Role of Microorganisms in Solid Waste Management

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Abstract

Daily enormous quantities of waste materials are generated in all villages, towns and cities of India. Incorrect waste management is harmful to human and environmental health. Being unpleasant, it causes many more issues like air pollution, water pollution when dumped into the water or nearby water bodies, it also depletes the ozone layer when burnt, thereby increasing the impact of climate change. It is evident that different types of waste are causing adverse effect on living organisms and environment. Biodegradation is an eco-friendly and cost effective technology as compared to other outdated or traditional methods such as incineration for waste decomposition. Biodegradation is nature's way of reutilizing and recycling wastes, or breaking down organic matter into nutrients that can be used and reused by other organisms. Utilization of potential and effective microorganisms for decomposition of solid waste is very helpful. The effective microbes or their consortium is used for transformation of wastes into nutrient rich compost or manure. The generated compost can be utilized as organic input in different areas of agriculture and horticulture. In this review, we have presented importance of solid waste management by application of effective microorganisms. Biodegradation or microbial decomposition of wastes will result in nutrient rich organic compost. With this knowledge unplanned and improper dumping of wastes can be addressed and proper utilization of decomposed wastes can be carried out.

Keywords: Solid waste, microorganisms, composting, biodegradation.

Introduction:

Swift urbanization, industrialization and exponential population growth has put high pressure on the natural resources, that directly as well as indirectly affects environment globally. Such tremendous changes in environment and society lead to generation of wastes. The management of solid waste is facing serious problems in current era, due to the unavailability of appropriate facilities to treat and dispose of the huge amount of solid waste generated every day in municipal cities. An incongruous management of wastes using conventional/traditional procedures (Aruna *et al.,* 2018**;** Alam and Ahmade, 2013) has made negative impacts on environment. Frequently it has been observed that wastes are burnt, disposed into water bodies, dumped by the roadsides (Ogwueleka, 2009). Around 50% of wastes generated are organic in nature (Sharholy *et al.,* 2008; Imam *et al.,* 2008; Getahun *et al.,* 2012); thus, the appropriate management of organic wastes will significantly diminish the dimensions of pollution arising from improper waste management.

In maximum Indian municipal areas, solid waste management system comprises of waste generation, collection, transportation and disposal. The management of solid waste needs proper organization, maintenance and upgrade for all activities. With time proper management of solid wastes are becoming costly and complex because of incessant and unplanned urbanization. So it becomes difficult to provide proper services at each urban area. Overall exercise is to degrade the generated wastes along with agricultural waste and reuses the same as fertilizer in agriculture or horticulture. With the application of efficient microorganisms or their consortiums it's possible to generate organic compost. The process of conversion of biodegradable solid wastes or organic matter into nutrient rich manure can be carried out by a huge assortment of life forms comprising mainly bacteria, actinomycetes, fungi, algae and protozoa. Bacteria and fungi play vital role in decomposition of organic wastes and both are abundantly available groups (Mattes *et al.*, 2010). Composting of wastes is eco-friendly and very economical technology used by technologists as well as farmers.

Solid waste and its biodegradability

Waste is defined as any undesirable or unwanted solid, liquid, or gaseous material (Rajan *et al.,* 2019) and if these wastes are not properly managed it will spoil both environment and human health. Moreover solid wastes are defined as waste not transported by water; that has been rejected for further use. It includes industrial, mining, municipal and agricultural wastes so on. The main content of theses wasters are large organic matter, ash and fine earth, paper and plastic, glass and metals (Sharholy *et al.,* 2007). In most metro cities and towns solid waste management is one of the toughest tasks. Metro cities as well as towns are facing severe pollution problems due to the generation of huge quantities of solid waste (Kumar *et al.,* 2004).

Waste management has become an important field of research because of swelling concern of environmental pollution and resources shortage (Brewer, 2003). Because of theses wastes human and animal diseases prevail, air and soil environment are getting spoiled and the entire natural ecosystem got imbalanced (Zaved *et al.,* 2008). As per Environment Protect Agency in 1989, only 10% of this MSW is being recycled, while 80% goes in to landfills, and 10% is incinerated. If proper attention has not been given to the generation and management of solid wastes it will give birth to serious health, environmental and economic issues. Not much attention is given to solid waste management in budget, which make decision-making process slow. With time it is becoming more problematic, due to lack of wakefulness about rules and regulations, as well as environmental concerns with poor resources, have created a disordered condition (Dass, 2007). The situation of waste management is significantly dissimilar between established and emerging countries because developing nations are lacking of proper collection and disposal mechanism of waste.

Based on the biodegradability, wastes can be classified into biodegradable, moderately degradable, and non-biodegradable. Different microorganisms have potentiality to act on biodegradable wastes; they can be aerobic and anaerobic microbes as a result of speeding up rate of degradability. Some agricultural wastes such as cow dungs, poultry droppings, straw etc. are examples of biodegradable wastes (Bhat *et al.,* 2018). Degradable organic wastes are known as biodegradable wastes (Abdel and Mansour, 2018). Moderately

degradable wastes are those wastes which can degrade slowly as compared to biodegradable wastes as they possess strong textured constituents e.g., wood and cardboards etc. (Bhat *et al.,* 2018). Finally non-biodegradable wastes, are those wastes which cannot be broken down biologically or non-biodegradable (Alam and Ahmade, 2013) e.g., mines, mineral materials, polythene bags, leathers, plastics etc.

Table 1: Different types of waste

Waste based on matter	**On the basis of degrading feature**	**On the basis of environmental impact**	**On the basis of source**
• Solid • Liquid • Air emissions	• Bio-degradable • Non- biodegradable	• Hazardous • Non-hazardous	• Household • Medical • Radioactive • Electronic • Industrial • Nuclear

People from rural areas don't use separate containers like plastic or metal containers to keep segregated waste as biodegradable and non-biodegradable (Dass, 2007). The total quantity of waste generated on day to day basis in each of the villages is considerably low when compared with urban areas. There is huge difference in generated waste composition as waste collected from towns was found to be 48% decomposable, 30% recyclable and 22% inert material. While as wastes from surrounding villages have approximately 73% decomposable, 20% recyclable and 7% inert materials. So it is evident that wastes generated in rural areas contain more of biodegradable component.

Role of potential microorganisms in solid wastes management

Microorganisms are ubiquitous in nature; they carry out variety of essential functions. Different microorganisms have adapted themselves to specific environmental niches. Technologies developed from microbial world are successfully applied to a wide range of environmental issues, particularly in waste management. All naturally formed substances are biodegradable, so they can be degraded or decomposed by microorganisms such as bacteria or fungi. Potential and effective microorganisms have facilitated reasonable, cost-effective and eco-friendly responses which would have been impossible through chemical or physical engineering approaches (Satyanarayana *et al.,* 2012). When solid wastes are burnt, greenhouse gases such as carbon dioxide and nitrous oxide are released, these lead to ozone layer depletion and greenhouse effect (Bhat *et al.,* 2018). A significant way of successfully combating this hazard is through the use of microorganisms.

Numerous microorganisms have efficacy to oxidize or decompose different organic compounds into simpler ones and stabilized end products (Atalia *et al.,* 2015). Theses microorganisms including mesophilic bacteria, actinomycetes, fungi and protozoa have

capability to colonize a heap of biodegradable solid waste (Gajalakshmi and Abbasi, 2008). Other than this different bacteria have potential to degrade hydrocarbons i.e., hydrocarbons-degrading ability (Yakimov *et al.,* 2007). Kafilzadeh *et al.,* (2011) reported diverse types of bacteria, with good hydrocarbons degradability potential; e.g., *Bacillus* sp., *Corynebacterium* sp., *Staphylococcus* sp., *Streptococcus* sp., *Shigella* sp., *Alcaligenes* sp., *Acinetobacter* sp., *Escherichia* sp., *Klebsiella* sp., and *Enterobacter* sp. of which *Bacillus* sp. has the best hydrocarbons degradability potential. So microbes play important role in management of solid wastes, it can be upgraded for productive results with the help of composting technology. Well composting is recognized system for rapid stabilization and humification of organic matter (Adani *et al.,* 1995), as well as an eco-friendly and economical substitute technique for managing solid organic waste (Huang *et al.,* 2006). When organic material or waste is converted under aerobic circumstances it gives us compost (Lasaridi *et al.,* 2018) and composting is measured as a harmless method of waste management. In general composting means conversion of diverse biodegradable wastes into nutrient rich products that are highly beneficial and can be used as biofertilizers and soil amendments (Cai, *et al.,* 2007; Bai, *et al.,* 2010; Yu, *et al.,* 2019). Other than direct composting procedure oorganic wastes can be transformed into renewable biogas and compost with the application of potent microorganisms under controlled conditions (Wang *et al.,* 2011). Organic ccompost helps in improving soil fertility, pathogen resistance and plant yield (Majbar *et al.,* 2018). With the help composting technology, microorganisms transform organic ingredients such as manure, sludge, leaves, fruits, vegetables and food wastes into product like soil humus (Rynk, 1992; Reinikainen and Herranan, 1999).

Figures 1 & 2: Heap preparation of agricultural wastes

Wide range of microorganisms have been used efficiently for solid waste management such as *Bacillus* sp., *Corynebacterium* sp., *Staphylococcus* sp., *Streptococcus* sp., *Scenedesmus platydiscus*, *S. quadricauda*, *S. capricornutum*, *Chlorella vulgaris*, etc. Like bacteria produces enzymes which can break down complex carbohydrates into simpler forms (Hamdy, 2005), and use them as

nutrients or food. Effective microorganism technology was given by Dr. Teuro Higa, Professor of Horticulture in Okinawa, Japan in 1995 for development of microbial consortium, this technology was used for management of wastes and its conversion into quality compost. Effective microorganisms are regarded as mixed broth culture of microorganisms that "work together with the beneficial in the area to which it is added, creating a synergy among microorganisms and larger forms of life". Different researches have suggested that effective microorganisms can be used in different fields like agriculture, livestock, gardening and landscaping, composting, bioremediation, cleaning septic tanks, algal control and household uses (Higa and Chinen, 1998). Various microorganisms are used as component of microbial consortium or effective microorganism: Lactic acid bacteria - *Lactobacillus plantarum, L. Casei, Streptococcus lactis,* Photosynthetic bacteria, *Rhodopseudomonas palustrus, Rhodobacters paeroides,* Yeasts - *Saccharomyces cervisiae, Candida utilis,* Actinomyces - *Streptomyces albur, S. griseus,* Fermenting fungi – *Aspergillus oryzae, Mucor hiemalis. So these* Effective microorganisms can be used for management of generated solid wastes or organic wastes. They will convert generated wastes into nutrient rich compost, which can be further used in agricultural and horticultural areas. Composting is a biological process which transforms varied organic wastes into compost that is humus like substances by mixing effective microorganisms under optimal conditions of moisture, temperature and aeration. Through composting organic waste materials are decomposed and stabilized into a product that can be used as soil conditioner and organic fertilizer (Ahmad *et al.*, 2006).

Conclusion

Improper waste management is a common practice which is not safe and can be replaced with safer waste management method such as composting. The world is tending towards improving environmental and human health. As a form of organic fertilizer, composting can play a significant role in achieving this goal. Managing waste at source is more important than the conventional way of handling waste. Bacterial biodegradation is one of the effective methods to treat solid wastes, in addition to being eco-friendly, wealth creating and a sustainable method. An effective or operative system of waste management is the need of the hour and should be economically and environmentally sustainable. So researchers should put more efforts to find out novel potential microbial isolates that will multiply process of composting and can be utilized in all concerned areas.

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