1.3.2 Specific objectives

The following are the specific objectives that will be assessed to help reaching the main objective above.

i) To quantify the amount of plastic materials i.e. plastic bottles, plastic bags and other plastic materials dumped along the gradient of distance from the park exits.

ii) To quantify the amount of iron scraps dumped along the highways from vehicles passing through that road and analyze whether the road humps have an impact on deposition of such materials.

iii) To quantify the amount of tyres and tubes dumped along the highway and analyze if road humps have impact on deposition of such materials.

1.4.0 Research Hypotheses

i) Amount of plastic materials decrease as you move in the centre of the park from either direction of the highway.

ii) Iron scraps dumped are distributed throughout the park along the highway with the peak level at the road humps.

iii) Tyres and tubes dumped are distributed throughout the park along the highway with the peak level at road humps.

1.5.0 Significance of the Study

In spite of being one of the most popular and sought-after tourist destination (Hawkins *et al*.1998), MINAPA is facing some challenges that seem to be more detrimental to animals health and survival, littering of waste mainly non-biodegradable materials along the highway such as plastic bags, plastic bottles, tyres and iron scraps from cars that are passing along the highway is the challenge that MINAPA is facing nowadays.

Therefore, this study will act as a tool to be used by planners to provide input to the decision making processes associated with a broad range of applications including, waste characterization, site characterization, cleanup or remediation assessment, and site monitoring. In addition, suggestion and recommendation from this study also will be vital in making decision and policy on how to rescue the park which is critically in danger due to the impacts of improper dumping of wastes.

CHAPTER TWO

LITERATURE REVIEW

2.0 General Introduction

This chapter presents review of literature relevant to this study. It consists of definition of key terms and concepts used, trend of wastes collected at different time intervals along the highway through park, an overview of the ecological impacts of pollutants to the park, Tanzanian solid waste management policy context and the conceptual framework for this study.

2.1.0 Key Terms and Concepts

Plastic

A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are moldable. All plastics are polymers mostly containing carbon and hydrogen and few other elements like chlorine, nitrogen etc. polymers are made up of small molecules called as monomers which combine and form single large molecule called polymer (UNEP, 2006).

Iron scrap

According to WiseGeek (2013), they defined scrap iron as ferrous metal that is waste. It might come from things such as destroyed architectural structures, old automobiles or broken appliances.

Wildlife

According to Tanzania Wildlife Policy (2007) wildlife means those species of wild and indigenous animals and plants, and their constituent habitats and ecosystems, to be found in Tanzania, as well as those exotic species that have been introduced to

Tanzania, and that are temporarily maintained in captivity or have become established in the wild.

Litter

All kinds of rubbish, refuse, junk, garbage or scrap; and any articles or material abandoned or unwanted by the owner or the person in possession thereof, but does not include dust, smoke or other like products emitted or produced during the normal operations of any mining, extractive, primary or manufacturing industry (Nolan, 2002).

National Park

According to Kidegesho (2010), national parks are protected areas where all human activities are prohibited except non-consumptive tourism.

National Parks (NPs) are large areas of scenic and natural beauty maintained to provide protection for one or more ecosystems and for scientific, educational, and recreational use; is not usually used for commercial extraction of resources (Primack, 2000)

Highway

A highway is any public road or other public way on land; the term exists in distinction to waterway generally under the control of a state or provincial agency instead of a local road authority (Merriam-webster, 2013).

According to oregonlaws.org (2013), highway means every public way, road, street, and place, including bridges, viaducts and other structures within the boundaries of

this state, open, used or intended for use of the general public for vehicles or vehicular traffic as a matter of right.

2.2.0 Ecological impacts of pollutants to the park

Pollutants such as plastic materials, papers, iron scraps and tyres has a negative effect on the environmental aesthetics and ads to a negative visitor experience, that is apart from ecological ones (Turrentine, 2003). Furthermore, pollutants have impacts on the ecosystem of the park by deterioration of natural resources. This may affect the economy of countries where tourism is the most important economic sector. In mountain areas with high concentrations of tourism activities, improper disposal can be a major despoiler of the natural environment. Solid waste and littering can degrade the physical appearance of water bodies and cause deterioration of water quality, also can block waterways and storm water drains, increasing the potential for flooding and erosion (Finlayson, 1991).

According to Fagence (1990), he stated that improper disposal can be a major despoiler of the natural environment. Solid waste and littering can degrade the physical appearance of water bodies and cause deterioration of water quality. Toxic waste kills animals by directly poisoning them, affecting their reproductive ability, and causing teratogenic impact (deforming their offspring).

2.3.0 Pollutants and its amount collected along the highway through Mikumi National Park

Types and amount of wastes collected from July to December 2011

Furthermore, within the period of six months from July to December in the year 2011, the amounts of wastes/litter collected were large as it is shown in the table below, July being the month that large amounts of wastes has been dumped that is 470 kilograms, this is because in the month of June- October people do not engage in agricultural production and hence can travel unlike the months of November – April, majority are busy in the field preparing and cultivating their farms (Mumba, 2010). Tyres and tubes also is the type of waste that has been collected in large quantity within that period of six months i.e. 618 kilograms. The grand total of all wastes collected was 1973 kilograms with the monthly average of 328.8 kilograms. Though the types and amounts of wastes dumped along the road keeps on changing from one month to another, this has been influenced by the following; firstly the number of people who are crossing the park via the highway, the number of cars passing across the park and the number of tourists entering the park as well as poor understanding and poor attitudes of conservation among the people who are passing through the highway.

Table 1: Types and amount of wastes collected from July to December 2011

S/N	Types of Wastes	July (Kg)	August (Kg)	September (Kg)	October (Kg)	November (Kg)	Dec (kg)
1	**Plasticbottles**	52	58	30	20	18	28
2	**Empty tins**	95	48	55	40	30	35
3	**Plastic Bags**	38	21	22	14	11	10
4	**Paper /boxes**	8	15	20	22	20	22
5	**Tyres / tubes**	155	75	85	105	118	80
6	**Metal**	102	82	89	92	58	25
7	**Glasses**	5	12	9	5	8	16
Total	**1973**						
Mean	**328.8**						

Source: MINAPA Litter collection Report 2011

Types and amount of litter collected in July 2012

Basing on the data collected from secondary sources at MINAPA office, in July 2012 the amount of wastes collected was as shown in the Table 2 below, plastic bottles are the most dumped wastes in the park though it shows less weight i.e. 30 kg as compared to metal materials (85 Kg), tyres and tubes (215 Kg), this is because metal materials, tyres and tubes are heavier than plastic bottles. Other types of wastes that are significantly dumped include empty tins, plastic bags, paper and boxes with their respective quantity being tabulated in the table below.

Table 2 : Types and amount of litter collected in July 2012

S/N	Type of Litter	Weight in Kg
1	Plastic bottles	30
2	Empty tins	14
3	Plastic bags	7
4	Paper and boxes	16
5	Tyre and tube	215
6	Metal materials	85
7	Glass and mirror	15
8	Wood	20
Total		**402**

Source: MINAPA Litter collection Report 2012

2.4.0 Solid pollutants in wildlife ecosystem

The term solid waste means material such as household garbage (includes recycling), food wastes, yard wastes, and demolition or construction debris. It also includes discarded items like household appliances, furniture, scraps metal, machinery, car parts and abandoned or junk vehicles and used plastic materials (Ferraro, 2002). Solid waste is a problem that must be properly managed. While it is generally understood that proper waste management helps protect human health and the environment and preserve natural resources, many do not realize that solid waste also impacts climate change (Blanco, 1994). Solid wastes have more impacts to wildlife as compared to domesticated animals, example plastic may also cause ulcerations in the stomach and intestinal linings, and it is suspected at causing damage to other anatomical structures. Finally, ingestion of plastic may contribute synthetic chemicals to body tissues. Some plasticizers, for example, may concentrate in fatty tissues, their toxic ingredients causing eggshell thinning, aberrant behavior, or tissue

damage. When highly contaminated tissues are mobilized, these toxins may be released in lethal doses. A more obvious effect of plastic pollution is the aesthetic one (EPA, 1993). Some animals, mistaking plastic for food and eat them. For example, approximately 15 percent of the world's 280 species of sea birds are known to have eaten plastic in the form of pellets, bits of Styrofoam, even plastic toys. In addition, sea turtles, apparently regarding plastic bags as jellyfish upon which they regularly feed, have been found with balls of plastic in their stomachs (Fine, 1989).

Sample (1996) contended that; improper dumping pollutes their natural habitats and can lead to the death of fish, birds and small animals. Some of the trash we dispose off is toxic if consumed by animals, and if these toxic wastes end up in water bodies, it becomes dangerous to aquatic life.

Moreover, when solid wastes are improperly dumped in the environment, chemicals and other contaminants found in solid waste can seep into our groundwater and can also be carried by rainwater to rivers and lakes that provide essential wildlife habitat. These contaminates can also end up in our ground water, rivers and lakes that are our sources for drinking water (MacDonald, 2000).

Moreover, in areas with high concentrations of tourist activities and appealing natural attractions, waste disposal is a serious problem and improper disposal can be a major despoiler of the natural environment, rivers, scenic areas, and roadsides. For example, cruise ships in the Caribbean are estimated to produce more than 70,000 tons of waste each year. Solid waste and littering can degrade the physical appearance of the water and shoreline and cause the death of marine animals (UNEP, 1997).

2.5.0 Tanzanian solid waste management policy context

This paragraph introduces the policy context that enacts upon the solid waste management practices in all areas including in national parks. It is important to get a sense of the available policies since the implementation of it can have effects on the recommendations of this study. Therefore here are description of Tanzanian institutions and regulatory instruments that specify the standards to be followed as well as the economic instruments that provide incentives and disincentives.

2.4.1 National institutions

The Tanzanian government considers environmental management as a multi-sectoral undertaking whose success depends on the cooperation of government agencies responsible for various aspects of the environment (URT, 1997). Overall environmental matters including dumping of pollutants in reserved areas are managed by the Division of Environment, under the Vice President's Office, and implemented through relevant Ministries, for this case MNRT and specialized committees (Mniwasa, 2001). Furthermore, the vice- president's office erected the National Environmental Management Council (NEMC) in the year 1983. This national organ works in partnership with other entities concerned with environmental issues. NEMC is the leading advisory, coordinating and regulatory agency responsible for the protection of the environment and sustainable use of natural resources in Tanzania (UNHABITAT, 2009a). Its main functions are to enforce pollution control and to perform the technical arbitration role in Environmental Impact Assessments (EIA) (URT, 1997).

2.4.2 National policies, laws and regulations

Environmental management is a fairly new topic among policy makers in Tanzania. Although the National Environmental Policy dates from 1997, the law that provides the basis for implementation of this policy only was enacted in 2004 and came into force in 2007, the 2004 Environmental Management Act (EMA). Different parts in the law provide legal and institutional framework for sustainable management of the environment, prevention and control of pollution, waste management, environmental quality standards, public participation, and environmental compliance and enforcement. Furthermore, it gives NEMC the mandate to perform its activities (URT, 1997).

Despite the fact that the government of Tanzania under the Ministry of National Resources and Tourism has imposed some rules and regulations in the Wildlife Policy in recognition of the importance of conservation of biological diversity to the livelihood of mankind, the state will retain the overall ownership of wildlife (MNRT, 1998). The government will access user rights to various stakeholders, provide clear policy guidelines, stimulate public and private sector investment in the wildlife industry and provide support to investors (MNRT, 1998:7). Thus, the government is in charge of overall matters related to wildlife that are found within the country including monitoring of wildlife areas, implementing policies as well as rules and regulations in governing all categories of protected areas.

Recently, a National Waste Management Strategy and Action Plan were realized of which the 2009 regulations on solid and hazardous waste are part. The contents and modes of implementations of this plan and these regulations however remain unclear (Mniwasa, 2001).

Furthermore, Government of Tanzania put a ban on manufacturing, importation, selling, buying and use of plastic bags that are of below standard (EMA, 2006). This is the strategy to minimize improper solid waste disposal and the use of products which are environmental unfriendly. The plastic bags prohibited are those below 30 microns (0.03mm) of thickness. The regulations also apply for plastic sachets of 65 microns (0.065mm) used for water, juice or milk packaging (EMA , 2006 cited from Simon (2008). It is however, very difficult to enforce this rule mainly because of lack of awareness on the rule itself and about which types of plastics are exactly banned. Moreover, people have no alternative for plastic packaging and bags. NEMC currently is in the process of drafting a policy advice on how to move forward with the ban of plastic bags (Simon, 2008). Though these regulations are put in place, proper and serious implementation should be taken so as to rescue the park from the problems of improper dumping and use of prohibited plastic materials.

2.4.3 Decentralized authorities

According to the 2004 Environmental Management Act, every region in Tanzania should have a Regional Environmental Management expert who is responsible for advising local authorities on matters relating to the Environmental Management Act (EMA, 2004). Furthermore, each city, municipality, district, town council and even township, ward, village and neighborhood should appoint an Environment Management Officer responsible for implementation and monitoring of the act through by-laws and regulations including fines. However, according to Pallangyo (2007), local authorities dealing with environmental management often have very few resources including environmental experts and funds to implement activities. Many local authorities therefore struggle to internalize these new environmental

officers in their organization. An exception to this rule is the village level. Long before the EMA came into force, villages already had their voluntary Village Environmental Committee (VEC).

2.5.0. Economic Instruments

User charges, product charges, subsidies and grant programs; tax deduction, and deposits on returnable bottles are examples of economic instruments that can be employed to encourage or discourage certain behavior with effects on the environment. These instruments are proposed in the 2004 EMA but their actual use in reality seems to be limited. According to NEMC, a research is now undertaken to define and design different economic instruments that target improvement of solid waste management (EMA, 2004).

2.6.0 Conceptual Framework

Ecosystems are complex and dynamic (ever changing). This makes linking any one effect to a specific cause very difficult. Conditions cannot be controlled sufficiently to allow the effects of individual pollutants to be observed. Ecological impacts from hazardous waste are supported by definitive cause-and-effect relationships between specific pollutants and ecological endpoints. It is clearly known that, any kind of waste/pollutant if not well managed can cause severe impacts to the environment and health of living organisms which inhabit within the affected area will be at risk. Plastic materials, iron scraps from cars, and tyres which are found along the highway of MINAPA are some of the wastes that park has experienced, some of the negative impacts to the park ecosystem that might be caused by these pollutants are; deterioration of natural resources, deterioration and blockage of water bodies i.e.

river, transmission of diseases to animals, behavioral changes in some of the park's animals. Apart from that, open dump sites destroy the beauty of a place. When land is polluted, the nutrient cycle may be disrupted (EPA, 2011). In this conceptual framework of the study, the dependent variables are the impacts of wastes on the park's ecosystem and the independent variables are the wastes that are dumped on the highway while the intermediate variable is the highway itself (Figure 1)

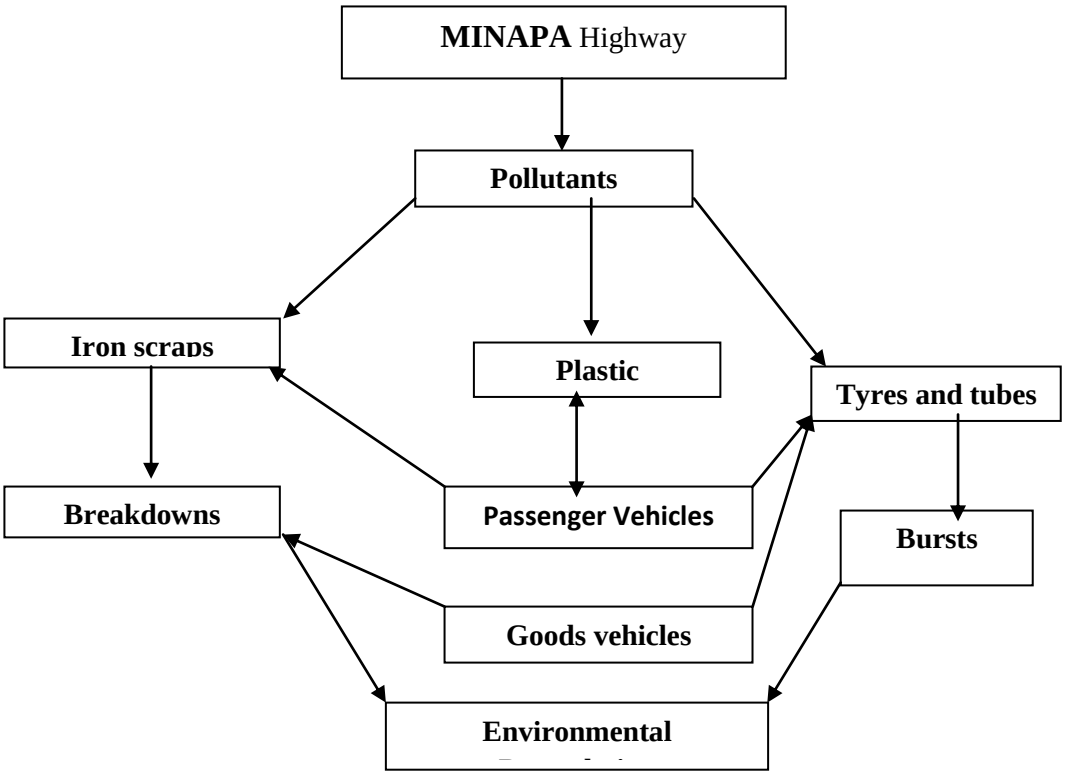

Figure 1 : Conceptual Framework showing the Impacts of Wastes on Park highway

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 General Introduction

This chapter presents methodologies that were used in this study. It provides description of the study area, research design, sampling methods, data collection methods and analysis methods and procedures.

3.1.0 The Study Area

3.1.1 Location

MINAPA is located 283km (about 175 miles) west of Dar es Salaam and 107km (67 miles) from Morogoro town on the highway to Iringa, Tanzania to Zambia. MINAPA was gazetted in 1964 covering an area of 1070 km^2. It was later extended in 1975 to cover the current area of 3,230 km^2 and to share a common boundary with Selous Game Reserve to the South forming a vast track of protected wilderness. The park is policed by a team of rangers who work hard to keep the habitat and Wildlife well protected. Northern part of the park there is a good network of tourist roads, most of which are accessible all year round. These roads lead through all the different habitat types allowing for excellent game viewing. The Southern part of the park is mostly inaccessible and it remains a pristine and untouched refuge for Wildlife (Figure 2).

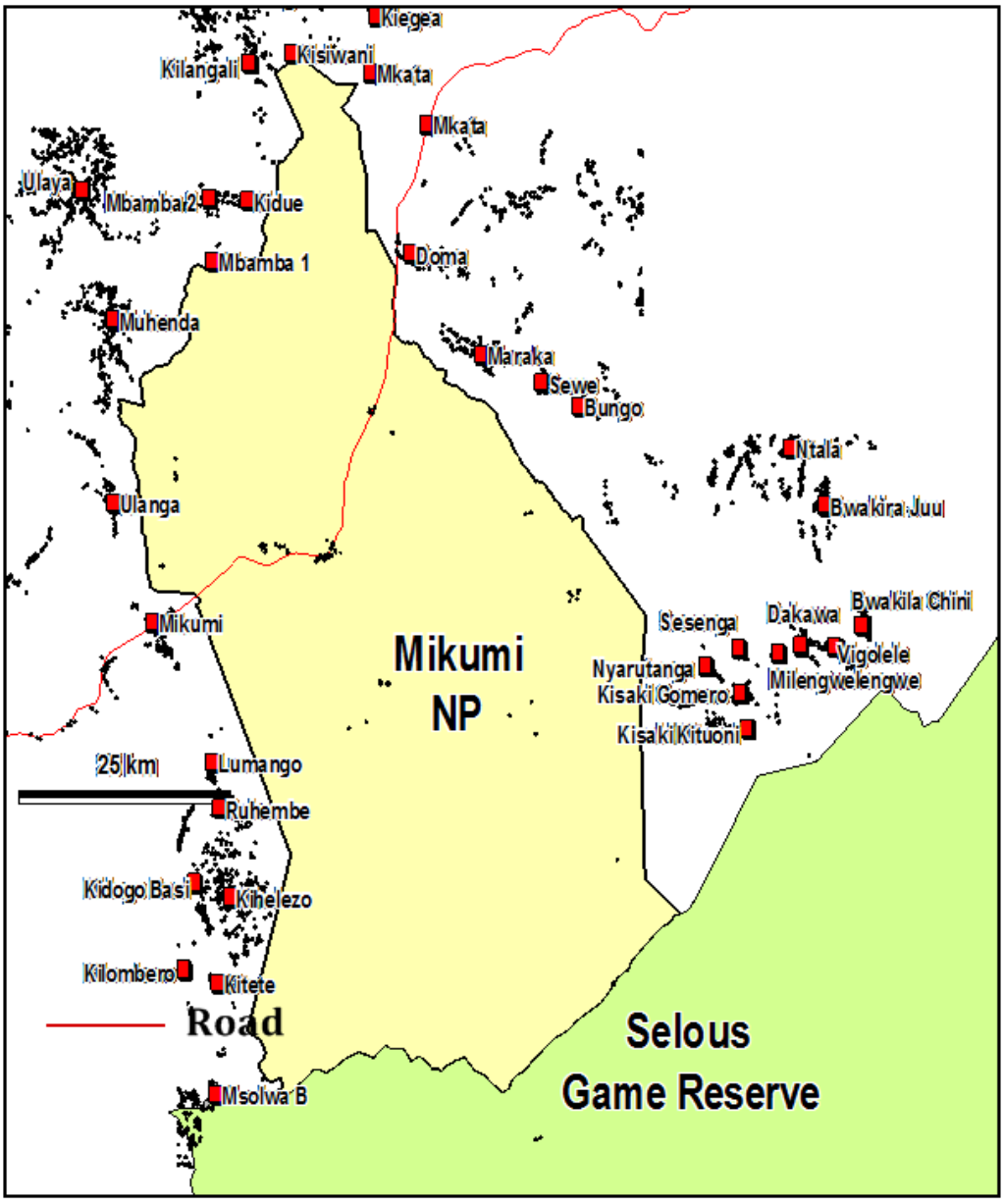

Figure 2 : Mikumi National Park Map showing the highway and boundary of the Park.

Source: MINAPA, Ecology Department.

3.1.2 Climate

Climate in MINAPA varies from warm to hot and humid, with little change. Unlike the northern parks, the nights in Mikumi are not cold, but rather warm year round.

The most warm months are October to March and the coolest are June to August. Elevations in Mikumi vary greatly (from 199 to 1259m/653 to 4131ft) and temperatures drop by about 6.5°C for every 1000m you climb (or 3.5°F per 1000ft). Mikumi has only one wet season and it continues from November to May. Rains occur daily, usually in the afternoon, but seldom last throughout the entire day during wet season. The dry season is from June to October. However, there is always a definite dry period in January and February. Temperature ranges from 16-28°C (TMA, 2010).

3.1.3 Biodiversity

MINAPA is a biodiversity hotspot with vast number of animal species and more than 200 plant species. The park is well-known for its population of elephant (*Loxodonta africana*), giraffes (*Giraffa camelopardalis*), buffaloes (*Cyncerus caffer*), zebras (*Equus burchellii*), elands (*Taurotragus oryx*), Kudu (*Tragelaphus strepsiceros*), wildebeest *(Connochaete staurinus*), roan (*Hippotragus equinus*) and sable antelope (*Hippotragus niger*). Predators include tree-climbing lions (which are in large number), leopards (*Panthera pardus)*, wild hunting dogs (*Lycaon pictus*) and black-backed jackal (*Canis mesomelas*). More than 400 species of birds have been recorded including Eurasian migrants such as red billed oxpecker (*Buphagus erythrorhynchus*), marabou stork (*Leptoptilos crumeniferus*) and lilac breasted roller (*Coracias caudatus*), which stays between October and April. There are more interesting bird species in the Miombo woodland, for example, Shelley's double collared sunbird (*Cinnyris mediocris*), Pale billed hornbill (*Tockus pallidirostris*) and violet-crested turaco (*Tauraco porphyrelophus*) as well as violet-backed starling (*Cinnyricinclus leucogaster*). The main feature of the park is the Mikumi flood plain,

along with the mountain ranges that border the park on two sides. Open grasslands dominate the flood plain, eventually merging with the Miombo woodland covering the lower hills.

3.2.0 Data Collection Methods

This section explains various procedures that were applied in data collection in the field; it consists of research design, data collection techniques i.e. sampling procedures and sampling points, primary data as well as secondary data.

3.2.1 Research Design

This study adopted longitudinal research design where data were collected from a single point more than once, and this was done every day for three weeks consecutively. The collected waste was measured separately at each collection point A- J. Moreover, waste quantification and characterization was conducted throughout the highway at each collection point and wastes were packed on sacks ready for subsequent measurement.

3.2.2 Sampling Procedures

Basing on the nature of this study, several waste sacks were collected daily within three weeks along the highway which has the length of 50 km in which wastes were collected and sorted, sorting was done to analyze the types of waste which was collected along the highway through MINAPA. Waste sorting were done at source of generation i.e. after each 5 km, each type of waste was packed in separate sacks and measured.

3.2.3 Sampling Points

Basing on the length of the highway, ten designated collection points were located along the highway named with letters A, B, C, D, E, F, G, H, I and J. Each point was set after five kilometers which means that the whole length of the highway i.e. 50 km was covered. Therefore, different kinds of wastes were collected, sorted, characterized and measured at each sampling point i.e. A-J. However, for tyres and tubes and iron scraps incidential data collection were done purposively at the road humps to analyze the effect of the humps and the behavior of drivers.

3.3.0 Sources of data Collection

3.3.1 Primary Data

Primary data were collected from field that was conducted along the Mikumi National Park highway which stretches 50 Kilometers long. Different kind of waste (primary data) was collected from ten collection points located along the road.

3.3.2 Secondary Data

Secondary data collection was done through review of secondary sources of data that means related literature such as books, journals, reports from MINAPA etc.

3.5.0 Tools of Data Collection

Wastes was collected from the field by using hands and then packed in storing sacks. The tools that were used in data collection includes gloves that was used to protect hands from direct contaminations of wastes, notebook for keeping records of data, weighing machines for measuring weight of wastes, carrying sacks for storing different kinds of waste products collected.

3.6.0 Data Analysis

The data collected were stored in a personal computer for subsequent data analysis. Statistical analyses were performed by using MICROSOFT EXCEL 2007 and Statistical Packages for Social Sciences (SPSS) 16.0 version for windows. Daily record of wastes collected from 10 collection points stationed after every five kilometers were summed and analyzed using descriptive statistics. Weights of materials analyzed are presented as Mean ± standard error (SE). Moreover, non parametric tests like Mann-Whitney test, Kruskal-Wallis test were performed to compare means, and for all statistics $p < 0.05$ were considered significant. In addition to that, analyzed data are presented in Tables, Charts, as well as Graphs.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents findings and discussion of the study. The chapter will be having results of the data collected from the field in the month of May 2013 statistically represented in tables and graphs, discussion of the results, ecological impacts caused by wastes that are always dumped and mitigation measures that have been applied by the park to mitigate highway waste.

4.1.0 Results

4.1.1 Quantity of different wastes collected per day along the highway

Data collected daily for 21 consecutive days in May 2013 along the highway through MINAPA included plastic bags/bottles, metal materials, tyres and tubes, empty tins, paper and boxes as well as wood materials summarized in table 3. Among the waste materials collected, tyres and tubes scored the highest Mean (21.0 ± 1.2), followed by metal materials (17.1 ± 0.1), plastic materials (14.6 ± 0.61). The remaining products had mean value less than 11 kg (Table 3).

Table 3: Quantity (in Kg) of solid pollutants collected per day along the highway passing through MINAPA for a period of one month (May 2013)

Types of Waste/Month	Mean ± Standard Error (S.E) (Overall)	N (Total)
Plastic waste	14.6 ± 0.6	306.6
Metal Waste	17.09 ± 1.1	358.9
Tyres and tubes	21 ±1.2	452
Empty tins	10.2 ± 0.1	216
Papers and boxes	7.4 ± 0.9	156.6
Wood	9.6 ± 0.2	203

4.1.2 Quantity of Plastic waste dumped along the highway

Plastic waste collected in various points within the park differed among weeks of data collection (Kruskal-Wallis test: x^2 =11.977, df =2, p =0.003). The first week mean rank = 20.45 ± 0.6 kg, second week mean rank = 18.30 ± 0.6 kg but, third week mean rank = 7.75± 0.6 kg. Splitting the data between two consecutive weeks i.e. first week versus second week and second week versus third week, results suggest that the first two weeks, plastic materials collected were similar (Mann-Whitney test : U = 42.00, p = 0.544) and scored relatively higher ranks. However, when comparing the amount of plastic materials collected during the second and third week, the statistics suggest significant difference (Mann-Whitney test: U=14.00, p = 0.006).

4.1.3 Quantity of tyres and tubes

Tyres and tubes collected within three weeks also show a significant difference in mean of waste materials collected (Kruskal-Wallis test: X^2=15.393, df= 2, p-value = 0.0001). However, the mean rank for first, second and third week were 19.10 ±1.2 kg,

20.75 ±1.2 kg, 6.65 ±1.2 kg respectively. Comparing the means of the first and second week, the test revealed that the means were not statistically significant different (Mann-Whitney test: U= 42.5, p= 0.570). However, when we compared the second week and the third week, the results suggest significant difference in mean (Mann-Whitney test: U = 5.00, p = 0.001).

4.1.4 Quantity of metal waste (Iron scraps)

Metal waste collected within three weeks also show a significant difference in mean of waste materials collected (Kruskal-Wallis test: X^2 = 14.156, df = 2 and p-value = 0.001). However, the mean rank for first, second and third week were 20.70 ± 1.1 kg, 18.75 ± 1.1 kg and 7.05 ± 1.1 kg correspondingly. Comparing the means of the first and second week, the test revealed that the means were not statistically significant different (Mann-Whitney test: U= 43, p-value = 0.594). However, when we compared the second week and the third week, the results suggest significant difference in mean (Mann-Whitney test: U= 10.50, p-value= 0.003).

4.1.5 Distribution of solid pollutants along the gradient of distance from park exits

The figure below (Figure 3) shows the distribution of plastic materials, metal waste, tyres and tubes along the gradient of distance from the park exits (point A to J). Tyres and tubes as well as metal waste being found mostly near road humps.

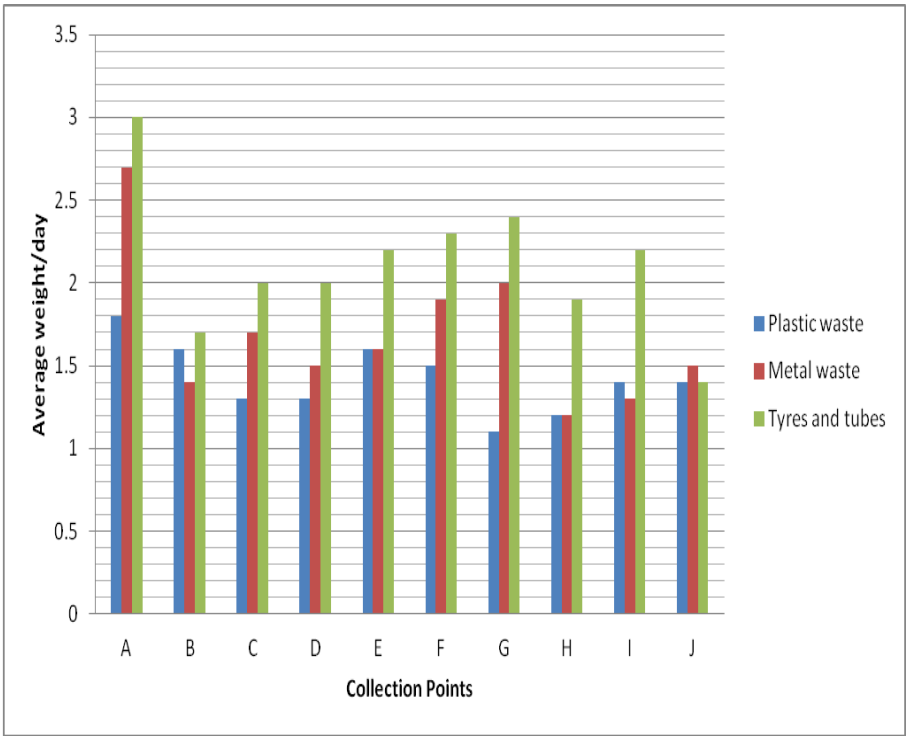

Figure 3 : Amount of solid pollutants along the highway through MINAPA

4.1.6 Percentage of wastes collected per month along MINAPA highway

Figure 4 below represents the amount of solid waste products which were collected along the highway through MINAPA highway in the month of May 2013. Wastes are represented in forms of percentages in which tyres and tubes cover a large percent (29%), and plastic bags showing the least percent (21%). Other types of wastes and their respective percentages are shown below.

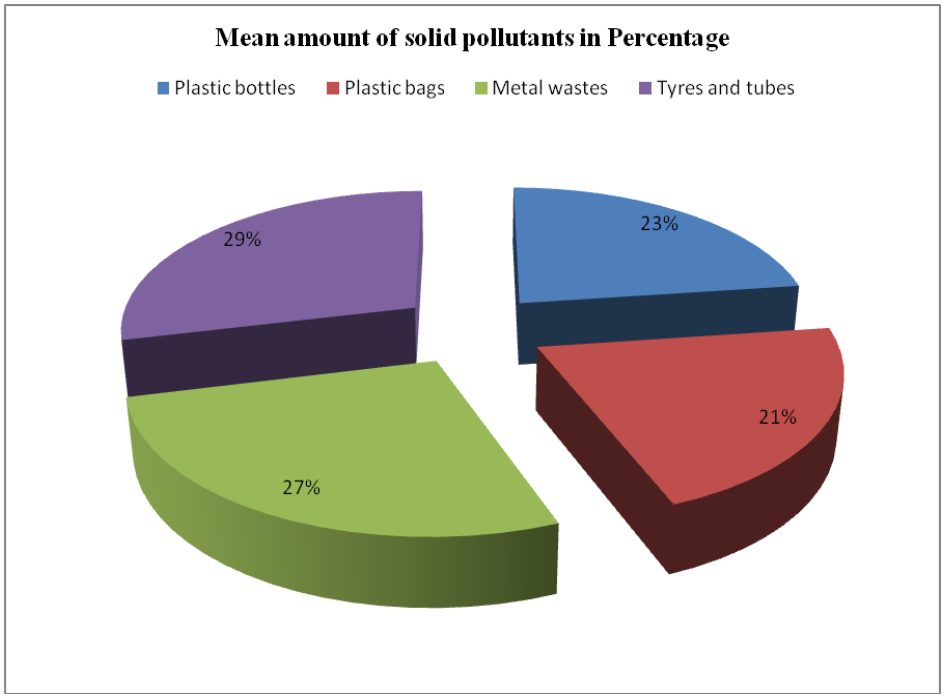

Figure 4 : A Pie chart showing the mean amount of solid waste collected along MINAPA highway in percentage.

4.2.0 Discussion of results

4.2.1 Amount of plastic wastes dumped along the highway

The overall findings of the current study suggest that plastic materials were decreasing as we move further inside the park from either direction. This might be due to the fact that passengers who usually buy water, juices, or other food stuffs contained in plastic materials start consuming or drinking at the bus stop before or even when bus start off, and drop the containers soon after finishing. Mikumi and Doma villages situate at least 2 kilometers from the park boundary, thus it is possible that by the time the bus enter the park, majority of passengers who were either drinking or eating food contained in plastic materials finish and thus drop them right there inside the park.

Plastic waste are non-biodegradable that cannot be decomposed easily by natural processes, hence being dumped or disposed improperly in large amount may lead to severe environmental effects, example plastic wastes may cause harm to wildlife, although there is little research on the specific impacts of plastic waste on land-based wildlife, there is a concern that incorrectly managed landfills could lead to either the escape of plastic waste or the escape of landfill leachate containing the chemicals associated with plastic, furthermore plastic wastes have the impacts on the ecosystem by introducing alien species to the ecosystem which were absent before (Derraik, 2002; UNEP, 2006). Moreover, dumping food along the highway contained in plastic containers may change the behavior of some animals, mostly baboons and some birds which highly depend on feeding from wastes dumped by road users. They may change from wilderness behavior and develop some kind of dependence on the food found along the highway. Similar case is reported by Caley *et al*. (2012) conducted in Kibale National Park observing the behavioral changes exhibited by baboons, the result showed that 10 percent of baboons among all which were marked and monitored for one year were found to be habituated.

4.2.2 Quantity and spatial distribution of tyres and tubes left off by road users along the highway

The results of this study suggest that tyres and tubes are distributed throughout the park along the highway with the peak level at the road humps, but this does not signify that tyre burst occurs only at road humps but rather it take place at any point along the highway (Figure 3). Among all wastes collected along MINAPA highway tyres and tubes weighed greater than other types of waste probably due to high density of a tyre (Table 3). Tyres and tubes waste are the results of flat tyre accidents

that are occurring along the highway, although more wastes of this type were collected largely near road humps among all collection points along the highway, point which shows large quantity of tyres and tubes is the first collection point from western part of the highway i.e. collection point A which has the daily average weight of 3 kilograms (Figure 3). The reason behind this, is similar to the reason as to why metal waste are found in a large quantity in the first point from the west; large road humps and roughness of the road which leads to many flat tyre accidents. Tyres and tubes collected were large in terms of weight but there are other types of waste such as plastic materials, empty tins and paper and boxes, that have less weight compared to tyres but they were collected in large volumes. Similar case was observed in Serengeti National Park where 33 tons/year of metal scrap waste were collected in the year 2010 (Mumba, 2010). Tyres are inert in landfills. Whole or substantially whole tyres in thin layers can contribute usefully to the permeability of leachate drainage layers within the structure of the landfill. Fragmented tyres can act as useful inert substrate for the biochemical activity which will lead to the stability of the landfill site (USEPA, 2000).

4.2.3 Quantity and distribution of metal wastes dumped along the highway

Most of the metal wastes that are found along the highway have been left by road users after cars breakdown. Metal wastes had greater weight, but its actual volume was lower compared to other types of wastes (Table 3). Example, a single piece of metal could weigh twice as much a single sack of plastic waste. Moreover, the distribution of iron scraps (metal waste) was found to be relevant to the research hypothesis of this study which states that, the amount of iron scraps dumped is distributed throughout the park highway at road humps sites (Figure 3); the location

where iron scraps were found was at the areas where car breakdown occurred and this was specifically near road humps. This is because flat tyres occurs mostly in areas where there is road humps which restrict drivers from driving with high speed, moreover these road humps are very large to the extent of causing accidents and car breakdowns to negligent drivers who does not follow driving regulations inside the park i.e. 50 KPH. In places having no road humps, drivers tends to drive beyond the speed limit suggested by the park authority that is 50 KPH thus cause more accidents, car break downs, flat tyres to occur which are the main source of producing metal wastes. Large amount of metal wastes were found in the first collection point, point A (Figure 3). The average weight for this point was 2.7 kilograms per day, this could be probably due to the reasons which are roughness of the road in this particular area and large road humps, the first ten kilometers (A to B) from western part of the highway are considerably rough as compared to other remaining parts of the road. The similar observation is reported in Yankari National Park in Nigeria (Awofolu, 2005). Metals are totally recyclable and recycled, and further to this it can be recycled indefinitely with no decline in properties (UNECE, 2006). But, metal does not rust in the traditional sense, it oxidizes very slowly. This process gives off iron ashes which are carbon based and good for the soil. But in real sense these ashes have impacts to other microorganisms found in the soil (USEPA, 1995). Therefore, iron scraps might have been considered as the solid pollutant that have least environmental impacts, but in real sense, metal waste have indirect environmental impacts that cannot be noticed easily (ISRI, 2008).

4.3.0 Mitigation measures taken by MINAPA to remedy the impacts

Due to the fact that, the impacts of wastes that are always dumped along the highway by road users is clearly known to conservationists, MINAPA has already taken some measures to remedy the extent of impacts which are highly threatening the parks' ecosystem. Some of the measures include; collection of litter/wastes along the highway on a daily basis, this in some ways have helped to reduce the amount of wastes that when left uncollected would harm wild animals that are found in the park. Though the process of collecting litter is costfull but the park has managed to do it. In addition to that, laws and regulations prohibiting road users from dumping wastes along the road, and all wastes produced inside the cars to be kept inside the car and taken out of the park have been enforced. Though these regulations are there, but they are not executed as they are supposed to be, thus making people not to abide with them.

Furthermore, the parks' authority has once established education programmes to road users where they used to educate people who are using the highway on the importance of conserving the parks' environment for the safety of park ecosystem as a whole. They used fliers, brochures and direct oral education from experts who were educating people in buses and other passenger's cars. Though this programme did not last long but it raised awareness to road users on the importance of stopping from dumping wastes along the road. It made them know the impacts which the park will face when excessive littering will continue.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

This chapter constitutes the conclusion, recommendation as well as the section which explains areas which need to be researched further.

5.1 Conclusion

This study concludes that, the littering of the park by plastic materials is high at the entrance and decrease as we move inside the park. Also, the road humps constructed inside the park to retard the speed of vehicles causes lots of tyre burst and drop of metal scraps and other solid materials in the site. Moreover, the study concludes that effort by MINAPA on collection of waste materials reduces the level compilation although this is costfull.

5.2.0 Recommendation

5.2.1 General recommendation

Long term solution to all challenges that are facing national parks in Tanzania is to provide education and involving all people in planning process. Tourists and other road users will continue to negatively impact these areas unless there is continual education about why it is necessary to preserve these conservation areas. Educating passengers can be done by using posters, brochures, fliers, audio and video clips having educative materials about the importance of conserving or keeping the highway free from waste. These media should be designed in a simple and understandable language and distributed in every car that is going to pass through the

highway. Once education is provided as a part of the solution, will influence more people to care about the problem at hand.

Moreover, strict law enforcement should be done and strict measures should be applied to those who will be caught disposing solid waste along the highway. Drivers and bus attendants should make sure each passenger get to understand what is supposed to be done when the car approaches the national park, their cars must have dust bins and bus attendants should make sure that no one is throwing wastes out of the car, otherwise strictly measures should be taken to those who will be caught throwing wastes on the road. MINAPA authority should make sure that laws and regulations enforced are administered correctly.

MINAPA should introduce time in-time out method as the method of determining the speed used by cars that are passing through the highway. The speed limit suggested by TANAPA while driving inside any national park is 50 KPH or less, hence driving beyond this speed might cause accidents which are probably the cause of solid wastes such as iron scraps and tyres and tubes. Therefore, if this method is used, drivers who are violating the speed suggested by TANAPA will be spotted and caught by estimating the time used by the car to pass through the MINAPA highway.

Moreover, conservation fees to assist in collection of the solid waste should be introduced to road users. This will facilitate the park authority to carry out a solid waste collection programme that is done in a daily basis. This programme is very costfull therefore conservation fees that will be introduced will help to cater for the previous cost used by the park in the process of collection of solid wastes that are found along the highway.

Lastly, MINAPA should introduce the method of providing rewards for good drivers who have good records of not causing accidents, always driving at the speed suggested by the park. Introduction of this method will motivate other drivers who are regularly using MINAPA highway to follow all the regulations while passing through the highway.

5.2.2 Areas for further research

The issue of biodiversity conservation is the most important thing that every person should take and be responsible for it. Usually problems and challenges towards conservation are identified after scientific research being conducted in that particular matter. As far as national parks is concerned, MINAPA is among the top five biggest national parks in Tanzania with large number of visitors (tourists), large number of animals including the big five animals, and varieties of plant species. Being in this state, MINAPA is facing so many challenges that need to be identified and solved. The highway that is passing through the park has become the source of so many problems such as road kills, disturbance to wild animals as well as littering (illegal dumping of wastes). This report is based on quantification of pollutants (waste) that has been dumped by road users who are passing through Mikumi national park highway; quantifying the pollutants is something crucial towards identification of the actual problem that is caused by those pollutants. Therefore, further research should be conducted to assess the impacts caused by those pollutants that are dumped along the highway. Assessment of impacts may be specific to each kind of waste, e.g. assessment of the impacts caused by plastic materials to animals found in the park. This will help conservationists to know which kind of waste among all the types of waste that is plastic materials, metal wastes, tyres and tubes, paper and boxes, as well

as empty tins, is more dangerous to the park ecosystem. In addition to that, knowing which kind of waste is unhealthier than others will make conservationists, planners and policy makers to be in better position to devise mitigation measures to the problem, to make amendments to the existing policies and regulations and to plan for the better approach of handling matters relating to conservation.

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