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Management of Secondary Sewage Sludge by Vermicomposting for Use as Soil Amendment

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Abstract: Laboratory study was carried out for efficient management of sewage sludge generated by municipal wastewater treatment plant. The experiment dealt with the stabilization, through the action of epigeic earthworm, *Eudrilus eugeniae*, of mixtures containing sewage sludge, *Eichhornia crassipies* and *Parthenium hysterophorus.* Chemical analyses of secondary sewage sludge (collected from Hebbal treatment plant, Bangalore) were carried out to estimate the change in composition of various chemicals in sludge before and after vermicomposting. Combined effect of vermicomposting and addition of *P. hysterophorus* and *E. crassipes* resulted in conversion of sludge into a useful soil amendment in place of fertilizers to enhance the soil quality and increase the plant growth. A reduction in pH value is achieved after vermicomposting in all the three substrates used in the study. The study shows a significant increase in levels of Phosphorus in all the vermicomposted samples with highest of 0.34% by weight in the sample Sludge + *P. hysterophorus* while the value in plain sludge is only 0.17% by weight. This increased value promoted rapid and better germination in the germination studies carried out using *Lycopersicon esculentum* seeds.Effectiveness of vermicomposted samples as effective soil amendments was assessed through studies using tomato seeds. Aqueous vermicompost extracts of above material were used for this assessment. The results clearly indicated a maximum rate of 80% germination in case of sludge + *P. hysterophorus* and water samples while the least germination rate was observed in plain sludge sample. Subsequently the biomass value was maximum of 1.00g in case of the substrate sludge + *P. hysterophorus.*Serial dilution was carried out for the total microbial count, which was found to be nearly two-fold higher in vermicomposted sludge with *E. crassipes* and *P.hysterophorus* samples than in plain sludge, *E.coli* was absent in all the vermicomposted substrates.

Key words: Vermicomposting · Earthworm · Sewage Sludge · Heterotrophic Bacteria · Enteric Pathogen

INTRODUCTION

Effluent treatment plants (ETP) generally consist of physical, chemical and biological process to treat the wastewater discharged from industries or residential complexes. The dissolved organics in wastewater is generated as sludge mainly during primary and secondary treatment of municipal wastewater. During recent years the methodology of solid waste management has shifted from conventional disposal strategies such as incineration, landfill etc. to conversion of sludge into value added products [1]. The solid wastes generated from agricultural activities include crop residues and animal excreta meet special attention for disposal or utilization. The usage of these solid wastes by recycling can supply nutrients to crops and improve soil physical conditions and its fertility [2 - 4]. Further a wide variety of pathogenic microorganisms have been reported to be present in the sludge generated from treatment of municipal wastewater.

A literature review on solid waste management suggested that these solid wastes should be biocomposted before applying to soil in order to achieve biological transformation of the organic matter and to avoid potential risks of pathogens [5, 6]. Biocomposting of solid wastes bring about stabilization of the organic matter and effectively reduces pathogen concentrations in sludges to very low levels [7, 8]. Incorporation of earthworm in biocomposting process has been considered to be an appropriate technology for biowaste management for producing nutrient enriched compost. Various investigators have established the

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viability of the technology using earthworms as a treatment system for different wastes [9-15]. Earthworms hosts millions of beneficial microbes (including the nitrogen fixers) in their gut and excrete them in soil along with nutrients nitrogen (N) and phosphorus (P) in their excreta i.e. vermicast [16]. Earthworms also enhance soil microbial activity by improving the environment for microbes [17, 18].

MATERIALS AND METHODS

Municipal Sludge and Earthworm: The sewage sludge was obtained from Hebbal municipal sewage treatment plant (STP), Bangalore, India. The sludge was stored in small containers (20 x 6 x 4 cm) for two weeks; this was carried out to avoid exposure of earthworms to the initial temperature increase during the thermophilic phase of composting of organic content of sludge. The weeds *P. hysterophorus* and *E. crassipes* were collected and shred and placed in different containers and allowed for partial decomposition for a period of three weeks by adding thin slurry of cow manure. The earthworm, *Eudrilus eugeniae,* was used in this study. The earthworms were collected by hand sorting and maintained in agricultural waste amended with cattle manure at a temperature of 26°C±2° before the setting up of the experiments.

Substrates Used for Study:

- Sludge alone without earthworms (S)
- Plain sludge with earthworms(VS)
- Sewage sludge and *P. hysterophorus* 3:1 with earthworms(SP)
- Sewage sludge and *E. crassipes* 3:1 with earthworms(SE)

The ingredients were mixed well and moistened with thin slurry of cow manure. Twenty matured earthworms were introduced into vermicomposting bins containing one kg each of above substrates. The substrates to be ready for further investigations were placed in natural environment in order to maintain favorable temperature for earthworms.

Chemical Analyses: Chemical analyses of nutrient levels were carried out for the above mentioned samples.

Physico-Chemical Parameters analyzed were pH, electrical conductivity, free ammonia, Total Kjeldahl Nitrogen, phosphorus, potassium, sodium, chloride, sulphate, calcium oxide, copper and lead using standard methods [19].

Microbial Analysis in Vermicompost: The heterotrophic microbial populations in the vermicomposted samples were determined using spread plate method. The composted samples were homogenized and extracted in sterile water and dilutions were made up to 10^{-5}. Nutrient agar was used for plating and 1 ml aliquot of each diluted sample was poured, spread and plated. Escherichia species were enumerated using Eosin Methylene Blue agar. All the bacterial plating work was completed within 4 hours of sampling. The bacterial numbers were expressed as CFU g^{-1} (Colony Forming Units per gram) after 36 hours of incubation at 37°C.

Germination Studies: Aqueous extracts (10 %) of the following samples were prepared for germination studies using *Lycopersicon esculentum;*

- Plain Sludge
- Vermicomposted sludge
- Vermicomposted *P. hysterophorus* + sludge
- Vermicomposted *E. crassipes* + sludge
- Vermicompost derived from agricultural waste and cow manure
- Garden soil
- Water

Germination Test: Twenty tomato seeds soaked for 30 min in the above extract samples were placed on to Petri dishes covered with filter paper. The paper was kept moist during the entire period of study using the respective extracts. The germination and growth were observed for 10 days. The number of seeds germinated in each Petri-plate used during the test was counted and rate of germination was calculated using the formula given below:

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seed in Petri dish}} \times 100$$

Biomass of the Germinated Seeds: The weight of 20 tomato seeds taken prior to and after germination test (with pulmule and radical) using different extracts were weighed, tabulated and results were compared with controls.

RESULTS AND DISCUSSION

Chemical Analysis of Sludge and Sludge Mixed with Additives: Classified as the *primary nutrients* —nitrogen (N), phosphorus (P) and potassium (K)—are common nutrients that are utilized in large amounts by crops.

Table 1:Chemical properties of vermicompost derived on using sludge with other organic matter

		Substrates			
Sl No	Parameters	Sludge	Vermicomposted Sludge	Vermicomposted Sludge with *Parthenium sp*	Vermicomposted Sludge with *Eichhornia sp*
1	pH	6.8	6.13	6.18	6.3
2	Electrical conductivity (mircomhos/cm)	930.0	3026.67	4413.33	2806.67
3	Free Ammonia(% by wt)	1.0	0.25	0.67	0.72
4	Total Nitrogen(% by wt)	3.0	1.73	1.84	2.0
5	Phosphorous(% by wt)	0.17	0.23	0.13	0.27
6	Potassium as K(% by wt)	0.45	0.17	0.26	0.13
7	Sodium as Na(% by wt)	0.12	0.32	0.28	0.35
8	Chloride as Cl(% by wt)	13.2	1.2	2.04	1.57
9	Sulphate as SO4(% by wt)	0.67	0.15	0.76	0.67
10	Calcium oxide(% by wt)	38.0	43.92	41.6	41.55
11	Copper as Cu(% by wt)	<0.1	0.11	0.1	0.11
12	Lead as Pb(% by wt)	<0.10	0.36	0.18	0.10

Table 2: Total microbial count and *E.coli* in the vermicompost derived from different substrates

Sl.no	Vermicompost	Total microbial count 10^{-5} CFU/g	E.coli
1.	Vermicomposted sludge	1050	_
2.	Sludge + *P. hysterophorus*	1300	_
3.	Sludge + *E. crassipes*	784	_
4	Sludge	450	72

The study indicated a reduction in the value of nitrogen from its value of 3.0 % by weight in plain sludge to 1.73% in vermicomposted sludge, 1.84% in Sludge + *P. hysterophorus* and 2.0 in Sludge + *E. crassipes* (Table 1). The decrease of mineral N in casts can be due to Nitrogen becoming microbial biomass, volatilized, denitrified, or leached [20]. Though there is decrease in total nitrogen, the germination studies have shown the possibility of increase in levels of available nitrogen on vermicomposting. The study indicated increase in levels of phosphorus in all the vermicomposted samples with highest of 0.34% by weight in the sample *Sludge + P. hysterophorus* while the value in plain sludge is only 0.17% by weight and an increase in Potassium level on use of *E. crassipes* as an additive. In the present investigation, the level of potassium was 0.45% in plain sludge before vermicomposting came down to 0.13%on vermicomposting. The biomass addition might be responsive for decline in observed values from that of original sludge.

Microbial Analysis

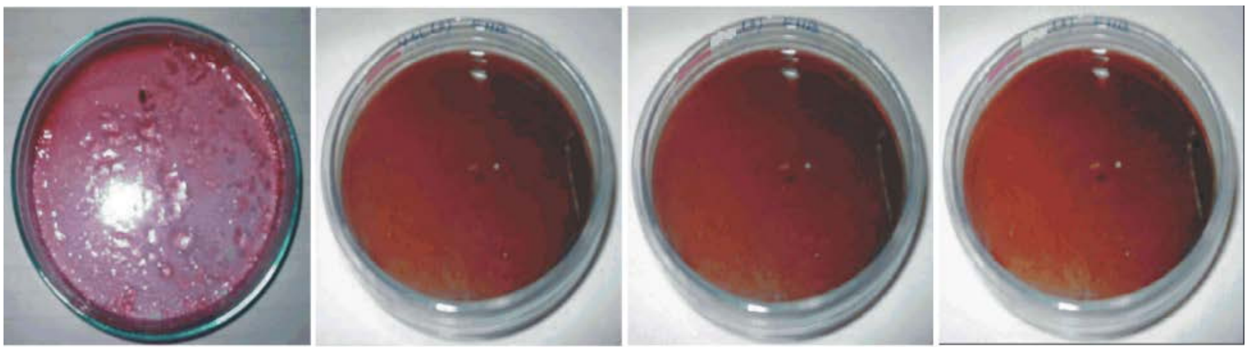
Total Microbial Count and *E.coli* Levels in Vermicompost from Sludge: The castings were collected on the first day of appearance of castings, after two weeks and after complete vermicomposting and analyzed for presence of *E.coli* by spread plate technique on EMB (Eosin Methylene Blue) agar. Absence of metallic sheen confirmed the absence of *E.coli.* Similar results on pathogen reduction after vermicomposting process due to action of earthworms has been reported earlier [21, 22]. The increased growth with progressive decrease with dilution might be due to enhancement of the sludge with useful bacteria by earthworms during vermicomposting. Various studies undertaken by scientists indicate *Pseudomonas*, cellulolytic *bacillus sp*. and heterotrophic bacterial population were increased at the end of vermicomposting period, indicating the selective nature of earthworms in the removal of microorganisms [16].

Total microbial count was found to be nearly two to three fold higher in vermicomposted sludge and vermicomposted sludge with *E. crassipes* and *P. hysterophorus*, than in plain sludge. *E.coli* was absent in all the vermicomposted. The results have been tabulated in Table 2.

Germination Studies: The germination tests using *Lycopersicon esculentum* indicated a maximum rate of 80% germination in extracts of Vermicomposted sludge + *P. hysterophorus* and water while the least germination rate was observed in extracts of plain sludge. Subsequently the biomass was maximum of 1.00g in case of the substrate sludge + *P. hysterophorus*.

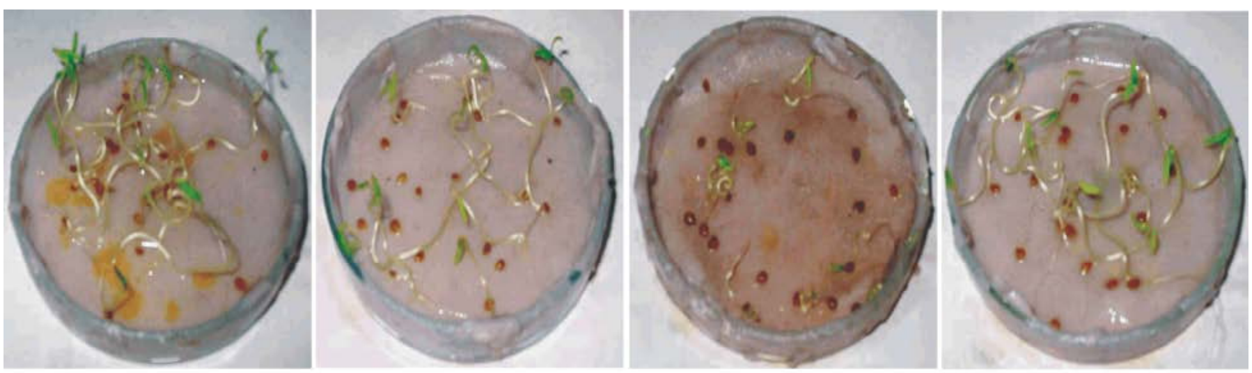
Table 3: Germination of tomato seeds using various substrates

Sl no	Sample	No of seeds germinated 7th day	10th day	Weight of seeds in grams (10th day)	Germination Rate in percentage (%)
1.	Water	14	16	0.6700	80
2.	Garden soil	11	14	0.5114	70
3.	Vermicompostsample	13	11	0.5066	55
4.	Plain sludge	6	9	0.2554	45
5.	Vermicomposted sludge	9	13	0.4342	65
6.	Sludge + *Parthenium sp.*	13	16	1.0093	80
7.	Sludge + *Eichhornia sp.*	8	12	0.5553	60
8.	Standard value (Control seeds)			0.0352	70 (min)



A: Plain Sludge B: Vermicomposted Sludge C: Sludge + *P. hysterophorus* D: Sludge + *E. crassipes*

Plate 1: *E.coli* on the EMB agar plates



A: Plain sludge B: Vermicomposted sludge C: Sludge +*P. hysterophorus* D: Sludge + *E. crassipes*

Plate 2: Germination of *L.esculentum* seeds in different aqueous extracts

Though similar studies have not been undertaken, various other studies have indicated a significant increase in germination rate of different seeds of crops in vermicompost and its fractions [23]. Maximum percentage of germination was observed with 15% vermicompost amendment in tomato during pot studies [24] and significant improvement in soil qualities was observed in plots treated with vermicompost [25]. Table 3 highlights the contrasting differences in rate of germination and weight of the tomato seeds germinated at the end of study period.

During the study period the set up was constantly monitored and the plates were photographed at periodic intervals to visually compare the growth pattern among various samples used. Plates 1 and 2 show the germination pattern observed on 10th day.

CONCLUSION

This study indicates that the weeds *P. hysterophorus* and *E. crassipes* can be effectively used as additives in the process of vermicomposting of sludge. Farmers can adopt vermicomposting of sludge before application in the field as this process eliminates the pathogen *E.coli* and makes the sludge safe to be handled. Further, the quality of sludge also improves on vermicomposting.

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