

Challenges and Solutions of Solid Waste Disposal Systems in Fako Division, South West Region of Cameroon

Abstract

With rapid urbanisation occurring recently in Fako, there is need for renewed evidence on the functionality of solid waste disposal systems. This paper therefore seeks to investigate the effects of waste disposal systems and facilities in Fako Division of the South West Region of Cameroon. Data from secondary sources was collected from HYSACAM (waste management company), Ombe Industrial Zone and Hospitals. This was complemented by 352 questionnaires administered in the four towns of Buea, Mutengene, Tiko and Limbe. Data analysis was achieved with the help of conventional graphical plots and statistical techniques by using Microsoft Excel 2016 and the Statistical Package for Social Sciences (SPSS) Version 20 to compute and produce statistical tables, correlation analysis and bar graphs. Results revealed that most of these wastes are disposed of in open dumpsites and directly into waterbodies (rivers and streams) and the least along the roadsides, littered around residential areas and in farmlands. Industrial wastes are channelled directly into the sea, waste from hospitals is incinerated and most of the waste in Limbe and Buea is disposed of in unsanitary landfills which are managed by the HYSACAM Company. This study recommends a framework for waste handling to minimize environmental and health hazards. It also recommends the sensitization of the population on the hazards associated with improper waste management and their involvement and participation in the waste management process. An appropriate solution for waste disposal is a landfill where waste is unloaded, spread into thin layers, compacted and covered with inert material.

Keywords: contamination, water resources, disposal facilities, municipal wastes

Introduction

Solid waste is described as any discarded materials that arise from human activities ~~and are not free-flowing including~~ such as bottles, metals and plastic scrapers, garbage, papers, glasses, ~~and~~ food/animal product, disposable carrying bags, woods, ~~or~~ malfunctioned electronic devices (Babybonela, 2013). They can be classified as domestic, commercial/market, industrial, hospital, or street sweepings. Population growth and urbanization are the two most crucial factors behind waste generation. Global average waste generation varies between 0.11 and 4.54 kg/person/d (World Bank, 2019). Globally, rates of waste generation have been increasing. It is forecasted that the volume of municipal solid waste (MSW) will double from the current waste generation rate of 1.3 billion tons per year in 2012 to 2.2 billion tons per year by 2025 (World Bank, 2012). As urbanization continues to take place, the management of municipal solid waste poses major public health and environmental problem particularly in urban areas all over the world (Aluko, 2012). Increasing population levels, booming economy, rapid urbanization and the rise in community living standards have greatly accelerated the solid waste generation rate in developing countries (Minghua *et al.*, 2009). Driven by urban population growth, increasing waste generation rates will severely strain existing MSW infrastructure in the urban areas of low and middle-income countries. While urbanization is a challenge, it creates a high concentration of people and services, which provides an opportunity to deliver efficient MSW services.

Municipal solid waste (MSW) management is inextricably linked to urbanization, development, and climate change (Oteng-Ababio, 2014). These growing waste generation rates in developing countries experiencing increasing affluence have been phenomenal (UN-Habitat, 2011). In most developing countries, the challenge relates more to effective waste collection and better waste treatment systems to reduce greenhouse gas emissions from the waste sector. In Sub-Saharan Africa, which has collection rates ranging from 17.7% to 55% (World Bank, 2012), and low waste collection efficiency, dumping waste on the roadside is a common practice (APO, 2007). Although the use of covered and compactor trucks for collecting waste is increasing, transporting solid waste by inefficient and open vehicles is a common practice in urban areas (APO, 2007). Municipalities which are usually responsible for waste management in the cities, have the challenge to provide an effective and efficient system to the inhabitants. However, they often face problems beyond the ability of the municipal authority to tackle (Sujaudinet *al.*, 2008) mainly due to lack of organization, financial resources, complexity and system multi dimensionality (Burntley, 2007). Owing to the growing population, the quantity and variety of solid wastes from domestic, social, industrial activities, development of technologies, agricultural activities, livestock keeping, and commercials, continue to increase in most African countries (Ravindra, 2015). Moreover, local authorities have the roles of ~~the presence of~~ effective and efficient solid waste collection, storage, and transportation with disposal centres including solid waste collection and transportation utensils or equipment such as bins and trucks (Nyampunduet *al.*, 2020).

In urban areas, especially in the rapid urbanizing cities of the developing world, problems and issues of Municipal Solid Waste Management (MSWM) are of immediate importance. This has been acknowledged by most governments. However rapid population growth overwhelms the capacity of most municipal authorities to provide even the most basic services. Typically, one to two thirds of the solid waste generated is not collected (Zurbrugg, 2003). As a result, the uncollected waste, which is often also mixed with human and animal excreta, is dumped indiscriminately in the streets and in drains, ~~and such~~ contributing to flooding, breeding of insect and rodent vectors and the spread of diseases. In particular, the open dumping in uncontrolled sites, open burning of waste fractions and the mismanagement of the leachate produced in final disposal sites, are the main issues detectable (Modaket *al.*, 2015). Furthermore, even collected waste is often disposed of in uncontrolled dumpsites and/or burnt, polluting water resources and air. Major challenges regarding the waste in the developing world are found to be the composition of waste, absence of waste separation scheme at source, ineffective waste collection methods, lack of financial support and policies related to waste management, and absence of coordination between different governmental institutions (Tanveeret *al.*, 2022).

The global waste crisis is an effect of untreated, unsafe disposal and inefficient waste collection. In urban Africa, solid waste management is one issue facing authorities in the fast-growing cities especially in developing countries (UNEP, 2010). The steady growth of urban populations and the rapid increase in solid waste generation has emerged as one of the main pressing issues of human society, especially in developing countries (Markandya, 2006). In most of the developing countries, solid wastes are being dumped on land without adopting any acceptable sanitary land filling practices. The situation is worsened in slum areas with additional problems of high-density population, traffic, air and water pollution.

Municipal Solid Waste Management in Cameroon is a major environmental problem facing many municipalities, like in other developing countries that are facing high rates of urbanization (Mbenget *al.*, 2012). With the increasing population, increasing economic activities and rapidly changing lifestyles, Cameroon is faced with greater challenges towards managing solid waste. Cameroon's Municipal Solid Waste Management policy is based on a public-private partnership, the Hygiene and Sanitation Company Cameroon (HYSACAM) which ensures regular collection and processing service for domestic waste in the major cities (Ymele', 2012). In Fako Division the Hygiene and Sanitation Company (HYSACAM) is responsible for the management of waste in the Buea and Limbe municipalities. Despite this the towns are still dirty with piles of uncollected waste spotted at roadsides, in gutters, littered around residential areas, open dumpsites, along river beds and in surface water bodies causing contamination and health problems. ~~reasons why this study carried out with its objective to investigate the effects of solid waste disposal systems in Fako Division~~ The objective for this study was to investigate the effects of solid waste disposal systems in Fako Division,

2. The Study Area and Methodology

Fako Division is in the South West Region of Cameroon and it is located between latitudes 4°4' and 4°2' ~~North~~ north of the Equator and longitudes 8°7' and 9°25' ~~East~~ east of the Greenwich Meridian. It is along the foot of Mount Cameroon, from the Bimbia River at the Gulf of Guinea. Fako Division shares boundaries to the ~~North~~ north with Meme Division, to the ~~West~~ west with Ndian Division, to the ~~East~~ east with the Littoral Region and to the ~~South~~ south with the Atlantic Ocean. It is made up of five ~~Sub-Division~~ sub-divisions, Muyuka, Buea, Tiko, Limbe and Idenau. The study is limited to the four main towns of Buea, Tiko, Mutengene and Limbe (Figure 1). ~~Fako Division has a total surface area of 2060 km².~~ Fako Division has a total surface area of 2060,060 km² and an estimated projected population of ~~1-316-079~~ 1,316,079 (BUCREP, 2016).

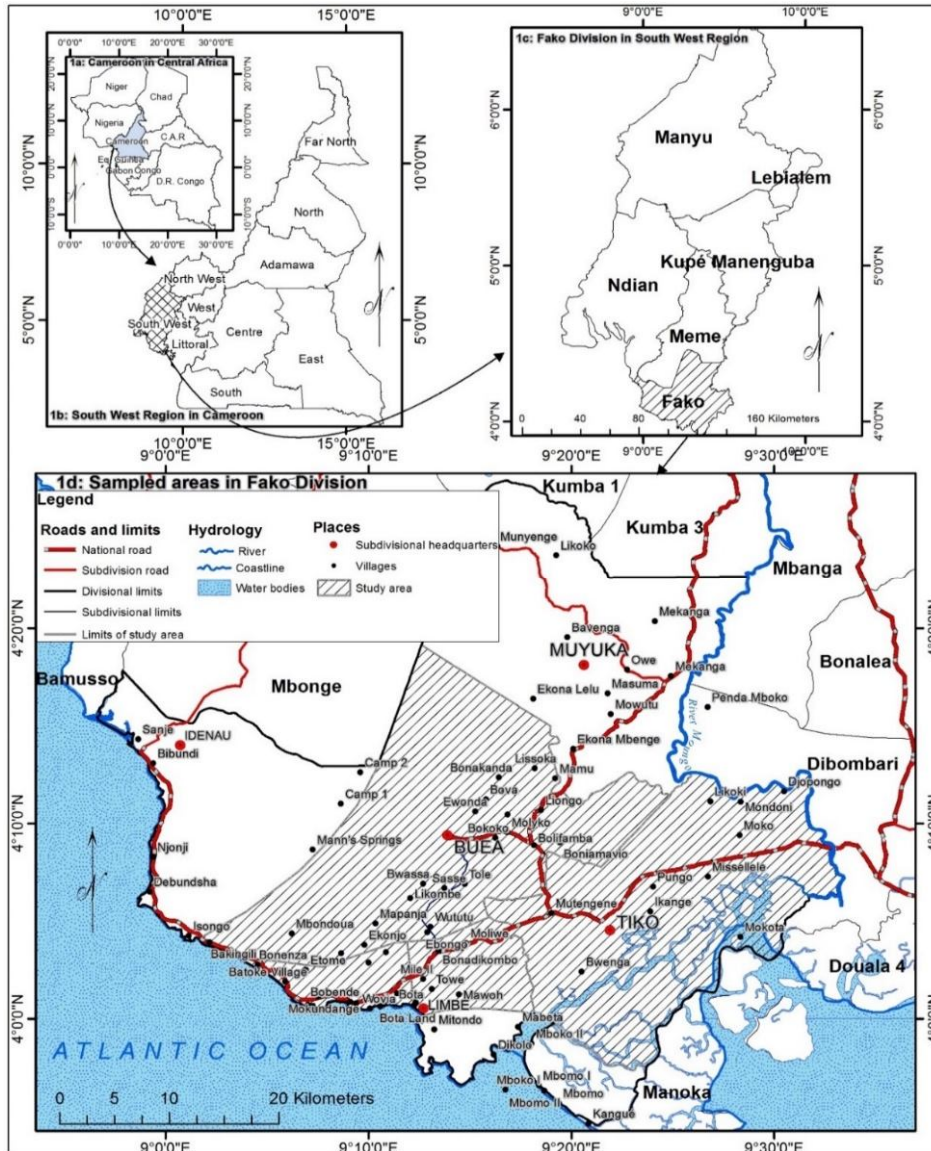


Figure 1: Location of the Study Area

Source: Administrative Map of Cameroon (NIC, 2020)

The Mount Cameroon region is one of the regions in Cameroon that is experiencing a rapid population growth in recent **times**. Highlands such as mountains which offer site advantages like climate, fertile soils, watershed function, defense, and an abundant plant and animal species continue to attract population. This growth is manifested by changes in number, density, size and pattern of settlement and the multiplication of socio-economic activities. The change in population over time results from natural increase, rural exodus and net migration which have caused the existing urban centres of Buea, Limbe, Tiko, and Mutengene to become important growth poles with cosmopolitan populations. Fako Division is one of the regions in the country that is experiencing an exponential population growth. National Population Census in 1976 and 2005 shows that in the entire Fako Division, the population has increased steadily from 157,032 inhabitants to 432,427 inhabitants in 2010 (BUCREP, 2010). The **Recent** recent estimated projected population is **1,316,079** (BUCREP, 2016) which has also resulted in increased

urbanization. The region is witnessing increasing human concentrations as seen from the rapid increase in population and the multiplicity of socio-economic activities and increase in solid waste production. The increase in population and urbanization has led to the increase in waste generation which has put pressure on the few waste disposal systems that are available in Fako. The absence of a proper waste management system and the fact that the HYSACAM Company does not collect waste from all sites in Fako Division has left the land and waterbodies at the mercy of waste which might be polluting them. There is the common practice of indiscriminate waste disposal in open dumpsites, along the roads and in gutters, open burning, overflow cans, composing, and unsanitary landfills.

3. Methodology

The research design was a mixed method design composed of the explanatory and descriptive ~~method~~ methods. The opinion of the population was sampled with the use of direct questionnaires ~~administration~~ administered in a stratified sampling technique in the four towns of Buea, Mutengene, Tiko and Limbe. The questionnaire had as structure and content; the age range and level of education of the respondent, how many people live in each household, approximately how much solid waste they generate per week and which waste disposal system ~~is~~ was being used. The questionnaires were administered randomly in the different towns taking into consideration the population of each town which are like strata (~~Table 1~~) as in Table 1.

Table 1: Questionnaires Distribution

Location	Population	Number Administered	Percentage
Buea	149,308	139	39.5
Tiko/Mutengene	134,027	112	31.8
Limbe	95,756	101	28.7
Total	379,091	352	100.0

A total of 352 questionnaires were administered in the four towns as indicated on ~~table~~ Table 1 above based on the total population of each of the towns. Buea had the highest number of questionnaires, followed by ~~Limbe, Tiko and Mutengene~~ Tiko/Mutengene and Limbe. Interviews were also conducted with stakeholders in Fako Division as follows: the ~~deputy mayor~~ Deputy Mayor of Buea council, the technical services of the three councils (Tiko, Buea and Limbe), the General Supervisors (GS) of the ~~Regional~~ regional hospitals in Buea and Limbe, the Baptist Hospital in Mutengene, the Mount Mary Hospital in Buea and the ~~Distriet~~ district hospital in Tiko. There was personal interaction with the Heads of the Technical ~~services~~ Services of the HYSACAM Company in Limbe and Buea, and the population at large. The section of the population that could not read nor write were interviewed directly. These interviews were conducted during the fieldwork to help the researcher in the collection of data.

Table 2: Persons Interviewed

Person interviewed	Date	Key issues	Duration
Deputy mayor Mayor, Buea Council	February 2021	Who is responsible of waste management in the municipality?	15mins 15 mins
General Supervisors, Regional hospitals in Buea & Limbe,	May 2022	Where do they dispose solid waste and how frequent-?	30mins each 30 mins each

General Supervisors Baptist Hospital in Mutengene, the Mount Mary Hospital in Buea, District Hospital in Tiko	March 2021	What systems have they put in place for waste disposal to protect public health ?	1hour
Head of Technical Service, HYSACAM Company; Buea Limbe	May 2022	- How often waste is collected from the dumpsites, - Unsanitary landfills, overflow waste cans	30mins each 30 mins each
Technical Service, SONARA	May 2022	Where solid waste is disposed, any treatment before disposal	30mins 30 mins
Production Department Rubber Factory			45mins 45 mins
Production Department Banana Factory			45mins 45 mins
Technical Department Brasseries Depot		Where waste is disposed of especially plastics	45mins 45 mins

Secondary data information of statistics on the evolution of the population was obtained from the Central Bureau for Census and Population Studies (BUCREP) in Buea. Data was collected from HYSACAM on the quantity of waste that they have had been collected and dumped in the various landfills over the years. Information on types of wastes generated and how they are were disposed was collected from five hospitals. Data was also collected from Ombe Industrial Zone on the types of waste generated and disposed of over the years. Data analysis was achieved with the help of conventional graphical plots and statistical techniques using statistical packages such as Microsoft Excel 2016 and the statistical Package for Social Sciences (SPSS) Version 20 to compute and produce statistical tables, correlation analysis and bar graphs.

4. Results

4.1 Waste Disposal Systems and Facilities

The rapid growth of population and urbanization in Fako Division is contributing towards quantity, quality and the variety of waste in the form of biodegradable, non-biodegradable and hazardous wastes at their worst as far as the disposal systems and the environment are concerned. The typical municipal solid waste in Fako contains general wastes (organics and recyclables), special wastes (household hazardous, medical, and industrial waste wastes), and construction and demolition debris. Most of these wastes are disposed of in open dumpsites along the roadsides, in valleys, littered around residential areas, in farmlands and in surface water bodies (Figure 2). There are were also the two poorly designed unsanitary landfills located in Isokolo in Limbe and Mussaka in Buea municipalities which are were managed by the HYSACAM Company.

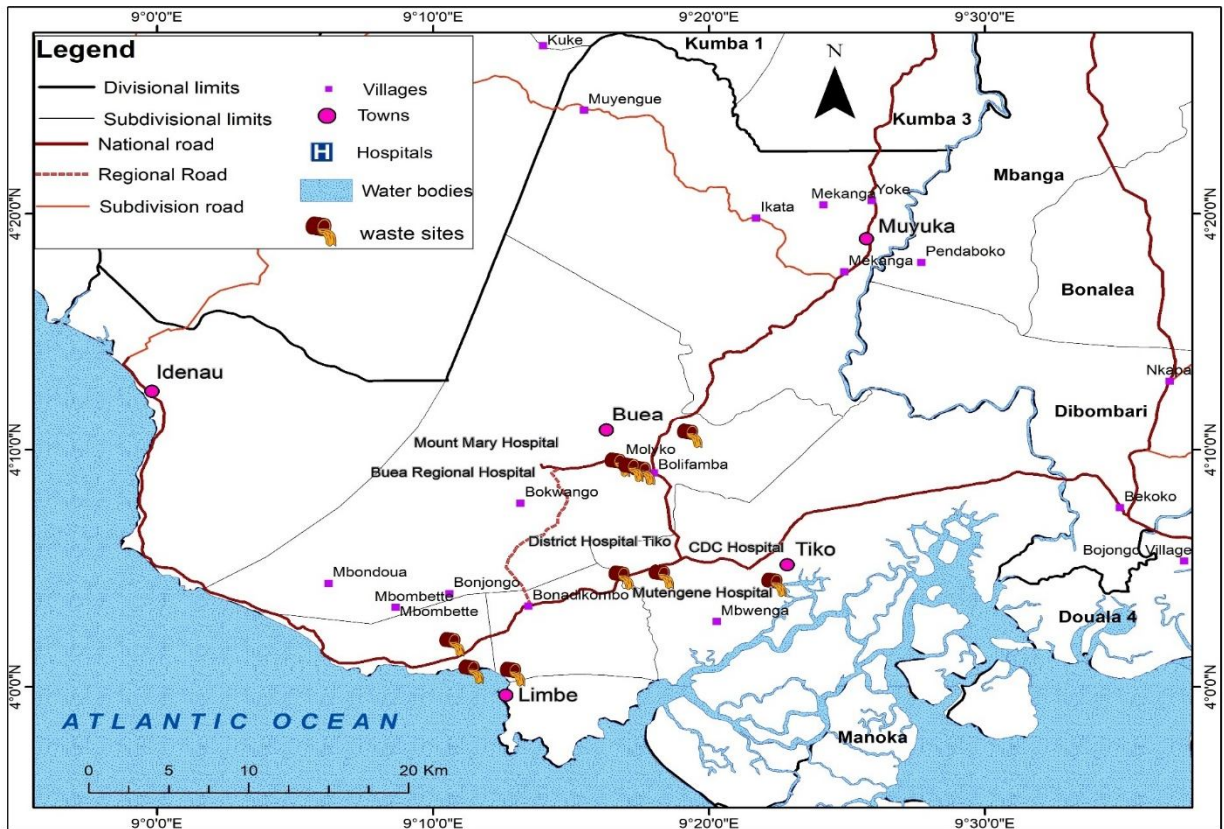


Figure 2: Spatial distribution of waste dumpsite
Source: Fieldwork, May 2022

The municipalities of Buea and Limbe waste management is handled by the HYSACAM Company which has created an open unsanitary landfill where their waste is disposed of. These poorly designed landfills can cause the contamination of water, soil, and air. Tiko municipality have not put in place any waste management system, which leaves the population to decide where to dispose of their waste. The population of Fako Division from the statistics of the questionnaire (Table 3) disposes of household waste into trash cans which are emptied by HYSACAM in the cases of Limbe and Buea. The biodegradable and non-biodegradable waste are disposed of in pits which are dug around residential areas, homes and some institutions like hospitals, in culverts, streams and rivers, while some especially the non-biodegradable plastics around households are burnt.

Table 3: Household Waste Disposal Facilities

Location	Household Waste Disposal							
	Trash can		Pit		Culverts		Streams/Rivers	
	F	%	F	%	F	%	F	%
Buea	48	41.74	51	42.50	22	31.88	18	37.50
Mutengene	16	13.91	15	12.50	9	13.04	3	6.25
Tiko	29	25.22	27	22.50	11	15.94	2	4.17
Limbe	22	19.13	27	22.50	27	39.13	25	52.08
Total	115	100	120	100	69	100	48	100

Household waste disposal facilities in Fako ~~are were~~ frequently ~~in~~ trash cans, and pits dug around ~~the~~ houses. ~~However,~~ culverts, ~~and in~~ rivers and streams ~~were being abused as disposal points~~. The highest percentage of users of trash cans in homes was recorded by the population of Buea, followed by Tiko and Limbe, with the population of Mutengene making the least use of trash cans. The population of Buea recorded the highest disposal of household waste in pits, followed by Limbe and Tiko with the same percentage and Mutengene ~~was~~ the least. Limbe recorded the highest population disposing household waste in culverts, followed by Buea, Tiko and Mutengene. The population of Fako also uses streams and rivers as disposal systems with Limbe having the highest percentage of the population that ~~is using~~ ~~uses~~ streams and rivers for waste disposal followed by Buea, Mutengene and Tiko respectively. These household ~~waste wastes~~ include unused food, peels of vegetables, rotten food, unused papers, plastic bags, plastic materials like wrappers, paper bags, plastic paper containers, broken plastic buckets, unused cotton material, electronic ~~waste wastes~~, smoke, dust, pharmaceutical and personal care products (PPCPs) just to name a few.

The population of Fako Division utilizes medical health care facilities which are located in all three municipalities of Tiko, Buea and Limbe. These hospitals generate a lot of waste and have put in place different facilities for the disposal of these ~~waste wastes~~. A number of the hospitals in the study area (Table 4) indicated that they manage their ~~waste wastes~~ within ~~the~~ hospital premises.

Table 4: Hospital Waste Disposal Facilities

Type of waste	Waste disposal systems/facilities				
	Limbe Regional Hospital	Buea Regional Hospital	Tiko District Hospital	Mount Mary Hospital	Baptist Hospital Mutengene
Sharps	Incineration	Incineration	Incineration	Incineration	Incineration
Pathogenic wastes	Placenta pit	Placenta pit	Placenta pit	Placenta pit	Placenta pit
Biodegradable	Open dumping	Open dumping	Open dumping-	Open dumping	combusting
	HYSACAM	HYSACAM	combusting		
Non-biodegradable	Open dumping & HYSACAM	Open dumping & HYSACAM	Open burning & dumping	Open burning & dumping	Open burning & dumping

The hospitals sampled for waste disposal facilities in Fako were the two regional ~~Hospitals~~ ~~hospitals~~ in Limbe and Buea, the Tiko District Hospital, the Baptist Hospital in Mutengene and the Mount Mary Hospital in Buea. The hospitals reported that their waste is emptied from the wards daily and the incinerator burning is also done daily as the waste production rate ~~is was~~ overwhelming. Sanitation workers of the Hygiene and Sanitation Units in the hospitals ~~are were~~ responsible for the collection and the transportation of wastes from the wards inside trash cans which ~~are were~~ mostly plastics directly to the site where the waste disposal systems ~~are were~~ located within the hospital premises. In the Tiko District Hospital and Limbe Regional Hospital for example, waste bins ~~are were~~ emptied at least once a day, typically in the morning while in the Mount Mary and Baptist hospitals in Mutengene the trash cans ~~are were~~ emptied twice a day in the mornings and afternoons. In all the healthcare facilities

surveyed, the waste collection systems adopted ~~are~~were plastic bins and plastic bags which ~~are~~were manually transported to the waste disposal sites within the hospital premises. The pathological waste ~~is~~was disposed of in the placenta pits which ~~have~~had been dug ~~into~~in the ground and the inner part cemented and covered with ~~a lid~~lids. The hospitals also ~~have~~had provisions for biodegradable and non-biodegradable ~~waste~~wastes, which ~~are~~were disposed of in separate dug open pits ~~which are~~covered with soil and compacted when full.

4.2 Open Dumping

Open uncontrolled dumping ~~is~~was the most common method of solid waste disposal in Fako Division. The open ~~dumps~~dump pits ~~make~~promote every uneconomical use of the available space and allow free access to animals, insects and flies. Degrading ~~waste~~wastes in such ~~dumps~~dump pits emits greenhouse gases, like methane, and toxic leachates which pollute subsurface and surface waters and enhance the risk of disease transmission to the population. Most of the open dumps in Fako ~~are~~were along ~~the road~~roads, in surface water bodies, along the banks of rivers, in culverts, waterways, in pits, and on the ground in sites around some residential areas. Open dumping along roads ~~is~~was a common scenario in the towns of Mutengene and Tiko. The trash stays along ~~the~~roadsides and decays and during ~~the rainy season~~rain seasons, ~~the waste is~~wastes ~~are~~ washed by runoff into gutters and finally into waterbody systems contaminating ~~the water~~waterbodies with ~~the~~leachate. The paved roads in Fako are characterized by poor road culverts which could be seen in Buea and Limbe filled with trash. This ~~is~~was because the vehicles of the HYSACAM Company ~~delay~~delayed ~~the~~collection of the trash and the population ~~turn to dump~~would dump ~~the waste to overflow~~that overflows into ~~the culverts which~~and blocks ~~the culverts~~and thus degrades the environment.

Poorly disposed waste ends up in culverts, gullies, waterways, rivers and streams around the towns and the proliferation of waste like ~~plastic~~plastics usually chokes and blocks passages of ~~the~~drainage and sewage systems leading to flooding in the wet season. Open dumping ~~is~~was the main implemented waste treatment and final disposal system, mainly visible in the Fako Division in the towns of Buea, Tiko, Mutengene and Limbe. The population of Fako that ~~is~~was close to the open waste ~~dumps~~dump pits like the residents of Isokolo in Limbe ~~are~~were affected by the smell of decomposing ~~waste~~wastes and the nuisance ~~is~~was worst during ~~the~~rainy ~~period~~periods as the area becomes infested with flies and insects.

The industries and factories in Fako Division ~~are~~were located close to the sea and they indicated that their hazardous ~~waste is~~wastes were thoroughly treated before ~~it is~~discharged ~~discharge~~ into the sea. They generate different and similar waste types over the years as from 2015 to 2021 (Figures 3 to 9). The different types of ~~waste~~wastes include; ordinary industrial ~~waste~~wastes, hydrocarbon ~~waste~~wastes, hydrocarbon sludge, metal scrap and special industrial ~~waste~~wastes. Different types of waste have been disposed of in the different years in different quantities. The hydrocarbon sludge decreased in quantity from 2015 to 2017 and increased in 2018 and dropped in 2019 with no quantity recorded in 2021.

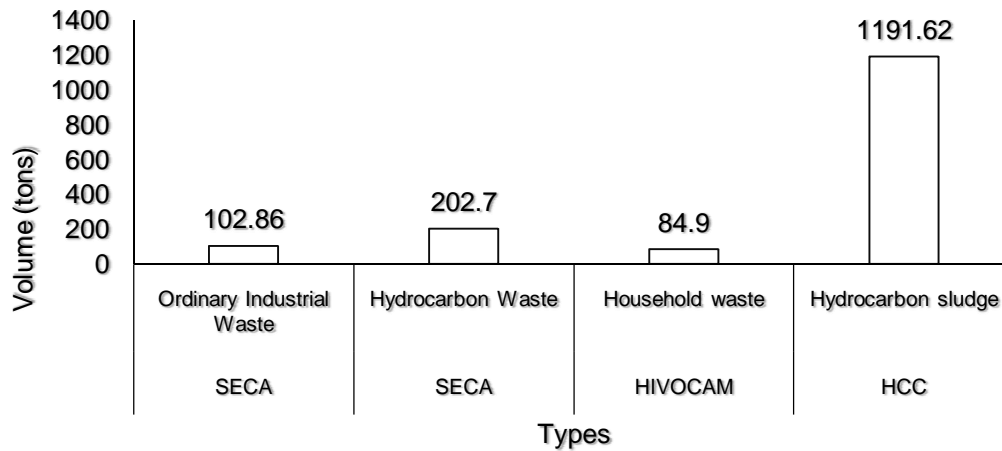


Figure 3: Types/Quantity of Industrial waste disposed in 2015

Source: Ombe Industrial Zone

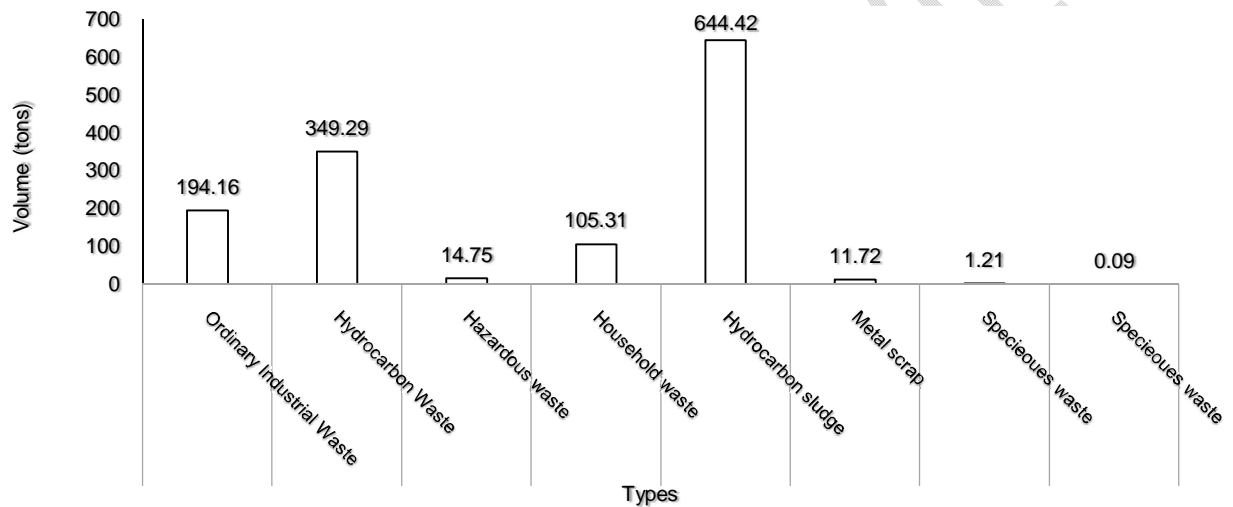


Figure 4: Types/Quantity of Industrial waste disposed in 2016

Source: Ombe Industrial Zone

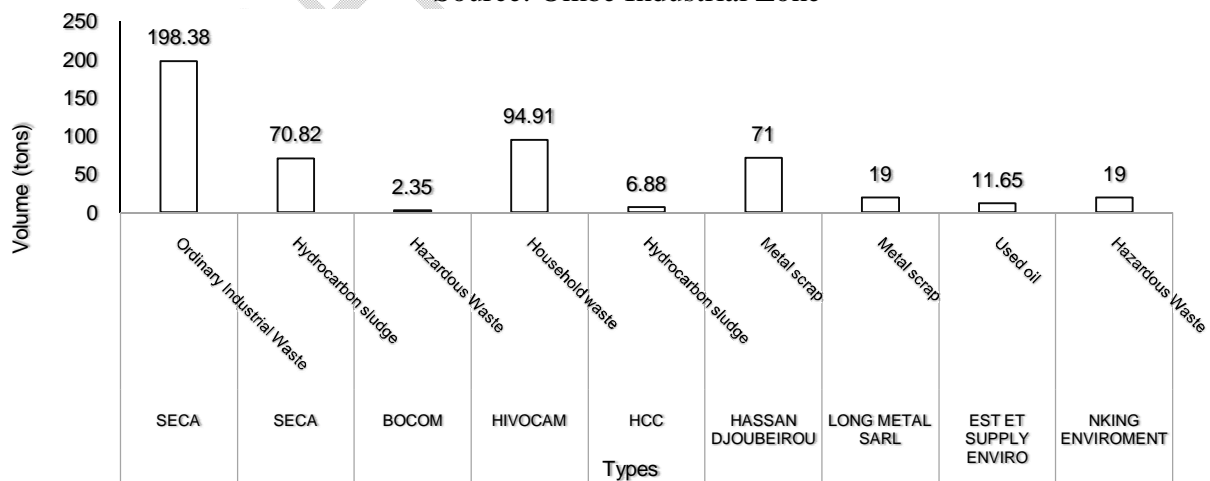


Figure 5: Types/Quantity of Industrial waste disposed in 2017

Source: Ombe Industrial Zone

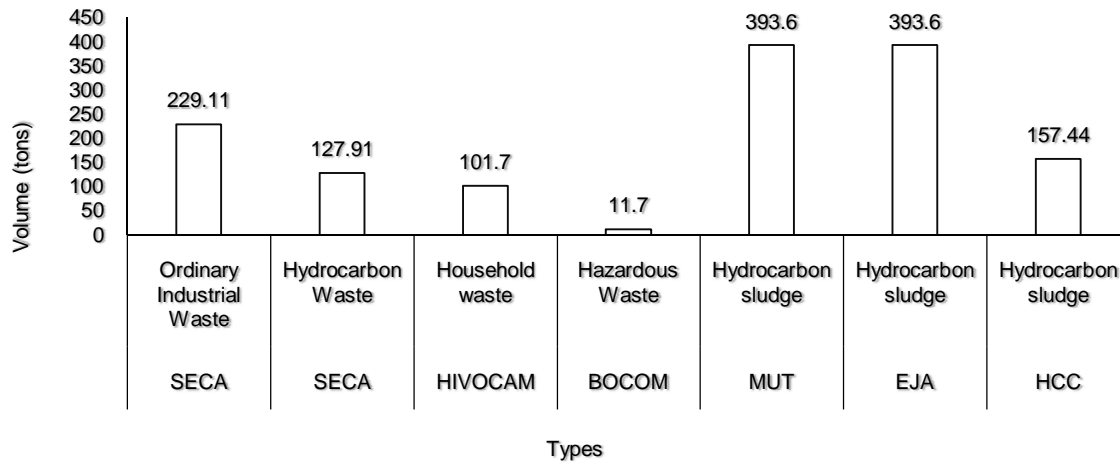


Figure 6: Types/Quantity of Industrial waste disposed in 2018
Source: Ombe Industrial Zone

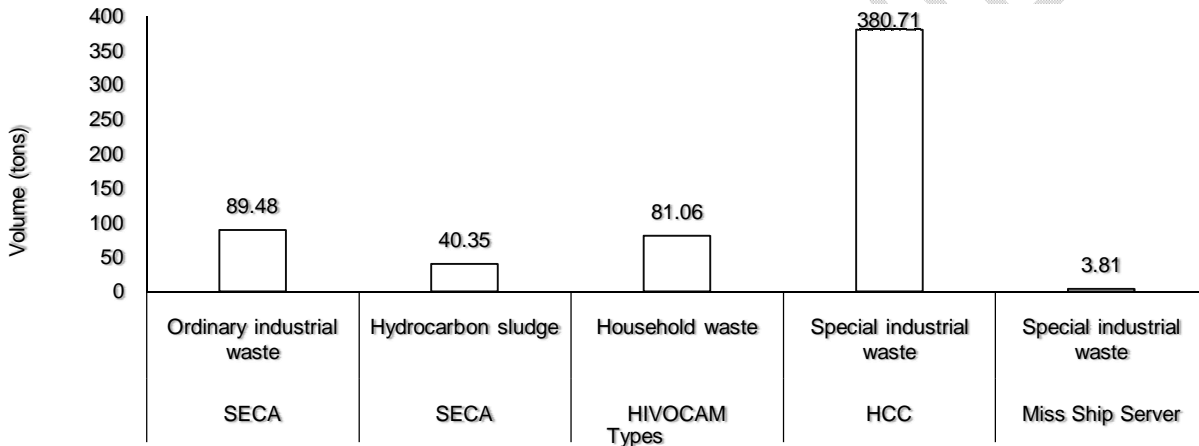


Figure 7: Types/Quantity of Industrial waste disposed in 2019
Source: Ombe Industrial Zone

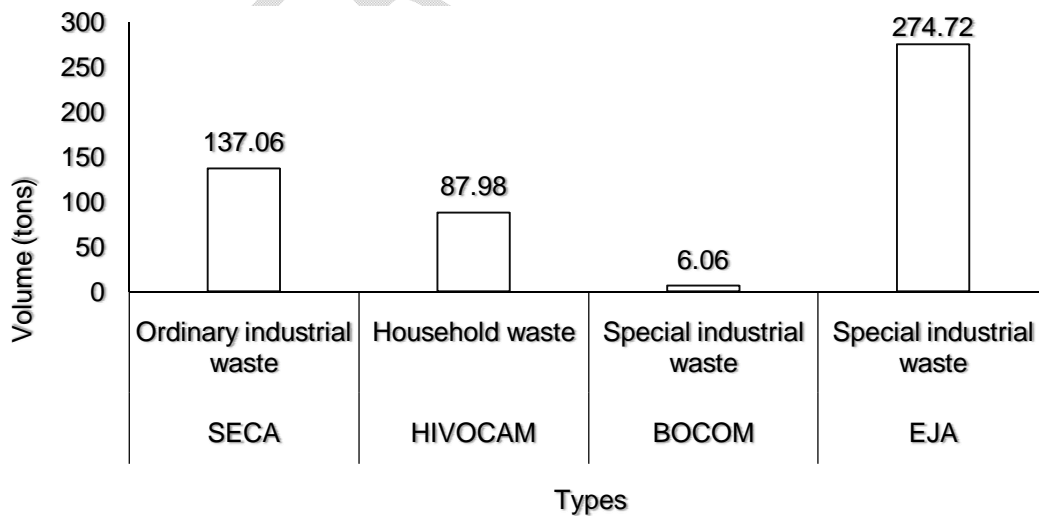


Figure 8: Types/Quantity of Industrial waste disposed in 2020
Source: Ombe Industrial Zone

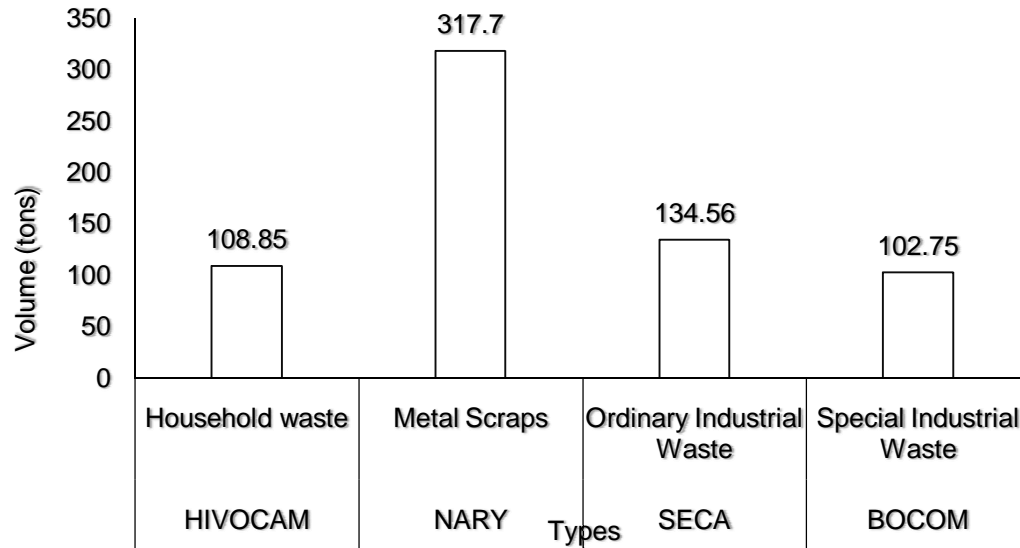


Figure 9: Types/Quantity of Industrial waste disposed in 2021

Source: Ombe Industrial Zone

Generally, the Ombe Industrial Zone produces hazardous waste with the most alarming being the sludge from the National Refinery Company (SONARA), Rubber Factory and the Palm Oil Factory in Idenau. These hazardous wastes are continuously being channeled into water bodies which are their disposal systems.

4.3 Open burning

Open burning is frequently used as a way of dealing with undisposed waste, especially in areas where waste collection is non-existent like in the Tiko Municipality and residential areas in the towns of Limbe and Buea that are far off from HYSACAM cans. It is used to reduce the volume or odour of dumped or uncollected solid waste. Settlements that are not close to the road and to water sources burn their wastes and the people use the ash as manure for their farms. The consequences on their health are severe for it causes they cause respiratory diseases among the population who burn their waste due to the lack of formal waste collection services. In most cases, it is the non-biodegradable wastes that is being burnt, plastics in particular while the biodegradable is used as organic manure or compost. However, the ash from the non-biodegradable is left open on land which will subsequently end up in water bodies by runoff or infiltration.

4.4 Incineration

Incineration is another solution to waste disposal in Fako. This was widely used in all the hospitals to reduce the potential infectious properties and volume of medical wastes and also to reduce the potential toxicity and volume of hazardous chemical and biological wastes. The principal gaseous products of waste incineration are carbon dioxide and water vapour. Incineration produces byproducts such as soot particles and other contaminants released in exhaust gases and leaves a residue bottom ash of incombustible and partially combusted wastes that must be emptied from the incinerator chambers. Some hotels in Fako incinerate

their ~~waste~~wastes and also a few students' residential areas in Buea. The pollutants like the ~~residue~~residual bottom ash of incombustible and partially combusted ~~waste~~wastes that ~~are~~were emptied from the incinerator chambers ~~are~~were likely to be washed away by runoff into surface water from ~~the~~dumpsite/dumpsites or infiltrate through ~~the~~porous scoria rocks underlying the substratum of the Fako geology and into the water table thereby contaminating the water resources.

4.5 Landfills

The municipalities of Buea and Limbe have unsanitary landfills ~~as~~like the solid waste disposal systems located at Mussaka and Isokolo. These landfills ~~are~~were open with no protection from around and ~~the~~waste ~~is~~was dumped carelessly in successions by HYSACAM trucks on daily bases. These open dumpsites ~~have~~had no barrier to keep out animals; they ~~lack~~lacked enough equipment to transport or compact ~~the~~waste to reduce ~~its~~volume and there ~~are~~were no environmental control measures. This open dumping ~~is~~was an effective way of isolating waste from the population; but adverse effects still ~~emerge~~emerged. These unsanitary landfills or open waste dumps ~~have~~had no barrier between the waste and the ground below. The annual trend shows ~~Municipal~~municipal solid waste deposited in the Isokolo dumpsite ~~is~~was rapidly increasing and accumulating over time from 2011 to 2020 in the Limbe municipality (Figure 12).

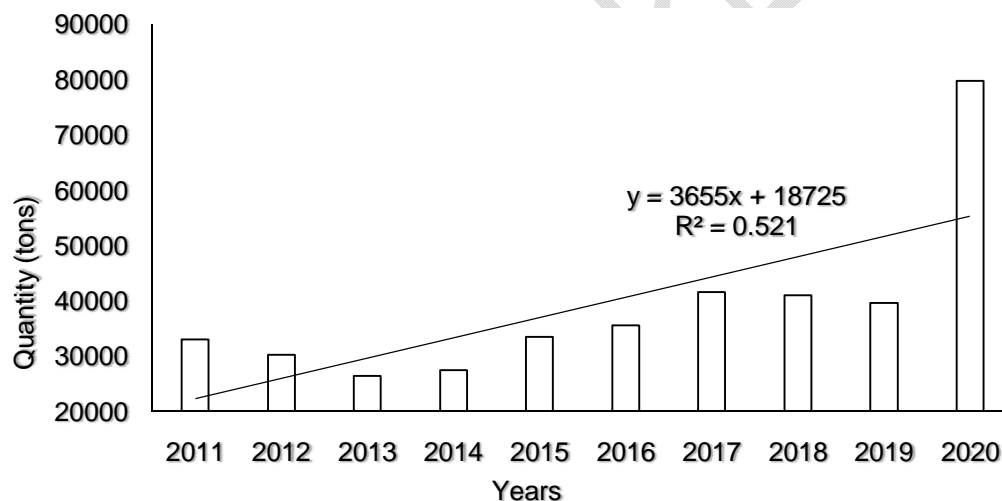


Figure 10: Annual trend of waste collected and disposed of in Limbe
Data Source: HYSACAM

In ~~the~~Buea ~~municipality~~Municipality, the annual trend indicates an almost equal quantity of waste generation and disposal at landfill in Mussaka from 2009 to 2015, then a drop in 2015 to 2017 and a spring from 2018 to 2020 (Figure 11).

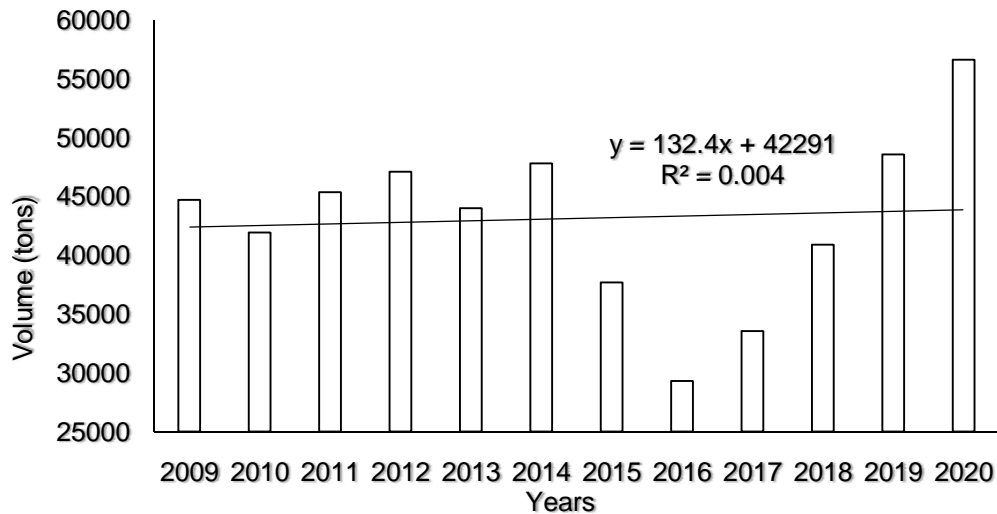


Figure 11: Annual trend of waste collected and disposed of in Buea
Data Source: HYSACAM

The annual trend of waste disposal at the Isokolo and Mussaka unsanitary fields generally has been on the rise. This increase in waste indicates the increased effects the open waste dumps are having on the environment and health of the population. There has been an increase in solid waste generation as a result of the rapid population growth and economic development in these urban areas in Fako. This is putting pressure on the HYSACAM company which normally was supposed to collect 80 tons of garbage per day as of their contract but is now collecting 104 tons of waste per day. As such, they are unable to meet up with the appropriate management of municipal waste due to lack of sufficient equipment, skilled labour and finances. After some years, a dumpsite undergoes biologically, chemically, and hydrologically-mediated changes resulting in a weathering process of the refuse and, consequently, becomes a source of pollutants and may result to health hazards.

5. Discussion

The results revealed that the typical solid waste in Fako contains general wastes (organics and recyclables), special wastes (household hazardous, medical, and industrial wastes), and construction and demolition debris. Most of these wastes were disposed of by open burning and open dumping which were open dumpsites along roadsides and river beds, in valleys, gutters, and culverts, littered around residential areas, in farmlands and directly into surface water bodies and in the unsanitary landfills and open dumpsites in Limbe and Buea which were operated by the HYSACAM Company. These poorly designed landfills cause contamination of the environment thereby affecting the health of the population. Jhamnani and Singh, (2009) observed in similar studies that the main waste generated in municipalities is from households, the markets, agricultural products, retail and commercial markets, hospitals and paper industries, kitchens, slaughterhouses, factories, industries and construction and demolition activities. Landfilling is the preferred method of municipal solid waste (MSW) disposal. However, poorly designed landfills can cause the contamination of soil, air and groundwater. The most common danger to human health from these landfills is from the use of groundwater that has been contaminated by leachate. This is also similar to the works of Keller (1982) who posits that open dumps are the oldest and the most

common way of disposing solid wastes. In many cases, they are located wherever land is available, without regard to safety, health hazard, and aesthetic degradation. **That the solid wastes are often piled as high as equipment allows and in some instances, the refuse is ignited and allowed to burn and in others, the refuse is periodically levelled and compacted***so what? There is something lacking or missing in this sentence highlighted in yellow. Please correct it and delete the yellow highlight and this italicized, underlined comment highlighted in red.* As a general rule, open dumps turn to create a nuisance by being unsightly, breeding pests, creating a health hazard, polluting the air, ~~and~~ polluting groundwater and surface water resources (Milla & Huang, 2012).

Some of the ~~waste~~wastes around residential areas is burnt or just allowed to be carried by runoff into water bodies. The hospitals ~~used~~use incinerators for ~~the~~burning of ~~sharps~~*what are sharps?* and pits for pathological, non-biodegradable ~~waste~~wastes and composting for ~~biodegradable~~biodegradation. Open dumping and open burning are the main implemented waste treatment and final disposal systems, mainly visible in low-income countries (Ferronato & Torretta, 2019). In developing countries, the management of waste falls to local ~~government~~governments, most regional governing authorities are small-scale, and do not have neither sufficient financial ~~or~~ human resources, ~~nor~~the machinery ~~or~~nor technology to properly manage waste. ~~There~~Therefore, there are ~~therefore~~many unresolved issues of waste not being collected, open dumping in valleys, water bodies and the inclusion of infectious clinical ~~waste~~wastes in waste brought to general disposal sites (Milla & Huang 2012). Some households and residential areas ~~disposed of~~dispose their ~~waste~~wastes in streams and rivers as is the case in Limbe and Buea where waste is dumped directly into the surface water resources in Bonadikombo and Molyko (Dirty South). When wastes is disposed into streams or rivers, the velocity of the streams reduces and the substances become habitats for the growth of parasites and bacteria such as plasmodium, cholera and faecal coliforms (*E-coli*) (Banseka et al., 2022). Thus, the population becomes vulnerable to different types of diseases and epidemics.

A few households in Fako also practice composting, sorting at the level household where they have separate trash cans for biodegradable and non-biodegradable trash. The biodegradable is used as manure in their farms and gardens while the non-biodegradable is either burnt or sent to HYSACAM. The Baptist ~~hospital~~Hospital in Mutengene also practices composting where the compost is used as organic manure for farming and for the production of cooking gas, ~~which~~This is similar to studies carried out in Yaounde by ~~Folefack, (2008)~~ Folefack (2008) where compost was used as manure for market gardening and the production of cooking gas. Waste for example paper and ~~sharps~~*what are sharps?* from hospitals ~~are~~were disposed of by open burning, dug pits and incineration and the ash ~~is~~was washed into culverts and subsequently into surface water bodies and infiltrated into groundwater (Longee et al., 1986). Some plastic ~~waste ends~~waste end up in streams and rivers clogging ~~the~~river bed ~~and~~as confirmed by a bulk ~~could be~~seen floating along the seashore in Limbe. Some of the ~~plastic could be seen blocking~~plastics blocked drains and ~~causing~~caused flooding and the contamination of surface water bodies. These findings are in line with similar studies by Fogwe (2015) and Fogwe and Asue (2016). These plastics under ultraviolet light from the sun degrade into microplastics (Andrady, 2015) that are almost impossible to recover and ~~are disrupting~~disrupt food chains and ~~degrading~~also degrade ~~the~~animals' natural habitat. Once in the ocean, most plastics turn to stay at or close to the surface where the photo-chemical, mechanical and biological

processes degrade larger items into smaller, less than 5 mm, forming microplastics (Andrady, 2015).

6. Conclusion

Rapid population growth in Fako Division, combined with urbanization and economic development processes, has resulted in an increase in waste production in various forms. The growing urban population means more solid waste, and higher impact on environment and health. Increased solid waste results into increased demand on existing solid waste management services. Many of the human activities generate waste and these are major causes of environmental and health challenges including infectious diseases such as malaria, cholera, dysentery, respiratory complications and injuries among others. Open dumping, open burning and unsanitary landfilling were found to be the main implemented waste treatment and final disposal systems, mainly visible in Fako. The municipalities of Tiko, Limbe and Buea in the Fako Division have not put in place proper waste disposal systems and facilities for the disposal of the rapid waste generation by the fast-growing population. This has made the population to practice indiscriminate waste disposal by open burning, open dumping, unsanitary landfills, dumping in culverts, pits, along the roads, dumping in river beds, in farms and directly into surface water bodies. This is due to inappropriate siting, design, operation, or maintenance of dumpsites and landfills, the insufficient infrastructure to take care of the waste and the fast-growing population with its overwhelming waste production. A common scenario with residents in Fako Division is the carefree attitude about the location of dumpsites as they make sure their compounds are always clean and rid of waste while the gutters, roads sides and streams are close to their houses and around residential areas are suffocating with waste. There is need for the rapid growing population to be massively sensitized on the hazards associated with improper waste management and also to fully participate in the waste management process. Despite rapid population growth, an integrated waste management system with well-coordinated policies, strong financial support, and infrastructure can reduce waste-related problems.

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