**Prospects of Biosolids in Agriculture**

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ABSTRACT

The widespread use of chemical fertilizers and extensive mining activities has contributed to the deterioration of the environment quality and soil systems. Sewage sludge production is rapidly increasing resulting from the continuous increase in population, urbanization and industrialization. There is an increasing interest in the agricultural application of sludge obtained by wastewater treatment plants, due to their possibility of recycling of valuable components such as organic matter, Nitrogen (N), phosphorus (P) and other plant nutrients. Biosolids are primarily the nutrient-rich organic solid materials produced as a by-product of agro-industries and also the municipal waste-water treatment process, previously referred to as sewage sludge. Wastewater solids become biosolids, when they are stabilized by digestion or other treatment process and can be beneficially used in agriculture as either a liming agent or fertilizer. Biosolids supplies high levels of organic matter, as well as nitrogen (N), phosphorus (P) and other nutrients essential for plant and crop growth. Biosolids improves soil properties such as structure, moisture content, organic matter content and porosity.

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

INTRODUCTION

Biosolids are primarily the nutrient-rich organic solid material produced by the municipal waste-water treatment process, previously referred to as sewage sludge. Wastewatersolids become biosolids when they are stabilized by digestion or other treatment process and can be beneficially used in agriculture as either a liming agent or fertilizers. Biosolids is a term coined in the United States that is typically used to describe several forms of treated sewage sludge that is intended for agricultural use as a soil conditioner. The term biosolids distinguishes high quality, treated sewage sludge from raw sewage sludge and from sewage sludge containing large amounts of pollutants. The chemical and biological composition of sewage sludge depend on the waste water composition (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).

Biosolids products that are rich in nutrients can be beneficially used as a soil conditioner for land application. Biosolids offer landholders high levels of organic matter, as well as nitrogen (N), phosphorous (P) and other nutrients essential for plant and crop growth. Biosolids also contribute to soil properties such as structure, moisture retention, moisture content and cation exchange capacity. The nutrients in biosolids are slow release with 15–25 per cent of the N and P becoming available in the first year and the remainder over subsequent 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.

Biosolids also contain trace element contaminants that result from industrial and commercial wastes being released into the wastewater system. Biosolids undergo extensive sampling and analysis of a range of metal contaminants to determine the final grade for classification of the product. The biosolids are divided into five contaminant grades from A to E (A the least contaminated) with the final product classification determined by the lowest grade for any one contaminant. Most of the product going into the land application program is contaminant 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)

Lime in the form of calcium oxide can be added to dewatered biosolids to help reduce odour and destroy pathogens. The end product contains significant levels of hydrated lime and some calcium carbonate. Its alkalinity (pH about 12) ensures that the product has undergone a significant reduction of pathogens. It is used as a substitute for agricultural lime, with a liming value generally contains low levels of nitrogen and phosphorous and is approximately 30 per cent organic matter.

LAB has some odour of ammonia, due to its strong alkaline nature, which converts much of its nitrogen to ammonia gas. It is applied at a rate to provide the same liming effect asthe recommended rate of agricultural lime on that soil.

Dewatered biosolids

Dewatered biosolids (DWB) is widely used for land application in rural areas. A centrifuge or belt press is used to dewater biosolids to approximately 20 per cent solids. The product contains a range of plant nutrients, but its main benefit to agriculture is its nitrogen, phosphorous and organic matter levels, improving soil fertility and physical properties.

DWB is black, with an appearance of moist organic soil. It can be quite odorous at times and this can linger for several weeks after application depending on the weather conditions. The quality of the product often determines the level of odour.

Organic matter

Biosolids contains high levels of organic matter and this is one of the main reasons people want to use it. Incorporation of organic materials, such as SS into soil promotes its biological activity (Saviozzi *et al*. 1999). Organic matter improves soil physical quality and root environment by increasing soil water holding capacity and improving soil aggregation and by reducing soil bulk density. Application of biosolids can also increase soil cation exchange capacity. These effects should persist for several years after application, depending on climatic conditions, soil structure and management. Organic matter supplied by biosolids application may also encourage the growth of beneficial soil microbial populations that inactivate pathogens and are important in nutrient cycling and organic matter for soil heal.

1. Microbiological properties of biosolids

An important question with biosolids use in agriculture is what health risks do pathogens in biosolids pose for animal and human health. Wastewater treatment processes are designed to reduce the pathogen numbers in biosolids. Although bacteria numbers decrease with time after application some can persist for some months after biosolids application, and can even increase. This does not in itself pose a significant health risk, although usual hygiene practices apply when handling the product. Research has shown that management of areas treated with biosolids according to the NSW Guidelines minimizes risks to the health of humans and grazing animals either directly or through the food chain.

1. 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

Sewage sludge is a rich source of organic matter. Organic content of sludge in urban sewage is generally high, usually more than 50 per cent of dry matter. Addition of organic matter in the form of sewage sludge will have profound effect on soil physical properties and positive soil conditioning effect on most soils. The improved aeration and drainage following sludge amendments can have indirect effects on soil plant relationships of heavy metals through affecting growth. increased soil aggregate formation and stability may be greater than for animal manures due to stability of organic compounds in biosolids. Improved water infiltrationis important especially on upland areas where the top soil is shallow and low in organic matterdue to soil removal by erosion and grading in terrace formation. Increasing rate of sewage sludge for growing wheat decreased the bulk density and increased total porosity.

Impact on Soil Microbial Properties

In general, addition of organic manure in the form of sewage sludge will increase soil microbial activities, their population and microbial biomass. Consequently, the soil life goes through a considerable changing. Application of sludge containing low concentration of heavy metals improved soil microbial activities. Since in calcareous alkaline soils metal get fixed into the soil, therefore, any adverse effect on microbial biomass will be temporary. Sewage sludge application provides the substrate for the action of microbe and thereby increase the soil enzyme activities (Stark *et al*. 2008) Ultimately the microbial population/biomass will increase and their activities will enhance. The increase in dehydrogenase activity with increasing levels of tannery sludge (TS) was also reported by Patel and Patra (2014). They explained that dehydrogenase is known to oxidize soil organic matter.

Impact of on Soil Chemical Characteristics

Addition of sewage sludge to an agricultural soil will increase organic matter content in the soil, which leads to production of humic and carbonic acids that play a fundamental role in conditioning soil properties. These acids in calcareous soils will lower the soil pH. Humic substances have high cation exchange sites.

Effect of biosolids on crop growth

In 60 per cent of the cases studied crop yields were not significantly affected but in 26 per cent of the cases liquid sludge application resulted in significantly increased crop yields. The beneficial effects on soil structure. Reductions in wheat grain yield, from 6 – 10 per cent, were noted on the clay and calcareous loam soils treated with liquid sludge and the sandy loam and clay soils treated with bed-dried sludge. However, this yield reduction was not thought tobe due to metals but the most likely explanation was lodging of the crop as a result of excessive nitrogen in the soil. Sewage sludge addition can increase nutrient availability and restore the degraded soils (Gomez-Rico *et al*. 2008).

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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