academicJournals

Vol. 11(8), pp. 393-412, August 2017
DOI: 10.5897/AJEST2017.2340
Article Number: 60C213665187
ISSN 1996-0786
Copyright © 2017
Author(s) retain the copyright of this article
http://www.academicjournals.org/AJEST

African Journal of Environmental Science and Technology

Review

Waste management in the case of Bahir Dar City near Lake Tana shore in Northwestern Ethiopia: A review

Biruk Abate Fenta

Faculty of Chemical and Food Engineering, Bahir Dar Institute of Technology, Biotechnology Institute, Bahir Dar University, P.O. Box 26, Bahir Dar, Ethiopia.

Received 7 April, 2017; Accepted 26 May, 2017

Urbanization is a global phenomenon with more pronounced consequences on waste management in developing countries. The rate of infrastructure development is mostly outpaced by the rate of waste generation. Bahir Dar city, as a rapidly urbanizing city in the southern part of Lake Tana, is not an exception. On top of production of more wastes, the waste management practice is challenged by low prioritization of waste management, limited revenues for financing waste management with the ever-increasing population of this city. This paper reviewed the current waste management system in Lake Tana basin taking Bahir Dar as case. The mechanism of Bahir Dar municipality to coordinate the public and private sectors in the city has played a vital role in waste management. However, the daily monitoring of waste management by the community development section has not been sufficient. It is also observed that the liquid waste has an effect on the lake and its resources. Effective involvement of both private and public sectors should improve waste management and provide door-to-door collection and facilitate drainage disposable canals. Therefore, an integrated solid and liquid waste management practice should be implemented for the City Lake Tana basin and also for the surrounding environment. This has to include development plans for improving sustainable sanitation and disposal of the sewage system, and adopt the best practices of waste management for the City-Lake Tana basin ecosystem.

Key words: Development plan, finance, municipality, urbanization, wastes.

INTRODUCTION

Waste was an early problem of mankind, and a growing one that is of major concern to every nation of the world (Allende, 2009; Genemo and Yohanis, 2015). It is an issue mostly witnessed in urban areas as a result of high surge in population growth rate and increase in per capita income thus posing a danger to environmental quality and human health (Javaheri, 2006). The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses (Jilani, 2002). In the previous old years', solid waste management systems have involved complex and multi- faceted trade-offs among a plethora of technological alternatives, economic

E-mail: abatebiruk@gmail.com. Tel: 251910584469.

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

instruments, and regulatory frameworks. These changes resulted in various environmental, economic, social, and regulatory impacts in waste management practices which not only complicate regional policy analysis, but also reshape the paradigm of global sustainable development (Ana et al., 2010).

Municipal solid waste management has thus become a major issue of concern for many underdeveloped nations, especially as populations increase (Bartone, 2000). The problem is compounded as many nations continue to urbanize rapidly. For instance, 30 to 50% of population in most developing countries is urban (Thomas, 1998) and in many African countries, the growth rate of urban areas exceeds 4% (Senkoro, 2003; Samuel and Enoch, 2014). When the governments of African countries were asked by the World Health Organization to prioritize their environmental health concerns, results revealed that solid waste was identified as the second most important problem (after water quality), less than 30% of urban populations have access to proper and regular garbage removal (Senkoro, 2003; Samuel and Enoch, 2014).

The U.S. Environmental Protection Agency issued many regulations and limitations to control unfriendly environment projects, among this regulation one is landfill site criteria, and also many agencies in different countries of the developed world were established to control this process (EPA, 1996). Developing countries just started to establish such agencies and institutions in this field (PAEA, 2006). The issue of landfill site selection is complicated and time consuming. During the last few decades and particularly when environmental planning emerged this issue became systematic and technical. The evolution of GIS made this field much easier and manageable. GIS has very distinguishing, powerful functions and it is an ultimate method for preliminary site selection as it efficiently stores, retrieves, analyses and displays information according to user-defined specification as a result, can play an important role in decision making and planning process (Daneshvar et al., 2005). The fundamental analytical function of a GIS based spatial decision support system include query analysis, proximity or buffer analysis, overlay analysis, neighbourhood analysis and network analysis. Various combinations of these functions are commonly used during the geographical data analysis process (Bartone, 2000).

In Africa, rapid urban growth since the 1960s has put pressure on land resources within the areas surrounding cities, and has led to increased generation of waste. Although, cities function as the engine of growth in most developing countries by providing job opportunities, education, knowledge and technology and ready markets for industrial and agricultural products, unprecedented urban growth places enormous stress on natural resources, existing amenities and cause environmental deterioration (Edward 2008). The problem is aggravated by the open dump nature of disposing waste, especially in the slum areas of most African cities (Hammer, 2003). Traditionally, administrations in African states permitted uncontrolled dumping in abandoned quarry sites with no provision for sanitary landfill, causing huge health problems (Martin, 1992; Hammer, 2003). A large part of the problem is inadequate financial and data resources for site selection and management (Mwanthi et al., 1997).

Waste management is an all-encompassing term which describes several distinct processes. It includes the elimination or reduction of waste, recycling of waste material, the treatment and distraction of waste, that is, physically destroying, chemically detoxifying or otherwise rendering waste permanently harmless and disposing or depositing the material into the air, water or land (Ward and Dubos, 1972). Most of the municipal waste models identified in the literatures are decision support models and they are based on cost benefit analysis, life cycle assessment and multicriteria decision making (Morrissey and Browne, 2003).

The Federal Democratic Republic of Ethiopia Solid Waste Management (FDRE SWM) Proclamation No. 513 (2007) defines Solid Waste and Solid Waste Management (SWM) as follows: 'Solid Waste' implies anything that is neither liquid nor gas and is discarded as unwanted. 'Solid waste management' means the collection, transportation, storage, recycling or disposal of solid waste, or the subsequent use of a disposal site that is no longer operational. The term 'municipal solid waste' (MSW) covers solid wastes generated by households, commercial and industrial premises like shops, hotels, garages and agriculture, by institutions such as schools, hospital care homes and prisons and from public spaces such as streets, bus stops, parks and gardens (Christian, 2012).

As urbanization continues, solid waste management (SWM) becomes a major public health and environmental threat in urban areas. The daily life in industrialized nations can generate several pounds of waste per consumer, not only directly in home, but also indirectly in factories (Sarker et al., 2012). The problem for these societies, with their ever greater variety, amount and durability of refuse, is getting more serious. However, today, developed nations use solid waste as a multi dollar business and they can manage it to an acceptable level. On the contrary, third world countries face particular challenges in the management of solid waste, as in other aspects of environmental management (Eshun, 2002).

Therefore, even though SWM is nowhere adequately executed and is a global problem, municipalities from the developing countries are highly faced with this problem and as long as life has existed in this world, the disposal of waste has been a problem (Eshun, 2002). Agrawal (2002) has argued that collection of solid waste in urban areas is difficult and a complex job because the generation of waste from different sources in a diffuse process complicate the collection task. Especially in under developed countries, the problem of disposal of

waste is both difficult and unsolved which further leads to several illnesses caused by infectious and parasitic diseases.

According to Forum for Environment (2010), one of the challenges that the Ethiopian cities such as Bahir Dar faces is the problem of sanitation in general and SWM in particular. Bahir Dar is among the well-known cities in Ethiopia and also a center of industrial and commercial activities. Adjacently, the daily waste generation rate in the city is also increasing from time to time (FFE, 2010). But the current waste collection capacity and disposal system is not matching with the rapid expansion of the city and its corresponding waste generation. It encounters problems like shortage of containers, road side waste bins, public toilets and the absence of proper and well prepared disposal site (FUPI, 2006). Hence, the people give no or little attention to SWM and they dump wastes along the roads and open spaces and beside this, most of the industries and health centers in the city do not start treating and/or reusing their waste properly (FUPI, 2006).

Waste water results from human and animal activities that are unwanted or hazardous. Humans pollute their environment with industrial and domestic wastes. In this case, whenever people do their daily activities, they bring negative effects on the environment. Environmental pollution increases as the density of people increases. Unsanitary environments are favourable for the outbreak and spread of different types of communicable diseases. Sewage may drain directly into major watersheds with minimal or no treatment. When untreated, it has serious implications on the quality of environment and health of aqueous biota and human beings. While some chemicals, especially heavy metals and pesticides pose grave risks even at low concentration and remain a threat for long periods due to their bioaccumulation in animal/human systems, pathogens cause a variety of debilitating ailments (Suryawanshi, 2013; Tchobanoglous et al., 1997; Tchobanoglous et al., 2003).

Most of the disease-causing agents that contaminate water and food come from human and animal wastes. Without proper management, they result in communicable diseases (Suryawanshi, 2013; Bhide and Sundaresan, 1980, 1983). More than half of the population of less developed countries does not have access to sanitation and more than 80% of the waste water generated is directly discharged into surface water bodies (Suryawanshi, 2013; Bansal et al., 2007). In Bahir Dar City, the sanitation facility coverage gap remains unacceptably large and lack of space for the construction of latrines is one of the reasons. The habit of open field disposal of liquid waste is one of the main causes of soil and water contamination and consequently a cause of many communicable diseases (Shekdar, 1999).

Waste is classified differently in different contexts. But in the context of subject of this review, the following classification is adapted from Suryawanshi (2013) as:

Biodegradable waste*:* which originates from plant and animal sources, which may be broken down by microbes or other living organisms. While these wastes may appear physically different, they tend to be fairly homogeneous in biochemical composition (carbohydrates, fats and proteins) for anaerobic digestion for biogas production by virtue of their high methane potential.

Hazardous/toxic waste: Is a waste with properties that make it potentially dangerous or harmful to human health or the environment. They can be the by-products of manufacturing processes, discarded used materials, or discarded unused commercial products (cleaning fluids, pesticides).

Recyclable waste: Is the removal of items from the waste stream to be used as raw materials in the manufacture of new products (paper, glass bottles and ceramics).

Inert waste: Is consists of construction and demolition waste, dirt, rocks, debris, etc. with relatively lower environmental impact by virtue of its non-biodegradability (Suryawanshi, 2013).

Ethiopia is one of the many developing countries in sub-Saharan Africa where municipal authorities are struggling to provide adequate urban environmental services. Bahir Dar is one the fastest growing cities in Ethiopia with a current population of > 290 thousand. If the current annual population growth rate of 6.6% continues, the city population will be doubled in just 11 years and need to have adequate solid and liquid waste management system (Christian, 2012). Currently, the city records steadily growing population number, which is due to a high birth rate and migration rate, and the waste generation is increasing (UNEP, 2010).

In this regard, a review survey was carried out on the solid waste generation rate, assessment of SWM systems, waste disposal and problems of SWM. Thus, this review revised documents from books, thesis works, annual waste management conference reports, journals on waste management, newsletters, abstracts and proceedings which can properly address the main factors that strongly hinder proper waste management and the extent to which community is aware of appropriate waste disposal systems in Bahir Dar city.

Solid waste management in Bahir Dar city

Description of the study area

Bahir Dar is the capital city of the Amhara National Regional State (ANRS) in northern Ethiopia. It is located near Lake Tana, the headwaters of the Blue Nile, and is a major tourist destination (Merkuz, 2014). Bahir Dar city has a flat plateau earth structure which is located at 11°36"North latitudes and 37°23"East longitudes. The naming of the city as Bahir Dar is connection with its

proximity to the two water bodies of Lake Tana and River Abay (Nile). Hence, literally Bahir Dar means a city situated on or very close to the shore of Lake Tana and Blue Nile. Today, it is one of the fast growing and largest cities in the country. In line with its growth, different service sectors such as education, health and transport and communication have grown. The city has expanded rapidly throughout the 20th century and today sewage discharge into Lake Tana has become a serious and highly visible problem (Matthew, 2011). At the same time, as the city modernizes, it is converting more and more land into streets, parking lots, hotels, etc., increasing the amount of surfaces that cannot absorb the seasonal rains in the area. This storm runoff overflows sewage systems and creates an influx of contaminated water entering Lake Tana (Wondie, 2009).

However, waste management and disposal service problems of Bahir Dar have been identified as the second and third priority issues next to housing and flood/drainage problems (Bahir Dar City Administration, 2010). The main types of solid wastes produced in the city are household, commercial, industrial, construction leftovers and agricultural waste. The city does not have a proper landfill site; rather it has a simple open dumping place where all types of wastes are dumped in and in the vicinities haphazardly (Metaferia, 2001).

According to Rachael and Khosrow (2013), SWM has become an issue of increasing global concern as urban populations continue to rise and consumption patterns change. The health and environmental implications associated with SWM are mounting in urgency, particularly in the context of developing countries including Bahir Dar city; and therefore in the industrialized countries, public health, environment, resource scarcity, climate change, and public awareness and participation have acted as SWM drivers towards the current paradigm of integrated SWM.

Development drivers

Until 2008, Bahir Dar had a SWM system named 'bring-system' or 'communal container system' where waste was brought to a communal container on the street. The principal stakeholders in that system included the waste generators (households, commercials, institutions), the Sanitation and Beautification Team of the municipality and the informal waste collectors (Kassa, 2009).

The waste generators had the responsibility of storing the solid waste at home and have it transported by themselves, their children, house servants or by informal waste collectors from the source of generation to one of the 70 metal containers (8 m^3) capacity. The informal waste collectors went from door-to-door and collected waste either on client basis or by asking if people have solid waste to be disposed off. The reward for the collection services was either in kind (mostly food) or in cash. The payment ranged from 0.02 to 0.09 USD per each collection event, depending on the quantity of the waste and the distance to the container site (Kassa, 2009).

The municipality offered its services through provision of 70 temporary waste storage containers distributed throughout the city. Each of these metal containers was guarded by a municipality guard. To that end, 70 container guards were employed with the duty to send people away when containers were full. Another responsibility of the municipality was the transportation of these containers to the disposal site by its own trucks, in which there were two trucks; their crew included three drivers and four assistants (Christian, 2012).

A major problem in the SWM of that time was the general shortage of containers. One of the main reasons was limited space availability, which also led to the selection of inappropriate container locations (e.g. far away from densely populated areas). The container shortage combined with insufficiently frequent emptying resulted in the containers being regularly overfilled, despite the presence of guards. Some containers in the city centre needed emptying twice per day - a service the municipality could not provide. As a consequence, the people started disposing their waste in open areas which had negative impact on public health, the environment and the aesthetics of the city. In addition, the municipality had no legal ground to collect a SWM fee from residents for waste transportation and disposal, so the budget had to be obtained from other sources of tax (Kassa, 2009). SWM was a very big financial burden for the municipality (Christian, 2012; Arto, 2010).

Institutions

The main stakeholders in the MSW system in Bahir Dar includes Bahir Dar City Administration (CA), Regional Amhara Bureau of Environmental Protection, Land Administration and Use (BoEPLAU, Regional Amhara Health Bureau (BoH), Regional Amhara Government (ANRS), United Nations Development Programme (UNDP) and Federal Environmental Protection Authority (EPA, 1997) according to the study of UNEP source document for the city waste management (FFE, 2010).

Service contributors

Dream light (DL)

It is a private company responsible for collection, transportation, disposal and recycling of municipal solid waste in 8 out of 9 kebeles of Bahir Dar, UNEP, Forum for Environment (2010).

Green dream (GD)

This Community Based Organization (CBO) is comprised

of 30 female workers and responsible for solid waste collection in a door-to-door manner in one kebele (Shumabo), UNEP, Forum for Environment (2010b).

In Ethiopia, among the well-known cities, Bahir Dar is one of the fast growing tourist destination cities. It is also a center of industrial and commercial activities. Adjacently, the daily waste generation rate in the city is also increasing from time to time (Forum for Environment, 2010). But the current waste collection capacity and disposal system is not matching with the rapid expansion of the city and its corresponding waste generation. It encounters problems like shortage of containers, road side waste bins, public toilets and the absence of proper and well prepared disposal site (FUPI, 2006). Hence, the people give no or little attention to SWM and they dump wastes along the roads and in open spaces. In addition, most of the industries and health centers in Bahir Dar did not start treating and/or reusing their waste properly. Bahir Dar city has 17 kebeles (now administered in 9 administrative centers) from these kebeles, 04 commercial center, 06 heavily populated, and 17 city outskirt are obtained (Koyachew, 2016).

Informal recyclers

Koralews are informal itinerant buyers going from door to door to collect recyclable and reusable materials such as pieces of metals, plastics, glasses, corrugated iron sheets, tins, car batteries and others. They buy these materials and sell them to one of the 55 middlemen. 70 Koralews are working in Bahir Dar (Worku, 2012). The number of Koralews is increasing now in the city, contributing as waste recyclers. *Lewaches* are persons going from door to door to exchange recyclable materials especially clothes and shoes for new plastic barrels, sauce panels, spoons, etc depending on the type and oldness of the cloth and their number is increasing on wards from about 50 to more than this amount. *Lewaches* are working in Bahir Dar (Christian, 2012). Dumpsite pickers collect recyclables and reusable materials from the disposal site and sell it to either middlemen or Dream Light PLC. There are 10-15 dumpsite pickers at *Gordma* working every day except Sundays (Worku, 2012). Children and beggars living on the streets go around from door-to-door and ask for food leftovers, reusable textiles and recyclable materials that they use themselves or sell to middlemen. Many Ethiopians give away materials to the poor due to religious considerations (Christian, 2012; Arto, 2010).

Pig farmers

There are two pig farmers located in the north-east of Bahir Dar city centre. About 550 pigs (Worku, 2012) live in the larger one, while the smaller farm has about 100 pigs. Both farms have workers going around the city with mule-pulled carts to pick up for free a total amount of 2.5 t/day of kitchen waste from hotels, restaurants and theuniversities (UNEP, Forum for Environment, 2010b).

Formal recyclers

Middlemen: Parts of the recyclable materials collected by *koralews*, *lewaches,* street persons and formal waste collectors are sold to middlemen, who in turn sell them to brokers of recycling companies in Addis Ababa, the capital city of Ethiopia. There are 55 middlemen collecting and selling metals, plastics and glasses and 1 middleman for textiles and shoes (Christian, 2012). These middlemen are registered at the Bureau of Trade and Industry, thus have a license for trading materials and need to pay taxes.

Waste generators and the civil Society

***Households*:**

Bahir Dar has roughly 80’000 households (extrapolation based on CSA, 2007). They are responsible for filling their solid waste in collection bags and for payment of the service fees. The community in each Kebele Administration has the right to elect a *kebele* council. However, these *kebele* councils have very limited power in comparison with the City Administration.

Commercials

The business sector which includes shops, hotels, restaurants, markets, garages etc. has 7,040 commercials (UNEP, 2010a). They are responsible for filling their solid waste in collection bags and for payment of the service fees.

Institutions

Institutions include governmental and non-governmental bureaus, schools, universities, colleges, hospitals and clinics, training centres, prisons, churches, mosques, etc. They are responsible for filling their solid waste in collection bags and for paying the service fee*. Bahir Dar University (BDU):* There are two campuses but currently they are four of BDU, the Polytechnic Institute but now Bahir Dar Technology Institute (POLY Campus).

Forum for environment (FfE)

This NGO is actively participating in raising environmental

awareness and has initiated the development of an integrated sustainable waste management plan for Bahir Dar. FfE Bahir Dar has one paid employee (secretary) and 40 members with different backgrounds. According to the information source (UNEP, 2010a), there is no specific formal structure/platform (committee, regular meetings or specific person within the municipality) for communication of stakeholders. In the case of particular matters, the stakeholders contact each other informally mainly per phone (Fenzie, 2011; Christian, 2012).

Components of physical system in Bahir Dar

Regarding this point in Bahir Dar, the households, commercials, institutions, forum for environment (FfE) and others in which in detail are including as: Bahir Dar has roughly 80'000 households (extrapolation based on Central statistics Agency, UNFPA (2008) as the City Administration (CA) and which includes about 18 *Kebele* Administrations (KA) under it. The households are responsible for filling their solid waste in collection bags and for payment of the service fees. The Kebele Administrators have very limited power in comparison with the City Administration (UNEP, 2010). Commercials as business sector include shops, hotels, restaurants, markets, garages, etc. They are responsible for filling their solid waste in collection bags and for payment of the service fees (UNEP, 2010a). Institutions include governmental and non-governmental bureaus, schools, universities, colleges, hospitals and clinics, training centres, prisons, churches, mosques etc. They are responsible for filling their solid waste in collection bags and for paying the service fee (UNEP, 2010). Forum for Environment (FfE) which is NGO is actively participating in raising environmental awareness and has initiated the development of an integrated sustainable waste management plan for Bahir Dar. FfE Bahir Dar has one paid employee (secretary) and 40 members with different backgrounds. According to the information source (UNEP, 2010a), there is no specific formal structure/platform (committee, regular meetings or specific person within the municipality) for communication of stakeholders. In case of particular matters, the stakeholders contact each other informally mainly per phone (Fenzie, 2011; Christian, 2012).

The physical components of the solid waste system in Bahir Dar City-Lake Tana basi is divided into four parts: Generation, collection and transport, resource recovery, and disposal. The daily generation of MSW in Bahir Dar amounts to a total of 102.5 t/d, commercial waste is 28 t/d, residential waste is 54 t/d, the institutional waste is 17 t/d and the street sweepings is 2.5 t/d. From the study review of UNEP, the composition of total municipal solid waste in Bahir Dar and depicts the origins of the waste material fractions. 32% of the total MSW consists of ash and soil, 30% is food waste and 13% is made up of yard waste. The large share of ash and soil component in residential waste (47%) is explained by the predominant use of firewood and charcoal in households. The ash residues are usually disposed on the ground, later put in the waste collection bag from where it is collected by Dream Light workers. The seasonal variation is expected to be minimal due to steady consumption behavior throughout the year (Christian, 2012).

Per capita generation of waste in Bahir Dar was assessed to be 0.25 kg/day for residential and 0.45 kg/day for all residential, commercial, institutional and street sweeping waste streams. The waste projections show that the waste generation will increase similar to the population growth. Hence in 2021, when the population is doubled, waste generation will also be doubled (199 t/day) according to the stated information source of UNEP (2010a).

Based on the share of organic content (food and yard wastes) in the different waste sources (UNEP, 2010a), the sum of food and yard wastes from the residential (16 t/d), commercial (16 t/d), institutional (12 t/d) and street sweeping waste streams (1t/d) results in a total organic waste quantity of 45 tons per day, which equals 44% of the total amount of daily generated waste in Bahir Dar. According to UNEP (2010a), hazardous waste of Bahir Dar City includes: wastes from hospitals and medical laboratories, chemically contaminated containers and trimmings from agriculture, pesticide retailer shops, university and school laboratories, tanneries, textiles, printing enterprises and expired drugs, biological wastes from hospitals and biological research facilities, the dry cells from each sources and car batteries from garages, used condoms from hotels and pensions and fluorescent lamps.

Residential hazardous waste amounts to 156.6 kg/d (0.3% of total residential waste stream), commercial hazardous waste was recorded to be 124.8 kg/d (0.5% of commercial waste). Institutional hazardous waste was 120.7 kg/d (0.7%) and street sweeping hazardous waste was 0. This makes a total of 402.1 kg of hazardous waste generated per day, which is 0.4% of the total MSW in Bahir Dar according to the written document source (UNEP, 2010a).

According Koyachew (2016), the surveyed solid wastes discharged from the houses contain plastic, wood, paper and cloth (82.5%), metal (3%), food and fruit residuals (7.6%) and others (6.9%). In addition, the survey result shows that 26.6% of the household's burn wastes in their compound, 5.5% dump in a pit, 36.7% dump outside the compound on open space, ditches and roads, and the remaining 0.3% of the households recycle their waste directly. Only 30.9% of the home effluent is collected by the municipality. The new private door to door waste collection service is covering most of the city. Hence, residents will no more discharge home effluents on open spaces, ditches and roads. Further, the recycling and composting measures may generate money to the

Table 1. Type of waste sources by weight in Bahir Dar City, 2010.

Type of waste	Weight (%)
Food	86.6
Paper	3.3
Plastic, leather and plastic	2.2
Glass	0.6
Textile	2.2
Metals	0.3
Others	4.8

Source: (UNEP, 2010a, b).

municipality and private processors.

As indicated in Table 1, the waste materials of Bahir Dar city from food is 86.6% which is the highest among the rest waste sources expressed by weigh and the glass waste contains the least amount as compared to the rest wastes.

According to Figure 1, the composition quantities expressed in tone in Bahir Dar City Municipal Solid Waste of residential is high in quantity as compared to commercial and street sweeping.

Figure 2 presents an overview of the composition of total municipal solid waste in Bahir Dar and depicts the origins of the waste material fractions. 32% of the total MSW consists of ash and soil, 30% is food waste and 13% is made up of yard waste. The large share of ash and soil component in residential waste (47%) is explained by the predominant use of firewood and charcoal in households. The ash residues are usually disposed on the ground, later put in the waste collection bag from where it is collected by Dream Light workers. The seasonal variation is expected to be minimal due to steady consumption behavior throughout the year (Christian, 2012).

Table 2 described the incremental effect of municipal solid waste generation expressed in tones per year from 2010 to 2022 due to the assenting effect of total population in the city from year to year. This shows that waste generation increases from year to year as the purchasing and consumption effect of the increasing population living in the city increases. Figure 3 describes waste projections which are going up in quantity from the year 2010 to 2022 which shows that the projection increases as the urbanization, purchasing and consumption power of the residents living in the city increases. This shows that the waste generation rate is almost doubling similar to the population growth; in 2021 (when the population doubles) the waste generation will be doubled.

Based on income group classification, plastic bag waste generation rates analyzed show that a mean waste generation rate of 0.40, 0.26, 0.26 and 0.20 g Capita-day for poor, lower, middle and high income groups respectively in terms of volume, the mean plastic bag waste generation of poor, lower, 26 middle and high income groups were 1.19, 0.78, 0.78 and 0.58 cm^3, respectively (Table 3).

Regarding plastic bag waste generation in Bahir Dar, the total of 24.87 ton of plastic bag waste was generated annually (Table 4). This is equivalent to more than 12 million Plastic bags per year that enter into the environment as the waste. If this number of plastic bags were made into a double plastic sheet, it would cover 1.41 square kilometer (2.82 sq km when they were made into single sheet) and if each side of plastic bag join together, it would be 466323.33 km long. The plastic bag waste generation increased from 2007 to 2016 and onwards (UNEP, 2010). According to Al-Salem et al. (2009), plastic solid waste presents challenges and opportunities to societies even in developed countries regardless of their sustain-ability awareness and technological advances. There is a possibility of advanced thermo-chemical treatment methods cover a wide range of technologies and produce either fuels or petrochemical feedstock. Currently, non-catalytic thermal cracking is receiving renewed attention, due to the fact of added value on a crude oil barrel and its very valuable yielded products, like waste as virgin monomer, as synthetic fuel gas, or as heat source (inci-neration with energy recovery and these processes avoid land filling, where the non-biodegradable plastics remain a lasting environmental burden (Anke et al., 2012).

Waste collection and transport

Since Dream Light's (Private waste collector) entry into the SWM system of Bahir Dar City in 2008, it is the waste generators responsibility to put their mixed waste into any (non-standardized) bags and place them in a designated location on their compound or along the road UNEP (2010b). Some high-standard hotels require having their wastes collected up to twice per day. There are controllers who can organize and supervise their collection team to empty the generators waste bags into push-carts or into strong plastic bags and bring them to collection points There, the workers await the Dream Light collection truck to empty the bag contents (UNEP, 2010b). According to the UNEP (2010b) study, an overall collection rate of 71% is stated, which is 73 tons/day from a total of 102.5 t/day generated. The remaining amount of 29.5 t/d is not being collected and according to UNEP (2010b), burned, buried or simply dumped on the lakesides or into rivers. There was a small business group (Million and his 55 workers) responsible for parts of the street sweeping and institutional sanitation activities (emptying of septic tanks) in Bahir Dar but recently conducted bidding-competition, a new business group (Masfen) outcompeted the other competitors and hence will be responsible for street sweeping for the next year (Christian, 2012).

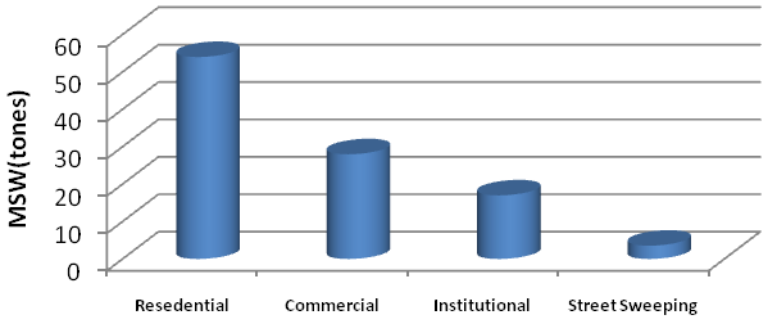

Figure 1. MSW composition quantities in tones in Bahir Dar City 2010. Source: UNEP, 2010a.

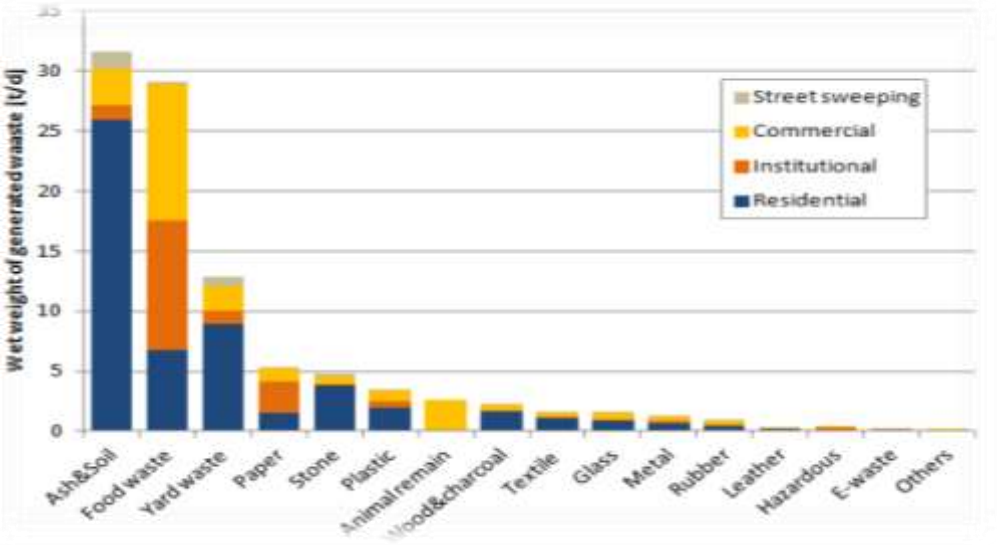

Figure 2. MSW streams in Bahir Dar City and their compositions as wet weight of generated waste. Source: Based on data from UNEP (2010a).

Some parts of the street sweeping are outsourced to 'Million & Guadegnochu' (Million and Friends), the rest are swept by the city service itself. The street sweeping workers fill the street waste into plastic bags and leave them along the streets from where they are picked up by Dream Light or Green Dream workers. Green Dream is community based organization comprised of 30 female workers and responsible for solid waste collection in a door-to-door manner in one kebele (Shumabo). Initially, Green Dream has received financial and technical assistances from the CA and EPA, whose intention was to initiate competition in the solid waste market and to avoid monopolization by Dream Light. Green Dream has no means of transporting large amounts of wastes, so they provide the waste bags for Dream Light's trucks to be picked up and disposed of (Christian, 2012).

There are informal recyclers in the city like *Koralews* who are informal itinerant buyers going from door to door to collect recyclable and reusable materials such as metals, plastics, glasses, corrugated iron sheets, tins, car batteries and others. They buy these materials and sell them to one of the 55 middlemen. There are persons gave a local name *Lewaches* going from door to door to exchange recyclable materials, especially clothes and shoes for new plastic barrels, sauce panels, spoons, etc, depending on the type and oldness of the cloth. Dumpsite pickers collect recyclables and reusable materials from the disposal site and sell it to either middlemen or Dream Light PLC. Children and beggars living on the streets go around from door-to-door and ask for food leftovers, reusable textiles and recyclable materials that they use themselves or sell to middlemen (Worku, 2012).

There are formal recyclers categorized in the norm of middlemen that collect parts of the recyclable materials collected by koralews, lewaches, street persons and formal waste collectors, and sell to middlemen, who in

Table 2. Municipal solid waste generation expected up to 2022.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Population	218975	233427	248833	265256	287763	301425	321319	342526	365333	389232	414921	442306	471498
Waste generation (tones)	98.5	98.5105	112	119.4	129.5	135.6	144.6	154	164.4	175.2	186.7	199	212.2

Source: UNEP, 2010a.

turn sell them to brokers of recycling companies in Addis Ababa. There are 55 middlemen collecting and selling metals, plastics and glasses and middleman for textiles and shoes. These middlemen are registered at the Bureau of Trade and Industry, thus have a license for trading materials and need to pay taxes (Worku, 2012). There are no officially designated waste collection locations in Bahir Dar, but about 100 widely accepted collection points on the side of the road which were selected based on easy accessibility with pushcarts, workers, collection trucks and acceptable' distance to residents in order to avoid complaints due to odour and aesthetics (Worku, 2012).

Recycling of solid wastes in Bahir Dar seems insignificant (<1%) (UNEP, 2010b). However, this is an underestimation because the UNEP study only accounted municipal composting as recycling activity and did not include informal recycling activities. Organic recycling is currently practiced as follows: the municipal composting site is located 3 km south of the city and the municipal workers transport the filled container by truck to the composting site about once per week. Thus, 8 m^3 (3t) of fresh substrate arrives approximately 4 times per month, where it is manually sorted, turned and decreased in size. After 3 to 4 months, the finished compost is picked up by the municipality and brought to the city to be used for planting of flowers (UNEP, 2010b).

According to UNEP (2010b), no treatment facilities exist in Bahir Dar. All healthcare and industries and some governmental institutions follow their own way of removal. Most of them burn their waste; while some others dispose it to the nearby river Blue Nile or into Lake Tana (UNEP 2010c). There is no documented evidence that shows the criteria used for the selection of the area as dumpsite regarding prior study of hydrology, geology, socio-economic and environmental issues. The dumpsite is surrounded by land use activities such as informal settlement and agricultural activities. The liquid human waste (from emptying of septic tanks in Bahir Dar) is also dumped in close proximity of *Gordma* landfill site (UNEP, 2010c).

Finding suitable sites for landfills is one of the most difficult tasks in solid waste management as the sanitary landfill site selection must address social, environmental and technical concerns. Therefore, GIS based assessment should be employed for different criteria including geology, soil, slope, land use, and stream network (Radwan et al., 2017). Similarly in Bahir Dar City, there are problems of solid waste disposal sites selection. There are no standard transfer stations in the city. Institutions and industries follow their way of removal of waste and the available dumping sites are not well planned. Applying and integrating GIS and remote sensing techniques to select the best possible solid wastes dumping is one way of solving the problem (Tirusew and Amare, 2013). The study has shown land use, slope, water sources, settlement and transport facilities as determining factor in order to find appropriate site for solid waste dumping. By this analysis, the most suitable sites were located in southern and south east of the town and are bare and grass lands (Figure 4).

Regarding to the suitability analysis of solid waste dumping site in Bahir Dar City to River and lake, the farther lands from lake and river banks got more preferences for solid waste dumping site suitability. In Bahir Dar town, there is a lake at the northern side, Lake Tana and the River Abbay at northwestern part. Hence, to maintain the environmental health of these water sources at least 2000 m buffered distance should be ringed through straight line calculation. Based on this, the green area is for study suitability and the blue one is for Lake Tana. Accordingly, considering only the lake, the green shaded area was the most suitable for solid waste dumping site (Figure 5).

According to Figure 5, all the parameters were weighted with their respective percent of influence and overlay to produce the suitability map. According to the degree of importance, they have the role of selecting suitable solid waste dumping site. The map (Figure 5) has four colors (classes): yellow, green, blue and violet. The most suitable area for solid waste dumping site is marked by

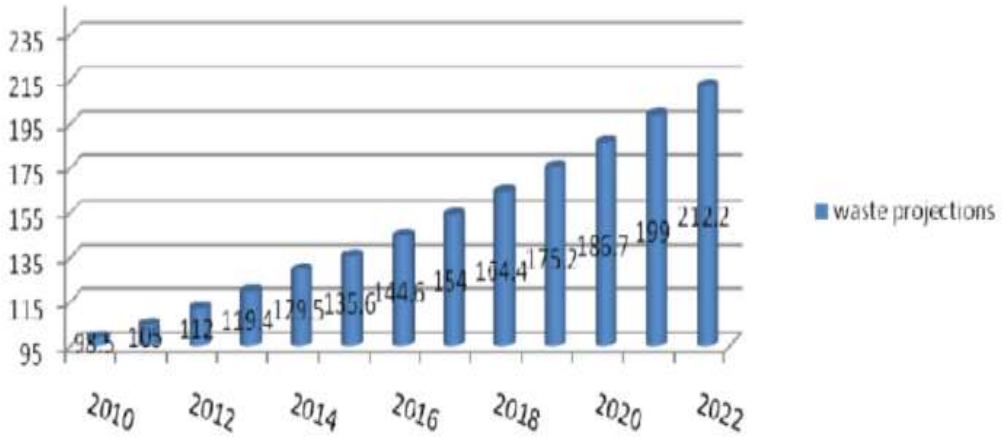

Figure 3. Waste projections for 2010-2022 years in tons in Bahir Dar City. Source: (UNEP 2010a).

Table 3. Plastic bag waste generation rates with income level, 2007.

Descriptions	Per income group			
	Poor	Lower	Middle	High
Number of households	70(66.6%)	20(19%)	8(7.6%)	7(6.8%)
Average family size	5.14	4.4	3.75	3.14
gm/capita/day	0.40	0.26	0.26	0.20
gm/house hold/day	2.1	1.14	0.98	0.63
cm^3/capita/day	1.19	0.79	0.78	0.58
cm^3/household/day	6.12	3.48	2.93	1.82
Density (gm/cm^3)	0.34	0.33	0.33	0.34

Source: Ayana (2007). Plastic bag waste generation rate in Bahir Dar City, MSc thesis, Addis Ababa University, July 2007.

Table 4. Households' plastic bag waste generation rates in a day, week and year, 2007.

Generation rate	Day		Week		Month		Year	
	Weigh	Volume	Weigh	Volume	Weigh	Volume	Weigh	Volume
Per capital	0.35 g	1.05 cm^3	2.46 g	7.33 cm^3	10.54 g	31.41 cm^3	128.26 g	382.16
Total	67.89 kg	0.2 m^3	477.19 kg	1.42 m^3	2044.54 kg	6.09 m^3	24879.8 kg	74.13m^3

Source: Ayana (2007). Plastic bag waste generation rate per capita in Bahir Dar City, M.Sc Thesis, Addis Ababa University, July 2007.

yellow color shaded. Out of the total area of the study site, about 11.9% (2528 ha) fall under this category. They are located on south and south east part of the, far away from settlement and urban center, and is covered by grass lands.

Sustainability of waste reduction

In the sustainability aspects, this sub-section provides an overview of the enabling environment for the municipal solid waste system in Bahir Dar and hence the Lake Tana Basin. It combines the results from the document 'Assessment of the SWM system in Bahir Dar City-Lake Tana basin and the gaps identified for the development of an ISWM plan' (UNEP, 2010b) with field observationsand information gathered through interviews with SWM stakeholders. Implementing waste management strategies are widely used for waste avoidance and reduction strategies which can include waste avoidance,

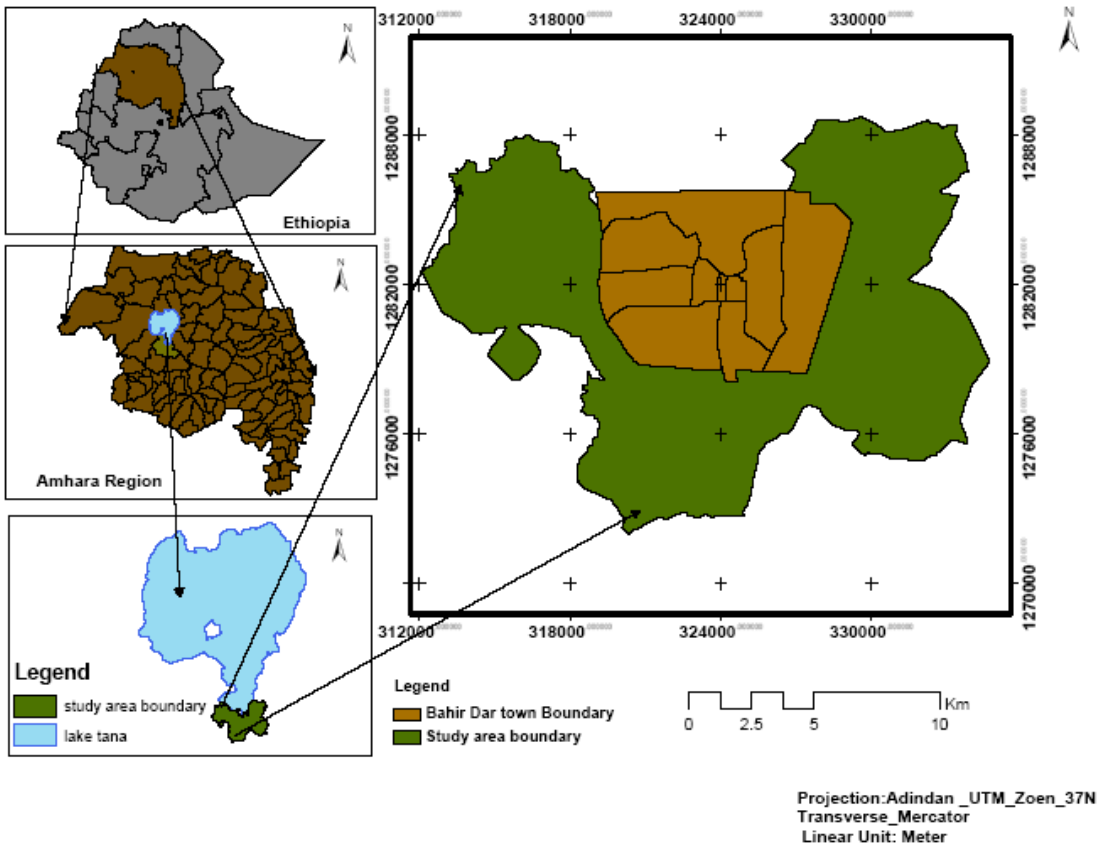

Figure 4. Map of Bahir Dar City. Source: Tirusew and Amare (2013).

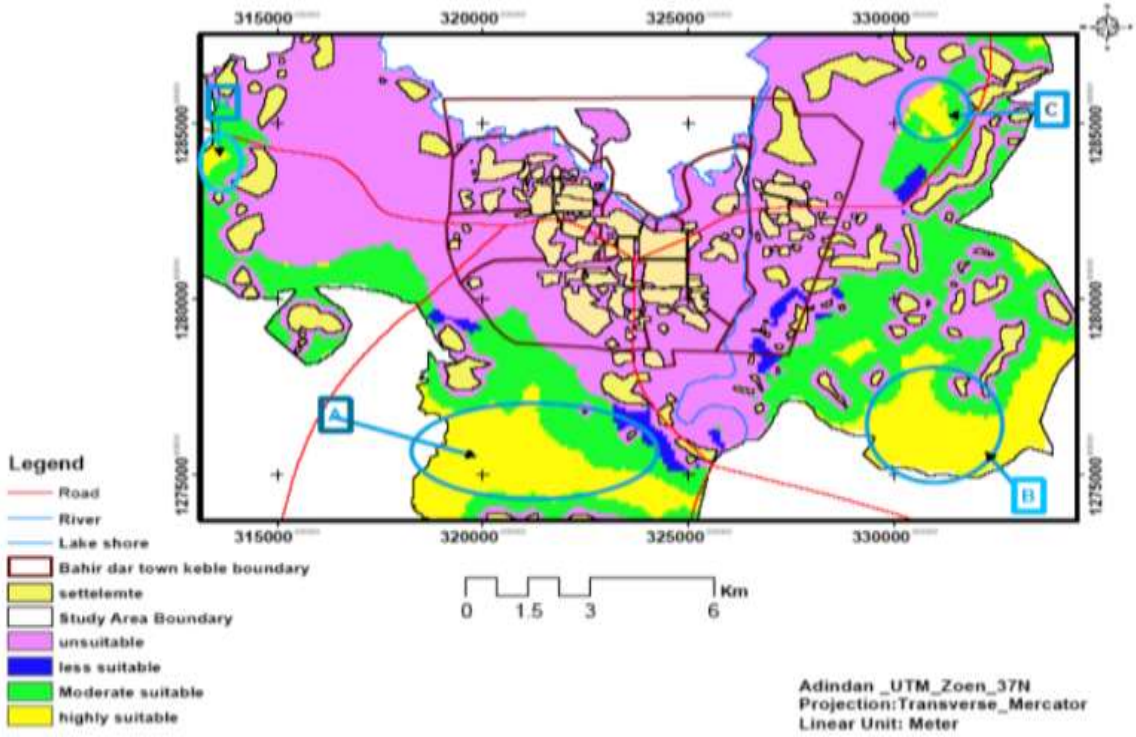

Figure 5. Final suitability map for solid waste dumping. Source: Tirusew and Amare (2013).

dispose, re-use and recycle depending on the waste type and source. To prolong sustainability, the following technical aspects should be accounted for (Christian, 2012).

Technical aspects of waste minimization

Collection and transport

With regarding to collection and transport, no waste segregation is currently practiced at source; apart from the small-scale segregation of recyclables for informal recycling .There are no standard solid waste transfer stations in Bahir Dar. As the disposal site is close enough to the city (3 to 4 km), the existence of a transfer station is financially not justified. It is difficult to designate unofficial collection points for temporary storage of waste during collection. The collection points are not allocated by the municipality but by Dream Light. In the case of frequent complaints about the location of collection points, the City Administration intervenes and tries to find other collection points more distant from the residents. Solid waste collection (71%) does not cover all solid waste generators. Based on discussions with Dream Light, the following collection rates are roughly estimated with respect to their source: 70% of the total waste generated in the households is collected, 80% from total generated in commercials, 50% from total generated waste in institutions and 70% of the total waste laying on the 35 km of asphalt road. Transportation trucks are not standardized for solid waste transportation purposes, spare parts are not locally available - they have to be imported from the capital Addis Ababa. There is no financial or technical support, no public recognition for waste recyclers. Only a small amount of organic solid waste (0.5 t/d) is used to produce compost in the municipal composting plant (Christian, 2012).

Disposal

There are no treatment facilities in Bahir Dar for MSW and it is open dumpsite (no sanitary landfill). No sound operation practices performed at disposal site. No designated cells, no machinery (compactor or graders) working at disposal site, and 71% (73t/d) of generated MSW is collected and disposed of at disposal site. According to UNEP (2010b), no treatment facilities exist in Bahir Dar. All healthcare and industries and some governmental institutions follow their own way of removal. Most of them burn their waste; while some others dispose it to the nearby river Blue Nile or into Lake Tana (UNEP, 2010c).

Environmental aspects

Dumpsite *Gordma* is close to rural settlements and leads to pollution of groundwater sources through leachate (Worku, 2012), and 29% of generated waste (29.5 t/d is not collected by Dream Light or Green Dream). This waste is either burned or buried in compounds or disposed to lakesides or into rivers, leading to pollution of environmental compartments.

Socio-cultural aspects

Participation in the current solid waste system needs to be differentiated into the following two parts: Participation required at the source of waste generation (collecting waste, putting it into bags and in the designated place to be picked up) is considered to be good, particularly considering the short time since the introduction of this new system. However, payment rate of collection fee is low (about 50%) thus considered as poor (UNEP 2010b). Awareness of public towards SWM is still considered to be low, although it has increased considerably in the last two years. When Dream Light started its business, it organized awareness raising campaigns to teach people how to handle waste. Its managers also participated to demonstrate that touching waste is neither dangerous nor despising (Christian, 2012). It took about one year until the waste collectors started to be fairly recognized for their contribution to a clean city. The working condition for waste collectors is acceptable but needs to be improved. The protection clothes (overall, gloves) are replaced by Dream Light twice per year only at pre-set dates. This means that workers have to continue working with damaged equipment until then. The salary for waste collectors (400 ETB/month) classifies the work as a low-income job, yet Dream Light considers most workers to be grateful having an income generating opportunity at all. The salary is comparable to the salary of a waiter in a good middle class hotel in Bahir Dar or of a guard working for a private company. In comparison, the controllers (group leaders of waste collectors) receive 800 ETB/month. Dream Light explicitly offers their waste collecting jobs to street persons, prostitutes and other underprivileged members of the society.

Financial-economic aspects

The payment rate for the solid waste collection service has been low until now: Only about 50% of the households pay the collection fee. About 90% of the commercials and institutions receiving waste collection services pay the fee regularly. This is on one hand due to the individual agreements Dream Light worked out with them, on the other hand, the hotels, restaurants, shops etc. are depending on a clean environment for the satisfaction of their guests and customers. As a result of the low payment rate of households, a committee comprised of different stake-holders, including City Administration, EPA, hotel association, and Dream Light,

worked for three months on the development of an improved payment system. In the old system, each household was required to pay a monthly fee of 0.68 USD to Dream Light's fee collectors who went from door-to-door to collect the fee in cash (Christian, 2012).

Commercials and institutions had individual agreements with Dream Light based on the waste quantity and frequency of collection/disposal. The new system follows the idea of the system practiced in Addis Ababa. It is based on the assumption that the water consumption correlates with waste generation, that is, a household that consumes high amounts of fresh water also generates high quantities of solid waste. Thus, the payment for water and for waste collection will be linked. This new system is possible due to the fact that all households in Bahir Dar have a water meter installed on their compound and each household is responsible to go to the Regional Bureau of Water supply once per month to pay the monthly water bill. The new progressive system is divided into four progressive categories depending on the amount of fresh water consumed per month. City Administration and Dream Light do not expect major protests due to the implementation of the new payment system (Christian, 2012).

However, special agreement will have to be arranged with recreational facilities like public swimming pools (which consume a disproportionately high amount of water). The main advantage of the new system is the leverage in case of non-payment. In addition, institutions that until now mismanaged (burned, buried and openly disposed) their waste by themselves will most likely use DL's collection service as they have to pay for it anyway. With the new payment system Dream Light expects to be able to cover all their expenses related to collection services (440'000 ETB/month). Until now, Dream Light's business was economically not sustainable. Thus, the loan of 1.6 Mio ETB UNDP provided for 4 years is not only meant to cover the expenses for the Organic Recycling Centre, but also to cover the current running costs for waste collection (Christian, 2012).

Institutional aspects

Integration and coordination of the current institutional arrangement of the SWM is unsatisfactory. Each sector is working independently (UNEP, 2010b).There is no clear bridge between the federal (national) institutions and the regional (or local) in-situations. The City Administration who has outsourced waste collection, transport, treatment and disposal services to Dream Light is responsible for monitoring these activities. The Regional Bureau of Health as well as the Regional EPA expressed their pity that their advices regarding hazardous waste handling, official collection points/transfer stations and upgrading of the current open dumpsite are not taken seriously by the City Administration. In general, the cooperation of stakeholders is described by the majority as very loose (rather than conflicting) and leaves considerable room for improvements in the future (Christian, 2012).

Policy and legal aspects

The region has not yet enacted any law on environmental issues. It is rather using the federal laws but facing difficulty in implementation, enforcement and monitoring. Bahir Dar does not have its own detailed rules and regulations specific to SWM that clearly indicates the responsibilities of the actors involved in SWM. There are no clear rules and regulations pertaining to SWM apart from general guidelines, an approach which is not effective at all (Kassa, 2009).

LIQUID WASTE MANAGEMENT

In Bahir Dar, 20% of the households do not have access to latrines, using open fields and disposing waste water into the available open spaces. Because of the lack of latrines, waste disposal sites and poor collection practices, only 35% of the city's liquid waste was collected (Fesseha, 2012). In the absence of a city sewerage system, the overall drainage in the town is a problem aggravated by the plain geographical terrain and rapid urban growth. Waste water generation potential increases with increasing use of flush toilets, which in turn requires increased wastewater treatment plants. This implies the ever-growing Bahir Dar City with modern buildings using flush toilets will produce more waste water that should be treated (Fesseha, 2012). `

The waste water management practices of the major institutions of Bahir Dar City-Lake Tana basin are not also environment friendly. Felegehiwot Referral Hospital, Bahir Dar Prison, Bahir Dar University Technology Institute (POLY Compus) waste water from students' cafteria, and the old hotels like Ghion, Tana and recently built hotels like Avanti and Garnd etc, generated waste water is directly discharged towards the Lake Tana and this produces an offensive smell. The environment seems highly polluted and has not yet been looked into by the sanitation authorities of the city (Fesseha, 2012). These institutions do not have their own wastewater treatment and management systems. They simply discharge waste water into Lake Tana through tubes and open ditches. Such discharges pollute the environment and create offensive smell and aggravate the conditions for the spread of communicable diseases. There was no well-organized coordination among the concerned bodies regarding waste water management. Eutrophication, waterborne diseases, shortage of water and adequate sanitation are still a major challenge for Bahir Dar-Lake Tana basin (Goraw et al., 2011).

Table 5. Distribution of latrines availability by education, monthly income (in Birr) and space availability in Bahir Dar City.

Variables	Latrine availability		Total	X^2	P-value
	Yes (%)	No. (%)	No. (%)		
Educational status	(n=270)				
Illiterate	78(29.0)	15 (5.5)	93 (34.4)	0.84	P<0.001
Literate	139(51.5)	38 (14.0)	177 (65.6)		
*Monthly income	(n=270)				
Less than 500	139(51.5)	49 (18.1)	188 (69.6)		
501 – 750	39 (14.4)	3 (1.1)	42(15.6)	10.3	P<0.001
751 – 1000	19 (7.0)	1 (0.4)	20 (7.4)		
Above 1000	18 (6.7)	2 (0.8)	20 (7.4)		
Space availability	(n=270)				
Have space	66 (24.5)	10 (3.7)	76 (28.1)	3.9	P<0.001
Have no space	148(55.8)	46 (17.0)	194 (71.9)		

Source: Fesseha and Mekonnen (2012), Bahir Dar University.

Table 6. Logistic regression predicting likelihood of reporting for availability of latrine, March 2008, Bahir Dar City.

Variables	B	S.E.	Wald	df	Sig.	Exp (B)
Education						
Illiterate	(Ref)					
Literate	0.526	0.350	2.258	1	0.133	1.693
Space availability						
No	(Ref)					
Yes	0.751	0.407	3.398	1	0.065	2.119
Income						
Income group			9.024		0.029	
Less than 500 Birr	(Ref)					
500 -750	-1.466	0.629	5.435	1	0.020	0.231
751-1000	-1.730	1.051	2.709	1	0.100	0.177
More than 1000	-1.016	0.775	1.718	1	0.190	0.362
Constant	-2.00	10.462	18.733	1	0.000	0.135

Source: Fesseha and Mekonnen (2012), Bahir Dar University.

According to this review study, only 28% of the housing units used septic tanks to collect and treat the generated wastewater. Most of them had no space in their compound for waste water discharge, 64.3% discharged the waste water they generated into streets. In this study, 80% of the respondents had access to latrines, while 20% used open fields (Tables 5 and 6).The fecal and chemical pollution levels have been significantly increased and clearly discernible in the Bahir Dar Lake Tana basin (Goraw et al., 2011). The liquid waste disposal survey shows that 22% of the households in the study area used septic tanks, 9.1% dispose on drainage, 36.4% on open field, 12% on pit and the remaining 40.3% on the roads. This needs creating awareness on liquid waste management as well as providing regular services to collect the liquid waste (Koyachew, 2016).

Regarding to Table 6, a total of 270 respondents were interviewed at the household level, of whom 81 (30%) were males and 189 (70%) were females. Ninety three (34.4%) of the respondents were illiterates, while 177 (65.6%) were literates. One hundred eighty eight (69.6%) of the households were getting a monthly income of less than ETB 500. One hundred and ninety five (72%) of the households had no space in their compound to dispose of the wastewater they generated. Availability of empty land directly affects the collection and safe disposal of waste water. Only seventy five (28%) of the housing units used septic tanks to collect and treat the generated wastewater. Among the total respondents, who had no space in their compound for waste water discharge,

Table 7. Household facility, 2014.

Cooking place		Respondents	%
Own kitchen		87	58
Sharing with others		18	12
On open place		45	30
Latrine facility		F	%
Yes		103	68.6
No	Use public latrine	10	6.7
	Use open place and canal	37	24.7

Source: Koyachew (2016).

64.3% discharged the waste water they generated into streets. In this study, 80% of the respondents had access to latrines, while 20% used open fields. With regard to the toilet facility, 44.6% of the local area households do not have toilet, 28.8% use shared toilet and the remaining 26.6% own private toilet. Hence, the city administration is expected to construct standard communal toilets in collaboration with community organisations and development partners (Koyachew, 2016).

As shown in Table 7, the inadequacy of sanitation services resulted in defecating in open fields and discharging of raw waste water into inappropriate places and these, in turn, have created serious environmental problems.

In connection with their low income, poor housing facility of a household has also a significant impact on waste management. The facilities used to properly manage solid waste at the household level include latrine, kitchen and safe communal cooking home. However, the household survey indicated that 42% of the respondents do not have their own kitchen and among them about 30% are cooking their food in open space. The remaining 12% use kitchen by sharing with others. In addition, 31.4% of the households do not have their own latrine and 24.7% of them excrete on open spaces and channels while only 6.7% use public latrine (Table 7). In the same token, the *kebele* officers admitted the fact that most of the public latrines are removed to use the place for construction and hence a household without its own latrine may use toilet in open areas. Therefore, it should be noted that even though low income households produce wastes, they cannot afford the management costs and thus they dispose illegally.

In the city of Bahir Dar (Figure 5), there are no municipal solid waste treatment facilities and no solid waste transfer stations. Presently, the only method of disposal is open, uncovered disposal fields (FFE-Bahir Dar, 2010). Due to the city's proximity to Lake Tana, the possibility for open, unlined landfills to contaminate local drinking water, or for refuse to be washed into the lake fro storm runoff, is high (Wondie, 2009). The lake is so contaminated that many, including a woman from Bahir Dar that was interviewed, refuse to swim in it (Matthew, 2011). The maps on the following pages provide aerial views of the two cities studied for Bahir Dar City-Lake Tana basin. Nevertheless, there is evidence to suggest that waste management in Bahir Dar has improved significantly in recent years. Most notably, the city of Bahir Dar recently moved from government funded waste management collection to private sector collections, a transition that started in 2009 (Matthew, 2011). The private waste management company currently active in the city is called Dream Light Waste Management P.L.C., which was created in response to the poor cleanliness of the city. The company relies heavily on engaging the community through household waste management and house to house collections, all in return for small service fee (FFE-Bahir Dar, 2010). Household waste collection has greatly reduced the amount of open pit dumps on city streets. The local community covers about 50% of Dream Light's costs through service fees of $0.80 US dollars per household and $1-75 US dollars per commercial site (FFE-Bahir Dar, 2010).

From these findings, it is suggested that improper waste management and toilet use are associated with sickness in Bahir Dar, Ethiopia, and that these issues must be analyzed across the city kebeles/sub cities. According to Figure 6, the city of Bahir Dar is directly on a large body of water- Lake Tana which experiences large inflows of waste and runoff from the city. Governement, international organizations and local NGOs can help combat this problem by funding lined landfills with effective caps. If modern lined landfills can be built in urban areas, then water contamination would likely decrease. Additionally, covering the trash with a cap would prevent it from affecting the environment around it (FFE-Bahir Dar, 2010). There is definitely a major problem involving unlined disposal areas and drinking water contamination, which international and domestic actors can play a part in remedying. Regarding the water pollution, 5.9% of the households are subject to water pollution. The major causes of water pollution are mainly residential and commercial wastes. The residential waste accounts for 66.9% of the water pollution (liquid waste being discharged in the open field) and commercial waste accounts 33.1% (inorganic and organic waste) Figure 7 describes the whole city with centre includes the Lake Tana and this is the existing one with a big change on upgrading and huge construction of commercial buildings even if opportunities and challenges for development are highly concentrated in this city according to the study of Koyachew (2016).

CONCLUSION

This review study has attempted to analyze the status and spatial coverage of waste management service of Bahir Dar City-Lake basin in general. In particular, the study explored residents' solid waste physical composition and generation rate, resident's solid waste

Figure 6. Aerial view of Bahir Dar (Source: Wondie, 2009).

Figure 7. The whole city with centre including the Lake Tana (Source: Koyachew, 2016).

management practice, and institutional structure and capacity of sanitation, actions or practices on waste management by policy makers, municipality, peoples, private sector, Dream light and like organizations of the city.

The review shows that even though various studies and programs are undertaken to curtail the problem of solid waste, the service still falls short of the required level. Technical measures, including waste sorting, recycling and composting, and infrastructural measures for leachate collection and gas venting should be upgraded to standardize the city waste management system. Concern for financial viability and long-term planning for waste management is important indicators of sustain the strengthening of SWM planning. Similarly, the formation of the Dream Light and others with their motivating role in waste management at local level has been driving this practice towards sustainability. Therefore, it is a good practice, leading towards the fulfilment of the municipal vision of a safe and clean municipal area enable SWM practice of the Bahir Dar city - Lake Tana basin.

The municipality's mechanism for coordinating the public and private sectors has played a vital role in waste management. However, the daily monitoring of waste management by the community development section has not been sufficient. Effective involvement of both private and public sectors has made it possible to improve waste management and provide door-to-door collection. The role of the private sector in recycling is important and it can contribute to sustainable waste management by reducing the quantities of plastics and sound financial management and regular and reliable payment of the contractor is important for satisfactory private sector participation. The municipality of the city can achieve its

target of solid waste management with active involvement of the private sector, minimizing municipal expenditure by means of effective management practice. According to the review, nearly two-thirds of all households in Bahir Dar discharge waste water into streets and flood water drainages. There is a poor level of awareness about existing regulations on sanitation among the experts as well as the public. The City Service Administration Office authorities did not seem to give due attention to waste water management in the city. There is weak implementation of the regional hygiene regulations. In addition, space availability is an important factor affecting waste water management at household level in the city.

Generally, this research investigated three main factors which are exacerbating the existing unsatisfactory status of waste management service of Bahir Dar City. These are very weak institutional arrangement and capacity of sanitation due to the city administration and health office structure is twisted by long bureaucracy and delay in implementation of activities, lack of practical decentralization of power and regular interference of higher officials, absence of kebelle specific structure of the waste management department, and high burden of work with significant services solid and liquid waste management. Interms of capacity, very poor institutional capacity of the department is arising out of the very low financial capacity, absence of cost recovery mechanism and financial autonomy, insufficient manpower resource, low motivation and productivity of workers due to failure to address fundamental need of workers, scarcity of waste management facilities, weak enforcement of rules and regulations, fragile networks and linkage of the responsible department with other sectors and organization and mandate restrictions of the department.

Very poor solid waste management practices of the city residents due to the first weakness of households is poor handling of temporary storage material of their house, that is, they drop out solid waste around it and they also exposed it to rain and light, did not well covered, and placed near to residence. Second, the greater part of the city residents did not separately store solid wastes other than salable and exchangeable with Liwach and Quraleos. They did not also carry out sustainable solid management activities such as recycling, reusing and composting. Apart from this, they regularly apply temporarily illegal solid waste disposal at about the city main streets. Moreover, they have also low emphasis to clean their surrounding area and nearby road. Due to very limited participation and contribution of stakeholders, the provision of municipal solid waste management of the city is dominantly performed by municipality with very limited contribution of policy makers, municipality, peoples, private sector, Dream light and like organization, and communities. Besides this, the involvement of community base organizations, nongovernmental organizations and private sector is mandatory for practicing holistic waste management of this rapidly growing and populated city.

To reverse the adverse outcomes of the Bahir Dar City-Lake Tana basin, waste management practice the following measures need to be taken from now.

Waste management training and resource centers should be established in order to improve the standards of waste management in the city and hence the city administrator could formulate a clearer role for its sustainable waste management and resource mobilization centre and so the necessary instructions should be given to waste management in order to improve the solid waste management capacities of the city municipality. In order to increase the quality and efficiency of services in the local operational context, more research and studies in waste management should be undertaken and the established waste management and resource mobilization centre should work with the institutions which are educating urban planners at various universities in the region.

In order to implement effective waste management in the city, the administration could formulate short-term and long-term plans for waste management and the municipality could employ urban planner for urban development planning. Increasing public awareness about waste management; controlling the offenders through strict enforcement of regulations; assigning qualified environmental health workers to each kebele and sub-city to enforce the sanitation regulations and coordinating the efforts at the grassroots level should be followed. The urban health extension program should also take measures to mitigate the problems. Therefore, an integrated solid and liquid waste management should be implemented for the City- Lake Tana basin and also for the surrounding environment. This has to include development plans for improving sustainable sanitation and disposal of the sewage system, and adopt the best practices of waste management system for the City-Lake basin areas. All stakeholders in the city and around it should participate in striving towards sustainable construction in order to embark on the environmental impact issues. Since waste perceived as major obstacle particularly in the construction infrastructures, the city administrator is obligated to develop tools or model to enhance the quality of waste management during the infrastructure construction life cycle.

Scientific researches related to sustainable waste management practices should be done on waste minimization, recycling, waste conversion to energy, bio-fuels, chemicals or other useful products and this should include but not limited to the following technologies of waste-to-energy, anaerobic digestion, composting and bio-fertilizer production, other thermal or biological conversion technologies and also strategies to promote diversion to higher and better uses (e.g. organics diversion, market analysis, optimized material management, logistics, etc.) and land filling. The

researches should be applied and can include economic or cost/benefit analyses, feasibility studies for untested technologies or management strategies, life cycle analysis or inventory, and analyses of policies that relate to the above (e.g. extended producer responsibility, recycling goals, carbon legislation, bottle bills, etc).

Therefore, this review study did not attempt to measure the amount of waste water generated, the degree of environmental pollution, or its impact on underground water and the soil. Nearly two-thirds of all households in Bahir Dar discharge waste water into streets and flood water drainages. There is a poor level of awareness about existing regulations on sanitation among the experts as well as the public. The City Service Administration Office authorities did not seem to give due attention to waste water management in the Town. There is weak implementation of the regional hygiene regulations. In addition, space availability is an important factor affecting waste water management at household level in the city. Therefore, the following measures need to be taken to reverse the adverse outcomes: increasing public awareness about waste management; controlling the offenders through strict enforcement of regulations; assigning qualified environmental health workers to each *kebele*/sub-city to enforce the sanitation regulations and coordinating the efforts at the grassroots level. The urban health extension program should also take measures to mitigate the problems. Finally, a more comprehensive systematic study should be conducted on the impact of waste water that is generated in the city into Lake Tana.

An investigation of waste management practices in the cities of Bahir Dar has underscored the challenges of waste management and the potential for private sector involvement in urban areas. It is recommended that private sector waste management be promoted by financing private sector companies in urban areas. Dream Light Waste Management Company operating in Bahir Dar has been shown to be more effective than previous practices in waste collection, and at a lower expense to the local people. That said, while improving the amount of waste collected from households, Dream Light may still contribute to environmental and health problems by placing waste in unlined, uncovered, disposal sites in the city. The city of Addis Ababa meanwhile is a prime candidate for private sector involvement in waste management as effective household collection will reduce the amount of open disposal sites/bins on city streets. The main issues in both urban areas are the lack of lined, covered landfills available to receive waste. If government and NGO actors are also able to construct modern lined, capped landfills, then unlined drinking water sources can be better protected, lowering rates of water contamination, and preventing disease and illness. The unprotected water sources like boreholes are at a high risk of being contaminated by waste through groundwater percolation. Sources of drinking water are causing sickness at a varying scale across all regions, specifically in rural areas. If lined disposal sites are created in rural villages, they can handle waste without contaminating groundwater. Government and NGOs can also help protect ground water by building latrines in rural areas, which will greatly reduce human waste from contaminating water sources. International donor involvement in the financing and building of lined landfills and latrines could greatly reduce the contamination of groundwater and sickness rates in urban and rural areas alike.

RECOMMENDATIONS

Based on the findings of this review study, the following measures are very important to overcome waste management problem of Bahir Dar City.

Preparing and delivering waste management or disposal techniques should be done for the city youths particularly for women in each kebele administrations to structure and dissiminate gender

Preparing sound Dream Light institutional arrangement that is free from high interference of higher officials and bureaucracy, which has both horizontal and vertical integration and kebelle specific teams, allows stakeholders participation, and characterized by real decentralization of tasks and authority. The city Dream Light should give priority to fulfill infrastructure facilities, that is, place back the public solid waste containers and introduce dust bins with a close supervision, frequent emptying of waste and even distribution, and also organize efficient controlling mechanism and sanitation agent to prevent illegal solid waste disposal.

Increase Dream Light revenue by employing different revenue means like introducing user charges, penalties for persons who illegally dispose their waste, employing resource recovery activities, and government subsidies. But the department should also introduce cost accounting financial monitoring and financial evaluation. Improve solid waste collection by preparing permanent programs, increasing the number of collection trucks, by employing other methods of collection like block and curbside collections, control and supervision field workers, increase human resource of the department, increase the number and strength of Dream Light.

Improve the number and productivity of sanitation workers by giving reasonable salary increment, perdiam payment, moral respect, training, promotion opportunities, changing their requirement type, and providing health insurance and health protection facilities. Prepare specified rules and regulations that focused on local problems such as institutional issues about the town's waste management service responsible body, stakeholder's participation and sustainable solid waste management options, and strictly enforce this rules and regulation under close supervision and inter

organizational linkage.

For the stakeholder related measures, the Dream light open its door to private sectors and also ensure their involvement in planning and implementation of municipal solid waste management activities. Promote and initiate communities and different community based organizations of the town to involve in waste management. In addition, organize voluntary groups that work on municipal waste management by giving different incentives and providing necessary equipments that are used for waste management.

Due to urbanization, inequality, and economic growth; cultural and socio-economic aspects; policy, governance and institutional issues; and international influences have complicated SWM in developing countries including Bahir Dar City. This has limited the applicability of approaches that were successful along the SWM development trajectories of industrialized countries, and therefore it is very important for finding new SWM approaches for developing country contexts in the post-normal science and complex, adaptive systems thinking.

Therefore, Dream Light of the town should create interaction with nongovernmental organizations (NGOs) and donor agencies and watch these bodies as partner for delivery of waste management; because they are one means's to get financial support for purchasing different solid waste management facilities, managerial and technical skill building trainings. In addition, they can also provide awareness rising and skill building support to community based groups (private sector, Dream light and organization of youth and women), informal sectors, formal sectors, and also to the Dream Light itself. Recognizing and encouraging the emerging role of handcrafts through reduction of taxes, and by providing space and equipments to produce recycled materials and creation of market for it.

All these new processes should be emerged and practiced slowly by injecting compatible technologies, that is, advanced mechanical recycling of plastic waste as virgin or second grade plastic feedstock, and thermal treatments to recycle the waste as virgin monomer, as synthetic fuel gas, or as heat source (incineration with energy recovery) as these processes avoid land filling, where the non-biodegradable plastics remain a lasting environmental burden. Considering systems analysis models and tools in a synergistic way will certainly provide opportunities to develop better solid waste management strategies leading to conformity with current standards and foster future perspectives for both the waste management industry and government agencies and also the urbanizing cities.

Biological treatment of solid, liquid and gaseous wastes is probably the only way that leads to sustainability. All biodegradable wastes can be treated by product-oriented processes of bioconversion in facilities using advanced technology. Regulating and speeding up natural biological processes, for example short-time composting, can be one of the steps to achieve an optimal system for processing organic waste. The products like compost or biofertilisers of desired quality can be used as growing medium or horticultural substrate, substitute for peat in a container medium for the nursery plants, soil improvements that influence the physical, chemical and biological properties of the soil.

Regarding policy recommendation, the city shall follow a multi-sectoral approach to waste management as a matter of urgency, incorporating principles of ecosystem based management from the watersheds into the nearby water bodies, connecting sectors that will reap immediate benefits from better solid and liquid waste management. Successful and sustainable management of waste requires a cocktail of innovative approaches that engage the public and private sector at local, national and transboundary scales. Planning processes should provide an enabling environment for innovation, including the community level. Innovative financing of appropriate waste infrastructure should incorporate design, construction, operation, maintenance, upgrading and/or decommissioning. Financing should take into account, the fact that there are important livelihood opportunities in improving waste treatment processes. In light of rapid global change, communities should plan waste management against future scenarios, not current situations. Solutions for smart waste management must be socially and culturally appropriate, as well as economically and environmentally viable in the future. Education and awareness must play a central role in waste management and in reducing overall volumes and harmful content of waste produced, so that solutions are sustainable.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Agrawal A (1995). Indigenous and Scientific Knowledge: Some Critical Comments," Indigenous knowledge And Development Monitor. PhD Dissertation, Montreal University of Technology and management, Canada.

Allende R (2009). Waste history in the Gambia. MSc Thesis, University of the Gambia. URL/Accessed on 20 January 2013.

Ana P, Graça M, Ni-Bin C (2010). Solid waste management in European countries: A review of systems analysis techniques. J. Environ. Manage. 94):1033-1050.

Anke B, Jan B, Raf D (2012). Recycling and Recovery of Post-Consumer Plastic Solid Waste in a European Context. Thermal Sci.16 (3):669-685.

Arto S, Kari S, Aino-Maija K Y (2010).Summary of the Progress Review of the Improvement of self-sufficiency and sustainability in sanitation waste and energy project in Bahir Dar (SAWE), Project Code ETI 23815801.

Ayana Y (2007). Plastic Bag Waste Generation Rate in Bahir Dar Town. Addis Ababa University School of Graduate Studies Department of Environmental Science, MSc Thesis in Environmental science.

Bahir Dar City Administration (2010). Integrated Solid Waste

Management Plan, Strategic Action Plan (Draft).
Bansal AK, Mitra A, Arora RP, Gupta T and Singhvi BSM (2007). Biological treatment of domestic waste water for aquaculture. Agric. J. Biosci. 2:6-12.
Bartone C (2000). Strategies for Improving Municipal Solid Waste Management. Workshop on Planning for Sustainable and Integrated Solid Waste Management. Washington, DC: Urban Management Division, World Bank. Manila pp. 18-22.
Bhide AD, Sundaresan BB (1980). Street Cleansing, Storage and Collection of Solid Wastes in Developing Countries - Indian Experience'.Proc.ISWA Congress, London, June 1980.
Bhide AD, Sundaresan BB (1983). Solid waste management in developing countries. Indian national Scientific Documentation Centre, New Delhi; P 222.
Christian RL (2012). Feasibility Assessment Tool for Urban Anaerobic Digestion in Developing Countries. A participatory multi-criteria assessment from a sustainability perspective applied in Bahir Dar, Ethiopia. M.Sc Thesis in Environmental Sciences (major in Environmental Technology), Wageningen University Netherlands, Final 24 January 2012.
Daneshvar R, Fernandes L, Warith M, Daneshfar B (2005). Customizing arcmap interface to generate a user- friendly landfill site selection GIS tool. J. Solid Waste Technol. Manag. 31(1):1-12.
Edward A (2008). Seeing the House from the Environment: Environmental Concerns of Informal/Slum Settlement in Accra, Ghana. M.Sc Thesis in Environmental Management, August 2008.
Environmental Protection Authority (EPA) (1996). Environmental Guidelines: Solid Waste Landfill, Environmental Protection Authority.
Environmental Protection Authority (EPA) (1997). Environmental Policy of the Federal Democratic Republic of Ethiopia.Federal Urban Planning Institute, FUPI (2006). Executive Summary of Bahir Dar Integrated Development Plan (bdidp), Federal Urban Planning Institute and Bahir Dar Metropolitan City Administration, Bahir Dar, Ethiopia.
Eshun J K (2002). Draft Guidelines for Ground water Investigation and Monitoring for Landfills, MA Thesis, Netherlands Environment Protection Authority South Australia.
Fesseha HM (2012). Liquid waste management: The case of Bahir Dar, Ethiopia. Bahir Dar University, Department of Geography. Ethiop. J. Health Dev. 26(1):49-53.
Forum for Environment, UNEP (2010).Solid Waste characterization and quantification of Bahir Dar City for the Development of integrated solid waste management plan.
Forum for Environment, FFE (2010). Assessment of the Solid Waste Management System of Bahir Dar Town and the Gaps Identified for the development of an ISWM Plan". In Ethiopian Environment Review, Addis Ababa.
Genemo B, Yohanis B (2015). Municipal Solid Waste Disposal Site Selection of Jigjiga Town Using GIS and Remote Sensing Techniques, Ethiopia. Int. J. Sci. Res. Publications. 5:4.
Goraw G, Byamukama D, Manafi M, Kirschner A, Farnleitner AH (2010). A Pilot Study on Anthropogenic Faecal Pollution Impact in Bahir Dar Gulf of Lake Tana, Northern Ethiopia. Ecohydrol. Hydrobiol.10(2 -4):271-280.
Hammer G (2003). Solid waste treatment and disposal: effects on public health and environmental safety. Biotechnol. Adv. 22:71-79.
Javaheri H (2006). Site Selection of municipal Solid Waste Landfills Using Analytical Hierarchical Process Method in a Geographical Information Technology Environment in Giroft. Iran. J.Environ. Health Sci. Eng. 3:177-184.
Jilani T (2002). State of Solid Waste Management in Khulna City. Unpublished Undergraduate thesis, Environmental Science Discipline, Khulna University Khulna, P 2585.
Kassa G (2009). Management of Domestic Solid Waste in Ethiopia. VDM Verlag Dr. Müller, Saarbrücken, Germany.
Koyachew EK (2016). The problem of solid waste management and people awareness on appropriate solid waste disposal in Bahir Dar City: Amhara region, Ethiopia. 3(1):1-8.
Martin D, Williams H (1992). Market-area analysis and accessibility to primary health-care centers. Environ. Plann. 24:1009-1019.
Matthew C (2011). Waste Management in Ethiopia. Environmental Policy Review 2011: Chapter5, East Africa Update 2011.
Merkuz A (2017). Agriculture in the Lake Tana Sub-basin of Ethiopia. Social and Ecological System Dynamics .Part of the series AESS Interdisciplinary Environmental Studies and Sciences Series. pp. 375-397.
Metaferia (2001). Upgrading the city of Bahir Dar: Action Plan for Flood Control and Drainage Final Design Report". Metaferia Consulting Engineers and Devecon Architects and Engineers, Ethiopia.
Morrissey A J, Browne J (2003). Waste management models and their application to sustainable waste management. Waste Manag. 24(4):297-308.
Mwanthi MA, Nyabola LO, Tenambergen ED (1997). The present and future status of municipal solid waste management in Nairobi. Int. J. Environ. Health Res. 7:345-353.
Palestinian Agency for Environmental Affairs, PAEA (2006). Solid waste standards report, Ramalla.
Rachael EM, Khosrow F (2013). Systems approaches to integrated solid waste management in developing countries. Waste Manag. 33(4):988-1003.
Radwan J, Sameer SM, Abdel FH, Ahmed GM, Mohammad BA (2017). Geospatial Implications Assessment of Zahrat Al Finjan Solid WasteLandfill, North of West Bank, Palestine. Peer-reviewed J.Islamic University-Gaza. 25(2):1-9.
Al-Salem SM, Lettieri P, Baeyens J (2009). Recycling and recovery routes of plastic solid waste (PSW): A review. Waste Manag. 29(10):2625-2643.
Samuel WA, Enoch AK (2014).Solid Waste Management in Urban Areas of Ghana: Issues and Experiences from Wa. J. Environ. Pollut. Hum. Health 2(5):110-117
Sarker BC, Sarker SK, Islam MS, Sharmin S (2012). Public Awareness about Disposal of Solid Waste and its Impact: A Study in Tangail Pourashava, Tangail. J. Environ. Sci. Nat. Resour. 5(2): 239-244.
Senkoro H (2003). Solid Waste Management in Africa: A WHO / AFRO Perspective, Paper 1, Presented in Dares Salaam at the CWG Workshop.
Shekdar AV (1999). Municipal solid waste management – the Indian experience. Indian Assn. Environ. Manag. 27:100-108.
Suryawanshi P (2013). Solid and Liquid Wastes: Avenues of Collection and Disposal. Int. Res. J. Environ. Sci. 2(3):74-77.
Tchobanoglous G, Burton F L, Stensel HD (2003). Waste water engineering: Treatment and reuse, 4th edn, Metcalf and Eddy, Inc. Toronto pp. 07-23.
Tchobanoglous G, Theisen H, Eliassen A (1977). Solid waste: engineering principles and management issues. Mc Graw-Hill. Kogakusha, ltd. Tokyo.
Thomas-Hope E (1998). Solid waste management: critical issues for developing countries. Kingston: Canoe Press.
Tirusew AE, Amare SM (2013). Solid waste dumping site suitability analysis using geographic information system (GIS) and remote sensing for Bahir Dar Town, North Western Ethiopia. 7(11):976-989.
UNEP (2010a). Assessment of the Solid Waste Management System in Bahir Dar Town and the Gaps identified for the Development of an ISWM Plan. Forum for Environment, June 2010.
UNEP (2010b). Solid Waste Characterization and Quantification of Bahir Dar City for the Development of an ISWM Plan. Forum for Environment, June 2010.
UNEP (2010c). Target Setting for ISWM of Bahir Dar City, Ethiopia. Forum for Environment, August 2010 workshop in the Amhara National Regional state. 23rd January, Bahir Dar, Amhara.
United Nations Population Fund (UNFPA) (2008). Federal Democratic Republic of Ethiopa Population Census Commission .Summary and statistical Report of the 2007 Population and Housing Census, Population Size by Age and Sex. December 2008, Addis Ababa.
Ward D, Dubos R (1972). Only one Earth, the Care and Maintenance of a Small planet. London, Penguin.
Wondie (2009). The impact of urban storm water runoff and domestic waste effluent on water quality of Lake Tana and local groundwater nears the city of Bahir Dar, Ethiopia. Ithaca, NY: Cornell University, (2009). Web. 22 September 2011.
Worku D (2012). Recycling practices and potentials in Bahir Dar City and the influence of land fill leach ate on groundwater quality, MSc Thesis. Faculty of the Graduate School of Cornell University, USA.