Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

UTILIZATION AND APPLICATION OF SEWAGE SLUDGE AS AGRICULTURAL COMPOST

Prof. K.Soundhirarajan[1], R.Leena[2]

[1]*Department of Civil Engineering ,Gnanamani College of Technology*

[2]*Department of Environmental Engineering , Gnanamani College of Engineering*

Abstract—*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.*

Keywords: *Sewage sludge; Infiltration; Soil aeration, pH, Electrical conductivity, Seed germination, Heavy metals*

I. INTRODUCTION

Sewage sludge refers to the residual, semi-solid material that is produced as by-product in sewage treatment of municipal wastewater. Biosolids is defined as organic wastewater solids that can be reused after stabilization processes such as anaerobic digestion and composting. 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 an organic matter that has been decomposed and recycled as fertilizer for soil amendment. Compost which is rich in nutrient is beneficial for land in many ways including soil conditioner, fertilizer, addition of vital humus or humic acids and as natural pesticide for soil.

Sewage enters the primary tank 50% of the suspended solid matter will settle out within short period of time that should be removed before anaerobic process gets active. In an Ihmoff tank the sludge gets digested and continuously extracted from the tank mechanically and passed to separate digestion tank at high temperature for efficient digestion of sludge. The amount of sewage sludge produced is proportional to the amount and concentration of wastewater treated, and it also depends on the type of wastewater treatment process used. United States municipal wastewater treatment plants in 1997 produced about 7.7 million dry tons of sewage sludge, and about 6.8 million dry tons in 1998 according to EPA estimates. As of 2002, about 60% of all sewage sludge was applied to land as a soil amendment and fertilizer for growing crops.

Nutrients for healthy plant growth are divided into three categories: primary, secondary and micronutrients. (N), (P) and (K) are primary nutrients, which are needed in fairly large quantities compared to the other nutrients. (Ca), (Mg) and (S) are secondary nutrients which are required by the plant in lesser quantities but are no less essential for good plant growth than the primary nutrients. (Zn) and (Mn) are micronutrients which are required by plants in very small amounts. Most secondary and micronutrient deficiencies are easily corrected by keeping the soil at the optimum pH value.

II. SLUDGE CHARACTERISTICS

A.SLUDGE DIGESTION

The sludge digestion breaks the organic matter of the sludge into liquid and simple compounds which are stable and unfoul in nature. A portion of the solids is converted into liquid and gases due to which the volume of the sludge is reduced by 60-75 percent. Sludge digestion process removes coliforms by 99.8% by digestion for 30 days at 95-100F temperature. The first step of digestion is called as of “acid production”, in which stage the group of bacteria acts on the organic matter and produce fatty acids and lower the pH-value to about 6.2. The second stage is known as period of “acid regression”. Another type of organisms act in this stage and anaerobic digestion takes place and various gases such as methane, carbon dioxide, etc. In the second stage the pH-value increases and reaches upto about 6.8. The last or the third stage of sludge digestion is known as ‘period of intensive digestion’ and it takes long times. The more resistant organic matters such as protein amino acids, etc are acted upon by another group of bacteria and the pH-value further rises to about 7.4. Under natural conditions the total time taken for the complete sludge digestion is about three month.

B. CONCENTRATION OF SLUDGE

This method is also called as sludge thickening or sludge conditioning and is the process of removing water contents from the sludge. In simple method the sludge can be concentrated by adding chemical coagulants in it and

resettling in the sedimentation tanks. Thickening of sludge by gravity is commonly adopted for concentration of sludge by combination of activated sludge and primary sludge. Continuous flow tanks are deep circular tanks with central need and overflow at the periphery. These are designed for a hydraulic loading from 20,000 to 25,000 lpd/sq.m. If the loading rates are below 12,000 lpd/sq.m, they may create odour problems. If the normal sludge contain more solids, the sludge may be diluted with the plant effluent. The recommended solid loading for primary and trickling filter and mixture of primary and activated sludge are 100,60,40 kg/d/sq.m respectively. With these loadings the underflow solids concentration shall be about 8-10% with primary, 6-8% with primary and trickling and 2-6% with primary and activated sludge.

C. SLUDGE DEWATERING AND DRYING

The dewatering of concentrated sludge is done by continuous centrifugal process. In this process, the outer casing of a centrifuge contains a revolving solids bowl, in which a screw conveyor rotates at slightly lower speed. The sludge enters the bowl through the hub of the conveyor. When the cylinder revolves, the centrifugal force causes the solids to deposit on the wall of the bowl, from where it can be removed. The digested sludge can be elutriated, dewatered, filtered and heat-dried to form powder. If fresh sewage is applied on the land, it will give bad odour. On the other hand, if digested sludge runs over a porous bed upto a depth of 20-30 cm under favourable climatic conditions it will dry within a week or two without any odour Air-drying of sewage can be done in open air or under glass cover roof. The open drying beds are generally 30-45 cm deep and are filled with graded gravel or stone ballast over which 10-15 cm thick layer of sand is spread. In some cases cinder, coke breeze and blast furnace slags are also used for the above purpose. The sewage sludge is applied on these beds in about 20-30 cm depth and is followed to dry. After 20-30 days the sludge is dried and collected from the bed. Open drains are laid in the bottom of the bed which collects the drained liquor.

D. SLUDGE DISPOSAL

The sludge is usually disposed as manure to the soil, In some cases wet sludge, raw or digested as well as supernatant from digester can be lagooned as a temporary measure but such practice may create problems like odour nuisance, ground water pollution and other hazards to public health. Wet or digested sludge can be used as sanitary landfill or for mechanized composting with city refuse. Dried sludge may be used for lawns and for growing deep rooted cash crops and fodder grasses, where direct contact of edible part is low. From public health point of view, heat dried sludge is the safest, though deficient in humus, if it convenient for handling and distribution. It can be used along with farmyard manure.

III. EXPERIMENTAL STUDY

A. COLLECTION OF SAMPLE

The sewage sludge sample is collected from the Sewage Treatment Plant at Namakkal. The dewatered sludge is preferred than dried sludge because digestion takes place in presence of moisture. The sludge is removed from storage bin using shovel. Sludge must be handled with care it should not be touched with bare hands since it might contain pathogens and toxic constituents.

The collected sample is transferred into a thick plastic bag which is not sealed inorder to prevent the anaerobic conditions which is to be developed. The sludge sample is transported carefully without any spills

B. COMPOST PREPARATION

Bin type composting technique is used for sewage compost. Two bins are covered with perforated 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

TABLE 1: COMPOST PREPARATION RATIO

COMPOST	SLUDGE	COW DUNG
COMPOST 1	2 kg	-
COMPOST 2	2 kg	1 kg

The sludge should be mixed daily with thick wood stick and maintained in a moist condition by storing at shaded area provided with hole for aeration. The process should be carried for 45 days.

C. MIXING OF SLUDGE

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. The aeration system typically supplies the mixing. Adequate mixing is provided when the diffusers supply air at a rate of 0.3 to 0.6 L/m3·s (20 to 35 cu ft/min/1000 cu ft). Supplemental mixing is required when the rate of aeration or oxygenation needed to meet the rate needed to keep the organisms in suspension. Either mechanical mixer or mechanical aerator requirements may be used to supplement mixing needs.

D. DETERMINATION OF PH

PH is tested to determine alkalinity or acidity of the sludge. Two products of aerobic digestion that tend to lower the digester pH are carbon dioxide and hydrogen ions. A pH drop can occur when ammonia is oxidized to nitrate if the alkalinity of the wastewater is insufficient to buffer the solution. In situations where the buffering capacity of the sludge is insufficient, it may be necessary to chemically adjust the pH (Metcalf & Eddy, 1991). If pH adjustment is necessary, the proper chemical dosage can be determined by performing a bench-scale jar test and proportioning the chemical dosage from the jar test to the digester volume.

Compost microorganisms operate best under neutral to acidic conditions, with PH's in the range of 5.5 to8. During the initial stages of decomposition, organic acids are formed. The acidic conditions are favorable for growth of fungi and breakdown of lignin and cellulose. As composting proceeds, the organic acids become neutralized, and mature compost generally has a pH between 6 and 8.

TABLE 2: PH VALUES OF COMPOST

NO OF DAYS	PH VALUE OF COMPOST 1	PH VALUE OF COMPOST 2
1-5 DAYS	7.0-6.0	7.0-6.5
5-15 DAYS	6.0-5.5	6.5-5.0
15-30 DAYS	5.5-6.5	5.0-6.0
30-40 DAYS	6.5-7.5	6.0-7.0
40-45 DAYS	7.5-8.0	7.0-8.0

E. DETERMINATION OF TEMPERATURE

Temperature of the sludge is measured daily during digestion period. The liquid temperature in an aerobic digester significantly affects the rate of volatile solids reduction that increases as temperature increases. As with all biological processes, the higher the temperature, the greater the efficiency. At temperature lower than 10°C (50 °F) the process is less effective. In most aerobic digesters temperature is a function of ambient weather conditions and is not controlled.

TABLE 3: TEMPERATURE OF COMPOST

NO.OF DAYS	TEMPERATURE OF COMPOST (C1)	TEMPERATUREOF COMPOST (C2)
1-5	28-32°C	28-33°C
5-15	32-38°C	33-38°C
15-30	38-42°C	38-44°C
30-40	42-45°C	44-46°C
40-45	45-47°C	46-48°C

F. DRYING OF SLUDGE

A portion of sludge from both bins are taken and dried for further analysis. The sludge is taken out from both bins and transferred to a thick sheet. It is placed under hot sun for 3-5 days until it is completely dry. The dried sludge is coarsely powdered thoroughly. Then the powdered sludge is taken for further analysis. Dried and powdered sludge is used for determining the Electrical Conductivity and Total Coliforms.

G. DETERMINATION OF ELECTRICAL CONDUCTIVITY

Conductivity is measured with a probe and a meter. A voltage is applied between the two electrodes in the probe immersed in the sample water. The drop in voltage caused by the resistance of the water is used to calculate the conductivity per centimetre. Conductivity (G), the inverse of resistivity (R) is determined from the voltage and current values according to Ohm's law. The meter converts the probe measurement to micro mhos per centimetre and displays the result for the user.

TABLE 4: ELECTRICAL CONDUCTIVITY VALUES OF COMPOST

ELECTRICAL CONDUCTIVITY mho/cm	COMPOST1 (C1)	COMPOST2 (C2)
BEFORE COMPOSTING	2.70	2.78
AFTER COMPOSTING	3.30	3.80

H. DETERMINATION OF COLIFORMS

The Coliform bacteria are often referred to as "indicator organisms" because they indicate the potential presence of disease-causing bacteria. Not all microorganisms are harmful. Main harmful species of Coliform bacteria that present in the sewage sludge are E.Coli. Even though not all species of E.Coli are harmful, only certain strains of E.Coli are harmful. But the absence of E.Coli indicates the sample is safe. The control has indicated the presence of 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.Coli should 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.

TABLE 5 : COLIFORMS VALUES OF COMPOST

COLIFORMS	COMPOST(C1)	COMPOST 2(C2)
BEFORE COMPOSTING	ABSENT	ABSENT
AFTER COMPOSTING	ABSENT	ABSENT

I. SEED GERMINATION TEST

The seed germination test is determined to test whether the sludge is used as fertilizer for crops. Layer two towels moisten, but don't soak, the towels with clean tap water using a spray bottle. Too much moisture promotes bacterial and fungal growth. If water wells up around your finger when you press on the towel, it is too wet. Place the roll in a plastic bag or plastic wrap and set in a container with the open end of the towel up. Place the container in an area that suits the crop's germination needs. For crops that need prechilling, place the container in the refrigerator for a few days then move to a warm location to start the test. For warm season crops, the top of a refrigerator or computer tower works well. A basement or north-facing windowsill is best for cool season crops. Allow some indirect light for most seeds. Do not place in direct sunlight.

Check the towel moisture each day and add water when necessary. You can start checking the seeds as early as 3 days after setup. If you find moldy seeds, count them as dead and remove them or the mold may spread to other seedlings. You can count and remove the healthy seedlings as they develop. Keep track of how many days it takes the seed to germinate for future reference. The test is over when all the seeds have germinated or the normal number of days to germination is up.

TABLE 6 : SEED GERMINATION TEST VALUES

TYPE OF SEED	TOTAL NUMBER OF SEEDS	NUMBER OF SEEDS GERMINATED
TOMATO	20	16
SPINACH	20	15
LADIES FINGER	20	20
CHILLI	20	18

GERMINATION % OF TOMATO SEEDS:

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

$$= (16 / 20) * 10$$

$$= 80\%$$

80% of tomato seeds are germinated in this test.

GERMINATION % OF CHILLI SEEDS:

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

$$= (18 / 20) *100$$

$$= 90\%$$

90% of chilli seeds are germinated in this test.

GERMINATION % OF LADIES FINGER:

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

$$= (20/20) * 100$$

$$= 100\ \%$$

100% of ladies finger seeds are germinated in this test.

GERMINATION % OF SPINACH:

$$\text{Germination\%} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds in towel}} \text{ x } 10$$

$$= (15/20)* 10$$

$$= 75\ \%$$

75% of spinach seeds are germinated in this test.

J. MEASURING PLANT GROWTH

After the seed germination test the healthy seeds are planted in agro bags with soil and sludge in the ratio of 2:1. The soil and sludge is mixed with water and filled in the agro bags and the seeds are added to it. The comparison of two plant will state the growth strata. The plant growth can be monitored by following these procedure it includes initially setting the ruler at the base plant by making zero at the ground level, measuring the height of the plant includes regular interval of monitoring at interval of three to four days. Calculating the average growth rate by using the formula:

$$\frac{(S2 - S1)}{T}$$

FIGURE 1:TOMATO PLANT

FIGURE 2 : CHILLI PLANT

FIGURE 3: LADIES FINGER

FIGURE 4 : SPANISH PLANT

K. MEASURED SPINACH PLANT GROWTH IN 2 MONTHS

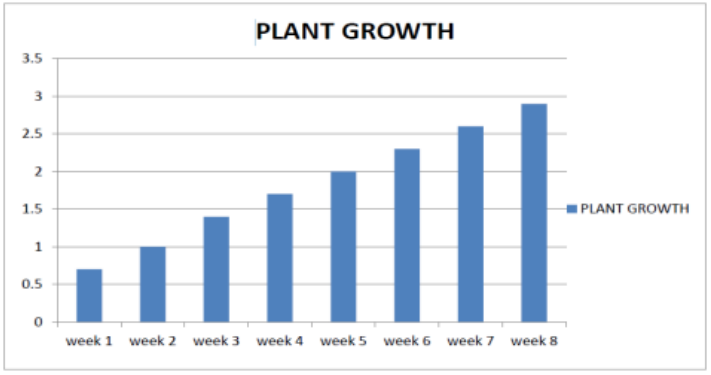


FIGURE 5 :GROWTH WITH COMPOST 1

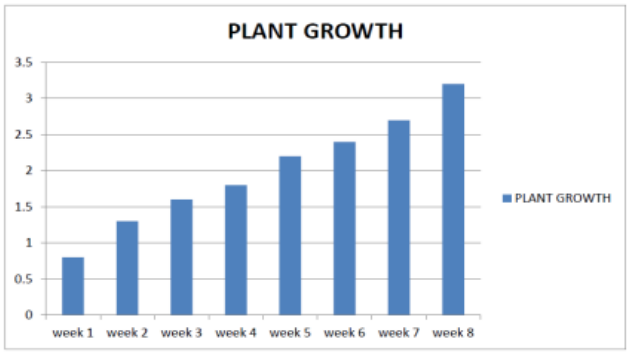


FIGURE 6: GROWTH WITH COMPOST 2

L. MEASURING CHILLI PLANT GROWTH IN 2 MONTHS

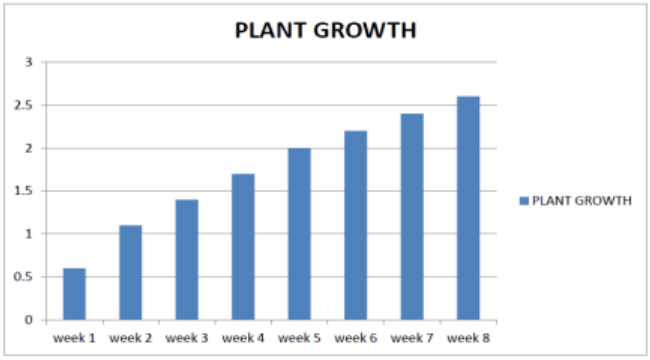


FIGURE 7 :GROWTH WITH COMPOST 1

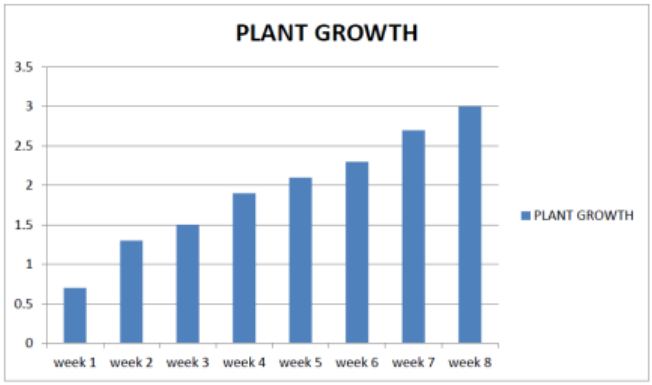


FIGURE 8 :GROWTH WITH COMPOST 2

M. MEASURING TOMATO PLANT GROWTH IN 2 MONTHS

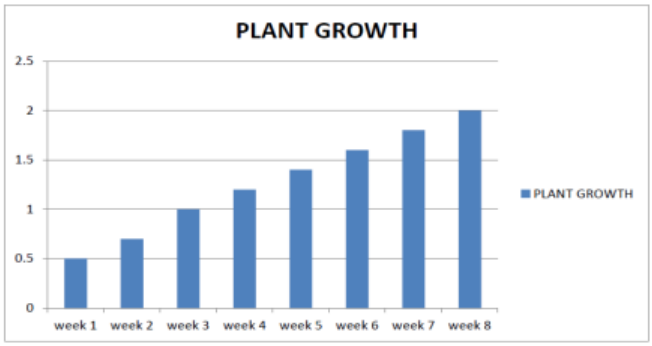
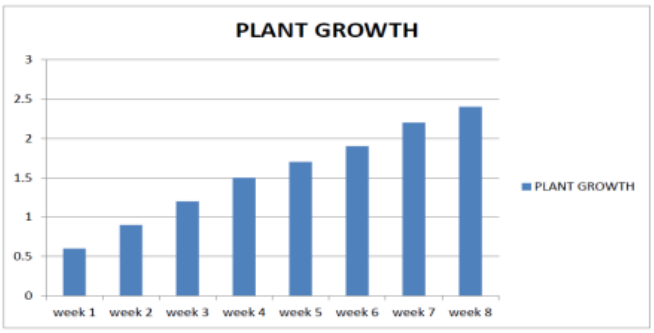


FIGURE 9 ;GROWTH WITH COMPOST 1



FIGIURE 10 :GROWTH WITH COMPOST 2

N. MEASURING LADIES FINGER PLANT GROWTH IN 2 MONTHS

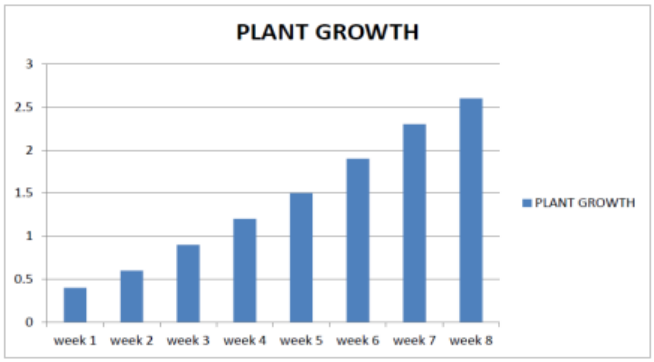


FIGURE 11: GROWTH WITH COMPOST 1

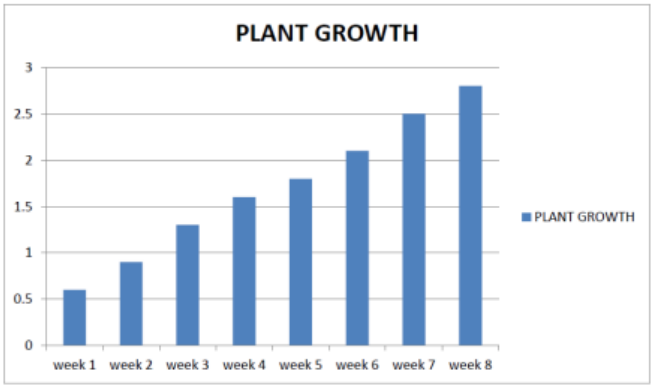


FIGURE 12 :GROWTH WITH COMPOST 2

O. ANALYSIS OF NUTRIENTS

The sludge contains various nutrient which is essential for the plant growth such as nitrogen, phosphorus and potassium. Nitrogen and phosphorus is available both as organic and inorganic forms. The macronutrients present in the sludge are analyzed. A comparison is brought between the compost samples before and after aerobic digestion.

TABLE 7 : ANALYSIS OF NUTRIENTS

NUTRIENT VALUE	NITROGEN Kg/hectare	PHOSPHORUS %	POTASSIUM %
BEFOR DIGESTION	350	0.290	0.010
AFTER DIGESTION	550	0.390	0.074

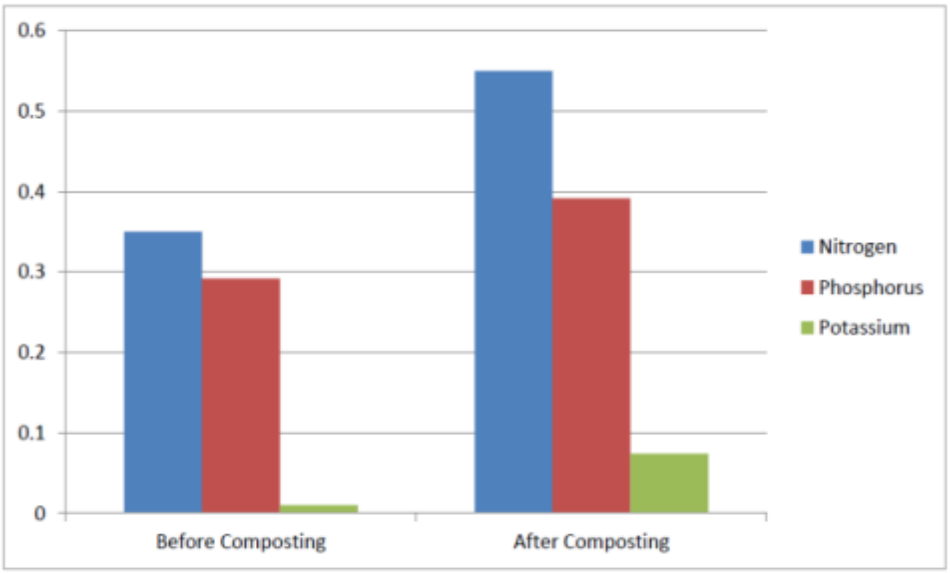


FIGURE 13 : COMPARISON OF NUTRIENT

P. DETECTION OF HEAVY METAL IN COMPOST

The concentration of heavy metals in the compost 1 and compost 2 is analysed 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 analyser 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 in growing edible plants.

TABLE 8 : HEAVY METAL DETECTION IN COMPOST

HEAVY METAL	ABSORBANCE OF COMPOST		CONCENTRATION OF COMPOST 1 & 2	PERMISSIBLE LIMIT FOR LAND APPLICATION
	C 1	C 2		
Arsenic	BDL	BDL	BDL	75
Cadmium	1.2388	1.0668	BDL	85
Copper	1.0567	1.0336	BDL	4300
Chromium	0.0018	BDL	BDL	3000
Iron	0.0021	BDL	BDL	-
Lead	0.0086	0.0074	BDL	840
Manganese	0.0066	0.0052	BDL	-
Nickel	0.0061	0.0044	BDL	420
Zinc	BDL	BDL	BDL	-

IV. 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 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.

REFERENCES

[1] Federal register (1993) 40 CFR Parts 257 and 503, Standards for the disposal of sewage sludge

[2] U.S EPA (1997 b) Control of pathogens and vectors in sewage sludge, U.S Environmental Protection Agency, EPA 625-R-92-013 (revised), Washington, DC.

[3] Metcalf & Eddy, Inc. (1991) Wastewater Engineering: Treatment, Disposal and Reuse

[4] Crain, G.F., P.S.Berger, and R.L. Calderon (1997) Coliform Bacteria and Waterborne Disease Outbreaks

[5] WEF (1995b) Bio solids Composting, Water Environment Federation, Alexandria, VA

[6] Wenger, G. (1992) " The Benefits of Bio solids from a Farmer's Perspective".

[7] Wenger, G Proceedings, The Future Direction of Municipal Sludge (Bio solids) Management, WEF specialty conference, Portland, OR.

[8] U.S EPA(1984) Environmental Regulations and Technology, Use and Disposal of Municipal Wastewater Sludge, EPA/625/10-84-003.

[9] Moen, G. (2000) " Comparison of Thermophilic and Mesophilic Digestion". University of Washington, Seattle, WA.

[10] U.S EPA (1983) Process Design Manual for Land Application of Municipal Sludge, EPA 625/1-83-016.

[11] Epstein, E. (1997) The Science of Composting, Technomic Publishing Co,. Lancaster, PA.

[12] Haug, R.T. (1993) The Practical Handbook of Composting Engineering, Boca Raton, FL.

[13] ASCE (2000) Conveyance of Residuals from Water and Wastewater Treatment, ASCE Manuals and Reports on Engineering Practise, Reston, VA.

[14] Chang, A.C., A.L. Page, and T.Asano(1995) :Developing Human HealthRelated Chemicals Guidelines for Reclaimed Wastewater and Sewage Sludge Applications in Agriculture", WHO, Geneva, Switzerland.

[15] Manual on utilization of sewage sludge compost as soil a soil conditioner and fertilizer for plant growth.

[16] Process Design Manual on Land Application of sewage sludge and domestic septage.

[17] Manual for composting sewage sludge by Beltsville Aerated-Pile method.

[18] Fertilizer Manual.

[19] Hammer, M.J. (1986) Water and Wastewater Technology. John Wiley & Sons, New York.

[20] Andreoli et al (2007) Sludge treatment and disposal

