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Vermicomposting Process of Organic Waste and Paper Mill Sludge

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Abstract:- Industrial development and increase in population has generally been equated with ecological degradation that leads to environmental pollution. Every year millions of tones of pollutants are introduced into the environment by various industries. Thousands of small scale and even some bigger industrial units dispose waste, more often toxic and hazardous, in open spaces and nearby water sources. Over the last decade many cases of serious and permanent damage to environment by these industries is reported.

An experimental study was conducted to obtain the vermicompost using partially decomposed fruit waste with paper industry sludge's. The earthworm species used for this process was Eudrillus eugeniae. The microorganism culture Pleurotus was added to enhance the degradation process. Moisture content was maintained by providing proper percentage of water. The partially decomposed organic waste and industrial sludge's were converted into castings by earthworms. The castings was obtained on the top surface of the bin were in the range from 20 to 30 days depending on the type of waste and sludge used. The castings obtained were sieved, dried, tested and used as manure. Thus the vermicomposting process helps in the disposal of organic waste and industrial waste in a safe, economic and useful manner.

I. INTRODUCTION

Industries produce a large quantity of wastewater and sludge's during their each processing stage. When this industrial waste comes into contact with the environment they produce serious impacts on it. It is difficult to generalize the industrial wastes since its characteristics differ from industry and also from its different processing plants.

Before final disposal one can process and treat the waste so as to reduce the "wasteful wasting of waste". Some of the techniques available to achieve this objective are volume reduction, recovery of resources, energy recovery. That's why the world is entering new branch of bio information technology. This study has been done for reducing the pollution problems due to solid waste and industrial sludge's by converting it into compost by using earthworms very successfully, economically and usefully.

A. *Solid Waste*

The solid waste is complex in character and its volume is greatly increased due to increase of living standards and population density. Hence the importance of efficient solid waste management is increasingly recognized. Solid waste is the term now used internationally to describe non-liquid waste material arising from domestic, commercial, hospital, industrial, agricultural and mining activities. Solid waste comprises countless different material dust, food waste, paper, metals, plastics, glass, discarded clothing, garden waste etc. Solid waste includes both combustible and non-combustible waste. Disposal of solid waste should be properly managed. They cause insanitation conditions, and hazard to human being. Day to day management of municipal solid waste is a complex and a costly task.

a) ORGANIC WASTE -Fruit Waste
Usage of fruits produces two types of waste - a solid waste of peel / skin, seeds, stones etc – a liquid waste of juice and wash waters. In some fruits the discarded portion can be very high(e.g. mango 30-50%,banana 20%,pineapple 40-50% and orange 30-50%).Therefore, there is often a serious waste disposal problem, which can lead to problems with flies and rats around the processing room, if not correctly dealt with. If there are no plans to use the waste it should be buried or fed to animals well away from the processing site. Only waste produced during the same day should therefore be used - it is not advisable to store - up wastes to use for eg at the end of a week's production.

b) INDUSTRIAL SLUDGE -PAPER MILL SLUDGE
Biodegradation of paper waste has suggested the utilization of paper waste for composition. Bioconversion of paper mill sludge in to compost by using worms studied.Sludge from paper and pulp mill is mainly cellulose fiber generated at the end of pulping process. They are composed essentially of fibrous fines and some inorganic such as kaolin clay, calcium carbonate, titanium dioxide and other chemicals used in manufacturing process.

B. *VERMI COMPOSTING*

Vermi is the Latin word for worm. Vermicomposting is simply composting with worms. Vermicomposting refers to the method of converting organic waste in to worm castings**(E. Albanell, J. Plaixats, T. Cabrero, 1988)** It is one of the most cost efficient and environmentally friendly methods of waste disposal. In an ideal condition earthworms can consume practically all kinds of organic matter and they can eat their own body weight per day for example one kilogram of worms can consume one kilogram of residues every day. And yet their casts contain eight times as many microorganisms as their feed. And the casts don't contain any disease pathogens-pathogenic bacteria are

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reliably killed in the worm's gut. Worm casts also rich in nutrients such as Nitrogen, Phosphorous and Potassium**(Dr.D.Augestine selvaseelan, 2000)**Vermicompost involves aerobic decomposition of organic waste by using microorganisms. Maximizing the waste-processing rate depends on maintaining high earthworm density throughout the vermicomposting process.In particular temperatures, moisture, waste character, earthworm densities are the factors. The density of earthworms in any Vermicomposting system is related to rate of waste processing.

C. Earthworms

Aristotle, the Greek Philosopher, referred to them as " intestines of earth" because of their habit of ingesting and ejecting the soil. The main activity of earthworms involves the ingestion of soil, mixing of different soil components and production of surface or sub surface castings. The earthworms consume the soil organic matter and convert it into humus within a short period of time and increase the soil fertility. EUDRILUS EUGENIAE is popularly known as the African Worm or Night Crawler is a large worm that grows extremely rapidly and is reasonably prolific.

- It is an ideal candidate for protein production.
- It is a good species for use under tropical condition.

II. MATERIALS

A. Feed Materials

The fruit waste was collected from the Pazamuthir nilayam located at saibaba colony. The Paper Sludge was collected from BIPCO Industry at Mettupalayam and their characteristic was analysed.

Parameter	**Initial Characterisitcs of Fruit Waste**	**Characteritics of Partially Decomposed Fruit Waste**	**%Mix Fruit+ Paper sludge**
Nitrogen**(%)**	0.580	0.750	0.210
Phosphorus**(%)**	0.200	0.310	0.090
Potassium**(%)**	0.480	0.800	0.300
Calcium**(%)**	0.210	0.350	0.310
Magnesium**(%)**	0.150	0.250	0.150
Total Solids**(%)**	63.500	60.500	71.800
Volatilesolids**(%)**	79.800	75.800	69.800
PH	7.100	8.100	8.200
Carbon**(%)**	29.500	22.500	29.500
Chloride**(%)**	0.500	0.600	0.500
Sulphate**(%)**	0.015	0.019	0.0180
Lingin**(%)**	33.800	26.800	25.500
Cellulose**(%)**	26.100	20.800	21.500
Protein**(%)**	4.900	3.900	3.100
COD (mg/kg)	600.00	500.00	650.00

Table 1: Characteristics of Waste Before Composting

Parameter	**Paper Mill Sludge**
Nitrogen (%)	1.430
Phosphorous (%)	0.710
Potassium (%)	1.180
Chlorides (PPM)	199.938
Sulphate (PPM)	8221.050
PH	7.290
EC (ds/m)	0.040
Zinc	12.00
Copper	22.00
Iron	920.00
Cadmium	5.50
Manganese	48.0
Chromium	-

Table 2: Initial Characteristics of industrial sludge

B. EXPERIMENTAL SETUP

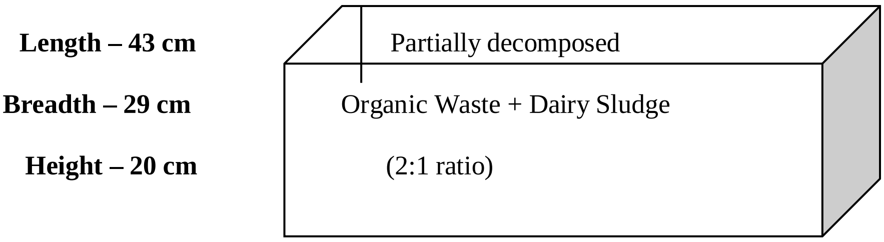

Fig 1: Worm Bin Set Up

A laboratory scale set up of worm bin was made up of earthen material in the form of an open rectangular box with size 43cm x 29cm x 20cm. The worm bin was provided with wire like holes at bottom for drainage and on periphery for better ventilation. The bin was placed in a steel stand and a tray was kept at the bottom of bin to collect the drained liquid. The bin was covered at top using wire mesh to prevent the entry of birds, rats etc. The experimental set up was placed in a cool dark place.

C. EXPERIMENTAL PROCEDURE

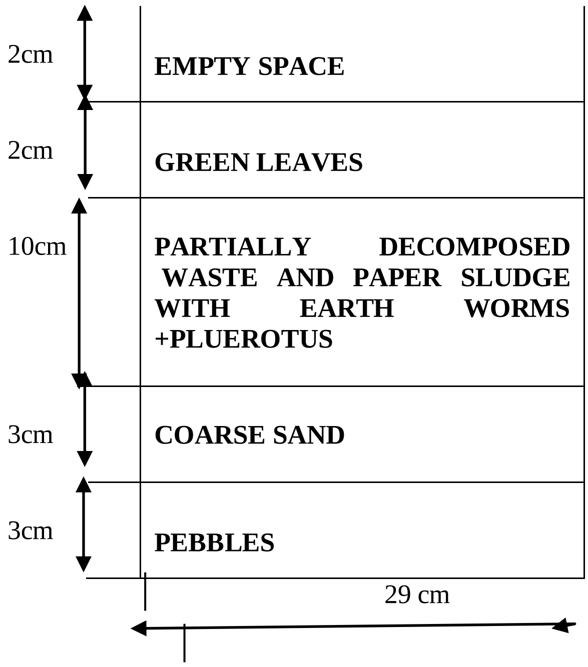

Fig. 2: Reactor setup

Waste Mix	C1	C2	C3	C4	C5
Organic waste (kg)Fruit waste	5.000	5.000	2.500	2.490	2.490
Industrial Sludge Paper mill sludge(kg)	-	-	2.500	2.490	2.490
M.O(Pleurotus) (kg)	-	-	-	0.020	0.020
Total (kg)	5.000	5.000	5.000	5.000	5.000

Table 3: Details of mix ratio

M.O- Microorganism

- The basal layer of 3cm thick pebbles followed by 3cm thick layer of coarse sand to ensure proper drainage in each bin
- The third layer was filled with different combinations of partially decomposed waste with of industrial sludge for a thickness of 10cm in each reactor. Sludge is added to stabilize the feed composition.
- Earthworms of about 75 numbers were inoculated into the bin.
- Then a layer of green leaves was placed for a thickness of 2cm to supply the necessary nutrients to the compost.
- Finally 2cm thick empty space was left at the top to collect the casting.

When partially decomposed organic fruit waste and sludge are subjected to earthworms, bacteria readily degrade the simple compounds; while complex wastes are first broken down to simpler one by enzymes produced by earthworms and are then degraded by bacteria. Since the earthworms ensures maximum energy utilization resulting in more biomass production, which speed up the waste decomposition to a higher rate.

The worms feeding activity assimilate only 5-10% for their growth and rest is excreted as vermicast. About 30-45 days, the volume of material has dropped substantially and the original bedding is no longer recognizable. At this point, the finished compost and worms can be moved over to one side of the bin and new bedding is added to the vacant side.

III. RESULTS AND DISCUSSION

The technical feasibility study of adopting vermicomposting was conducted to convert Organic wastes and industrial sludges to biofertilizer. Two reactors were loaded with appropriate proportion of fruit Waste and industrial sludges with the microorganism Pleurotus and earthworms.

Table 4: Physical and Chemical characteristics of fruit waste + paper mill sludge

Days	pH	Temp (°C)	E^C (Mmhos/cm)	COD* (mg/g)	TS* (%)	VS* (%)	AC* (%)	C/N
0	6.8	29	2.17	736	59.20	78.43	21.57	67.36
4	7.0	27	3.56	712	58.99	76.20	23.80	60.53
8	7.0	28	2.60	700	58.20	75.60	24.40	56.60
12	6.9	29	2.13	632	56.50	72.31	27.69	43.80
14	6.9	29	2.81	614	53.50	70.63	29.37	36.80
16	7.0	29	2.79	572	52.52	67.31	32.69	30.12
18	6.9	28	2.61	521	50.15	65.61	34.39	22.61
20	6.8	27	2.71	463	48.13	62.60	37.40	19.63
22	7.0	26	2.80	401	45.50	57.51	42.49	12.70
24	7.0	25	2.65	385	43.28	54.65	45.35	10.28
26	7.1	25	2.21	372	40.28	53.00	47.00	9.81
28	7.8	24	2.81	341	38.82	52.00	48.00	8.28

Table 4: Physical and Chemical Characteristics of Fruit Waste - C1

* - remaining

Days	PH	Temp (°C)	E^C (Mmhos/cm)	COD* (mg/g)	TS* (%)	VS* (%)	AC* (%)	C/N
0	8.2	29	27.8	900	59.73	64.82	35.18	32.08
4	8.1	27	26.2	865	58.23	63.50	36.50	29.20
8	6.4	26	28.4	824	57.42	62.89	37.11	27.61
12	8.3	26	32.8	743	55.71	60.21	39.79	23.41
14	8.0	27	32.4	694	52.10	57.28	42.72	19.84
16	7.9	28	28.4	612	50.62	53.60	46.40	14.20
18	6.7	26	33.4	529	47.21	50.24	49.76	10.10
20	7.2	26	30.2	487	44.68	46.81	53.19	9.87
22	7.2	25	30.1	420	43.20	45.00	55.00	8.26
24	7.1	25	30.2	400	43.00	44.10	55.90	7.25
26	7.0	25	29.5	384	42.50	42.80	57.20	6.35

Table 5: Physical and Chemical Characteristics of Fruit Waste and Paper industry waste - C2

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Days	pH	Temp (°C)	E^C (Mmhos/cm)	COD* (mg/g)	TS* (%)	VS* (%)	AC* (%)	C/N
0	8.7	29	14.9	1000	52.98	60.70	39.30	65.71
4	8.2	28	14.2	956	51.32	59.00	41.00	63.20
8	6.7	29	14.7	918	50.29	59.20	40.80	58.26
12	7.8	28	14.7	780	49.87	56.78	43.22	50.42
14	7.2	27	15.1	720	45.61	51.92	48.08	42.36
16	8.9	29	14.0	600	44.98	49.25	50.75	33.50
18	9.1	28	14.3	512	42.10	43.83	53.17	24.20
20	9.2	27	14.6	492	41.00	43.00	57.00	19.20
22	8.3	27	14.5	425	40.18	42.85	57.15	9.54
24	7.3	26	14.2	350	37.21	41.19	58.81	6.20
26	7.3	27	14.2	342	36.20	40.20	59.80	5.23
28	7.4	26	14.3	300	35.21	39.00	61.00	3.15

Table 6: Physical and Chemical Characteristics of Fruit Waste and Paper industry waste - C3

Days	pH	Temp (°C)	E^C (Mmhos/cm)	COD* (mg/g)	TS* (%)	VS* (%)	AC* (%)	C/N
0	8.1	27	10.28	900	54.75	69.79	30.21	68.64
4	7.9	26	10.20	850	53.20	67.00	33.00	63.20
8	8.1	28	10.27	728	50.28	64.28	35.72	51.28
12	8.2	28	10.29	695	49.20	63.00	37.00	45.21
14	7.1	27	10.28	612	47.14	60.64	39.36	40.61
16	7.0	26	11.26	582	43.21	56.28	43.72	21.26
18	7.1	26	10.21	395	40.81	50.20	49.80	11.82
20	7.0	25	10.29	325	38.60	48.28	51.72	8.59
22	7.2	24	10.28	298	36.20	46.20	53.80	6.28
24	7.1	24	10.29	264	35.00	45.40	54.60	4.69
26	7.1	25	10.29	228	34.20	43.00	57.00	3.59

Table 7: Physical and Chemical Characteristics of Fruit Waste and Paper industry waste - C4

Days	PH	Temp (°C)	E^C (Mmhos/cm)	COD* (mg/g)	TS* (%)	VS* (%)	AC* (%)	C/N
0	6.9	28	13.16	900	62.79	65.21	34.79	51.88
4	6.7	26	13.52	834	61.23	64.00	36.00	46.20
8	6.7	27	13.36	824	60.79	63.62	36.38	42.17
12	6.8	26	13.86	795	57.39	60.21	39.79	31.68
14	7.1	27	13.40	643	56.98	57.80	42.20	23.61
16	7.2	27	13.29	600	55.90	54.00	46.00	22.81
18	7.2	26	12.94	586	55.33	53.90	46.10	16.21
20	7.3	26	12.98	510	54.90	52.00	48.00	14.80
22	7.2	25	12.98	432	54.28	49.28	50.72	12.15
24	7.1	26	12.91	400	54.10	47.20	52.80	10.23
26	7.3	25	12.30	364	53.21	46.30	53.70	9.15

Table 8: Physical and Chemical Characteristics of Fruit Waste and Paper industry waste - C5

* - remaining

- **Fruit Waste and Paper Mill Waste**

  The physical and chemical parameters pH, temperature, EC, COD, TS, VS, AC, C/N variations are represented in Figure 4.1 (a) to (h).

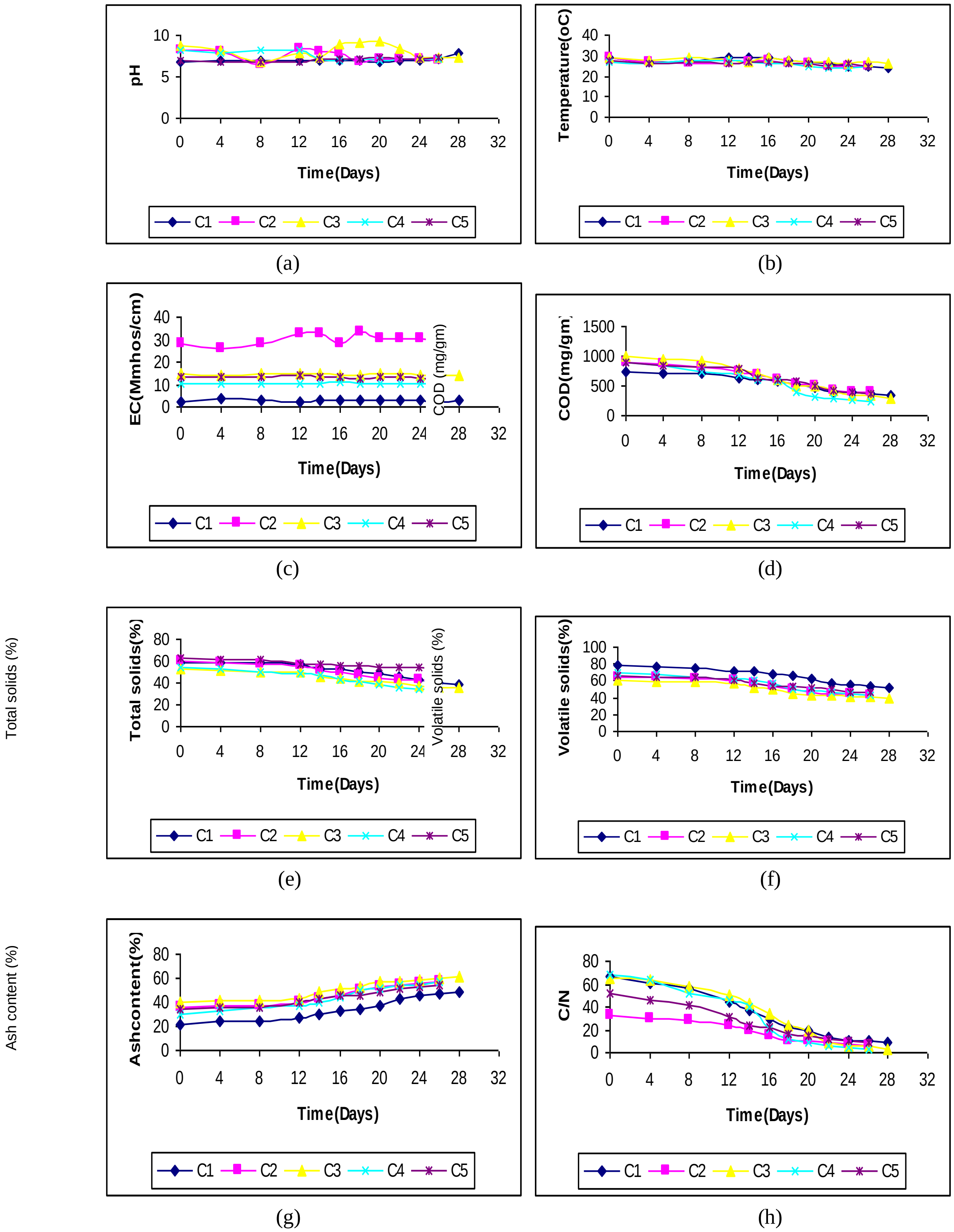

Fig. 3: Variation of (a) pH, (b) temperature, (c) Electrical Conductivity, (d) COD, (e) Total Solids, (f) Volatile Solids, (g) Ash content and (h) C/N for FW with Paper Mill waste

Parameter %	Vermicast(Fruit +Paper sludge)
Nitrogen	2.3
Phosphorous	0.51
Potassium	0.54
Calcium	1.79
Magnesium	0.6
Carbon	8.26
Chlorides	0.62
Sulphates	0.003
lignin	12.8
cellulose	27.5
protein	10.82
Iron	0.042
Zinc	0.00035
Manganese	0.00028
Chromium	NIL
copper	0.00125
Boron	NIL

Table 9: Micro and Macro nutrients of vermicast

IV. CONCLUSION

On analysis of the data the following conclusions were made

- The results from the casting analysis had revealed that the organic waste and the sludge can be converted into usable form with its nutrient release. Though there may not be a great increase in nutrient, the small change in nutrient value and the reduction in C/N ratio make the plant to uptake.
- The castings which is rich in microorganism enhance the plant growth hormones
- The result showed the increase in Earthworm population in the case of paper mill sludge than in tannery industry.
- This is a eco friendly and cost effective methods.
- It is an ideal method for the management of solid waste.
- To conclude hold promise to play a significant role in protecting environment as it uses waste as raw material and in building up of soil fertility and improving soil health for sustainable agriculture.

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