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Sewage Sludge and Its Impact on Soil Health

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The green revolution in India has resulted in a tremendous increase in fertiliser usage; nonetheless, balanced nutrient supply remains a critical restriction in the growth of Indian agriculture. Excess nutrient mining, such as crop removal of N, P, K, and micronutrients, exceeds fertiliser supply. The situation will worsen in the future as more has to be produced from diminishing land resources as the world's population grows. As a result, fertiliser treatment must be increased in order to maintain soil fertile and agriculture viable. The soil's nutrient providing capability is becoming a limiting issue as a result of continual intense farming and the adoption of high yielding crop cultivars with high nutrient requirements.

Due to rising prices, the use of chemical fertilisers in crop production cannot be overstated; thus, they must be complemented or replaced by accessible organic waste or manures. To maintain fertility and increase crop yields, intensive farming often requires a considerable supply of organic matter. Sewage sludge/biosolids are a rich source of organic nutrients and a byproduct of municipal and industrial wastewater treatment. Sewage sludge is generated by sewage treatment plants as a consequence of the removal of solids and organic waste from sewage.

As an organic waste, sewage sludge is an excellent source of plant nutrients such as N, P, K, S, Ca, Mg, Fe, Cu, Mn, and Zn, as well as other organic elements. Because these nutrients are critical for plant growth and development, sewage sludge might be used as a fertiliser supplement. Sewage sludge is a sewage treatment plant byproduct that arises from the removal of particles and organic materials from sewage (municipal as well as industrial waste water). It is then digested, thickened, pasteurised, and lime stabilised, among other things. However, these approaches are expensive and pollute the environment. Because sewage sludge is an excellent source of organic matter and plant nutrients, land application of sludge for crop production is a viable and cost-effective disposal option.

However, some heavy metals may be present in excess in sewage sludge and may be phytotoxic (e.g., Zn, Cu, and Ni) or detrimental to human health (Cd, Pb, Hg). Cadmium, which enters the food chain more easily than mercury, is of particular concern among these heavy metals. Large amounts of sludge application may also result in salt buildup. Given the aforementioned issue, the use of sewage sludge in agricultural production requires vigilance to prevent degradation of soil quality and its negative impact on plant and human health. In view of above problem, use of sewage sludge in crop production needs precaution to avoid deterioration of soil quality and its harmful effect on plants and human health. The many types of sewage sludge, as well as their preparation methods, are listed below.

Table: 1 Different types of sludge

Sewage sludge	Production method and some crucial aspects
Conventionally treated sludge	The sludge is digested to guarantee that the microbiological content is reduced by 99 percent.
Enhanced treated sludge	Various methods are used to treat the sludge, which completely eliminates the pathogen. Drying sludge to make granules (98 percent dry solid), lime pasteurisation or digestion, and heat treatment are some of the methods used.
Composted sludge	Undigested sludge that has been dewatered composts the fastest. Sludge that has been composted is an odourless, friable soil-like substance. To improve aeration, cereal straw or another agent is added to the sludge. The composted material has a limited availability of nitrogen but is rather rich in phosphorus.
Lime treated sludge	In a controlled environment, undigested sludge cake is combined with lime or discarded lime materials to generate a friable and readily handleable product. The product's pH is high, which causes ammonia to escape, lowering N concentration and P availability.

Nutrient content in sludge

Municipal sewage sludge and effluents are high in organic matter and include significant levels of major and micronutrients. As a result, the continued use of sewage sludge and sewage irrigation significantly decreases the soil's nutritional need. Due to the mixing of industrial wastes with sewage, sewage sludge and effluents may include significant levels of harmful heavy metals such as Pb, Cd, Ni, Cr, Hg, and others. Because of phytotoxicity and environmental degradation, higher concentrations of heavy metals may restrict their long-term usage in agriculture. In addition to heavy metals, sewage sludge may include dangerous toxics such as medicines, detergents, different salts, pesticides, toxic organics, flame retardants, and hormone disruptors. After adequate treatment of sewage sludge, the detrimental effects may be reduced to an acceptable level, allowing it to be utilised for agricultural purposes with a low application dosage.

Use of sewage sludge environment concern

There are social and legal concerns of uncontrolled use of sewage sludge for agriculture due to potential problems of elevated transfer of heavy metals to the food chain. Absorption, accumulation and tolerance to heavy metals may vary between different crops and at different levels of sewage sludge amendments (SSA). Residues of treated municipal wastewater can be applied to the land to serve as a fertilizer and soil conditioner. Based on its content of nitrogen and phosphorus, communal sludge shows good fertilizer properties. Sludge recycling as fertilizer has several advantages which include the return of the organic materials into the bio-cycle. Sludge also replaces the application of chemical fertilizers whose production also requires a lot of energy. Sewage sludge having high content of organic matter, macro and micronutrients, can be used as fertilizer/soil conditioner for food, vegetable crops, horticultural plants and pasture, which in most cases can be beneficially recycled. In the past, sewage sludge was regarded as a waste product due to expected high level of contaminants such as pathogens, pollutants and synthetic materials discharged in sewer from homes and industries, which were often incinerated, dumped in ocean or used as land fill. As a result of rapidly increasing population, urbanization and industrialization, wastewater production and sewage sludge generation have increased manifold. Due to high cost of mineral fertilizers and escalating trends in their prices, there is an increasing trend of using sewage sludge in agriculture, especially under intensive cropping in arid and semi-arid

regions of the country. Therefore, application of sewage sludge to agricultural soils may be sustainable and economical due to nutrient cycling and disposal of sewage sludge. Land application of sludge for crop production also provides a feasible and cost effective alternative disposal means.

The natural background concentration of metals in the soil is normally less available for crop uptake and hence less hazardous than metals introduced through sewage sludge applications. Research carried out shown that the amounts of Cd, Ni, Cu, Zn and Pb applied

Figure: 1 Sewage sludge in outlet tank produced

Analyses five years after sludge applications, with the exception of Cu and Zn applied to a calcareous loam soil. These field experiments also determined the extent of transfer of metals from sludge treated soil into the leaves and edible parts of six crops of major importance to UK agriculture and the effect of metals on yields of these crops. Although all the plots received sufficient inorganic fertilizer to meet crop requirements for nutrients, the applications of sludge had some effects on crop yields. In 60% of the cases studied crop yields were not significantly affected but in 26% of the cases liquid sludge application resulted in significantly increased crop yields, attributed to the beneficial effects on soil structure. Reductions in wheat grain yield, from 6-10%, 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 to be due to metals but the most likely explanation was lodging of the crop as a result of excessive nitrogen in the soil. Increases in metal concentrations in the soil due to sludge applications produced significant increases in Cd, Ni, Cu and Zn concentrations in the edible portion of most of the crops grown: wheat, potato, lettuce, red beet, cabbage and ryegrass. In most cases there was no significant increase of Pb in crop tissue in relation to Pb in the soil from sludge application, suggesting that lead is relatively unavailable to crops from the soil. The availability of metals to crops was found to be lower in soil treated with bed-dried sludge cake compared with liquid sludge, the extent being dependent on the crop. Even though the Ni, Cu and Zn concentrations in the soils treated with high rates of application of liquid and bed dried sludges were close to the maximum levels set out in the EC Directive and the zinc equivalent of sludge addition exceeded the maximum permitted in U.K. guidelines, no phytotoxic effects of metals were evident, with one exception. This was in lettuce grown on clay soil, when Cu and Zn levels exceeded upper critical concentrations at high rates of sludge application.

Planting, grazing and harvesting constraints

To minimize the potential risk to the health of humans, animals and plants it is necessary to coordinate sludge applications in time with planting, grazing or harvesting operations. Sludge must not be applied to growing soft fruit or vegetable crops nor used where crops are grown under permanent glass or plastic structures. The EC Directive (Council of the European

Communities, 1986) requires a mandatory 3 week no grazing period for treated sludge applied to grassland but prohibits the spreading of untreated sludge on grassland unless injected. Treated sludge can be applied to growing cereal crops without constraint but should not be applied to growing turf within 3 months of harvesting or to fruit trees within 10 months of harvesting. When treated sludge is applied before planting such crops as cereals, grass, fodder, sugar beet, fruit trees, *etc.*, no constraints apply but in the case of soft fruit and vegetables, the treated sludge should not be applied within 10 months of crop harvesting. In general, untreated sludge should only be cultivated or injected into the soil before planting crops but can be injected into growing grass or turf, with the constraints on minimum time to harvesting as already mentioned.

Environmental protection to manage soil health

Care should always be taken when applying sewage sludge to land to prevent any form of adverse environmental impact. The sludge must not contain non-degradable materials, such as plastics, which would make land disposal unsightly. Movement of sludge by tanker from sewage treatment plant to agricultural land can create traffic problems and give rise to noise and odour nuisance. Vehicles should be carefully selected for their local suitability and routes chosen so as to minimize inconvenience to the public. Access to fields should be selected after consultation with the highway authority and special care must be taken to prevent vehicles carrying mud onto the highway. Odour control is the most important environmental dimension of sludge application to land. Enclosed tankers should be used for transporting treated sludge, which tends to be less odorous than raw sludge. Discharge points for sludge from tankers or irrigators should be as near to the ground as is practicable and the liquid sludge trajectory should be kept low so as to minimize spray drift and visual impact. Untreated sludge should be injected under the soil surface using special vehicles or tankers fitted with injection equipment. The care is needed to prevent sludge running off onto roads or adjacent land, depending on topography, soil and weather conditions. On sloping land there is the risk of such runoff reaching watercourses and causing serious water pollution. Sludge application rates must be adjusted accordingly and, under certain circumstances, spreading might have to be discontinued. In addition to the problem of surface runoff, pollution may arise from the percolation of liquid sludge into land drains, particularly when injection techniques are used or liquid sludge is applied to dry fissured soils. In highly sensitive water pollution areas, sludge should be used only in accordance with the requirements of the pollution control authority as well as of good farming practice. Sludge storage on farms can optimize the transport and application operations but every effort must be made to ensure that storage facilities are secure.

Future thrust

Higher doses of sewage sludge application in agriculture lead to food grain contamination and pollution of soil and water bodies. Based on research that sewage sludge application has long term residual effect effort are going on by utilising Bhagwanpur sewage treatment plant with the assumption that one time application of lower dose of sewage sludge in combination with chemical fertilizer may provide feasible proposition to supplement a part of major nutrient along with micronutrient without affecting the quality of soil and food produce that could be a way to maintain soil fertility. Our scientists found, more carbon dioxide in the atmosphere will stimulate the growth of plants, which will in turn stimulate the production of the root compounds that breakdown carbon and soil minerals. So sewage sludge is a vital source which not only consist a good amount of Soil organic carbon (SOC) but also major and minor nutrients which can manage the soil health because it also consist a various type of micro organism species which is helpful to maintain the soil fertility as well as soil health.