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Enhancement of aerobic biodegradation process of organic waste

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Abstract - *The improvement of organic solid waste by aerobic decomposition is the main topic of this paper, particularly in the context of aerobic bioreactor landfills. Traditional waste management practices such as open burning, dumping, and landfills have several negative effects on the environment and society. By increasing biodegradation under a regulated environment, bioreactor landfills provide an innovative solution. Tests, experiments, and methods used to investigate the effectiveness of bioreactor landfills in the decomposition of organic waste are presented in this research. Waste was collected from Katraj transfer station in Pune city. An experimental setup was provided with an Aeration system and soil layers in a bioreactor container. To speed up the breakdown process, microorganisms including Phanerochaete chrysosporium and Trichoderma were introduced. Results of nutrients analysis of soil, physical characteristics of waste, temperature, moisture content, settlement measurement, leachate analysis, and BOD/COD ratio measurements. Are included in this report. Experiments show that the presence of microorganisms speeds up the decomposition process and promotes the settling of the waste. Initially, the BOD/COD ratio was higher indicating enhanced biodegradability. BOD/COD ratio decreased gradually and remained constant after 5 weeks resulting in 100% degradation of waste.*

The Study concludes that aerobic bioreactor landfills efficiently enhance the degradation of organic waste. With the introduction of microorganisms and proper management strategies. Resulting in a faster landfill recovery period and lowering environmental impact. Bioreactor landfills may have higher startup expenses, but, it reduces long-term operating and maintenance cost

Key Words:

C.O.D.- Chemical Oxygen Demand

B.O.D.- Biological Oxygen Demand

N.P.K.- Nitrogen Phosphorous Potassium

1.INTRODUCTION

The build-up of solid waste. is said to be at vital points in practically every part of the earth. There are several techniques used today to remediate solid waste. which include composting, recycling, landfilling, and incineration. The aerobic decomposition process, which is one of the most practical ways to recycle the organic part of solid waste, is the main topic of this study. Because aerobic decomposition produces less leachate and other toxic gases, it is quicker and less harmful to the environment. The increased energy production from the breakdown of organic matter in the presence of oxygen can be used to explain the quicker pace of aerobic decomposition. Aerobic bacteria multiply more quickly and carry out breakdown activities because of the increased energy availability. Trichoderma and Phanerochaete chrysosporium were the microorganisms utilized in this experiment. There is a discussion of the advantages of utilizing both microbes.

2. METHODOLOGY

3.1 Bioreactor Landfill

A bioreactor dump is a specific kind of landfill that speeds up the biodegradation of garbage by using a controlled atmosphere. Traditional landfills just drop garbage and wait for it to break down, whereas bioreactor landfills utilize a variety of approaches to mimic the conditions found in nature to break down waste more quickly. Systems for monitoring temperature, moisture content, and other factors are in place at these landfills. In general, bioreactor landfills are a potential method of waste management that can increase the efficacy and efficiency of waste biodegradation while also minimizing negative environmental effects and generating renewable energy.

3.2 Experimentation

The project's analytical work must be carried out through experimentation. Through this procedure, results may be interpreted.

3.3 Need for Experimentation

1) The aerobic process is intricate. The entire process may be understood by experimentation.

2) Experimentation will aid in determining the various aspects of the aerobic response.

3) To comprehend or forecast the reaction, the factors might be associated.

3.4 Study area

The Katraj transfer station in Pune City will be where the biodegradable solid trash is picked up. The city's fast growth in the production of solid waste, which causes

environmental damage, is one of its negative effects. Pune's population, which is getting close to 34,000, is thought to produce 1,200MT of solid trash per day.

Segregated waste is listed into the following categories:

- Flower
- Vegetable
- Leaves
- Fruit
- Household waste or leftover food.

3.5 Reactor Assembly

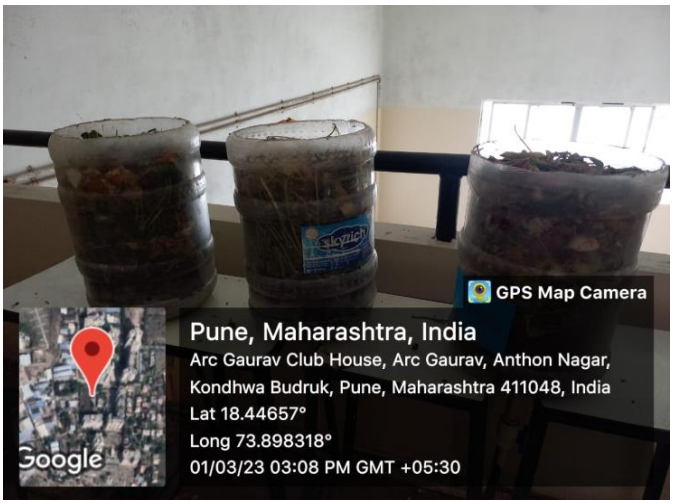


Fig. Setup

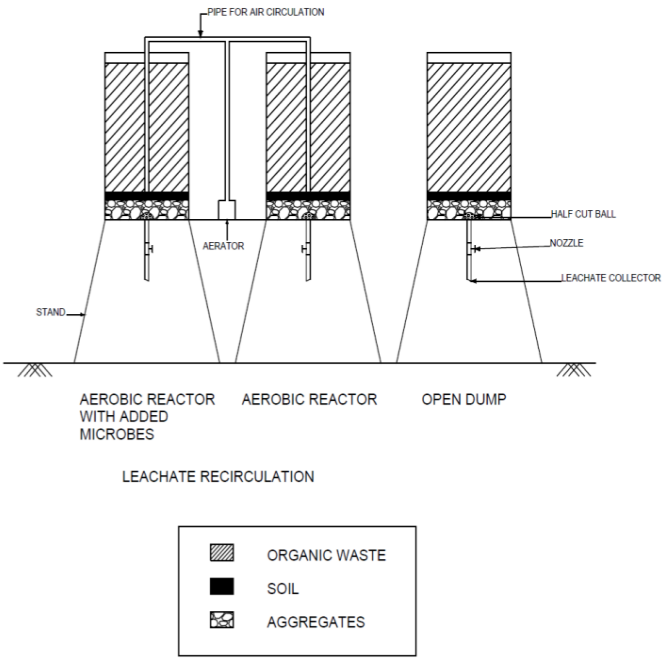


Fig. Reactor setup

1) Body of reactor-

20-liter plastic bottles were used to act as a bioreactor. Bottles were cut from the top and a hole was drilled at the bottom to make a collection system. Pipes were connected to the hole and sealed by a multipurpose sealant. The valve was fitted to the pipe for the controlled collection of leachates. Plastic balls half cut and drilled with holes were stuck at the bottom where leachate enters the pipe. This was done to restrict the entry of large particles which may block the pipe. The apparatus was checked for leakages and assembled.

2) Aggregate layer-

A layer of aggregate was made to ensure the collection of leachate equally. To act as a buffer zone between waste and the base of the reactor. And to act as a coarse barrier between waste and base.

3) Soil layer-

A layer of soil was added of approximately 2-3cm. Soil helps to control the flow of leachate. It also acts as a natural filter. And it acts as a fine barrier between the waste and the underlying layer of coarse aggregates.

4) Aeration system-

Fish tank aerators were ordered and the pipe of the aerator was drilled. This pipe was immersed in waste directly. This ensured a constant supply of air at the rate of a 1.5-liter minute.

5) Pre-treatment on waste-

Cutting organic waste is done in small pieces with a knife. Due to this surface degradation increases and waste degrades in less time.

3.6 Micro-organisms to be added to the waste sample.

Fungi and microorganisms were utilized with the material. Macromolecular biological catalysts include microorganisms. Microorganisms interact with substrates to produce various compounds or products. Microorganisms are required for nearly all cellular metabolic processes to proceed at speeds quick enough to support life. To speed up the pace of decomposition, microorganisms were introduced to the sample. The National Laboratories of India have a variety of microorganisms. The selection of suitable microorganisms proved challenging. The most effective microorganisms were chosen after studying several research publications and considering the scientific statement.

These two microorganisms are available in the National Chemical Laboratory of Pune. The order was placed online on the site of NCL.

Thus, received micro-organisms were developed for their culture and subculture. Micro-organisms to be added:

1. Phanerochaete chrysosporium
2. Trichoderma

These micro-organisms were received in agar form.

- Phanerochaete chrysosporium

A saprophytic fungus called Phanerochaete chrysosporium may break down the woody portion of dead plants organically. Therefore, P. chrysosporium thrives best on plants that are already dead or are in the process of dying. The loss of lignin from the plant structure can cause symptoms like white spots of cellulose on the plant.

There is no known human or animal disease caused by this fungus.

- Trichoderma

It serves to promote growth by acting as a biofertilizer.

Trichoderma can hasten the composting process. It neutralizes both acidic and alkaline soils and brings pH levels to the ideal range for nutrient availability to plants, compost serves as a soil buffer.

3.7 Process of culture development.

1. Three hundred grams of peeled potatoes were cut into small pieces.
2. These peeled potatoes were boiled in more than a liter of water for 30 minutes.
3. The starch water formed was filtered by a clean muslin cloth.
4. The final volume of 1 liter is made. 20g of Dextrose and 0.1g of yeast extract is added.
5. This solution is then filled in test tubes which are sealed with cotton.
6. These test tubes were sterilized.
7. 20g Agar was then placed with the help of a meta loop in a sterilized atmosphere.
8. Test tubes were placed in a controlled atmosphere in the incubator.
9. After a week, culture was formed.

3. RESULTS AND DISCUSSION

4.1 Nutrient analysis of soil (NPK)

Nutrient analysis of soil, aggregate, and organic waste was carried out and nitrogen, phosphorus, and potassium content were measured in the sample. The initial nutrient content of analysis was in the range as it was effective in the process of degradation of the organic matter. The nutrient content of the samples is shown in Table 6.1. The result showed that potassium content in soil was sufficient for the degradation of waste.

Sr. No.	Sample	Nitrogen	Phosphorus	Potassium
1	Soil	247.5 kg/ ha (240-480 kg/ ha)	142.5 kg / ha (110-280 kg/ ha)	907.5 kg/ha (676.5-900 kg/ha)

Table 4.1 NPK value of soil

4.2 Initial stage analysis of organic waste

It included an analysis of the waste that was to be filled in the reactor. The physical characterization of the waste going in each reactor was checked and the percentage characterization of the waste remains the same as that of the landfill site.

Physical characterization was done for every reactor and readings were filled in the table shown below.

Flowers	3%
Leaves	4%
Husk	14%
Vegetables	54%
Miscellaneous	12%
Fruits	13%

Table 4.2 Composition of organic waste Component Percentage by weight.

4.3 Analysis of moisture content and temperature of the sample.

This analysis consisted of the physical observation of the reactor. Physical observations were taken every week to ensure that the moisture content and temperature are within the required range.

Variation in the pH affects the process of degradation rate. Initially, the pH of the reactor was as low as 6.2. Initial pH was low in the first 10-15 days due to faster degradation of organic matter and release of acid into the leachate. During the acidic phase, waste showed a similar trend throughout the process, with an average pH range of 6.5 to 7. Table 4.3 Moisture content, pH, and temperature of sample:

Parameter	observed value	Recommended value	References
Moisture content	10.74	8.45	Pohland (1986); Rees (1980)
pH	6.2	6-7	Ehrig (1983) Farquhar and Rovers(1973)
Temperature	38°	45°	Rees (1980) Harts et al.(1986)

Table 4.3 Moisture content, pH, and temperature of sample:

4.4 Analysis of Settlement and Leachate

This analysis consisted of daily taking measurements of settlement and leachate collection. The analysis of leachate was carried out daily to know the reduction in various parameter concentrations. This analysis gave the variations that occurred as per the phases of the degradations process in the reactors. The analysis of leachate included different parameters such as pH, total dissolved solids, chemical oxygen demand, and biochemical oxygen demand for 3 days.

Parameter	Value for aerobic reactors	Value for open dump
Total dissolved solids	50.3 mg/l	102.4 mg/l

Table 4.4 Test of solids on leachate

In an aerobic landfill, oxygen is introduced to support the aerobic degradation of organic waste, which helps to reduce the production of leachate. As a result, the TDS concentration in the leachate of an aerobic landfill is generally lower compared to that of anaerobic landfills.

4.5 Settlement Observations

Week	Aerobic bioreactor + Microbes	Aerobic bioreactor	Open Dump
1	6.3	5.2	5.3
2	10.7	9.5	9.1
3	15.6	14.1	13.2
4	20.1	17.2	15.8
4.5	20.9	19.9	18

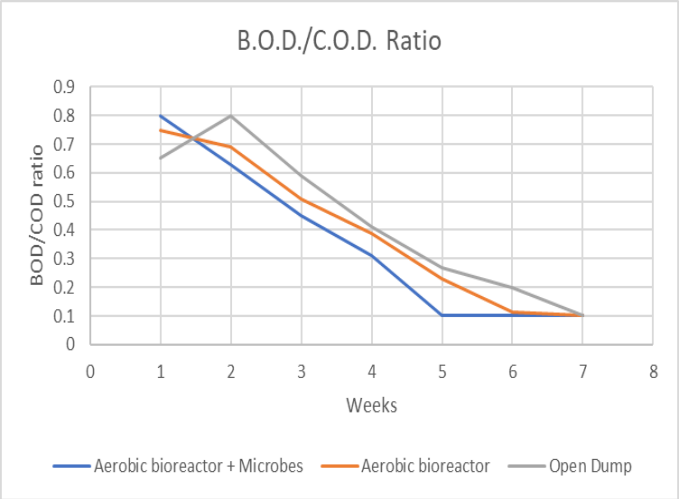
Table 4.5: Settlement Observations, cm

A sudden increase in the settlement in the initial stage was observed. This initial settlement was due to the self-weight of the mass. The settlement is directly proportional to the degradation rate of the organic matter. As the degradation rate increases, the utilization of the organic matter takes place which results in the settlement of the resource in the reactor. The settlement reaches the saturation value as the organic matter degrades completely. A final settlement of 20.1 cm was observed in the reactor. The rate of settlement in the reactor with the addition of enzymes was more than in the reactor without microbes.

4.7 BOD/COD Ratio Observations

Week	Aerobic bioreactor + Microbes	Aerobic bioreactor	Open Dump
1	0.8	0.75	0.65
2	0.63	0.69	0.8
3	0.45	0.51	0.59
4	0.31	0.39	0.41
5	0.1	0.23	0.27
6	0.1	0.112	0.198
7	0.1	0.1	1.006

Table 4.7: BOD/COD Ratio Observation



Graph of B.O.D / C.O.D. over time

Discussion on BOD/COD Ratio

BOD/COD ratio is necessary to determine the degradation rate. When the degradation rate is more than the BOD/COD ratio is also more. Initially, B.O.D. / C.O.D. is more because of the high rate of degradation. Then, it seems to be slowing

down. It completely stops at the 20th week. Resulting in 100% decomposition.

4. CONCLUSIONS

- Degradation is a gradual process. But the addition of micro-organisms speeds up the process. The rate of settlement is more by 4.5 times in the reactor with micro-organisms.
- The land gets recovered in much less time with just a few measures such as leachate recirculation and the addition of micro-organisms.
- The leachate recirculation ratio enhances the biodegradability process, it also maintains the moisture content required for the degradation process and micro-organisms prove more effective when added with leachate.
- Leachate acts as a nutrient to the micro-organisms.
- After the addition of micro-organisms, the BOD/COD ratio increases, which indicates that the biodegradability of organic waste is increased.
- The initial cost of this method is high but operational and maintenance cost is low.
- Hence large-scale use of this project can improve the degradation process and recover landfill sites in very less time with a good cost/benefit ratio.

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