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**Urban Solid Waste Management**

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## Urban Solid Waste Management

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### Abstract

This review article creates awareness among people to manage solid waste by using different methods because if these wastes are not properly disposed then different environmental problems are created. Books and journals were utterly examined for this study. Waste is by product which is produced by human activities through different resources. Population growth, urbanization and exceeding economy are factors due to which its management is a challenge. Incineration, composting, pyrolysis, gasification and landfilling are different procedures which are used to manage wastes. Current strategies for treatment of solid waste are used to reduce or to recover solid waste, useful products are produced by waste through these processes which are then used in different ways.

**Keywords:** *Solid waste, pyrolysis, gasification, composting, landfilling*

## 1.0 INTRODUCTION

By-product which is produced by human activities is called waste, it is same like the useful products physically but it has less usage (White, Dranke & Hindle, 2012). Waste can be defined as all unnecessary or unfeasible materials. Any material which is useless after its primary use, or is of no value and cannot be utilized again is a waste (Batool, Chaudhry & Majeed, 2008). Geographical regions, seasonal changes and social practices are different factors which determine type of waste (Jin, Wang & Ran, 2006; Adams, 1999). It can be classified on the basis of their physical states or can be categorized on the basis of safety level, origin, material and physical properties (White et al., 2012). Mainly wastes are divided into two groups i.e. solid waste and waste water (Ammar, 2014).

Solid waste is the heterogeneous accumulation of material that is discarded from the urban area, it also contains wastes from agricultural and industrial areas (Sufian & Bala, 2007). Increase in population growth, urbanization and community standards are factors that increases the amount of waste in developing countries (Manaf, Samah & Zukki, 2009; Minghua et al., 2009; Hassan, 2000). Population growth has direct influence on waste which increases the pressure on the resources, misuse of these resources produces waste (Singh, Singh, Araujo, Ibrahim & Sulaiman, 2011).

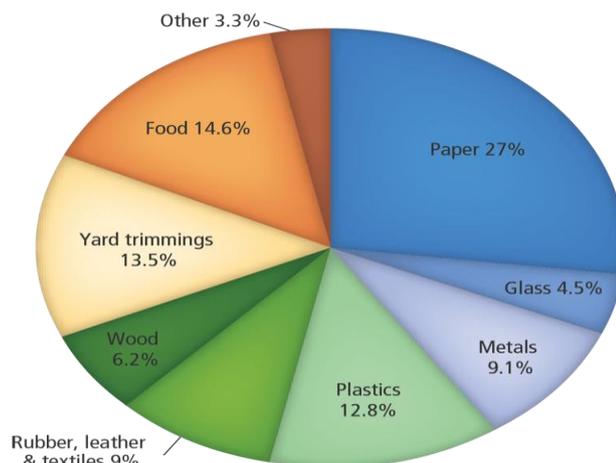
### 1.1 Types

Solid waste is further divided into different categories. Municipal waste includes waste that is produced by domestic activities, commercial activities as well as the waste that is produced by the community, it is commonly known as garbage. Industries are generator of MSW. Industrial waste is waste that is produced from different industries like refineries, power plants, chemical plants, light and heavy manufacturing, food processing industries and types of waste from these industries include food waste, wood pulp, construction waste, demolition, ashes (Daassi, Zouari-Mechichi, Frikha, Rodriguez-Couto, Nasri & Mechichi, 2016; Olotuah, 2005).

Waste that comes from houses and apartments contains left over food, papers, plastic bags, broken or pieces of glass, fabrics, utensils is known as residential waste which is generated by the residents (Mwesigye et al., 2009). Commercial Waste includes auto repair shops, restaurants, markets, medical facilities and waste consisting of pieces of leather, dirt, timber, concrete, bricks. Institutional waste includes waste from schools, colleges, hospitals, universities, government buildings and types of waste is similar to that of residential and commercial waste (Bello, Ismail & Kabbashi, 2016).

### 1.2 Sources and Composition

Composition is different in different places due to different lifestyles through which the usage of material is estimated. Composition estimation is important to manage the waste. Waste are generated due to human activities, in developing countries 55-80 % solid waste is generated from households and 10-30 % is produced from commercial areas, while waste is also produced from the industries, streets and institutions (Nabegu, 2010). Waste from different sources have different physical as well as chemical composition, it includes paper, leather, batteries, food, yard and others (Valkenburt, Walton, Thompson, Gerber, Jones & Stevens, 2008). This composition is influenced by social and economic factors (Fei-Baffoe, Miezah, Obiri-Danso, Kadar & Mensah, 2015). Quantity and composition is also influenced by the usage of goods and source- sorting activities (Dahlen, 2008).



**Figure 1: Components of solid waste**

### 1.3 Characteristics

**1.3.1** Solid wastes are corrosive due to presence of alkalis and acids that can corrode the containers of metals.

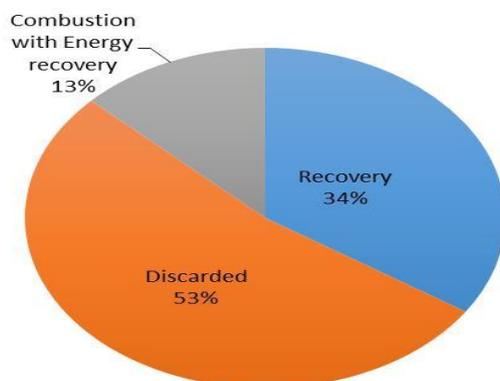
**1.3.2** These are ignitable that can generate fire under certain circumstances. Waste oils and solvents can create fire.

**1.3.3** They are reactive, explosive, can form toxic fumes upon heating and are unstable.

**1.3.4** They are harmful and deadly when absorbed or ingested (Alam & Ahmade, 2013).

### 2.0 MANAGEMENT

Management of solid waste is challenge in developing countries, because burden on the budget of municipal committee is increasing due to population growth (Guerrero, Maas & Hogland, 2013). Population growth, urbanization and exceeding economy are factors due to which management of solid waste has become a challenge (Minghua et al., 2009). In populated areas it is very difficult to manage waste because of unavailability of appropriate facilities to treat the waste (Rathi, 2006; Sharholy, Ahmad, Mahmood & Trivedi, 2005). Current strategies for treatment of solid waste are used to reduce or to recover solid waste, these strategies are also used to utilize the materials in waste. These methods depend upon the availability of lands and cost (Moeller, 2005).



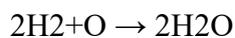
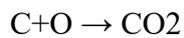
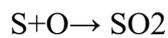
**Figure 2: Management of MSW**

## 2.1 Compaction

Waste material is compressed and compacted that breaks larger and brittle products of waste. It is clearly visible in vehicles of garbage collections (Alam & Ahmade, 2013).

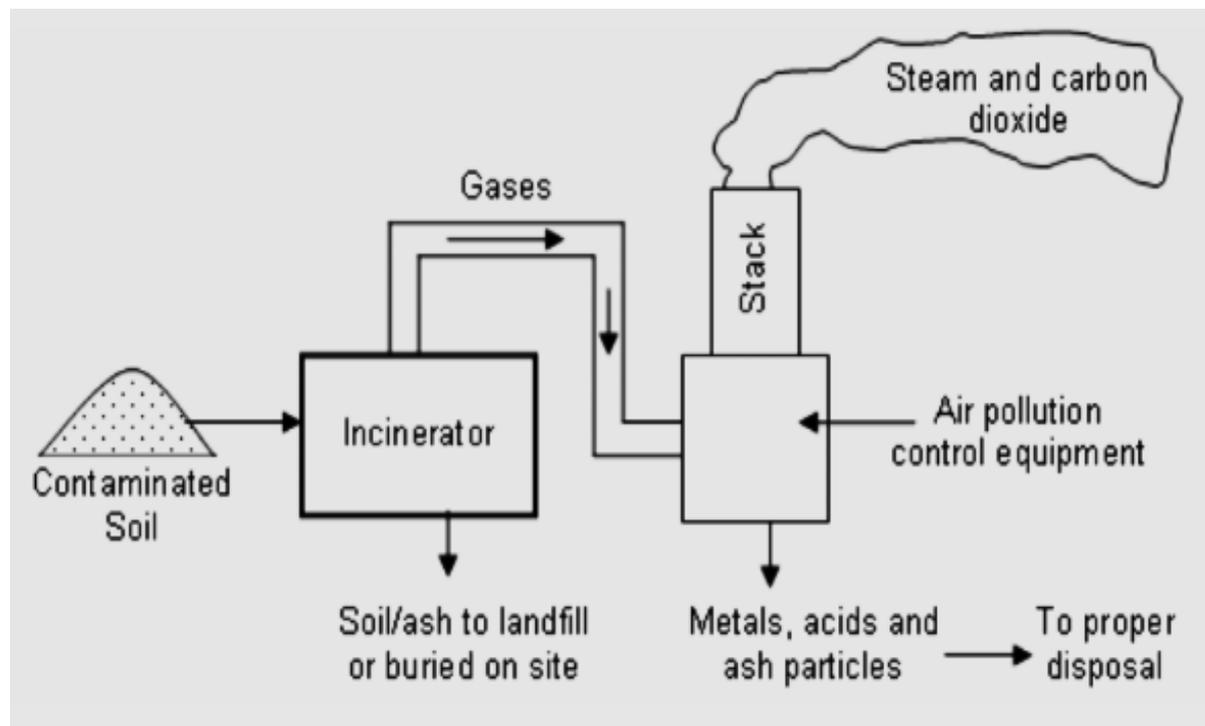
## 2.2 Incineration

Controlled burning of solid waste at high temperature of 1000°C and above, in oxygen rich environment that produces different gases like NO<sub>x</sub>, CO<sub>2</sub>, H<sub>2</sub>O, SO<sub>2</sub>, ashes, and other non-combustible residues. It reduces 80-90% volume of waste (Young, 2010). Reaction occurring in incinerator are as



Incinerators are like combustion chambers where elements are changed into gases, macromolecules, metals and acid gases are also produced in less proportion (Puna & Santos, 2010). CO is produced due to incomplete burning of waste with less air (Russo, 2005). Solid waste is the principle source of fuel because of its specific heat (Formosinho, Pio, Barros & Cavaleiro, 2000). Mostly this process is used for waste which has higher proportion of organic matter (Vogel, 1983). Destruction rate depends on the temperature and time of residence, temperature above 900°C and 2-5 seconds is enough for destruction of molecules (Puna & Santos, 2010).

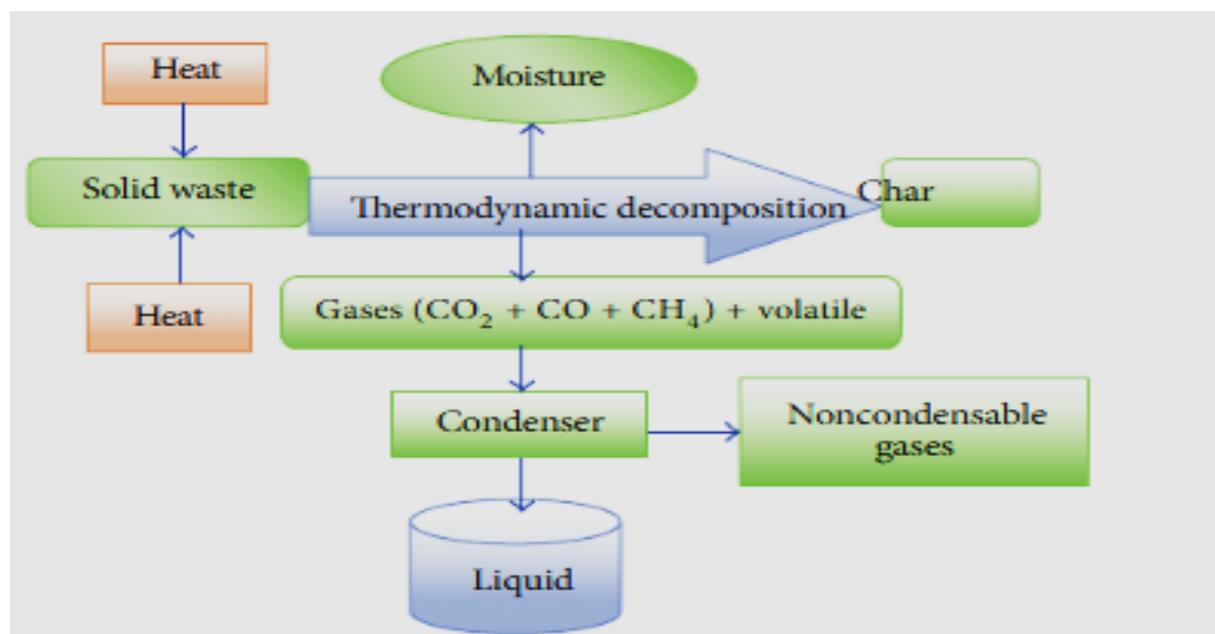
Co-products in incinerator are slag and ashes but it is easy to store them because their volume is reduced. Ashes are deposited in landfills while slag on other hand is passed through valorization for separation of metals that can be recycled and other waste is deposited in landfills (Puna & Santos, 2010).



**Figure 3: Incineration process**

## 2.3 Pyrolysis

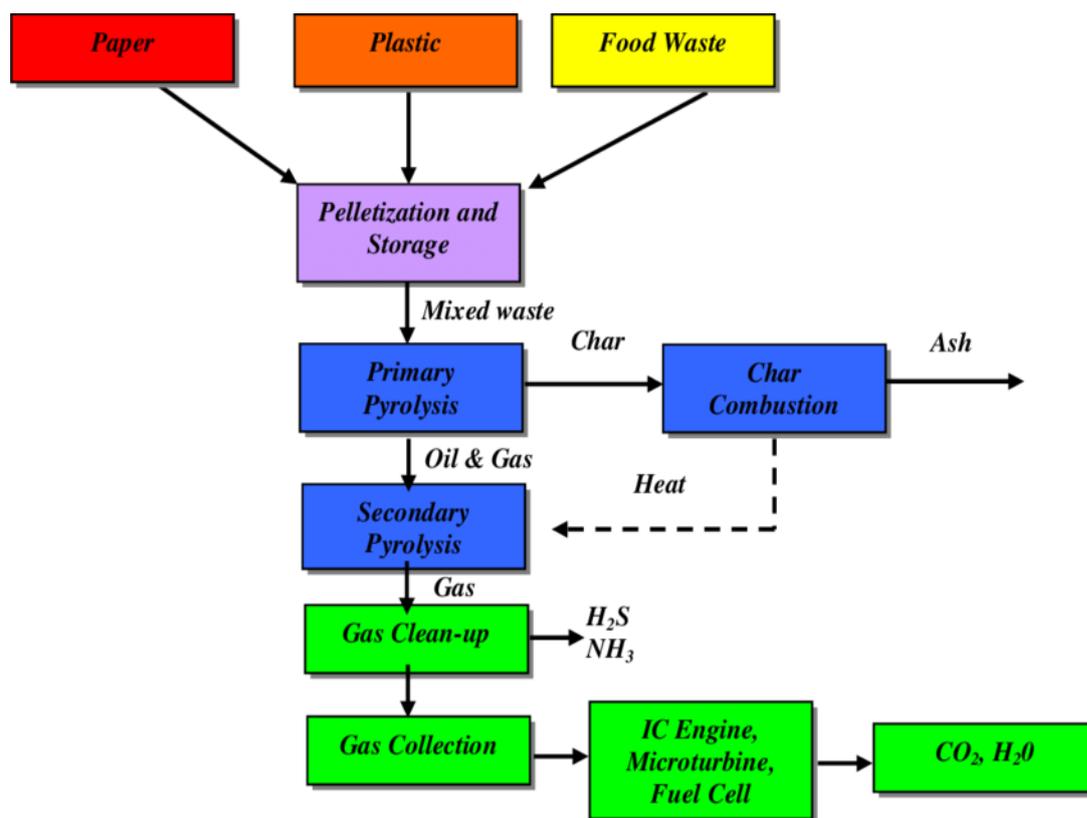
This word is derived from two Greek words; pyro (fire) and lysis (breakdown) (Mohan, Pittman & Steele, 2006; Solomon, Serio & Suuberg, 1992). It involves breakdown of waste at higher temperature without oxygen supply (Bridgwater, 2018) then char, gases and oil are obtained at temperature 450°C-750°C (Sannita, Aliakbarian, Casazza, Perego & Busca, 2012; Williams & Besler, 1995). Initial reactions are of decomposing type converting low volatile compound into high volatile ones (Moustakas & Loizidou, 2010). Mostly this process is applied on waste of industries i.e. tyres, plastics (Williams, 2013; Yang, Sun, Xiang, Hu & Su, 2013). This process is effected by the heating (Martinez, Puy, Murillo, García, Navarro & Mastral, 2013). It is not toxic process (Kaminsk & Scheirs, 2006).



**Figure 4: Pyrolysis process**

### 2.3.1 Processing steps in pyrolysis

Human, animal, crop wastes, paper and plastics are used in this process (Serio, Basilakis, Kroo, & Wojtowicz, 2002; Wojtowicz & Serio, 1996). All these products are polymeric and are changed into useful components that may be fuels in liquid or gaseous form (Serio, Kroo & Wojtowicz, 2003). Firstly pellet is formed from waste and then it is heated, as result of which gases, liquids and solids are formed. Solid are changed into liquid in initial stage and then these liquids are changed into gases through cracking i.e. H<sub>2</sub>, CO, CO<sub>2</sub> and CH<sub>4</sub> (Serio et al., 2008).

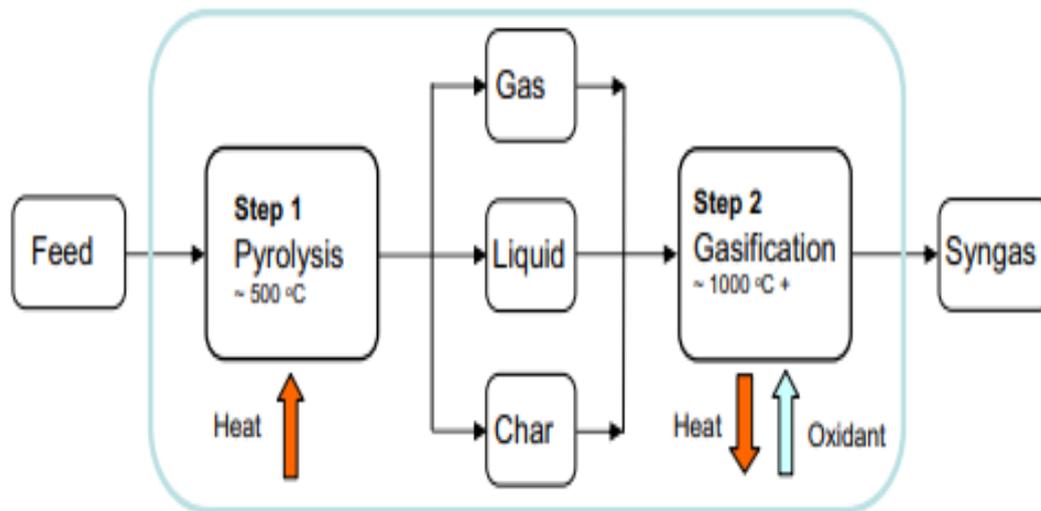


**Figure 5: Sequence of steps of pyrolysis**

## 2.4 Gasification

It can be defined as process in which solid contents are changed into gases (syngas) by using other gasification compound (Basu, 2010; Leal Quiros, 2004; Di Blasi, 2000), O<sub>2</sub>, H<sub>2</sub>O and CO<sub>2</sub> are used as gasifying media (Rapagna, and, Kiennemann & Foscolo, 2000), mostly it is used for organic contents (Childress, 2008). It is used to take energy from waste, best for industrial waste as compared to MSW because of its heterogeneity (Heermann, Schwager & Whiting, 2000). It is complex process that mostly occurs at higher temperature (>600° C) but it depends on type of waste and reactor (Arena & Mastellone, 2009). In this process exothermic and endothermic reaction occurs (Arena, 2012).

Firstly devolatilization occurs at temperature of 700° C then gases, tar and char are released. Tar is not suitable product because it contains heavy metals (Sikarwar et al., 2016), it may cause blockage in gasifier, so this can be reduced by different processes i.e. thermal cracking and oxidation (Fitzpatrick et al., 2009; Li & Suzuki, 2009). Then in second step char and HC are changed into syngas (Morrin, Lettieri, Chapman & Mazzei, 2012; Kawaguchi, Miyakoshi & Momonoi, 2002). Syngas is useful product, about 20% is used in power generation (McGowan, 2010; Wilhelm, Simbeck, Karp & Dickenson, 2001), and it is also used in fuel fertilizers and chemicals (Soni & Naik, 2016; Mountouris, Voutsas & Tassios, 2008). Product depends on composition of waste, temperature, pressure and design of reactor (Parthasarathy & Narayanan, 2014). It is efficient process with less cost (Palancar, Serrano & Aragon, 2009), but products which are formed have small range (Chum & Overend, 2001).



**Figure 6: Steps of gasification**

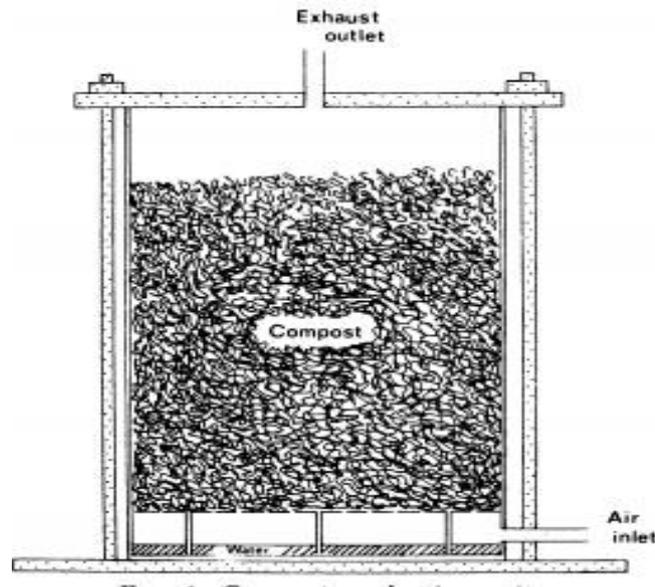
## 2.5 Composting

It is process that is used for the solid waste which is organic in nature (Hester, Harrison, Swan, Crook & Gilbert, 2002; Guanzon & Holmer, 1993). In this process waste is changed biologically into compost (darker substance). Aerobic microorganisms convert these complex compounds into simpler form (Ipek et al., 2002), which is used in agricultural fields (Castaldi, Garau & Melis, 2004; Mondini, Fornasier & Sinicco, 2004). Fungi, bacteria and other microorganisms are used in this process (Tweib, Rahman & Kalil, 2011). Mostly kitchen waste (vegetables, fruits, egg shells) and waste of garden (flower, roots) are composted biologically as well as fish waste and sewage waste can also be treated through this process. This reduces volume that can easily be disposed (Khalib, 2014). This process can occur in nature but it requires long time, so it is not attractive (Gabhane et al., 2012). Accelerators and inoculation of microbes are used to increase this process (Wei, Xi, Zhao, Wang, Liu & Jiang, 2007; Zubillaga & Lavado, 2006; Bolta, Mihelic, Lobnik & Lestan, 2003). Bulking agents (woodchips and saw dust) as well as chemicals are used to absorb odor and to adjust ratio of C/N and to increase aeration (Laos, Mazzarino, Walter, Roselli, Satti & Moyano, 2002).

Organic fertilizers can be produced through this process with the use of organic additives. Effective and indigenous microorganisms are used to accelerate this process. EM includes yeast, photosynthetic and lactic acid bacteria (El-Shafei, Yehia & El-Naqib, 2008). While main source of IMO are cyanobacteria and fungi (Sekeran, Balaji & Bhagavathipushpa, 2005). These microorganisms use C and N for energy and amino acids as result of which this process is accelerated (George, 2010). There are two types of composting process, in turned system waste is piled up to 2m height and then aeration is done for the waste, mostly this process is done indoors to decrease production of leachate (Hester, Harrison, Swan, Crook & Gilbert, 2002). Then pipes are used to spray water into heaps and inoculum is also added, then turning of heaps is done by loaders then temperature is increased (50-60° C) within heaps that is enough to kill pathogens, then after 1 month content is dried and is transported to yard (Das & Bhattacharyya, 2017).

In forced aeration system, at the first stage breakdown of substrate by microbes is encouraged by aeration. As result of which energy is released by respiration of microbes which produces heat (Abu Qdais & Hamoda, 2004). It is important for devastation of pathogens, these

conditions are not optimum for breakdown of MSW (MacLeod, Savage, Pahl & Baird, 2008). Then second phase with temperature of 45-55° C is required for breakdown of waste (Farrell & Jones, 2009). Third stage is similar in both types in which toxic  $\text{NH}_4^+$  is converted to  $\text{NO}_3^-$ . Here fungi as well as actinomycetes are used for degradation of lignin (Hester, Harrison, Swan, Crook & Gilbert, 2002).



**Figure 7: Compost production unit**

## 2.6 Landfilling

It is method in which biological, chemical as well as physical processes are used for the degradation of waste as result of which gases and leachate are formed (Pacey, Augenstein, Morck, Reinhart & Yazdani, 1999), in this process a large land area is used for disposal of waste (Al-Jarrah & Abu-Qdais, 2006; Robinson, 2005). It is cheapest way of disposal that is mostly used (Mahmood, Batool, Chaudhry & Daud, 2015), almost 71% of wastes are disposed through this method (Zacarias-Farah & Geyer-Allely, 2003), in which 53% of wastes have hardboard, paper, yard (Fei, Zekkos & Raskin, 2015). Within landfills anaerobic conditions are maintained, if emission of gases from these sites are not controlled then they cause environmental problems and leachate which is produced in these sites reaches to groundwater, which increases the risk of human health (Erses, Onay & Yenigun, 2008).

Landfills cause threat to groundwater (Fatta, Papadopoulos & Loizidou, 1999), solid waste releases its wastes and by products which are produced through decomposition that are mixed with water which moves through waste. Organic as well as inorganic compounds are present in this liquid which is known as leachate. It penetrates into soil, due to this penetration groundwater is contaminated (Saarela, 2003; Abu-Rukah & Al-Kofahi, 2001; Looser, Parriaux & Bensimon, 1999). The contamination of water is estimated through detection of impurities by the experiment (Moo-Young et al., 2004).

## 3.0 CONCLUSION

Solid waste is increasing day by day due to human activities, it is important to control waste because due to solid waste land and water pollutions are also increasing. Population growth, urbanization and exceeding economy are factors due to which management of solid waste has become a challenge. Different methods are used to control the waste that convert useless

materials into useful products. Best method to control waste is recycling and reusing, then composting is preferred. Landfilling is not preferred because it can increase the chance of ground water pollution.

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