Urbanization and industrialization accompanied with increased production of sewage sludge from different sources in India. Its disposal and management in a cost effective and environmentally friendly way is one of the serious problems of the country. An estimated 38,354 million liters of sewage with an equivalent amount of sludge per day is presently generated in India (Kaur et al. 2012). Due to high economic and environmental costs involved in its disposal through incineration and land filling operation, land application of sewage sludge in agriculture may be a more preferred option as it provides an opportunity to recycle the plant essential nutrients and organic carbon (OC) to soil which provides win-win strategy of solid waste management and also manure for crop production to maintain green and clean mother earth. However, their potential hazardous over long period usage has to be carefully monitored and regulated from time to time.

Introduction

Sewage sludge is the residual, semi-solid substance produced as a by-product during the sewage treatment of industrial or municipal wastewater. Properly treated and processed, sewage sludge are nutrient-rich organic materials. Moreover, sewage sludge can be recycled and applied as fertilizer to improve and maintain productive soils and stimulate plant growth. The management options other than directly letting in to waterbodies helps in controlling water pollution.

Scenario of sewage generation in world and India

According to central pollution control board (CPCB), New Delhi, about 38354 million liter per day (MLD) wastewater generated from cities and towns is the main cause of freshwater pollution in India. However less than half of this quantity only about 11786 MLD is treated by the sewage treatment plants and rest of the sewage is discharged without treatment. Therefore, almost all the water bodies including lakes, ponds wetlands, streams, rivers and their catchments areas are severely polluted due to the discharge of untreated or partially treated sewage effluent.

Sewage sludge as potential source of manure for crop production

During the recent years, waste minimization and recycling or reuse policies have been introduced so as to reduce the amount of waste generated and alternative waste management strategies are being exploited, to reduce the negative environmental footprints. Sewage sludge as raw material for industrial production, energy production and soil amendment. The research reports clearly indicates the use of sewage sludge enhances the overall growth and yield of agricultural crops and reduce the application of chemical or synthetic fertilizers.
Management options for sewage sludge

Different sources of sludge generation

a) Municipal sewage sludge: It is the sludge generated from waste water treatment of municipal water which is directly let into the outskirts of the city or nearby tanks after treatment or in some cases directly discharged. It is a good source of plant nutrients hence farmers having their farmlands near by peri urban areas use it as an alternative source of manure for crop production because of meagre of animal manure due to low livestock population.

b) Tannery sludge: Tannery sludge is a potential source of organic matter, macro and micronutrients, essential for plant growth; it improves the soil productivity. However, the application of tannery sludge to agricultural land may introduce toxic heavy metals (Cr, Fe, Mn, Cu, and Ni) into the food system.

c) Brewery sludge: Due to increasing environmental concerns and regulations, there have been attempts to utilize this brewery byproduct in an ecofriendly manner of brewery waste water sludge (BWS) as an organic fertilizer in agriculture.

d) Bio methanated sludge: Distillery waste is rich in organic matter and nutrients especially nitrogen, potassium and can also be utilized as a source of irrigation water in water scarcity areas. Thus, the availability of nutrients in distillery effluents and the possibility of substituting these for inorganic fertilizer in agriculture have a great promise.

e) Dairy sludge: The dairy industry consumes 2 to 6 m$^3$ of water per tonne of milk entering the plant. Over 75,000 tonnes of sludge gets generated in India from the treatment of wastewater from milk processing plants. Nutritional composition of dairy sludge depends on the different dairy products production and its methodologies. For example, cheese factories have 50% more phosphorus than
fresh milk dairies. Dairy sludge has lower levels of heavy metals or other harmful components than sewage sludge.

**Physico-chemical properties of sewage sludge**

Generally, the sewage sludge is made up of 20% fat, 50% carbohydrate (sugar, starch and fibre), 30-40% organic matter, 3-4% N, 1.5-2% P and 0.7-1.5% K. The pH of the sewage sludge is normally ranged 6.5 - 7.0 (Swapnil et al. 2011). Apart from the basic beneficial constituents of sewage sludge it is characterized by the presence of certain toxic heavy metals that is a global environmental concern when it comes to their land application. One of the prime reason for heavy metal contamination in sewage sludge is unplanned or miss-managed urban sewage system that leads to mixture of sewage with industrial wastewater and also from commercial sources, waste water runoff from city roads etc. Concentrations of elements like Cu, Cd, Co, Ni and Zn were found to be constantly greater in sewage sludge.

**Effects of sewage sludge on soil properties**

Land application of sewage sludge has earned popularity in view of its potential to recycle valuable components of sewage sludge such as organic matter, N, P, and other plant nutrients and more so especially for soils deficient in organic matter. Soil properties like structure, porosity of soil, soil moisture, electrical conductivity, cation exchange capacity and humus content are significantly modified due to addition of sewage sludge (Pascual et al., 2009). However, indiscriminate sludge application may disturb the soil properties due to presence of higher levels of toxic constituents and heavy metals.

High levels of organic matter and available nutrients in organic amendments like sewage sludge lead to enhanced soil microbial activity biochemical activity and also microbial biomass initially. Sewage sludge amendments can affect soil enzyme activity in following ways.

1. Solid phase surface properties of sewage sludge could lead to increased stabilization of extracellular enzymes.

2. It could enhance soil enzymatic activity by providing substrates such as peptides and proteins thereby increasing microbial proliferation. Though sewage sludge amendment added to the soil results in increased soil microbial, enzymatic activities, but the presence of heavy metals in the sludge may also affect the soil enzymatic activities indirectly resulting in reduced soil enzyme activities during longer incubation and higher heavy metal availability.

**Remediation of heavy metals toxicity in contaminated soils**

For remediation of heavy metal contaminated soils, a wide array of techniques has been proposed. Physical remediation, chemical remediation, phytoremediation, and agro-ecological engineering techniques are the major remediation techniques of heavy metals in soils.

Excavation, removal, washing, and land filling of metal contaminated soils are some of the physical remediation techniques which are very effective at lowering risk, however, they are expensive to implement.

Although phytoremediation, i.e., use of hyper accumulator plants (Typha sp.) for ameliorating contaminated soils, has received considerable attention but one of the major problems associated with this approach is low metal removal rate for example. In addition, phytoremediation is of limited applicability in urban soils.

Primary mechanisms involved in chemical remediation of heavy metals through different amendments are cation exchange, adsorption, surface complexation and precipitation. Alkaline...
materials used as chemical immobilization treatments include calcium oxides, fly ash, and calcium and magnesium carbonates. They can reduce heavy metal solubility in soil by increasing soil pH and concomitantly increasing metal sorption to soil particles.

**Effect on growth and development crop plants**

Land application of sewage sludge for agricultural purposes has been a widely practiced disposal method due to its multiple benefits of recycling of plant nutrients, improvement in soil’s physicochemical and biological properties, rich source of organic matter, all of which contribute significantly towards plant growth, development and increasing crop yields. Sewage sludge application provides varying amounts of macronutrients mainly nitrogen and phosphorus to crops.

**Heavy metal effects on plants**

Sensitivity of plants to metal toxicity can be associated with the tendency to accumulate the metal in shoots. The concentrations of trace metal elements in plant parts follow a pattern with the concentration in roots > leaves > stems > grain. Thus, the potential hazard from metals is apparently reduced if only the seed is harvested and used as a food source. The translocation factor (TF) is a common index that is used for estimating the movement of heavy metals from roots to shoots thereby evaluating the relative risks associated with consumption of the shoot parts of plants. Decreasing values of translocation factors for heavy metals with increasing application of sewage sludge indicating stronger accumulation of heavy metals in roots than in shoots.

**Environmental issues related to agricultural utilization of sewage sludge**

It contains various potentially toxic elements such as heavy metals, persistent organic pollutants, different polychlorinated biphenyls, dioxins, alkyl sulfonates, nanoparticles, from personal care products, pharmaceuticals and pathogenic agents (i.e. bacteria, protozoa, viruses).

**Conclusion**

Production of majority of the agricultural crops has also been benefitted from the land application of sewage sludge. But the major problem associated with its use in the crop land arises due to increase in the concentration of bioavailable heavy metals to soil when applied at excessively high rates or when the sludge bears high concentration of these metals. However, low doses of sludge application do not cause heavy metals accumulation above the safe limit in edible portion of the crops to cause health hazards to both humans as well as animals. It is therefore recommended that prior to application in the soil the dose of sewage sludge must be standardized for a particular crop based on heavy metal and other pollutant concentrations.

**References**

