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Experimental Investigation for Utilization and Application of Sewage Sludge as Agricultural Compost

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ABSTRACT: Sludge generated from sewage treatment plants is typically regarded as waste, demanding significant expenses for both treatment and disposal. However, composting through aerobic digestion emerges as a cost-effective and highly efficient technique for both disposal and utilization of this sludge. By subjecting the sludge to aerobic digestion, it undergoes a transformation that effectively eliminates all disease-causing organisms present within it.

The resultant compost derived from the sludge not only eliminates potential health risks but also contains valuable fertilizing nutrients essential for promoting plant growth. Consequently, the application of sludge compost can serve as a natural fertilizer, enhancing the nutrient content of the soil. It is important to note that this approach is environmentally safe, offering a sustainable method of managing sewage sludge while contributing to the overall health of the ecosystem.

KEYWORDS: Sewage treatment, Sludge management, Nutrients required for plant growth, Sewage sludge as compost.

I. INTRODUCTION

Sludge is semisolid slurry. It is produced as sewage sludge from wastewater treatment processes or as a settled suspension obtained from conventional drinking water treatment and numerous other industrial processes. The management of sludge originating from wastewater treatment is highly complex and costly activity, which, if poorly accomplished, may jeopardize the environmental and sanitary advantages expected in the treatment systems. The sludge must be treated before disposal the treatment methods include sludge digestion, sludge thickening & dewatering and sludge conditioning. The sludge is then dried in drying beds and by mechanical drying techniques then it can be disposed in sea, land and used for agricultural purposes.

Compost is the result of the natural decomposition of organic materials such as food scraps, leaves, and yard waste. It is a nutrient-rich soil amendment that improves soil structure, promotes plant growth, and reduces the need for chemical fertilizers. Composting is an eco-friendly practice that contributes to a healthier and more sustainable environment.

II. SEWAGE MANAGEMENT

- The increasing demand from society and environmental agencies towards the better environmental quality standards has manifested themselves in public and private sanitation service administrators. Due to low indices of wastewater treatment prevailing in many developing countries, a future increase in the number of wastewater treatment plant naturally expected. As a consequence, the amount of sludge produced is also expected to increase.

- Dewatering of sludge is a crucial step in sludge management as it serves to reduce the moisture content of sludge and biosolids for various reasons. One significant advantage of dewatering is the significant reduction in costs associated with transporting sludge to the final disposal site. By reducing the volume through dewatering, the expenses related to trucking the sludge become notably lower.

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➢ Sludge drying beds are typically used to dewater digested biosolids and settled sludge from plants using the extended aeration activated-sludge treatment process without prethickening. After drying, the solids are removed and either disposed of in a landfill or used as a soil conditioner.

III. POLLUTANTS IN SLUDGE

➢ Class A sludge is typically pasteurized, and is also known as “exceptional” quality.Class B sludge is typically “undigested” and is volatile.Pathogens are not a significant health issue if sewage sludge is properly treated.

➢ One of the main concerns in the treated sludge is the concentrated metals content (arsenic, cadmium, copper, etc., some of which are also critical plant micronutrients); certain metals are regulated while others are not.

IV. NUTRIENTS REQUIRED BY SOIL FOR PLANT GROWTH

Soil may be defined as the weathered superficial layer of the earth’s crust that typically is made up of decomposed and partly decomposed parent rock material with Soil is a complex system which includes mineral (inorganic) matter, The chemical composition of soil is influenced by the characteristics of the original materials from which it was derived and the various transformative processes it has undergone throughout its history mass of unchanging composition. Rather, they are characterized by large spatial variability in both the horizontal and vertical dimensions. The chemical makeup of soils is shaped by the amalgamation of mineral and organic components constituting the soil composition.

Nutrients are divided into three categories: primary, secondary and micronutrients.(N), (P), and (K) are classified as primary nutrients due to their significant requirement by plants in relatively large quantities compared to other nutrients. On the other hand, (Ca), (Mg), and (S) are considered secondary nutrients as they are needed in smaller amounts by plants, but are equally essential for promoting healthy plant growth as the primary nutrients. (Zn) and (Mn) are micronutrients that are vital for plant growth, albeit in trace amounts. These nutrients are required by plants in very small quantities. Maintaining the soil at the optimal pH value is often an effective method for addressing most micronutrient deficiencies and ensuring plants have access to these essential elements.

There are three important nutrients required by plants. Nitrogen and phosphorus are required in appreciable quantities, while needs for sulfur are less. Deficiencies of S are much less.

V. SEWAGE SLUDGE AS COMPOST

- Sewage sludge can be converted into compost, making it a valuable resource for sustainable soil management.
- Composted sewage sludge is rich in nutrients like organic matter, nitrogen, phosphorus, and micronutrients, which enhance soil fertility.
- The application of sewage sludge compost improves soil structure, moisture retention, and promotes beneficial microbial activity.
- Recycling sewage sludge as compost reduces waste and supports environmentally friendly agricultural practices.
- Composting sewage sludge provides a cost-effective and eco-friendly solution for soil enrichment and sustainable plant growth..
- Application of sludge has been observed to improve the physico-chemical and biological properties of soils which in turn facilitate better growth of plants.it increases the humus content of the soil.

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VI. OBJECTIVE OF THE STUDY

i. To stabilize the sludge by aerobic digestion process.
ii. To determine the pH and temperature during digestion process.
iii. To analyze the electrical conductivity of the sludge.

iv. To find the presence or absence of E.Coli bacteria.

v. To estimate the amount of Nitrogen, Phosphorus and potassium content in the slud

vi. To find the presence or absence of heavy metals in the sludge.

vii. To use sludge as compost to grow plants.

viii. To measure the growth of plants and compare it.

VII. COMPOST PREPARATION

Bin type composting method is followed for composting the sewage sludge. Two bins are used for composting. The bins are covered with caps which are perforated. The perforations are made with help of hot iron rod. Sewage sludge was mixed with the following components in two bins at suitable proportions shown in the table given below:

- Sludge
- Cow dung

COMPOSITION OF COMPOST

COMPOST	SLUDGE	COW DUNG
COMPOST 1	2Kg	-
COMPOST 2	2Kg	1Kg

The sludge is mixed daily which aids in digestion. The sludge is mixed well with help of thick wood stick. The bins are stored in a shaded area and the holes

Provide aeration. The compost was maintained in a moisture condition. The composting process is carried out for 45 days. PH and temperature is measured daily. In this composting process organic matter undergoes biological degradation to a stable end product. Sludge that has been composted properly is nuisance free humus like material. Approximately 20 to 30% of the volatile solids are converted to carbon dioxide and water. During the decomposition process of organic material in sludge, the compost undergoes a rise in temperature within the pasteurization range of 50 to 70°C. This elevated temperature range facilitates the destruction of enteric pathogens, ensuring their eradication. Properly composted bio-solids may be used as soil conditioners in agricultural or horticulture applications. Mixing is essential in aerobic digesters. A well-mixed biomass ensures adequate contact between the organisms and their food supply and ensures uniform distribution of oxygen throughout the digester.

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VIII. pH IN COMPOST

The pH level in compost plays a crucial role in the decomposition process. Ideally, compost should maintain a slightly acidic to neutral pH range, typically between 6 and 7. This acidity fosters the activity of beneficial microorganisms, ensuring efficient breakdown of organic matter. Monitoring pH levels helps optimize composting conditions for successful nutrient-rich compost production.

PH VALUES OF COMPOST

NO.OF DAYS	pH VALUE OF COMPOST (1)	pH VALUE OF COMPOST (2)
1-5 DAYS	7-6	7-6.5
5-15 DAYS	6-5.5	6.5-5
15-30 DAYS	5.5-6.5	5-6
30-40 DAYS	6.5-7.5	6-7
40-45 DAYS (Mature compost)	7.5-8	7-8

IX. TEMPERATURE IN COMPOST

The temperature determined is observed from normal to mesophilic range. Since the digestion begins the microbial reactions tend to liberate heat which is an exothermic reaction. It is proved that the temperature increases as digestion begins.

TEMPERATURE VALUES OF COMPOST 1&2

NO.OF DAYS	TEMPERATURE OF COMPOST (1)	TEMPERATURE OF COMPOST (2)
1-5 DAYS	28-32 C	28-33 C
15-30 DAYS	38-42 C	38-44 C
40-45 DAYS	45-47 C	46-48

X. ELECTRICAL CONDUCTIVITY IN COMPOST

The Electrical Conductivity is the measure of the ability of a solution to conduct an electrical current. As the concentration of ions increases, the conductivity also increases.

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Electrical conductivity is used to measure the amount of nutrients in the compost that are in the form of salts.Electricity moves better through solutions high in salts, so the higher the EC reading the saltier the product, (high levels of nutrients).

ELECTRICAL CONDUCTIVITY OF COMPOST 1&2

ELECTRICAL CONDUCTIVITY	COMPOST 1	COMPOST 2
BEFORE COMPOSTING	2.7	2.78
AFTER COMPOSTING	3.3	3.8

XI. COLIFORMS IN COMPOST

Coliform bacteria are commonly referred to as “indicator organisms” due to their role in signaling the possible presence of bacteria that can cause diseases. Not all microorganisms are harmful. Main harmful species of Coliform bacteria that present in the sewage sludge are E.Coli.

After composting (C1 & C2) there is no indication of the presence of E.Coli. Therefore this shows the sample is pathogenic free. But in drinking water standard the indication of the presence of E.Colishould be less than 1 CFU/1000 ml. So this sample is safe for used as a manure for agriculture Purposes. Among the composts C2 is the better combination.

COLIFORM AVAILABILITY IN COMPOST 1&2

COLIFORMS	COMPOST 1	COMPOST 2
BEFORE COMPOST	ABSENT	ABSENT
AFTER COMPOST	ABSENT	ABSENT

XII. PERCENTAGE OF SEED GERMINATION

Seed germination serves the purpose of evaluating the quality of seeds and predicting the performance of both the seed and seedling when planted in the field.

Rate of germination was calculated using the formula given below:

$$\text{Germination\%} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds in towel}} \times 100$$

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TYPE OF SEED	TOTAL NO.SEEDS	NO OF SEEDS GERMINATIONS
TOMATO	20	16
CHLLY	20	18

GERMINATION % OF TOMATO SEEDS:

80% of tomato seeds are germinated in this test.

GERMINATION % OF CHILLI SEEDS:

90% of chilli seeds are germinated in this test.

After the seed germinated test the seeds which are not germinated are rejected. The germinated seeds are taken to the field to grow the plants.

XIII. MEASURING AND COMPARING PLANT GROWTH

Position the ruler at the base of the plant: To establish a starting point, it is essential to ensure that the measurement begins at the reference point. For shorter plants, a ruler can be employed for precise measurements, while taller plants may necessitate the use of a measuring tape, yardstick, or meter stick to achieve accurate results.

Record the height of the plant.

Calculate the average using the growth rate formula: The average daily growth rate of a plant can be determined by dividing the change in size by the duration of its growth period.

The equation is to the growth rate formula;

(S2-S1) / T

Where,

S1=first measurement, S2=second measurement, and

T =the number of days between each.

XIV. NUTRIENTS IN COMPOST

The macronutrients present in the sludge are analyzed. A comparison is brought between the compost samples before and after aerobic digestion.

NUTRIENT VALUE IN THE COMPOST

NUTRIENT VALUE	NITROGEN (N) Kg/Hectare	PHOSPHORUS (P)	POTASSIUM (K)
BEFORE DIGESTION	350	0.292	0.010
AFTER DIGESTION	550	0.392	0.074

From the above table it is clear that nutrients values get increased after aerobic digestion of the sludge compost.

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DETECTION OF HEAVY METALS IN COMPOST

HEAVY METAL	ABSORDANCE		CONCENTRATION COMPOST 1&2
	Compost 1	Compost 2	
Arsenic	BDL	BDL	BDL
Iron	0.0021	BDL	BDL
Cadmium	1.2388	1.0668	BDL
Copper	1.0567	1.0336	BDL
Nickel	0.0061	0.0044	BDL

*BDL – Below Detection Level.

The concentration of heavy metals in the compost 1 and compost 2 is analyzed using the Atomic Absorption Spectrometer (AAS). The absorbance values are obtained for the heavy metals. The plotted absorbance value shows the concentration of heavy metals in the compost sample. Since the concentration of heavy metals is in a very trace amount, the analyzer denotes the concentration as Below Detection Level (BDL).

As the heavy metals concentration is very low when compared to the permissible limits for land application of sewage sludge, it can be used for in edible plants.

XV. CONCLUSION

The sewage sludge which has nutrient value for plant growth can be utilized to grow plants rather than using conventional chemical fertilizers. The cost of fertilizer is high when compared to sewage sludge compost. Since the sewage sludge compost is economically reliable it can be used to grow plants. Land application of sewage sludge is good method of sludge disposal. The sludge which occurs as end product of wastewater treatment system is considered to be a waste, but it has a lot of fertilizing values. Sludge not only used as a fertilizer it also acts as soil conditioner which helps the soil to enrich by the addition of nutritional values

The sludge obtained from the sewage treatment plant is digested to bring out more fertilizing nutrients as digestion proceeds. The PH of the digested sludge is determined because acidic sludge cannot be applied to the soil which will inhibit the plant growth. The electrical conductivity is found to compare the presence of nutritional salts before and after digestion. The main contaminant in sludge is pathogens specifically coliforms which are determined to know whether it is present or absent because it will tend to produce diseases.

The analysis of nutrients (Nitrogen, Phosphorus & Potassium) in the sludge is determined. The field study on plant growth response to compost is studied, the plants grown with compost 2 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 compost produced is very less in heavy metal concentration so it could be utilized for growing edible plants. Thus aerobic digestion of sludge brings out valuable compost which could be utilized for plant growth.

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