Int.J.Curr.Microbiol.App.Sci (2017) *6*(3): 1487-1495

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 3 (2017) pp. 1487-1495**
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2017.603.171

Urban Organic Solid Wastes as Farmland Manure and Fertilizers: A Review

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Keywords

Urban solid waste, Compost, Sewage sludge, Soil amendments, Fertilizers.

Article Info

Accepted:
22 February 2017
Available Online:
10 March 2017

A B S T R A C T

The proper management of solid waste, the concept of prevent and minimize waste and maximize reuse, recycling and use of environmentally friendly alternative materials. With increasing population made management of municipal solid waste (MSW) as a severe problem. In the present paper the aspects of urban organic solid waste management pertaining to agriculture application special emphasis to manure and fertilizers are reviewed. The application of organic solid waste materials in agriculture as a fertilizer has been highlighted. The use of solid waste materials as a fertilizer, nutrient supplier, media for nursery, soil amendments, compost etc promoted the use in agriculture as well as solve problem of disposal but also will increase productivity in agriculture. However, negative effects of solid waste materials such as heavy metal level, biological contamination, ground water pollution and human health, must also be taken into consideration.

Introduction

In present century urbanization and industrialization produces enormous amount of urban solid wastes. The wastes, qualitatively and quantitatively, contaminate environment and present a potential health risk for humans and domestic animals. Improving waste management is recognized as a major environmental challenge. The proper management of solid waste minimize adverse effects on environment and improve resource efficiency. The concept of prevent and minimize waste and maximize reuse, recycling and use of environmentally friendly alternative materials.

According to Central Pollution Control Board, 1,27,486 TPD (tons per day) of municipal solid waste (MSW) was generated in India during 2011. Out of total waste generated, approximately 89,334 TPD (70%) of MSW was collected and only 15,881 TPD (12.45%) was processed or treated (CPCB, 2012). The rate of municipal waste generation in India in 2011 was 127458.1 TPD. This was divided by urban population to get per capita waste generation rate of 0.356 kg/day. The amount of waste generated per capita estimated to increase at rate of 1-1.33% annually (CPCB, 2012).

Municipal Solid Waste management is becoming a critical problem which leads to loss of resources and increased environmental risks. Urban solid waste consists of more than 40 percent of organic waste, so composting most of this waste would be the best way to reduce the quantity to one fourth resulting in nutrient rich soil amendment. Composting is

an age old practice for the biological conversion of organic waste to humus like substance which can enhance physical, chemical and biological soil properties. For the assurance of an effective solid waste management, implementations of appropriate solid waste treatment strategies are vital. This can be enhanced through the utilization of technologies that are most economically efficient, sustainable and eco-friendly Atalia1 *et al.,* (2015).

Production of organic fertilizer from solid wastes and its subsequent utilization in crop production and soil rehabilitation and reduce volume of wastes that were brought to dumpsites, minimize environmental pollution and degradation and increase productivity of agricultural land. Fertilizer as a source of plant nutrients for farm production not only reduces cost of fertilizer but serves as ultimate solution for restoring lost fertility of agricultural soils as well as soil health which leads to sustained soil productivity.

The important aspects of solid waste management pertaining to agriculture application are reviewed in different section such as composting, media preparation of nursery raising and transplanting, fly ash application, human waste uses and soil amendments etc.

Composting

The concept of large-scale composting of municipal waste was developed in the Netherlands in 1932 (Slater and Frederickson, 2001). The Major characteristics of quality compost are: full ripeness, organic matter content, absence of weed seeds and pathogenic organisms, purity, pH value from 6 to 7.8, absence of heavy metals and toxic substances, particle size <13 cm, dark color, agreeable earthy odour and moisture content below 50%.Application of different organic fertilizers i.e. manure, compost and vermicompost is essential for sustainable management of soil in safe food production (Milošev *et al.,* 1998; Čuvardić *et al.,* 1999; Čuvardić 2005; 2006). The application of urban solid biodegradable waste compost in agriculture are elaborated below

Naderia and Ghadirib (2010) investigated the effects of urban waste compost (UWC), manure and chemical fertilizer on the initial growth of corn. Results showed that increase in urban waste compost and manure increased corn dry matter, height, stem diameter, leaf area, leaf number, and leaf N. It can be concluded that manure and compost can be effective nutrient sources for corn production and can be considered as potential alternatives to chemical N fertilizer. Therefore, manure and compost can be effective nutrient sources for corn production and can be considered as potential alternatives to chemical N fertilizer.

Varma and Kalamdhad (2013) used different proportion of Composting of Municipal solid waste (MSW) mixed with different proportion of cattle manure i.e. 1:1.5 (Trial 1), 1.5:1 (Trial 2) and 1:1 (trial 3) were compared in a rotary drum composter. It was observed that trial 2 produced higher quality compost with final total nitrogen (2.16%), final total phosphorus (3.24 g/kg), final Total Organic Carbon (17.04%) and final electrical conductivity (EC) (2.78 dS/m) within 20 days of composting. The results showed that characteristics of MSW mixed with different proportion of cattle manure significantly influence the compost quality and process dynamics in rotary drum composter

Gautam *et al.,* (2010) assessed the feasibility of composting of source separated organic matter of municipal solid waste (MSW) generated in low, middle and high income areas of Jabalpur city Results of MSW analysis indicated the presence of high

percentage of Biodegradable organic matter, acceptable moisture content and C/N ratio. All quality parameters in the compost samples were found to be within the acceptable limits set by international standard. The pH ranged between 7.8-8.1, organic matter 45%, moisture 36% and have acceptable amount of plant nutrients C (35%), N (0.05%), P (0.002), Na (4.8%), K (0.35%). The compost quality could further be improved by adding cow manure, poultry manure or yard waste etc. Its use in plant production or land reclamation may be helpful to maintain soil fertility and improve moisture holding capacity. MSW Composting could be adapted country wide to recycle/reuse the organic residue as solid waste management option.

Bundela *et al.,* (2010) reviewed the different effects of MSW compost application on soil microbial biomass and activity appreciable amount of heavy metals in MSWC does not seem to have any detrimental influence on microbial biomass and enzyme activities in soil. But there are some reports which show that heavy metals present in MSWC decrease the proportion of microbial biomass C in total soil organic matter. The increase in soil microbial biomass with the MSWC amendments is mainly due to the microbial biomass present in the organic residues and the addition of substrate C, which stimulates the indigenous soil microbes. Effect of HMs on soil microbes depends on soil as well as MSW characteristics and its amendment rates. Therefore physicochemical analysis of MSWC is necessary before its land application. More research is needed with different soil types and MSW amendment rates to evaluate the effect of MSWC application on soil microbial biomass and reach the final conclusion.

Transplanting media

Municipal solid waste is approximately 60-90% biodegradable and might be used as a bulking material to absorb excess water, occupied by nutrients and supply a useful raw product for agriculture and horticulture. Numerous studies have addressed the use of compost in nursery plant production. Organic residues such as urban solid wastes, sewage sludge, pruning waste, spent mushroom and green wastes, after proper composting, can be used in growth media to replace peat or growing media and used for vegetable transplant nursery. The some of the reviews in this background are highlighted

Papamichanlak *et al.,* (2014) determined the effect of mixing MSWC and peat in cucumber transplant production by conducting the experiment. The study concluded that Municipal solid waste compost was found to be a suitable alternative component of mixed-peat substrates for watermelon seedlings provided it accounts for less than 30% of the mixture combined with fertilizers with more positive effects when minerals were provided through hydro fertigation rather than basic fertigation.

Pala and Bhattacharyya (2003) applied the water extracts of municipal solid waste compost (MSWC) to seed of three crops – rice, wheat and cucumber. The study found that 1 : 7.5 (MSWC: water) extract provided the optimum conditions for seed germination after which the toxicity phenomenon became evident and provides precaution regarding applying MSWC in fields and always try to maintain the optimum level at which the seeds can germinate properly

Chrysargyris, *et al.,* (2013) studies the impacts of municipal solid waste compost (MSWC) in different media combination on melon seed germination and seedling production in nurseries study. The six media [(% v/v): peat: MSWC (100:0) as control; peat: MSWC (85:15); peat: MSWC (70:30); peat: MSWC (55:45); peat: MSWC (40:60) and peat: MSWC (0:100)] were prepared

from commercial peat and MSWC. The study found that under nursery conditions, addition of MSWC (especially in content greater than 30%) reduced leaf numbers produced, seedling fresh weight. No significant differences observed in leaf stomatal conductance in plants grown in different MSWC contents. Thus, low content (up to 30%) of MSWC may act as an alternative substitute of peat in melon seedling production.

Castillo *et al.,* (2004) conducted three year trial on different types of growing media to evaluated the nursery-produced tomatoes using (Five mixtures of substrates were used: old peat (65%) + white peat (30%) +perlite (5%), old peat (65%) + MSW compost (30%) + perlite (5%), MSW compost (65%) + white peat (30%)+ perlite (5%), MSW compost (95%) + perlite (5%) and MSW compost (50%) + cocofiber (50%). However, growth and development of the tomato seedlings in the mixture: old peat (65%) +MSW compost (30%) + perlite (5%) were similar to that obtained with the standard mixture: old peat (65%)+ white peat (30%) + perlite (5%). The quality of the MSW compost used, particularly in terms of its pH and EC, influenced the percentage of seedling emergence and subsequent seedling development; The MSW compost used as a single substrate and the mixture of MSW compost and cocofiber had highly irregular seedling growth indices and therefore less favorable performance; this was not the case with mixtures of MSW compost and peat.

Fly ash application

The use of coal as a prime energy source and generate the fly ash. Disposal of high amount of fly-ash from thermal power plants absorbs huge amount of water, energy and land area by ash ponds. In order to meet the growing energy demand, various environmental, economic and social problems associated with the disposal of fly-ash. Therefore, fly-ash management would remain a great concern of today. Fly-ash has great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. The high concentration of elements (K, Na, Zn, Ca, Mg and Fe) in fly-ash increases the yield of many agricultural crops. However, several studies proposed that FA can be used as a soil additive that may improve physical, chemical and biological properties of the degraded soils and is a source of readily available plant micro- and macro-nutrients. Numerous studies revealed that the lower fly ash incorporation in soil modifies the physico-chemical, biological and nutritional quality of the soil. Jala and Goyal (2006) reviewed various attributes of fly ash and explore the possibility of exploiting them for agronomic advantage. Presence ofhigh concentration of elements such as K, Mg, Fe, Zn and Ca in readily available ionic form increases their uptake by plants. Soils prone to soil or water erosion can be stabilized through fly ash amendment. A careful assessment of soil and fly ashis required before its application as a soil-ameliorating agent.

Basu *et al.,* (2009) identified the advantages of fly-ash use in agriculture. The potentiality of fly-ash for its use in agriculture due to the fact that it contains almost all the essential plant nutrients i.e., macronutrients including P, K, Ca, Mg and S and micronutrients like Fe, Mn, Zn, Cu, Co, B and Mo, except organic carbon and nitrogen. The second advantage that can substitute lime, a costly amendment for acid soils, it cannot be a substitute for chemical fertilizers or organic manures. Fly-ash is also useful for stabilizing erosion-prone soils. Use of fly-ash instead of lime as soil ameliorant can reduce net CO2emission and thereby lessen global warming. Pandey and Singh (2010) revealed the effectively use of fly ash in barren or

sterile soil for improving quality and enhancing fertility. There were several potential beneficial and few harmful effects of FA application in soil:(a) Beneficial effects: (i) improves soil texture; (ii) reduces bulk density of soil; (iii) improves water holding capacity; (iv)optimizes pH value; (v) increases soil buffering capacity; (vi)improves soil aeration, percolation and water retention in the treated zone (due to dominance of silt-size particles in FA); (vii)reduces crust formation; (viii) provides micro-nutrients like Fe, Zn, Cu, Mo, B etc.; (ix) provides macro-nutrients like K, P, Ca, etc.; (x) reduces the consumption of soil ameliorants (fertilizers, lime); (xi) FA can also be used as insecticidal purposes;(xii) decreases the metal mobility and availability in soil.(b) Harmful effects: (i) reduction in bioavailability of some nutrients due to high pH (generally from 8 to 12); (ii) high salinity; (iii) high content of phytotoxic elements, especially boron.

Sewage sludge

The sewage sludge contents plant macro and micro nutrients as well as organic matter which make sludge disposal in soil as best option. Nitrogen has received most attention and it is normally the most abundant sludge nutrient. One of the best alternatives to waste disposal is through the soil-plant system as a fertilizer. Based on properties different wastes can be co-recycled in order to take simultaneously the best profit and minimize environmental pollution. The some of application of sewage sludge in term of fertilizer as describe below.

Ahmed *et al.,* (2010) Carried out using six different doses of sewage sludge were treated and barley was grown in the amended soils. In barley plants it was observed that higher yield, the higher the nitrogen contents. Electrical conductivity rose with organic amendment. Also it improved nutrient level of soil, particularly nitrogen and available phosphorus. In conclusion, sewage sludge used in this study was very poor sources of phosphorus plant growth, primarily because aluminium treatments were used to precipitate phosphorus in the sludge phosphorus in the sludge was in organic form so microbial mineralization had little effect on phosphorus availability.

Singh (2015) evaluated the effect of organic wastes on soil is soil microbial biomass. Soil microbial biomass is very sensitive to environmental impact and there are already several studies evaluating the effect of organic wastes on soil microbial properties. The study concluded that agricultural utilization of urban waste may be beneficial. The physicochemical analysis of sewage sludge is necessary before adecision is made to use it for land application and, Research is needed on application to different soil types and at urban waste amendment rates to evaluate effects on soil microbial biomass.

Černý *et al.,* (2012).conducted the field experiment on achernozem soil to estimate fertiliser N efficiency of silage maize by the difference method as influenced by the type of N fertiliser i.e. mineral-MF vs. sewage sludge-SS, and N rate. The average values of recovery efficiency of applied N (REN) were calculated as 41–57%. The use of SS increased the yield of silage maize by 19–25% compared to control, above all first and second year after their application. Mineral-fertilizer-N equivalents (MFE) for SS were calculated as 55 and 64%

Ozyazıc *et al.,* (2013) determined the effects of sewage sludge applications on the yield and yield components of plants under crop rotation system. Seven treatments were compared. The results showed that all the yield components of wheat and yield of white head cabbage and tomato increased significantly with increasing rates of sewage

sludge as compared to control. As a result, 20 t ha^{-1} of sewage sludge application could be recommended suitable dose for rotation of wheat-white head cabbage-tomato in soil and climatic conditions of Bafra Plain.

Human excreta application

The human excreta are rich in nutrients and called as black gold and may be applicable directly or indirectly to crop production system. The selected applications are explained below.

Gensch *et al.*, (2011) used urine treatment for agriculture production in Philippines and showed that urine treatment produced the best marketable yield, were comparable to results of the synthetic fertilizer treatment, which produced no significant difference or slightly lesser yields. Compared with no fertilizer application, the addition of urine in quantities corresponding to plant needs significantly increased the marketable yield by 1.5 to 5 times, depending on the type of plant and the study location. The final composted product is a nutrient-rich, humus-like substance with a high organic carbon content that allows for improved water retention and a longer lasting fixation of essential nutrients. The addition of charcoal (coming from carbonized rice husks, coconut shells, tree clippings, aids in the absorption of nutrients.

Pradhan *et al.*, (2007) used human urine as a fertilizer in cabbage cultivation and compared with industrial fertilizer and non fertilizer treatments. Urine-fertilized plants may grow more rapidly, so the plants can be harvested earlier, thus making more efficient use of the land. The use of urine fertilizer could reduce the demand for industrial fertilizer to some extent, which would reduce the environmental pollution released during fertilizer manufacture and transportation. The results show that human urine could be used as a fertilizer for cabbage and does not pose any significant ygienic threats or leave any distinctive flavor in food products.

Organic soil amendments

Diacono and Montemurro (2010) reviewed the long-term experiments (3–60 years) on the effects of organic amendments used both for organic matter replenishment and to avoid the application of high levels of chemical fertilizers. Repeated application of exogenous organic matter to cropland led to an improvement in soil biological functions. For instance, microbial biomass carbon increased by up to 100% using high-rate compost treatments, and enzymatic activity increased by 30% with sludge addition. Long-lasting application of organic amendments increased organic carbon by up to 90% versus unfertilized soil, and up to 100% versus chemical fertilizer treatments. (Crop yield increased by up to 250% by long-term applications of high rates of municipal solid waste compost.

McGeehan (2012) evaluated the waste-based and organic amendments for their ability to improve soil fertility and crop performance. Organic matter content and available N, P, and K were significantly increased by the various amendments although the extent of increase was determined by the composition of the amendment. All solid amendment types (composts, biosolids, and LYF/LYW) greatly increased the organic matter content.

Mekki *et al.*, (2013) investigated fertilizing potential of three agro-industrial wastes (Compost (C), Dehydrated Manures (DM) and Digestate (D)) on soil properties, on seeds germination and the plants growth. Results showed that addition of wastes, modified several soil properties as pH, Electrical Conductivity (EC), Water Retention Capacity (WRC) and Soil Organic Matter (SOM).

Hence, SOM increase from 1.5% in unamended soil to 2, 2.3 and to 3.1% in soils amended with (D), with (DM) and with (C) respectively.

Adjia1 *et al.,* (2008) assessed the impact of amendment using untreated municipal solid wastes on the trace element contents of periurban areas soils was carried out in Ngaoundere. The results revealed that the soil total concentrations of Cu, Zn, Cd and Pb were below the typical agricultural soil critical level for the soil control and out of the critical level for amended soils. The results of study also showed that municipal solid wastes used as fertilizer offers important benefits as aliming material because of its high pH and high organic carbon, Ca and Mg contents. However, The results revealed that amended sites were polluted with Cu, Zn, Cd and Pb. This is therefore hazardous for agricultural purposes since the bioavailability of heavy metals depends also on their total concentrations in soil.

In conclusion, application of urban solid waste can be used in agriculture as a soil conditioner but also as a fertilizer. Composting is conversion of organic waste into valuable fertilizer. Compost has potential to use as fertilizer thus it is increasingly used in agriculture as a soil amendment improving the physical and chemical properties of soil. Large amounts of urban solid waste compost are frequently used in agriculture to meet crop nitrogen requirements and for addition of organic matter. In addition to this urban solid waste compost has also been reported to have high salt concentrations, which can inhibit plant growth and negatively affect soil structure. The MSW also contents of heavy metals, to lower the risk of soil contamination with heavy metals and harmful organic compounds, the production and application of MSW compost should be duly legislated and strictly controlled. The integrated application of different waste materials will also enhance the management and disposal of solid waste as fertilizer.

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How to cite this article:

Ingle, P.M., H.N. Bhange, B.K. Gavit and Purohit, R.C. 2017. Urban Organic Solid Wastes as Farmland Manure and Fertilizers: A Review. *Int.J.Curr.Microbiol.App.Sci.* 6(3): 1487-1495. doi: https://doi.org/10.20546/ijcmas.2017.603.171