SOLID WASTE CHARACTERIZATION AND QUANTIFICATION OF BAHIR DAR CITY FOR THE DEVELOPMENT OF AN ISWM PLAN

Forum for Environment

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Forum for Environment

in
collaboration with

Bahir Dar
City Administration

Dream Light Plc

Bahir Dar University

Bahir Dar
Forum for Environment

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ANRS Region Bureau of Environmental Protection, Land Administration and Use

1. Background

1.1. Setting the Boundaries

Bihar Dar city is the capital of the Amhara National Regional State in the Federal Democratic Republic of Ethiopia. It is located at 11" 38'N, 37" 10'E on the southern side of Lake Tana (where Blue Nile river starts). The altitude of the city is about 1801m above mean sea level. The city covers an area of 16,000 hectares.

The boundaries set for data collection is in terms of geographical and/or administrative coverage and in terms of different sectors and waste generators with respect to various waste streams. The different points of concern in this regard for city Bahir Dar are discussed below.

1.1.1. Geo-Demographical & Administrative

Geographical Size of the Area and Zoning (Zoning and possible waste streams in each zone)

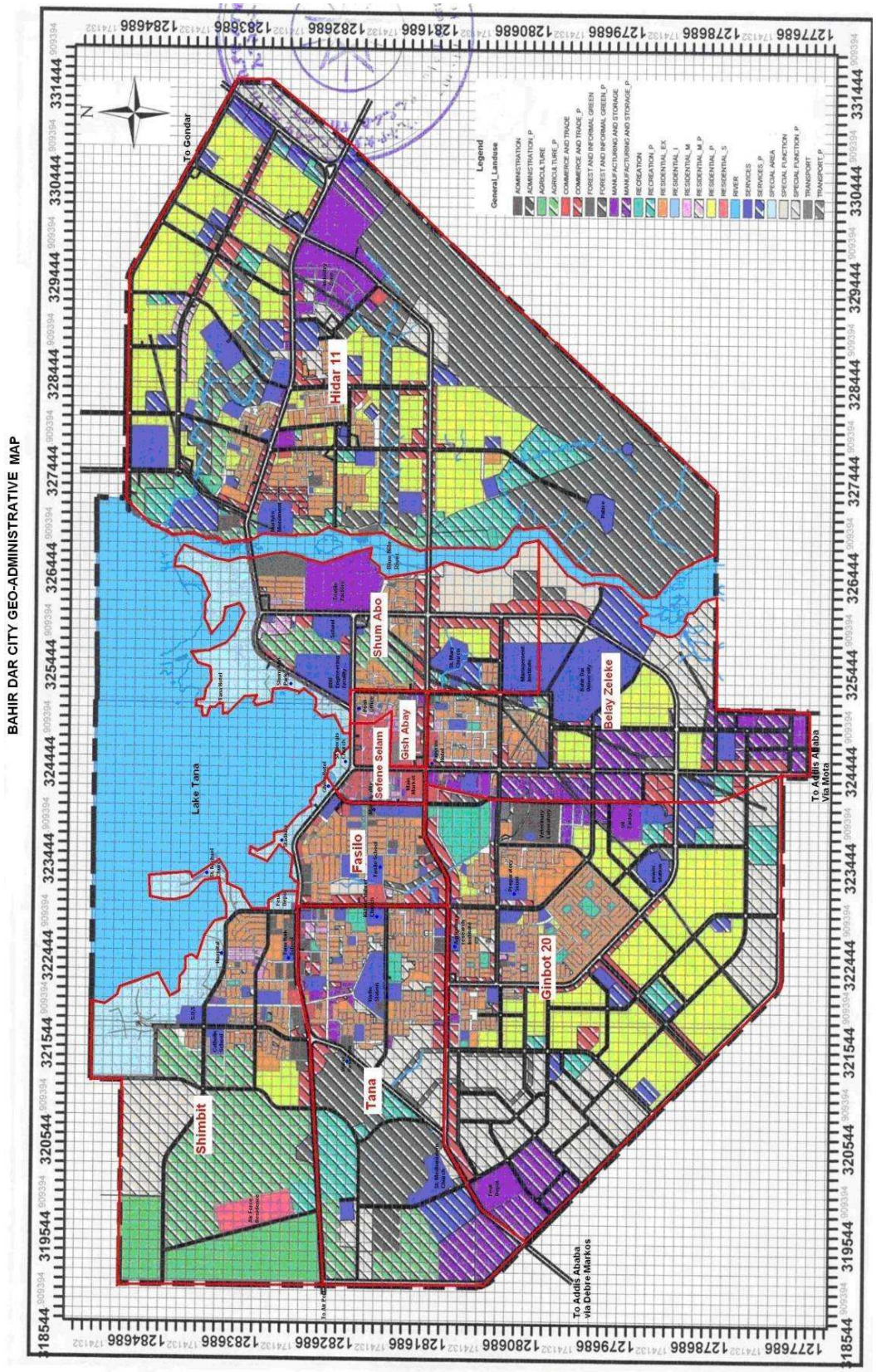
There are 9 "kebeles"/zones (the lowest administrative level) in Bahir Dar town each have sub-zones. These kebeles and sub-zones and the identified possible waste sources/streams are indicated in the table below (Table 1) and the geo-administrative map of the city is depicted on Figure 1.

Kebele/Zone	Sub-kebele/zone	Possible waste streams
Sefene selam	A(04),B(05),C(06)	R+C+ service/health care+Inst+C&D+street sweeping
Gishabay	A(01),B(02),C(12)	R+ service/health care+ C+ C&D+ street
Fasilo	A,B,C,D	R+ service/health care+ C+ C&D+ street
Belay Zeleke	A,B,C,D,E	R+ inst+ C+ C&D+ street
Hidar 11	A,B,C,D,E	R+ inst+ C+ C&D+ Agri.+ Ind.
Shimabo	A(08),B(09),C(10)	R+ inst+ C+ C&D+ Agri.+ Ind.+ street
Shimbit	A,B,C,D	R+ inst+ C+ C&D+ Ind.+ street+ health care
Ginbot 20	A,B,C,D,E,F	R+ inst+ C+ C&D+ Ind.
Tana	A,B,C,D	R+ inst+ C+ C&D+ Ind.

R: Residential **Inst:** Institutional **C&D:** Construction and Demolition
C: Commercial **Ind:** Industrial **AGri:** Agricultural

Table1: Possible waste streams in each kebele /zone

Figure 1. Administrative and Land use in Bihar Dar City



1.1.2. Land Use

The core city has an estimated area of 16000 hectares. The city is divided into 9 administrative kebeles. Each kebeles has been further divided into zones (A, B, C, D and F). Most of the administrative kebeles comprise mixed land use i.e. residential; commercial, institutional etc. this has difficulty to set clear the boundaries of different sectors and waste generators with respect to various waste streams.

In Bahir Dar area significant numbers of the urban dwellers and about 26% of the rural residents are engaged in agricultural activities. Water body of Bahir Dar accounts just over 31% of the total land. Human settlement accounts to about 30% of the total land area of the city (including rural, urban and informal settlements).

No.	Land use	Area (Ha)	Percent
1	Agriculture	6,588.00	23.72
2	Formal urban settlement	4,214.00	15.17
3	Forest & Woodland	70.00	0.25
4	Marshy land	1,880.00	6.77
5	Vacant & Rocky	2,327.00	8.38
6	Water Body	8,718.00	31.39
7	Rural Settlement	2,982.00	10.74
8	Informal settlement	992.00	3.57
Total		27,771.00	100.00

Table 2: Land cover of Bihar Dar city(including satellite kebeles or rural)

Source: Bahir Dar Municipality Cadastre Studies Office, 2009

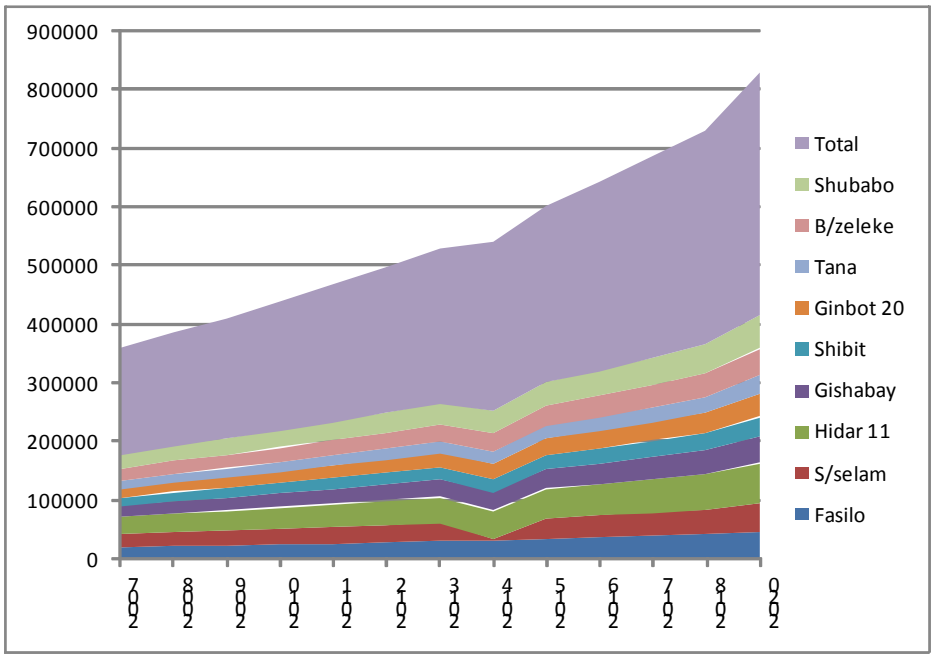
1.2. Demographic Details

According to the population and household census of 2007, the population of Bahir Dar is 220,344 /including rural kebeles/. When disaggregated by place of settlement, the rural population of Bahir Dar constituted 40,250 while the urban population is 180,094. In terms of gender composition the female population of Bahir Dar is slightly higher than the number of male population. Out of 180,094 urban populations 93,005 are female and 87,089 are male. Annual population growth of the city is about 6.6%. From this 2.6% is the birth rate and 2.8% is migration rate. Average household size was 4.4 in 2005[1].

[1] source: finance and economic bureau of Amhara Regional State and Bahir Dar City Administration

Kebele	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020
Fasilo	19905	21219	22619	24112	25703	27400	29208	31136	33191	35382	37716.7	40206	45688
Sefene Selam	21250	22653	24148	25741	27440	29251	31182	3240	35434	37772	40265.3	42923	48776
Hidar 11	30000	31980	34091	36341	38739	41296	44021	46927	50024	53326	56845.1	60597	68860
Gishabay	17874	21186	22584	24074	25663	27357	29163	31087	33139	35326	37658	40143	45617
Shibit	14754	15728	16766	17872	19052	20309	21650	23079	24602	26226	27956.4	29802	33865
Ginbot 20	16796	17905	19086	20346	21689	23120	24646	26273	28007	29855	31825.7	33926	38552
Tana	13703	14610	15574	16602	17697	18865	20110	21438	22853	24361	25968.8	27683	31457
Belay Zeleke	20000	21320	22727	24227	25826	27531	29348	31285	33349	35550	37896.8	40398	45906
Shubabo	24484	26100	27823	29659	31616	33703	35927	38299	40826	43521	46393.2	49455	56199
Total	**180768**	**192699**	**205417**	**218975**	**233427**	**248833**	**265256**	**287763**	**301425**	**321319**	**342526**	**365333**	**414921**

Table 3: Time series of population by administrative zones /kebeles 13 years projected data based on 2007 census data.



Chat 1: Time series of population projection (2007-2020) by administrative zones /kebeles

1.3. Industries, Institutions, Healthcares and Commercial Undertakings

1.3.1. Industries

There are 9 major industries in Bahir Dar city. These are 1 textile, 1 tannery, 2 leathers, 2 agro-industries, 1oil and 1 plastic, 1 abattoir. The Bahir Dar textile factory and the tannery are the most significant ones as compared to the others.

1.3.2. Institutions, Healthcares and Commercial Undertakings

The number and geographical distributions of different institutions, healthcare facilities and commercial undertakings in Bahir Dar city are listed in the table below.

Institution	B\zeleke	Hidar 11	S/selam	Gishabay	Tana	Shimbt	Shumabo	Ginbot 20	Fasilo	Total
Govt. and non-govt. bureaus insurance, bank	5	17	24	3	21	39	21	18	43	191
Schools, college, training centers	5	18	6	3	6	7	5	7	13	70
universities	1	-	-	-	-	-	1	-	-	2
Commercial centers										
Hotels, rest, lodges, juice centers	31	31	481	164	25	39	33	15	16	835
Garages, shops, market centers	407		3,890	818	290	429	173	125	73	6205
Fuel retailer centers	1		2		1	1	2	2	-	9
Healthcare and laboratory										
Hospitals	-	-	-	-	-	1	-	-	-	1
Clinic/health care centers/	1	5	7	7	2	5	1	1	3	32
Pharmacy /drug store/	-	1	15	10		6	-	1		33
Lab(soil, animal)		1					-	1		2

1.4. Primary data on solid waste generation

Following are also some data as per the Bahir Dar EPLAU (2005) survey.

Table 9: waste composition

Type of waste	% by weight
Food	86.6
Paper	3.3
Plastic, leather & plastic	2.2
Glass	0.6
Textile	2.2
Metals	0.3
Others	48

Waste generation rate in the city is 0.223kg/d/capita

Table 10: Distribution of waste production among the waste streams

Waste stream	Amount kg/d	% share
Residential	12610	55
Commercial	4202	19
Industrial	3930	17
Service provider	988	4
Municipal waste	1044	5
	22774	100

From the total waste generated, only 51% was properly collected and disposed. 86% of the total waste generated is degradable (easily decomposable).

2. Waste streams

2.1. Waste generating sectors

According to Bahir Dar city arrangements, waste generating sectors are described as follows,

1. Institutions: Institutions include Amhara National Regional State bureaus, agencies, offices, schools (high schools), government's colleges and universities and non-government offices, private schools and colleges.
2. Health care: (Hospitals, Health centers, and clinics)
3. Industries: (Tanneries, Textiles, Plastics shoe factory, Edible oil, and agro processing industries)
4. Residential: All households living in Bahir Dar city administration boundary
5. Street sweepings
6. Construction and Demolition structures
7. Agricultural sources
8. Commercial sectors

2.2. Define Municipal and Non-municipal wastes

A) **Municipal Solid Waste (MSW)** – for Bahir Dar city case municipal waste covers residential and commercial non-hazardous waste. It is a waste type that predominantly includes household waste (domestic waste). The C & D debris and special wastes like hazardous wastes—usually not categorized under MSW. It is sometimes also defined to mean all solid wastes that a city authority accepts responsibility for managing in some way.

B) **Residential Wastes**

Residential waste generated by households living either in single-family houses or multi-family buildings may contain organic waste (for example, from the kitchen and gardens), recyclable waste (for example, plastics, paper, cans, etc.), non-recyclable waste (that has no recycling value), and hazardous waste (batteries,

some oils, etc). Usually, the municipality is responsible for collection and disposal of such waste, thus it is treated as municipal waste.

C) **Commercial waste** (shops, hotels, garages, and agricultural wastes)

Food Non-hazardous commercial waste generated by the businesses sectors is considered as municipal waste; however, waste generators through private sector usually arrange in this category. Agricultural wastes like spoiled food waste, crop residues, rubbish, and others.

D) **Street Wastes:**

This include wastes pick up from the streets and carried out as municipal waste to the disposal site.

E) **Institutional Wastes**

Government and Non-Government Bureaus, Schools, Universities, Colleges, Training Centers, Churches, Mosques…etc are categorized in institutional waste sources.

F) **Non- municipal wastes** are wastes different from residential and commercial wastes in Bahir Dar city case. Wastes like construction and demolishing waste, industrial waste, health care wastes, laboratory wastes construction and demolishing wastes-wastes from buildings and other structures are classified as demolishing wastes. Wastes from construction, remodeling, and repairing of individual residence, commercial building and other structures are classified as construction wastes. These include dirt, stones, concrete, bricks, plaster, lumber, shingles, and plumbing, heating, and electrical parts.

Health Care Centers - (Hospitals, Health Centers, Clinics and Medical Laboratories, Pharmaceutical centers)

Industries (Tanneries, Textile, Plastic Shoe factory, Edible oil, Agro Processing industries)

2.3. Hazardous and non-hazardous waste

A) **Hazardous waste** (industrial, health care and laboratory wastes)

A waste that poses substantial or potential threats to public health or the environment generally exhibiting one or more of these characteristics: ignitable, oxidizing, corrosive, eco-toxic, radioactive, etc.

Hazardous waste is generated by different sectors including industries, healthcare facilities, laboratories, construction and demolitions, sludge and urban agriculture. Some hazardous waste is also generated by residential sector; however, the data on residential hazardous waste is usually collected under municipal waste. For hazardous waste, the data should be collected based on the classification of hazardous waste which is based on the content of hazardous substances. Considering the nature and the complications is testing the waste for the presence of the hazardous substances, the data for such wastes is directly collected from the generator instead of going for the procedure of collection and analysis of the waste samples.

Since Ethiopia ratified the Basel Convention, the following the Basel classification of hazardous wastes can be applied.

Generally hazardous wastes of Bahir Dar City include

- Wastes from Hospitals and medical laboratories
- Chemicals: chemically contaminated containers and trimmings from agriculture, pesticide retailer shops, university and school laboratories, tanneries, textiles, expired drugs and different chemicals
- Biological wastes from Hospitals and biological research facilities
- Dry cell from each sources and car battery from garages
- Used condoms from Hotels, Pension
- Fluorescent lamps from each sources

B) Non-hazardous wastes

Non-hazardous wastes are those wastes that do not posses hazard characteristics and excluded in the Basel Convention Classification system. These wastes are generated from the aforementioned sources of the waste for the City.

Non hazardous waste is routinely generated waste, including general facility refuse such as pare, cardboard, glasses, wood, plastics, scraps, metals, dirt, and rubber. In general non hazardous waste includes mixed or household waste, packaging waste, compostable and inert wastes.

3. Solid waste data collection, analysis and presentation procedure

Once the information on the demarcation of various waste sectors and waste streams is available, the next step would be to set the procedures for data collection, analysis and presentation. For date collection the first step would be the finalization of list of materials available in solid waste generated by various sectors.

3.1 List of materials available in solid waste generated by various sectors

Below are the lists of material types, which are supposed to be available in various waste streams in Bahir Dar city.

1. Paper
   - Paper Bags
   - Newspaper
   - Office paper
   - Magazines and catalogues
   - Phone Books and directories
   - Other Miscellaneous paper not mentioned
1. Glass
   - Bottles and containers
   - Flat Glass
   - Ceramics
3. Metal
   - Ferrous metals
   - Non-ferrous metals
   - Remainder/composite metal
4. Plastic
   - Plastic bottles
   - Festal
   - Miscellaneous plastic containers
   - Remainder/composite plastic
   - Tires
5. Food
6. Landscape and agricultural
   - Leaves and grass
   - Pruning's and trimmings
   - Branches and stumps
   - Agricultural crop Residues
   - Manure
7. Textiles
8. Construction & Demolition
   - Concrete
   - Asphalt paving
   - Asphalt roofing
   - Lumber
   - Gypsum Board
   - Rock, soil and fines
   - Remainder/composite cons
9. Hazardous waste
   - Paint
   - Vehicle and equipment fluids
   - Used oil
   - Batteries

- Remainder/composite household hazardous
- Fluorescent lamps, cosmetics

10. Street sweeping
    - Dead animals, sugarcane, dust, etc.

3.2 Waste data Collection and Sampling

3.2.1 Sampling methods and Procedures

Determination of the required number of representative samples from each solid waste generator is the next important activity.

- The method we followed for sampling is the random sampling method. In order to make simple our sampling we indicate first the number of samples to be taken and how could we take them in each kebele and sub-zone.
- The number of samples depends primarily on the cost versus its utility. Usually for solid waste data, the confidence level (C.L) is set at 80% or 90% (CACADIA 2003). Consider here 80% confidence level. Accordingly, the number of samples to be collected for each waste stream is determined which is shown on the table below for Bahir Dar city case.
- Since the number of samples is influenced by level of variation of materials in the samples we took a little bit higher number of sample for commercials than residential.

3.2.2 Waste streams and number of samples allocation

Each waste stream and numbers of sample are indicated in the following table

No	Waste stream	No of samples
1	Residential	31*8=272hh
2	Institutional	16
3	Healthcare& Laboratory facility	5
4	Street sweeping	5
6	Industrial	5
7	Commercial	34*8=248cc
8	Agricultural	3
9	C & D	9
Total		108samples=563HH

Table 12: waste stream and numbers of sample

A total of 108 samples are considered to be analyzed for possible waste streams in the city. All these samples are distributed accordingly as shown in the table below.

3.2.3Timing for Sample Collection

3.2.3.1 Zoning

The residential and commercial samples are made to be collected at household level and samples from 8 households are considered to be brought together and mixed at arranged sites and constitute one sample for sorting. Hence, a total of 175 households shall be selected for sampling for residential waste stream making the number of samples in this stream to be 35, and 195 commercial establishments from commercial waste stream.

As explained earlier the waste generating sectors are located mixed in the city, particularly the residential, commercial and institutional sectors. Therefore, it has been not possible to produce specific waste zoning map for each of the possible waste generating sectors. The waste samples are then to be taken based on the existing administration and existing solid waste management practices in the city. The distribution of the residential and commercial waste samples is made to be in line with the administrative zones in each kebele, also taking into account the degree of variations in the waste composition. Detail breakdown of the residential and commercial waste samples is indicated in the tables below.

3.2.3.2 Timing

To get a representative data, the timing of sample collection could be a vital factor. Based on the economic viability and time constraints, the study is made by collecting one time data (one period or season), which later will be adjusted to represent the entire period of waste collection. Existing experience and local knowledge is used to be economical and effective for collecting the wastes, particularly the commercial and residential wastes. Hence for residential waste 7 days waste from

selected households shall be collected for analysis. For commercial waste and others most commonly a one day waste is taken for the selected sites.

3.2.3.3 Income level

Effort was made to see possibilities for obtaining the residential waste sample as per the income profile (high, middle and low income) of the society. This concept was discussed among the concerned stakeholders as it was good. However, a number of limitations were identified to its consideration. The major one was to find the income profile data of the city.

3.2.4 Selection of Sites and Method for Sample Analysis

For residential and commercial a sample is taken from 8 selected households or commercial centers. The 8 HH waste is taken, mixed and reduced three times to get a sample with average composition. For Street sweeping a sample is taken from 1/8 of 1km street waste. For the other sector a sample is taken from one household. The samples of different waste streams are analyzed by hand sorting. The quantification of wastes will be made by measuring the sorted waste for different material types and this be recorded for the next data analysis.

3.2.5 Construction and demolition wastes(C&D) Sampling

Currently there are different types of construction activities taking place in almost all the administrative kebeles. Most of the constructions are related to buildings, and the waste composition variation is expected to be less. The particular sites for sampling are to selected on random basis.

3.2.6 Industrial Waste Sampling

There are few (6) industries in the city at present. But a lot more are expected to be established. For this particular task almost all the available industries at present shall be analyzed for their waste quantification and characterization. Hence 6 industries will be surveyed.

3.3 Moisture content and calorific value determination

The moisture content and calorific value determination are supposed to be done at Bahir Dar University laboratory**.** 14 lists of materials have been identified for the quantification and characterization of Bahir Dar city solid waste. It is understood that moisture content shall be determined for most of these materials. Total of 120 samples are taken for moisture content determination. Samples are collected immediately during analysis and properly sealed and aggregated with the main data.

Since the calorific value measuring device was out of function, it was not possible to determine the calorific values of the samples.

4. Data analysis and presentation of Municipal waste in Bahir Dar

4.1. Waste composition in Bahir Dar city

Raw weight, moisture content and Dry weight of collected sample Residential waste in Bahir Dar city

Component	Raw weight (Kg)	Moisture content (%)	Dry weight (Kg)	Percentage
Food waste	80.35	45.97 %	43.41	12 %
Paper	18.226	33.8 %	6.16	2.8 %
Plastic	23.76	11.94 %	20.92	3.68 %
Textile	12.67	9.44 %	11.474	1.6 %
Rubber	5.455	< 1 %	5.43	0.84 %
Leather	2.971	3 %	2.88	0.15 %
Yard waste	107.105	30.3 %	74.65	17.9 %
Wood& charcoal	19.045	13.11 %	16.55	2.95 %
Glass	10.55	< 1%	10.52	1.6 %
Metals	7.78	< 1 %	7.753	2 %
Ash & soil	310.1	16.24 %	259.74	47 %
Stone	45.565	< 1 %	45.38	7 %
Hazardous	1.913	< 1 %	1.8996	0.29%
E-waste	0.725	< 1 %	0.718	0.11 %
Total	**646.215**		**464.0746**	**100 %**

Material Composition of residential waste sector In Bahir Dar city

Raw weight, moisture content and Dry-weight of collected sample <u>commercial</u> waste in Bahir Dar city

Component	*Raw weight(Kg)*	*Moisture content (%)*	*Dry weight(Kg)*	*Percentage*
Food waste	160.9	67.6 %	52.13	47.0%
Paper	15.84	22.1 %	12.34	5.00%
Plastic	11.82	21.8 %	9.26	3.00%
Textile	5.43	23.36 %	4.16	2.0%
Rubber	4.755	< 1 %	4.73	1.00%
Leather	0.55	3 %	0.53	0.16%
Yard waste	29.385	37.56 %	18.35	8.50%
Wood & charcoal	5.625	28.46 %	4.024	1.64%
Glass	8.665	< 1 %	8.6	2.50%
Metals	5.505	< 1 %	5.486	1.60%
Ash & soil	43.29	37.2 %	27.17	13.00%
Stone	9.065	< 1 %	9.03	2.60%
Animal remain	37.85	70 %	11.34	10.70%
Hazardeous	1.78	< 1 %	1.767	0.52%
E-waste	0.01	<1 %	0.0099	0.00%
others	3.53	5 %	3.35	1.00%
Total	**343.995**		**172.2769**	**100.00%**

Waste Material Composition of <u>commercial</u> sector

Raw weight, moisture content and Dry weight of collected sample Institutional waste in Bahir Dar city

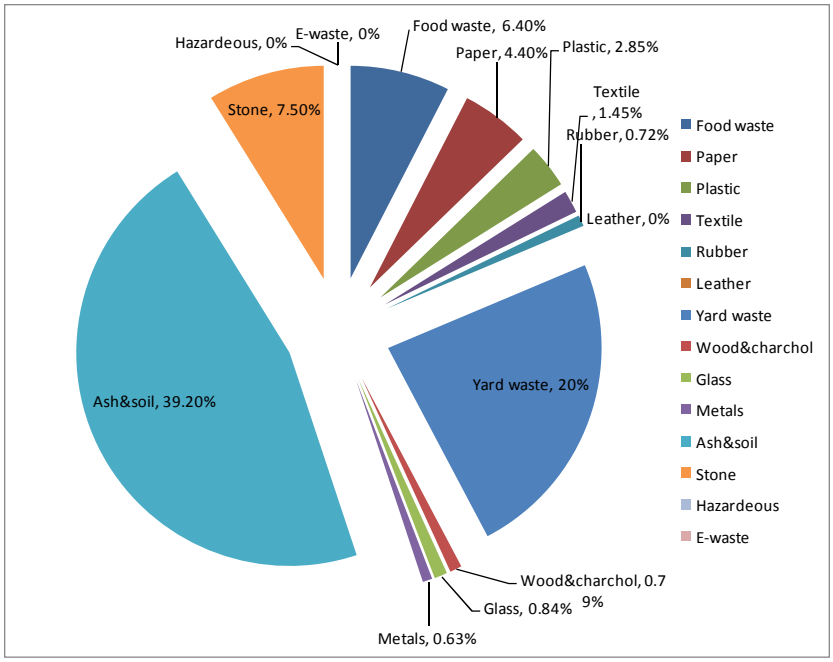
Component	*Raw weight (Kg)*	*Moisture content (%)*	*Dry weight (Kg)*	*Percentage*
Food waste	672.9	54.95%	303.14	63.52%
Paper	161.66	5.55%	152.67	15.30%
Plastic	31.885	8.5%	30.115	3%
Textile	7.92	22.22%	6.16	0.75%
Rubber	4.28	< 1 %	4.26	0.40%
Leather	0	-	0	0%
Yard waste	65.74	16.9%	54.63	6.20%
Wood& charcoal	11.18	25.46 %	8.4	1.10%
Glass	3.4	<1 %	3.36	0.32%
Metals	12.685	< 1 %	12.8	1.20%
Ash & soil	73	35.2 %	47.3	6.90%
Stone	5.86	< 1 %	5.8	0.55%
Hazardous	7.58	< 1 %	7.52	0.71%
E-waste	1.2	< 1 %	1.17	0.11%
Others	0.08	5 %	0.076	0
Total	**1059.37**		**637.401**	**100%**

Waste Material Composition of institutional sector

Raw weight, moisture content and dry weight of collected sample <u>street sweeping</u> waste in Bahir Dar city

Component	Raw weight	Moisture content	Dry weight	Percentage (raw)
Food waste	4.08	52.7%	1.93	6.40%
Paper	2.8	9.615%	2.53	4.40%
Plastic	1.81	9.05%	1.646	2.85%
Textile	0.92	3%	0.89	1.45%
Rubber	0.46	< 1%	0.43	0.72%
Leather	0	0	0	0%
Yard waste	13	13.4%	11.26	20%
Wood & charcoal	0.5	25.46%	0.37	0.786%
Glass	0.53	<1%	0.51	0.84%
Metals	0.4	<1%	0.38	0.63%
Ash & soil	24.92	7.18%	23.13	39.20%
Stone	4.79	< 1%	4.76	7.50%
Hazardous	0	0	0	0%
E-waste	0	0	0	0%
Total	**63.63**		**47.836**	**100%**

Waste Material Composition of <u>street sweeping sector</u>



Total composition of MSW in Bahir Dar city

Component	Residential (kg) from 34 samples	Commercial (kg) from 31 samples	Institutions (kg) from 16 samples	Street sweeping (kg) from 5 samples	Total (kg)	Percentage
Food waste	80.35	160.9	672.9	4.08	918.23	43.45%
Paper	18.226	15.85	161.66	2.8	198.536	9.4%
Plastic	23.76	11.82	31.885	1.81	69.275	3.28%
Textile	12.67	5.43	7.92	0.92	26.94	1.27%
Rubber	5.455	4.755	4.28	0.46	14.95	0.7%
Leather	2.971	0.55	0	0	3.521	0.2%
Yard waste	107.105	29.385	65.74	13	215.23	11.9%
Wood & Charcoal	19.045	5.625	11.18	0.5	36.35	1.7%
Glass	10.55	8.665	3.4	0.53	23.145	1.1%
Metals	7.78	5.505	12.685	0.4	26.37	1.25%
Ash & soil	310.1	43.29	73	24.92	451.31	24.36%
Stone	45.565	9.065	5.86	4.79	65.28	3%
Animal remain	0	37.85	0	0	37.85	1.8%
Hazardous	1.913	1.78	7.58	0	11.273	0.5%
E-waste	0.725	0.01	1.2	0	1.935	0.09%
Others	0	3.53	0.08	0	3.61	0.17%

Total	**646.215**	**343.995**	**1059.37**	**63.63**	**2113.21**	**100%**

4.2 Quantification of MSW

4.2.1 Quantification of Residential Waste

For residential waste we took samples of 7 days waste from 8 households, mix it to get average composition and reduce it 3 times using the UNEP guide lines. Hence the sample becomes a 7 day's waste of a HH in average.

Total weight found from all the samples (34samples) = 646.215 kg

In Bahir Dar most of the houses are multifamily (56% of Bahir Dar residents live in a rented room together with the owner of the house) in average 2.5 families live in a house (compound).

The average family size of Bahir Dar is 4.4.

Hence waste generation per capita per day of residential waste is:

646.215kg/(34hh)=646.215/(34samples*2.5 average families in a house hold*4.4 average family size *7 days)= **0.24685 kg/cap/day**

The total amount of waste generated daily is: 0.24685*218975(population of 2010) =**54050.775~54 tons/day**.

4.2.2 Quantification of Commercial waste

4.2.2.1 Hotels

The total weight of the samples from hotels (10 hotels are taken as a sample) is 171.835kg.

To get the total tonnage of hotels waste

171.835*(835/10) =**14,348 kg/day ~14 tons/day**.

4.2.2.2 Other commercial sectors

344-172=172kg

Total tonnage =172*(8614/5*1/21) =14,110.55kg/day**~14.1 ton/day**.

Total commercial weight =28 tons/Day.

4.2.3 Quantification of institutional waste

There are 253 institutions in Bihar Dar. 16 institutional samples out of the total were considered in this study.

Total weight of institutional samples =1059kg.

Total tonnage of institutional waste =1059*253/16=16745kg=16.745one/day~**17tons/day**

4.2.4 Quantification of street sweeping waste

There are a total of 35 km Asphalt roads in Bahir Dar where most of street waste is generated. We took 5 samples from 5 different 1km streets. Then 1/8 of the total weight is taken for characterization.

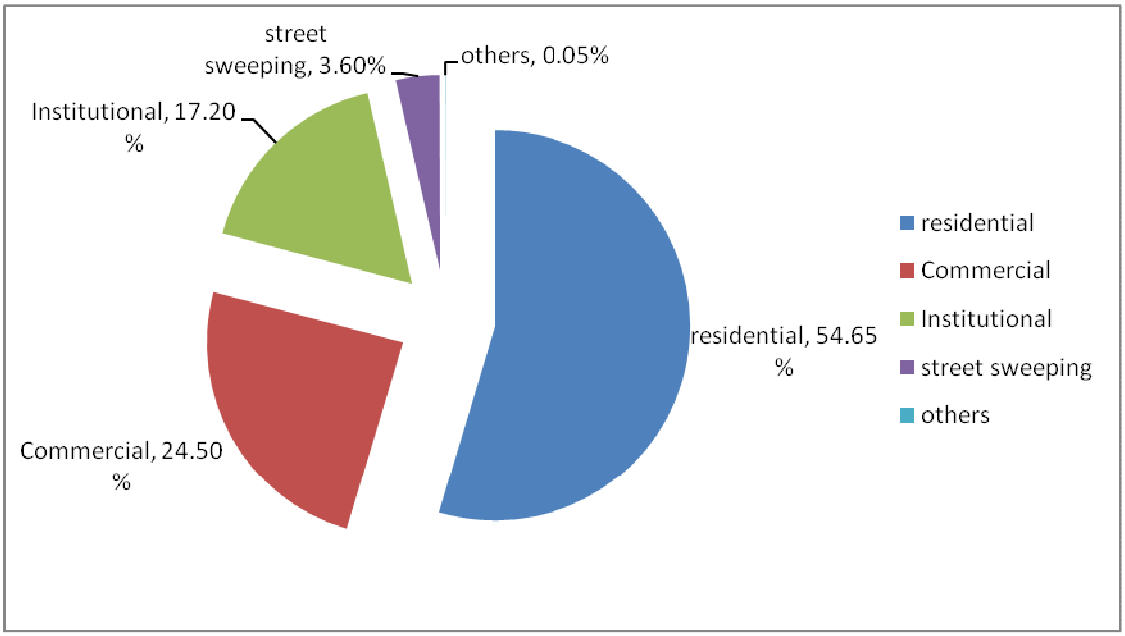
Total weight of samples (5 samples from 5km) =63.63*8=509.04

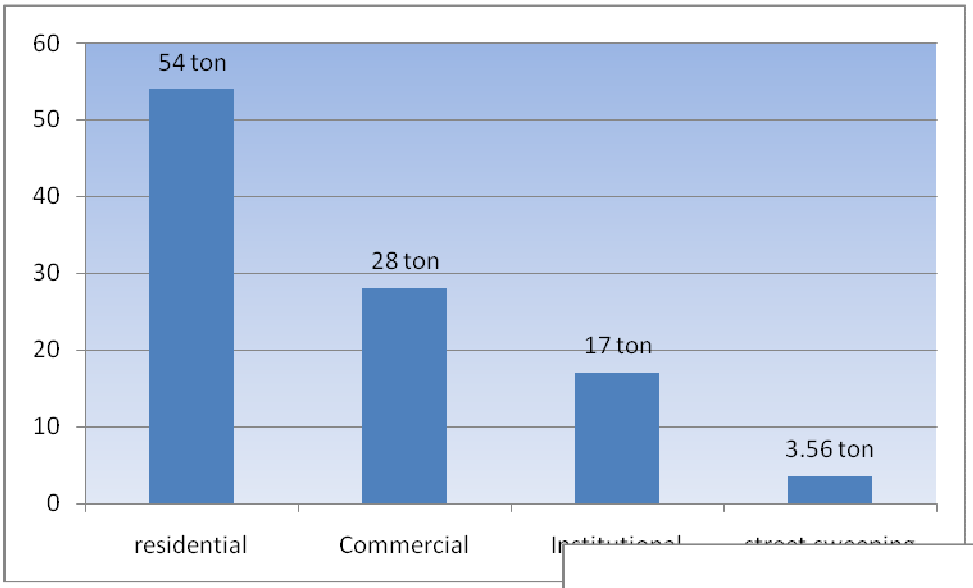
Total tonnage of street sweeping =509.04*35/5=3,563.3~**3.56 tons/day**

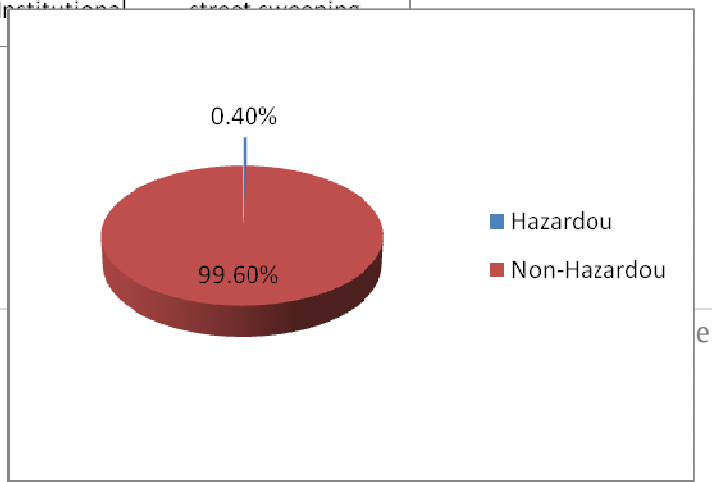
4.3 MSW composition

Sector	**daily total tonnage(tone)**
Residential	54
Commercial	24.2
Institutional	17
street sweeping	3.56
Total	**98.8**

Table13: MS waste composition in Bahir Dar in tones







4.4 MSW Hazardous and non hazardous

►residential hazardous:

0.29%*54tone/day=156.6kg/day

►Commercial hazardous

0.52%*24tone/day=124.8kg/day

►Institutional hazardous waste

0.71%*17tone/day=120.7kg/day

►street sweeping hazardous waste

0.00%*4tone/day=0

Total =402.1kg/day.

402.1/99,000=0.4%

The remaining 99.6% of MSW is Non-hazardous

4.5 Organic and Inorganic MSW

From the materials found Yard waste, Food and soil wastes are organic

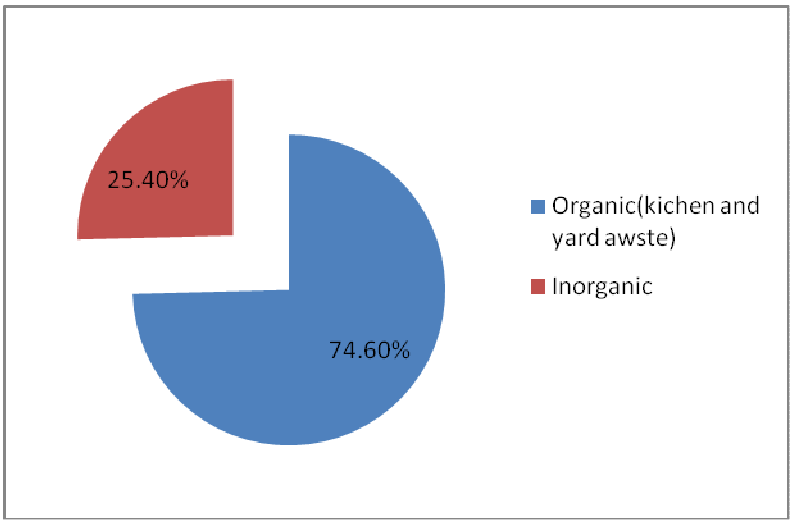
Residential organic=16.2tons/day

Commercial organic =13.32tons/day

Institutional organic =11.8tons/day

Street sweeping organic =1.1tons/day

Total =42.42tone/day



Ash & soil:

Residential=25.4 tons/day

Commercial =3.1tons/day

Institutional =1.2tons/day

Street sweeping=1.6tons/day

Total =31.3tone/day

Total organic =31.3+42.42=73.7tons/day=74.6 %(kitchen and yard waste).

4.6 The per capita of waste and Waste generation projections for future

The per capita of waste is 0.25kg/day for residential and 0.45kg/day for all residential, commercial, institutional and street sweeping (MSW).

*Per capita waste is: 98800/218975=0.45kg/day/capita

4.7 MS Waste Projection

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 (tons)	98.5	105	112	119.4	129.5	135.6	144.6	154	164.4	175.2	186.7	199	212.2

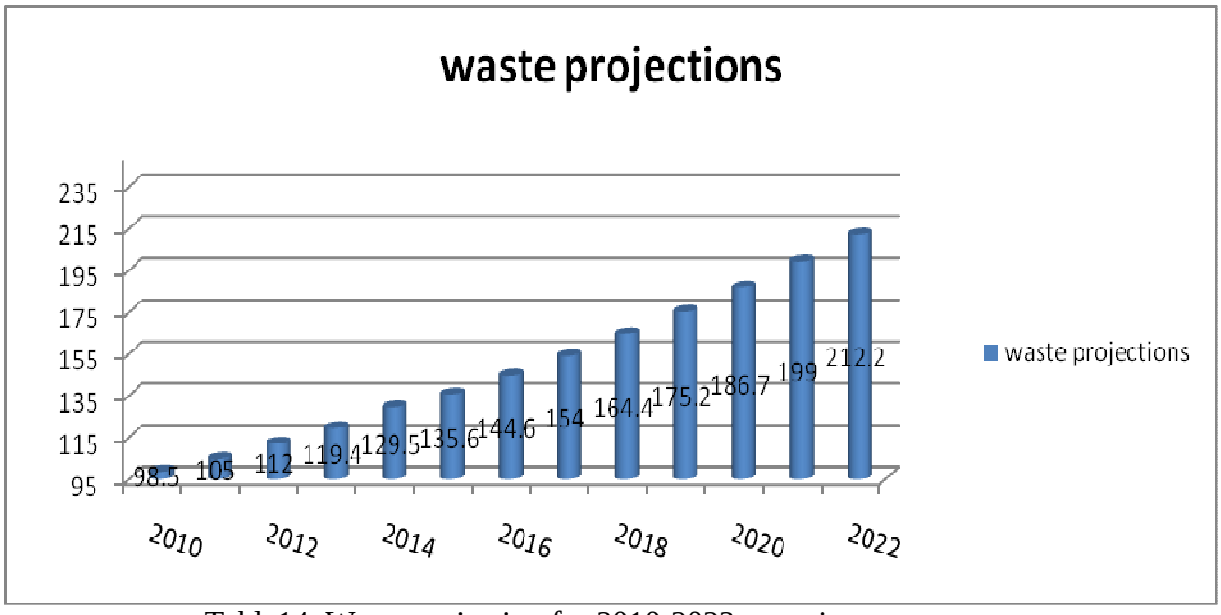


Table14. Waste projection for 2010-2022 years in tons

*N.B the waste generation rate is almost doubling similar to the population growth;
In 2021(when the population doubles) the waste generation will also double

5. Composition & Quantification of C&D waste in Bahir Dar city

Construction and demolition waste can be substantial in amount and may create a bigger challenge for the generator as well as the authorities for its collection and disposal in the future. But the current situation of C&D waste in the city indicates almost all the C&D waste generated is reused/recycled.

There are two levels of survey for C&D waste data collection, which may help to quantify and characterize the waste. First one would be the samples (vehicles) entering at waste disposal facility(landfill) and the other one is getting the information at the C&D sites. The second one is more crucial because a major proportion of C&D waste could be reused and recycled and may not be transported to disposal site.

In our city case the second one is happening there is no C&D waste transported to the disposal site. Most of the waste is reused there around the site. So we choose the second method for the data collection.

Types of materials, quantification and composition

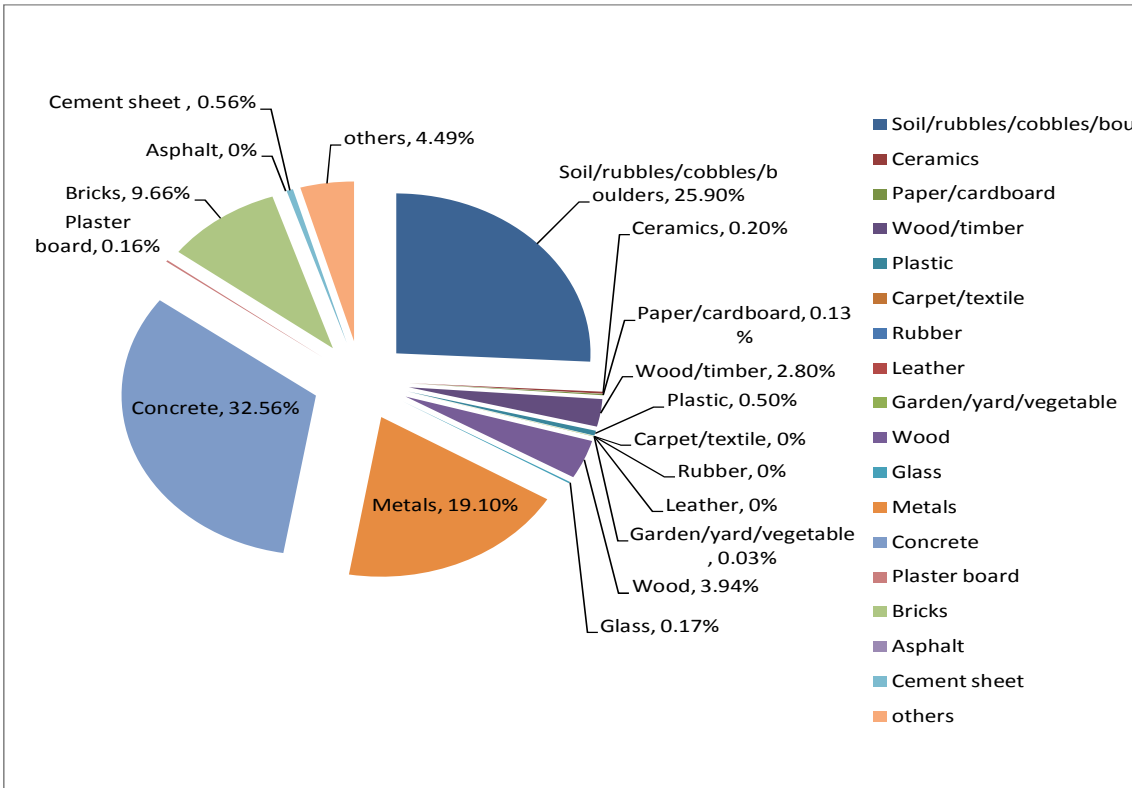
Construction and demolition (C&D) waste is not a monolithic waste stream, but it is a family of waste streams. Therefore, it is important to define the types of materials, which could be available in C&D waste. The most common materials could be paper/cardboard, garden/vegetation, wood/timber, carpets, other textiles, rubber, glass, plastics, metals, hazardous wastes, ceramics, soil/rubble <150mm, cobbles/boulders, clean soil, concrete, plasterboard, bricks, asphalt/bitumen, cement sheet, insulation and others.

Based on the local information and pilot surveys, a list of materials are prepared as we took 9 samples from 9 kebeles and there are 90 construction sites in the city. After we took the samples and the number of days the construction needed to be finished we get the annual value of the waste generated in the site. The average data for 9 samples is as follows.

No	**C&D waste**	**Average waste /year (tons)**
1	Soil/rubbles/cobbles/boulders	13.46667
2	Ceramics	0.10995
3	Paper/cardboard	0.07

4	Wood/timber	1.465
5	Plastic	0.266
6	Carpet/textile	0
7	Rubber	0
8	Leather	0
9	Garden/yard/vegetable	0.013
10	Wood	2.05
11	Glass	0.089993
12	Metals	9.926667
13	Concrete	16.933
14	Plaster board	0.0833
15	Bricks	5.025
16	Asphalt	0.2
17	Cement sheet	0.29
18	Others	2.333
	Total	**52.12158**

Table 16: C&D waste quantity and composition in Bahir Dar city



Quantification:

90*52.12=**4691**tons/year C&D waste is generated annually and almost of the wastes is reused in the site and some are brought to sales such as cement sheet.