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Characterization and Recycling of Organic Waste after Co-Composting − A Review

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Abstract

Co-composting produces a valuable compost material that can be used as valuable soil amendment. The process of the co-composting and control of the composting factors are the current challenges for the researchers. There are different factors that govern the quality, stability and the maturity of the co-compost in terms of amount of plant nutrients and reduction of heavy metals. Among these, C:N ratio is a parameter that can affect the loss of plant nutrients. Different studies showed wide ranges of C:N ratios (14-40) for maturity of quality compost. Temperature, aeration and types of the bulking agents also regulate the process of co-composting. Most widely used co-composted materials are animal manures with agro-wastes (sawdust, wheat straw, rice straw, corn stalks etc.). This practice brought substantial loss of heavy metals and maximum retention of plant nutrients. Higher nutrients contents of the compost and favourable soil properties as a result of co-composting of the saw dust, cow dung and egg shells have been reported. The application of co-composted dairy manure with wheat straw and sawdust produced higher plant biomass. Co-compost of cattle manure with rice straw produced an organic matter, total N and C:N ratio contents suitable for soil amendment. Therefore, this review focuses on the characteristics and utilization of organic waste after a reasonable co-composting process.

Keywords: co-composting, livestock manures, sewage sludge, nutrient transformation, chemical characterization

1. Introduction

Cattle farms are producing a huge amount of manure throughout the world which must be managed through proper disposal practices to avoid the adverse impacts on environment (Burton & Turner, 2003). This has become a significant management problem in several countries. The issue of waste management is increasing due to the current environmental awareness. It has stimulated the researchers to identify economically feasible and environmental friendly technologies for animal manure to be used as a source of soil fertilizer (Zhang & He, 2006). Composting is microbial based aerobic process considered to be an environmentally sound way to minimize organic waste and produce organic fertilizer or soil conditioner (Gajdos, 1992). The process is able to transform unstable organic waste (such as sewage sludge, municipal solid waste, tannery waste, animal manure, poultry manure etc) into stable ones by converting them into a humus like structure called compost which results into a valuable agronomic by-product (Kashmanian et al., 2000).

Composting presents a low-technology and low-investment process to add value to organic solid waste through conversion into an organic fertilizer known as compost (Neves et al., 2009). It also considerably reduces odour emissions, biodegradable hydrocarbons, and dries up the waste making it unattractive to insects (Barrington et al., 2002). Co-composting is an important bio-waste treatment for achieving sustainable process and zero waste. Waste co-composting also enhances the compost quality by the comprehensive usage of diversified material properties (Fang & Wong, 1999). This type of waste management is well accepted when compared with other types, such as incineration or landfill. Certain physical and chemical characteristics of animals manure are not adequate for composting and may limit the efficiency of composting process. Several modifications in the process of composting has been suggested such as the addition of biodegradable waste, bulking agents etc to reach the optimal C:N ratio, degradation rate and compost quality (Herwijnen et al., 2007).The selection of appropriate bulking agent would modify manure composting substrate properties (moisture, porosity, C:N ratio, pH) (Petric et al., 2009).

The performance of the co-composting process and the quality of the end-product (the compost) are governed by the composition of the waste material, bulking agents and the management strategies. Composting and co-composting are among the few natural process available for the disposal of solid pollution combined with resource regeneration via stabilizing different types of organic waste. Co-composting has received increasing interest as a method of handling various types of livestock manures (Ogunwande et al., 2008) and presented a low investment technology. As in the most production processes, the implementation of large-scale composting brings greater economic benefits. Co-composting of more than one type of waste can be a more sustainable management process of solid waste (Neves et al., 2009). The addition of a bulking agent for composting optimizes substrate properties such as air space, moisture content, C:N ratio, particle density, pH and mechanical structure, affecting positively the decomposition rate (Neves et al., 2009).

The majority of research studies have mainly focused on monitoring the influence of bulking agent types on the composting of manure (Petric et al., 2009), but the research articles describing the effect of bulking agents on the physico-chemical characteristics of composting manures are deficient. Therefore, efforts have been made to review the co-composting of different materials and its effects on plant nutrient transformations under varied conditions.

2. Factors Affecting Co-Composting

Compost maturity depends on several factors such as characteristics of initial wastes (C:N ratio, pH, organic matter, moisture and porosity) and process conditions (time and process) (Khalil et al., 2008). Temperature is another parameter to evaluate evolution of the composting process, since it determines the biological reactions rate, as well as the sanitation capacity of the process. Carbon to N proportion is a most widely used parameter in composting and cocomposting (Gloueke, 1991). Generally, composting could be carried out under a wide range of initial C/N ratios, namely, 11 to 105, depending on the starting materials (Eiland et al., 2001; Ghosh et al, 2007). Tuomela et al. (2000) indicated that initially higher C:N ratio will cause a slower beginning of the process and the required composting time to be longer than usual while Tiquia and Tam (2000) reported that low initial C:N ratio results in higher emission of NH_3. Huang et al. (2004), by co-composting of pig manure and sawdust at the initial C:N ratios of 30 and 15, reported that the pile with initial C:N ratio of 30 reached maturity within 49 days. Recent studies have shown that composting can be carried out effectively at a lower C:N ratio of 15 (Zhu, 2007). Eiland et al. (2001) composted miscanthus straw with pig slurry at the initial C:N ratio of 11 to 35 with the degradation rate of 40 to 80 %. Kumar et al. (2010) found that composting of food waste together with green waste at the initial C/N ratio ranging from 14 to 20 was effective with the C:N ratio of 19.6. A decrease in the C:N ratio implies an increase in the degree of humification of the organic matter.

Composting is a biotechnological process characterized by an initial phase in which different microbial communities degrade organic matter into simpler nutrients and thermophilic temperatures are developed owing to the heat generation. The higher temperatures achieved in this phase appear to be the most important factor in killing heat-sensitive microorganisms. In a second stage, complex organic macromolecules such as humic acids are formed and temperature decreases to ambient levels, leading to a product that may contribute to soil conditioning and fertility (Hsu & Lo, 1999). Huang et al. (2004) evaluated that composting piles of higher C:N ratio would show a slower rise in temperature, lower maximum temperature and shorter thermophilic phase. Temperature is a simple and excellent indicator of how well the composting process is progressing and how much oxygen is being used (Walker, 2004). Misra et al. (2003) reported that higher temperatures during composting contribute to the killing of weed seeds and pathogens.

The aeration rate (AR) is considered to be the most important factor influencing successful composting (Diaz et al., 2002). Insufficient aeration can lead to anaerobic conditions due to the lack of oxygen, while excessive aeration can increase costs and slow down the composting process via heat, water and ammonia losses. The optimal AR depends on the composition of the raw materials and ventilation methods (Guo et al., 2012). Turning is often cited as the primary mechanism of aeration and temperature control during windrow composting (Michel et al., 1996; Tiquia, 1996), while turning frequency is commonly believed to be a factor which affects the rate of composting as well as compost quality (Tiquia, 1996).

Nitrogen losses can be reduced firstly by adjusting C:N ratio (Lhadi et al., 2004; Meijide et al., 2007); secondly, reducing N losses by manipulating the temperature changes (Hiraku et al., 2004). Substantial loss of nitrogen results in the reduction of nutrient value of compost products. Among all practicable N conservation measures, an amendment was thought to be the most efficient method to reduce N loss during composting. For example, alum, peat, and zeolite lime and coal fly ash amendments have been used to reduce ammonia volatilization and heavy metals mobility during composting (Bernal et al., 1993; Kithome et al., 1999; Fang & Wong, 1999; Qiao & Ho, 1997). The type of bulking agent had a significant effect. There are a lot of bulking agents that could be used as a carbon source. Farmers make their choice on the basis of the availability of specific bulking agent. To-date, a majority of conducted studies have mainly focused on monitoring the influence of bulking agents on the composting of different types of manure (Petric et al., 2009). Yeoh et al. (2011) reported the selection of an inoculation of bacteria or fungus which may shorten the composting time, improve the compost quality and inhibit the growth of some plant pathogens.

3. Co-Composting Animal Manure

Understanding the quantity and quality of waste is an essential step for the productive management of a co-composting process (Yeoh et al., 2011). The factors that affect composting are essential in evaluating the performance of an overall composting process (Yeoh et al., 2011). Karnchanawong and Tadkaew (2013) reported higher nutrient content of the compost and the higher porosity of the soil mixture, as a result of the co-composting of the saw dust, cow dung and egg shells. Dehshan et al. (2013) reported co-compost of cattle manure with rice straw produced an organic matter, total N and C:N ratio contents suitable for soil amendment. Huang et al. (2006) studied the organic matter transformation during co-composting of pig manure with saw dust using chemical and spectroscopic methods and concluded with a stable organic matter in the mature compost. Zhang and He (2005) investigated the physicochemical properties in co-composting of swine manure with pine saw dust and found that 30% swine manure with initial C:N ratio of about 40 was desirable for composting with organic substrate. The importance of different factors affecting the quality, the stability and the maturation of the co-compost final product by composting pig feces and corn stalks under different aeration rates, C:N ratio and moisture content reported that the lowest initial C:N ratio had the lowest germination index. Aeration considered to be the main factor affected the stability of the final co-compost product while C/N ratio contributed to maturity and moisture content had a significant effect on compost quality (Guo et al., 2012).

Frederick et al. (2003) amended dairy manure of 83% of moisture with either straw dust or straw and reported that an initial C/N ratio more than 40 to minimize N loss. Li-li et al. (2013) compared the co-composting process of rabbit manure mixed with mushroom residue and rice straw and reported that both compost could help seed growth and a much more efficient way to utilize the material. On comparison, the co-composted manure with rice straw showed significant effects on improving seed growth than with mushroom residue. Dahshan et al. (2013) reported the addition of a bulking agent for composting cattle manure, especially, rice straw which produced compost with an organic matter, total nitrogen, and C:N ratio suitable for soil amendment.

Huang et al. (2006) examined the transformation of organic matter during the co-composting process of pig manure with saw dust. Organic C, C:N ratio and elemental analysis indicated the presences of more stable organic matter in the matured compost. Hao et al. (2004) investigated greenhouse gases emission during composting of straw bedded manure and wood chip bedded manure and concluded that the net contribution of greenhouse gas emission was greater for CH_4, since it is 21 times more effective at trapping heat than CO_2 and suggested further study to evaluate the impacts of composting on overall greenhouse gases emission and C sequestration. Wang et al. (2004) investigated the comparison of the co-composting process of dairy manure with wheat straw and sawdust which showed the positive initial plant growth response without fertilization.

The co-composting process of pulp and paper industry sludge with sawdust under aerobic conditions with two different treatments of cow dung only and the one with cow dung with effective microorganisms showed that the pulp and paper industry sludge co-composted with sawdust at the ratio of 3:1 by mixing cow dung and this could have successfully converted into valuable compost (Lakshmi et al., 2010). Eneji et al. (2003) reported that composting farm wastes before soil application could reduce the vulnerable P fraction, while increasing more resistant P fractions.

Neves et al. (2009) investigated the influence of the lipids content by co-composting cow manure with food waste and concluded with a positive effect due to the oily waste addition. Due to the hydrophobic properties of this specific waste, which may imply reduce need of a bulking agent. Tripetchkul et al. (2012) reported co-composting of coir pith and cow manure to evaluate the influence of C:N ratios i.e. 30, 25 and 20 on the physicochemical changes and found that simple pile turning yielded effective co-composting of coir pith comparatively with low C:N ratio. Considering the composting performance and the amount of coir pith to be utilized, the initial C:N ratio of 30 was considered suitable for coir pith composting. Karnchanawong and Tadkaew (2013) reported higher nutrient contents and vegetable growth using co-compost of saw dust, cow dung and egg-shell and the soil applied with this material was found with higher porosity. Zhang and He et al. (2006) reported total P loss during mineralization of organic P and consumption by microbes after co-composting of swine manure with pine sawdust. Eneji et al. (2003) reported favorable changes in the organic matter and elemental composition during composting of livestock manure for the use as soil amendment.

4. Co-Composting of Poultry Manure

Ogunwande et al. (2008) reported that moisture loss increased as C:N ratio and turning frequency increased when co-composted raw chicken manure with saw-dust. A significant loss of total N through ammonia volatilization and total C losses were attributed to the degradation of organic matter. The study indicated that C:N ratio significantly affected total N and P while C:N and turning frequency has a significant effect on total C and K. Tiquia et al. (2001) reported that co-composting of poultry manure and yard trimmings showed physicochemical and biochemical changes in compost mass, increase in enzymatic activities, decrease in the water soluble components (i.e., water extractable C, inorganic N and heavy metals) and removal of phytotoxicity. Steiner et al. (2010) focused on reducing N losses by using poultry litter co composted with biochar which acted as absorber of ammonia and total N losses were reduced by up to 25% by lowering ammonia concentration by up to 64%. Salma et al. (2006) co-composted poultry manure, olive mill waste and mineral rich wastewater and reported higher levels of nutrients, low C:N ratio of 15-17, free of phytotoxicity in co-compost and no negative impacts on soils. Tiquia and Tam (2000) examined the changes of N during co-composting of chicken litter i.e. the mixture of chicken manure, wood shaving, waste feed and feathers, reduced the value of chicken litter as N fertilizer and contained more stable organic matter in composted chicken litter. Huck et al. (2013) co-composted pine apple leaves and chicken slurry and reported no foul odor, low heavy metals content and considerable amount of nutrients with phytotoxic free seed germination.

5. Co-Composting of Municipal Solid Waste

Marco et al. (2013) used disposed white rot fungus Trametesversicolor after its application in the biotechnological process and co-composted with organic fraction of municipal solid waste and suggested that the final compost obtained through co-composting process ensured the higher stable final product than that obtained through organic fraction of municipal solid waste composting. Municipal solid waste with cow manure, poultry manure and yard trimmings etc helped to maintain soil fertility and improved moisture holding capacity of soils and found an acceptable release of plant nutrients (Gautam et al., 2010). Fourti et al. (2008) assessed co-composting of municipal solid waste and sewage sludge in semi-arid pedo-climatic conditions and finally confirmed amongst others that temperature is the main parameter to consider in composting since it acclimatizes the functioning of all the others parameters, specifically the microbial activity and diversity.

6. Co-Composting of Sludge

The effects of bamboo charcoal on N conservation and Cu, Zn mobility during sludge composting concluded that N loss and Cu and Zn mobility could significantly lessened through bamboo charcoal capability of ammonia adsorption (Hua et al., 2009). Wu et al. (2010) carried out N transformation during co-composting of herbal residue, spent mushrooms and sewage sludge at different ratios of 3:1:1 (sewage sludge:sawdust:spent mushrooms or herbal residue) and 3:1:2 (sewage sludge:sawdust:spent mushrooms or herbal residue) and concluded that the germination index values for all samples at maturity were above 80%, demonstrating optimal maturity. The addition of spent mushrooms or herbal residues augmented sewage composting.

The microbial and enzymatic activities during co-composting process of empty fruit bunches and partially treated with palm oil mill effluent showed that different species of uncultured bacteria dominated the process from the phylum proteobacteria in the thermophilic stage to the phylum chloroflexi in the maturing stage (Baharuddin et al., 2009). Hock et al. (2009) investigated the characteristics and physicochemical changes in the windrow in co-composting process of oil palm mesocarp fiber and palm oil mill effluent with anaerobic sludge. The final co composted product was achieved within 50 days with C:N ratio of 12.6 with considerable amount of nutrients and low levels of heavy metals.

7. Use of Co-Composted Waste Material

7.1 Nitrogen/Carbon Losses during Co-Composting

Composting is a bio-oxidative process in which organic matter is transformed by N mineralization, ammonia volatilization, nitrification, denitrification and partial humification into compost which is free of phyto-toxicity, pathogens and with certain humic properties by aerobic microorganisms. It comprises three major phases: mesophilic, thermophilic and cooling phase (the compost stabilization phase) (Tiquia & Tam, 2000; Singh & Kalamdhad, 2012; Neves et al., 2009). Nitrogen mineralization is of extreme importance because it converts organic N into ammonium (NH_4). Ammonia (NH_3) volatilization and de-nitrification may lead to significant losses of N (Martins & Dewes, 1992; Bernal et al., 1996). One of the most negative effects of composting animal manures is the loss of N through NH_3 volatilization which reduces the fertilizer value of the manure and constitutes an important economic loss (Tiquia & Tam, 2000). Ammonia emissions result from aerobic or anaerobic bacteria in manure (Zhang et al., 1991). Several studies have shown that NH_3 volatilization increased with an increase in pH, moisture content, aeration, NH_3 concentration or temperature (Bishop & Godfrey, 1983). These losses during composting of animal manure range from 21% upward to 77% (Martins & Dewes, 1992; Rao Bhamidimarri & Pandey, 1996). Nitrogen losses varied depending on several environmental factors such as aeration, moisture content, and temperature (Bishop & Godfrey, 1983). Ogunwande et al. (2008) reported that C:N ratio had significant ($P \leq 0.05$) effect on pile temperature, total N, total C, C: N ratio, dry matter, P and K while turning frequency had significant ($P \leq 0.05$) effect on pile temperature, pH, TC, C:N ratio and K. The decreasing level of C:N ratio is correlated by the loss of TOC to produce carbon dioxide and smaller increase of nitrogen as the decomposition progressed. The decreasing pattern of the C:N ratio and TOC, and the increasing pattern of nitrogen content were reported by Abdullah et al. (2013) and Goyal et al. (2005) on sugarcane trash, cattle dung, pressmud, poultry waste and water hyacinth composting. The key to the development of compost technology is to control the changes and N losses, and this has attracted the attention of many compost researchers (Cordovil et al., 2007; Meijide et al., 2007; Wu et al., 2010; Huang et al., 2005; Hua et al., 2009).

Apart from N, C is another element that is most likely to be lost during the composting process. Zhang and He (2006) reported that N and P decomposition primarily occurred in the mesophilic phase, while organic carbon decomposed in the thermophilic phase during co-composting of solid swine manure with pine sawdust and 30% swine manure with initial C:N ratio of about 40 was more desirable for composting organic substrates. The nutrient loss especially nitrogen is an unavoidable problem during the composting of organic waste (Cooperband & Middleton, 1996; Rao & Pandey, 1996). Carbon may be lost due to either bio-oxidation, in which carbonaceous materials are lost as CO_2 (Bishop & Godfrey, 1983; Eghball et al., 1997) or mineralization of C, in which inorganic C is converted to organic C (Bernal et al., 1998). The compost quality could further be improved by adding cow manure, poultry manure or yard waste etc (Gautam et al., 2010). The adjustment of the C:N ratio of lingo-cellulosic composts by the addition of N source from animal residues proved to a reliable composting process and the end products characterized by a good degree of stability, and compatible with safe and effective soil utilization (Cayuela et al., 2009).

7.2 Effects of Co-Composting on Soil Quality

The application of stabilized co-composted manure to soil can affect soil fertility by improving physical, chemical and biological properties of the soil (Dick et al., 1993). The physical changes involve modifications of soil bulk density, structure, strength and water relations. The chemical changes include the accumulation of organic plant nutrients, the soil's ion exchange capacity, chelating activity and buffering ability. Composted animal manure can enlarge the nutritional base for soil microorganisms. Incorporated manure composts also become part of the soil humus and employ their influence on long-term basis. Such inclusions of soil amendments are particularly important where the soils are poor enough in terms of OM content (Tiquia & Tam, 2002).

The effect of compost on soil pH depends both on the initial pH of the compost and the soil pH (Tiquia & Tam, 2002). Organic amendments significantly increase the soil reducing exchangeable acidity, exchangeable Al, and exchangeable Fe that altered soil chemical properties in a way that enhanced the availability of phosphorus pH (Schulz et al., 2014; Chng et al., 2014). Manures have been proven to lower the pH of alkaline soils (Chang et al., 1991). Increasing the pH of acidic soils has also been demonstrated frequently by the use of livestock manure (Hue, 1992; Whalen et al., 2000; Baziramakenga et al., 2001). Elamin (1991) demonstrated that the decomposition of organic matter tended to improve the soil physical and chemical proprieties.

End product of co-composted plant residues and animal manure greatly influence the biochemical and structural properties of the soil. Mineralization of plant residue has been demonstrated to be the best soil amendment and animal manures as organic fertilizer (Mondini et al., 2010). The addition of plant residues tended to increase the microbial pool due to lack of N availability, the addition of animal by-products led to the rapid increase of the microbial biomass (Cayuela et al., 2008). Co-composted biochar incorporation induced soil alkalization which increasd soil nitrification (Lehmann et al., 2003; Yamato et al., 2006; Amlinger et al., 2007).

7.3 Heavy Metals during Co-Composting

Compost usually contains heavy metals based on initial raw material. Generally, these heavy metals (micronutrients) are essential for plant growth. The micronutrients present in the compost, such as Zn, Cu and Fe, are utilized by the plants during the fertilizing process. These trace elements are required for a better plant growth in trace quantities but in large quantities can cause phytotoxicity, consequently can impose hazardous risks to human and fauna (Eneji et al., 2003; Simth, 2009; Van Herwijnen et al., 2007). However, constant and extensive application of organic compost will lead to the accumulation of heavy metals in the soil and an increase in toxic levels. Heavy metals can render the growth, morphology and metabolism of soil microorganisms, consequently affect the fertility of soil reduced (Bragato et al., 1998). Uptake of heavy metals by plants and successive accumulation in human tissues and bio magnifications by the food chain can adversely affect human health and environment concerns (Wong et al., 2006; Chiroma et al., 2013). Addition of lime during composting process, natural zeolite and bamboo charcoal amendments tend to immobilize metals and reduced heavy metals availability and leachibility. (Singh & Kalamdhad, 2013) suggested that bioavailability and leachability of metals should be assessed before adding composted manure to the agricultural fields. Composting process tended to increase total P, K, Cu, and Zn (Jusoh et al., 2013) due to the losses of organic C, H, N, and O in the forced-aeration piles as demonstrated by (Tiquia & Tam, 2002) where CO_2 and H_2O during composting process, leaving Cu and Zn behind and giving a relative increase in the concentrations of these elements. The organic amendments tend to increase organic P compared with soil alone as showed by Chang et al. (2014). Moreover the high sorption capacity caused by aromaticity of the bio char (co-composted) influenced nutrient cycling (Glaser et al., 2002). Biochar applied in higher amounts, soil nutrient availability increased in highly weathered tropical soils comparable (Lehmann et al, 2002, with ~560 Mg ha^{-1}; Lehmann et al., 2003, with 67.6–135.2 Mg ha^{-1}; Steiner et al., 2007, with 11 Mg ha^{-1}). According to Kostov et al. (1995), compost had a significant impact over manure in respect of nutrient release.

7.4 Bulk Density during Co-Composting

Reduction in soil bulk density may be expected when soil is mixed with less dense organic material, but there may also be associated with alteration of soil structure. The magnitude of change for bulk density and other soil properties likely to vary with soil texture as demonstrated by Aggelides and Londra (2000). Decreased bulk density and increased water holding capacity of soil have been characterized by the addition of the organic amendments. Bulking agents acted as moisture adjuster due to their low moisture level and higher cellulose content, which can be a source of carbon (Abdullah et al., 2013). The addition of bulking agent (yard trimmings, woodchips, rice husks) to the chicken litter help to reduce the loss of N by reducing ammonia loss (Wan et al., 1999, Tiquia & Tam, 2000). The decrease bulk densities and increase soil water holding capacities of the organically amended treatments in comparison to the control is due to enhanced aggregation of soil particles by the addition of organic matter (Khaleel et al., 1981; Grandy et al., 2002; Elsharawy et al., 2003).

7.5 Agronomic Benefits of Co-Composting

Plant growth significantly increased with compost amendment (Schulz et al., 2014). Co-composting rabbit manure with rice straw and mushroom residues was found efficient to utilize the material to enhance seed production (Li-li et al., 2013). Chicken manure resulted in an increase growth attributes as well as forage yield as indicated by Ismaeil et al. (2012). Several researchers reported that nitrogen and phosphorus uptake, as a function of chicken manure application, progressively exceeded with composted manure (Magid et al., 1998; Postma et al., 1998; Hue & Sobieszczyk, 1999; Abusuwar & El Zalal, 2010). The increase in organic P with the increasing of time is essential to mineralize P in soil for crop use and influenced the crop yield and growth (Chang et al., 2014). Agronomic considerations including increase crop productivity, reduced fertilizer and pesticide use have been reported with the application of composted manure (Schulz & Glaser, 2013; Jaffery et al., 2011; Blackwell et al., 2013).

8. Conclusions

Co-composting is an effective solid waste management that helps to manage a variety of solid waste (poultry waste, animal waste, food waste agro-waste, municipal solid waste, industrial sludges and effluents etc.) and converts them into a valuable product that may enhance the fertility of the soil by acting as soil conditioner. This process is simple having lowest operational cost and an alternative of costly fertilizer used for enhancing the soil nutrients. The process of co-composting can help to promote the complexation of heavy metals whose mobility and availability tend to decrease with decreasing toxicity. Bio-degradable waste can successfully be co-composted with different types of organic wastes to get higher quality cocomposted product. There is a need to study quality characteristics and possible benefits of compost.

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