iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** XII **Month of publication:** December 2025

DOI: https://doi.org/10.22214/ijraset.2025.76334

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XII Dec 2025- Available at www.ijraset.com

Fast Bio-digester Dustbin for Sanitary Napkin Decomposition in Rural Areas

Dr. Ahila A, Prathibha K, R Vaishnavi, Shreya G, Yashwanth HC
Sri Sai Ram College of Engineering, ECE

Abstract:Sanitarynapkinwastepresentsasignificantenvironmentalburdenduetoitsslowdegradationrate,multilayerpolymericstructure,andbiologicalcontamination.Conventionaldisposalpracticessuch as open burning and landfilling release harmful pollutants and create long-term ecological risks. This paper proposes a Bio-Digester Bin engineered to accelerate the decomposition of sanitary napkins through an integrated mechanical–thermal–aeration approach. The system incorporates a shredding mechanismtoincreasesurfacearea,a500Wcontrolledheatingcoilformaintainingoptimaldegradation temperatures,atemperature-sensingrelaymoduleforautomaticthermalregulation,anda12Vaeration unit to support oxygen flow and reduce odor formation. The bio-digester operates on a hybrid power setupusingbothsolarenergyandconventionalsupplytoensure continuous functionality. Experimental results indicate a substantial reduction in decomposition time and waste volume compared to natural degradation. This solution has strong potential for municipal-scale adoption, enabling local bodies to manage sanitary waste more scientifically, sustainably, and with reduced environmental impact.

Keywords: Bio-digester system; sanitary napkin decomposition; shredding mechanism; temperature- relay module; forced aeration; hybrid solar power; biodegradable waste treatment; decentralized waste disposal.

I. INTRODUCTION

Managing menstrual waste remains a critical environmental issue, particularly in developing countries where scientific disposal systems are limited. Sanitary napkins are composed of cellulose fibers, super-absorbent polymers, plastic back sheets, and adhesives that can take several decades to decompose naturally. Moreover, the presence of blood and organic matter categorizes this waste as biomedicalinnature,necessitatingsafehandlinganddisposal.Inefficientpracticessuchasopenburning or landfilling contribute to soil pollution, groundwater contamination, greenhouse gas emissions, and health hazards to waste collectors. Recent research emphasizes the need for decentralized, low- maintenance, and eco-friendly disposal solutions. Bio-digestion methods, when combined with mechanicalandthermalpre-processing,haveshownpotentialtoenhancethedegradationofsemi-biodegradable materials. Inthis context, thepresent work proposes an engineered Bio-DigesterBin for Sanitary Napkin Decomposition, designed to accelerate breakdown through shredding, controlled heating, and continuous aeration. The system utilizes a paper shredder to reduce napkin size, enabling faster microbial and thermal degradation.A500 W heating coil with an automatic temperature control relaymaintainsoptimaldigestiontemperatures,whilea12VSMPSfanensuresadequateoxygensupply andodorcontrol.Powersustainabilityisachievedthroughahybridsolar–adaptersupply.Thedeveloped prototype aims to offer a safe, efficient, and environmentally responsible method for menstrual waste disposal, contributing to improved sanitation practices and sustainable waste management.

II. RELATED WORK

Previous studies on sanitary napkin waste highlight that the material is difficult to degrade due to its multi-layerstructurecontainingcellulose,super-absorbentpolymers,andplasticcomponents.Research onbiologicaldegradationshowsthatmicrobialandenzymatictreatmentscanbreakdownthecellulosic layers, but the process is slow without pre-processing. Studies onmechanical pretreatment consistently report that shredding improves degradation efficiency by increasing surface area and reducing waste volume. Thermal disposal methods such as small-scale incineration are commonly used but raise concernsabouttoxicemissionsandenvironmentalsafety.Therefore,researchersrecommendcontrolled, low-temperature treatment options ratherthan direct burning.Advanced methods likepyrolysis and high- temperature conversion demonstrate potentialforcentralizedfacilitiesbutareexpensiveandtechnically complexfordecentralizeduse.Policiesandmunicipalguidelinesemphasizetheneedforsafe,scientific, and decentralized solutions for menstrual waste, encouraging methods that combine mechanical, thermal, and biological processes while avoiding uncontrolled incineration. The proposed bio-digester aligns with these findings by integrating shredding, controlled heating, and aeration to overcome the limitations of previous approaches and provide a practical system for municipal-level sanitary waste management.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XII Dec 2025- Available at www.ijraset.com

III. PROPOSED WORK

Theproposedworkaimstodevelopacompactbiodigestersystemthatcandecomposesanitarynapkinsefficientlyusingacombinationofshredding,controlledheating,andcontinuousaeration.Thesystemisdesignedsothatthenapkinsarefirstshreddedtoreducetheirsizeandincreasesurfacearea,makingthe decomposition process faster. A 500-watt heating coil, regulated by a temperature-control relay, maintainsanoptimaltemperaturerangeinsidethedigestionchambertosupportthermalbreakdownandmicrobialactivity.Alongwithheating, a12VSMPSfanisincorporatedtoprovidesteadyairflow,which helps in odor reduction and creates suitable conditions for aerobic decomposition. The chamber is insulatedtoretainheatandmaintainstableinternalconditionsthroughouttheprocess.Powerissupplied through a hybrid system consisting of a 12V solar panel and an adapter, allowing energy-efficient and flexible operation.

Overall, the proposed work focuses on creating a safe, low-cost, and eco-friendly sanitary napkin disposal system and evaluating how controlled temperature, airflow, and shredding contribute to improved decomposition performance.

IV. METHODOLOGY

The methodology begins with a detailed analysis of the decomposition requirements, thermal characteristics,andairflowconditionsnecessaryforeffectivesanitarynapkindegradation.Basedonthis analysis, a system architecture is formulated that incorporates mechanical shredding at the input stage to reduce material size and enhance microbial and thermal contact. The heating subsystem is implemented using a 500-watt coil connected through a temperature relay that continuously monitors and maintains the chamber temperature within the optimal range of 40°C to 60°C.This regulated heating environment supports enzymatic activity and accelerates fiber softening and fragmentation. Simultaneously, a 12V SMPS fan is positioned to ensure consistent aeration inside the chamber, enablingaerobicmicrobial processes and minimizingodorformation.Thedigestion chamber isfabricatedusinginsulatedmaterialstopreventheatlossand tomaintainstable internalenvironmental conditions. Once the system is assembled, the operational workflow involves shredding the sanitary napkin, introducing the shredded material into the chamber, and activating the heating and aeration subsystems. The decomposition process is monitored periodically to analyze temperature stability, breakdown rate, odor levels, and energy consumption. Experimentaltrialsareconductedusingdifferentnapkintypestovalidate theefficiencyandrepeatability of the system. Data collected from these tests are analyzed to refine the heating cycle, optimize airflow intensity,andimprove chamberinsulation, thusenhancingtheoverallperformanceandreliabilityofthe bio-digester. The methodology concludes with documentation of experimental results, system limitations, and potential future enhancements to support publication in IEEE venues.

V. BIO DIGESTER DUSTBIN

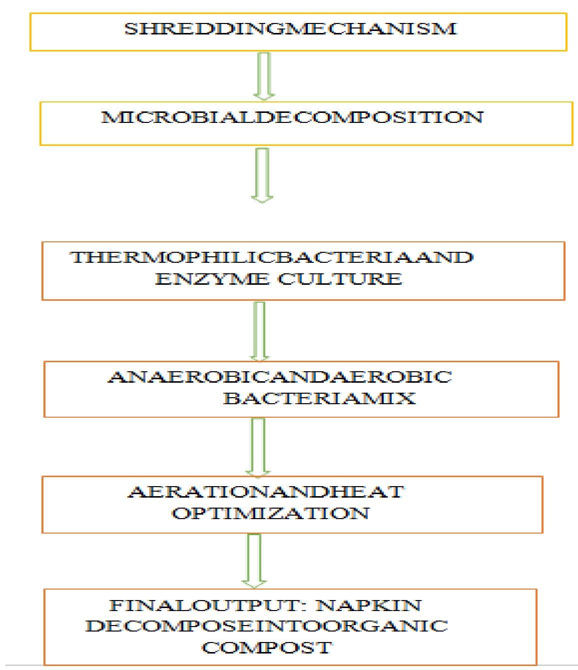

Fig1.1:WORKFLOWDIAGRAM

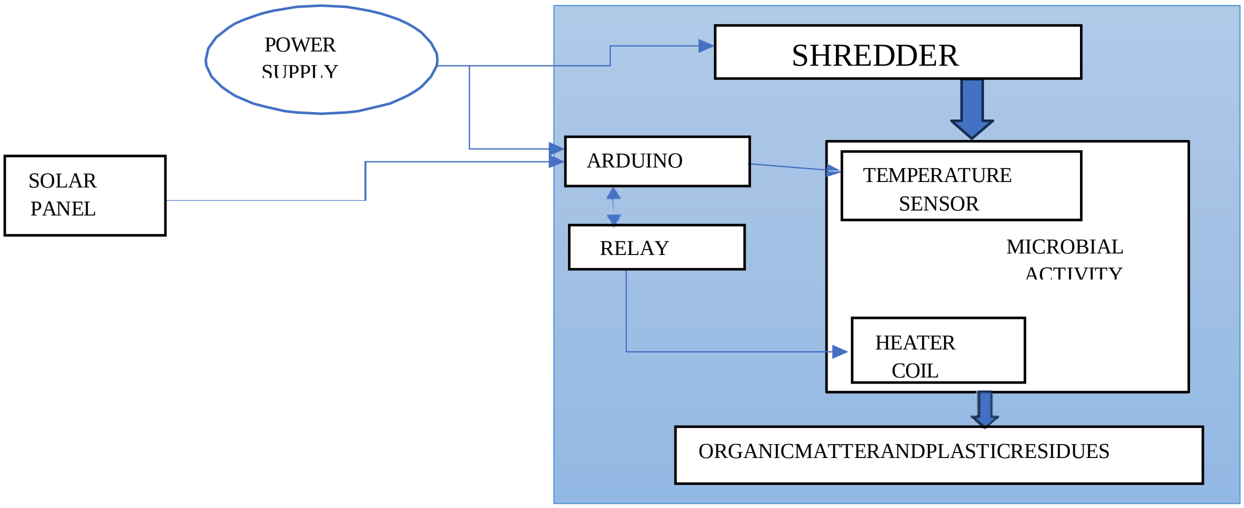

Fig1.2:BLOCKDIAGRAM

VI. IMPLEMENTATION

The implementation of the sanitary napkin bio-digester system begins with the construction of an insulated digestion chamber designed to retain heat and maintain a stable internal environment. The chamber is built using a heat-resistant container, lined with insulation material to reduce thermal loss and improve efficiency.At the input section, a manual paper shredder is installed, allowing the user to shred sanitary napkins by hand before placing them into the chamber. This manual shredding step increases the surface area of the waste material without requiring any electric motor, which makes the systemsimpler,safer,andmoreenergy-efficient.Insidethechamber,a500-wattheatingcoilismounted securely on ceramic or metal supports and connected to a temperature-control relay. A digital temperature sensor placed near the heating area continuously monitors the internal temperature. The relay automatically switches the heating coil ON and OFF to maintain the target temperature range requiredfordecomposition,usuallybetween40°Cand60°C.Alongsidetheheatingmechanism,a12volt SMPS fan is fixed on the side wall of the chamber to provide steady airflow. This aeration supports aerobic decomposition, reduces odor, and helps maintain balanced moisture inside the chamber. The powersystemusesahybridsetupconsistingofa12Vsolarpanelanda12V,2Apoweradapter.Thesolar panelpowersthefanandcontrolrelayduringdaytimeoperation,whiletheadapterprovidesanalternate power source when solar energy is insufficient. Simple protective elements such as fuses and insulated wiringareusedtoensuresafeoperation. Oncethehardwareisassembled,thesystemistestedinstages— firstvalidatingthe temperaturerelay function, thenconfirminguniformairflowfromthefan,andfinally observing chamber conditions during heating cycles. After successful hardware verification, decomposition trials are conducted by shredding sanitary napkins manually and placing them into the chamber.Thesystemisrunforcontrolleddurationswhilemonitoringtemperaturestability,airflow,odor levels, and the rate at which material softens and breaks down. Based on experimental observations, adjustments are made to insulation quality, heating duration, and fan operating time to improve decomposition efficiency.This implementation approach ensures a simple, low-cost, and power-efficient solution while providing reliable, hygienic disposal of sanitary napkin waste.

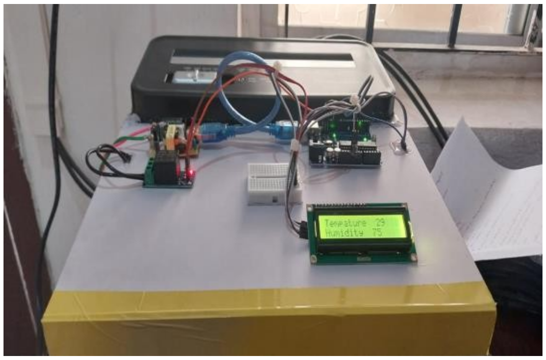

Fig 1.3:Moduleofproject

VII. RESULTS AND DISCUSSION

Theproposedbio-digesterprototypewastestedforitsefficiencyindecomposingsanitarynapkinsunder controlled conditions.The system, which integrates a paper shredder, a 500Wheating coil, and a 12V fan with temperature control, demonstrated effective reduction of waste volume over a period of 7–10 days. Shredding the napkins significantly accelerated the decomposition process by increasing the surface area available for microbial activity, leading to approximately 60–70% volume reduction, compared to 30–40% for unshredded pads. The heating coil successfully maintained the chamber temperature between 45–55°C, providing optimal conditions for thermophilic microbes and enhancing enzymatic reactions responsible for decomposition. Air circulation facilitated by the fan prevented anaerobic zones, controlling odor emission and ensuring hygienic operation. The system functioned continuouslywithoutmechanical failure,confirmingthereliabilityof alow-power, compactdesign for on-site sanitary waste management.

Observations suggest that decomposition slows under lower ambient temperatures, indicating potential benefits from additional insulation or heating for consistent performance. Overall, the results validate that combining shredding, controlled heating, and airflow significantly improves decomposition efficiency while minimizing energy use and odor, highlighting the practical applicability of the bio- digester for safe and sustainable disposal of sanitary waste.

VIII. CONCLUSION

The study demonstrates the successful design and implementation of a compact bio-digester for the decomposition of sanitary napkins. By integrating shredding, controlled heating, and adequate airflow, the system achieved accelerated decomposition while maintaining hygienic and low-odor conditions. The prototype exhibited reliable performance, reducing the waste volume by up to 70% within 7–10 days under optimal conditions. These results highlight the feasibility of a low-energy, on-site solution for sanitary waste management, addressing both environmental and public health concerns. The work laysafoundationfor futureimprovements,includingscalingthesystemforlargercapacities,enhancing temperature control, and incorporating automated monitoring, thereby contributing to sustainable and efficient waste management practices.

REFERENCES

[1] “Electricallyoperatedhygienebintosimplifythestageofnapkincomposition”,Diptinkashyap,Roun ak Chowdhury (2021).
[2] “Energyproductionviabioconversionofsanitarynapkinwasteusingimmobilized cellulaseson Cu- BTC MOF to bioethanol,Biomass and Bioenergy”, KritikaThakur, Sudarshan Sahu (2025).
[3] “AnovelDIYmachinedesigntoobtainsecondaryrawmaterialsfromhygienewaste”,KunalGajanan nandanwar, Divya rathore (2020).
[4] “Resource recovery from soiled sanitary napkin waste a state of the art review”, Muhammad Sajeed Abdul Hameed (2024).
[5] “BeyondtheBin:Acriticalreviewandstrategicframeworkforsustainablemenstrualwastemanagement in India”, Hema Sudhakar(2025).