



Toxics Link  
for a toxics-free world

Dioxin & Furans

# Safe Disposal?



Pb

Phthalates

Cr

Cd

## **About Toxics Link**

Toxics Link is an Indian environmental research and advocacy organisation set up in 1996, engaged in disseminating information to help strengthen the campaign against toxics pollution, provide cleaner alternatives and bring together groups and people affected by these problems. Toxics Link has a unique expertise in areas of hazardous, plastic, medical and municipal wastes, international waste trade, and emerging issues of pesticides, Persistent Organic Pollutants (POPs), hazardous heavy metal contamination, etc. We have successfully implemented various best practices and have contributed to policy changes in the aforementioned areas apart from creating awareness among several stakeholder groups.

Toxics Link's Mission Statement - "Working together for environmental justice and freedom from toxics, we have taken upon ourselves to collect and share both information about the sources and the dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives."

## **Acknowledgement**

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# Safe Disposal?



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# EXECUTIVE SUMMARY

**This study is crucial because small-scale electric incinerators are being used in many schools across India and little is known about the end products released into the environment along with ash and flue gas released during combustion.**

Sanitary napkins are essential for menstrual hygiene, yet their improper disposal presents significant environmental and health risks. India generates around 1,50,000 tonnes of non-biodegradable sanitary waste every year. Improper disposal of soiled napkins has negative consequences for both humans and the environment. One such disposal method is the use of small-scale electric incinerators commonly used at malls, complexes, and schools in India. This report examines the presence of toxic compounds in ash and flue gas generated from small-scale sanitary napkin incinerators. The key findings of the study highlight the release of hazardous substances, including phthalates,

dioxins, furans, and heavy metals, underscoring the need for safer disposal methods.

Building on our previous research findings on toxic compounds in sanitary napkins of various brands, this study investigates the pollutants released post use of the napkins, during and after incineration. The focus is on small-scale electric incinerators, commonly used in Indian schools, which operate at lower temperatures. These incinerators have been promoted in accordance with the Menstrual Hygiene Management (MHM) and the Central Pollution Control Board (CPCB) guidelines. The findings provide insight into the potential hazards posed by these incinerators, though the results may not be applicable to larger, high-temperature systems.

This study is crucial because small-scale electric incinerators are being used in many schools across India and little is known about the end products released into the environment



**1,50,000**  
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**India every year**

along with ash and flue gas released during combustion. In this study, we tested the ash and flue gas samples to detect the presence of heavy metals, phthalates, and dioxins/furans.

Toxic compounds were detected in all three samples during incineration. Sample 1 (cotton), used as a control, exhibited the highest total phthalate concentration in ash (9.19 mg/kg), followed by Sample 2 (a branded antibacterial napkin) at 8.67 mg/kg. Sample 3 (another branded napkin) had the lowest concentration of phthalates (0.489 mg/kg). Heavy metal analysis revealed elevated concentrations in Samples 1 and 3 (5.94 mg/kg and 5.97 mg/kg, respectively). Cadmium was detected only in

Sample 2, while chromium was present in all samples at lower concentrations (0.01-0.12 mg/kg). Mercury was not detected. Dioxins and furans were identified in the flue gas of all samples, though within permissible limits.

The presence of heavy metals and phthalates in ash at concerning concentrations suggests potential risks to human health and the environment. The release of dioxins and furans, even at low levels, can prove to be harmful in the long-run. Additionally, high lead levels in two samples highlight the need for effective management of incineration ash to minimise exposure.



# 01.

# INTRODUCTION

## 1.1 Background

Sanitary napkins are an essential menstrual hygiene product used by women from puberty to menopause [1]. Different estimates of sanitary waste generation have been made according to different studies. India generates approximately an estimated 1,50,000 tonnes of non-biodegradable sanitary waste annually [2]. Another study estimates the daily generation of sanitary napkins and baby diaper waste to be around 925 tonnes [3].

The rising demand for disposable sanitary napkins, particularly in urban areas, is a trend that is projected to grow even further [4]. According to the National Family Health Survey-4, Bihar has shown incredible growth in adopting the use of disposable sanitary napkins from 2016-19 [3]. The women in the highest quintile in terms of wealth are twice as likely to use sanitary napkins as compared to the lowest quintile as per the National Family Health Survey-5 [5]. For instance, Delhi, Arunachal Pradesh, Goa, Andaman and Nicobar Islands, and Puducherry were found to be having a high percentage of girls in the age group of 15-24 years who were using sanitary napkins [5]. States like Bihar, Madhya Pradesh, and Meghalaya showed the least percentage of menstrual product usage in India [5].

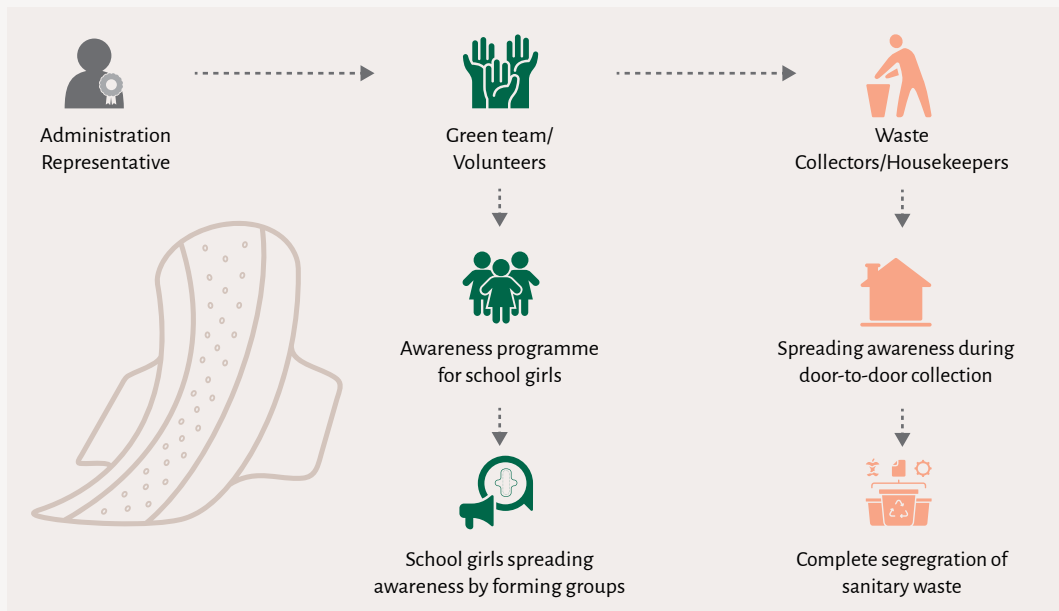
However, these products are predominantly made using non-biodegradable plastics [6], posing significant environmental challenges when they are not disposed of properly [7]. This waste, primarily comprise of plastics, remains in landfills for over 700 years [4]. The country currently lacks a viable method for large-scale recycling of this waste. Additionally, the process is complicated by the fact that very few cities are practicing effective source segregation of different types of waste products [7].



For instance, cities like Indore, Bhopal, and Pune have set a positive example with their waste segregation efforts, offering a model that other cities and rural areas could follow [7]. Another good example of an effective waste management campaign (to segregate sanitary waste) used in the town of Karad (Maharashtra) is shown in Figure 1.

The flowchart shown in Figure 1 is one of the examples of best practices in sanitary waste management. However, this ideal process is far from what happens on the ground in most

of the cities in India, where improper disposal practices remain widespread. Sanitary napkins are often discarded alongside regular household waste or dumped in open areas, attracting pests and creating sanitation hazards. In some cases, napkins are flushed down toilets, leading to clogged sewage systems [4]. This poses a serious problem, particularly for India's aging urban drainage infrastructure, where blockages can cause flooding and increase the risk of waterborne diseases [9]. Below is a discussion on some of the disposal methods used by people to dispose of sanitary waste.



**Figure 1: The flowchart shows campaigning strategy followed by the Karad Municipal Council, India (Source: [7])**

## 1.2 Disposal mechanisms currently in use

According to a report [10] published by the Central Pollution Control Board (CPCB), several methods are currently in use to dispose of sanitary napkins. These include:



- **Open disposal of the napkins:** In this method of disposal, the napkins are thrown wherever deemed convenient by the user.



- **Use of regular garbage bins:** This refers to throwing the soiled napkin in a dustbin or a regular garbage bin with or without wrapping it.



- **Pit burial:** It is a method most commonly used by rural women where the soiled napkins are thrown in a deep pit.



- **Burning:** Some women from rural areas prefer to burn the napkins as they are responsible for the final disposal of menstrual waste.



- **Incineration/hygiene bins:** Institutions such as schools have started using small-scale incinerators or hygiene bins to segregate and dispose of sanitary waste.




- **Toilet Flush:** Many girls tend to flush the soiled napkins in the toilet.

According to the Menstrual Hygiene Management (MHM) guidelines, 'safe disposal' refers to the proper disposal of sanitary napkins in a manner that prevents human contact and minimises environmental pollution [10]. It also includes burning napkins using small scale incinerators in hospitals/health clinics [10]. On the other hand, 'unsafe disposal' involves discarding sanitary napkins in an open or uncontrolled manner, which leads to land and water contamination and increases the risk of infections for humans [10].

To address this issue, small-scale incinerators have been introduced in schools across India as a means of sanitary waste disposal. Cities such as Pune, Bengaluru, and Goa have implemented them, and Delhi alone has installed such units in 550 municipal schools [7]. These incinerators are increasingly adopted across India in accordance with the Central Pollution Control Board (CPCB) Menstrual Hygiene Management (MHM) guidelines [7].

As per CPCB guidelines [10], these incinerators may be used in public places like female toilets, community toilets, malls, complexes and residential societies for the disposal of sanitary waste. The guidelines also suggest that an incinerator should have the capacity to burn 150-200 napkins in a day and must comply with the general emission standards described in 'standards for incineration' section of the Solid Waste Management Rules, 2016 [10].

CPCB has also set strict norms for the permissible levels of toxic compounds like dioxins and furans [10] as well as heavy metals like Lead, Chromium, Cadmium, and Mercury [11] when using incineration as a method for waste disposal. As per rules, the Total Dioxins and Furans should not exceed 0.1 ng TEQ/Nm<sup>3</sup>

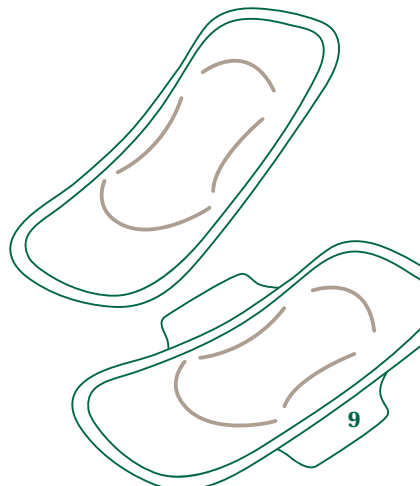


**Delhi alone has installed incinerator units in 550 municipal schools**

(Toxic Equivalent per normal cubic metre) [12]. Additionally, the concentration of heavy metals should not exceed 50 mg/kg in the ash recovered from the incinerators [11].

For Tier 1 cities, CPCB recommends alternate waste management solutions such as landfilling, sending sanitary waste to waste-to-energy plants or co-processing in cement kilns and power plants [10]. The growing adoption of these incinerators underscores the need to assess their long-term environmental and health implications.

However, while incineration is being promoted as a viable solution, it has significant drawbacks. Sanitary napkins contain plastics and chemicals that release toxic compounds when burned [6]. A past research [13] has highlighted the release of heavy metals during the combustion of plastics, further raising concerns about environmental and human health risks. Given these potential hazards, it is essential to evaluate the long-term impact of using small-scale incinerators.



### 1.3 Rationale - Environmental and Health risks of small-scale sanitary waste incinerators

Incineration is one of the most commonly used methods for disposing of sanitary waste. However, if not conducted properly, it can worsen environmental and public health issues. Incomplete combustion at low temperatures can lead to the release of harmful gases, while the resulting ash may contain hazardous residues [7]. Incineration at high temperatures, combined with effective emission control systems, ensures better combustion and significantly reduces the release of toxic compounds compared to cheaper, less efficient incinerators [14].

However, small-scale sanitary waste incinerators do not follow these high-temperature combustion system and emission control standards. As a result, the plastics, when burned at lower temperatures, do not undergo complete combustion and may release toxic compounds like phthalates, heavy metals, and dioxins/furans. For example, it was observed that some schools in Rajasthan have been using electric incinerators. These incinerators have a temperature range of 0-300°C. There is a tray for collecting the ash generated during incineration and a single chamber through which the emissions are released into the environment.

Little is known about the efficiency of these incinerators in removing toxic compounds during incineration. Due to this, monitoring emissions from these small-scale incinerators is essential, particularly in the absence of large-scale incinerators that meet WHO safety



Figure 2: Small-scale incinerators showing a single chamber for burning the napkins and releasing the fumes from the top

standards. Small-scale incinerators often lack proper emission control mechanisms, which may result in the release of toxic compounds at higher concentrations [14]. The high plastic content in sanitary napkins, approximately 90% [7], poses serious risks to both the environment and human health. It should also be noted that toxic compounds like dioxins, furans and phthalates have been found in sanitary products of different countries across the world.

This study is thus crucial in assessing whether small-scale incinerators release harmful compounds into the environment, potentially leading to contamination and exposure of surrounding communities to their toxic effects. Understanding the extent of these emissions will help inform policymakers and drive the development of safer alternatives for sanitary waste disposal.

## 1.4 Aims and Objectives

The aim of the study was to detect the presence of toxic compounds in the ash and flue gas generated from the incineration of sanitary napkins, assessing the potential health risks and environmental impacts associated with using small-scale incinerators for sanitary waste disposal.

Currently, there is limited publicly available data on the presence of phthalates and heavy metals in ash from small-scale incinerators. Most existing research focuses on large municipal solid waste incinerators. For instance, researchers [15] have detected seven phthalates, including dibutyl phthalate and bis

**Sanitary napkins  
contain about**

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**plastic, posing risk  
to both health and  
environment**

(2-ethylhexyl) phthalate, in the bottom ash of municipal waste incinerators. These findings highlight the widespread presence of phthalates in various products and suggest that they may persist in waste byproducts after incineration. However, the extent to which phthalates and other toxic compounds remain in ash from small-scale incinerators—operating at lower temperatures and without emission control systems—remains largely unstudied. This gap in knowledge is particularly concerning given the widespread use of such incinerators in government schools across India for the disposal of sanitary napkins.

To address this knowledge gap, the following objectives were identified:

- Testing of ash samples to detect the presence of heavy metals and phthalates
- Testing of flue gas to detect dioxins or furans released during incineration

The findings of this study provide valuable insights for policymakers, helping them determine whether small-scale incinerators are a viable solution for sanitary waste disposal or if safer, more environmentally friendly alternatives should be considered.

# 02

# TOXIC COMPOUNDS COMMONLY FOUND IN SANITARY NAPKINS

Sanitary napkins are designed with multiple layers to enhance absorption and comfort. However, these layers may contain various toxic substances, including heavy metals, phthalates, and volatile organic compounds, which pose risks to human health [16]. This section discusses some of the key toxic compounds commonly found in sanitary napkins and their potential impact when incinerated.

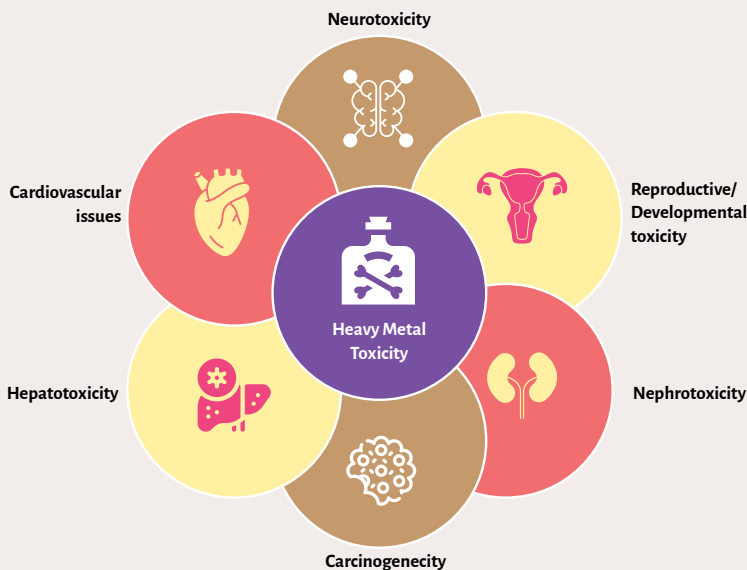
## 2.1 Heavy Metals

Studies have demonstrated the presence of heavy metals in incineration byproducts. Past research [17] has detected significant concentrations of heavy metals in both fly ash and bottom ash samples from hospital waste incinerators in China, with concentrations ranging from 1.1 to 121,411 ppm. Their findings indicated that fly ash generally contained higher concentrations of these toxic metals. Similarly, it has also been observed that lead (Pb) tends to persist in the bottom ash after incineration [18].

While these studies primarily focused on large-scale municipal solid waste (MSW) incinerators,

it is critical to investigate whether similar contamination occurs in small-scale sanitary napkin incinerators, which operate at much lower temperatures (around 300°C). Incomplete combustion at such temperatures may prevent the complete breakdown of hazardous materials, potentially allowing heavy metals to remain in the ash.

The release of heavy metals into the environment through incineration poses serious health risks (see Figure 3). Various toxic effects of heavy metal exposure on the human body, include neurotoxicity, organ damage,



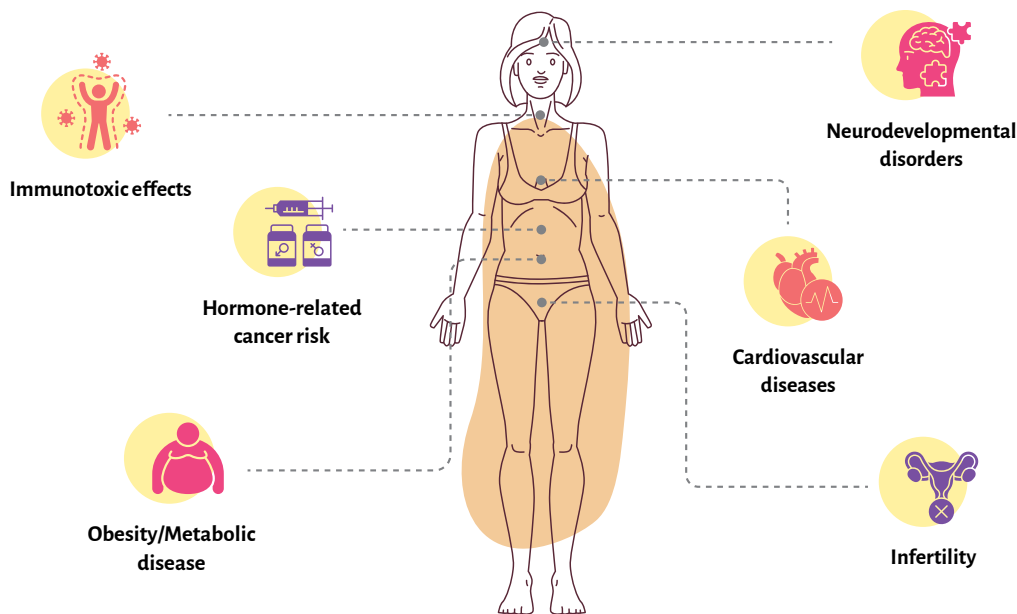
**Figure 3: Impacts of heavy metals on the human body**

and developmental disorders [19]. Given these risks, it is crucial to assess the presence of heavy metals in ash samples from small-scale incinerators and explore strategies to prevent their release into the environment.

## 2.2 Bisphenols

Bisphenol A (BPA), commonly found in plastics, exhibits estrogenic properties and has been linked to various health concerns [20]. Exposure to BPA has been shown to be causing developmental abnormalities in zebrafish

larvae, including cardiac oedema, spinal malformations, and craniofacial deformities at concentrations ranging from 1 to 200 mg/L [20]. In humans, BPA exposure has been associated with breast and testicular cancer, immune suppression, metabolic disorders, and cardiovascular disease (see Figure 4) [20]. Additionally, BPA and related compounds may contribute to endocrine disruption, leading to hormonal imbalances and reproductive issues, including the feminisation of males and altered sexual behaviour.



**Figure 4: Impact of Bisphenols on human health**

Alternatives to BPA, such as Bisphenol F (BPF) and Bisphenol S (BPS), have also been found to exhibit similar or even more severe toxic effects. It has been reported that these compounds can negatively impact neurodevelopment and the endocrine system, with a toxicity ranking of BPA > BPF > BPS [22]. Moreover, it was found that BPF and BPS are just as carcinogenic as BPA, making them unsuitable as alternatives [23]. Alarmingly, some legacy endocrine-disrupting chemicals (EDCs) persist in human tissues long after exposure, reinforcing the urgency of stricter regulations and potential bans on these harmful substances [22].

## 2.3 Phthalates

Phthalates are di-esters of 1,2-benzene dicarboxylic acid and are widely used as plasticisers in various industries [24]. They are classified into two categories based on their molecular weight. High molecular weight

phthalates, such as di(2-ethylhexyl) phthalate (DEHP), di-isononyl phthalate (DiNP), and di-n-octyl phthalate (DnOP), are commonly used as plasticisers in polyvinyl chloride (PVC) products. In contrast, low molecular weight phthalates, including diethyl phthalate (DEP) and dibutyl phthalate (DBP), are found in plastics and cosmetic products [24]. Because phthalates are not chemically bonded to the polymer matrix, they can leach out over time, contaminating the surrounding environment [25].

Sanitary napkins have been identified as a source of phthalate exposure. A study [26] on sanitary napkins from six countries reported phthalate concentrations ranging from 1.73 to 11.94 ppm (1733 to 11,942 ng/g). The dominant phthalates detected included DiBP, DnBP, and DEHP, which pose significant carcinogenic and endocrine-disrupting risks [26]. Similarly, Toxics Link had investigated the presence of

harmful chemicals in sanitary napkins from 10 different brands and found high concentrations of phthalates in multiple products [6]. Notably, two brands (also used in this study) contained particularly high levels of these toxic compounds.

Given the widespread use of sanitary napkins and the potential for long-term exposure to phthalates, further research is necessary to assess their health risks and explore safer alternatives.

## 2.4 Dioxins and Furans

Fly ash from incinerators contains highly toxic substances known as dioxins and furans. The flue gases from municipal solid waste (MSW) incinerators often release these compounds at concentrations exceeding permissible limits [27]. Notably, dioxins emitted from small-scale incinerators tend to be more toxic than those from large-scale facilities [28].

Among these compounds, 2,3,7,8-tetrachloro-dibenzo-p-dioxin (TCDD) is the most potent and is used to assess dioxin and furan toxicity in toxic equivalency quotients (TEQs) [29]. TEQs are calculated by multiplying the weight of a given sample in grams with a factor called Toxic Equivalent Factor (TEF). TEF is actually a ratio of the toxicity of the given sample and TCDD [30].

Dioxins and furans are non-polar, hydrophobic, and lipophilic compounds, making them highly resistant to degradation through hydrolysis or oxidation-reduction processes [31]. Chlorine content plays a significant role in dioxin formation during incineration [28]. Some dioxins and furans may also contain bromine instead of chlorine, potentially altering their

toxicity and environmental persistence [31]. It has been demonstrated that heating fly ash samples containing iron (Fe), lead (Pb), zinc (Zn), and copper (Cu) chlorides and oxides at MSW incinerator temperatures led to the release of aromatic compounds similar to those from waste combustion [32]. This suggests that incinerating bleached products, such as sanitary napkins, may result in the release of chlorinated aromatic compounds.

Sanitary napkins often contain bleached cotton [6], which could contribute to dioxin and furan emissions during incineration. Given their toxicity and persistence, further investigation is necessary to assess their environmental and health impacts.



# 03.

# HEALTH IMPACTS OF WASTE INCINERATION

## 3.1 Exposure Risks from Ash and Flue Gas

The incineration of sanitary napkins poses significant health risks to workers and nearby communities through exposure to toxic ash and flue gases. These emissions contain hazardous substances, including heavy metals, dioxins, furans, and phthalates, which may lead to both short-term and long-term health effects.

Heavy metals present in incineration ash have been linked to neurological and carcinogenic effects in humans [13]. Additionally, products made from incineration ash can leach heavy metals into the environment, posing further risks through direct and indirect exposure [13].

Dioxins, which readily bind to soil and dust particles, can be inhaled as airborne contaminants, increasing exposure risks [30]. Dietary exposure is also a major concern, as dioxins and furans accumulate in high-fat foods such as meat, fish, and eggs. Individuals who consume these foods regularly may be at a heightened risk [33].

**Children are vulnerable to dioxins, heavy metals, and polychlorinated biphenyls (PCBs) exposures, largely responsible for cognitive and behavioural impairments**

Children are particularly vulnerable to exposure, as dioxins, heavy metals, and polychlorinated biphenyls (PCBs) have been associated with cognitive and behavioural impairments [34]. Women of reproductive age may also be more susceptible to phthalate exposure, which has been linked to reproductive toxicity, even at environmental concentrations [25][35]. Although phthalates do not bioaccumulate (retention in the body over a period of time) due to their chemical properties, their widespread presence in the environment raises concerns about long-term health effects [25].

Dioxins and furans are known to cause both carcinogenic and non-carcinogenic effects in humans [29]. As these compounds accumulate

in fat cells, women—who typically have a higher percentage of body fat—may face disproportionate health risks [36].

Research on the long-term effects of dioxin and furan exposure has yielded conflicting results. A study found that populations living near a municipal solid waste incineration plant had a hazard quotient for both carcinogenic and non-carcinogenic risks below unity, with estimated cancer risks remaining within acceptable limits [37]. However, this is in contrast to World Health Organization [38] classification, which categorises chronic dioxin exposure as carcinogenic. Additionally, studies have reported an increased risk of cancer among individuals residing near incineration sites [34].

Given these findings, further research is needed to fully understand the long-term health implications of exposure to incineration byproducts.

## 3.2. Environmental Impacts and existing regulations

### 3.2.1 Air Quality Concerns

Improper incineration of waste can cause harmful emissions, significantly degrading local air quality. The combustion process can generate up to 210 different types of dioxins and furans, which may disperse into the

environment [29]. Studies have shown that dioxin and furan concentrations near municipal solid waste (MSW) incinerators, traffic tunnels, and waste dumping sites can be up to 40 times higher than the average levels recorded in Gothenburg, Sweden [31].

### 3.2.2 Soil and Water Contamination

The disposal of incineration ash in landfills poses significant environmental risks, particularly through soil and water contamination. Toxic compounds from ash can leach into surrounding ecosystems, further exacerbating pollution concerns [13].

Effective waste segregation and recycling measures can help reduce the heavy metal content in incineration ash from large-scale waste processing facilities [13]. Additionally, the stabilisation and solidification of ash—a widely adopted practice in European countries—provides a safer disposal method by minimising the leaching of hazardous substances [49].





### 3.2.3. Regulatory Framework

According to CPCB, treated flue gas from household waste incinerators must contain dioxins and furans at concentrations no higher than  $0.1 \text{ ng TEQ/Nm}^3$  [40]. The same emission standards apply to biomedical waste incineration. The CPCB also recommends a minimum temperature of  $800 \pm 50^\circ\text{C}$  for the first combustion chamber and  $1050 \pm 50^\circ\text{C}$  for the secondary chamber to ensure effective waste breakdown and emissions control [40].

The United States Environmental Protection Agency (USEPA) prescribes higher incineration temperatures for solid waste, ranging from  $871^\circ\text{C}$  ( $1600^\circ\text{F}$ ) to  $1371^\circ\text{C}$  ( $2500^\circ\text{F}$ ), with an exposure time of 30 to 90 minutes. For liquid and gaseous waste, the exposure time should be at least 2 seconds to ensure complete combustion [41].

Regarding ash disposal, the Government of India mandates that if incineration ash contains toxic metals exceeding the limits set under the Hazardous Waste (Management, Handling, and Transboundary Movement) Rules, 2008, it must be disposed of at an authorised hazardous waste storage and disposal facility [42]. However, it remains unclear whether these regulations are consistently followed in schools and colleges where small-scale incinerators have been installed.

Biomedical and hazardous waste incineration is a significant source of air pollution, contributing approximately 64% of total dioxin and furan emissions [43]. In recent years, emission standards have improved, with dioxins and furans now being regulated in alignment with European standards.



**Biomedical and hazardous waste incineration contributes 64% of total dioxin and furan emissions**

# 04.

# METHODOLOGY

## 4.1 Sample Collection

Initially, we planned to collect ash and flue gas samples from incinerators installed in government schools. However, due to challenges in obtaining these samples, our team contacted a Jaipur-based company that supplies incinerators to government schools in Rajasthan. To ensure consistency with the installations in schools, we procured an incinerator similar to the ones used in Rajasthan schools.

The incinerator measured 270 × 510 × 230 mm, weighed approximately 15 kg, and featured a temperature control knob with a range of 0 to 300°C. For this study, we operated the incinerator at its maximum temperature of 300°C, which is significantly lower than the minimum temperature of 800°C required for the complete combustion of waste [40]. Given this discrepancy, analysing emissions and ash samples for toxic substances was imperative.

To facilitate dioxin testing, a steel pipe was welded to the incinerator's exhaust pipe, allowing secure attachment of the glass equipment used for sampling. The incinerator was thoroughly cleaned with acetone before use to eliminate any foreign contaminants that could interfere with the results.

### 4.1.1 Selection of Sanitary Napkin Samples

Samples from three different brands were selected for incineration:

- Non-sterilised Cotton purchased online (Sample 1)
- Branded Anti-Bacterial XL Pads (Sample 2)
- Branded 100% Cotton Extra Large sanitary napkin (Sample 3)

Findings from our 2022 research report, *Wrapped in Secrecy: Toxic Chemicals in Menstrual Products* [6], indicated that these napkins contain phthalates, with Sample 2 showing high concentrations of multiple phthalates and Sample 3 containing elevated levels of DIDP, DINP, and DEHP.

### 4.1.2 Sample Categorisation

The collected ash samples were categorised as follows:

- **Sample Control (1):** Ash from incinerated cotton obtained online
- **Sample 2:** Ash from incinerated anti-bacterial sanitary napkin
- **Sample 3:** Ash from incinerated 100% cotton extra large sanitary napkin

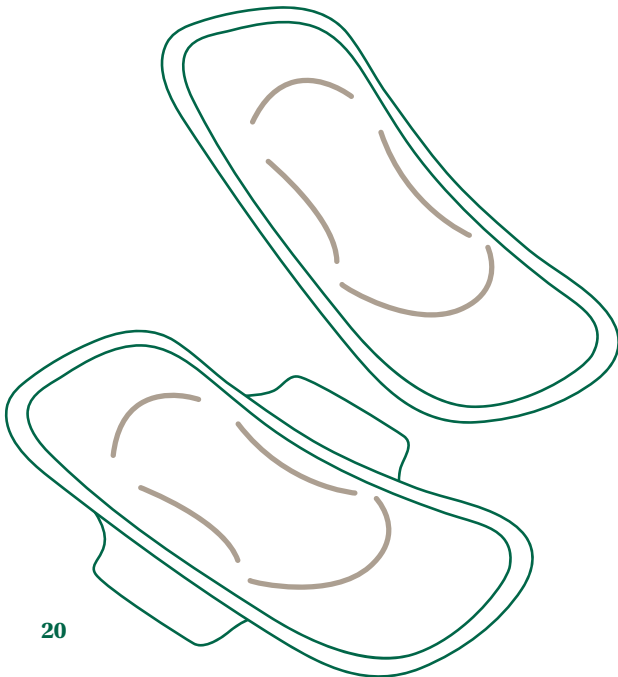
### 4.1.3 Incineration

All samples were burned in the incinerator, and the resulting ash was collected in glass bottles. The smoke and gases released during burning were collected using a Dioxin and Furan testing kit from Thermo Environmental Instruments. The kit included:

- A metal box with a thimble filter to capture solid particles.
- A glass bottle with XAD (a chemical absorbent) to trap gases.

The incinerator's maximum setting was 300°C, which is nearly three times lower than the recommended temperature for safe waste burning [7]. However, when burning sanitary napkins and cotton, the heat released by the materials caused the temperature inside the exhaust pipe to exceed 700°C. Without any waste inside, the incinerator barely reached 300°C.

Unlike government-recommended incinerators, which have two separate chambers for efficient burning, this incinerator had only one chamber.



## 4.2 Analytical Techniques

### a. Dioxin and Furan Analysis

Dioxins and furans were collected using a dioxin and furan testing kit and analysed by a NABL-accredited food and pharma testing laboratory, following USEPA Method 23A.

- Sampling: An Isokinetic Source Sampling Kit was used to collect emissions, with XAD-2 resin capturing dioxins and furans.
- Temperature Control: The probe and filter were kept at 120°C, while flue gas was cooled to below 200°C before passing through the XAD-2 resin. Moisture was removed using silica gel.
- Sample Collection & Cleaning: The equipment were thoroughly rinsed with acetone, toluene, and hexane, and all washing was combined into one container.
- Sample Storage: The extract was concentrated to 5 mL and sent to the lab for analysis.
- Sampling Volume & Duration: At least 5,000 litres of flue gas were collected in 300-400 minutes, ensuring accurate detection.

### b. Ash Analysis

- Ash samples from incinerated sanitary napkins and cotton were analysed at a NABL-accredited food and pharma testing laboratory for phthalates and heavy metals (Cadmium, Chromium, Mercury, and Lead) using Gas Chromatography-Mass Spectrometry (GC-MS).

# 05. RESULTS

The incineration of cotton (Sample 1, control) and two sanitary napkin brands (Sample 2, Sample 3) at 300°C resulted in different levels of phthalates in the ash.

## 5.1 Phthalate Concentrations

- Sample 1 (Cotton – Control): The highest total phthalate concentration (9.192 mg/kg).
  - Di-n-octyl phthalate (5.36 mg/kg) and Bis-(2-ethyl-hexyl) phthalate (2.41 mg/kg) were the most abundant (See Table 1 for details).
  - Other detectable phthalates: Diethyl phthalate (0.843 mg/kg) and Dibutyl phthalate (0.525 mg/kg).
- Sample 2: Total phthalates: 8.675 mg/kg.
  - Diethyl phthalate (8.11 mg/kg) was the dominant compound detected.
  - Dibutyl phthalate (0.431 mg/kg) and Bis-(2-ethyl-hexyl) phthalate (0.134 mg/kg) were also present.
- Sample 3: The lowest total phthalate concentration (0.489 mg/kg).
  - Diethyl phthalate (0.173 mg/kg),

Dibutyl phthalate (0.103 mg/kg), and Bis-(2-ethyl-hexyl) phthalate (0.213 mg/kg) were detected.



| S No. | Test Parameters                      | Units of Measurement | Results        |                |                |
|-------|--------------------------------------|----------------------|----------------|----------------|----------------|
|       |                                      |                      | Sample 1       | Sample 2       | Sample 3       |
| 1     | Dimethyl Phthalate (DMP)             | mg/kg                | 0.014          | BLQ (LOQ-0.01) | BLQ (LOQ-0.01) |
| 2     | Diethyl Phthalate (DEP)              | mg/kg                | 0.843          | 8.11           | 0.173          |
| 3     | Dibutyl Phthalate (DBP)              | mg/kg                | 0.525          | 0.431          | 0.103          |
| 4     | Benzyl-Butyl Phthalate (BBP)         | mg/kg                | BLQ (LOQ-0.01) | BLQ (LOQ-0.01) | BLQ (LOQ-0.05) |
| 5     | Bis-(2-ethyl-hexyl) Phthalate (DEHP) | mg/kg                | 2.41           | 0.134          | 0.213          |
| 6     | Di-n-octyl Phthalate (DnOP)          | mg/kg                | 5.36           | BLQ (LOQ-0.01) | BLQ (LOQ-0.05) |
| 7     | Bis-Isodecyl phthalate (DIDP)        | mg/kg                | BLQ (LOQ-0.05) | BLQ (LOQ-0.05) | BLQ (LOQ-0.05) |
| 8     | Dicyclohexyl phthalate (DCHP)        | mg/kg                | BLQ (LOQ-0.01) | BLQ (LOQ-0.01) | BLQ (LOQ-0.01) |
| 9     | Di-Isononyl Phthalate (DINP)         | mg/kg                | BLQ (LOQ-0.05) | BLQ (LOQ-0.05) | BLQ (LOQ-0.05) |

**Table 1: Concentrations of different phthalates in the ash obtained from all 3 samples used in the study. BLQ is Below the Limit of Quantification and LOQ is Limit of Quantification**

### Findings

- Cotton Sample 1 retained the highest phthalate levels, followed by Sample 2, while Sample 3 had significantly lower levels.
- Di-n-octyl phthalate was only found in Sample 1, and its concentration was 18 times higher than in Sample 2 and 11 times higher than in Sample 3.
- Overall, Sample 2 was found to contain the highest concentration (8.11 mg/kg) of a single phthalate (DEP).

## 5.2 Heavy Metal Concentrations

- **Lead:** Highest in Sample 1 (5.97 mg/kg) and Sample 3 (5.94 mg/kg), while Sample 2 had significantly lower levels (0.02 mg/kg).
- **Cadmium:** Sample 2 had the highest content (0.14 mg/kg), while Samples 1 and 3 were BLQ (see Table 2).
- **Chromium:** Sample 2 had the highest concentration (0.12 mg/kg), followed by Sample 3 (0.05 mg/kg) and Sample 1 (0.01 mg/kg).
- **Mercury:** BLQ in all samples.

| S No. | Test Parameters | Units of Measurement | Results        |                |                |
|-------|-----------------|----------------------|----------------|----------------|----------------|
|       |                 |                      | Sample 1       | Sample 2       | Sample 3       |
| 1     | Lead            | mg/kg                | 5.97           | 0.02           | 5.94           |
| 2     | Cadmium         | mg/kg                | BLQ (LOQ-0.05) | 0.14           | BLQ (LOQ-0.05) |
| 3     | Chromium        | mg/kg                | 0.01           | 0.12           | 0.05           |
| 4     | Mercury         | mg/kg                | BLQ (LOQ-0.05) | BLQ (LOQ-0.05) | BLQ (LOQ-0.05) |

**Table 2: Concentrations of heavy metals in the 3 ash samples**

### Observations and Implications

- Phthalates remained in the ash post-incineration, with higher concentrations in Samples 1 and 2 than in Sample 3.
- Sample 3 had the lowest phthalate content, likely due to differences in material composition.
- Lead levels were high in Samples 1 and 3, raising concerns about disposal and environmental contamination.
- Chromium was found in relatively lower concentrations in all 3 samples, highest being in Sample 2 while the lowest being Sample 1.
- Low-temperature incineration (~300°C) may not fully degrade hazardous compounds, allowing phthalates and heavy metals to persist in the ash.
- Further analysis of flue gas emissions is needed to detect the presence of airborne pollutants.

Sample 1 had three compounds above 1 ppm, whereas Samples 2 and 3 each had only one. Compounds below the limit of quantification (BLQ) were marked as 0.

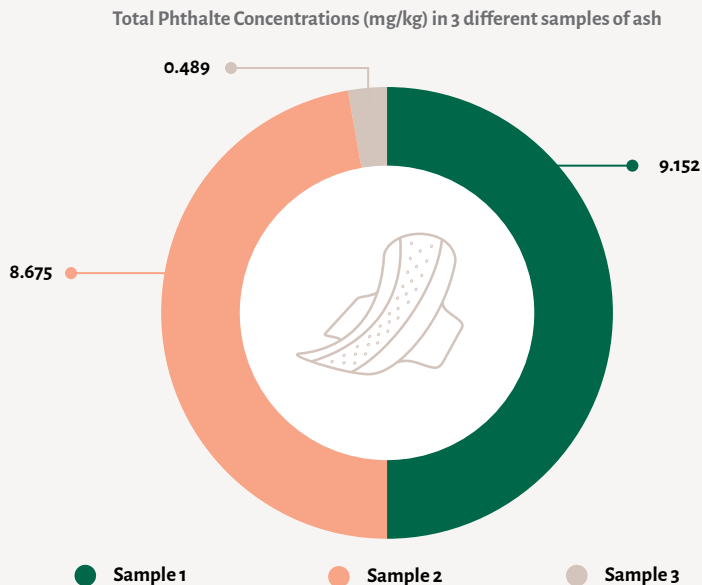
## 5.3 Dioxin and Furan Concentrations in Flue Gas

Dioxins and furans were detected in the flue gas from all three samples, with a consistent concentration of 0.0003 ng TEQ/Nm<sup>3</sup>. This value is well within the CPCB limit of 0.1 ng TEQ/Nm<sup>3</sup>. Notably, the incinerator lacked an emission control system.



# 06. DISCUSSION

The analysis of ash and flue gas samples highlights the environmental and health risks of using small-scale incinerators for sanitary waste disposal. All ash samples contained heavy metals and phthalates at concentrations that could pose risks to human health and the environment. Notably, although Sample 3 claimed to be phthalate-free, its incineration residue still contained detectable phthalates—albeit at much lower levels than the other samples.



**Figure 5:** The pie chart shows total phthalate concentrations in 3 different samples of ash generated after incineration

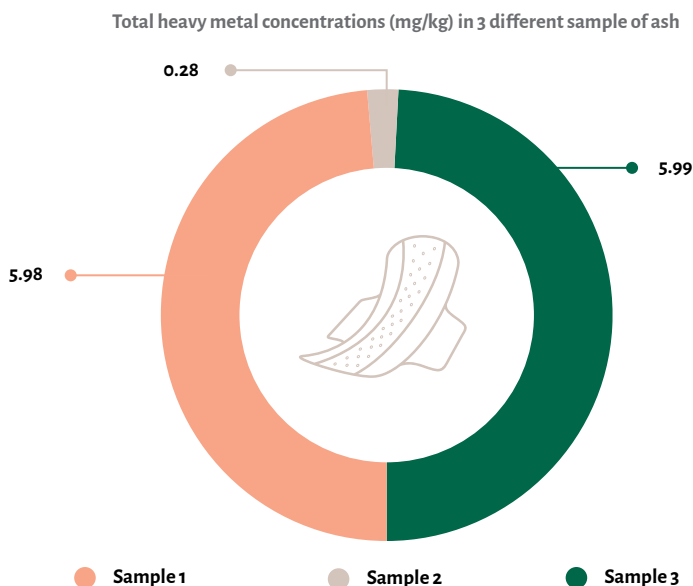
The total phthalate concentrations (see Figure 5) in Samples 1 and 2 exceeded thresholds associated with reproductive toxicity,

developmental effects, and liver and thyroid impacts [44]. This is particularly concerning in poorly ventilated settings where incineration is

performed frequently, potentially leading to human exposure to hazardous compounds.

The data also revealed differences in metal retention between samples. Lead (Pb) levels were highest in Samples 1 and 3, whereas Sample 2 had significantly lower concentrations. Cadmium (Cd) was detected only in Sample 2, while Chromium (Cr) was present in all samples, peaking in Sample 2. Mercury (Hg) was below the limit of quantification in all cases.

Total heavy metal concentrations in all 3 samples are shown in Figure 6. It is interesting to see that the heavy metal concentration is the lowest in Sample 2 which has shown to contain a high total phthalate concentration. These findings suggest that the composition of sanitary napkins vary from one brand to the other, affecting the toxicity of incineration residues and emphasising the need for safer waste disposal methods.



**Figure 6:** The pie chart shows heavy metals concentrations in 3 samples of ash

Regarding dioxins and furans, emissions across all samples were within CPCB's permissible limit ( $0.1 \text{ ng TEQ/Nm}^3$ ). However, since these results are based on limited sampling, the long-term impact remains uncertain. Daily incineration without an emission control system may result in the gradual accumulation of dioxins and furans in the environment, increasing the risk of chronic exposure through contaminated dust inhalation.

Overall, this study underscores the potential hazards of small-scale sanitary napkin incineration, particularly at  $300^\circ\text{C}$ . The findings raise concerns about phthalate and heavy metal retention in ash, brand-based material differences, and the risks of incomplete combustion, reinforcing the need for improved waste management practices.

## 6.1 Phthalates in Incineration Ash

As discussed in Section 2.3, phthalates are widely used as plasticisers in plastic products, and their persistence in ash after incineration indicates incomplete decomposition at 300°C. Notably, the control sample (Sample 1, cotton) exhibited the highest total phthalate concentration (9.192 mg/kg), with Di-n-octyl phthalate (5.36 mg/kg) and Bis-(2-ethyl-hexyl) phthalate (2.41 mg/kg) as the dominant compounds. This suggests that even materials considered “natural”, such as cotton, may contain phthalates from processing, packaging, or contamination.

Among the sanitary napkin samples, Sample 2 had a significantly higher total phthalate concentration (8.675 mg/kg) than Sample 3 (0.489 mg/kg). The dominant compound in Sample 2 was Diethyl phthalate (8.11 mg/kg), which was almost entirely absent in Sample 1 and found in very low amounts in Sample 3. These findings suggest variability in sanitary napkin formulations, with some brands incorporating higher phthalate content in adhesives, absorbent layers, or plastic coverings.

Conversely, Sample 3 exhibited the lowest total phthalate concentration, indicating potential differences in material composition or manufacturing processes. The lower phthalate levels in Sample 3 suggest that this brand may be using alternative plasticisers or reduced phthalate content, making it a potentially safer option in terms of chemical emissions from incineration.

Interestingly, Di-n-octyl phthalate was detected only in Sample 1 and was below the limit of quantification (BLQ) in both

sanitary napkin samples. This suggests that this specific phthalate may be less commonly used in synthetic absorbent materials and more prevalent in treated cotton or packaging materials.

## 6.2 Heavy Metals in Incineration Ash

Heavy metal concentrations in the ash varied significantly across the three samples, with elevated lead (Pb) levels detected in Sample 1 (5.97 mg/kg) and Sample 3 (5.94 mg/kg), while Sample 2 had significantly lower lead content (0.02 mg/kg). This suggests that the materials used in sanitary napkin production may influence the presence of heavy metals in the ash.

Cadmium (Cd) was detected only in Sample 2 (0.14 mg/kg), while in Samples 1 and 3 it was below the limit of quantification (BLQ). Chromium (Cr) was present in all three samples but was highest in Sample 2 (0.12 mg/kg). The presence of cadmium and chromium suggests that some sanitary napkins contain trace metals, possibly from dyes, adhesives, or chemical treatments used during manufacturing. The elevated levels in Sample 2 highlight the potential for brand-specific variations in heavy metal contamination.

Mercury (Hg) was below the limit of quantification in all three samples. This indicates that mercury is not a significant contaminant in sanitary napkin incineration within the detectable limits of this study.

## 6.3 Dioxins and Furans

The presence of dioxins and furans in the flue gas indicates that low-temperature incineration (~300°C) facilitates the formation of these

toxic compounds. Although the measured concentrations remained within CPCB's permissible limits (0.1 ng TEQ/Nm<sup>3</sup>), it is important to note that even small amounts of dioxins and furans can pose long-term health risks through continuous exposure. These persistent organic pollutants (POPs) bioaccumulate in the environment and human tissues, potentially leading to adverse health effects over time [34].

To mitigate the risks associated with dioxin and furan emissions, higher incineration temperatures and improved combustion control may be necessary. Further studies should evaluate long-term exposure risks and assess whether emission control measures, such as gas filtration systems or alternative disposal technologies, could further reduce dioxin and furan emissions.

## 6.4 Potential Health and Environmental Risks

The persistence of phthalates and heavy metals in incineration ash raises significant concerns regarding the disposal and management of incinerator residues. Small-scale incinerators, particularly those operating at relatively low temperatures (~300°C), may not fully degrade complex organic compounds, resulting in hazardous residues. Several key risks can be identified, including:

### 6.4.1. Toxic Ash Disposal

- The presence of phthalates and heavy metals in ash suggests that direct disposal into soil or water bodies may lead to environmental contamination.

- Phthalates are known endocrine disruptors [45], while heavy metals such as lead (Pb) and cadmium (Cd) are highly toxic to human health and ecosystems when they leach into soil, air, and water [39].
- In the absence of advanced treatment methods [39], ash from small-scale or industrial-scale incinerators may continue to release toxic compounds into the environment over time.

### 6.4.2. Incomplete Combustion of Organic Compounds

- The variation in phthalate retention among the samples indicates that some compounds, which are below the optimal incineration range for complete organic degradation, may not fully decompose at lower temperatures.
- Industrial incinerators typically operate at 850–1100°C [7] to ensure the complete breakdown of toxic chemicals, while small-scale units may leave behind partially degraded hazardous compounds.

### 6.4.3. Airborne Pollutant Formation

- While this study focused on ash composition, it is important to note that phthalates and heavy metals [39] can volatilise during combustion, potentially forming toxic fumes.
- The formation of dioxins and furans—highly toxic persistent organic pollutants (POPs)—is a known risk during the incineration of sanitary napkins [7].
- The presence of lead in ash also raises concerns about airborne exposure if incineration residues are not effectively managed.

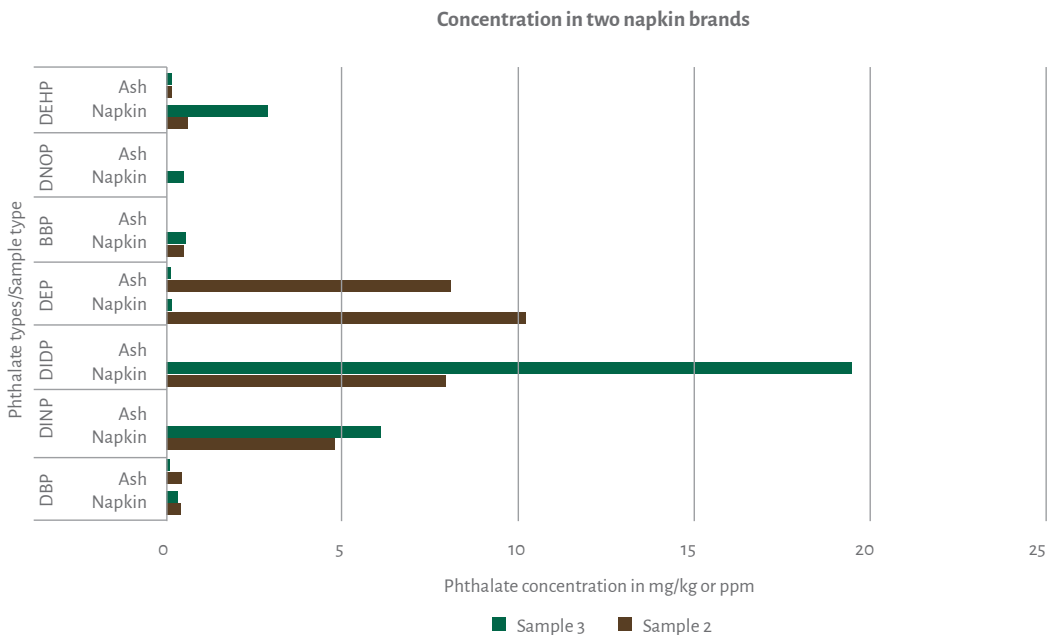
#### 6.4.4. Brand-Specific Variability

- The significant differences in phthalate and heavy metal concentrations between Sample 2 and 3 suggest that not all sanitary napkins pose the same risk when incinerated.
- Some brands may use materials with higher phthalate or heavy metal content, while others may contain fewer hazardous substances.
- This variability highlights the importance of regulatory oversight and greater material transparency to ensure safer disposal methods.



## 6.5 Comparison with Literature

- The presence of Diethyl phthalate as the dominant phthalate in Sample 2 aligns with findings from previous research indicating its common use in plastics and cosmetics [45]. Additionally, studies on incineration residues from plastic-containing materials suggest that phthalates tend to persist in bottom and fly ash of waste incinerators [15], supporting the observed results.
- Previous research [39] has also documented heavy metal contamination in the ash of waste incinerators, reinforcing the need for proper ash disposal strategies. The variability in heavy metal content across different brands further supports the idea that raw material selection significantly impacts post-incineration toxicity.
- Dioxins and furans were detected in the flue gas of all the three samples. Dioxins and furans are generated during incineration of plastic and chlorinated compounds such as those found in sanitary napkins at temperatures between 200-800 °C [7].
- When we compare the results of this study with an earlier report by Toxics Link, we can see that incineration helps reduce the concentrations of phthalates in almost all cases (see Figure 7). The figure below shows an interesting comparison of phthalate levels before and after incineration for the two brands of sanitary napkins we tested (Sample 2 and 3).



**Figure 7: The bar graph shows impact of incineration on phthalate concentrations in sanitary napkins of two different brands**

It's important to understand that when the value is shown as 0, it doesn't mean the chemical is completely missing from the product. It could also mean that the testing method used couldn't detect it. Phthalates might still be present in trace amounts.

Prior research [39] has also documented the presence of heavy metal contamination in incineration ash, emphasising the necessity for proper disposal strategies. The observed variability in heavy metal content across different brands further underscores the influence of raw material selection on post-incineration toxicity.

Dioxins and furans were detected in the flue gas of all three samples. These compounds are typically generated during the incineration of plastic and chlorinated compounds, such as

those found in sanitary napkins, at temperatures ranging between 200–800°C [7].

### Key Findings

- **Toxic Residues:** Incineration at low temperatures leads to the retention of phthalates and heavy metals in bottom ash, posing potential long-term environmental and health hazards.
- **Product Variability:** Differences in the composition of sanitary napkins across brands suggest inconsistent levels of hazardous content.
- **Airborne Pollutants:** Dioxins and furans were detected in flue gases from all samples. Although within regulatory limits, their ability to bioaccumulate presents significant long-term health concerns.

- **Waste Management Challenges:** Improper disposal of incineration ash and release of airborne contaminants can contribute to widespread environmental pollution.

## 6.6 Recommendations for Safer Disposal Practices

Based on the findings of this study, several measures can be recommended to mitigate the health and environmental risks associated with small-scale sanitary napkin incineration:

- **Increasing Incineration Temperature**  
Raising the combustion temperature above 850°C [7][38] would facilitate the more complete degradation of toxic compounds and minimise the formation of hazardous residues. This can be achieved by using biomedical/hazardous waste incinerators where the emission control system will further reduce the exposure to harmful compounds.
- **Improving Incinerator Design**
  - Small-scale incinerators could incorporate filtration systems to capture airborne toxins and limit dioxin emissions.
  - An outlet pipe should be installed up to a certain height to safely vent flue gases, preventing the accumulation of toxic compounds in confined spaces and reducing human exposure. This is particularly important in case the incinerator has been installed within a toilet.

- **Safely Disposing Ash**

- Ash should not be directly released into the environment.
- It should be collected and treated as hazardous waste if phthalate or heavy metal concentrations exceed regulatory thresholds.

- **Encouraging Safer Product Alternatives**

- The variation in hazardous substance content among different sanitary napkin brands suggests that some products pose a lower risk than others. Encouraging manufacturers to reduce the phthalate and heavy metal content in hygiene products would contribute to safer disposal outcomes.
- Safer alternatives such as napkins made from biodegradable/ compostable raw materials should be encouraged instead of using plastics to further simplify the disposal mechanisms.
- Producers should try to recycle materials from the soiled napkins to minimise the waste entering the landfills. As of now, producer, importers, and brand owners are supposed to recycle any packaging made of plastic, paper or glass as part of their extended producer responsibility (EPR) [48]. The EPR should also be extended to recycle materials extractable from soiled napkins.

### ➤ **Further Research & Monitoring**

- While this study tested the ash and flue gas samples on a limited number of parameters, a comprehensive examination of gaseous emissions is necessary to fully assess the environmental impact of incineration.
- Random testing should be conducted at different sites to ensure compliance with the emission norms.

### ➤ **Policy Recommendations**

- Regulatory frameworks and monitoring practices for sanitary waste disposal should be strengthened.
- Clear guidelines for manufacturers to ensure the production of safer hygiene products should be established.

### ➤ **Public Awareness Initiatives**

- Communities should be educated on the risks associated with improper sanitary waste disposal.
- Waste segregation at the source should be promoted to prevent sanitary waste from reaching landfills.

## 6.7 Future possibilities through sustainable alternatives

Several researches have explored various eco-friendly alternatives to conventional sanitary napkins. Biodegradable sanitary napkins made from agricultural and plant-based fibres present a safer alternative to synthetic and non-biodegradable materials [46]. Studies indicate that biodegradable pads

manufactured using banana pseudo-stem waste, organic cotton, muslin, and canvas fabrics are more environmentally sustainable and cost-effective compared to synthetic options [46]. Additionally, biodegradable materials such as corn starch have been successfully incorporated into the bottom layer of sanitary pads as a leak-proof component [47].

Natural substances with antimicrobial properties have also been tested for inclusion in the top layer of sanitary pads, where direct dermal contact occurs [47]. The utilisation of invasive plant species, such as water hyacinth, for sanitary napkin production presents an innovative approach that simultaneously addresses environmental sustainability and waste management challenges [48]. These advancements highlight the potential for transitioning towards safer and more eco-conscious menstrual hygiene products.

To maximise the benefits of these innovations, biodegradable sanitary napkins should be made widely accessible, and awareness campaigns should be conducted to educate consumers on their environmental and health advantages over conventional plastic-based products.

## 6.8 Limitations of This Study

Several challenges were encountered during the execution of this study.

One of the primary challenges was obtaining samples directly from government schools where sanitary napkin incinerators were installed. Consequently, fresh sanitary napkins were used instead of real-world waste, increasing project costs and limiting representativeness.

Another significant limitation was the high cost of dioxin and furan testing. These analyses are expensive, and only a few laboratories offer them. Due to financial constraints, a limited number of samples were analysed, restricting the dataset's comprehensiveness.

Additionally, technical challenges with the incinerator affected the study. Frequent thermostat malfunctions led to interruptions in sampling, necessitating its removal to ensure the incinerator's continuous operation. Also, the incinerator's maximum setting was 300°C, which is nearly three times lower than the recommended temperature for safe waste burning [7]. However, when burning sanitary napkins and cotton, the heat released by the materials caused the temperature inside the exhaust pipe to exceed 700°C. Without any waste inside, the incinerator barely reached 300°C. It should also be noted that unlike government-recommended incinerators, which have two

separate chambers for efficient burning, this incinerator had only one chamber.

These constraints impacted data collection and also contributed to project delay. Furthermore, the cotton sample (control) was labelled "not sterilised", but no prior testing was conducted to confirm the presence or absence of phthalates before incineration. It may be noted here that the sanitary napkins used for this study were earlier tested for the presence of phthalates before incineration during our previous study in 2022, but the cotton sample used in this study was not tested prior to incineration. This could have had an impact on the results.

Future studies should address these limitations by employing alternative sampling strategies, securing sufficient funding, ensuring access to real-world waste, and utilising reliable incineration equipment to enhance the robustness of results.



# 07.

# CONCLUSION AND KEY RECOMMENDATIONS

This study underscores the serious environmental and health risks posed by the use of small-scale sanitary napkin incinerators, especially when operated at suboptimal temperatures. It also draws attention to variations in product composition across brands, indicating that some sanitary products may carry greater risks than others. To mitigate these impacts, the following urgent and collaborative actions are required from manufacturers, policymakers, and waste management stakeholders:



## Technological Improvements

- Upgrading incinerators to reach recommended combustion temperatures.
- Integrating emission control technologies to minimise toxic release.



## Policy and Industry Action

- Mandating manufacturers to clearly label and disclose ingredients if any that may pose risks to human health, enabling consumers to make informed choices about their use.
- Identifying, recommending and promoting safer and more sustainable technologies for sanitary waste disposal to minimise risks to both public health and the environment.
- Encouraging production and adoption of biodegradable and eco-friendly menstrual products, eventually making those affordable and accessible to all.

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