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Conversion of Industrial Waste into Agro Wealth by *Eisenia foetida*

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Abstract

Organic waste is extensively increasing with increased human population, intensive agriculture and industrialization. The disposal of waste has become important for a healthy quality of environment. The conversion of waste into beneficial materials is an important aspect of resource through recycling and environmental cleaning. The recycling of wastes through vermi composting, reduces problems of disposal of wastes. From the present work with composting efficiency earthworms such as Eisenia foetida was selected for Sugar and Sago waste. This waste was mixed with dry cow dung in 1:1 ratio and applied a number of physico chemical parameters such as bulk density, moisture content, specific gravity etc., and analyzed in the worm treated and worm untreated substrate. The result shows the Sugar and Sago waste were converted into vermi compost by earthworm Eisenia foetida, is the best economic in waste conditions and compare to Sago press mud and sugar waste. It has the best composting efficiency and the composting time is also very fast.

Keywords: Industrial waste, Sago press mud, sugar waste, *Eisenia foetida,* compost.

Introduction

Vermicompost is the process of composting using earthworms to create a heterogeneous mixture of decomposing food waste or any other waste materials[1]. Vermicast is also called worm castings. It is the end product of the breakdown of organic matter by earthworm. These castings contain reduced levels of contaminants and a higher saturation of nutrients[2]. Vermicomposting is used not only as an alternative source of organic fertilizers but also to provide economical animal feed protein for the fish and poultry industries worldwide. They contain more available nutrients per weight than the organic waste from which they are produced[3]. They increase N, P, and K content in the soil and are readily available for plant growth[4]. Transplantation of earthworms and mulching facilitate transfer of nutrients to plants[5]. Species identified as potentially useful to break down organic wastes were *Eisenia foetida*, *Dendrobaena veneta* and *Lumbricus rubellus* from temperate areas and *Eudrilus eugeniae* and *Perionyx excavates* from the tropics[6]. In India vermiculture is being tested for treatment of agricultural, sugar, food processing wastes[7]. Solid wastes can be defined as "The waste which have been ejected for further use and which can neither be transported by water into streams nor can readily escape into the atmosphere"[8]. They include all the discarded solid materials from domestic, municipal, agricultural and industrial activities[9].

The animals are important contributors to soil fertility and humification processes[10]. Further; earthworms should be considered as keystone organisms in regulating nutrient cycling processes in many ecosystems[11]. Earthworms may alter the balance between ecosystem conservation and loss of nutrients, particularly C and N. Farmers consider them as beneficial because some species play a significant role in organic matter decomposition and mineral cycling[12]. Recycling of wastes through vermi technology reduces the problem of non utilization of agro wastes[13]. In recent years vermi compost has gained importance because of its higher economic value compared with compost derived from traditional methods[14]. The potential of earthworms as a biological tool should be much better to promote farming and sustainable development with the use of selected species of earthworms[15].

Figure-1
Eisenia foetida

The most commonly used solid waste treatment and disposal methods are composting, sanitary landfills or controlled tripping, thermal processes i.e. incarnation, pyrolysis, recycling and reuse[16] several agricultural product based industries release solid waste rich in organic matter. If these, press mud is an important organic waste produced by Sugar industries[17]. The effluent from sugar industries contains a large amount of dissolved organic matter which is readily decomposed by biological action[18]. Consequently, discharge of these liquors to surface water causes serious damage to aquatic life[19].

Press mud is a subsidiary of the sugar industry and this is generally used as manure. During the course of clarification of sugar cane juice, most of its impurities are precipitated[20]. These are filtered in filter press. The cake which is discharged after washing is called "Filter mud"[21]. It is also called Filter cake. The resultant product of Press mud contains certain mineral and organic matter including wax. Efforts are being made to develop the industry for manufacture of can wax [22].

Sago effluent is one of the most important polluting agents of aquatic environment. In India Sago manufactured from the starch obtain from the tubes of Tapioca[23]. There are about 1000 sago and starch industries in small scale sector scattered throughout the state of which about 800 units are located and causing serious environmental problems.

Earthworms are commonly referred as Farmer's friend. Vermicasts are useful as excellent organic manure. It is porous and has moisture absorbing capacity. It increases uptake of nutrients. Vermicasts are considered as plant growth promoters or soil conditions and help to increase crop productivity[24]. Earthworms are used as bio agents for composting. The process of releasing the organic compounds by the earthworms is known as "vermicomposting'.

The following are the beneficial conditions where the earthworms are suitable to use:

Earthworms are useful for effective sewage and sludge management. Earthworms in sludge produces increased oxygen consumption decreased anaerobic decomposition and increased mineralization capital and operating costs of vermicomposting are comparable to those for other sludge management systems. Millions of tones of livestock excreta and wide range of animal waste including chicken, duck, pig cattle dung, slurry during wastes, plant residues and food processing wastes can be disposed by using them as substrate for vermin composting[25]. Bacteria and *Eisenia foetida* worms can be used in large scale industries for vermicomposting. Non toxic organic wastes from food processing industries, distilleries etc., can be handled by vermicomposting. Earthworm eat up anything except rubber, metal, plastic and glass.

Reclamation of uncultivated land for agricultural use can be done by introduction of earthworms. Nutrient cycling and improvement in the physical structure of soils occur through earthworms[26]. Earthworms could be for extraction on heavy metals ions from sludge prior to land filling. Fishermen often use these earthworms as bait. Earthworm casts can be used as casting material for mushroom growth. Fruiting body formation occurs optimally with the use of the earthworm casts as causing material[27].

Earthworms are being used in different systems of medicines in India like Ayurveda, Unami for the treatment of protein deficiency, pains, boils, snakebites, jaundice, small pox and rheumatism[28]. An account of their ability to eat anything and everything and convert it into vermicast, it was decided to study the efficiency of earthworm is composting sugar and sago industry wastes which process a maintenance to local environment.

Material and Methods

Sugar and Sago waste material was collected from the industrial area for the experimental purpose. The industries are surrounded by good agricultural environment but the solid wastes from the industries are dumped in the surrounding area. The main aim of this study is the decomposition of solid waste from sugar and sago industries by using earthworms. The collected solid waste was mixed with dry cow dung at the ratio of 1:1. These substrates was placed in pots and used for experimental purpose. In the experimental pots earthworm *Eisenia foetida* were introduced and predetermined at the end of 60 days worms were collected and its length was noted.

Substrate for decomposition: Solid wastes from sugars and sago industry were dried and mixed with dry cow dung at the ratio of 1:1. The mixture was used as the substrate for vermicomposting. Four experimental pots were taken up serially number as P1, P2 and S1, S2 (P= Pressmud; S= Sago industry waste).
P1 = Control 2 kg substrate (without worms)
P2 = 2 kg of substrate with *Eisenia foetida* species of earthworm Which is the Chinese species (exotic) family; Lumbricidae
S1 = Control 2 kg substrate (without worms)
S2 = 2 kg of substrate with *Eisenia foetida* species of earthworm Which is the Chinese species (exotic) family; Lumbricidae
A total number of 100 worms of uniformed species were introduced into each experimental pot named as P2 and S2.

Figure-2
Vermicomposting in industrial waste

Table-1
Physico chemical characteristics of sample (s_2) in comparison to control s_1
S_1 = Control (Press mud) S_2 = Substrate (Press mud)

Particulars	Initial		30 days		60 days		Mean value	
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
Bulk density(g/cm^3)	0.293	0.293	0.351	0.68	0.325	0.749	0.323	0.604
Moisture (%)	720	720	948	1399.1	939	1367.7	869	1162.2
Specific gravity (g/cm^3)	1.421	1.411	0.210	0.310	0.196	0.298	0.606	0.670
Temperature (^{0}C)	22.8	22.8	25.3	30.7	27.4	29.5	25.1	29.9
pH	8.0	8.0	7.0	7.2	7.2	7.6	7.4	7.6
EC (m mhos/cm)	2.6	2.6	2.5	2.3	3.4	4.9	2.8	3.2
Alkalinity (g/kg)	0.102	0.102	0.112	0.302	0.924	0.102	0.397	0.168
Acidity (g/kg)	110	110	110	110	110	110	110	110
Calcium (mg)	166.7	166.7	173.4	189.2	182	198.3	174.0	184.7
Chloride (mg/g)	99.4	99.4	109.4	100.4	138	145.4	115.6	115.1
Nitrogen (mg/l)	545	545	581	565	569	598	555	569.3
Phosphorous (mg/l)	153	153	240	285	380	440	257.6	292.6
Potassium (mg/l)	500	500	543	580	581	610	544	563.3
Organic carbon (% by wt)	3.9	3.9	3.8	3.8	3.6	3.7	3.8	3.8
Organic matter (% by wt)	67.33	67.33	65.19	64.92	64.91	62.97	65.78	65.97

From the above table the values are high at 60 days compared to the remaining values.

Table 2
Physico chemical characteristics of sample (s_2) in comparison to control s_1
S_1 = Control (Sago waste) S_2 = Substrate (Sago waste)

Particulars	Initial		30 days		60 days		Mean value	
	S1	S_2	S1	S_2	S1	S_2	S1	S_2
Bulk density(g/cm^3)	0.330	0.330	0.613	0.85	0.393	0.752	0.445	0.662
Moisture (%)	714.9	714.9	890.1	1720	867.2	1509.2	824.06	1314.7
Specific gravity (g/cm^3)	0.338	0.338	0.657	0.210	0.435	0.1928	0.473	0.606
Temperature (^{0}C)	20.8	20.8	22.7	29.5	24.4	30.5	22.6	29.8
pH	7.0	7.0	6.0	6.8	6.1	6.5	6.3	6.7
EC (m mhos/cm)	1.2	1.2	2.0	1.5	3.1	7.2	2.1	3.3
Alkalinity (g/kg)	0.219	0.219	0.431	0.322	0.232	0.122	0.293	0.221
Acidity (g/kg)	110	110	110	110	110	110	110	110
Calcium (mg)	25.65	25.65	29.12	32.1	23.64	48.1	29.137	35.25
Chloride (mg/g)	71	71	79.24	60.98	88.2	107.92	79.48	79.96
Nitrogen (mg/l)	90	90	90	94.5	92.4	99.4	90.81	94.63
Phosphorous (mg/l)	340	340	348.1	390	399.0	440	362.37	390
Potassium (mg/l)	500	500	576.8	680	592	720	556.14	633.4
Organic carbon (% by wt)	2.7	2.7	2.53	2.59	2.55	2.42	2.62	2.57

From the above table it shows that at 60 days the conditions are more suitable for the growth of the worms.

The industrial wastes were initially analyzed before subjecting to vermicomposting changes in the chemical characteristics of the substrate were analyzed at a 30 and 60 days. The growth of worms was measured and length at the end (30 and 60 days). Analysis of substrates (Industrial wastes P & S)

Physical Parameters Bulk density: (glcm^3): The soils with high bulk density are inhibitive to root regeneration, low permeability and difficult filtration. The bulk density is inversely proportional to the space of soil. Air-dried sample in an oven at 105^{0}C was kept until a constant weight was attained, transferred a litter dried sample to a measuring cylinder and noted the volume and recorded the weight of this volume by using a balance.

Moisture content (%): The moisture content in the soil was present in the form of precipitated water or through irrigation or drains through percolation, evaporation or uptake by plants. Air dried sample of soil was taken and weighs. Air-dried sample in the oven at 105^0C was taken until constant weight was attained. Cooled in a desiccators and recorded the final weight of sample.

Specific gravity (g/cm^3): The specific gravity of the soil was directly proportional to its bulk density used as an index of soil quality. Air-dried sample in an oven at 105^0C was taken until constant weight was attained. Filled a pre-weighted glass bottle of known volume with dried sample and recorded its weight.

Temperature (^{0}C): Temperature is basically an important factor for chemical and biological reactions in the ecosystem. A rise in temperature of water accelerates chemical reactions, reduces solubility of gases, amplifies the odour and texture which elevates metabolic activity of organisms.

Chemical Parameters: **^{pH} (Hydrogen ion concentration):** 10gm of air dried sample was taken to 100ml of distilled water. Suspension of 1:10 W/v dilution was shaken and left for 30 minutes. The pH of suspension was estimated by pH meter.

Electrical conductivity: (m-mhos/cm): 10gm of air dried sample was taken to 100 ml distilled water. Suspension of 1:10W/v was taken and left for 30 minutes. The Electrical conductivity of suspension was estimated.

Alkalinity (g/kg): 10 gm of air – dried sample was taken to 100ml of distilled water. The suspension 1:10 W/v dilution was taken and left for 30 minutes. Filtered it though a filter paper (Whattman No. 44) and determined its alkalinity.

50 gm of air-dried sample was taken from the prepared suspension in a flask and added 2-3 drops of phenolphthalein indicator. A slight pink color appears phenolphthalein alkalinity (due to hydroxide or carbonate) was present (non appearance of pink color was indicative of presence of free CO_2 but absence of phenolphthalein alkalinity. Titrated the solution against sulphuric acid (0.02N) until solution become colorless (end point). Noted the reading as phenolphthalein alkalinity and added 2-3 drops of methyl orange indicator in the same flask and continued for titration against sulphuric acid until yellow color of solution turns orange (end point).

Acidity: (g/kg): 10 gm of air-dried sample was taken to which 100ml of distilled water. The suspension 1:10w/v dilution was shaken and left for 30 minutes. Filtered it through a filter paper and determined the activity. 100 ml of air-dried sample was taken from prepared suspension in a flask and added 2-3 drops methyl orange indicator. If the color turns yellow methyl orange acidity was absent (non appearance of yellow color is indicative of present of methyl orange activity). Titrated against sodium hydroxide solution (0.05N) until solution become pink color yellow (end point). Noted the reading as A. Added few drops of phenolphthalein indicator in the same flask and continued for titration against sodium hydroxide solution (0.05N) pink yellow color of solution turns pink color (end point) noted the reading as B.

Calcium: (mg/l): 10gm of air-dried sample was taken to 100 ml of ethyl alcohol. Taken and left for 10 minutes and filtered the suspension through the filter paper (Whattman No.80). Further the soil residue on filter paper with 40% ethyl alcohol and transferred the residues to a beaker added 100ml of ammonium acetate solution stirred and allowed standing for overnight. Filtered the supernatant through filter paper (Whattman No.80) and collected the titrate (soil extract). Noted the total volume of soil extract. 50ml of sample was taken from the extract in a flask and added 1ml of sodium hydroxide solution and a pinch of murexide indicator. Titrated against EDTA solution until the pink color turns purple (endpoint).

Chloide (mg/l): 10 gm of air-dried sample was taken to which 100ml of distilled water. Prepared the suspension 1:10 w/v filtered it through a filter paper (Whattman No. 44). 10 ml of filtrate was taken in a flask and added 5-6 drops of potassium chromate indicator. The color of sample becomes yellow. Titrated against Silver nitrate solution until a persistent brick red color appears (end point).

Nitrogen (mg/l): 50 gm of air-dried sample was taken in a micro-kjeldhal distillation flask and added 1 ml of borax buffer solution**.** Put 5 ml of boric acid indicator solution in a conical flask. Placed it below the condenser, dipped in contents of conical flask. Heated the Kjeldhall flask containing water sample. Continued the distillation for 10 minutes after that 40ml of distillate was collected in a conical flask. Removed the conical flask when distillation turns blue due to dissolution of ammonia. Titrated the distillate in conical flask against 0.01N hydrochloric acid. Turning blue color to faint pink or brown indicator was the end point. The blank was maintained with distilled water in a same way.

Phosphorous (mg/l): 1 gm of air-dried sample was taken to which 200ml of sulphuric acid (0.002N) was added. Suspension was taken and left for 30 minutes. Filtered the suspension through a filter paper (Whattman No. 50). 25 ml of filtrate was taken to that 1 ml of ammonium molybdate and 3-4 drops of stannous chloride solution was added. A blue color was appeared after 10 minutes recoded absorbance on spectrophotometer at 690 nm. The blank was maintained with distilled water in a same way. The standard phosphate solution of different strengths in similar manner was processed and calculated the concentration of standard phosphorous solution. Reduced the inorganic phosphorous content of sample by comparing its absorbance and noted the results in $MgPO_4$.

Potassium (mg/l): Prepared the soil extract as determination of calcium. Set the filters on the flame photometer reading at 769nm started the compressor and light the burner of flame photometer kept the air pressure at 5lbs and adjusted the gas feeder to have a blue sharp flame. Feed the standard potassium solution of the highest value in the range and adjusted the flame photometer to read full value of emission on the scale.

Adjusted zero value of the meter by feeding distilled water. Different standard potassium solution within the range one by one and recoded the emission value for each. Filtered the sample through filter paper and feed in flame photometer. Noted the reading for sample and reduce potassium content of the sample mg/l by comparing the value with standard value.

Organic matter (% by wt): 0.5 g of air-dried sample was taken in 500ml flask which 10ml of potassium dichromate gradually 20 ml of sulphuric acid was added, left for 30 minutes. And then added with 200ml of distilled water, 10ml of phosphoric acid and 1ml of Diphenyl amine indicator. Titrated the contents against ferrous ammonium sulphate solution. At the end point the dull green color changes to the brilliant green.

Results and Discussion

Low bulk density, 50% of water content shows considerable growth rates (3 to 4 cm) within 60 days and produces young ones, particle density was low in worm untreated substrate, temperature ranges from 25.1^0C to 29.9^0C, earthworms prefer soil with a pH between 7.6 , Electrical conductivity is low, low alkaline, but the acidity was higher in worm treated substrate, calcium present in the soil increases the activities of the earthworm, chloride composition was 8 to 9 mg/g, Nitrogen percentage was high indicates the process of composting complete and now the vermicompost read to harvest, Potassium and phosphorous content was high, reduction of organic carbon was due to the respiratory activity of earthworm. The degradation of organic matter plays an important role in vermicomposting.

Conclusion

The results obtained at the end of 60 days of composting of sugar mill waste (pressmud) and sago industry waste by using *Eisenia foetida* species of earthworms are significant. The degradation efficiency of *Eisenia foetida* species is high. This indicates that the worms were well acclimatized and converts the waste into proteins. Pressmud was more amenable compared to the sago waste. It can be concluded *Eisenia foetida was* the effective and economical waste conditioner.

Future aspects: The earthworms are highly useful to the farmers in agricultural fields because the solid waste was completely converted into the fertile soil for the plant growth and better yield and at the same time it helps to reduce the pollution, cleans the environment.

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