Comparative Study of Different Sewage Farming on Soil Quality

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AVINASH DWIVEDI

(Roll No.1170470003)

Under the Supervision of

Prof. ANUPAM MEHROTRA

to the

Faculty of Civil Engineering

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CERTIFICATE

"To whomsoever it may concern"

This is to certify that **Mr. Avinash Dwivedi** has carried out his research work presented in this thesis entitled **"Comparative Study of Different Sewage Farming on Soil Quality"** for the award of Master of technology in 'Civil Engineering' from Department of 'Civil Engineering', Babu Banarsi Das University, Lucknow, under my supervision. The thesis embodies results of original work and studies are carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University.

Mr. ANUPAM MEHROTRA
HEAD of DEPARTMENT
Department of Civil Engineering
Babu Banarsi Das University,
Faizabad Road, Lucknow
Date:
Place: Lucknow

DECLARATION

I hereby certify that the work which is being presented in this thesis entitled **"COMPARATIVE STUDY OF DIFFERENT SEWAGE FARMING ON SOIL QUALITY"** in partial fulfilment of award of degree of Master of Technology in **Civil Engineering** submitted in Department of Civil Engineering, Babu Banarasi Das University, Lucknow is an authentic record of my own work carried under the supervision of **Prof. Anupam Mehrotra,** Associate Professor, BBD University, Lucknow, India.

Date:

Place: Lucknow **(Avinash Dwivedi)**

ABSTRACT

Sewage Sludge is one the major issue facing for any Sewage Treatment Plant for its proper disposal. The final Sludge collected from STP's required large space for disposal and space should be far away from residential community. Sewage Sludge contains high amount of nutrients in the form of wastewater. These wastewater are treated in Sewage treatment plant and separation of Sludge from wastewater is taken out using various type of technology. The sludge separated from wastewater are further treated in sludge treatment unit and removal of maximum amount of water are done using various equipment. The treated water is reused for various purposes or discharge into river bodies and the sludge after treatment are send to disposal site. This study focuses on the utilization of these sewage sludge as a fertilizer and comparison of this sludge with chemical fertilizer. The content of nutrient in sewage shows significant results on application with various plants and discussed the effect of sewage farming on soil quality.

Keywords: Sewage Sludge, Chemical fertilizers, Normal soil, Nutrients value

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(Avinash Dwivedi)

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Important Formula:

1. Volume of Truncated cone (pot) : $(1/3)*pi * D*(r^2 + r * R+R^2)$

   R=Radius of top

   r= radius of bottom

   D=depth

2. Volume of Tapered Rectangular pot: $(1/3)*h*(t^2+t * b+b^2)$
t=length of bottom side
b=length of top side
h=height of container

LIST OF ABBREVIATIONS

cm	Centimeter
G	Gram
g/cm^3	Gram per cubic centimeter
BIS	Bureau of *Indian Standards*
Kg	Kilogram
kg/m^3	Kilogram per cubic meter
kN/s	Kilo Newton per second
L	Liter
L/m^3	Liter per cubic meter
M	Meter
m^2/kg	Square meter per kilogram
Mm	Millimeter
N/mm^2	Newton per square millimeter
µm	Micrometer
°F	Degrees Fahrenheit
°C	Degree Celsius
%	Percent
AC	Activated Carbon
DO	Dissolved Oxygen
BOD	Biological Oxygen Demand

COD	Chemical Oxygen Demand
TSS	Total Suspended Solids
STP	Sewage treatment plant
N	Nitrogen
P	Phosphorous
K	Potassium
S	Sulphur
pH	Potential of Hydrogen

CHAPTER 1
INTRODUCTION

1.1 Overview

The adequate management of sludge from urban wastewater treatment plants is a critical global environmental concern due to population growth in urban centres, which increases the production of industrial and household waste and the amount of wastewater that must be processed by treatment plants. The treatment of wastewater generates a semi-solid residue; the final disposal of this residue requires permanent technical and science-based solutions to prevent contamination of the natural environment. The most economical options that are available for the elimination of sludge entail its use as a fertiliser in agriculture or its disposal in landfills. The incentive to apply sludge in agricultural areas is significantly given the ability of this waste product to serve as a fertiliser and their soil positively influence. Conversely, the continual use of mineral fertilisers causes a loss of soil organic matter and other negative impacts (e.g. a decrease in soil fauna or contamination of water bodies) and reduces the capacity of soil to crop production. Considering its different components, the organic matter content in sludge improves the density, porosity and water retention capacity of soil and promotes the activation of microorganisms and soil enzymes. The Sewage sludge application (sanitised, stabilised and dry) favours germination and plant growth, increases the production of various crops and improves the quantity of plant protein and dry matter. The application of this waste product can produce a seasonal shift that causes the early flowering/fruiting of crops (e.g. flax and cotton) and reduce the growing period. Different risks are associated with the chemical composition of sludge, which are primarily related to its heavy metal content. The use of sludge affects the final concentration, solubility (the relative presence of fulvic and humic acid may aid the removal of heavy metals) and final bioavailability of heavy metals in the soil. Similarly, an excessive accumulation of metals negatively influences the development of mycorrhizae. An uncontrolled biosolids application can provoke a soil nutrient excess (N, P) and potentially contaminate aquifers. Deficits in the levels of K and Mn in plants have also been detected, which signals the need for chemical fertilisers to maintain sustained medium-term and long-term production. The sludge use also favours the persistence of pesticides that are applied during crop cultivation. Another consideration is the high variability in sludge composi- tion, which is dependent on the inputs of wastewater treatment plants, season and type of waste post-treatment. Therefore, the sludge chemical composition must be determined prior to its application in crop soils, and field assays should be performed to determine the fertili- sation capacity of sludge and its environmental implications.

Wastewater treatment plants (WWTP) generate two output streams: sewage sludge and treated effluent. Sewage sludge is generated through the removal of suspended solids and sludge from the influent wastewater, and treated effiuent is discharged to watercourse. Wastewater treatment can be a complicated process; several different designs are used, utilising mechanical, biological, and chemical methods, in various combinations. The difference between facilities depends mostly on the extent of water purification and disposal method used for sludge. In its simplest form the treatment process can be seen as including up to three levels or stages of treatments: primary, secondary, and tertiary. In primary treatment al1 wastes that either float or sink are removed by screening. This primarily removes debris from the raw sewage but most of the organic waste stays in the suspension or solution. After the initial screening, most of the organic waste is removed from the sewage through settling in tanks. From there the organic waste is subsequently removed into separate sludge treatment. In secondary treatment, the activity of naturally occurring microorganisms is encouraged to digest the organic residues in aerobic and anaerobic environments. This result in flocculation of solids produced by the microbial activity, which are removed from the wastewater process into sludge treatment process. Tertiary treatment of wastewater consists of physical (e.g. filtration) and chemical processes (e.g. addition of lime, iron or aluminium cornpounds) to flocculate solids and precipitate nutrients. After initial thickening of sludge, biological activity is supported for an extended time, mostly to reduce bulk and make the sludge more manageable. During stabilisation the odour potential and number of pathogenic organisms is reduced, and some mineralization of plant nutrients occurs (Ministry of Agriculture and Food, Ministry of the Environment, Ministry of Health 1986). In some parts of the world, composting of sewage sludge has become increasingly popular, and lime addition is also used. The addition of precipitants can occur at various stages of the wastewater treatment process, depending on the design of the facility. At some WWTP, increasing solids content by various methods is practiced to reduce bulk and make the sludge more manageable for utilization or disposal. Sludge value as a fertilizer and soi1 amendment depends to a large degree on the combination and extent of processes descri bed above, especially chemical treatments.

1.2 Need of Fertilizer:

Plants, like all other living things need food for their development and growth, and they require 16 essential elements. Hydrogen, carbon and oxygen are derived from the atmosphere and water soil. The remaining 13 essential elements (manganese, nitrogen, calcium, phosphorus, potassium, zinc, magnesium, sulfur, iron, copper, boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organic matter or by inorganic or organic fertilizers. The microorganisms in bio-fertilizers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of bio-fertilizers, healthy plants can be grown, while enhancing the sustainability and the health of the soil. Since they play several roles, a preferred scientific term for such beneficial bacteria is "plant-growth promoting rhizobacteria" (PGPR). Therefore, they are extremely advantageous in enriching soil fertility and fulfilling plant nutrient requirements by supplying the organic nutrients through microorganism and their byproducts. Hence, bio-fertilizers do not contain any chemicals which are harmful to the living soil.

1.3 Plant Nutrients:

1.3.1 Primary Macronutrients required for Plants:

The essential plant nutrients include carbon, oxygen and hydrogen which are absorbed from the air, whereas other nutrients including nitrogen are typically obtained from the soil (exceptions include some parasitic or carnivorous plants). There are 17 most important nutrients for plants. Plants must obtain the following mineral nutrients from their growing medium:

- The macronutrients:

  nitrogen(N), phosphorus (P), potassium (K), calcium(Ca), sulfur(S), magnesiu m(Mg),carbon (C), oxygen(O), hydrogen (H)

- The micronutrients (or trace minerals):

  iron(Fe), boron (B), chlorine (Cl), manganese (Mn), zinc (Zn), copper (Cu), moly bdenum (Mo), nickel (Ni)

These elements stay beneath soil as salt. So plants consume these elements as ion. The macronutrients are consumed in larger quantities; hydrogen, oxygen, nitrogen and carbon contribute to over 95% of a plants' entire biomass on a dry matter weight basis. Micronutrients are present in plant tissue in quantities measured in parts per million, ranging from 0.1 to 200 ppm, or less than 0.02% dry weight.

1.3.2 Nitrogen

Although Earth's atmosphere contains 78% nitrogen gas (N_2), most organism cannot directly use this resource due to the stability of the compound. Nitrogen is a major constituent of several of the most important plant substances. For example, nitrogen compounds comprise 40% to 50% of the dry matter of protoplasm, and it is a constituent of amino acids, the building blocks of proteins.[5] All organisms use the ammonia (NH_3) form of nitrogen to manufacture amino acids, proteins, nucleic acids and other nitrogen-containing components necessary for life. Nitrogen is required for cellular synthesis of enzymes, proteins, chlorophyll, DNA and RNA, and is therefore important in plant growth and production of food and feed. It typically makes up around 4% of the dry weight of plant matter. Inadequate supply of available N frequently results in plants that have slow growth, depressed protein levels, poor yield of low quality produce, and inefficient water use. The sources of nitrogen used in fertilizers are many, including ammonia (NH_3), diammonium phosphate ($(NH_4)_2HPO_4$), ammonium nitrate (NH_4NO_3), ammonium sulfate ($(NH_4)_2SO_4$), calcium cyanamide ($CaCN_2$), calcium nitrate ($Ca(NO_3)_2$), sodium nitrate ($NaNO_3$), and urea (N_2H_4CO).

1.3.3 Phosphorus

Phosphorus (P) is a major growth-limiting nutrient, and unlike the case for nitrogen, there is no large atmospheric source that can be made biologically available. Root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation in legumes, crop quality, and resistance to plant diseases are the attributes associated with phosphorus nutrition.

Although phosphorus uptake by plants is less compared to nitrogen and potassium, normal plant growth cannot be achieved without it. The concentration of soluble phosphorus (P) in tropical soil is usually very low, phosphorus is only available in micro molar quantities or less. Phosphorus is concentrated at the most actively growing points of a plant and stored within seeds in anticipation of their germination. Phosphorus is most commonly found in the soil in the form of polyprotic phosphoric acid (H_3PO_4), but is taken up most readily in the form of H_2PO_4. Phosphorus is available to plants in limited quantities in most soils because it is released very slowly from insoluble phosphates and is rapidly fixed once again. Under most environmental conditions it is the element that limits growth because of this constriction and due to its high demand by plants and microorganisms. Plants can increase phosphorus uptake by a mutualism with mycorrhiza.[6] The P-content in average soils is about 0.05% (w/w) but only 0.1% of the total P is available to plants. Some microorganisms are known to be involved in the solubilization of insoluble phosphate.

1.3.4 Potassium

Potassium (K) concentrations in most plants range from 1 to 4% by weight. Unlike the other primary nutrients, K forms no other compounds in the plant, but remains a lone ion. Potassium is also vital for animal and human nutrition, and thus healthy fruits, vegetables and grains must have adequate levels of K.

Potassium regulates the opening and closing of the stomata by a potassium ion pump. Since stomata are important in water regulation, potassium regulates water loss from the leaves and increases drought tolerance. Potassium deficiency may cause necrosis or inter veinal chlorosis. The potassium ion (K^+) is highly mobile and can aid in balancing the anion (negative) charges within the plant. Potassium helps in fruit coloration, shape and also increases its brix. Hence, quality fruits are produced in potassium-rich soils. Potassium serves as an activator of enzymes used in photosynthesis and respiration.[6]

Potassium deficiency may cause necrosis or inter veinal chlorosis, wilting, brown spotting, and higher risk of pathogens. K+ is highly mobile and can aid in balancing the anion charges within the plant. It serves as an activator of enzymes used in photosynthesis and respiration.

Potassium is used to build cellulose and aids in photosynthesis by the formation of a chlorophyll precursor.

Potassium fertilizers: Potassium chloride [KCl], Potassium sulfate [K_2SO_4], Potassium nitrate [KNO_3], Potassium-magnesium sulfate [K_2SO_4. $2MgSO_4$].

1.4 Secondary Macronutrients

Sulfur (S), calcium (Ca), and magnesium (Mg) are considered secondary macronutrients because they are less commonly yield-limiting than the primary macronutrients (N, P, and K), yet are required by crops in relatively large amounts.

1.4.1 Calcium

Calcium is one of the main secondary nutrients necessary for healthy plant growth. Important sources of calcium are various fertilizers such as a single and a triple superphosphate, a precipitate, a calcium nitrate, etc. The other way forenriching soils by calcium is liming. For this purpose, a dolomite, a magnesite andvarious calcium carbonate minerals are used.

1.4.2 Magnesium (Mg)

Magnesium is an essential component of chlorophyll, so it is essential for photosynthesis. It also regulates the uptake of other essential elements; serves as a carrier of phosphorus compounds, facilitates translocation and metabolism of carbohydrates. It considered as highly mobile nutrient in plants; relatively immobile insoils. Magnesium is an activator and component of many plant enzymes required in growth process, and enhances production of oils and fats. Magnesium fertilizers include: Dolomite [$CaMg(CO_3)_2$], Magnesium sulfate, Epsom sal.ts[$MgSO_4.7H_2O$], Magnesium oxide [MgO] contains 55% Mg .

1.4.3 Sulfur (S)

Integral component of amino acids, therefore essential to protein synthesis. It considered as essential component of oils in aromatic compounds (e.g., garlic and onion), production of chlorophyll, essential for nodule formation on legume roots, increases size and weight of grain crops, aids in seed production. Highly mobile nutrient in plants; mobile in soils.

Sulfur is a structural component of some amino acids (including cystein and methionine) and vitamins, and is essential for chloroplast growth and function; it is found in the iron-sulphur complexes of the electron transport chains in photosynthesis. It is needed for N_2 fixation by legumes, and the conversion of nitrate into amino acids and then into protein.

1.5 The Micronutrients or Trace Minerals

Boron (bo): affects water absorption by roots translocation of sugars;

Chlorine (cl): isan essential to some plant processes, acts in the enzyme systems;

Manganese (mn): is essential in plant metabolism, nitrogen transformation;

Iron (fe): helps in carrying electrons to mix oxygen with other elements;

Zinc (zn):is important in plants metabolism, helps form growth hormones, and reproduction;

Copper (cu): helps in the use of iron, and helps respiration;

Molybdenum (mo): improve plant development, reproduction,

1.6 TYPES OF FERTILIZERS

There are two types of supplies for agriculture, specifically fertilizer and pesticide. It can be said that fertilizer is food, and pesticide is medicine for plants in conventional agriculture. Among the materials used in agriculture, fertilizer is the most widely used. Based onthe production process, it can be roughly categorized into three types: CHEMICAL, ORGANIC AND BIOFERTILIZER.

1.6.1 CHEMICAL FERTILIZERS (Synthetic Fertilizer)

Fertilizers play an important role in increasing crop production. The main macronutrients present in inorganic fertilizers are nitrogen, phosphorus, and potassium which influence vegetative and reproductive phase of plant growth.

1.6.1.A The Advantages of Using Chemical Fertilizers

Nutrients are soluble and available to the plants, therefore the effect is direct and fast, the price is lower and more competitive than organic fertilizer, which makes it more acceptable and often applied by users. They are quite high in nutrient content; only relatively small amounts are required for crop growth.

1.6.1.B Disadvantages of Chemical Fertilizers

The use of chemical fertilizers alone has not been helpful under intensive agriculture because it aggravates soil degradation. The degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and low crop yields.

Due to its high solubility, up to 70% of inorganic fertilizer can be lost through leaching, denitrification and erosion and reducing their effectiveness.

Over application can result in negative effects such as leaching, pollution of water resources, destruction of microorganisms and friendly insects, crop susceptibility to disease attack, acidification or alkalization of the soil or reduction in soil fertility.

1.6.2 ORGANIC FERTILIZERS

Organic fertilizer refers to materials used as fertilizer that occur regularly in nature, usually as a byproduct or end product of a naturally occurring process.

Like any fertilizer, organic fertilizers typically provide the three major macronutrients required by plants: nitrogen, phosphorus, and potassium. Organic fertilizers include naturally occurring organic materials, (e.g. manure, worm castings, compost, seaweed), or naturally occurring mineral deposits.

1.6.2.A Types of Organic Fertilizers

1- Animal manures:

Animal manures are probably the most commonly available organic material used for their fertilizer value. Animal manure is essentially a complete fertilizer

2- Sewage sludge:

It is a recycled product of municipal sewage treatment plants. Forms commonly available are activated, composted and lime-stabilized

3- Plant substances

They are often rich in specific nutrients, such as nitrogen.

4- Composts

Although making compost from a variety of raw materials is possible, the finished products are remarkably similar in their final concentrations of nitrogen, phosphorus, and potassium.

1.6.2.B Advantages of Organic Fertilizers

Organic fertilizers are better sources of nutrient in balanced amounts than inorganic fertilizers where soil is deficient in both macro and micronutrients.

Organic based fertilizer use is beneficial because it supplies micronutrients, and organic components that increase soil moisture retention and reduce leaching of nutrients.

Organic fertilizers can be used on acid tolerant and those better suited to neutral or alkaline conditions.

In addition to increasing yield and fertilizing plants directly, organic fertilizers can improve the biodiversity (soil life) and long-term productivity of soil, and may prove a large depository for excess carbon dioxide.

Organic nutrients increase the abundance of soil organisms by providing organic matter and micronutrients for organisms such as fungal mycorrhiza.

1.6.2.C Disadvantages of Organic Fertilizers

Hard to get, Not sterile, Low nutrient content, Generally costs significantly more than synthetic fertilizer, Organic certification requires documentation and regular inspections, Organic fertilizers still release nutrients into their surroundings; these nutrients can find their way into local streams, rivers, and estuaries just as nutrients from synthetic sources do.

1.6.2 BIOFERTILIZERS

Biofertilizers are commonly called microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable form through biological processes.

The term ‘biofertilizer’ include selective micro-organism like bacteria, fungi and algae which are capable of fixing atmospheric nitrogen or convert soluble phosphate and potash in the soil into forms available to the plants. Soil microorganisms play an important role in soil processes that determine plant productivity. Bacteria living in the soil are called free living and some bacteria support plant growth indirectly, by improving growth restricting conditions either via production of antagonistic substances or by inducing resistance against plant pathogens.

The interactions among the rhizosphere, the roots of higher plants and the soil borne microorganisms have a significant role in plant growth and development. The organic compounds, released by roots and bacteria, play an important role in the uptake of mineral nutrient. The hormones produced by the rhizosphere bacteria have direct effects on higher plants. Biofertilizer is most commonly referred to the use of soil microorganisms to increase the availability and uptake of mineral nutrients for plant

1.6.3.A Advantages of Biofertilizers

Biofertilizers have definite advantage over chemical fertilizers.

- The use of biofertilizers effectively enrich the soil and cost less than chemical fertilizers, which harm the environment and deplete non-renewable energy sources..
- Chemical fertilizers supply over nitrogen whereas biofertilizers provide in addition to nitrogen certain growth promoting substances like hormones, vitamins , amino acids, etc.,.
- On the other hand biofertilizers supply the nitrogen continuously throughout the entire period of crop growth in the field under favorable conditions.
- Continuous use of chemical fertilizers adversely affect the soil structure whereas biofertilizers when applied to soil improve the soil structure.
- The effects of chemical fertilizers are that they are toxic at higher doses. Biofertilizers, however, have no toxic effects.

The utilization of microbial products has several advantages over conventional chemicals for agricultural purposes:

(1) MICROBIAL PRODUCTS ARE CONSIDERED SAFER THAN MANY OF THE CHEMICALS NOW IN USE;

(2) NEITHER TOXIC SUBSTANCES NOR MICROBES THEMSELVES WILL BE ACCUMULATED IN THE FOOD CHAIN;

(3) SELF-REPLICATION OF MICROBES CIRCUMVENTS THE NEED FOR REPEATED APPLICATION;

(4) TARGET ORGANISMS SELDOM DEVELOP RESISTANCE AS IS THE CASE WHEN CHEMICAL AGENTS ARE USED TO ELIMINATE THE PESTS HARMFUL TO PLANT GROWTH.

(5) PROPERLY DEVELOPED BIOCONTROL AGENTS ARE NOT CONSIDERED HARMFUL TO ECOLOGICAL PROCESSES OR THE ENVIRONMENT.

1.6.3.B Types of Bio fertilizers

The following common types of biofertilizers are available to the farmers in various countries

- Nitrogen fixing biofertilizers eg. RHIZOBIUM, BRADYRHIZOBIUM, AZOSPIRILLUM and AZOTOBACTER.
- Phosphorous solubilising biofertilizers (PSB) eg. BACILLUS, PSEUDOMONAS and ASPERGILLUS
- Potassium mobilizing biofertilizer FRATEURIA AURENTIA
- Plant growth promoting biofertilizers eg. PSEUDOMONAS

Table 1.1 Type of Bio fertilizer

Sr. No	Name of the product	Classification	Role
1.	**Nitrogen fixer Biofertilizer**		
a.	AZOTOBACTER VINELINDII	Biofertiizer	N-fixer
b.	AZOTOBACTER CHROOCOCCUM	Biofertiizer	N-fixer
c.	AZOTOSPIRILLUM LIPOFERUM	Biofertiizer	N-fixer
d.	ACETOBACTER XYLINUM	Biofertiizer	N-fixer
e.	RHIZOBIUM	Biofertiizer	N-fixer
2.	**Phosphate solubilizer Biofertilizer**		
a.	PSEUDOMONAS PUTIDA		
b.	BACILLUS MEGATHERIUM		
3.	**K-solubilizer**		

a.	FRATEURIA AURENTIA		

The products in above table are some examples of bio fertilizers which provides N, P, K to the plant.

1.6.3.C How biofertilizers work?

- Biofertilizers fix atmospheric nitrogen in the soil and root nodules of legume crops and make it available to the plant.
- They solubilize the insoluble forms of phosphates like tricalcium, iron and aluminium phosphates into available forms.
- They scavenge phosphate from soil layers.
- They produce hormones and antimetabolites which promote root growth.
- They decompose organic matter and help in mineralization in soil.
- When applied to seed or soil, biofertilizers increase the availability of nutrients and improve the yield by 10 to 25% without adversely affecting the soil and environment.

CHAPTER 2

LITERATURE REVIEW

Some existing literatures or research papers are discussed in order to present the current work efficiently. These literatures are very useful and also the base of the current work.

Ma. Del Mar DELGADO ARROYO [1] state in their research paper that the use of an organic residue (sewage sludge compost) for four years (1996-1999), to study effects of sewage compost on crop yield and chemical properties of soil under field condition. Productivity studies showed that the greatest growth is obtained in mixed II treatment (12000 kg/ha sewage sludge compost plus 350 kg/ha urea) with 20 % more than mineral fertilization, followed by mixed I (8000 kg/ha sewage sludge compost plus 350 kg/ha urea) with 10 % more than mineral fertilization. No toxic effects arising from the heavy metals in the plant were observed. Moreover, the concentration of heavy metals in the soil are below Spanish and European legal limits.

A. SUS [2] studied the high nutrient and organic-matter contents of sewage sludge make it a useful soil amendment for farmers. In this study at four locations in Bavaria, the application of sewage sludge produced corn yields that were similar to or better than those produced by an equal application (in terms of N) of chemical fertilizer. High rates of sludge (800 m^3/ha) further improved crop yields, although such are impractical for farmers' fields. Residual beneficial effects of sewage-sludge application were seen also in terms of subsequent yields of barley. Application of sludge also improved biological and physical properties of the soils. More long-term studies are needed to better understand how sewage sludge contributes to the improvement of soil fertility and crop yields.

Lucrezia Lamastra [3] explained in their paper that an effective analytic method for organic pollutants detection in the sewage sludge has been developed, showing an excellent repeatability and recoveries. Ecotoxicological risk assessment was evaluated using risk quotients (RQs) for sludge-amended soil. Most of the analyzed samples do not contain NP, NPnEOs, and DEHP at levels higher than the limit established by the draft-working document of the European Commission on Sludge. The assessment using RQs reports that NP and NPnEOs never give values higher than 1, and for DEHP the obtained RQs exceed the value of 1 just three times. Data obtained were compared to the data from other European and Asiatic countries, showing a huge variability for all the compounds considered.

Md. Lokman Hossain [4] the study was conducted to evaluate the effects of sludge (industrial and residential) on seed germination and growth performance of Swietenia mahagoni seedlings at the nursery of Institute of Forestry and Environmental Sciences, Chittagong University (IFESCU), Bangladesh. Before sowing of the seeds, different combinations of sludge were incorporated with the nutrient-deficient natural forest soils. Seed germination and growth parameters of the seedlings (shoot and root length, collar diameter, fresh and dry weight of shoot, and root and total dry biomass) were recorded after one, two and three months of seed sowing. Physio-chemical parameters (pH, organic carbon, nitrogen, phosphorus, and potassium) and heavy metals (chromium, nickel, manganese, cadmium and zinc) of each treatment were also analyzed before sowing of seeds and after harvesting of seedlings. Results show that the seed germination percentage and the seedling growth parameters varied significantly in the soil added with sludge in comparison to control. The highest germination percentage (92%) was observed in the treatment of soil with residential sludge of 3:1 compared to control. The highest growth and biomass of the seedlings were recorded in the soil with industrial sludge of 3:1. So, from the present findings it may be recommended that soil and industrial sludge (3:1) can be used as fertilizer in nursery for the growth of S. mahagoni seedlings.

Rocío VACA [5] The use of organic wastes in agriculture can improve the soil's productive capacity, and physical and chemical characteristics. This study evaluated the effects of sewage sludge, sewage sludge compost and inorganic fertilizer applications on nickel, copper and zinc contents in soil and corn grains (Zea mays L); maize productivity, and grain nutritional quality. Sewage sludge and sewage sludge compost at 18 Mg ha–1 and a mineral fertilizer (N-P-K) with a formulation of 150-75-30 were applied. Significant differences were observed in organic matter, phosphorus and zinc content between sewage sludge-soil and compost-soil, and inorganic fertilizer-soil ($P < 0.05$). Copper concentration was significantly high in compost-soil ($P < 0.05$). Productivity in compost-soil and sewage sludge-soil mixtures was higher than in inorganic fertilizersoil. Grain quality, measured by relative percentage of starch, total nitrogen, protein, acid detergent fiber and neutral detergent fiber were adequate for human consumption. Application of sewage sludge or compost did not increase heavy metal concentrations in grain with respect to inorganic fertilizer-soil.

Joseph S. Mtshali [6] Sewage sludge generated from wastewater treatment plants are being merited greater attention in light of their potential for improving soil properties and for providing important nutrient and trace element supplements that are essential for plant growth. Because of the differences in sludge characteristics among sludges that undergo different levels of treatment as well as the extensive and variable nature of pollutant inputs to wastewater, the fertilizer potential and pollutant risk of sewage sludge intended for agricultural application has to be specifically evaluated for each sludge. Sewage sludge generated from seven wastewater treatment plants in Swaziland were analysed for a range of physico-chemical characteristics including organic matter, nutrients, cation exchange capacity, pH and trace elements. Despite the differences in sludge processing and sludge storage ages, the sludge samples generally show high levels of organic matter, nutrients and trace elements needed for plant growth. The potential risk of heavy metal toxicity was evaluated by comparing the levels of heavy metals in the sludge samples with widely quoted and well known regulatory limits of a number of countries and the levels were found to be within acceptable risk level with respect to agricultural application. The research results indicate a positive outcome for the wastewater treatment plants in Swaziland that currently keep large piles of unused dried sludge within their premises.

Khalid Usman [7] Intensive farming generally needs large addition of organic matter to maintain fertility and enhance crop yields. Sewage sludge/biosolids are by-products of municipal and industrial wastewater treatment and a rich source of organic nutrients. Sewage sludge having high content of organic matter, macro- and micro-nutrients, can be used as fertilizer/soil condi- tioner for food, vegetable crop, 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 occasion or land fill. As a result of rapidly increasing population, urbanization and industrialization, wastewater produc- tion 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. However, there may be a risk in use of sewage sludge due to potentially harmful contents present in the sludge such as heavy metals and pathogens. This paper, therefore, presents a review on various aspects of sewage sludge used in agriculture.

Franz X. Stadelmann [8] in the use of sewage sludge as an agricultural fertilizer is at the center of an intense debate. The primary benefit of using sewage sludge as a fertilizer is the recycling of valuable plant nutrients from the consumer back into the agricultural system. But this benefit is offset by the risk posed by the introduction into the environment of potentially harmful chemicals contained in the sewage sludge. The benefits and the risks must be weighed against one another. In the short term, we should use only the highest quality sewage sludge; in the long term, we need to develop systems and techniques that satisfy criteria for both sustainability (nutrient recycling) and precaution (environmental protection)

M.Jamil M.Qasim and M.Umar [9] A field experiment was conducted to study the effect of addition of different levels of domestic sewage sludge on the soil properties and yield of wheat crop. Addition of sewage sludge raised soil pH, increased organic matter, EC_e, NPK, Ca+Mg and trace metals (Fe, Cu, Mn and Zn) with its increasing levels. Different treatments of sludge also increased the yield and yield attributing components as compared to untreated (control) treatments. Significantly maximum plant height (107 cm), number of tillers (433 m^{-2}) and straw yield (9.82 t ha^{-1}) were obtained where 80 t ha^{-1} sewage sludge was applied while spike length, number of productive tillers m^{-2}, number of grains $spike^{-1}$, 1000-grain weight and grain yield were maximum in the treatments amended with 40 t ha^{-1} of sewage sludge. The study indicates that sludge application at the rate of 40 t ha^{-1} can enhance economic yield of wheat and also improve soil productivity.

L. Bonfiglioli [10] In this paper, an overview on sewage sludge characteristics and recovery routes is presented. Starting from an analysis of typical sewage sludge characteristics as found in literature, the most promising disposal options are presented. A focus on incinerated sewage sludge ash (ISSA) follows. Most of the authors agree on considering pyrolysis and gasification as the most viable treatments for sludge in the near future. For this reason, the last two chapters offer a brief description of these two processes and their products.

Vinod Kumar [11] Sewage sludge (Biosolids) generation is fastly increasing resulting from the regular increase of population, urban planning and industrial developments worldwide. The sludge needs to be adequately treated and environmentally managed to reduce the negative impacts of its application or disposal. The present review deals with the different applications of sewage sludge for sustainable agriculture. The scattered literature is harnessed to critically review the uses of biosolids to promote sustainable practices focusing on the productive uses of sewage sludge or biosolids. Biosolids or sewage sludge is the byproduct of municipal wastewater, sewage effluent and effluent treatment plants. The treatment plants are generating huge amount of biosolids. The present review focuses on the different applications of biosolids or sewage sludge as in many countries the biosolids or sewage sludge are frequently using for various purposes like for biogas production, land filling, organic fertilizer, soil amendment, and to enhance the crop yield of agricultural crops. Therefore, biosolids or sewage sludge is in the consideration as a resource worldwide. Besides this higher content of different heavy metals and microorganisms are the important constraints for the application of biosolids or sewage sludge in the various fields. Thus, this review emphasizes the different applications and possible limitations for the use of biosolids or sewage sludge as a resource. Efforts have been made on the possible pretreatment of biosolids or sewage sludge to make it more feasible for their applications. Therefore, different properties of biosolids or sewage sludge, their applications along with possible limitations have been discussed in the present review to formulate the biosolids or sewage sludge as a resource for the sustainable development.

Siti Noorain Roslan [12] The volume of biosolids produced in Malaysia nowadays had increased proportionally to its population size. The end products from the waste treatments were mounting, thus inevitable that in the end the environment will be surrounded by the waste. This study was conducted to investigate the suitability of biosolids to be reused as fertilizer for non-food crop. By varying the concentration of biosolids applied onto the soil, growth of five ornamental plant samples were tested for eight consecutive weeks. The results show that the pH of the soil after the addition of biosolids ranges from 6.45 to 6.56 which is suitable for the plant growth. The soil samples that contains biosolid also show higher amount of macronutrients (N, P, K) and the heavy metals content are significantly increased in the plant however it does not exceed the guidelines drawn by the Environmental Protection Agency. It is also proven that there was only small significant different in the performance of plant growth between biosolids and commercial fertilizer. It can be seen that biosolids was able to perform just as well as commercial fertilizer.

Lidiia Svirenko Viktoriia Bondar [13] Ukraine is well-known in the world as a country with soil rich for humus. Approximately 68% of arable soils in Ukraine have been classificated as chernozem. For last decades decrease of organic matter content in soils of various agri-climatic zones has been surveyed in the country. The main reason of the mentioned process is enormous lack of organic fertilizer (manure) in agriculture connected with decrease in livestock (in 3 times since year 1992). Besides there is expansion of technical crops for biofuel production (like Brassica napus, Helianthus annuus), which are the provocateurs of soils exhaustion. At the same time such important source of organic matter for application in agriculture as sewage sludge (SS) from wastewater treatment plant (WWTP) is not used in Ukraine nowadays. To stop arable soils degradation in regions it is necessary to develop up-to-date management for fertilizer production on WWTPs. The base for the process has to be the acceptance of the goal-oriented National programme, corresponding governmental decrees and implementation of national standard for using sewage sludge as fertilizer.

Xiao Han Sun [14] The objective of this study is to evaluate the possibility of recycling the liquid product obtained from sewage sludge by the hydrothermal treatment as a kind of organic fertilizer and its effect on the plant growth. A small scale hydrothermal treatment experiment was performed and proved that the liquid product contains high content of nitrogen and low content of micronutrients. Therefore, the liquid product has the potential to be used as a kind of liquid fertilizer. In a seed germination test, the liquid product indicated low phytotoxicity. Moreover, in a Komatsuna cultivation experiment, the liquid product showed accelerate effect to the crop yield which is not lower than the chemical fertilizer. Through the low-temperature hydrothermal treatment, the sewage sludge was converted into liquid organic material that could be used as a delayed-release nitrogen fertilizer for the growth of Komatsuna. These results indicated the possibility of establishing a comprehensive system for recycling sewage sludge into a kind of organic fertilizer.

Prof. K.Soundhirarajan, R.Leena [15] Sewage sludge which results as byproduct of municipal wastewater treatment contains adequate amount of organic matter. The application of biosolids to land for agricultural purposes is beneficial because organic matter improves soil structure, tilth, water holding capacity, water infiltration, soil aeration, macro and micro nutrients aid plant growth. In early days sewage sludge was treated as waste products due to the presence of pathogens and pollutants which may also contains synthetic materials, as the result of rapid development and urbanization the generation of sewage sludge also increases to a considerable amount. In-order to handle this situation fertilizers can be replaced with biosolids in agricultural farms. This paper represents the review of sludge as agricultural compost.

CHAPTER 3

METHODOLOGY

Three Soil namely Dry sludge mix , normal soil and chemical fertilizer mix soil were for the research purpose. The comparative study of growth of three plants namely

Tomato, Alovera and Chilli plant with all three soil were performed. Initially the physical characteristics of all three plant with three different soil were noted down.

3.1 Methodology:

Initially the dry sludge is mix with normal soil and arrangement of nine pot with different dimension were made. The formula of volume is given in list of table section.

Table 3.1 Dimension of pot

Pot Description	Quantity	Length / Radius top (cm)	length / Radius bottom (cm)	Height / Depth (cm)	Volume (cm^3)
Tomato	3	9	6	15	2686
Alovera	3	34	24	27	22936
Chilli	3	11	8	18	5146

Fig 3.1 Plants taken for project

On Day 1 only dry sludge is mix with normal soil. The application of fertilizer is done after vegetative stage.

Fig 3.2 Pre-irrigation stage

3.2 Growth Stage:

Growth stages of plants, in very general terms, can be split into four periods:

- Establishment from planting or seeding during vegetative growth until first flower appears
- From first flowering to first fruit set
- From fruit ripening to first harvest
- From first harvest to the end of last harvest.

Dry Sludge is taken from 6.5 MLD STP based on SBR technology located at

Vrindavan Society. Sewage of society treated in this plant having wastewater characteristic given below:

Table 3.2 Characteristics of wastewater

Discharge Parameter	Inlet	Outlet
Ph	8.2	7.2
COD	256	40
BOD	190	12
TSS	165	10

The final sludge is taken out from Centrifuge unit which removes the water content from wastewater and separate out only the sludge.

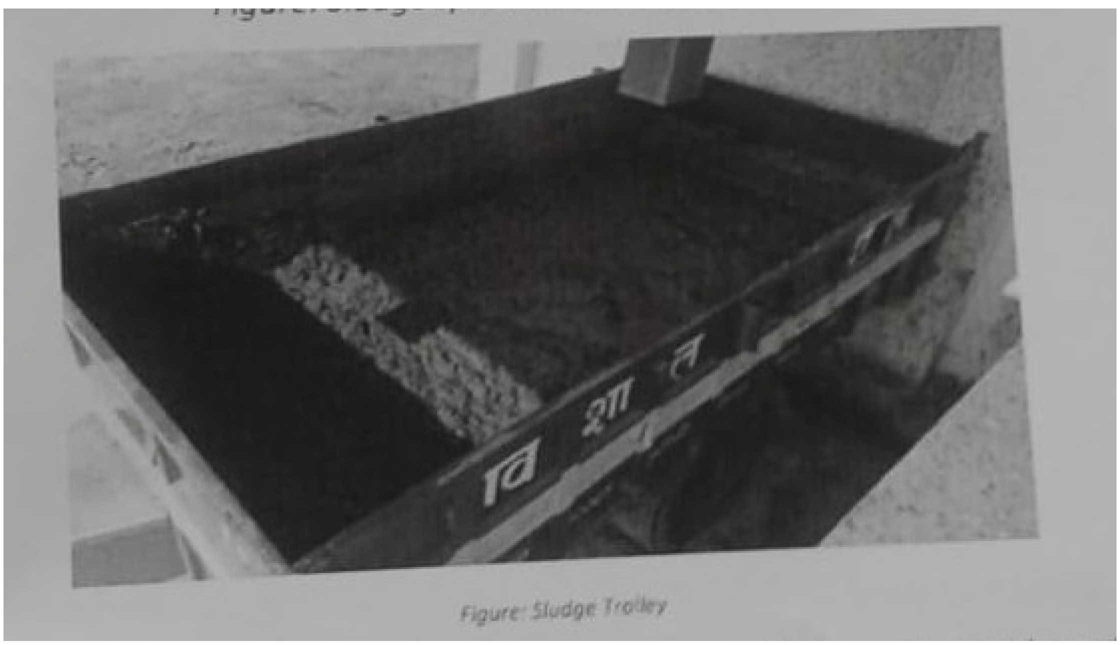

Fig 3.3 Sludge Trolley

The sludge is collected in trolley and send to disposal site. some quantity of sludge is dried in drying bed and used for project work. Two trolley is removed daily from STP plant.

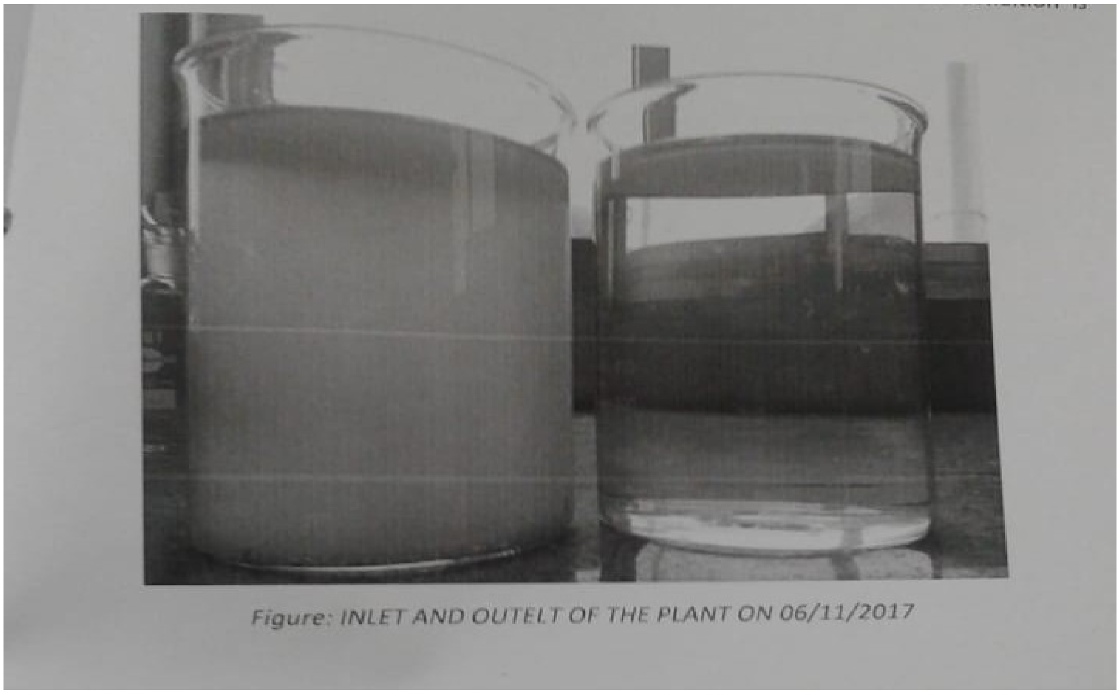

Fig 3.4 Inlet and Outlet quality of wastewater

The treated water is used for irrigation of sludge mix soil. The treated water is taken before chlorination.

Fig 3.5 Early Growth of plant on 25th day

Physical reading were taken after 25th day of plantation.

CHAPTER 4
RESULT & DISCUSSION

The soil were tested in Sawen Laboratory Pvt Ltd for the below parameters.

Table 4.1 Lab test report of soil

	Dry Sludge	Normal soil	Chemical Fertilizer mix
pH	6.9	9.033	9.226
Moisture	0.0784	0.9841	0.6098
Ca + Mg	9.2	4.8	9.4
Av. S	8.51	0.02	9.37
Av. P	0.32	0.56	2.24
Av. N	17.64	2.8	4.2

After 60 day of plantation the growth of plant with sewage sludge is much better than other two. From the overall analysis that had been conducted, it was found that the plant being supplied by fertilizer had dead at early stage which is on 6th week. This was the overload content of nutrients in the fertilizer. Theoretically, daily sludge application using the designed concentration will not cause any major problem to the plant but differ to the daily fertilizer application which caused harm and toxicity to the plant.

4.1 Content of nutrient in plants

2 sets of data were obtained during the analysis as the plants that being fed with fertilizer were dead due to excess supply of nutrients. The nutrient content in plants receiving sewage sludge and treated water are shown in table 4.1 while ratio between nutrients cater by plants fed with sewage sludge and treated water of SBR plant are presented in table 4.1 above.

The optimum N:P ratio for most plants ranges from 5:1 to 10:1. According to table 4.1 the sewage sludge provides the dosage in the optimum range of plant.

The comparative growth of all plant is shown below:

Fig 4.1 Growth of Alovera

The growth of Alovera is best grown with Dry Sludge mixture soil in comparison with height, no. of leaves.

Fig 4.2 Growth of Chilli

The growth of chilli is best with dry sludge mixture in comparison with height and no. of leaves.

Fig 4.3 Growth of tomato

The growth of tomato is not best suited in pot. The tomato plantation is also done on field at 6.5 MLD campus.

Fig 4.4 Growth of tomato on field

4.2 Growth Development of Alovera

Initially the aloveera taken on the first day for plantation were 5.6cms, 4.8cms and 4.2cms

Aloovera height	Initial (cms)	Final (cms)
Sewage Sludge pot	4.2	42
Normal soil pot	5.6	31
Chemical fertilizer pot	4.8	21

Table 4.2 Height of Alovera in different soil

CHAPTER 5
CONCLUSION & FUTURE SCOPE

5.1 CONCLUSION

Sewage sludge potentially contains nutrients which can be used as fertilizers in order to enhance the plant growth. Major nutrients contain in sewage sludge is nitrogen, phosphorous, potassium and sulfur and might contains some micro nutrients. Though the utilization of sewage sludge will solve the problem for the disposal of STP sludge and it can be reused for developing green belts in the premises and nearby areas of STP. The analysis of nutrients (Nitrogen, Phosphorus & Potassium) in the sludge is determined. The study on plant growth response to sewage sludge is studied, the plants grown with sewage sludge shows better growth results. It is concluded that if there is presence of heavy metals then the compost could be utilized for flowering plants, if not it is used for edible plant. The sewage sludge produced is very less in heavy metal concentration so it could be utilized for growing edible plants. The height of Aloveera grown with sewage sludge shows better results in terms of height and no. of leaves as compares to normal soil and chemical fertilizer. Thus aerobic digestion of sludge brings out valuable compost which could be utilized for plant growth. The cost of project is nearly 8000 RS.

5.2 FUTURE SCOPE

In future the growth of various plant were done on field as it will show better growth and gives detailed reading. To accomplish this the future study areas are as given below-

1. Edible product quality can be checked with compare to normal soil and chemical fertilizer.

2. Some other vegetable and plant will be taken for research,

3. To study the other nutrient content of other soil.

4. To study the growth of different another plants planted in different manner.

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PROFILE

Name:	Avinash Dwivedi
Address:	3/201 Sector 3 Vikas Nagar Lucknow
Mob. No.:	8200225885
Email:	avirocks789@gmail.com