**PROSPECTS OF BIOSOLIDS IN AGRICULTURE**

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ABSTRACT

The widespread use of chemical fertilizers and intensive mining have both contributed to the degradation of the soil systems and the quality of the environment. Because of on going population growth, urbanization, and industrialisation, the production of sewage sludge is rising quickly. Due to the possibility of recycling valuable components including organic matter, nitrogen (N), phosphorus (P), and other plant nutrients, sludge obtained from wastewater treatment plants is becoming more and more popular for use in agriculture. Previously known as sewage sludge, biosolids are largely the nutrient-rich organic solid waste materials produced as a byproduct of the municipal waste-water treatment process and agro-industries. Wastewater solids can be used in agriculture as biosolids when they are stabilized by digestion or another treatment method.

**Keywords:** Biosolids, Sewage sludge, Recycling

INTRODUCTION

Previously known as sewage sludge, biosolids are largely the nutrient-rich organic solid material created by the municipal waste-water treatment process. When wastewatersolids are stabilized by digestion or another treatment method, they become biosolids and can be used in agriculture as fertilizers or liming agents. The word "biosolids," which was first used in the United States, is frequently used to refer to various types of treated sewage sludge used as a soil conditioner in agriculture. The word "biosolids" distinguishes between high quality, processed sewage sludge and sewage sludge that contains significant amounts of contaminants as well as raw sewage sludge. Sewage sludge's chemical and biological makeup is influenced by the makeup of the waste water (Melo *et al*., 2002)

It is estimated that Indian cities and towns together generate approximately 19,127 tons of sludge per day (Press Information Bureau, Government of India, Swachh and Swath Bharat-Report, National Informatics Centre (NIC), New Delhi (2015). It is projected that by 2050, about132 BLD of wastewaters with a potential to meet 4.5% of the total irrigation water demand would be generated thereby further widening this gap (Bhardwaj, 2005).

Nutrient-rich biosolids products can be beneficially applied to the soil as a soil conditioner. High levels of organic matter, as well as nitrogen (N), phosphorus (P), and other nutrients necessary for plant and crop growth, are provided by biosolids to landowners. Additionally, biosolids affect the structure, moisture retention, moisture content, and cation exchange capacity of the soil. The nutrients in biosolids are released gradually; 15–25% of the N and P are made accessible in the first year, and the remaining portion is made available over the following years.

Categories of Biosolids:

* The EPA has two categories of biosolids:
* Class A biosolids undergo more treatment process than Class B biosolids, to the point where the concentration of pathogens is reduced to levels low enough so that no additional restrictions or special handling precautions are required by the Biosolids.
* Class B biosolids treatment processes will reduce but do not eliminate pathogens. For this reason, federal regulations require additional measures to restrict public access and limit livestock grazing for specified time periods after land application of Class B biosolids.

Different forms of Biosolids

* Biosolids cake - raw sludge is stabilised biologically (most commonly by anaerobic digestion) and the liquid biosolids are dewatered to produce biosolids cake. The cake varies between 15 to 30 % solids for consistency, with the balance being water. The cake can be dried further by air drying.
* Biosolids pellets - raw sludge or liquid biosolids are dewatered to approximately 20% total solids then further heated in a dryer and dried to 95 % total solids and then pelletised.
* Lime amended biosolids - raw sludge or biosolids are first dewatered followed by stabilisation with the addition of lime.
* Composted biosolids - dewatered raw sludge or biosolids are composted, typically with other organic materials, to produce a high-quality product suitable for use

Pollutants and concentration limits:

* There are three sets of federal limits applicable to biosolids to be land applied These are termed Ceiling Concentration (mg/kg) Cumulative Pollutant Loading Rates (kg/hectare) Pollutant Concentrations (mg/kg).
* If these concentrations are not exceeded in the biosolids to be land applied, the Cumulative Pollutant Loading Rates do not need to be tracked.
* Ceiling concentration limits (CCL): These are the maximum concentrations of thenine trace elements allowed in biosolids to be land applied. Sewage sludge exceeding the ceiling concentration limit for even one of the regulated pollutants is not classified as biosolidsand, hence, cannot be land applied.

Trace element pollutants from commercial and industrial wastes that are discharged into the wastewater system are also present in biosolids. To determine the final grade for product classification, metal contamination in biosolids are subject to intensive sampling and analysis. The biosolids are sorted into five contamination grades, ranging from A to E (A being the least contaminated), with the lowest grade for any one pollutant determining the ultimate product classification. The majority of the product entering the program for land application is of contamination grade.The suitability of a particular biosolid for land application can be determined by physical, chemical and biological analyses.

Important properties of biosolids are:

1. Total solids

2. Volatile solids

3. pH and Calcium Carbonate Equivalent (CCE)

4. Nutrients

5. Trace elements

* PathogensNutrients are elements required for plant growth that provide biosolids with most of their economic value. These include N, P, K, calcium (Ca), magnesium (Mg), S, B, Fe,Mn, and Zn.
* Trace elements are found in low concentrations in biosolids. The trace elements of interest in biosolids are those commonly referred to as “heavy metals.”
* Federal and state regulations have identified the following nine trace elements: Arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn).
* Pathogens are disease-causing microorganisms that include bacteria, viruses, protozoa, and parasitic worms.

Can present a public health hazard if they are:

* Transferred to food crops grown on land to which biosolids are applied
* Contained in runoff to surface waters from land application sites
* Transported away from the site by vectors such as insects, rodents, and birds.
* Federal and state regulations specify pathogen and vector attraction reduction requirements that must be met by biosolids applied to land.

PROPERTIES OF BIOSOLIDS

1. Physical properties of biosolids:

There are two biosolids products: dewatered biosolids (DWB) and lime amended biosolids (LAB)

Lime-amended biosolids (LAB)

Dewatered biosolids can be mixed with lime in the form of calcium oxide to help reduce odor and eliminate microorganisms. In the final product, hydrated lime and calcium carbonate are present in substantial amounts. Its alkalinity (pH of roughly 12) guarantees that microorganisms have been significantly reduced in the product. It serves as a replacement for agricultural lime and has a similar liming value. It includes around 30% organic matter and has low amounts of nitrogen and phosphorus.

Due to LAB's strong alkaline nature, which transforms much of its nitrogen into ammonia gas, there is considerable ammonia odor. It is applied at a rate that will have the same liming impact on the soil as the prescribed amount of agricultural lime.

Dewatered biosolids

In rural areas, dewatered biosolids (DWB) are frequently applied to the soil. To dewater biosolids to about 20% solids, a centrifuge or belt press is utilized. The product contains a variety of plant nutrients, but high levels of nitrogen, phosphorus, and organic matter, which enhance soil fertility and physical characteristics, are its key advantages for agriculture.

DWB is a dark substance that resembles organic, damp soil. Depending on the weather, it can occasionally have a strong smell, which may persist for several weeks after application. The degree of odor is frequently determined by the product's quality.

Organic matter

One of the key factors driving demand for biosolids is its high organic matter content. The biological activity of soil is boosted by the incorporation of organic components like SS (Saviozzi et al. 1999). By boosting soil water holding capacity, enhancing soil aggregation, and lowering soil bulk density, organic matter enhances soil physical quality and the environment for roots. The cation exchange capacity of soil can also be raised by applying biosolids. Depending on the climate, soil structure, and management, these effects should last for several years following application. In addition to inactivating pathogens and aiding in nutrient cycling, the organic matter provided by biosolids application may also promote the development of beneficial soil microbial populations.

1. Microbiological properties of biosolids

What hazards do pathogens in biosolids bring to animal and human health when they are used in agriculture is a crucial question. Processes for treating wastewater are intended to lessen the amount of pathogens in biosolids. Although the overall quantity of bacteria decreases over time after application, some can endure for several months and even grow. Despite the fact that handling the product requires following standard hygiene precautions, this does not in and of itself constitute a serious health risk. According to research, managing biosolids-treated sites in accordance with the NSW Guidelines reduces hazards to people's and grazing animals' health, either directly or indirectly through the food chain.Chemical properties of biosolids

The chemical properties of biosolids are affected by various factors:

* Wastewater quality – extent of industrial pre-treatment
* Extent of wastewater treatment – primary, secondary, tertiary
* Process applications – use of chemicals

Methods for stabilization (e.g., lime treatment).

IMPACT OF BIOSOLIDS ON SOIL PROPERTIES

Impact on Soil Physical Properties

A plentiful supply of organic matter is sewage sludge. Urban sewage typically has a high organic component, typically greater than 50% of the dry matter. In most soils, adding organic matter in the form of sewage sludge will have a significant impact on the physical characteristics of the soil. Following sludge amendments, the improved aeration and drainage may indirectly change the associations between heavy metals in the soil and plant growth. Due to the stability of organic components in biosolids, increased soil aggregate formation and stability may be greater than for animal manures. Improved water infiltration is crucial, particularly in highland areas where the top soil is thin and deficient in organic matter as a result of soil erosion and terrace grading.Impact on Soil Microbial Properties.

In general, adding organic manure in the form of sewage sludge will boost the population, biomass, and activity of soil microbes. Consequently, there is a significant change in the soil life. Application of sludge with modest levels of heavy metal concentrations enhanced soil microbial activity. Because metal is cemented into calcareous alkaline soils, any negative effects on microbial biomass will only last a short time. The introduction of sewage sludge gives microbes a substrate for action, increasing the enzyme activities in the soil (Stark et al. 2008). In the end, both the microbial population and biomass will rise, and their functions will improve. Patel and Patra (2014) also noted that the amount of tannery sludge (TS) increased the dehydrogenase activity. They described how dehydrogenase is understood to.

Impact of on Soil Chemical Characteristics

An agricultural soil's organic matter content will rise as a result of the addition of sewage sludge, and this will result in the creation of humic and carbonic acids, which are essential for regulating the qualities of the soil. These acids will cause the pH of calcareous soils to decrease. High cation exchange sites are present in humic compounds.Effect of biosolids on crop growth

Crop yields were not considerably impacted by liquid sludge application in 60% of the cases tested, but they were significantly boosted in 26% of the cases. the advantages for soil structure. On the clay and calcareous loam soils treated with liquid sludge and the sandy loam and clay soils treated with bed-dried sludge, reductions in wheat grain yield of 6–10% were recorded. The most likely cause of the production drop, however, was assumed to be lodging of the crop as a result of too much nitrogen in the soil rather than metals. According to Gomez-Rico et al. (2008), sewage sludge addition can improve nutrient availability and repair deteriorated soils.

PRODUCTION OF BIOSOLIDS

Industrial waste Treatment

Wastewater or sewage treatment is a multistep process: 1.Primary Treatment (Physical Process)

* Removal of large objects using grates and screens
* Settling to remove suspended solids (primary sludge)
* Flocculating chemicals are added to enhance sedimentation

2. Secondary Treatment (Microbial Process)

* Supernatant or primary effluent contains high levels of dissolved organic load (Biological Oxygen Demand).
* Decomposition of organic matter.

1. Aerobic method

* Aeration to stimulate aerobic degradation activated sludge reactor
* Trickling filter reactor
* Pathogen Removal by Activated Sludge
* More than 90 per cent of E.coli. and Salmonella are destroyed
* Bacteria are removed by inactivation, grazing by ciliated protozoa, and adsorption to sludge solids

1. Anaerobic method:

* Septic Tanks typically treat small volumes of waste (e.g., from a single household, small commercial/industrial).
* WWTPs typically treat larger volumes of municipal or industrial waste.

ii. Thickening:

* Low force separation of water and solids by gravity, flotation, or centrifugation.
* Increase solids content by removing water.
* Lowers transportation costs.

3. Stabilization methods

i. Digestion (anaerobic and/or aerobic)

* Biological stabilization via conversion of organic matter to carbon dioxide,water, and methane.
* Reduces biological oxygen demand, pathogen density, and attractiveness of thematerial to vectors
* Reduces quantity of biosolids.

ii. Alkaline stabilization:

* Stabilization through the addition of alkaline materials.
* Raising pH to 12 reduces biological activity (esp. pathogen density) and attractiveness of the material to vectors.
* High pH immobilizes metals.

iii. Heat Drying:

* Drying of biosolids by increasing temperature during wastewater treatment.
* Destroys pathogens, eliminates most of water.
* Greatly reduces sludge volume.

iv. Conditioning: Processes that flocculate biosolids to facilitate ease of water separation (i.e., dewatering).

v. Dewatering:

* High force separation of water and solids by vacuum filtration, centrifugation, filter and belt pressing.
* Increase solids concentration to 15 per cent to 45 per cent and lowers nitrogen and potassiumconcentrations.
* Improves ease of handling, reduces land requirements, lowers transportation costs.

4. Advanced stabilization methods:

5. Composting: Composting is one of the most versatile and remunerative techniques for handling such biodegradable solid wastes by biological stabilization into a safer and more stabilized material called as compost.

6. Destroys pathogens and converts sludge to humus-like material Excellent soil conditioning properties.

ADVANTAGES AND DISADVANTAGES OF BIOSOLIDS

Advantages

* Improves soil properties for optimum plant growth, including structure, tilth, friability, fertility and water holding capacity.
* Reduce need for commercial fertilizers.
* Less leaching loss of nutrients.
* Slow release of nutrients.
* It returns valuable nutrients to the soil and enhances conditions for vegetative growth.
* It increases the microbial activities.
* Reduces the soil erosion.
* Easy to store, transport and use.

Disadvantages

* Process is labour intensive.
* Biosolids may contain hazardous chemicals.
* Odours from biosolids applications are the primary negative impact to the surrounding people.
* Contamination resulting from industrial waste.
* Land application can have negative impacts on water, soil, and air if not practiced correctly.

CONCLUSION

Recycling of organic waste through land application serves several purposes. Reuse of organic waste not only helps to reduce large amount of waste produced by the society but also cut down the cost of its disposal, besides, providing a beneficial way for recycling of nutrients lost from soil. Since sewage sludge is rich in organic matter and many macro and micronutrients, recycling of sludge for agricultural purpose seems to be an appealing solution for sustainable management of sludge. Sewage sludge production is rapidly increasing resulting from the continuous increase in population, urbanization and industrialization.

The beneficial effects of biosolids on soil fertility were evidenced in soils in terms of:

* Increased N-supply potential.
* Organic matter content.
* Nutrient uptake and biomass production.
* Land application of sewage sludge may be the least energy consuming and the most cost- effective means of sludge disposal or utilization.
* This can be a good approach to meet the nutrient requirements of crops but dangerous when improperly managed.

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