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Bioconversion of Wet Waste into Organic Fertilizer in Shirdi, Maharashtra, India

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A B S T R A C T

The increasing generation of municipal solid waste in urban and semi-urban areas poses significant environmental challenges. Shirdi, Maharashtra, being a major pilgrimage destination, generates large volumes of biodegradable waste daily. This study documents and evaluates the process adopted for the bioconversion of wet waste into organic fertilizer, emphasizing sustainable waste management practices. It includes process design, site context, technology evaluation, operational guidelines, quality testing, environmental impact assessment and market linkages.

Keywords : *Bioconversion, wet waste, organic fertilizer, composting, microbial inoculation, waste management.*

1. Introduction :

An increase in the human population, urbanization, and a lifestyle change has increased the waste load and thereby pollution loads on the urban environment to unmanageable and alarming proportions. The existing waste dumping sites are full beyond capacity and under unsanitary conditions, leading to pollution of water sources and spreading communicable diseases, foul smell and odors, release of toxic metabolites, anaesthetic ambiance, and eye sore, etc. It has been estimated that India, as a whole, generates as much as 25 million tons of urban solid waste of diverse composition per year. But per capita waste production in India is minuscule compared to the per capita production of waste in the industrialized countries. It is estimated that the per capita waste generated in India is about 0.4 kg/day with the compostable matter approximately 50-60%.[1]

Shirdi is a spiritual town in Ahmednagar (Ahilyanagar) district, Maharashtra, famous as the home of Shri Sai Baba, who lived here for over 50 years. Shirdi is considered one of India's holy pilgrimage destinations. Sai Baba preached love, equality, charity, forgiveness, and the oneness of religions. The town attracts over 60,000–1,00,000 pilgrims daily and during festivals.

Solid waste management is a critical issue for towns with high tourist inflows. Shirdi, known for the Shri Saibaba Temple, Dwarkamai, Chavdi, Gurusthan, Lendi Baug, and Sai Heritage Village,generates a substantial quantity of biodegradable waste from hotels, restaurants, temples, and households. Traditional disposal methods lead to environmental pollution, odor, and land usage problems. The local municipality has implemented a systematic process to convert wet waste into organic fertilizer using microbial culture powders and controlled drying processes.

2. Literature review :

i. **Temple floral waste:** Studies across India show temple floral waste is rich in petals (roses, marigolds, etc.), high-moisture, and suitable for composting/fermentation to create compost, biogas, or bioproducts. Treatment options include direct composting, microbial-assisted composting, and integration into vermicomposting after pre-treatment. [2]

ii. **Vermicomposting and parameters:** Earthworm species such as "Eisenia fetida" are commonly used. Optimal ranges found for ambient temperatures 13–25 °C for effective worm activity (species- and context-dependent), humidity around 70–90% in the bedding, and starting C:N ratio ideally ~25–30 for rapid stabilization. Monitoring pH, moisture, and C:N through the process is essential. [3]

iii. **Yields and efficacy:** Reported wet-to-compost/vermicompost yield conversions vary with feedstock moisture and pre-treatment; practical operating guidelines and field studies indicate wet yield rates from ~30% to 50% (wet weight basis) under well-managed systems — actual yields depend on moisture, bulking agent addition, and process (windrow vs vermibed). Vermicompost consistently shows high agronomic value and nutrient enrichment over raw waste.[3]

3. Study Area: Waste at Shirdi, Maharashtra :

Located in Rahata Taluka, Shirdi has a resident population of ~36,000 (2011 census) and an effective population of>100,000 during peak pilgrimage. Wet waste comprises 55–65% of municipal solid waste. Climatic conditions (hot summers and monsoons) influence drying and composting rates.[4]

3.1. Waste :

Waste is any material that is no longer useful, needed, or wanted and is discarded or thrown away. Anything that's thrown out because it cannot be used anymore is waste. Waste is unwanted or unusable materials that result from human activities, including households, industries, businesses, agriculture, hospitals, etc.

3.2. Types of waste :

Waste can be categorized by its nature, such as solid, liquid, and gaseous; by its moisture content, such as wet and dry; or by its properties, such as biodegradable and non-biodegradable. Other classifications include source (e.g., municipal, industrial, agricultural, medical, e-waste, construction) and hazard level (e.g hazardous, radioactive, non-hazardous) as shown in Fig.1.

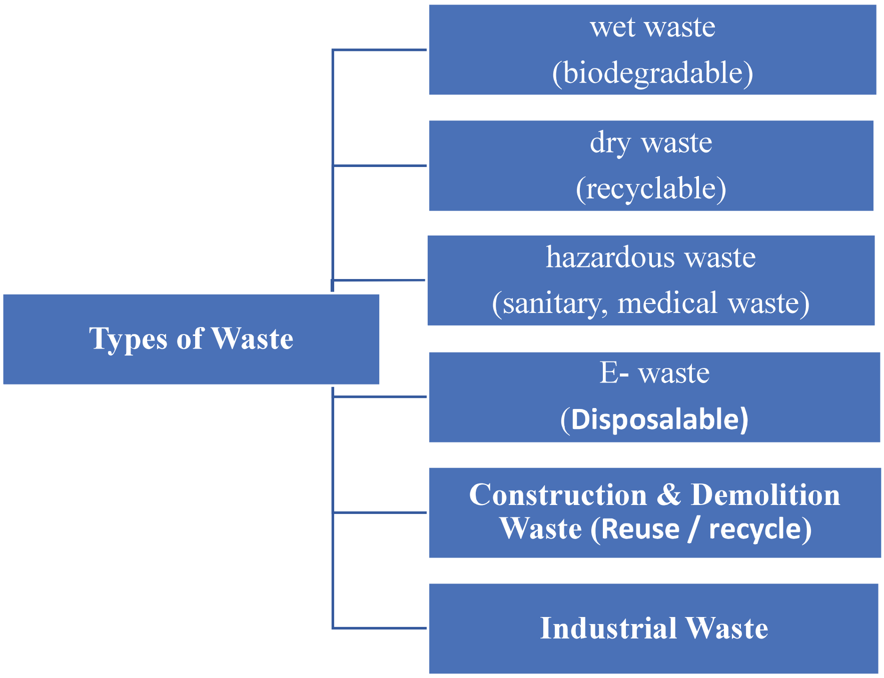

Fig.1. Types of Solid Waste

i. Wet Waste (Biodegradable Waste) :

Wet Waste is generated fromTemple offerings (flowers, garlands, naivedya), Restaurants, hotels, canteens, Households (kitchen waste),which are biodegradable waste, as shown in Fig.2.

Fig.2. Wet Waste

The uses of Wet Waste are for various processing units like Composting, Vermicomposting, Biogas production, Floral upcycling (incense sticks, colors, soap) etc.

ii. Dry Waste (Recyclable Waste) :

This includes all non-biodegradable materials as shown in Fig.3. The uses of Dry Waste are for various processing units like paper and cardboard, plastic bottles, wrappers, bags, Glass bottles, metal cans, Thermocol, Plastic cups/plates (used by tourists), Recycling, RDF (refuse-derived fuel), Shredding + sale for energy recovery, etc.

Fig. 3. Dry Waste

iii. Hazardous Waste (Sanitary, biomedical) :

Generated from households, hotels, and public toilet, Hospitals, Clinics, pathology labs, Veterinary facilities etc as shown in Fig. 4. The examples of hazardous waste are generated from Sanitary napkins, Baby diapers, Condoms, Expired cosmetics, Home cleaning chemicals, Mosquito repellents, Bandages, cotton (Blood-contaminated waste), Sharp objects (Razor blades Syringes & needles) etc.

Fig. 4. Hazardous Waste

There is need for disposal of Hazardous waste by storing them separately and sent to scientific landfill / incineration plants. These wastes are handled by authorized biomedical waste agencies.

iv. Electronic Waste (E-Waste):

E-waste is generally generated byHotels, shops, offices, Households, Temple trust facilities (guest houses, CCTV, servers), as shown in Fig. 5. The E-waste should be disposed at the authorised E-waste recycler. The e-waste is generated from Old mobiles, chargers, Computers, printers, LEDs, tube lights, Batteries, etc.

Fig. 5. E-waste

v. Construction & DemolitionWaste :

• These wastes are generated frombuilding repairs, Road worker any construction sites, as shown in Fig. 6. These wastes are generated from Cement debris, Bricks, Tiles, Soil, Iron rods, waste broken pillars, etc. This waste can be reused for road sub-base and making recycled aggregates.

Fig. 6. Construction Site Waste

vi. Industrial Waste (Small-scale) :

Industrial waste is generated by workshops, Packaging units, etc (Shirdi has limited industry) as shown in Fig. 6. These are generated from the use of Oil, Lubricants, Scrap metal, Rubber, Packaging waste, etc.

Fig. 7. Industrial Waste

3.3. Importance of waste management :

Waste management is important for protecting public health, preventing environmental damage, conserving resources, and creating economic benefits. Proper waste managementreduces pollution, disease vectors, and greenhouse gas emissions while recycling and reusing materials and creating jobs.

3.4. Waste Hierarchy: Reduce – Reuse – Recycle :

The waste hierarchy is a system that shows the best to worst ways to manage waste. It helps us protect the environment by reducing how much of waste we produce.It is usually shown as a pyramid, with the most effective option at the top, as shown in Fig.8

Fig. 8. Three 'R' For Environmental Management

3.4.1 Reduce :

The concept of reducing waste generated by reducing consumption is essential to the waste management hierarchy. The logic behind it is simple to understand: if there is less waste generated, then there is less to recycle, reuse, or manage. The process of reducing begins with an examination of what is being used, what it is used for, and how much it can be reduced. It also involves modification of process and packaging; substitution; minimization and elimination [5].

3.4.2 Reuse :

The reuse of items (for multiple times) or re-purposing them for a use different from what they are originally intended for is the next essential thing in the waste reduction hierarchy. Items may be reused for one's own use (or reuse) or donated so that others can use them [5].

3.4.3 Recycle :

The last stage of the 3R waste hierarchy is to recycle. Recycling means that the waste will be transformed into a raw material for manufacturing a new item. Thereare very few materials on the earth that cannot be recycled, hence it is very effective in waste management. Thus, the 3R approach lives at the very top of the waste management hierarchy [5].

3.5. Waste Characterization at Shirdi :

Estimated MSW generation: 15 tons/day; wet waste ≈ 9 tons/day. Components: food waste, temple flowers, vegetable waste, fruit waste, and some plastics requiring removal. Moisture content averages 60–70% requiring drying and aeration [6].

4. Methodology of Processing Wet Waste to Organic Fertilizer :

The process adopted for bioconversion in Shirdi follows a six-stage methodology: segregation of wet waste, addition of culture powder, drying, and segregation of final fertilizer, and all the processing stages are combined shown in Fig. 9.

4.1 Collection of Waste :

- The waste from all the areas (i.e., from the residence, hotel, temple, and hospitals) of Shirdi is collected
- The collected waste is brought to the dumping yard.
- The dumping yard is located on the outskirts of the city.

4.1 Segregation of Wet Waste :

- All collected municipal solid waste is first segregated.
- Only biodegradable (wet) waste is selected for processing.
- Non-biodegradable and hazardous components are removed to ensure quality feedstock.

4.2 Addition of Culture Powder :

- The segregated wet waste is treated with microbial culture powder to accelerate decomposition.
- Standard application: 1 bag of culture powder per dumper truck of wet waste (2–3 tons) mixed thoroughly for uniform microbial distribution.
- This ensures rapid microbial activity and effective conversion into compost.

4.4 Drying Process :

- The treated waste is spread and regularly turned to promote aeration and uniform drying.
- Complete drying is essential to prevent odor and to stabilize the organic matter.
- The drying process typically takes 30–45 days, depending on climatic conditions.
- Muddling or mixing of the waste ensures even microbial activity.

4.5 Sieving and Segregation of Fertilizer :

- After drying, the mixture is transferred via conveyor belts to a sieve where impurities such as plastics are removed.
- Inerts and plastics removed; clean, uniform fertilizer is collected.
- Depending upon particle size and composition, the final organic fertilizer is separated into different grades.
- This sieved product is the final organic manure suitable for agricultural use.

Fig. 9. Stages of processing wet waste to organic fertilizer

4.6 Quality Testing :

- Required parameters: moisture, pH (6.5–7.5), EC, C:N ratio (ideal 20–25:1), NPK values, heavy metals, and pathogen indicators.
- Only compliant batches are packaged

5. Illustration of the waste process :

The process is visually represented as follows:

- Segregation of wet waste (field collection and sorting)
- Addition of microbial culture powder (accelerates decomposition)
- Drying process (stabilizes organic matter over 30–45 days)
- Conveyor and sieving system (removal of impurities and grading of fertilizer)

Potential buyers include Shirdi Sai Temple parks, local nurseries, farmers, and commercial organic fertilizer distributors. Packaged compost can be sold to pilgrims as eco-friendly products [7,8].

6. Results and Discussion :

This process produces a nutrient-rich organic fertilizer that is environmentally safe and cost-effective. The key benefits observed include:

- Significant reduction of waste volume.
- Minimization of landfill usage.
- Production of marketable organic manure.
- Reduction in foul odor and disease vectors.

Shirdi's model highlights the importance of source segregation, microbial inoculation, and proper drying for successful large-scale composting. The environmental and economic impact of bioconversion is narrated briefly as follows:

- Environmental Impact: Reduction in methane emissions from landfill disposal, improved soil health when applied as manure, and a cleaner urban environment.
- Economic Impact: Revenue from selling organic fertilizer and reduced waste disposal costs for the municipality.

8. Conclusions :

The bioconversion process implemented presents a scientifically validated, community-compatible, and financially feasible approach in Shirdi, Maharashtra, demonstrates an effective and replicable model of turning urban wet waste into a valuable resource input. By combining segregation, microbial culture treatment, and mechanical sieving, this initiative contributes significantly to sustainable waste management and circular economy practices.

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