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Agricultural utilization of biosolids: A review on potential effects on soil and plant grown

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ABSTRACT

Environmental and economic implications linked with the proper ecofriendly disposal of modern day wastes, has made it essential to come up with alternative waste management practices that reduce the environmental pressures resulting from unwise disposal of such wastes. Urban wastes like biosolids are loaded with essential plant nutrients. In this view, agricultural use of biosolids would enable recycling of these nutrients and could be a sustainable approach towards management of this hugely generated waste. Therefore biosolids i.e. sewage sludge can serve as an important resource for agricultural utilization. Biosolids are characterized by the occurrence of beneficial plant nutrients (essential elements and micro and macronutrients) which can make help them to work as an effective soil amendment, thereby minimizing the reliance on chemical fertilizers.

However, biosolids might contain toxic heavy metals that may limit its usage in the cropland. Heavy metals at higher concentration than the permissible limits may lead to food chain contamination and have fatal consequences. Biosolids amendment in soil can improve physical and nutrient property of soil depending on the quantity and portion of the mixture. Hence, biosolids can be a promising soil ameliorating supplement to increase plant productivity, reduce bioavailability of heavy metals and also lead to effective waste management.

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1. Global production of solid wastes and biosolids: An update

The increasing global population has directly resulted in generation of huge amounts of diverse solid wastes worldwide. In this era of globalization; accelerated industrialization and urban development have led to the injudicious use of natural resources and consequent production of complex solid waste (Singh et al., 2014). Solid wastes from an urban area originate from a variety of sources like industrial, residential, and commercial sectors as well as from personal and public spaces (Table 1). Approximately, 4 billion tons of solid wastes (comprising of municipal, industrial and hazardous wastes), is produced annually on a global basis, of which generation of municipal solid waste (MSW) ranges from 1.6 to 2 billion tons (Vaish et al., 2016a). In any country, the quantity of solid waste generated is directly governed by factors such as economic prosperity and strength of its urban population (Hassan, 2000). In countries with higher income, residential sector contributes around 25–35% of the total waste generated (World bank, 1999). Solid wastes produced by the urban centers also comprise of industrial wastes produced by industries of small and medium scale (Singh et al., 2011a).

The global trend of waste generation reveals faster growth in rates of MSW generation on the lines of urbanization and increasing GDP. In the present waste generation scenario, 1.3 billion tons of MSW is generated by the world cities, which is likely to reach up to 2.2 billion tons by the year 2025 (Hoornweg and Bhada-Tata, 2012). Significant variations in accelerated waste generation rates, among the different regions and countries of the world is visible based on the degree of their urbanization, economic development, population and industrial growth (Srivastava et al., 2015; Vaish et al., 2016b). Regional variation in global MSW generation rates are clearly evident in a World Bank report which approximates 62 million tons of annual waste generation in the sub Sahara African region to 160 million tons in the Latin American and the Caribean region, reaching a figure of 572 million tons for OECD countries. According to the same report, the Asian region of the world accounts for a total generation of 433 million tons of solid waste annually comprising of 270 million tons by East Asia and Pacific region, 93 million tons by Eastern & Central Asia and 70 million tons by South Asia (Hoornweg and Bhada-Tata, 2012; Ofosu-Budu et al., 2015).

A study by World Bank predicts an increase by 1.14–1.73 times in rates of per capita urban waste generation in both developed and developing countries between the period of 1995 and 2025 (Hoornweg et al., 1999; World Bank, 2008). With high urbanization and industrialization, Shanghai in China generates 17,000 tons day^{-1} waste. Similar trends are also reported from major cities of developing countries like - Nepal, Pakistan, Guinea, Amman, etc. (World Bank, 2008). Similarly, the urban Indian population generates around 1,09,598 tons day^{-1} of MSW, which has been predicted to increase up to 3,76,639 tons day^{-1} by the year 2025 (Hoornweg and Bhada-Tata, 2012).

During 2004–2005, the yearly generation of MSW in India ranged between 35 and 45 million tones with Metropolitan cities like Mumbai, and Delhi generating 7000 and 6000 tons of waste per day respectively (Hanrahan et al., 2006). With the current population of 1.28 billion, which includes 33% urban population, per year generation of MSW in India is expected to augment over 150 million tons by 2025 (Hanrahan et al., 2006) and 300 MT by 2047 (Pappu et al., 2007). Huge areas of land are required for disposal of the enormous quantity of waste generated. In the year 1997, 20.2 Km^2 area of land was used to manage 48 MT of waste and 169.6 Km^2 area of land would be required for disposal of 300 MT by 2047 (CPCB, 2000; Pappu et al., 2007).With this trend of burgeoning population and increasing rate of waste generation, maintaining a pristine urban environment, for the future generations, appears to be a daunting task.

Biosolids is an important type of organic wastes among the various categories of solid waste (Singh et al., 2014). Biosolids also referred to as sewage sludge or domestic wastewater residuals is an insoluble biological solid residue or organic waste resulting from different sewage treatment processes (Singh and Agrawal, 2007, 2008, 2010a; Singh et al., 2011b; Usman et al., 2012) in wastewater treatment plants worldwide (Marguí et al., 2016). In the present day world of diminishing natural resources and energy crisis, the importance and need of developing a sustainable approach towards environmentally sound solid waste management cannot be ignored (Pappu et al., 2007). The improper disposal of solid wastes like biosolids and other biowastes pose a serious threat to the environmental quality leading to problems like groundwater contamination, degradation of soil quality, etc.

Over the time, different approaches of safe biosolids disposal such as incineration, soil application, land filling (Marguí et al., 2016; Kominko et al., 2017) and sea dumping have been explored (Sanchez Monedero et al., 2004). Disposal methods like land filling and ocean dumping have their own demerits due to scarcity of land, pollution problem and also don't lead to reuse of the beneficial constituents of biosolids (Wong, 1995; Singh and Agrawal, 2008). As a result, the United States and several European countries have banned the ocean dumping of biosolids since 1991 and 1998 (USEPA, 1999a,b; Zhidong and Wenjing, 2009). According to CPCB estimates, out of 22,900 million liters per day (MLD) of domestic

Table 1
Comparison among different types of solid wastes, their generation and treatment processes (Data adapted from – Jacobi and Besen, 2011; Singh et al., 2011a, 2015; Singh and Sarkar, 2015).

Type of waste	Sources	Treatment procedure
Household waste	Houses, Buildings, Companies, Schools, etc.	Sanitary land filling, Recyclable sorting plants, Composting plants, Dump site
Commercial waste (Small generator)	Shops, Bars, Restaurants, Companies, etc.	Sanitary land filling, Selective collection sorting plants, Dump site
Commercial waste (Large generator)	Shops, Bars, Restaurants, Companies, etc.	Sanitary land filling, Selective collection sorting plants, Dump site
Street waste	Sweeping and pruning	Sanitary land filling, Composting plants, Dump site
Medical waste	Hospitals, Clinics, Offices, Laboratories, and others	Incineration, Dump site, Sanitary land filling, Septic ditch, Microwave, Autoclave, Recyclable sorting plants
Industrial waste	Small and large industries	Industrial landfill, Dump site
Transport waste	Ports, Airports and terminals	Incineration, Sanitary land filling, Dump site
Agricultural waste	Agriculture	Empty packaging plants, Recyclable sorting plants, Incineration
Construction waste	Residential, Commercial construction and remodelling	Eco-point, Trans-shipment and sorting area, Recycling area, RCC landfill, Dump site
Hazardous waste	Household, Hospitals, Laboratories, Industries, etc.	Recyclable sorting plants, Dump site
e-waste	Household, Offices, Industries, etc.	Recyclable sorting plants, Dump site

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