BIOCONVERSION OF SLUDGE FROM INTEGRATED PAPER AND PULP INDUSTRIES

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ABSTRACT

Bioconversion is the environmentally sound alternate available for the stabilization and ultimate disposal of sludge. The main objective of the present study is to contextualize the knowledge, application and investigate systems for the onsite treatment of organic waste through bioconversion by Vermicomposting. A blend of primary and secondary sludge of 80:20 and 60:40 ratios respectively from integrated pulp and paper mill was used for composting separately with and without food and nutrients. It was observed that blend in ratio of 80:20 with food and nutrients proved to be very useful as value added compost. Further bioactivity of these blends was performed through microbial assay.

KEYWORDS

Bioconversion, Primary Sludge, secondary sludge, Vermicomposting, Bioactivity

INTRODUCTION

Paper mills draw its water supply from nearby river. An elaborate system of drains has been constructed inside the mill to segregate various types of effluents requiring different treatment to facilitate their final treatment. The industrial effluent is segregated into three main categories of Grade-1, Grade-2, and Grade-3. Grade -1 effluent is recycled and reused within the mills. Grade -2 effluent is biologically degradable and is relatively less pollutant. Grade -3 effluent goes out of the factory in a separate open channel and enters the primary clariflocculator for primary treatment yielding primary sludge. This primary sludge can neither be directly discarded nor it can be easily degraded as the concentration of biosolids is high, ground water contamination from landfill sludge disposal, toxicity and dispersal of airborne contaminants.

In such cases a viable sludge management option available is its bioconversion. A suitable ratio of primary to secondary sludge and its successful composting accelerated Biogrowth initiated early flowering and increased the yield compared to standard cow dung urea mixtures. The process can be proven simple and effective for solid waste disposal and would be especially useful for areas where most of the paper mills are located. This could become a source of income for the rural folk and reduce environmental pollution at the same time. An extensive literature survey about sludge problems [1-3], bioconversion [4-5], vermicomposting [6-9], waste water treatment in paper mills [10] helped in carrying out the work. Existing methods of disposal are expensive,

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harmful and increasing the burden on society. The aim of the investigation is to provide a scope for solid waste utilization, along with value addition. It could become a source of wealth for the rural folk and reduce environmental pollution at the same time. The method popularly known as "Gold from Garbage".

DESCRIPTION OF EFFLUENT TREATMENT PROCESS

An elaborate system of drains has been constructed inside the mill to segregate various types of effluents requiring different treatment to facilitate their final treatment. The effluent is segregated into 3 main categories of grade-1, grade-2 and grade-3.

Grade-1 effluent- Consists of cooling and condensate from paper machine, evaporators and turbines, which are collected and reused in the system. This clean water does not go into effluent stream and the entire quantity is recycled and reused within the mills.

Grade -2 effluent- Consists of white water from stock preparation, paper machine and pilot, the outflow from chlorination and hypo sections of the beach plant, wash water from chipper house and grit collector, sludge filter, vacuum pump drain water. This effluent is biologically degradable and is relatively less pollutant. The clariflocculator removes 85-90% suspended solids and 20-30% of the BOD loads. The remaining clarified effluent flows to grade-2 aeration pond for removal of residual BOD by surface aeration. The detention time in the aeration pond is 5 days for maximum flow of 8.0 MGD.

Grade -3 effluent- Goes out of the factory in a separate open channel and enters the grade-3 clariflocculator for primary treatment. The clariflocculator removes about 60 to 70 % suspended solids and about 20% BOD. After clarification it flows by gravity into lagoon no. 1 for anaerobic treatment. The detention time in anaerobic cum equalization lagoon is about 20 days. Urea and superphosphate are added daily at the inlet of the above lagoon to maintain BOD: N: P – 100:2:0.5 and to serve as nutrients for the anaerobic bacteria. Cow dung is added for maintaining the micro-organism population depending upon the requirement.

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Table 1

Physicochemical characteristics of grade-3 effluent before and after treatment

	Before treatment	After treatment
pH	7.8	7.3
BOD(mg/l)	27	17
COD(mg/l)	218	114
Suspended solids(mg/l)	73	36
Chloride(mg/l)	614	505

BIOCONVERSION

Bioconversion by composting has received increased attention as a cost effective and environmentally sound alternate for the stabilization and ultimate disposal of waste water sludge.

Composting is a process in which organic material undergoes biological degradation to a stable end product. The primary sludge actually lacks microbes, so a proper blend with secondary sludge provides micro-organisms necessary for composting. Bacterial activity appears to be responsible for the decomposition of proteins, lipids and fats at thermophilic temperatures, as well as for much of the heat energy produced. During the composting process, three separate stages of activity and associated temperatures are observed:

Mesophilic stage- the temperature in compost pit increases from ambient to 40°c with the appearance of fungi and acid producing bacteria.

Thermophilic stage- as the temperature of composting mass increases from 40°c to 70°c these micro-organisms are replaced by thermophilic microbes. It is in this temperature the maximum degradation and stabilization of organic material occurs.

Cooling stage- is characterized by reduction in microbial activity and replacement of thermophilic micro-organisms with mesophilic bacteria and fungi. Further evaporative release of water from the composted material will occur, as well as stabilization of pH and completion of humic acid formation. Earthworms are the established macrofauna involved in composting. They derive their nourishment from micro-organisms that grow upon the organic materials. At the same time, they promote further microbial activity in the residuals so that the fecal material that they produce is much more fragmented and microbiologically active then what the earthworms consume. During this process, the important plant nutrients in the organic material particularly Nitrogen, Potassium and Calcium are released and converted through microbial action into forms that are much soluble and available to plants than those in the parent compounds.

MATERIALS AND METHODOLOGY

- ✓ Collection of sample
- ✓ Characterization
- ✓ Ratio preparation

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- ✓ Bioactivity study of the blend and Biochemical tests of microbes
- ✓ Vermicomposting
- ✓ Field trials

COLLECTION OF SAMPLE

Grade-3 effluent's treated sludge was taken. Fresh primary sludge was collected from primary clarifier and activated sludge from activated sludge plant.

CHARACTERIZATION

Moisture content [11]: was determined by weighing the empty petriplates followed by taking approximate 30g each of primary, activated sludge, 80:20 blend and 60:40 blend of primary: activated sludge. Then the samples were kept in hot air oven at 110 degree. After 24 hours again their weights were observed.

Organic content [11]: known quantity (2g OD material) taken in a platinum crucible and kept in furnace at 525^0 for 4 hours. The residue is cooled and weighed and the inorganic percent is calculated.

RATIO PREPARATION

As per TAPPI standards [11] (T 228 cm-93) with sterile tongs 5g of specimen was removed from a petridish in a disintegrator jar with enough sterile water to give a pulp consistency of 1%.

A (80:20) ~ 400:100g

B (60:40) ~ 300:200g

o

From above stock solution 5g was taken separately and diluted in 495ml of distilled water.

Using the following sample by standard plate count method the bioreactivity of the samples were determined.

BIOACTIVITY STUDY OF BLEND AND BIOCHEMICAL TESTS OF MICROBES

Microbial activity of the blends 80:20 and 60:40 ratios of primary and secondary sludge was done for seven days. The number of microbes were counted and characterized by Gram staining [12] and IMVIC tests [12].

COMPOSTING

- o Four pits each of 1'x1'x2' size were made.
- o Dry leaf bed was laid.
- o In first two pits blend of primary and secondary sludge in the ratio of 80:20 and 60:40 (namely A & B) was filled up to one and half of the pit.
- o 70 earthworms in each pit were introduced followed by half layer of soil in the pit.
- o Similarly in next two pits C & D same 80:20 and 60:40 blend of sludge was filled along with urea, superphosphate and starch. Followed by earthworms and layer of soil.
- o At two days interval the temperature of compost was monitored, as it should lie in between 35^0 to 37^0.
- o After 14 days compost was checked for the growth and population of earthworms.
- o Compost sample was also subjected to bioactivity test using standard plate count method and readings were recorded.

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Figure 1 Compost pits in order A(80:20),B(60:40),C(80:20)+nutrients and D(60:40)+nutrients

FIELD TRIALS

Field trials for a period of four weeks were carried out in the month of November on different flowers in equal sized beds prepared either with vermicompost and soil or with normally used cow dung and urea mixture. The heights of the plants and flowers of marigold with vermicompost (vc) represented intense growth.

Table 2.

Observations of field trials

	Plant height		No. of leaves		No. of buds		Biomass	
		vc		vc		vc		vc
1 week	3’	3’	6	5	0	0		
2week	6’	8’	8	16	0	3		
3week	9’	13’	12	28	1	7		
4week	11’	18’	16	35	3	9	300g	725g

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RESULTS

Table 3

Microbiological growth of 80:20 blend

Dilutions/Days	10^{-2}	10^{-4}	10^{-6}
1	Too numerous	370	106
2	Too numerous	-	142
3	Too numerous	-	6
4	Too numerous	26	76
5	Too numerous	177	126
6	Too numerous	120	177
7	Too numerous	68	66

Table 4

Microbiological growth of 60:40 blend

Dilutions/Days	10^{-2}	10^{-4}	10^{-6}
1	Too numerous	370	106
2	Too numerous	-	142
3	Too numerous	-	6
4	Too numerous	26	76
5	Too numerous	177	126
6	Too numerous	120	177
7	Too numerous	68	66

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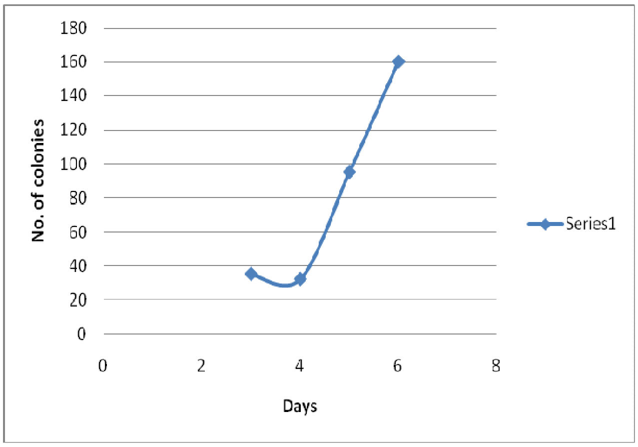

Figure 2: microbial growth of 80:20 blend

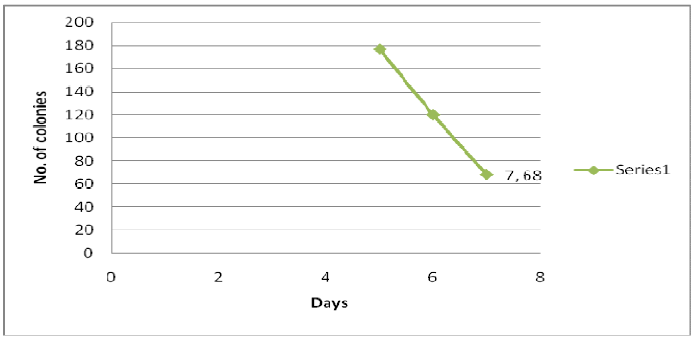

Figure 3 Microbial growth of blend 60:40 at 10^{-4} dilutions

Table 5

Characteristics of microbes

Test	Inference
Gram staining	Gram+ve , cocci
Indole production	Negative
Methyl Red	Positive
Voges proskauer	Negative

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COLONY MORPHOLOGY

Colonies were found to be circular, irregular, raised, convex and undulate (wavy) margins. The colonies observed were grey in colour and opaque.

Table 6

Characteristics of sludge

Parameters	Primary sludge	Secondary sludge	80:20	60:40
Moisture (%)	86.47	92.47	87.06	88.34
Organic content (%)	93.56	69.12	90.90	87.50
Bioactivity(CFU)	1990000	8600	-	-

Table 7

Characteristics of compost

SAMPLE	BIO COUNT (CFU)	MOISTURE %	pH	ORGANIC MATTER %	ORGANIC CARBON %	NITROGEN %	C:N RATIO
A (80:20)	$9.4x10^{-7}$	82	6.7	75	42	3.8	11.05
B (60:40)	Numerous	87	6.9	78	33	2.7	12.2
C (80:20)+nutrients	$5.4x10^{-7}$	53	7.5	45	24.3	1.2	20.25
D (60:40)+nutrients	$2.88x10^{-8}$	60	7.8	38	20	0.6	33.33

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DISCUSSIONS

The preliminary observations, indicates that the bioactivity of the individual sludge (primary and secondary) and the admixture of the sludge do have improved or increased. It was partially found that blend in ratio of 80:20 with food and nutrients proved to be very useful as value added compost. The decreased microbial count of 60:40 blend also allowed us to prefer 80:20 blend as a better ratio for composting. The ratio 80:20 blend's compost has undergone a successful field trial for flower marigold.
The biochemical test results also showed that the blend ratios do not contain any pathogenic microbes. Besides the aerobic sludge (secondary) does give a boost to the bioactivity.Further prolonged studies and aerobic methods shall enhance and convert the sludge to fully active compost. This approach of composting has provided a scope for solid waste utilization along with value addition. This could become a source of wealth for the rural folk alongside a check on the environmental pollution.

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