Low-Cost Sanitary Pad Disposal Unit

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ABSTRACT

The disposal of used sanitary pads presents a significant environmental challenge in developing countries, with India alone generating approximately 12.6 billion disposable pads annually. Current disposal technologies rely on incineration, which destroys all materials and releases toxic emissions, including carcinogenic dioxins and furans. Commercial incinerators are costly, consume high electrical power, and eliminate opportunities for resource recovery. This paper presents an open-source, density-based separation system designed to overcome these limitations. The device exploits the inherent density differences between plastic components (polypropylene, polyethylene) and cellulose-based absorbent materials, and separates them for subsequent recycling or composting, with no external emissions. At an estimated construction cost of approximately 22,000, the device offers a cost-competitive alternative to mid-range incinerators while providing superior environmental benefits aligned with circular economy principles.

Specifications table

Hardware name	Low-Cost Sanitary Pad Disposal Unit
Subject area	• Engineering and material science • Environmental,planetary and agricultural sciences • Biological sciences • Educational tools and open source alternatives to existing infrastructure
Hardware type	Mechanical engineering and materials science
Closest commercial analog	No analogous product is available commercially
Cost of hardware	22,000

1. **Hardware in Context**

Menstrual waste is the waste generated during menstruation, comprising menstrual blood and associated vaginal and uterine discharge, along with the materials used to collect the blood, such as disposable sanitary pads, tampons, menstrual cups, and cloth. [1] Management of menstrual waste is a significant challenge facing the world, particularly in developed countries where adequate disposal services are inadequate and underdeveloped. [2] In India, of approximately 336 million menstruating women, an estimated 121 million use disposable sanitary napkins, which are the largest contributor to menstrual waste in the country. [3] Considering that a healthy female undergoes 13 cycles of menstruation in a year and around 451 in a lifetime, at an average use of 8 sanitary pads per cycle, this generates more than 12.6 billion sanitary pads disposed annually, resulting in more than 113,000 tons of menstrual waste every year. [4,5] Such a huge amount of waste has a substantial effect on the environment, taking around 500-800 years for a sanitary pad to decompose and adding to the already rising plastic pollution in landfills. It also poses several risks of Hepatitis B and C, and HIV/AIDS infection to sanitation workers who are exposed to this waste. [6,20]

Understanding the material composition of sanitary pads is essential for developing effective disposal solutions. Although the actual composition of pads manufactured in India is not revealed, any absorbent product usually contains the following materials: [7]

Table 1 : Typical composition of a sanitary pad.
(Source: doi.org/10.1007/s10853-025-11151-7)

Layer	**Component**	**Function**	**Material**
1	Top Sheet	Fluid permeable layer that is soft on skin and allows fluid through to the next layer	Nonwoven Polypropylene (PP) or Polyethylene (PE)
2	Acquisition Layer	Distribute fluid to all areas in sanitary pad	Nonwoven cellulose
3	Absorbent Core	Absorb and lock in fluids	Cellulosic fibres and Super Absorbent Polymer (SAP)
4	Back Sheet	Moisture impermeable layer	Polypropylene (PP) or Polyethylene (PE)
5	Adhesive	Secure sanitary pad to undergarments	Hot-melt adhesive

These materials can be separated into plastics and biodegradable materials, which need to be separated for either recycling or disposal, which is the objective of this hardware project.

For the purposes of this work, we define a 'sanitary pad disposal machine' as a device designed to safely process used menstrual hygiene products. Till date, there are very limited methods available for disposing sanitary pads properly. Traditional methods include open dumping and landfilling, both of which are extremely problematic. In India, studies on menstrual waste show that 45% of pads are thrown with routine waste, 25% are disposed via burial, 23% are thrown in the open, 15% are burnt openly, and 9% are flushed down the toilet. [8] Landfill disposal occupies significant space and causes leaching of toxins and microplastics into the soil and groundwater. [9] Open dumping creates health hazards by incubating pathogens such as HIV, hepatitis, and tetanus. Other traditional methods, such as deep burial, composting, and pit burning, are also harmful for the environment in the long term, and lack scalability and proper regulation.

The predominant technology for sanitary pad disposal in public spaces currently relies on incineration, i.e. using electrical heating elements or combustion chambers to burn used pads at temperatures ranging from 300°C to 950°C, converting them to ash. These machines are priced in the range of 4,500 to 1,50,000, depending on their capacity, features and quality. However, incineration presents significant environmental and health concerns. Standard low-temperature incinerators operating around 300-400C produce harmful emissions, including carbon monoxide (CO), unburned hydrocarbons (UHC), and nitrogen oxides (NO_x). [10] More critically, the combustion of plastic components in sanitary pads can release toxic substances such as dioxins and furans, which are carcinogenic and are associated with serious health risks, including respiratory problems. [10, 20, 21]

Recently, material separation and recycling approaches have emerged as more sustainable alternatives. Technologies developed by companies like PadCare Labs employ density-based separation and reverse osmosis to separate plastic, cellulose, and superabsorbent materials without combustion. The separated materials are then upcycled into secondary products such as construction paper and agricultural water storage products. However, these systems are primarily large-scale centralized facilities and are not yet available for commercial use. [11]

Despite the availability of incinerators, significant gaps exist in sanitary pad disposal technology. First, current incinerators destroy all materials indiscriminately, eliminating the potential for resource recovery. Second, the cost of commercial incinerators remains prohibitive for many institutions, particularly in rural areas and smaller towns where only around 43% of women use sanitary napkins compared to approximately 68% in urban areas. [12, 18] Third, the environmental impact of combustion-based disposal contradicts global sustainability goals and circular economy principles. Finally, maintenance requirements, operational costs and high electricity consumption create barriers to widespread adoption of incinerators.

This paper presents a novel manual density-based sanitary pad separation system designed to address these limitations. Unlike incineration, the proposed hardware physically separates the plastic components from the cellulose-based absorbent material, allowing material recovery and recycling. The system is designed for public spaces such as schools, colleges, government offices, and public restrooms. At an estimated cost of approximately 22,000, the device offers a cost-competitive alternative to incinerators while providing additional environmental benefits by promoting resource recovery rather than destruction.

The separation process produces two output streams: cellulose material comprising 60-70% of pad weight, which can be composted to produce bio-fertilizer, and plastics, which can be sent to recycling facilities. Irradiating ultraviolet light (UV-C), which is one of the most reliable non-chemical disinfection tools, inside the shredding chamber enables a pathogen-free operation. UV-C radiation functions as a sterilizing agent by extensively damaging DNA and proteins, driving pathogens as well as blood cells into apoptosis, and ultimately leading to the creation of apoptotic bodies in the mixture. [13, 14, 15, 16, 17]

A secondary disinfection step is implemented in the separation chamber using brine solution (23.3% w/w NaCl) to eliminate any residual pathogens. The high osmotic pressure exerted by concentrated sodium chloride solution causes cellular dehydration in bacteria, with most pathogenic organisms unable to proliferate above 10% NaCl concentration. [22] Additionally, this brine treatment serves a dual function by inducing de-swelling of the superabsorbent polymer (SAP) present in the pad's absorbent core. Studies demonstrate that SAPs exhibit 88-98% reduction in water absorption capacity when exposed to 23.3% NaCl solutions, facilitating the release of absorbed fluids and de-swelling SAP to a powdered form. [23] During mechanical agitation in the brine medium, this powdered SAP preferentially associates with the hydrophobic plastic components, aiding in the separation of non-biodegradable components from the biodegradable ones.

Table 2 : Expected appearance of components after treatment

Component	**Nature**	**Expected Segregation**
Cellulose	Biodegradable	Bottom Layer
Plastics (PP, PE)	Non-biodegradable	Top Layer
Super Absorbent Polymer (SAP)	Non-biodegradable	Top Layer

2. **Hardware Description**

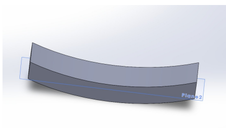
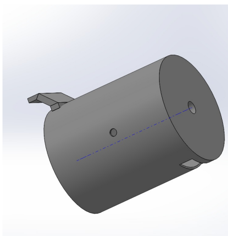
The sanitary pad disposal unit is designed specifically for rural settings, using low-cost, easily available materials and components for production. Rather than customizing blades with a large span, the shredding system has been manufactured by sharpening exhaust fan blades which are already available in the market at a low price, and fastening them to a shaft that rotates at a high speed. The chambers are made using stainless steel and acrylic materials. Disinfection is carried out using multiple ultraviolet-C (UV-C) ray emitting germicidal lamps installed inside the closed chamber and use of brine solution (NaCl). Air nozzles, which are connected to tire inflating pumps, are attached at different points of the shredding chamber to remove pieces stuck to the chamber or blades. The machine capacity and setup are customizable and can be altered on the basis of the scale of use and user convenience. Salient features of the design include:

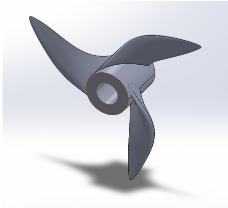
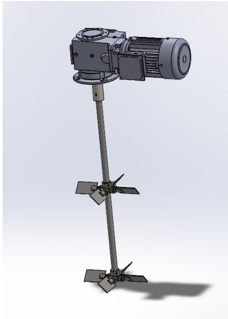
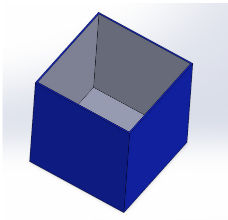
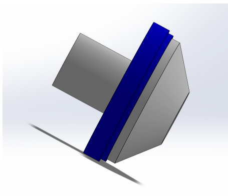
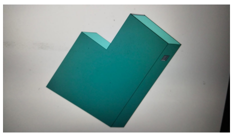
- Ease of manufacturing and installation
- Cost-effective design, resource recovery
- Portability
- No requirement of infrastructure
- Sterilization by germicidal UV-C irradiation
- Zero emissions
- Energy-efficient density-based separation of components
- Bio-fertilizer production
- Minimal negative impact on the environment

3. Design Files

All computer-aided design (CAD) files associated with this work are openly available at CAD Files.

Table 3 : List of hardware design files for the sanitary pad disposal machine

Design File Name	File Type	STL Rendering	File Location
Vent	CAD File, Image		Vent
Bin	CAD File, Image		Bin file

Design File Name	File Type	STL Rendering	File Location
Mixer Blade	CAD File, Image		Mixer Blade file
Euromixers	CAD File, Image		Euromixers file
Shaft	CAD File, Image		Shaft file
Contamination Tank	CAD File, Image		Contamination Tank file
Air and Water Nozzle	CAD File, Image		Nozzles file
Outer Box	CAD File, Image		Outer box file

4. **Bill of Materials**

Table 4 : List of hardware to be purchased for assembly

Designator	Component	No.	Cost per unit (in INR)	Total cost (in INR)	Source of Materials	Material Type
Bin	Shredder Body	1	999.00	999.00	`https://amzn.in/d/6a5U51J`	Metal
Mixer Blade	Exhaust Blades	3	999.00	900.00	`https://amzn.in/d/cm777wJ`	Plastic

Designator	Component	No.	Cost per unit (in INR)	Total cost (in INR)	Source of Materials	Material Type
Euromixer	MY1016 Motor	1	2999.00	2999.00	`https://amzn.in/d/3gIANBA`	Composite
Shaft	Shaft	1	401.00	401.00	`https://amzn.in/d/aTIJhk6&Metal`	
-	UV-C Germicidal Lamp	2	1020.00	2040.00	`https://jainsonslightsonline.com/products/philips-8w-uvc-tube`	Composite
-	24V Lithium-Ion Battery	1	8499.00	8499.00	`https://amzn.in/d/bDLHIFC`	Composite
-	Sodium Chloride (99.9%)	4	275.00	1100.00	`https://amzn.in/d/aKAwUxX`	Inorganic
-	Tire Inflator (Air Pump)	2	2517.00	5034.00	`https://amzn.in/d/0pFrnD9`	Composite

Note: Tax is not included in the BOM.

5. Build Instructions

The steps to manufacture the sanitary pad disposal unit are:

1. Construct the Shredder/Pre-processing Unit first, focusing on material disintegration and sterilization.

2. Secure high-shear blades onto a rotating shaft to create the primary shredding mechanism.

3. Mount the shaft and blades within a sturdy shredding chamber/hopper. 4. Connect the shredding shaft to a high-torque electric motor for power.

5. Install elastomeric isolators or vibration dampening pads beneath the motor and/or chamber to minimize operational vibration.

6. Stabilize the upper end of the shaft using a bearing-mounted top plate or a pillow block bearing fixed to the container top.

7. Integrate UV-C germicidal lamps inside the shredding chamber for material sterilization.

8. Include a pneumatic conveyance system (air pumps/blower) to push the shredded output towards the exit.

9. Fix a screening grate or baffle at the shredder's outlet to control particle size and prevent backflow.

10. Establish all necessary power connections for the motor, UV lamps, and air pumps.

11. Construct the Density Separator Unit next, focusing on separating plastic from cotton.

12. Fabricate a separation tank/container and mount it on a supporting structure to achieve the required working height.

13. Install a submerged impeller or agitator driven by a motor at the bottom of the separation tank to mix the material and brine solution.

14. Integrate a small, contained pre-processing area onto the main assembly frame for focused sterilization of pads before they are introduced into the shredder.

15. Connect the outlet of the Shredder unit to the inlet of the Separator unit using a pipe and a hinged chute with a manually operated gate that can be opened to transfer material and closed to isolate the units.

16. Mount both the Shredder and Separator units onto a unified, robust assembly frame for stability and alignment, with the Separator unit below the Shredder.

17. Establish the power connection for the Separator's mixing motor.

6. Operation Instructions

The steps to operate the sanitary pad disposal unit are:

1. Before you start, fill brine solution in the separation tank up to the marked level.
2. Turn ON the motor switch, the UV-C germicidal lamps and the air pumps. Let them run for 2-3 minutes to stabilize.
3. Insert the used pad inside the shredder and firmly close the lid to prevent splashing.
4. Wait for 3-5 minutes until shredding finishes.
5. Open the chute and allow shredded material to flow from the Shredder to the Separator.
6. Allow it to settle for at least one hour.
7. Tilt the Separator to obtain the floating plastic.
8. Filter the settled organic materials from the bottom layer.
9. Rinse and dry the materials before recycling.

7. Validation and Characterization

Following the complete processing cycle, i.e. shredding, brine treatment and mechanical separation, visual inspection confirmed successful stratification of materials into two distinct layers, one on top of the brine solution and the other submerged under it. The upper layer consisted of non-biodegradable materials, which includes the plastic components (polypropylene and polyethylene) combined with de-swelled SAP powder, while the lower layer contained dispersed cellulose fibers. No visible cross-contamination or material exchange between layers was observed, indicating effective density-based separation. This was verified as the machine was operated multiple times and a clear separation of components was observed in each experiment.

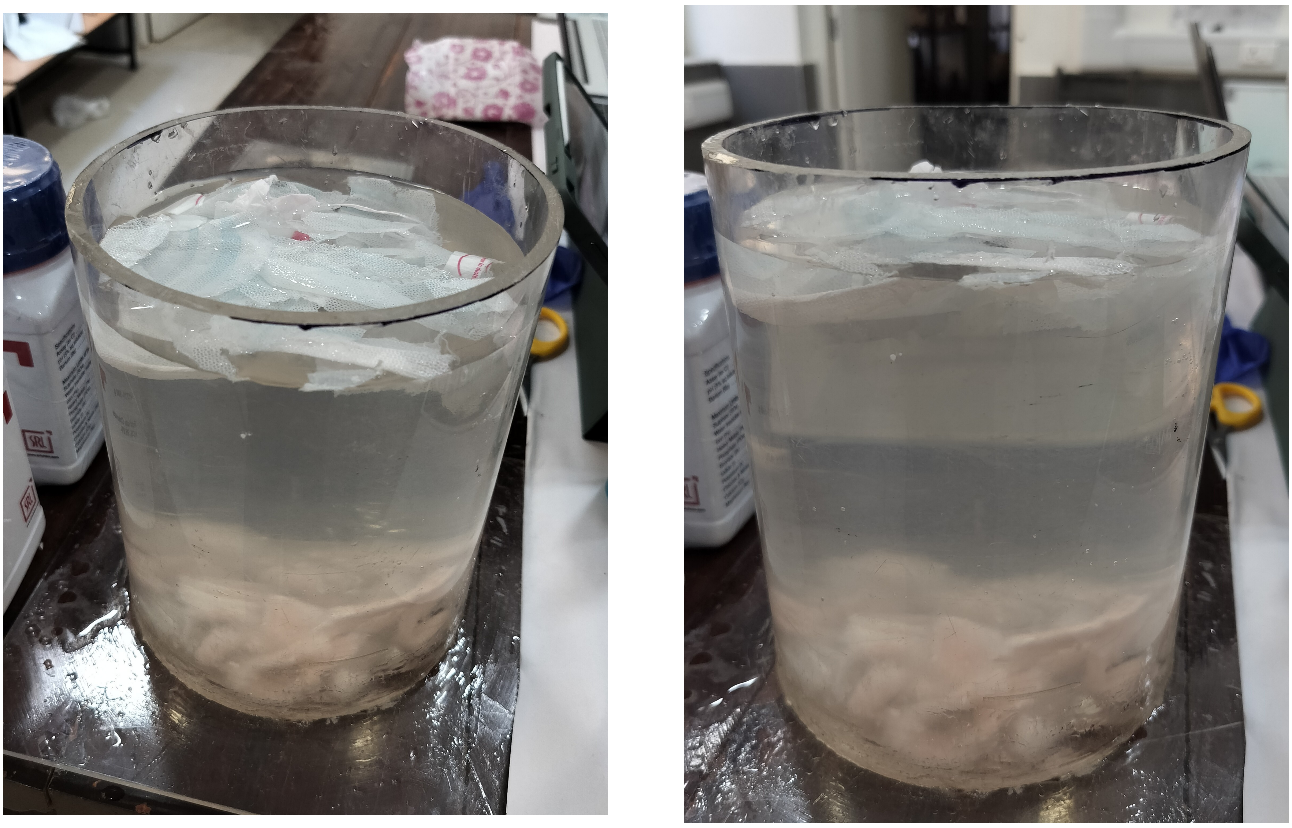


Figure 2: Appearance of two distinct layers of materials, indicating successful operation of the unit

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