

**COMPOSTING OF KHAT AND RELATED MATERIALS AS SOLID  
WASTE MANAGEMENT OPTION IN AWADAY TOWN**

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## ABSTRACT

The huge hip of solid waste has reduced the beauty of the town and became a breeding place of some rodents and vectors. Moreover; the waste encourages some people to dispose more and therefore exacerbates the poor sanitation of the town. The total daily average quantity of solid waste is determined to be approximately 13 tones according to the data obtained for April, 2008 from disposers (i.e. Khat shops or markets) and municipal waste collection department. The waste consists of leaves different plants such as khat, eucalyptus tree, small shrubs and grasses. And since the waste is dumped in an open air it is exposed to the chemical reaction facilitating conditions or factors such as temprature, air and moisture.

The process of composting was started by preparing four sites each with  $1\text{m}^3$  dimensions at Haramaya town. A track of Khat and related materials waste, which weighs 4 tones, was taken as sample from market center of Awaday. The compostible materials are separate from the waste stream and then shredded to an optimal size. The composing matter is segregate between two groups each with two piles and expose to two different sets of conditions. The piles in the first group are enclosing so as to prevent entry of rodents and exposure to sunlight. The other piles in the second group are left with no enclosure. However, the latter used to be covered with plastic sheets during rainy hours. Moreover, additional conditions and/or factors such as Aeration, moisture, particle size had been maintained and in a pile from each group, manure as facilitator has been used. Besides, temprature measurements have been taken daily till the end.

The temprature of the piles was found to pick up to a maximum of  $64^\circ\text{c}$ . Then the temprature starts to decline to a daily average of  $25^\circ\text{c}$  as the compost in the center of pile is cool or reaches it's maturity. The analytical results of the Nutrients contents of eight samples of composts taken give values 0.9-1.40 % for nitrogen, 532.00-803.00 ppm for available phosphorus and 6775.72-12445.24 ppm for available potassium. Above all the volume of waste piles have reduced from  $1\text{m}^3$  to  $0.40\text{m}^3$  (i.e.60%).

The result of the study indicates that composting has effectively reduced the volume of the waste and can serve as means of removal. Besides, the widely varying nutrients content is significant enough to use the resulting compost as alternative fertilizer.

There are mechanisms

other than these such as compaction that changes wastes in to hard solids and that in turn can be used as a fuel in the factory in place of furnace oil. The composting I adopted is simply changing of solid waste. It is not the same as organic compost formed at a factory level and traditional compost that examine feed stock the C:N ratio and decides the best feed stock use different layer of feed stock and ratio of them. In compost, nutrient content may be expressed on a dry or wet weight (as received) basis.

Composting basically involves establishing ideal temperature conditions for the compost Microorganisms and providing them with the right combination of:

- Energy sources (carbon feed stocks)
- Nutrients (nitrogen)
- Oxygen
- Water

Carbon and nitrogen needs can be met using many different materials = many compost recipes. The various composting methods differ in the way that oxygen is supplied/temperature is controlled.

•As the compost microbes consume O<sub>2</sub> and C feed stocks, they produce waste products, including:

- carbon dioxide (CO<sub>2</sub>)
- heat → water vapor

Inactivates pathogens and weed seeds

•They also:

- convert easily digestible feed stocks to less digestible (more stable) forms
- reduce material volume and mass (40%-80%)

Carbon to nitrogen ratio (C:N) of feed stocks:

Biological organisms need

- C for generating energy and creating structural components and building blocks of cells
- N for production of proteins, DNA, etc.-approximately 25 times more C than N (on the basis of weight)

•Therefore, ideally raw feed stocks are blended to provide an initial C:N ratio of around 25:1 to 35:1

- A single feedstock rarely has the correct C:N ratio getting the right C:N ratio is key to good composting (40-80%).

If initial C:N ratios are:

- significantly lower than 25:1

- N is lost as NH<sub>3</sub> = odors and lost nutrient value

- maintaining aerobic conditions is difficult = odors

- significantly higher than 35:1

- readily digestible C will decompose slowly, if at all

- lower temperatures will occur = decreased inactivation of pathogens and weed seeds

Oxygen availability–Key considerations:

- Compost microbes consume O<sub>2</sub> as they breakdown carbon forms

- If O<sub>2</sub> is deficient decomposition occurs anaerobically:

- slows composting process

- causes offensive odors

- can cause safety concerns (hydrogen sulfide) and formation of compounds that are toxic to plants

- Ambient air contains 21% O<sub>2</sub>

- to maintain aerobic conditions in a compost pile:

- should have at least 5% O<sub>2</sub> in pore spaces

- many compost microbes can function w/2% O<sub>2</sub>

Factors affecting passive O<sub>2</sub> delivery:

Feedstock particle size:

- smaller particles pack more tightly = smaller pores and less air flow

- particle size decreases during composting process

- addition of bulking agents (e.g., wood chips) helps keep pore spaces open

Volume of feedstock:

- the larger the size of the pile, the more difficult it is for air to penetrate entire pile

- limit pile size to 1.8m high and 3.6m wide

Factors affecting passive O<sub>2</sub> delivery:

Moisture content:

- At moisture levels  $\geq 65\%$ , pores are mostly filled with water, which greatly limits air flow.
- anaerobic and sour or explosive conditions can develop
- Compost microbes need  $\geq 15\%$  moisture to live
- Ideal range: 40–60% moisture
- Bagged compost: should have  $\leq 40\%$  moisture

Temperature–Key Considerations:

Temperature Ranges:

- Different microorganisms thrive and are predominant at different temperature ranges:
- 10-40°C: -"Mesophilic" range
- Occurs at beginning and end of process
- Disease suppressant properties acquired at these temperatures  $>40^\circ\text{C}$ : -"Thermophilic" range
- Needed to destroy pathogens, weed seeds, and fly larvae
- Also kills mesophilic organisms

Temperature Control:

Critical thermophilic temperatures for destroying:

Human Pathogens  $55^\circ\text{C}$

Weed Seeds  $63^\circ\text{C}$

Tomato Seeds  $66^\circ\text{C}$

Thermophilic temperatures are ideally maintained for several weeks and achieved by having adequate:

- Pile sizes (insulation)
- O<sub>2</sub>
- Digestible feed stocks
- Moisture

Excessive temperatures are prevented by:

- monitoring temperature, plus
- mechanical turning or forced aeration.

To sustain a composting operation, needs of biological organisms must be met. The needs of composting organisms are the same as those of all living things:

- Food (energy)
- Oxygen (something to respire)
- Water
- Nutrients
- A hospitable environment
- Temperature
- Neutral chemical (pH) conditions

## **1. Back ground**

Khat is a flowering evergreen plant. It is genus of *catha edulis* belong to Celastrus family. Leaves of khat are simple, elliptic and green above but lighter below and leathery. It is natural stimulant which it's twigs and leafs are chewed. Fresh khat leaves have strong smells which are awakening consumer of khat. In Hararege, they have different types of khat which have peculiar names such as "Dalota, Qarxi, Dima and Hafa". When it is fresh the leaf is straight up but at stay longer becomes wilted. The most favored part of the leaves is the young shoot near the top of the plant. However, leaves and stems at the middle and lower sections are also used. The plant usually grows from 1 to 2 meter high in east Hararege Ethiopia; occasionally, it can reach 7 meters in southern Ethiopia. Khat plants are grown among crops such as sorghum, maize, and legumes and sweat potato in Hararege. Khat consists of compounds similar to ephedrine it seems best included in a group amphetamines (Lewin, 1931).It consists of a significant number of chemicals, of these are two controlled substances, cathinone and cathine. As the leaves aged or dry, cathinone is changed to cathine which significantly decrease its stimulatory properties. Cathinone is estimated to be 10 more times strong than cathine and only exists in fresh leaves. However, the secondary active ingredient cathine does not lose much of its potency with age as cathinone. One or two days old Khat leaves are called "bulte" it's preference is less as it losses a maximum potency of cathinone. However, Khat can be preserved by freezing, the same way that vegetables and meats are kept fresh in refrigerator. In addition, Khat is very rich in ascorbic acid which is an excellent antidote to amphetamine-type compounds (Upenn African studies, 1985).

### **1.1 Traditional uses of khat**

Khat has been used since olden times as a recreational and religious drug by natives of eastern Africa, the Arabian Peninsula, and throughout the Middle East. In the east-central part of Ethiopia, chewing khat returns back almost eight hundred years to the beginning of the Christian –Muslim struggle in medieval Ethiopia .In a contemporary account of Emperor Amde Syon's (1314-1344) military campaign undertaken against sebra'din of Ifat around 1330, the latter is quoted as saying, "I will take up my residence at mar'ade, the capital of Amde Syon's kingdom, and I will plant khat there because the Muslim love the plant.'(Leaf of Allah, 2000)The story suggests that the use of khat

was a familiar practice among Muslim communities in east-central Ethiopia around the mid-fourteenth century. Ever since, khat has been a fundamental part of the social and cultural experience of the people of Hararege (Leaf of Allah, 2000). Khat originated from Ethiopia, specifically in Hararege with a gradual expansion to different parts of Ethiopia, Yemen and other parts of the world (Huffnagel, 1961).

## **1.2 Economic uses**

In Ethiopia khat is an important and potentially profitable cash crop. The employment opportunity created through the cultivation of khat is very high in that large numbers of people are involved in growing, harvesting, sorting, packing, transporting, loading and unloading the commodity (Iemessa Dechasa, 2001).

Khat is harvested 2-3 times a year. So farmers prefer harvesting khat than any other crop. It brings a huge amount of money. Approximately, farmers who can have irrigation water for khat get more than 20,000 birr per annum. However, in this year 2000E.C starting from January to April khat becomes very expensive one bundle of khat sold for 200-1500 Birr which has never happened like this before and is believed to raise the annual income of the people involved in khat commerce. Farmers living in eastern Hararege, Oromia region almost purchase all food crops from the market. They do not want to cultivate other crops. Not only in this part but also all over the country, expansion and cultivation of khat is increasing annually.

The federal democratic republic government of Ethiopia and the different regional governments obtain a significant amount of income from khat in a form of taxation. In 1999/2000 birr 0.464 billion worth of khat was exported to different countries and ranked second replacing hides and skins in export revenue (Iemessa Dechasa, 2001). The above figures do not, however, include the huge volume of khat smuggled to different countries. Still khat is one of the top ten items exported to different countries and is playing a big role in the economy of the country.

The wood of the plant is commonly used for fuel and due to its resistance to termite is used in the construction of houses and fencing. It is also used for making rafters, handles of farm tools (hammers and chisels) and handles of household articles such as pots and pans, rolling pins, and to

make forks, combs, spoons and for rulers. (Lemessa Dechasa, 2001)

### **1.3 Packaging and availability**

Khat is usually packaged with different leafs and grasses as farmers bring it from rural area. But it is packaged in plastic bags or wrapped in banana leaves to retain its moistness and freshness after it reaches merchants. In the market, merchants use different methods of packaging depending on the distance they send. For example from Awaday to Somalia wrapped by different leafs, to Addis Ababa by grasses, to export to London, Djibouti and other country after putting into grasses or leafs are wrapped by white cloth. It is often sprinkled with water during transport to keep the leaves moist. Khat also may be sold as dried or crushed leaves or in powdered form. Because khat in leaf form starts to lose its effectiveness after 48 hours, it is generally aired from Dire Dawa to abroad. This khat exports are dependent up on the demands of the importing countries some are seven, three, and two days a weak. Khat is becoming an increasingly growing export commodity to USA, Europe, Australia and Canada especially in cities where immigrants of Ethiopia, Somalia and Yemen and Middle East are populated (intelligent bulletin USA, May 2003). In some countries, which account khat as illegal commodity such as USA and Canada, it is exported in the form of dry leaf with in cardboard via Ethiopian mailing services (EMS). It is commonly sold in restaurants, bars, grocery stores, and smoke shops that supply to east Africans and Yemenis, after its importation from Ethiopia, Kenya, Egypt, and Arabia (intelligent bulletin USA, May 2003).

### **1.4 Effects of khat and mode of ingestion**

Chewing khat is overspread worldwide. Millions of people are estimated to be frequent users of khat for its euphoric effects and other desired effects. Fresh khat leaves, which are typically chewed like tobacco, produce a stimulant to the central nervous system. In Hararege, farmers, merchants, students and teachers are participating in chewing khat. The explanations of users about the effect of khat are described as increased levels of alertness, ability to concentrate, confidence, friendliness, contentment and flow of ideas (Kennedy, 1987). Also experienced are an enhanced imaginative ability and capacity to associate ideas, an improvement in the ability to communicate and a subjective improvement in work performance (Kennedy, 1987). In a khat chewing session, initially

there is an atmosphere of cheerfulness, optimism and a general sense of wellbeing. After about 2 hours, tension, emotional instability and irritability begin to appear, later leading to feelings of low mood and sluggishness. Some chewers also experience unpleasant effects during the chewing process describe anxiety, tension, restlessness and hallucinations (Mekonnen G, 2006). A user of khat when unable to get it either because of money or delay of the usual chewing time becomes furies and rigid; this condition is called “Harara”. The khat have its own ceremony, it is called “barcha”. In every social and cultural accustoms such as marriage and death khat is chewed and have a great social value. A user can chew a khat in two different forms; either he can try to fill his mouth with out swallowing it or some beginners of khat eat as food. The first way of chewing khat is called “Takzina” and he may swallow it by water after filling mouth, and this is called “lulu”. At that time, he fills great satisfaction and excitation. The user then chews from time to time to release the active components. The amount of khat that users are actually taking is not known but it depends on financial income and the doses are assumed to increase only very slowly. As usual, a user can take a bunch of khat with in a day depending on khat price and his income.

As the khat is chewed shoot and tip of it, most of the part is thrown as a solid waste. This part is seen in most part of Ethiopian City such as Awaday, Dire Dawa, Harar, Jijiga, etc. it becomes hip in every where. More over some khat users have no disciplined they throw khat left in every street and corner. For example, in university at the dormitory every corridor is full of khat left; this is a headache for Janitors. More over, in Addis Ababa and some cities there are shops of khat where every chewer can gather there and chewed khat with “shisha”. The shops are very small, over populated and over suffocation with cigarettes and shisha.

## **2. Solid waste**

Solid waste can be defined as material that no longer has any value to the person who is responsible for it, and is intended to be discharged through a pipe. It does not normally include human excreta. It is generated by domestic, commercial, industrial, healthcare, agricultural and mineral extraction activities and accumulates in streets and public places. The words “garbage”, “trash”, “refuses”, and “rubbish” is used to refer to some forms of solid waste. Solid waste is the waste that is different from waste water and atmospheric emission (gas), which may be semi-solid, solid, or even liquid, (Elleni, 2001). Waste is every one’s business; we all produce waste in nearly everything we do.

Every year, in the world solid waste is generated in large tones of "trash". This is mostly produced by developed country. For instance, a person living in an industrialized nation annually may produce as much as 500 Kg of municipal solid waste (Encarta, 2007). This includes a variety of items such as mix of potentially reusable or recyclable items and no recyclable materials. From this, a few of it is recycled; some is incinerated or buried in landfills others are disposed simple on the land near the city and town in the developing country. With a little forethought, we can able to reuse or recycle more than 70 percent of the land filled waste, which includes valuable materials such as glass, metal, and paper. This would reduce the demand on virgin sources of these materials and eliminate potentially severe environmental, economic, and public health problems (Annenberg Media, 2007).

### **2.1 Environmental management of solid waste**

Management of solid waste has traditionally been limited to the local or municipal governments .The basis is that such services enjoys the characteristics of public good and influencing public welfare and thus should not be left to individuals decisions on whether or not to deal with it. In Ethiopia the activity of solid waste management has traditional approach of collection and disposal. However, the polluter pay method has to some extent been started in Addis Ababa. This was demonstrated through door-to door private waste collectors (youth). This is a good indication that there is possibility of consolidating and expanding of the waste management activities on an organized basis. But, the way, the waste is collected is not hygienic. However, in Awaday the public has never been concerned about this. They say it is a matter of municipality and criticize authority. Moreover the public does not properly collect their solid waste and put on the collection track. Waste management is viewed to be non exclusive in nature. Likewise, once it provided to some portion of community, it

benefits the over all public welfare, not only the residents that specifically receive the service (Aly Ahmed, 2006).The service is non competitor and any residents can enjoy the benefits of the service with out diminishing of the benefit of another, thus waste management services has the free ride problem. It is not feasible to exclude from services those who don't pay.

## **2.2 Importance of solid waste management**

Solid waste management includes all activities that seek to minimize the health, environmental and aesthetic impacts of solid wastes. Solid waste management is a process of managing the activities of waste generation, storage, collection, transfer and transportation to, the final disposal site and care taken to consequences of disposal.

Solid waste management is the collection, transport, processing, or disposal of waste materials, usually once produced by human activities, in an effort to reduce their effect on human health or local amenity. Waste management is sometimes carried out by a department of the municipality, but it is known in this time in our country such as Addis Ababa, Hawassa, and Makale etc that this function is carried out by private youth organizations/micro-enterprises. However; in developed countries the management of commercial and industrial wastes is usually the responsibility of the generator (Wikipedia encyclopedia, 2008).The focus of solid waste management in recent decade has been to reduce waste materials effect on the environment and, to recover resources from them. Modern waste management stresses on three "R's": reduction, reuse, and recycling before storage and discard (Aly Ahmed, 2006).

## **2.3 Solid waste collection**

In industrialized countries, municipal solid waste is often collected from homes by curbside collection using purpose-built waste collection vehicles; however, many communities require residents, especially in rural areas, to convey their household wastes to collection sites known as transfer stations (Aly Ahmed, 2006). In Awaday some polishers of khat homes fetch wastes of khat and related material to the collecting track of the municipality. Other polishers used to take the waste to their homes for fueling purposes or dispose it in front of the Khat shops. In the early morning workers of municipality clean the street and collect the waste on the pushcart and dispose near the river which is found at the entrance of Awaday town on the way from Haramaya.

## **2.4 Risks and problems associated with solid waste**

If solid wastes have not managed properly, many negative impacts may result. Some of the most important are;

- ❖ Disposal of the solid waste on the left and right side of the road ditches usually blocks up the municipal drainage lines and causes flooding. This commonly happens in Awaday town during rainy seasons.
- ❖ Mostly in the rainy seasons the town's Khat waste together with other solid wastes serve as the breeding ground for vectors (mosquito and flies) that spread diseases.
- ❖ The solid waste of the town has been burning in open air and potentially causing air pollution.
- ❖ The uncollected khat and other solid wastes degrade the aesthetic of the urban environment, In Awaday; the now cleaned streets will soon be covered again with the waste before the cleaners finish their duties. Thus, discouraging efforts to keep the town clean and attractive.
- ❖ Waste collection workers face particular occupational hazards, including strains from lifting, injuries from sharp objects.
- ❖ Waste items that are being reused, some collectors, without effectively cleaned or sterilized can transmit infections to later users.
- ❖ Polluted water flowing from dumps and disposal sites can cause serious pollution of water supplies. The river at the entrance of Awaday is polluted by leachate from the solid waste burned above it.

## **2.5 Solid waste management planning**

Planning refers to the physical, financial, and human resource planning; the solid waste management planning includes collection, storage, disposal, and waste minimization measures (Aly Ahmed, 2006). However; Awaday municipality has no annual and/or long term plan to manage solid waste, and only have daily collection and disposal scheme.

## **2.6 Reduction**

Waste prevention, or "source reduction," means consuming and throwing away less. It includes:

- Purchasing durable, long-lasting goods;
- Seeking products and packaging that are as free of toxics as possible;

- Redesigning products to use fewer raw materials in production, have a longer life, or are used again after its original use (U.S Environmental protection agency, 2007).

Source reduction actually prevents the generation of waste in the first place, so it is the most preferred method of waste management and goes a long way toward protecting the environment (F.A. Rovers, 1995). For instance, it can save many eucalyptus trees from drying by farmers because of the use of leaf of tree as packaging materials for khat at early growth of tree. This means conservation of natural resource. As we know the effort of environmentalist is to conserve natural resources and energy by managing materials more efficiently.

Reduction of waste stream: includes reducing of wastes from source, it is evident that having less waste to discard is obviously better than, struggling with disposal methods. A simple and obvious choice is to cut back on the amount of waste by using and throwing out less in the first place. However, this phenomenon is not accustomed (thought of) in Awaday; rather the amount of solid waste is increasing because of lack of knowledge and increased consumption of khat.

Packaging is one of the major sources of waste paper and plastics. Packaging should be minimal. Its production should be environmentally clean and it should be made up of materials that can be reused or recycled repeatedly. Some packaging is purposely elaborate to make the contents more attractive. Smart buyers can support the use of environmentally friendly packaging by purchasing products with minimal packaging or with packaging made of recycled or recyclable materials (file:///E:/Garbage. Solutions. htm).

## **2.7 Recycling**

Recycling is re-processing of already thrown materials in to new products. Recycling converts materials that would otherwise become waste into valuable resources. In addition, it generates a mass of environmental, financial, and social benefits. Materials like glass, metal, plastics, and paper are collected, separated and sent to facilities that can process them into new products. Recycling is one of the best environmental success stories of the late 20th century. Recycling, including composting, and diverted million tons of material away from landfills and incinerators. By present, almost thousands of curbside collection programs served for developed country population. Curbside

programs, along with drop-off and buy-back centers, resulted in a diversion of large percent of the nation's solid waste in present (U.S. Environmental Protection Agency, 2007).

### **2.7.1 Benefits of recycling**

- Conserves resources for our children's future
- Prevents emissions of many greenhouse gases and water pollutants.
- Saves energy.
- Supplies valuable raw materials to industry.
- Creates jobs.
- Stimulates the development of greener technologies.

Recycling works and it does so in several ways. It reduces the monetary and environmental costs of land filling and incineration. It substitutes used materials for virgin materials, thereby reducing the demand for natural resources. It conserves energy and it creates jobs in the community. Many developed communities now actively recycle and include (Thomas E. Duston, 1993)

- Curbside recycling containers. The community provides containers in which individual families deposit such materials as newspapers; glass bottles and jars; tin and aluminum containers; plastic bottles and bags; mixed waste paper (cardboard, phone books, magazines, junk mail, office paper, brown bags); and used motor oil. The community arranges for curbside pickup and delivery to a recycling facility.
- Drop-off recycling zones. Groups of large recycling bins are installed on public property in one or more locations throughout the developed community.
- Recycling centers. The developed community provides the center itself and encourages residents to drop off or sell refuse materials there.
- Green waste diversion and composting programs. Leaves, grass clippings, and other organic waste materials are composted and used to enrich soil or as mulch or landfill cover.

Opponents of recycling argue that recycled goods are more expensive and that recycling takes away needed jobs. However, as more consumers choose to purchase recycled products and as recycling technology improves, the cost of these goods goes down, making them more competitive in the marketplace. And while diverting materials from landfills does take away disposal jobs, these jobs

are often replaced by jobs in the growing recycling industry (J.W Atwater, 1996). There's more to recycling than setting out your recyclables at the curb. In order to make recycling economically feasible, we must buy recycled products and packaging. When we buy recycled products, we create an economic incentive for recyclable materials to be collected, manufactured, and marketed as new products. Buying recycled has both economic and environmental benefits. Purchasing products made from or packaged in recycled materials saves resources for future generations

## **2.8 Reuse**

Containers and products which are broken repair or give it to someone who can repair it. Reusing items by repairing them, donating them to charity and community groups, or selling them; also reduces waste. Reusing products, when possible, is even better than recycling because the item does not need to be reprocessed before it can be used again (U.S Environmental protection agency, 2007).

### **2.8.1 Ways of re-using**

- ❖ Using durable coffee mugs
- ❖ Using cloth napkins or towels.
- ❖ Refilling bottles.
- ❖ Donating old magazines or surplus equipment.
- ❖ Reusing boxes.
- ❖ Turning empty jars into containers for leftover food.
- ❖ Purchasing refillable pens and pencils.
- ❖ Participating in a paint collection and reuse program.

Sustainability is the intelligent use of our resources natural and technological to meet our communities' needs both today and in the future. People worldwide are beginning to recognize that a healthy, functioning community relies on a healthy environment (Annenberg Media, 2007).

Pollution and overuse of resources can affect everything from the health of children to the availability of raw materials. Increasingly, we are realizing the importance of not only meeting environmental regulations but also taking extra steps to reduce waste, prevent pollution, and conserve resources. As more communities choose to pursue sustainability, successful environmental

programs will continue to emerge. These programs will become models on which to base global efforts to protect and restore the environment. Each individual has a role in building a sustainable future. At home, school, and work, we can make changes that will help preserve our resources for future generations. Many individuals and communities have already begun to find out how you can do your part (Annenberg Media, 1997-2007).

### **3. Compost**

Compost is the "aerobically derived remnants of organic materials" (Wikipedia Dictionary), meaning it's what you get when you combine the leftovers of plant and animal-based stuff, add a little air, water and nitrogen. The decomposition is performed primarily by aerobes (organisms with oxygen-based metabolism), although larger creatures such as ants, nematodes, and worms (this process is also known as vermiculture) can also contribute. This decomposition occurs naturally except for in extreme anaerobic conditions, like in landfills, very arid deserts or cold weather such as boreal winters or Polar Regions, which prevent the microbes and other decomposers from thriving. Decomposition happens even in the absence of some of these ingredients, but not as quickly or as pleasantly. Compost is used often at the consumer level in gardening and agriculture as a fertilizer-type soil additive, and can also replace commercial fertilizers (Hamoda MF, 1988).

Compost is organic material that can be used as a soil amendment or as a medium to grow plants. Mature compost is a stable material and contain humus that is dark brown or black and has a soil-like, earthy smell. It is created by combining organic wastes (e.g., yard trimmings, food wastes, manures) in proper ratios into piles, rows, or vessels; adding bulking agents (e.g., wood chips) as necessary to accelerate the breakdown of organic materials; and allowing the finished material to fully stabilize and mature through a curing process (Sesay et al, 1998). Natural composting, or biological decomposition, began with the first plants on earth and has been going on ever since. As vegetation falls to the ground, it slowly decays, providing minerals and nutrients needed for plants, animals, and microorganisms. Mature compost, however, includes the production of high temperatures to destroy pathogens and weed seeds that natural decomposition does not destroy (University of New South Wales, 2001)

#### **3.1 Benefits of compost**

- Suppress plant diseases and pests.
- Reduce or eliminate the need for chemical fertilizers.
- Promote higher yields of agricultural crops.
- Facilitate reforestation, wetlands restoration, and habitat revitalization efforts by amending contaminated, compacted, and marginal soils.

- Cost-effectively remediate soils contaminated by hazardous .
- Remove solids, oil, grease, and heavy metals from stormwater runoff.
- Capture and destroy 99.6 percent of industrial volatile organic chemicals (vocs) in contaminated air.
- Provide cost savings of at least 50 percent over conventional soil, water, and air pollution remediation technologies, where applicable.

Using compost improves soil structure, texture, and aeration and increases the soil's water-holding capacity. Compost loosens clay soils and helps sandy soils retain water. Adding compost improves soil fertility and stimulates healthy root development in plants. The organic matter provided in compost provides food for microorganisms, which keeps the soil in a healthy, balanced condition. Nitrogen, potassium, and phosphorus will be produced naturally by the feeding of microorganisms, so few, if any; other soil additives will be needed (V.Sussman, 1982).

### **3.2 How to make compost**

Composting is a technique used to accelerate the natural decay process. The technique converts organic wastes to mulch which is used to fertilize and condition soil. Leaf waste decomposes naturally in about two years. If you need compost in a hurry, speed up the process by turning the pile with a pitchfork once a week. Mixing the compost allows oxygen into the center of the pile, where it encourages the growth of bacteria and fungi. A pile that is turned regularly will become finished compost in two to four months. Fresh manure will activate the pile, causing it to decompose more quickly. Lime and fresh manure counteract each other, so it's best not to use both in your compost pile. Particle size has a lot to do with the speed of decomposition (V.Sussman, 1982).

#### **3.2.1 Compostible materials**

Most yard wastes can be composted, including leaves, grass clippings, plant stalks, vines, weeds, twigs and branches. Compostible food wastes include fruit and vegetable scraps, coffee grounds, eggshells and nutshells. Other compostible materials are hair clippings, feathers, straw, livestock manure, bone meal and blood meal (University of New South Wales, 2001).

Materials should not be composted if they promote disease, because odors, attract pests, or create other nuisances. These include meat, fish, poultry, dairy products, foods containing animal fats, human/pet feces, weeds with developed seed heads, and plants infected with or highly susceptible to disease, such as roses and peonies (University of New South Wales, 2001).

Materials that should be composted only in limited amounts include wood ashes (a source of lime), sawdust (requires extra nitrogen), plants treated with herbicides or pesticides (the chemicals need time for thorough decomposition), and black and white newsprint (composts slowly, so it should comprise no more than 10% by weight of the total pile) (NSW EPA, 2002).

### **3.2.2 Composting requirements**

- 1) Shredded organic wastes. Shredding, chopping or even bruising organic materials hastens decay. One way to shred leaves is to cut the lawn before raking, collecting the shredded leaves in a prepared place. It takes at least 1 cubic meter of shredded material to form a compost pile.
  
- 2) Good location. The compost pile should be located in a warm area and protected from overexposure to wind and too much direct sunlight. While heat and air facilitate composting, overexposure dries the materials. The location should not offend neighbors.
  
- 3) Nitrogen. Nitrogen accelerates composting. Good sources include fresh grass clippings, manure, blood meal and nitrogenous fertilizer. Lime should be used sparingly if at all. It enhances decomposition, but too much causes nitrogen loss, and it usually isn't necessary unless the pile contains large amounts of pine and spruce needles or fruit wastes.
  
- 4) Air. The compost pile and its enclosure should be well ventilated. Some decay will occur without oxygen, but the process is slow and causes odors.
  
- 5) Water. Materials in the compost pile should be kept as moist as a squeezed sponge. Too little or too much water retards decomposition. Over watering causes odors and loss of nutrients (NSW Agriculture, 1995).

### **3.3.1 Building an enclosure**

Enclosing the compost pile saves space and prevents litter. The enclosure should be collapsible or provide an entry large enough to permit the pile to be turned. It should measure at least 1m x 1m x 1m (a pile under 3 cubic meter generally does not decompose properly), but no taller than 1.8m (too much weight causes compaction and loss of oxygen). The enclosure can be built of wood, pallets, hay bales, cinder blocks, stakes and chicken wire, or snow fencing (V.Sussman, 1982).

### **3.3.2 Building the pile**

Aside from the basic requirements for decomposition and preventing odors and other nuisances, there is no set method for building a compost pile. One technique may be faster than another, but a variety of methods work well. Piles can be built in layers to ensure the proper proportion of carbon (e.g., leaves, woody materials) to nitrogen (grass, fertilizer), but the layers should be thoroughly intermixed after the pile is built (V.Sussman, 1982).

### **3.3.3 Process of composting**

Turning and mixing the pile with a pitchfork or shovel, or shifting it into another bin, provides the oxygen necessary for decomposition and compensates for excess moisture. A pile that is not mixed may take 34 times longer to decompose. Recommendations for mixing the pile vary from every 3 days to every 6 weeks. More frequent turning results in faster composting. Odors indicate that the pile is too damp or lacks oxygen, and that more frequent turning is necessary (NSW EPA, 2002).

Occasional watering may be necessary to keep the pile damp, especially in dry weather. Covering the pile with black plastic reduces the need for watering; it also prevents rainwater from leaching out the nutrients. A pile that is decomposing properly should generate temperatures of 50°C-70°C at its center. The heat kills most weed seeds, insect eggs and diseases. The pile should be turned when the center begins to cool. Turning the pile maintains the temperature and ensures that all material is exposed to the center heat. When the compost is finished, the pile will no longer heat up. Small amounts of fresh materials may be added but should be buried inside the pile to avoid pests and speed composting. It is better to add fresh materials to a new pile (Haug, R.T., 1993).

### **3.3.4 Finished compost**

Finished compost is dark brown, crumbly, and has an earthy odor. Depending upon seasonal temperatures, a well-built, well-tended pile generally yields finished compost in 8 weeks to 4 months. An unattended pile made with unshredded material may take longer than a year to decompose (Haug, R.T., 1993).

### **3.3.5 Alternate composting methods**

Compost can be made in a garbage can, barrel or drum that has a secure lid. Drill holes in the sides and bottom of the container to allow for air circulation and water drainage, and place it upright on blocks. Fill 3/4 of the container with organic wastes, add a little nitrogenous fertilizer, and moisten the materials. Every few days shake the container or turn it on its side and roll it to mix the compost. The lid should be removed after turning to allow air penetration. This method yields finished compost in about 24 weeks (Ithaca, NY14853, 2007).

Another method is to use a 120litter or 150litter containing plastic garbage bag. Fill the bag with organic materials, nitrogen and lime (one cup per bag helps counteract acidity caused by anaerobic composting). Shake well to mix materials. Add about 1 quart of water and close the bag tightly. Bags can be stored outdoors in the summer and in a heated basement or garage during the winter. No turning or additional water is necessary. The compost should be finished in about 6- 12 months, (V.Sussman, 1982).it is not advisable to use any container that once held toxic chemicals.

#### **4. Site description**

East Hararge zone is located in eastern part of the regional state of Oromia. In east Hararge zone, twelve (12) urban centers have their own municipal authorities. Awaday is one of urban centers, in this zonal administration, which is young and fast growing city in national regional state of Oromia. The establishment of Awaday” town was in 1946 E.C; according to informants, the name of the town was “Didimtu” Didimtu means (red & sandy top soil).The main and important factors that contribute to the town establishment were the geographical location of the town between Harare city and Haramaya town. Awaday town is the center of trade. Moreover, it has strategic location for khat trade and good climate condition that used to preserve khat production. According to the topography of the town, it is bounded by Harare national regional state to the south-east direction Harar city, to north-west Haramaya town, south-west Fadis warada and Gara Mulata warada and to the north-east Kombolcha warada (shown below in Fig.4.1). The location of this town is in the center of the above waradas, which have high potential of khat production; it has got a chance to develop domestic and international market in a town. It is located in the Eastern Hararge zone of Oromia region, at 419 kilometers from regional capital, Adama /Natheret, and about 510 kilometers away from Addis Ababa.

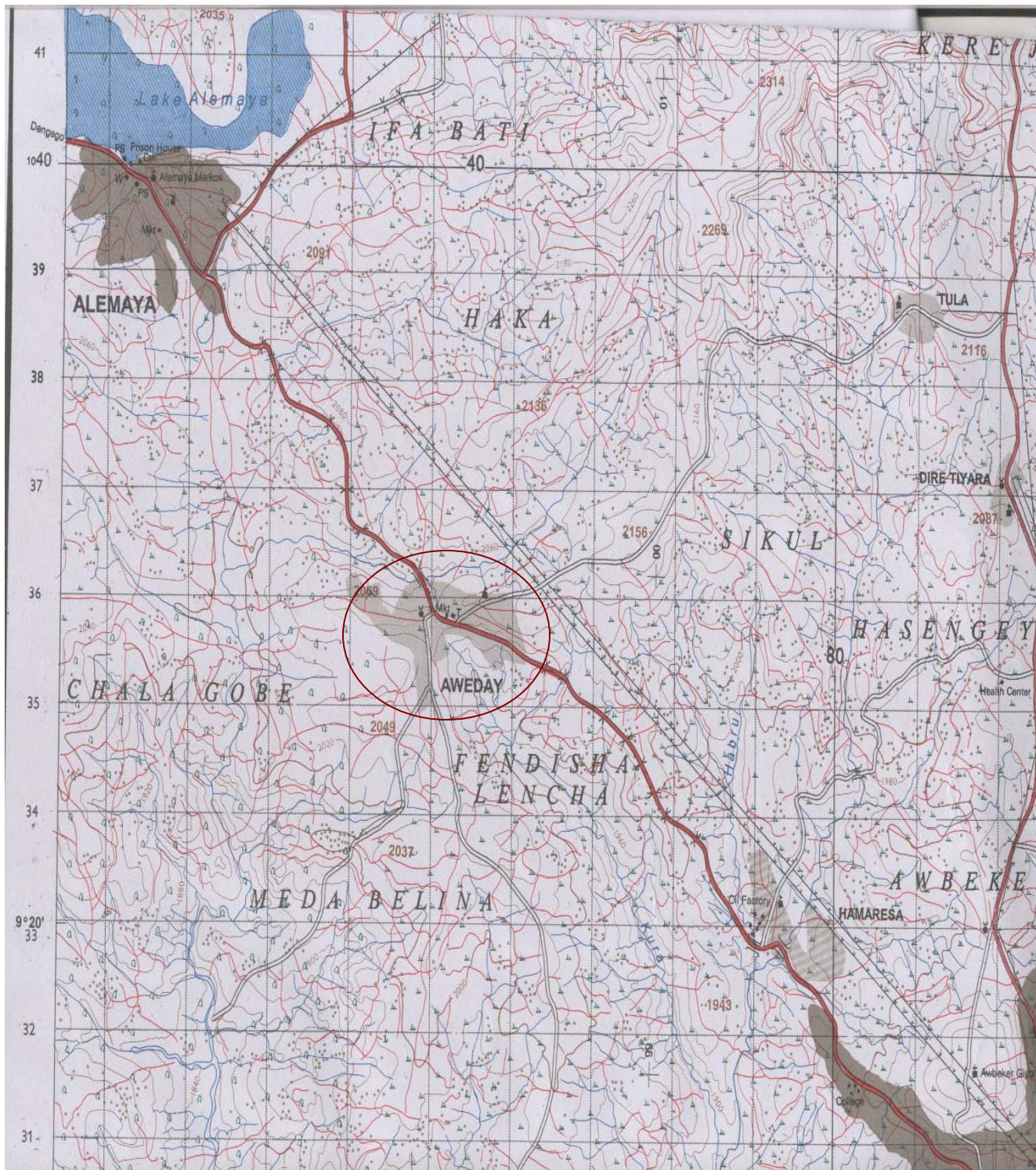


Fig.4.1 Map of Awadaya and the surrounding town and city

Now the study focused on the solid waste of khat and related materials in a market place of Awaday. The town is relatively better than the remaining urban centers, in terms of economic and social condition. It is the center of trade for agricultural production, such as, vegetable, fruit and khat. However, khat is the only product specialized here, as we go everywhere in the country the name of the town is supposed as a khat product. The town is under municipal reform process and ongoing decentralization process at local level. According to Awaday municipality recorded in 1999 E.C, the size of the population was 22,560 and 5,078 families.

The purchasing of khat was functional for 24 hours throughout the year. The exportable product of khat is processed and distributed to the international and domestic market. With regard to international market, the accessibility of better standard road (high way) connection to Dire Dawa international air port is a means to export more agricultural production, to Djibouti and others foreign countries. Asphalt road connection to Harare region, Addis Ababa city and gravel road connection to Jijiga, Somali regional state, is also another opportunity to supply the agricultural production (khat) for the local and foreign markets easily (Alyi Ahmed, 2006).

It is famous for its khat market. Approximately 50 tons of khat and its related materials per day reach the market in summer whereas relatively the production is lesser in winter times. In the summer as present in the (figure.4.2) below the municipality can collect 6-8 car of solid waste. Each car can contain 25 quintal of solid waste. From this observation we can conclude that about 15-20 tons of solid waste is produced.



Figure 4.2 khat waste and packing materials

Even if, the daily use and consumption of khat by millions of people in Ethiopia and other countries is increasing, very little concern was given about the waste related to khat. When khat prepared for market, it is usually packed with different materials such as leaf of eucalyptus tree, grasses and any green leaf to retain its moistness and freshness.

Again at market merchants want to pack khat in a new form. For this process different leafs and grasses come to the market for sale. (Fig4.3). Khat was usually covered with grass whenever transportation to far distance is desired. But the one transported to near distance is cover by leafs. This all coverage dispersed in market as waste.



Figure 4.3 Leafs used as packing materials of khat at market places

Often some parts of khat (mainly the stem and leaf) are cut when khat is prepared for export process. This remained part of khat is collected as pile. This waste is produced when khat prepared for transportation to Somalia, Djibouti and London. Moreover this is piled near the houses where the khat is prepared for exportation at the center of the town (fig.4.4). This khat waste is sold for those who use it as fire wood by the owner. In spite of this the pile is there through out the year and the production of khat waste is not match with the use of it as fire wood.



Figure 4.4 Pile of khat stick as a result of preparation for exportation near the houses located at the center of the town.

#### **4.1 Existing Solid waste management in Awaday town**

The existing management of solid waste relies on a centralized approach, with rapidly growing urban population; current institution is unable to provide an adequate level of solid waste management service. The municipality provided only one tractor for solid waste collection. It works for 3-4 hours within a day and takes 2-3 car in winter but it works more hours in summer and collect 6-8 car per day. This solid waste is less collected than produced. Moreover, the collected solid waste was simply disposed at nearby rural areas on the road of Awaday-Harar and Awaday-Haramaya. Farmers near Awaday used this solid waste as fire wood.

The street sweepers are hired as a temporary on contract basis. There was no motivation and incentive for them, the salary payment was on a daily basis. Most of them were seeking additional jobs after completed the street sweeping activities. There was no controlling system for them, weather done their jobs or not.

#### **4.1.1 Collection**

According to the annual report, the solid waste collection is limiting only main road, meaning that, street sweeping was the main solid waste services provided by the Awaday local urban government. Moreover; simply collection of solid waste without planning was the characteristic of solid waste collection system in the town. The town's municipality tries to collect the solid waste by organizing one micro-solid collector that has 7-10 members. This organization is work only for 5month and leaves its work. Now the municipality hired collectors as daily workers. Where collection is performed by non-mechanical means, the volume of material to be collected often exceeds the capacity of the collection system. Pre-collection is carried out by community women in some areas not served directly by municipal vehicles. These women use for fuel after drying it or reselling solid waste as packing materials or fuel for others.

#### **4.1.2 Transportation**

The current means of transportation to collect solid waste is pushcarts or handcarts and tractor, which is not efficient in terms of maintenance cost and service coverage. Moreover, density of solid waste during summer season and winter season is different, during rainy season, the weight of solid waste is increases, and loading manually is difficult and very costly.

#### **4.1.3 Storage**

There is no communal storage system. And dust bin provision by the local government is absent. The efforts made by the municipality to provide roadside bin has also failed due to inappropriate design. There was no temporary transferring area until the waste gets disposed off.

#### **4.1.4 Disposal**

Every corner of the city serves as khat waste and related materials dumping site. Places such as market centers, under bridges and road sides are specially used for the pilling up of the municipal,

household and commercial wastes. Which is supposed to have potential risk for health via degradation of the quality of water, soil, air and social environmental compenents?

## **5. Objectives of the study**

### **5.1 general objectives**

To compost khat waste and related materials as solid waste management option and analyze nutrient (such as N, K and P) contents of the resulting compost.

### **5.2. Specific objectives**

- To characterize the waste of khat and related materials.
- To identify the problems associated with the wastes of khat;
- To prepare organic compost from representative samples;
- To analyze the composition of the organic compost;
- To propose proper management of the khat and related materials wastes;

### **5.3. Materials and methods**

#### **5.3.1. Materials**

Samples of the khat and its related wastes will be collected from the town, therefore; sacks, plastic bags, balance, different types of glass wares, bottle, plot of land for preparation of compost, shears, a sharp spade or a shredder, a 2 mm mesh sieve, a forced-air oven, desiccators, electronic pH meter, a volumetric flask, an autoanalyser, small air condenser, an acid resistant cellulose filter paper, a polypropylene bottle, atomic absorption spectrophotometer e.t.c. will be required.

Chemical list; deionized water, nitric acid, potassium chloride tablets, anti-bumping granule , Sulphuric acid, hydrochloric acid, n-dodecane, l-1 cesium solution, distilled water.

### **5.4. Methods**

Compost can be made in six to eight weeks, or it can take a year or more. In general, the more effort one puts in, the quicker one can get the compost.

To achieve my objective the following method will be followed.

- ❖ Literature and journal review
- ❖ Consultation and discussion,

- ❖ Relevant data gathering both primary and secondary Measurements will be made for every visible weight.
- ❖ walk through inspection to a site
- ❖ interview relevant persons
- ❖ Laboratory analysis

## 6. Laboratory analytical procedures

Eight Samples of compost material collected during the dismantling of the compost well were analyzed for a suite of chemical determinants using standard laboratory techniques. Compost samples could be collected from the pile for analysis at the end of composting. Throughout all the analytical work, deionised water could be used and reagents were of analytical quality grade. Glassware was acid wash in 10 % nitric acid. Samples were thoroughly mixed in order to achieve homogeneity. Chemical analyses requiring air-dry compost samples would perform with material that could dry in an oven set at 80° C for 24 h and ground using a pestle and mortar to pass a 2 mm mesh sieve, to minimize sub-sample variability.

### 6.1 The moisture content of solid waste

Compost from all sampling layers was examined for moisture content. Eight Samples of each 5 g of air-dry fresh compost would be weighed and placed in a drying oven at 105 °C for overnight. Oven dried samples was cooled in desiccators for 1 h and reweighed. The percentage moisture content would be calculated from the equation.

$$\% \text{moisture} = \frac{W_1 - W_2}{W_1} \times 100 \quad \text{Where; } W_1 = \text{weight of fresh sample (Eq. 1)}$$
$$W_2 = \text{weight of dry sample}$$

### 6.2 End point titration of organic C

Weighed 2g air-dry compost and transfer to a 500ml Erlenmeyer flask. Added 10ml 1 N  $K_2Cr_2O_7$  solution with pipette to both samples and blank. Carefully added 20ml concentration  $H_2SO_4$  with measuring cylinder in the fume cupboard and swirled the flask and allowed standing asbestos or corking pad for 30 minutes. Then added 200ml distilled water and allowed it to cool. Added 10ml conc. orthophosphoric acid and just before titration, added 0.5 ml of barium diphenylamine sulphionate indicator. Titration both samples and blanks with 0.5 N ferrous sulfate solution until the color changed to purple or blue, then added ferrous sulfate solution drop by drop until the color flashes to green then continue to a light green end point.

## **6.3 PH**

### **6.3.1 Measuring PH in water suspension**

The pH of compost samples were determined using standard procedures. A sub-sample (5 g) of air-dried ground compost was transferred into a bottle and 25 ml of water were added. The bottles would be capped and shaken mechanically at 200 revs per min for 15 min. The pH of the suspension was measured using an electronic pH meter.

### **6.3.2 Measuring PH in KCl suspension**

Weighed 10g air-dried 2mm compost into 100ml beakers. Added 10ml 1M KCl solution for 1:1 or 25ml 1 M KCl solution for 1:2.5 compost/KCl suspensions. Transferred the samples to an automatic stirrer and stir for 30 minutes measure PH on the upper part of the suspension. We were used a glass rod for stirring, so stir for 1 minute and allowed the sample to equilibrate and measured PH after 1 hour at an accuracy of 0.1 units.

## **6.4 Electrical conductivity.**

Weighed 10g of compost samples into 250ml beakers. Add 50ml of distilled water and shook on the automatic stirrer for 30 minutes. Measure the temperature of the extract and set temperature compensation at this temperature. Fill the cell with extracted and read conductivity. Rinse the cell with extract to be measure between measurements. It is check the standard solutions and adjusted the conductivity meter during a sample batch.

## **6.5 Nitrogen**

Accurately weighed 1 g compost samples and transferred into digestion tubes. Added 2 g of catalyst mixture and few carborundum boiling stones mixed well and rinsed with little water just enough to moisten the mixtures. Added 7ml of conc.  $H_2SO_4$  and mixed by swirled. Placed the digestion tubes stand with the samples beside the block digester and fitted the exhausted manifold on top of it. Placed the tubes with racks and exhaust manifold on the digestion block, preheated in the fume-hood. Digested for 3hours or until the digestion is white on block digesters preheated to  $300^{\circ}C$  allowed to cool, and cautiously add 50ml of distilled water, and then cooled again. Transferred the

acid digested quantitatively to the macro-Kjeldahl flasks and rinsed using distilled water. Measured 20ml boric acid solution from dispensers into receivers Erlenmeyer flasks corresponding to the number of samples. Added to it 2 drops of indicator solution and placed under the condenser. Taken care that the end of the condensers were immersed in the boric acid solution to prevent any loss of ammonia. Poured 75ml of 40 percent NaOH carefully down the necks of the distillation flasks contained the digests and mixed gently. Fitted the prepared 250ml Kjeldahl distillation flasks contained the digest to the corresponding holder, closed it as soon as possible and started the distillation by heated the flasks contained the digests. When the distillations were complete, i.e. when about 80ml of distillate has been collected, removed the receiver flasks. Continue with the next samples. Added a stirrer bar and titrated the receiver flasks solution from green to a pink end point with 0.1 N H<sub>2</sub>SO<sub>4</sub>. Record the reading of the burette. Always standardized the acid obtained the exact normality of the titrate.

## **6.6 Available Phosphorus**

Weighed 2g air-dried compost <2mm mesh in flask with stoppers. Included one standard sample and two blanks with each series. Added 20ml of extracted solution Bray II, Shook exactly 1 minute by hand and filtered directly after mixed through a whatman No. 42 filter paper. The filtrate was turbid and filtered again through the same filter. Pipette 2ml of standard series, samples and blanks. Added 8ml boric acid 0.5 % and mixed. Added 2ml of mixed reagent and mixed. Measured the absorbance with a 10mm diameter cuvette at 882nm after 30 minutes but within 12 hours. The absorbance of the 4ppm P standard is about 1.0.

## **6.7 Total K**

Weighed 10g of compost passed through 2mm mesh sieve into 100 ml shaking bottle. Added 50ml of extracting solution and Shook for 30 minutes at minimum of 180 oscillations per minute. Filtered and collected the filtrate in a 100ml Erlenmeyer flask. Dilute extracts 5 times using the extracted solution.

Measurement K by flame photometer.

100 mg/l K diluted standard series: pipette 100ml of the potassium stock solution 1000ppm K, into 1 liter volumetric flask and diluted to volume with distilled water. Standard series working solution of

0-2-4-6-8-10 mg/l K: pipette into volumetric flasks, respectively 0-5-10-15-20-25 ml of the diluted 100 mg/l standard solution. Dilute to volume with Morgan's extracting solution.

## **7. The general features of solid waste of khat and related materials**

### **7.1 Physical appearance of solid waste**

The solid waste of Awaday is obtained through out the year. It contains leaves of different plants such as khat, eucalyptus tree, small shrubs and grasses. It has its own pleasing look and does not seem other solid waste that brings pests and vectors. It has no bad smells. However, during the rainy seasons it appears muddy and used to have bad smell. Thus becomes a breeding source of worms and different insects. In the mean time creating difficulties to the public (producers, consumers and brokers) whereby the normal exchanges are severely influenced. As a result it incurs them different shoes and cloths. Therefore, every person criticizes a municipality of the town heavily (Figure 7.1).



**Figure 7.1** physical appearance of solid waste of market place of Awaday.

## 7.2 Chemical characteristic of solid waste

The solid waste of khat and related materials undergo chemical reactions both in the winter and summer seasons. But the relative rates of reactions are expected to be more in the rainy seasons. This can be attributed to the enhanced availability and interactivity of different factors which facilitate the reactions during these times. The factors involved are precipitation (rain) or moisture, microbial organisms, and increased human activity.

## 7.3 Quantifying solid waste of Khat and related materials

Packaging materials such as leaves of different plants and grasses, chopped khat sticks and leaves of the khat itself contribute to the total volume of solid wastes in Awaday town. Moreover, Khat shops and farms are found to be the major disposers of the above mentioned solid wastes. Therefore, the total daily average quantity of solid wastes was determined to be approximately 13 tones (Table 7.1 ) according to the data obtained for April, 2008 from disposers (i.e. Khat shops or markets) and municipal waste collection department. However; the quantity of the solid waste of the town varies with season.

**Table 7.1** The daily average quantity of solid waste generation for April, 2008.

No.	Shop numbers	Daily average quantity of solid waste (kg)	Type of solid waste
1	001	1000Kg	Leaves and stick
2	002	260Kg	Leaves and stick
3	003	100Kg	Leaves and stick
4	004	200Kg	Leaves and stick
5	005	150Kg	Leaves and stick
6	006	125Kg	Leaves and stick
7	007	250Kg	Leaves and stick
8	008	200Kg	Leaves and stick
9	009	75Kg	Leaves
10	010	50Kg	Leaves

11	011	50Kg	Leaves
12	012	75Kg	Leaves
13	013	100Kg	Leaves and stick
14	014	50Kg	Leaves
15	015	100Kg	Leaves and stick
16	016	100Kg	Leaves and stick
17	017	75Kg	Leaves
18	018	275Kg	Leaves and stick
19	019	125Kg	Leaves and stick
20	020	125Kg	Leaves and stick
21	021	1500Kg	Leaves and stick
22	022	8000Kg	Leaves
23	Total Grand	12985Kg	

#### **7.4 The problems associated to Khat wastes**

The huge hip of solid waste in the town has reduced the beauty of the town and became a breeding place of some rodents and vectors. Moreover, the waste encourages some people to dispose more and therefore exacerbates the poor sanitation of the town. Besides, the number of the town cleaners is very small and does not match with the amount and rate of solid wastes disposed daily. In addition the street polishers work only 2-3 hours with in a day. The waste collecting cars used to take 2 or 3 times every morning with 4-5 persons. They are free whole day and are involved in other private jobs. However, the exchange of khat is 24 hours that mean solid waste is created through out day and night.

Again the collected solid waste is disposed every where on the road. Some times the farmers are giving tip to the driver of a car and disposed near their village or farm on the road. The solid waste collected by street polishers is disposed near the bridge which under, water flow found at the entrance of the town (Figure7.2). Every time the solid waste is burned without considering water used for irrigation purpose so as causing pollution of the air and water of the area.



Figure7.2 Dispose of solid waste under the bridge.

### **7.5 preparation of organic compost**

A track of a sample solid waste, which weighs 4 tones is contain variable leaves and few grasses, was taken from market center of Awaday. Then four plots of lands were prepared in Haramaya town. These four plots were placed adjacently enclosing  $1\text{m}^3$  volume (Figure7.3).



Figure7.3 The four plots of land for compost is adjacently placed.

Two piles were enclosed to prevent from rodents and exposure of sunlight (Figure7.4). However, two piles are left with out enclosure similar to traditionally known composting method in the surrounding. However, the bare piles used to be covered with plastic sheet during the rain hours but the plastic sheets is removed and get sunlight and air other times and the process are repeated till the end of the composting process. The enclosed ones were fenced with hard green plastic. After that sample of solid waste is shredded (cut) by an axe. The shredded solid is segregated into four parts and spread on the plot.



Figure7.4 A pile enclosed by hard green plastic.

Then the process of composting was started by trying to fulfill conditions and/or factors such as temperature control, aeration, moisture, particle size and in two pile facilitator (manure). Aeration has been made every 5 days to deliver  $O_2$  to compost microorganism (Figure7.5). Besides, moisture was applied by adding water to compost piles. The volume of water added to them was varying depending on the dryness of the piles. However; the watering was 40 liters for each pile every 5 days.

Generally the process of watering used to be the same as aeration. In addition to this particle size of the raw materials were made to vary between 0.1cm and 5cm. with the assumption that the smaller the size of organic wastes, the faster the compost will be ready for use.



Figure7.5 Aeration of composting

Mixing and watering have been repeated through out the process of composting. The rates of mixing and watering were enhanced in such away that both processes had been carried out every five days and tremendous changes could have been observed within two weeks (Figure7.6). Consequently, the temperature of the piles was found to pick up to a maximum of 64°C (table 7.2). Then the temperature starts to decline to a daily average of 25°C as the compost reaches it's maturity, unlike

the ambient temperature range (20-30°C) of the surrounding and the relative humidity falls in a range from 24% to 40%.



Figure7.6 mixing of compost

**Table 7.2** Data of daily average temperatures of compost No.1 and ambient temperature

Time (in days)	Daily average temperature in °C	Ambient temperature °C
16/7/2008	54	24
17/7/2008	54	24
18/7/2008	50	20
19/7/2008	54	24
20/7/2008	56	20
21/7/2008	58	22
22/7/2008	64	20
23/7/2008	64	24
24/7/2008	60	24
25/7/2008	56	22
26/7/2008	58	24
27/7/2008	58	22
28/7/2008	58	18
29/7/2008	44	22
30/7/2008	56	20
1/8/2008	58	24
2/8/2008	58	22
3/8/2008	56	20
4/8/2008	54	18
5/8/2008	48	28
6/8/2008	48	22
7/8/2008	60	28
10/8/2008	58	20
11/8/2008	58	24
12/8/2008	52	26
13/9/2008	46	26
14/8/2008	50	20
15/8/2008	50	26
16/8/2008	46	20
17/8/2008	48	24
18/8/2008	48	18
19/8/2008	44	22
20/8/2008	44	24
21/8/2008	42	18
22/8/2008	44	22
23/8/2008	44	24
24/8/2008	44	20
25/8/2008	38	24
26/8/2008	42	24
27/8/2008	44	24
28/8/2008	42	22
29/8/2008	42	20
30/8/2008	40	26
31/8/2008	36	22
1/9/2008	40	22

2/9/2008	42	22
3/9/2008	36	22
4/9/2008	38	20
5/9/2008	36	22
6/9/2008	34	20
7/9/2008	30	20
8/9/2008	32	20
9/9/2008	30	18
10/9/2008	32	22
11/9/2008	36	20
12/9/2008	32	22
13/9/2008	32	24
14/9/2008	30	20
15/9/2008	30	22
16/9/2008	30	20
17/9/2008	28	20
18/9/2008	30	18
19/9/2008	26	20
20/9/2008	20	18

**Table 7.3** Data of daily average temperatures of compost No.2 and ambient temperature.

Time (in days)	Daily average temperatures in °C	Ambient temperatures °C
16/7/2008	54	24
17/7/2008	54	24
18/7/2008	50	20
19/7/2008	54	24
20/7/2008	56	20
21/7/2008	58	22
22/7/2008	60	20
23/7/2008	52	24
24/7/2008	50	24
25/7/2008	48	22
26/7/2008	54	24
27/7/2008	56	22
28/7/2008	56	18
29/7/2008	50	22
30/7/2008	52	20
1/8/2008	56	24
2/8/2008	58	22
3/8/2008	57	20
4/8/2008	54	18
5/8/2008	50	28
6/8/2008	46	22

7/8/2008	48	28
10/8/2008	54	20
11/8/2008	56	24
12/8/2008	54	26
13/9/2008	48	26
14/8/2008	44	20
15/8/2008	48	26
16/8/2008	50	20
17/8/2008	46	24
18/8/2008	44	18
19/8/2008	44	22
20/8/2008	34	24
21/8/2008	34	18
22/8/2008	36	22
23/8/2008	38	24
24/8/2008	38	20
25/8/2008	34	24
26/8/2008	32	24
27/8/2008	36	24
28/8/2008	36	22
29/8/2008	34	20
30/8/2008	32	26
31/8/2008	30	22
1/9/2008	34	22
2/9/2008	36	22
3/9/2008	34	22
4/9/2008	36	20
5/9/2008	34	22
6/9/2008	32	20
7/9/2008	30	20
8/9/2008	28	20
9/9/2008	30	18
10/9/2008	34	22
11/9/2008	30	20
12/9/2008	32	22
13/9/2008	32	24
14/9/2008	30	20
15/9/2008	30	22
16/9/2008	30	20
17/9/2008	28	20
18/9/2008	28	18
19/9/2008	26	20
20/9/2008	22	18

**Table 7.4** Data of daily average temperatures of compost No.3 and ambient temperature.

Time (in days)	Daily average temperature in °C	Ambient temperature °C
16/7/2008	52	24
17/7/2008	52	24
18/7/2008	60	20
19/7/2008	60	24
20/7/2008	58	20
21/7/2008	56	22
22/7/2008	54	20
23/7/2008	54	24
24/7/2008	52	24
25/7/2008	46	22
26/7/2008	54	24
27/7/2008	54	22
28/7/2008	58	18
29/7/2008	56	22
30/7/2008	52	20
1/8/2008	48	24
2/8/2008	56	22
3/8/2008	58	20
4/8/2008	56	18
5/8/2008	52	28
6/8/2008	46	22
7/8/2008	44	28
10/8/2008	46	20
11/8/2008	54	24
12/8/2008	56	26
13/9/2008	44	26
14/8/2008	44	20
15/8/2008	48	26
16/8/2008	48	20
17/8/2008	46	24
18/8/2008	44	18
19/8/2008	42	22
20/8/2008	40	24
21/8/2008	40	18
22/8/2008	40	22
23/8/2008	42	24
24/8/2008	40	20
25/8/2008	32	24
26/8/2008	32	24
27/8/2008	36	24
28/8/2008	36	22
29/8/2008	34	20
30/8/2008	34	26
31/8/2008	36	22

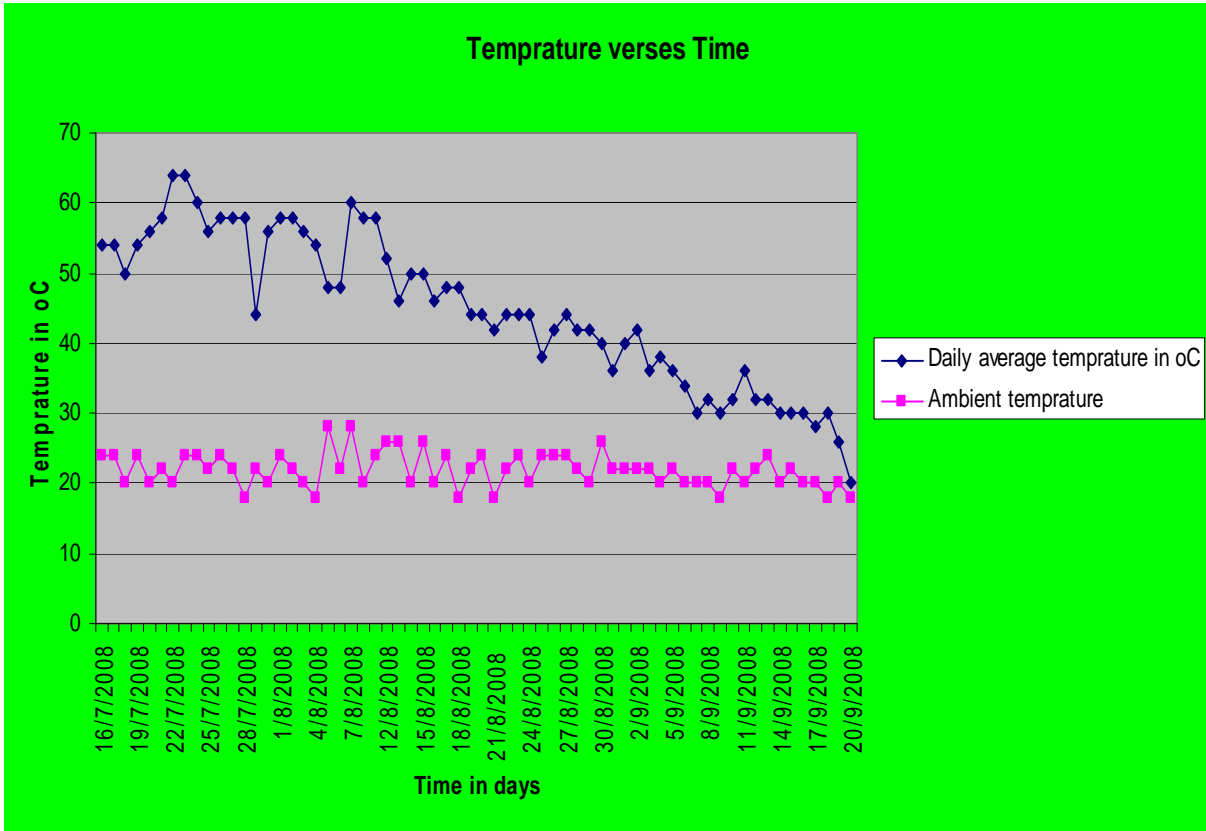
1/9/2008	32	22
2/9/2008	34	22
3/9/2008	34	22
4/9/2008	32	20
5/9/2008	30	22
6/9/2008	32	20
7/9/2008	28	20
8/9/2008	34	20
9/9/2008	32	18
10/9/2008	32	22
11/9/2008	32	20
12/9/2008	30	22
13/9/2008	30	24
14/9/2008	28	20
15/9/2008	28	22
16/9/2008	28	20
17/9/2008	26	20
18/9/2008	30	18
19/9/2008	24	20
20/9/2008	20	18

**Table 7.5** Data of daily average temperatures of compost No.4 and ambient temperature

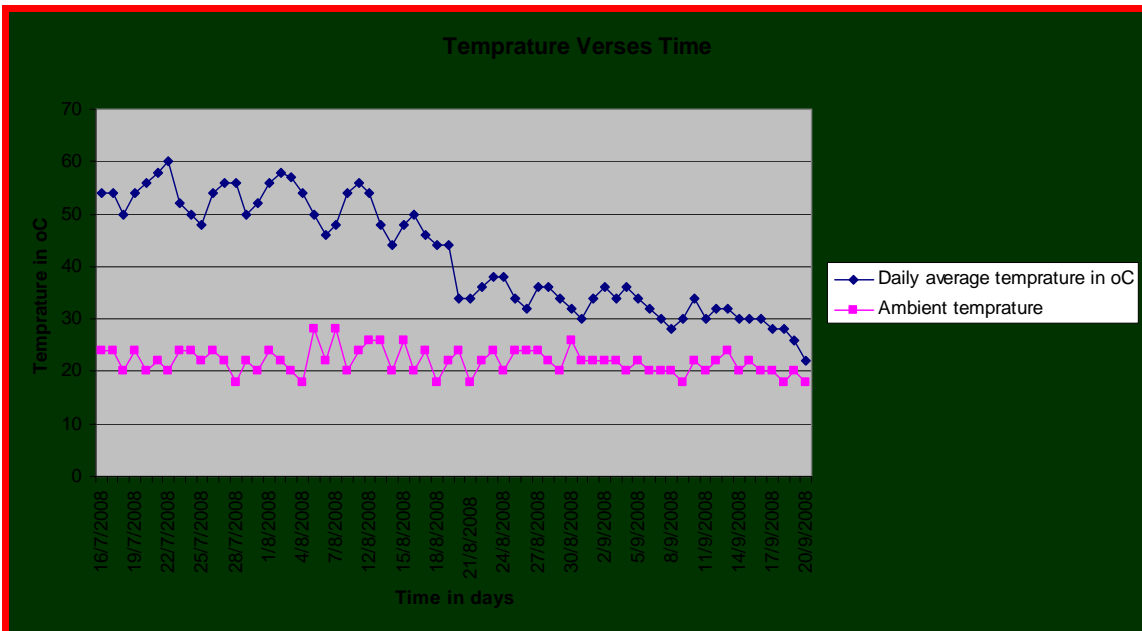
Time (in days)	Daily average temprature in °C	Ambient temprature °C
16/7/2008	52	24
17/7/2008	52	24
18/7/2008	45	20
19/7/2008	50	24
20/7/2008	54	20
21/7/2008	58	22
22/7/2008	44	20
23/7/2008	42	24
24/7/2008	48	24
25/7/2008	52	22
26/7/2008	56	24
27/7/2008	50	22
28/7/2008	54	18
29/7/2008	54	22
30/7/2008	46	20
1/8/2008	54	24
2/8/2008	56	22
3/8/2008	56	20
4/8/2008	50	18
5/8/2008	48	28
6/8/2008	44	22
7/8/2008	44	28

10/8/2008	48	20
11/8/2008	44	24
12/8/2008	46	26
13/9/2008	42	26
14/8/2008	40	20
15/8/2008	40	26
16/8/2008	38	20
17/8/2008	42	24
18/8/2008	28	18
19/8/2008	28	22
20/8/2008	32	24
21/8/2008	32	18
22/8/2008	30	22
23/8/2008	32	24
24/8/2008	28	20
25/8/2008	30	24
26/8/2008	28	24
27/8/2008	30	24
28/8/2008	30	22
29/8/2008	30	20
30/8/2008	28	26
31/8/2008	26	22
1/9/2008	30	22
2/9/2008	28	22
3/9/2008	26	22
4/9/2008	24	20
5/9/2008	22	22
6/9/2008	20	20
7/9/2008	22	20
8/9/2008	22	20
9/9/2008	20	18
10/9/2008	24	22
11/9/2008	22	20
12/9/2008	22	22
13/9/2008	22	24
14/9/2008	22	20
15/9/2008	22	22
16/9/2008	20	20
17/9/2008	20	20
18/9/2008	18	18
19/9/2008	18	20
20/9/2008	16	18

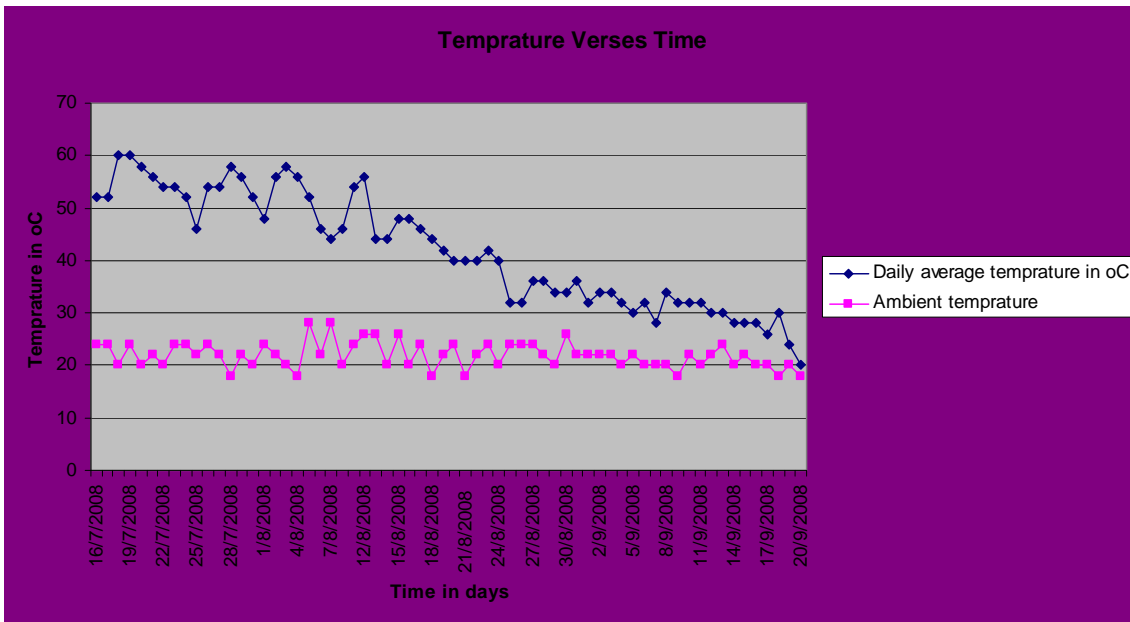
Graph 7.1. The compost No.1 variation of daily average temperatures and ambient temperatures.



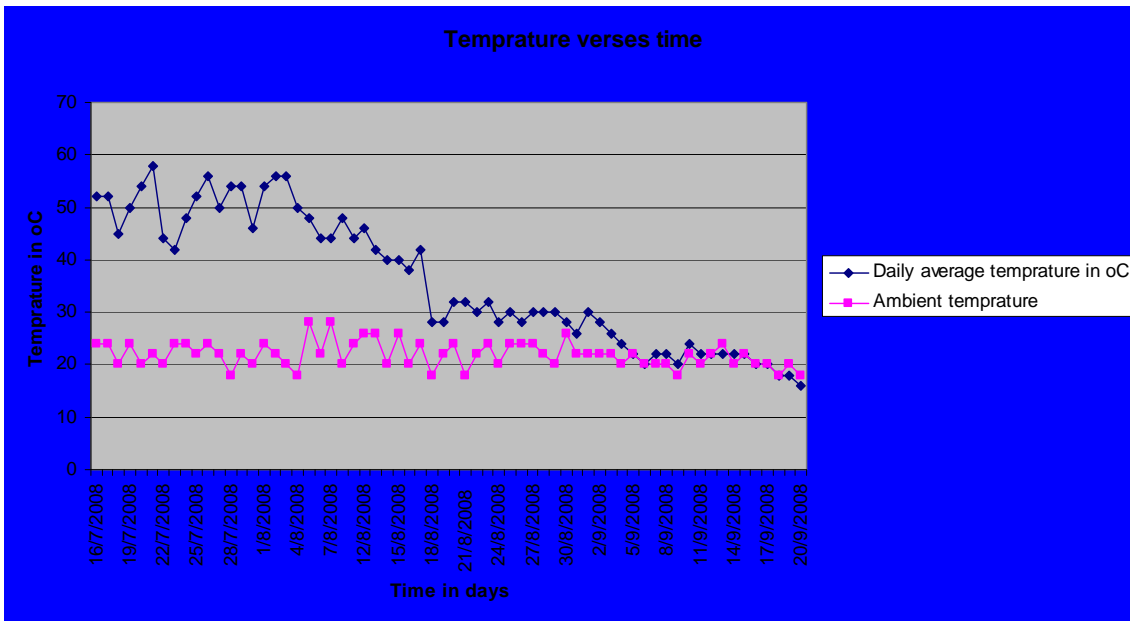
Graph 7.2 the compost No.2 variation of daily average temperatures and ambient temperatures.



Graph 7.3 the compost No.3 variation of daily average temperatures and ambient temperatures.



Graph 7.4. The compost No.4 variation of daily average temperatures and ambient temperatures.



Temperature control is needed because microbial decomposition releases a lot of heat. And composting piles are self-insulating; as a result, high temperatures can result. Therefore, at temperatures above 70 °C many compost microorganisms die and also lead to drying out of piles. Moreover, when it is coupled with low moisture levels spontaneous combustion can occur. However; the temperatures of the compost piles vary over time. Initially, temperature increases rapidly as readily digestible materials are decomposed and heat is released and as decomposition slows, the temperature falls.

## **8. Results and discussion**

### **8.1 Composition of Compost**

Eight samples were taken from four different compost piles. Two samples from each of the compost piles, then the samples examined for seven parameters at water works enterprise's laboratory. As a result variable values of nutrients (K, P, and N) contents, moisture content, electrical conductivity, PH, and organic carbon were obtained. Two samples were taken systematically at depths of 10cms and 30cms from each compost piles. The analytical values of parameters obtained for the different samples of a pile and for samples of the different piles showed variation and depend on depth. For instance the nutrient content nitrogen of samples of compost pile No.1 gave lesser values than samples of piles No.2 and No.4 but greater phosphorus content than piles No.2 and No.3 and better potassium than pile No.3 this is attributed to the addition of 200Kg of manure and bareness of compost No.1. The other differences were between pile No.2 and pile No.3; the former gave better contents of nutrients than the lateral. This is due to the fact that pile No.3 was opened to air through out the composting and may lost some of its nutrients content in the form of vapors

As it can be seen from Table 8.1, nutrients contents on eight samples of composts were taken and the result for nitrogen ranges from 0.9-1.40 %, available phosphorus ranges from 536.00-803.00 ppm and available potassium ranges from 6775.72-12445.24 ppm which is by far less than that of artificial fertilizer. Compost can vary because of the raw materials used, degree of decomposition, moisture content, nutrient content, salt content, acidity/ alkalinity and contaminants (organic and non-organic materials or heavy metals). Fewer amounts of nutrients may indicate incomplete decomposition or low amount of nutrients in the original material.

Table 8.1. Compositions of processed organic compost which are obtain from laboratory analysis.

Parameters	Processed organic compost
PH(1:2.5)	7.28-7.78
EC(ms/cm)	2.19-9.32
Organic carbon (%)	11.51-15.32
Moisture content (%)	5.80-9.65
Nitrogen content (%)	0.9-1.40
Phosphorus content (ppm or mg P <sub>2</sub> O <sub>5</sub> /Kg compost)	532.00-803.00
Available potassium (ppm or mg K <sub>2</sub> O/Kg compost)	6775.72-12445.24

## 8.2 PH

PH indicates acidity/alkalinity. Compost may help buffer soil toward neutral, pH = 7.0. It depends on the kind of material composted and the final pH of the compost. A pH change of 1 unit means a 10-fold increase or decrease of acidity. Most compost have a pH between 6 and 8 and also from laboratory analyses of compost samples the PH value ranges between 7.28-7.78 Therefore, the pH values obtained for analyzed compost samples are not far from the usual range. However; all the values fall in the alkalinity scale.

## 8.3 Organic matter

Organic matter content is the measure of carbon-based materials in compost and is typically expressed as a percentage of dry weight. Thus the samples analyzed for this parameter gave values in a range of 11.51-15.32. However, the least values were obtained for compost samples taken from pile No.1 and No.3 which are exposed to air and sunlight that are not enclosed.

#### **8.4 Moisture percent**

Moisture percent (content) is the measure of the quantity of water present in compost; expressed as a percentage of total weight and was determined to be from 5.80 to 9.65% for samples analyzed. However, the least values were obtained from samples taken from pile No.3 that range 5.80-7.22% and the rest were in a range 7.07-9.65%.The moisture content of compost affects its bulk density (weight per unit volume) which might in turn resulted due to handling and transportation.

#### **8.5 Electrical conductivity**

Electrical conductivity is a measure of soluble salt content. Soluble salts refer to the amount of soluble ions in a solution of compost and water. The concentration of soluble ions is typically estimated by determining the solution's ability to carry an electrical current, i.e., electrical conductivity. The units of measure for soluble salts are either mmhos/cm or dS/m (they are 1:1 equivalent). Most compost has a soluble salt conductivity of 1.0 to 10.0 dS/m, and the experimental result gave 2.19-9.32 (ms/cm) which was in the common range for most composts.

## **9. Conclusion**

From the process of composting, it has been found that the volume of waste has reduced significantly. The volume reduction is attributed to the decomposition of organic substances and compaction. Thus, simple and traditional way of composting is considered to be cost- effective and environmentally friendly method of waste reduction and removal unlike the technology based factory level composting which requires maintaining the C: N ratio feed stocks.

Although concentrations of nutrients found in the compost are typically not high, in comparison to most fertilizer products, the compost can be applied at much greater rates, and therefore, can represent a significant cumulative quantity.

The relatively less concentration of nutrients in the compost is due to the fact that nutrients are found in organic form and thus released slowly as the compost decomposes.

The compost's moisture content is found to be much higher than fertilizers. The moderate to low solubility of compost nutrients as compared to chemical fertilizers and their minimal effect on soil nutrient holding structures lessen their tendency to degrade ecosystem.

## 10. Recommendation

- The dwellers of town are not bothering about the solid waste of their town thus the concerned party and /or the authorities should strive to raise awareness with regards to solid waste among the residents of the town.
- Besides methods of collecting, storage, transporting and disposing municipal solid waste in the town needs to be improved and expanded through out the Town.
- More over proper sites for disposal must be selected and planned. In addition to placement of 4-6 dirty bins for temporary storage at different corners of the town where needed.
  
- It is recommended that the provision of solid waste management service could be marketable and the private sector should be involved in a provision of services. Also the authority can initiate and call private sector to participate in solid waste collection.
- To reduce solid waste of Awaday town, it is also recommended that
  - ❖ Mode of cutting khat must be changed. At the farm only the necessary part of khat leaf must be taken to the market;
  - ❖ Packaging materials of khat must be minimized;
  - ❖ The farmers should be encouraged to adopt reusable packaging materials instead of plants leaves.
  
- It is recommended to properly compost the solid wastes of the town by adding different source of nitrogen proportionally; such as blood meal, bone meal, grass clipping and manure. It has also been sought as good source of income and it could be made at a factory level since there are enough sources of raw materials for industry through out the year. Thus authorities are advised to initiate the investment in this part.
- Farmers should be encouraged to apply compost at optimal amount and rate as it increases physical and biological nutrient storage mechanisms to soils and since they have lower leaf-burn effects.
- Again it is recommended that clearly defined roles and jurisdiction, introduction of decentralized system, providing not only responsibility but also the power and financial capacity to the environmental authorities and finally introducing a controlled privatization.

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