# "Sustainable Biomedical Waste Management: A Comparative Study of Strategies to Reduce the Impact"

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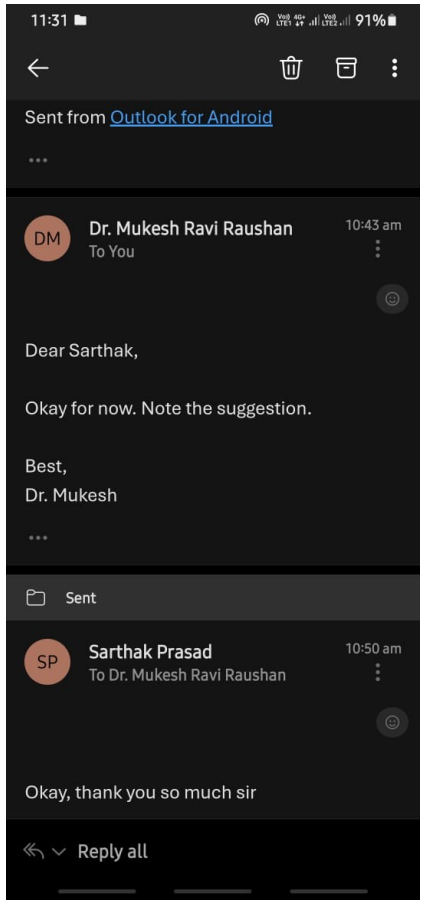
# Mentor Approval



# Introduction (1/2)

- Biomedical Waste (BMW) = By-product of healthcare (e.g., syringes, bandages, chemicals)
- India generates ~743 tonnes/day; ~103 tonnes untreated
- Improper disposal (open burning, burial) still common
- BMW Rules (2016, amended 2018 & 2019) exist but enforcement is weak
- **Importance of BMW Management**
- Protects human health and environment
- Prevents infection outbreaks and pollution
- Reduces antimicrobial resistance (AMR)
- Contributes to **SDGs**:
  - SDG 3: Good Health & Well-being
  - SDG 6: Clean Water & Sanitation
  - SDG 13: Climate Action

# Objectives of Your Study

- ✅ **Assess** the type, composition, and quantity of biomedical waste generated across healthcare facilities in India
- 🔍 **Compare** treatment technologies based on sustainability metrics:
  – Environmental impact
  – Cost-efficiency
  – Energy consumption
  – Residue safety
- 🛠️ **Identify** infrastructural, financial, and regulatory challenges in implementing sustainable BMW practices
- 📈 **Recommend** cost-effective, scalable, and environmentally sound BMW treatment strategies tailored for India's diverse healthcare system

# Methodology (1/2)

- 📘 **Research Type**: Secondary data-based, descriptive and comparative study
- 🧭 **Research Design**: Qualitative and comparative – assesses technologies by sustainability, cost, and efficiency
- 📊 **Data Sources**:
  – Government reports (e.g., CPCB, MoEFCC)
  – Institutional audits (AIIMS, PGIMER)
  – WHO guidelines
  – Peer-reviewed journals

# Methodology (2/2)

- 🔍 **Analysis Methods**:
  – Thematic analysis
  – Content analysis of existing reports
- ⚖️ **Ethical Consideration**: Proper citation and use of publicly available data
- ⚠️ **Limitations**: No primary data; may not reflect real-time rural or private sector practices

# Results (1/3)

- ✅ **1. <u>Comparative Evaluation of Technologies</u>**
- **Solar Autoclaves**: Most sustainable (Score: **78/100**); very low emissions and cost; highly suitable for rural/ remote areas.
- **Autoclaving**: Strong environmental and economic balance (Score: **74/100**); widely feasible for hospitals.
- **Microwave Disinfection**: Effective and moderate sustainability (Score: **65/100**); requires skilled staff and higher setup cost.
- **Plasma Pyrolysis**: High-tech but costly (Score: **51/100**); limited rural feasibility.
- **Incineration**: Widely used but **least sustainable** (Score: **36/100**); high emissions and cost.

# (Results) Environmental and Economic Impact

| Technology | $CO_2$ Emissions (kg/ tonne) | Cost (₹) | Residue Toxicity |
|---|---|---|---|
| Solar Autoclave | < 50 | Low (< ₹ 3,000/mo) | Negligible |
| Autoclave | 120–180 | Moderate | Low |
| Microwave Disinfection | 150–200 | Moderate | Low |
| Plasma Pyrolysis | 400–600 | High | Moderate |
| Incineration | 820–950 | Very High | High |

1. **Operational Feasibility**

- **Autoclaving and Microwave**: Best balance of **capacity, speed, and moderate training** needs
- **Solar Autoclaves**: Ideal for **low-volume, rural centers**
- **Incinerators**: High-capacity, but **costly and polluting**

# Results (3/3) Composite Sustainability Score (Out of 100

| Technology | Score |
|---|---|
| Solar Autoclave | 78 |
| Autoclaving | 74 |
| Microwave Disinfection | 65 |
| Plasma Pyrolysis | 51 |
| Incineration | 36 |

- **Solar Autoclaves** ranked highest in sustainability (Score: **78/100**)
  → Very low emissions, minimal cost, ideal for rural and off-grid healthcare centers
- **Standard Autoclaving** scored **74/100**
  → Efficient, low-emission, and cost-effective; suitable for most facilities
- **Microwave Disinfection** scored **65/100**
  → Effective and moderately sustainable; requires trained staff and higher initial cost
- **Plasma Pyrolysis** scored **51/100**
  → Technically advanced but expensive; limited rural feasibility
- **Incineration** scored **36/100**
  → High emissions and cost; still widely used but environmentally unsustainable

# Discussion (1/2)

- Solar and steam autoclaves are the most sustainable and cost-effective BMW treatment options.
- Incineration, though common, is environmentally harmful and expensive.
- Microwave disinfection is efficient but limited by cost and need for trained staff.
- The study supports a shift toward decentralized, eco-friendly technologies.
- Recommends policy reforms, better training, and digital tracking to improve waste management systems.

# Conclusion

- **Findings**
- 🌱 **Solar autoclaves and standard autoclaving** are the most sustainable and feasible treatment options, especially for rural and decentralized setups.
- 🔥 **Incineration**, though widely used, has the highest environmental and operational cost, making it the least preferred.
- 📡 **Microwave disinfection** is effective for medium-scale hospitals but requires skilled staff and higher investment.
- 🏥 **Institutional disparities** (e.g., AIIMS vs. district hospitals) highlight gaps in infrastructure, compliance, and training.
- 🌍 Policy must shift from compliance to sustainability, with a focus on technology adoption, training, decentralization, and digital tracking.

# References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# Thank You

Any Questions