



# Single-use menstrual products and their alternatives

Recommendations from  
Life Cycle Assessments

# Acknowledgements

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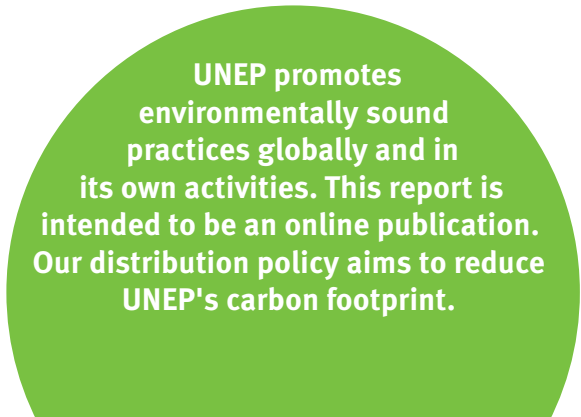
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# Executive Summary

**Single-use menstrual products such as tampons and pads are a significant contributor globally to single-use plastic waste. They can contain up to 90% plastic and are often individually wrapped.** In recent decades, use of single-use menstrual products continues to rise, especially in developed countries. While it is difficult to quantify their global use, **some 49 billion and 19 billion single-use menstrual products are consumed each year** in the EU and USA, respectively.

The varied composition of single-use menstrual products, together with the presence of organic matter after use, makes their recycling technically and economically expensive. As a result, **the vast majority of these products are landfilled or incinerated.** In Europe and in the USA approximately 87% and 80% respectively ends up in landfills where the plastic components **can take up to 500 years to break down, potentially releasing toxic chemicals into the environment as they degrade and generating microplastics that threaten the health of ecosystems.** In addition, single-use menstrual products are at times disposed of carelessly and incorrectly, for example, flushed down the toilet. Hence, they block sewers, cause flooding, and pollute freshwater and marine environments. Not surprisingly, **single-use menstrual products are one of the most frequently collected items in beach clean-ups in the UK**, with an average of 5 pieces of menstrual products waste picked up every 100 m on UK beaches.

All of this makes for a pressing need to consider alternatives to single-use menstrual products such as reusable menstrual cups, reusable pads and period underwear. **Taboos around the topic of menstruation have made it difficult to discuss more sustainable ways for women\* to manage their menstruation** to date, but this has started to shift. “Period poverty”<sup>1</sup> and the right of women to have access to safe and dignified ways to manage their menstruation is becoming an increasingly prominent political – and policy – matter.

To take advantage of this shifting discourse and aid policy makers tasked with regulating single-use menstrual products and their alternatives, this report sets out to summarise current knowledge about the relative environmental performance of such products. It is a meta-analysis of four Life Cycle Assessment (LCA) studies that compare different types of single-use menstrual products; as well as single-use and reusable menstrual products. These studies and their key findings are summarised in the *table at the end of the executive summary.*

Because there are few LCA studies on reusable pads and period underwear, this report also draws comparisons with the wider literature on baby nappies and adult incontinence products, as these are made of very similar materials with the same absorbent function in mind (both the single-use and the reusable alternatives).

LCA is a well-established tool for assessing the potential environmental impacts associated with a product or service. By taking a life cycle approach, it is possible to make recommendations for entire systems, and not just their single parts, minimizing the risk of taking decisions that fix one problem but cause other unexpected impacts.

This meta-analysis highlights that in all circumstances, **reusable menstrual products have substantially lower environmental impacts than commonly available single-use options.** The **menstrual cup**, in particular, **has consistently lower impacts** than the other product options, both single-use and reusable, making it a clear choice for consumers and policy makers. In one study, a locally made reusable pad was found to be competitive with the reusable menstrual cup in a developing country context due mostly to the fact that raw materials were locally sourced and packaging and transport requirements were reduced.



In Europe and the USA **over 80%** of menstrual products end up in landfills where the plastic components can take **up to 500 years** to break down.

<sup>1</sup> ‘Period poverty’ is an expression used to define the inability to access menstrual products or to achieve adequate menstrual hygiene due to poor knowledge of menstruation or social and financial constraints. Two prominent groups that face period poverty are students and homeless women and girls.

**\*UNEP recognises the importance that language be inclusive. While this report generally uses the term ‘woman’, it is both inclusive of all people who menstruate who do not identify as women – namely some transgender and non-binary persons and others with diverse gendered identities and experiences – and all who do identify as women.**

#### Other important findings from this analysis include:

- **Consumer behaviour is a key determinant of environmental impacts for both single-use menstrual products and reusable products** although consumers have far more leverage over their impacts with reusable products.
- **The use phase of the menstrual cup and specifically how it is washed and sterilised, constitutes its most significant environmental impacts.**
- For **single-use products, the environmental impacts lie mainly** in the production of materials used in tampon and pad manufacture and in the waste-disposal practices of the user and the municipality.
- Drawing on the similarity with reusable nappies, it is expected that **reusable pads and period underwear washed in an energy-efficient manner will have lower environmental impacts** than their single-use alternatives<sup>2</sup>.
- When comparing **the two most widely used single-use products – tampons and pads** – they were found to **have similar environmental impacts**, with consumer behaviour being as much of an impact driver (number of products utilized, hand-washing, and disposal behaviour), as the particular product features.

## CRITICAL PARAMETERS INFLUENCING THE ENVIRONMENTAL IMPACTS OF SINGLE-USE MENSTRUAL PRODUCTS AND THEIR ALTERNATIVES

LCA is able to provide a structured framework within which to model the environmental impacts of single-use menstrual products and their alternatives on the natural environment and society, however there are several parameters that should be considered when conducting and interpreting these studies. In the context of this analysis, we highlight the following:

**Material type and weight:** Material production (extraction and processing of raw materials) is consistently the largest contributor to the impacts of single-use products<sup>3</sup>. Consequently, further light weighting coupled with optimised material production and selection could further reduce the impacts of single-use products.

**Geographical context:** The environmental impacts of menstrual products depend on the specific context. Notably, whether or not a product is locally manufactured can significantly affect its environmental profile. This is due to the fact that raw materials may be sourced locally and packaging and transportation requirements reduced. Consumer behaviour is also strongly influenced by context and prevailing **social norms and attitudes** including attitudes to responsible disposal. Different social norms also strongly affect the acceptability of the different options available to women, especially tampons and menstrual cups.

**Affordability and social acceptability:** Cultural taboos and social norms, along with affordability and availability, are deciding factors when determining the products women choose to manage their menstruation. While quantification of these factors might not be possible within the scope of an LCA, these factors are too important not to be considered in any recommendation on menstrual products.

**Behaviour of consumers:** How a product is used can strongly alter its environmental impacts. This is true of both single-use and reusable menstrual products. For reusable products, the **frequency and manner** in which **they are washed and sterilised** strongly affects their environmental impacts. For reusable pads, whether they are washed by hand or in a washing machine, and the temperature of the wash is important. Whilst for menstrual cups, sterilising by pouring over water boiled in a kettle, or placing a lid on the pot if sterilising by boiling in water on a stove, can significantly reduce energy use and associated impacts. **The use phase is important, not only for reusable products, but also for single-use products.** The use of additional materials (such as toilet paper or plastic bags for wrapping single-use products prior to disposal) contribute significantly to overall life cycle impacts. Hand washing habits, such as the temperature of the water, the amount of water used (i.e., not keeping the tap running) and the type and amount of soap used, also influence environmental impacts. The potential for improved education and consumer guidance around the use of menstrual products to reduce their impacts should therefore be promoted.

<sup>2</sup> This conclusion is drawn from the LCA meta-analysis on nappies. UNEP (2021) *Single-use nappies and their alternatives: Recommendations from Life Cycle Assessments*. Available at: <https://www.lifecycleinitiative.org/library/single-use-nappies-and-their-alternatives/>

<sup>3</sup> Material production (or production of materials) includes extraction and processing of all raw materials (usually up to factory gate). Material production is not the same as manufacturing the products. Manufacturing is usually reported as a separate life cycle stage and contributes a relatively small share of the life cycle impacts.

## EXECUTIVE SUMMARY

**Functional equivalence:** The menstrual products studied are comparable in terms of function and size (within product groups). However, they are less consistent in terms of other aspects related to their use, such as infrastructure requirements (access to running water) and acceptability of use. The functional equivalence of products with and without applicators is not discussed and might be relevant to consumers particularly when considering different single-use and reusable products.

**Choice of environmental impact indicators:** LCA can be limited in terms of the environmental indicators included in the impact assessment methods.

For example, the LCA studies included in this analysis do not quantify the potential health impacts of these products, although other studies have found that both tampons and pads contain chemicals identified as carcinogens, neurotoxins, hormone disruptors and reproductive toxicants. Impacts arising from chemicals in products are generally underestimated in LCA studies due to gaps in data on the identity and quantities of chemicals used, as well as gaps in the ability of LCA models to describe the effects arising from the toxicity of these chemicals when they get into the environment. Another aspect not covered by LCA studies is the impact on marine litter of inappropriately disposed single-use menstrual products.

## RECOMMENDATIONS FOR POLICY MAKERS

Menstrual protection as a human rights issue is climbing the global agenda and consumer awareness and concern over the environmental impacts of single-use menstrual products is growing. Policy makers have a duty to act decisively, drawing on best practices to reduce plastic pollution and minimise environmental impacts while also protecting the health, safety and dignity of their citizens.

With an increasing number of governments supplying and/or subsidising menstrual products to those that cannot afford them, it is important that **public procurement of menstrual products be subject to sustainability criteria**, with governments opting for the **least environmentally detrimental option (informed by life cycle thinking) within the social and economic constraints of their context**.

This meta-analysis serves to highlight important environmental information on single-use menstrual products and their alternatives that policy makers should consider when developing policies that are gender-responsive, context specific and locally relevant. It seeks in particular to raise the awareness of **policy makers on the differences in environmental impacts between and within product categories** and the reasons for these differences (including habits, packaging, manufacturing location). The table below plots the results of the LCA studies reviewed in this meta-analysis into an easy-to-read matrix that takes a snapshot of the relative preference for the different menstrual products, based on geographical, technological, and behavioural contexts. It is a snapshot of what the LCA studies currently tell us under the various scenarios.



The menstrual cup, in particular, has consistently lower impacts than the other product options, both single-use and reusable, making it a clear choice for consumers and policy makers.

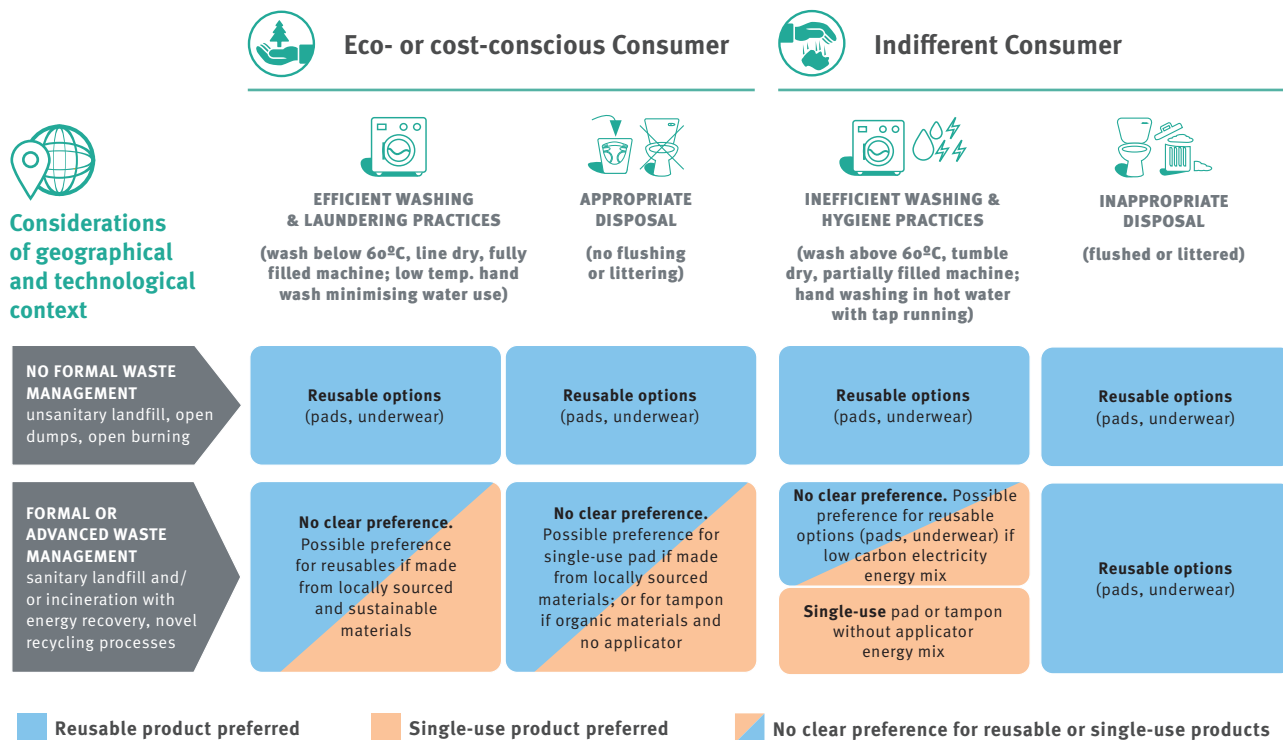
# LIFE CYCLE ASSESSMENTS OF MENSTRUAL PRODUCTS: WHAT THE SCIENCE TELLS US

## Single-use or reusable menstrual products depending on waste management context and behavioural considerations

This matrix helps countries, regions and cities to identify the closest scenario and current most appropriate options for their context. The content of the matrix is simplified, and the suggested preferences are indicative. Please read in conjunction with the text box below and refer to the full narrative of the meta-study for details.

**REUSABLE MENSTRUAL CUPS HAVE THE LOWEST ENVIRONMENTAL IMPACTS AND SHOULD BE CHOSEN WHENEVER PRACTICABLE (i.e., where there is cultural/social acceptance of cups and sufficient infrastructure for their safe and hygienic use)**

IF MENSTRUAL CUPS ARE NOT PRACTICABLE:



In general, reusable menstrual products have lower environmental impacts than single-use menstrual products, with the reusable menstrual cup having the lowest environmental impacts of all. However, there are several barriers to the uptake of reusable menstrual products, including low awareness of, and access to, reusable products, low cultural and social acceptance (especially for menstrual cups) and inadequate infrastructure (e.g., lack of hygienic conditions and privacy in bathrooms, lack of running water). It is important to remember that **reusable products are environmentally preferred when best practices are applied**, as is suggested by studies on absorbent hygiene product systems.

Thus, overarching recommendations are to:

- Educate consumers on reusable menstrual product alternatives and on how to efficiently sterilize (cups) and launder (pads).\*
- Encourage multiple reuses of reusable products. The longer the lifespan the lower the environmental impacts, so products should be used for as long as they remain functional. For cups preferably for at least a year.
- Advocate for reusable menstrual products, such as requiring public procurement to consider reusable products.
- Provide adequate infrastructure in schools and government facilities, and require workplaces to ensure adequate facilities (e.g., private, and clean bathrooms with working sinks).
- Focus efforts on transitioning to low-carbon electricity.

\* The energy used in sterilising cups can be reduced by placing the cup in small bowl or mug and pouring over water boiled in a kettle, or if sterilised by boiling in water, energy use can be minimised by using a small, covered pot and boiling on a stove top or microwaving for the minimum time recommended by the manufacturer. The energy use in laundering pads and period underwear can be minimised by pre-rinsing in cold water, washing them in an energy- and water-efficient washing machine (in a full load) and line-drying. If hand washed, they should be washed in a small tub in lukewarm water using the minimum amount of detergent necessary.

In those contexts **where single-use menstrual products are currently preferred**, actions to **lessen the environmental impacts of single-use menstrual products** include:

- Raise awareness on the benefits of using reusable menstrual products, with the aim to shifting social norms and attitudes
- Ensure adequate waste collection and appropriate disposal of single-use menstrual products
- Incentivise the design of pads and tampons that require less materials, along with the sourcing of lowest-impact absorbent materials, locally produced

Overall, the meta-analysis finds that **taking a life cycle perspective is essential for menstrual products systems**; while the **highest impacts of reusable menstrual products occur in the use phase, the choice and weight of materials in the manufacturing stage along with end-of-life treatments are important in both single-use and reusable systems**. For the menstrual products system it is especially important to recognise that it sits within a **wider social and economic system of providing women a safe, accessible and effective way of managing menstruation**.

There are relatively few LCA studies on menstrual products and further **studies in particular geographical contexts should be undertaken before promoting a particular product**. Furthermore, the LCAs in the literature do not cover the full range of products available, such as other reusable options like period underwear and reusable tampon applicators. Notwithstanding these limitations, this report highlights policy considerations in four broad areas:

## 1. Policies must address the stigmatisation and lack of information prevalent around menstruation and menstrual products

A dearth of information around sustainable alternatives for the management of menstruation as well as little awareness of the environmental impacts of single-use menstrual products points to the fact that **education campaigns and destigmatisation are a crucial first aspect of any policy on these products**. This should include education in schools, as well as campaigns and peer-to-peer transfer of information (e.g., through social media). Much greater education and information is needed on reusable menstrual products to give women the freedom to choose and to drive the social acceptance of reusable menstrual products. Further investigations on the health implications of menstrual products are also needed and policies need to address the lack of transparency, specifically around requirements for

manufacturers to disclose all ingredients on labels to ensure that consumers are properly protected. **The lack of information on health implications applies to both single-use and reusable products**. Along with further investigations on the potential health risks associated with materials, outreach on how to safely and hygienically use menstrual products should be done.

## 2. Consumer behaviour and the potential for mismanagement of single-use products at end-of-life must be considered when developing policies regarding menstrual products

How consumers handle both single-use and reusable menstrual products during the use phase and at end-of-life, greatly affects the environmental impacts of these products. For instance, many users of single-use menstrual products are unaware that these products should not be flushed down toilets. As a result, there is a strong likelihood that the end-of-life impacts of single-use pads and tampons are being under-represented in LCA studies, in which they are modelled as incinerated or landfilled at end-of-life. Furthermore, **education campaigns around the proper disposal of single-use menstrual products need to form a part of policy actions and clear and unambiguous messaging on packaging and labelling must be mandated**. Consumer education is also necessary to **provide best practice guidelines** for the use phase. For example, on hand washing for good hygiene and lowest environmental impacts as well as guidelines for washing and sterilising reusable products.

## 3. Policies should be geographically adapted and account for likely future developments in materials and production processes

Policies should consider country or region-specific characteristics of the consumer population that will be affected by the policy. **For menstrual products, the**



**choice of product is often dominated by social norms as well as product availability and cost, all of which may be barriers to the uptake of reusable products.** In certain contexts, practicability might be as important as cost and convenience. For example, a lack of access to toilet facilities with running water is a barrier to the uptake of the reusable menstrual cup. Additionally, **policies need to take into account that some aspects that determine environmental performance are geographically dependent**, such as available feedstocks for bio-based materials, available power generation technology, consumer behaviour with regard to reusable alternatives and use habits, and available waste management systems and disposal practices.

Related to this, policy makers should be aware that product designs, materials and production processes are evolving continuously and this may render current LCA studies outdated. **More recently developed technologies and materials may be at a disadvantage to other more established technologies** and materials due to their scale or lack of data availability. This is true of bio-based polymers and the potential for composting and

recycling single-use menstrual products at end-of-life. Further LCA studies at a higher level of standardisation are required. Current LCA results may also change if future developments in energy, transport and waste management systems are incorporated.

#### **4. Policies must recognise and manage trade-offs and risks of burden shifting between environmental impacts**

Care must be taken to recognise and manage the trade-offs between other quantified environmental impacts and with unquantified environmental impacts, notably cancer risks and risks to reproductive health due to carcinogenic, mutagenic, reprotoxic and endocrine-disrupting substances in products, allergies due to skin-sensitising chemicals, Toxic Shock Syndrome (TSS) and other bacterial infections. These are not currently quantified in LCA studies. **Policies must, therefore, be based on several sources of information.** For menstrual products, relevant gaps are impacts from chemicals, water pollution and adding to marine plastics due to flushing / littering single-use menstrual products.



**Table E1: Overview of LCA studies included in the meta-analysis.**

**The option with the lowest climate impact**

Study	Functional unit	Type				Geographic scope	Main conclusions
		Single-use		Reusable			
		Pad	Tampon	Menstrual cup	Pad		
<b>LCA studies comparing single-use menstrual products</b>							
<p><b>Quantification of social equity in life cycle assessment for increased sustainable production of sanitary products in Uganda</b></p> <p><i>Musaazi et al (2015)</i></p> <p>This study assesses a Ugandan designed and locally produced single-use pad (MakaPad), comparing it with an imported pad using data from a study in the literature. The analysis combines a social life cycle assessment and environmental life cycle assessment.</p>	The number of pads needed to provide effective protection from menstruation for one woman over one year	Locally produced pad made from locally sourced materials (MakaPad);				Uganda	Both the environmental LCA and the social LCA show that a locally made pad using locally sourced materials has environmental and social benefits compared to importing conventional pads.
		Imported conventional pad					
<b>LCA studies comparing single-use and reusable menstrual products</b>							
<p><b>The value of reusable feminine hygiene products evaluated by comparative environmental life cycle assessment</b></p> <p><i>Hait and Powers (2019)</i></p> <p>This study compares three menstrual products that were chosen as representative and viable alternatives in the US market.</p>	Menstrual protection for one year for one woman	Pad	Tampon with applicator	Menstrual cup		USA	The menstrual cup has substantially lower potential impacts than the single-use pad and tampon across all impact categories considered.
<p><b>Which hygienic products for which continent? Design for usage and sustainability</b></p> <p><i>Leroy, Y., Yannou, B., Murthy, L., Lallmahomed, A. and Bris, G. Y. (2016)</i></p> <p>This study analyses four feminine hygiene products in three different geographical contexts (Europe, USA and India). Each option was investigated with respect to its environmental, economic, hygiene, comfort and social performance, with the environmental assessment taking the form of a comparative LCA.</p>	Menstrual protection for 50 women over a one year period	Pad	Tampon, with and without applicator	Menstrual cup	Reusable pad	Europe, India, USA	The menstrual cup has the lowest potential environmental impacts of the four options, regardless of geographic location. However, when the environmental impacts are considered alongside the economic and social aspects, the reusable pad is found to be the preferred option in the Indian context.
<p><b>Comparative Life cycle assessment of menstrual products</b></p> <p><i>Vilabrille Paz, C., Citroth, A., Mitra, A., Birnbach, M. and Wunsch, N (2020)</i></p> <p>This study provides the comparative environmental life cycle impacts of the menstrual cup and tampons and pads made either of organic cotton or conventional materials like cellulose fibres and plastics. Because it identifies the use phase as a particular gap in previous LCAs it looks at the full life cycles of each product (raw materials production, product manufacture, distribution, use, and end of life).</p>	The use of menstrual products by one menstruating person for one year	Conventional pad; Organic pad	Conventional tampon; Organic cotton tampon	Menstrual cup		Germany	The menstrual cup is the preferred environmental option with a high degree of confidence. Furthermore, the importance of the use phase to the life cycle impacts of cups and tampons is shown in this study, notably hand washing, and in the case of cups, how they are sterilised.

# Abbreviations

TERM	DEFINITION
CMR	Carcinogenic, mutagenic and reprotoxic substances
	Greenhouse gas
ILCD	International Reference Life Cycle Data System
LCA	Life cycle assessment
LDPE	Low density polyethylene
OECD	Organisation for Economic Co-operation and Development
PE	Polyethylene
PP	Polypropylene
SAP	Super absorbent polymer
SSA	Sub-Saharan Africa
TPE	Thermoplastic elastomer
UNEP	United Nations Environment Programme
PUL	Polyurethane laminated fabric
SAP	Super absorbent polymer
TAC	Technical Advisory Committee
TCF	Totally chlorine free
UNEP	United Nations Environment Programme

## A NOTE ON TERMINOLOGY:

Various terms are used in the literature to describe period products and related products, such as panty liners. “Feminine hygiene products” has traditionally dominated the menstrual products industry, although this is generally taken to include other personal care products, such as douches, wipes and sprays, which are not considered in this report. Furthermore, by using the term “feminine” people can be excluded as there are some transgender and non-binary persons who use these items and who do not identify as women. Other terms applied include “sanitary products” and “hygienic products”. Words like ‘sanitary’ or ‘hygiene’ suggest uncleanliness and lack of hygiene. They are associated with preventing disease and sewage facilities. This has an impact on how the products are designed, used and disposed of because they continue to feed into the culture of secrecy and shame around menstruation and menstrual products. Therefore, in this report we have chosen to use the term “menstrual products”.

Furthermore, we recognise the importance for language to be inclusive. **While this report generally uses the term ‘woman’, it is both inclusive of all people who menstruate who do not identify as women – namely some transgender and non-binary persons and others with diverse gendered identities and experiences – and all who do identify as women.**

# 01 Introduction

## 1.1 BACKGROUND

In recent decades, the use of single-use, absorbent menstrual products, such as tampons and pads, has soared. **Manufactured from wood pulp, cotton and viscose rayon as well as several plastics (polyester, polyethylene, polypropylene etc.) these products have environmental impacts across their entire life cycle.** Although not immediately apparent, a conventional pad contains up to 90% plastic (Wen, no date), while both tampons and pads are most often sold individually wrapped in plastic. **These products are therefore a considerable contributor globally to single-use plastic products waste.**

Estimating the number of single-use menstrual products consumed globally – and the consequent volume of solid waste produced – is not straightforward. However, **estimates for the EU and USA, are that some 49 billion and 19 billion menstrual products<sup>4</sup> are consumed each year, respectively** (Cabrera and Garcia, 2019; Hait and Powers, 2019). And these figures continue to rise. For example, greater European production of nonwovens (sheet or web structures bonded through the action of a chemical agent or heating device, of which absorbent products, such as nappies and menstrual products, comprise the greatest share) grew on average by 4.4% per year over the last decade (EDANA, 2020). It is estimated that tampons, the preferred choice in Western Europe and the US, are used by a 100 million women, each using on average 11,000 to 14,000 over their lifetime (Cabrera and Garcia, 2019; Peberdy, Jones and Green, 2019). In the Netherlands, a woman uses between 11,000 and 16,000 menstrual products over her life, producing 150 kg of waste tampons and pads (WECF International, 2020), with similar numbers estimated for the UK, with a woman using on average 25 pads per month (Wen, no date). The global numbers for single-use pads are anticipated to be even higher than tampons, as cultural taboos around tampon use in some areas of the world suggest that single-use pad use is higher than tampon use worldwide (Peberdy, Jones and Green, 2019).

**The varied composition of single-use menstrual products, together with the presence of organic matter after use, makes their recycling technically and economically expensive,** and the vast majority are landfilled or burnt in incinerators (Cabrera and Garcia, 2019). **Sanitary waste (consisting of menstrual products, nappies and wet wipes) makes up 2.9 to 12.4% of the non-recycled waste stream in the EU,** depending on the region, resulting in 7.8 million tonnes of sanitary waste landfilled and incinerated in the EU in 2017 (Cabrera and Garcia, 2019). The solid waste generation associated with menstrual products is comparable with that of nappies (Hait and Powers, 2019). Although nappies weigh more than pads and tampons, a larger portion of the population uses menstrual products over a longer time period.

The majority of the products are landfilled after use. For example, **in Europe and in the USA approximately 87% and 80% respectively ends up in landfills** (Arena, Ardolino and Di Gregorio, 2016; Cabrera and Garcia, 2019). In landfills, the plastic components can take up to 500 years to break down (Cabrera and Garcia, 2019), potentially releasing toxic chemicals as they degrade and generating microplastics that threaten the health of terrestrial ecosystems (de Souza Machado *et al.*, 2018). **In addition, single-use menstrual products are at times not disposed of in accordance with manufactures' instructions and are flushed down the toilet.** Here they block sewers and cause flooding, in addition to polluting freshwater and marine environments where wastewater treatment is inadequate. For example, **single-use menstrual products are one of the most frequently collected items in beach clean-ups in the UK** (Cooper, 2018; Cabrera and Garcia, 2019), **with on average 4.8 pieces of menstrual waste picked up every 100 m of UK beaches** (Wen, no date). Visible plastic litter not only has an environmental impact, but also an economic impact, particularly on industries like tourism, fishing and shipping.



Much greater **education and information** is needed on reusable menstrual products to give women the freedom to choose and **to drive the social acceptance** of reusable menstrual products.

<sup>4</sup> Some 174 million boxes of tampons and 396 million bags of pads were consumed in the US in 2018 (Hait and Powers, 2019).

Furthermore, plastic breaking down over time into smaller and smaller pieces, eventually becoming “microplastics”, pose a threat to a wide range of organisms, such as birds and animals (SCBD, 2020). Microplastic pollution is now ubiquitous, with microplastics ingested by deep sea amphipods in six of the deepest marine ecosystems on Earth (Jamieson *et al.*, 2019).

The taboo around the discussion of menstruation has made it **difficult to discuss more sustainable ways for women\* to manage their menstruation**. However, in recent years this has begun to change, with “period poverty” and the right of women to have access to safe and dignified ways to manage their menstruation becoming an increasingly prominent political issue. Scotland has become the first country to pass legislation to make menstrual products freely available to women who need them (Specia, 2020). Nonetheless, **there is a long way to go towards destigmatising menstruation and tackling the human rights, health and environmental issues that the silence around menstruation causes** (Tingle and Vora, 2018). The recent upswing in social media campaigns is an encouraging sign, fostering increasing dialogue and knowledge around affordable and sustainable alternatives (Cooper, 2018).

With this emerging dialogue and the recognition that menstrual products contribute to plastic pollution,

together with an increasing number of governments considering measures to increase the access of women to these products, there is a pressing need to consider alternatives. *Resolution 9 of the fourth edition of the United Nations Environment Assembly (UNEA4) in March 2019, on “Addressing Single-use plastic products pollution” (UNEP/EA.4/R.9)*, “encourages member states to take actions, as appropriate, to promote the identification and development of environmentally-friendly alternatives to single-use plastic products, taking into account the full life cycle implications of those alternatives” (UNEP, 2019). UN Environment Programme was requested by UNEP/EA.4/R.9 to make available existing information on the full life cycle environmental impacts of single-use plastic products compared to their alternatives.

Guided by the UNEA4 resolution on “Addressing single-use plastic products pollution” (UNEP/EA.4/R.9), this study aims to provide an insight into how life cycle assessment (LCA) can be used to make informed decisions on single-use plastic products and their alternatives. In particular, it addresses single-use menstrual products and their alternatives. It is part of *a series of reports* covering other widespread single-use plastic products and their alternatives, including *bags, bottles, take-away food packaging, tableware, beverage cups, nappies* and face masks (personal protective equipment)<sup>5</sup>.

## 1.2 PURPOSE, SCOPE AND METHOD

This report provides insights from Life Cycle Assessments (LCA) to inform decisions on single-use menstrual products and their alternatives. The report is based on the review and analysis (meta-analysis) of selected existing LCA studies that compare single-use menstrual products and their alternatives. The different solutions for providing women with protection during menstruation considered in this report thus only include those options that have been covered in the LCA literature<sup>6</sup>. The following single-use (disposable) and reusable options are considered:

- Single-use tampon (with and without applicator)
- Single-use pad
- Reusable pad
- Reusable menstrual cup

Searches were initially performed on Web of Science to identify relevant peer-reviewed studies published between 2000 and 2020. Thereafter, further searches were performed using Google Scholar and Google to ensure the literature search was comprehensive and included both academic literature as well as company- and industry-sponsored LCA studies. A Technical Advisory Committee (TAC) and relevant professional networks were also consulted to identify studies that the web searches might have missed. LCA studies were evaluated according to the following criteria:

- **Type of product:** Studies that covered single-use (disposable) and reusable products designed to provide women with a sufficient level of protection during menstruation so that they are not prevented from carrying out their usual daily activities were included.

\* While this report generally uses the term ‘woman’, it is both inclusive of all people who menstruate who do not identify as women – namely some transgender and non-binary persons and others with diverse gendered identities and experiences – and all who do identify as women.

<sup>5</sup> All of these reports are available from <https://www.lifecycleinitiative.org/single-use-plastic-products-studies>

<sup>6</sup> Taking of hormones, either orally or released from an intrauterine device (IUD) (typically as part of a contraceptive program) may be used to reduce or eliminate blood flow during menstruation. However, as no LCA studies were available on this option, and the health and societal implications of taking contraceptives are numerous, the taking of hormones is not considered among the alternatives in this meta-analysis.

- **Completeness of the study:** Full LCA studies were selected over preliminary or screening LCA studies.
- **Transparency of the study:** Only studies that included sufficient details in the publication were shortlisted, particularly on methodological assumptions, sources of data and impact assessment methods.
- **Geographic coverage:** Electricity grid mix, available waste management technologies and efficiencies, and recycling rates differ significantly by geographic region. Thus, selecting studies to cover as many regions as possible was important for the meta-analysis. This report is intended to have global applicability, which provides further rationale for selecting studies for broad geographic coverage.
- **Publication date:** Technologies improve over time and so although the original screening considered publications from 2000 onwards, more recent studies were given preference in the final selection.
- **Language:** The meta-analysis only included studies published in English.
- **Peer-reviewed studies:** Preference was given to studies that have been through a peer review

process. Compliance with international standards is not a selection criterion, as this is often not explicitly stated in publications. Furthermore, it is assumed that the peer review process would focus on compliance with relevant standards.

Four studies fulfilled the criteria and were selected for the meta-analysis for menstrual products. Very few LCAs have been carried out on menstrual products, thus the meta-study incorporates the insights of all relevant studies found in the literature, with studies not fully meeting the criteria listed above still included in the discussion in Section 3. Single-use menstrual products fall under the broader scope of studies on absorbent hygiene products (which also covers disposable baby nappies and adult incontinence products). Findings of these broader studies therefore have relevance to menstrual products and insights from these studies are also included in the discussion.<sup>7</sup>

Table E1 summarises the reviewed studies on menstrual products, which cover both single-use and reusable products. Two of the studies have a developing country focus, looking particularly at local production, while the third has a North American focus and the fourth a European focus.

### 1.3 LCA METHOD IN BRIEF

Life Cycle Assessment (LCA) is a well-established tool for assessing the potential environmental impacts associated with a product or service, providing a structured framework within which to model its consequences on the natural environment and society. All stages of a product's life cycle are considered, from mining, extraction or growing of raw materials, to its manufacturing, distribution and use, right up to the final disposal of its components. LCAs have a number of benefits including:

- Creating awareness that decisions are not isolated, but that they influence a larger system;
- Promoting decision-making for the longer-term, by considering all environmental issues and potential knock-on effects associated with a decision choice; and
- Improving entire systems, and not just single parts of systems, by avoiding decisions that fix one problem but cause another unexpected issue.

An LCA identifies the impacts and significance of each life cycle stage of the product analysed and makes possible comparisons with different products or systems and between different materials. International standards on LCAs (ISO 14040 and ISO 14044) divide LCAs into four main stages:

- **Goal and scope definition:** Objective (goal) and the methodological approach (scope).
- **Inventory analysis:** All raw materials and emissions (inputs and outputs) are considered for each of the unit processes that make up the life cycle of the product. Inputs include the use of natural resources, such as land and water, as well as manufactured materials such as fuels and chemicals. Outputs are released to air, water and land, as well as all products and by-products. Taken together these unit processes make up the life cycle system to be analysed, as defined by the product system boundary. The Life Cycle Inventory (LCI) is a comprehensive list of resources and emissions (inputs and outputs).

<sup>7</sup> Arena, U., Ardolino, F. and Di Gregorio, F. (2016) 'Technological, environmental and social aspects of a recycling process of post-consumer absorbent hygiene products', *Journal of Cleaner Production*, 127, pp. 289–301 is covered in detail in another report in this series, that of "Single-use nappies and their alternatives: Recommendations from life cycle assessment".

- **Impact assessment:** Assesses the life cycle inventory by connecting resources and emissions to their corresponding impacts on the environment and human health. In this way, the inputs and outputs are summed up into common areas of environmental concern, for example, impacts on human health, impacts on ecosystems etc. This can be done at varying degrees of complexity, and a number of different Life Cycle Impact Assessment (LCIA) methods have been developed to quantify the potential environmental impacts of a product system.
- **Interpretation:** Findings are evaluated in relation to the defined goal and scope in order to reach conclusions and make recommendations.

It is important to note that although the LCA method is standardised, there is still room for a range of methodological choices that affect the results. Additionally, LCAs predict *potential* environmental impacts or damages,

as the necessarily global nature of the predictive LCIA models means they do not take the specific receiving environment into account. Life cycle inventory data (the basis for impact assessment) span multiple geographical locations across countries and continents in today's global supply chains, thus LCIA's predictive models are not like environmental impact assessment (EIA) models that accurately characterise the actual risks associated with emissions at a particular location. Indeed, the value of an LCA study lays not so much with the final numbers, but rather with the exploration and consequent understanding of the system it assesses. **Especially valuable is an LCA's ability to highlight hotspots along the value chain** (i.e., show the areas of highest potential impact), and also to **highlight trade-offs between different impacts**. It is seldom that one system or decision option performs better than another in all aspects of environmental impact. Understanding these trade-offs is a prerequisite towards improving the sustainability of product systems.





# 02 Meta-analysis of the LCA studies





This chapter presents the main findings and results of the analysed LCA studies, which are grouped into two clusters:

- LCA studies comparing single-use menstrual products
- LCA studies comparing single-use and reusable menstrual products

For each study a short description is provided together with a summary of the results and main conclusions. This is followed by a tabular summary of the study, which presents further details on the products studied and highlights key assumptions. Results are summarised using colour coding to depict the relative performance of products across the impact indicators considered in the study. Note that the colour coding only denotes relative and not absolute impacts and the reader is referred to the original reference to appreciate the range and scale of the impacts calculated by the studies. All LCA studies have an inherent degree of uncertainty and variability in their results. In order not to overemphasise findings, where the difference in impact category scores between two options is less than 10%, they are ranked equally in the tables.

## 2.1 LCA STUDIES COMPARING SINGLE-USE MENSTRUAL PRODUCTS

### 2.1.1 Quantification of social equity in life cycle assessment for increased sustainable production of sanitary products in Uganda: Musaazi et al (2015)

This study assesses a Ugandan designed and locally produced single-use pad (MakaPad), combining a social LCA and an environmental LCA. MakaPads are made in Uganda using papyrus as the absorbent material. Currently four million MakaPads are produced per year using papyrus reeds grown in the wild, primarily with manual labour (mostly women) and in a factory using solar power. The MakaPads are compared with an imported pad using data from a study in the literature.

#### Summary of results and conclusions

The **locally produced pads (MakaPads) have lower potential environmental impacts than conventional imported pads** across all environmental impact categories considered. Detailed findings of the environmental LCA include:

- The locally produced MakaPads have substantially lower potential impacts than imported pads for land occupation, aquatic eutrophication, non-carcinogens and ionising radiation. For non-renewable energy, respiratory organics and carcinogens the differences between the MakaPads and conventional imported pads are less pronounced.
- The relatively low impacts of the MakaPads are due to the sourcing of local, wild-grown papyrus and the use of solar electricity in the manufacturing facility.

- The manufacture of the plastic packaging (low density polyethylene (LDPE)), both that used to wrap each pad and that making up the outer packaging, account for the majority of the impacts of the MakaPad across most of the impact categories.
- The MakaPad requires almost 40% more packaging than imported pads due to being thicker than conventional pads. This offsets some of their benefits.

The social LCA found the MakaPad to be **more affordable and have higher potential for manufacturing wages to lift women out of poverty** than imported pads.

- The better affordability and the higher impact of manufacturing wages of the locally produced MakaPads relative to the imported pads are strongly dependent on the region in which the products are purchased and produced.
- A higher percentage of total annual income is used to purchase menstrual products in Sub-Saharan African (SSA) than in OECD countries, thus the difference in price between MakaPads and imported pads is more important in an SSA context than in a wealthier country context.

Both the environmental LCA and the social LCA show that **a locally made pad using locally sourced materials has environmental and social benefits** compared to importing conventional pads.



A study in **Uganda** found that, in addition to being **more affordable**, single-use pads produced from **locally-sourced raw materials** have **lower environmental impacts** than imported single-use pads.

**Table 1: Summary table: Word doc says Musaazi et al. (2015)**

		Products considered in study	
		MakaPads (locally made pad using locally sourced materials)	Imported pads
<b>Study scope</b>	Material	Papyrus, recycled paper, plastic	Plastic, wood pulp, paper
	Functional unit	The number of pads needed to provide effective protection from menstruation for one woman over one year	
	Number of packages	15 - 21 (10 pads per package)	11 - 15 (14 pads per package)
	Geographic region	Uganda	
	Life cycle stages	Cradle-to-grave (raw material extraction, energy production, assembly, transport to or within Uganda and incineration)	
	End of life assumptions	Incineration	Incineration
<b>Indicators</b>	Mineral extraction		
	Non-renewable energy		
	Global warming		
	Aquatic eutrophication		
	Aquatic acidification		
	Land occupation		
	Terrestrial acid/nitrification		
	Terrestrial Eco toxicity		
	Aquatic Eco toxicity		
	Respiratory organics		
	Ozone layer depletion		
	Ionising radiation		
	Respiratory inorganics		
	Non-carcinogens		
Carcinogens			
<b>Method</b>	Impact 2002+		
<b>Other comments</b>	Social LCA also undertaken which substantiates the results of the environmental LCA		
<b>Reviewed</b>	Peer-reviewed journal		

Lowest relative impact
  Highest relative impact

## 2.2 LCA STUDIES COMPARING SINGLE-USE AND REUSABLE MENSTRUAL PRODUCTS

### 2.2.1 The value of reusable feminine hygiene products evaluated by comparative environmental life cycle assessment: Hait and Powers (2019)

In this study a comparative life cycle assessment of three menstrual products was undertaken:

- Single-use tampon, with applicator
- Single-use pad
- Reusable menstrual cup

The three products are chosen as representative and viable alternatives in the US market. The functional unit is taken as one year of coverage (menstrual protection) for one woman for one year. The number of the single-use products to fulfil the functional unit is quite variable, since cycle length and the number of products used per day varies among women. Thus, although an average value of 240 products per year is applied in the study (for both tampons and pads), a range of 108 to 504 products is calculated (and applied in sensitivity analyses). The reusable menstrual cup is made from silicone and was assumed to last for ten years (as specified by the manufacturer). Therefore, only one tenth of a menstrual cup is required to fulfil the functional unit, although the lifetime assumption is examined in a sensitivity analysis.

#### Summary of results and conclusions

The menstrual cup has substantially lower potential impacts than the single-use pad and tampon across all impact categories considered.

- The **menstrual cup**, the heaviest of the three products, requires significant material and energy in its manufacture. It also uses significant amounts of water due to needing to be washed between uses. The **transport and use phase is the dominant contributor to most impact categories**, with the exception of resource depletion, human toxicity (cancer) and ecotoxicity, in which raw material extraction is the highest.
- For the **single-use products, the raw materials are the predominant source of impacts**, with the exception of eutrophication (both tampons and pads) and climate change including biogenic emissions (pads only), in which case the disposal phase is the highest contributor. For pads, wood pulp used in the manufacture of absorbent fluff,

along with polyethylene, another key component in absorbent fluff, are significant contributors to impacts. For tampons, rayon, the central component of the absorbent material in a tampon, is the main contributor to impacts.

- **In comparing the two single-use products, neither product is consistently better or worse across all impact categories**; each have the highest potential impact in three of the eight impact categories considered. For the tampon these categories are resource depletion, human toxicity (non-cancer) and climate change when biogenic emissions are included. For the pad these categories are eutrophication, human toxicity (cancer) and climate change when biogenic impacts are not included. Pads and tampons have comparable acidification and ecotoxicity impacts.
- On a single-score analysis (normalised mid-point impact category scores with equal weighting), the **single-use pad has the worst overall score**. Tampons have a single score 40% less than that of the pad while the menstrual cup score is 99.6% less than that of the pad. Normalised ILCD mid-point impact category results yield human toxicity (cancer) to be the most significant impact category for all three products. **Tampons have the highest potential non-cancer human toxicity impact**.
- Climate change impact is assessed both including and excluding biogenic carbon<sup>8</sup>. **When biogenic greenhouse gases are not included, tampons have a 38% lower climate impact than pads**. Conversely, when biogenic greenhouse gases are included, tampons have the highest climate impact. The climate impact of pads is partially offset by the amount of carbon sequestered in wood pulp.
- The **environmental impacts of the menstrual cup are insignificant in comparison to the disposable products**, with the menstrual cup having less than 1.5% of the impact of the most impactful product (tampon or pad) in each impact category. This extent of the difference is due in part to the long service life assumed in the study (10 years). Nonetheless, sensitivity analyses showed that **even if used for just one cycle (one month), the menstrual cup has lower impacts than the single-use products (assuming 20 pads or tampons are used in a month)**.

<sup>8</sup> Carbon taken up from the atmosphere into biological resources

The findings were found to be robust in light of sensitivity analyses undertaken to evaluate the influence of key assumptions.

- Changing the electricity dataset from the US average electricity mix to a Texas electricity mix, which relies less on nuclear power and more on natural gas, does not change the outcomes of the study (i.e., the ordering of the products with respect to impacts does not change) although the magnitudes of some impacts change.
- Removing the tampon applicator removes the materials of the applicator and reduces the mass of cardboard and polyethylene packaging required in the tampon system. This reduces the impacts of the tampon to the extent that it is preferred over the pad, with specific impact categories reduced between 3% (human toxicity) and 66% (eutrophication). Changing the ratio of wood pulp to polyethylene in the pad


also has the potential to reverse the preference between pad and tampon. However, in both cases, the menstrual cup remains the best option.

- The number of single-use products to fulfil the functional unit varies considerably across women (by more than 50% either way). A sensitivity analysis taking into account the potential range in the number of single-use products required in a year found that the majority of the differences between the pads and tampons are within this uncertainty in use, i.e., the differences in impacts between tampons and pads are smaller than the differences in impacts between low and high estimates of their use.
- The **environmental preference for the menstrual cup was found not to be sensitive to the assumed life span**, with the menstrual cup having lower overall impacts than the single-use products even if used for just one month.




Table 2: Summary table: Hait and Powers (2019)

		Products considered in study		
		Single-use pad	Tampon with applicator	Menstrual cup
Study scope	Materials	LDPE, wood pulp, paper	LDPE, PP, Rayon, polyester	Silicone
	Functional unit	One year of coverage for one woman		
	Number used	240	240	0.1 (reusable for 10 years)
	Weight [grams]	10	Approximately 5.5	Approximately 16
	Geographic region	USA		
	Life cycle stages	Cradle-to-grave		
	End of life assumptions	Landfill	Landfill	Landfill
Indicators	Resource depletion	In-between	Highest	Lowest
	Eutrophication	Highest	In-between	Lowest
	Acidification	Highest	Highest	Lowest
	Ecotoxicity	In-between	Highest	Lowest
	Human toxicity (non-cancer)	In-between	Highest	Lowest
	Human toxicity (cancer)	Highest	In-between	Lowest
	Climate change (with biogenic)	In-between	Highest	Lowest
	Climate change (without biogenic)	Highest	In-between	Lowest
Method	ILCD			
Other comments	Sensitivity analysis evaluated the influence of major assumptions, including changing the electricity from US average to Texas electricity mix, relative composition of absorbent material and with and without applicator			
Reviewed	Peer-reviewed journal			

 Highest relative impact

 In-between (neither highest nor lowest)

 Lowest relative impact


When it comes to comparing single-use pads and tampons, **neither product is consistently better or worse across all impact categories**; each have the highest potential impact in three of the eight impact categories considered.

## 2.2.2 Which hygienic products for which continent? Design for usage and sustainability: Leroy, Y., Yannou, B., Murthy, L., Lallmahomed, A. and Bris, G. Y. (2016)

This study analyses four menstrual products in three different geographical contexts (Europe, USA and India):

- Tampon
- Single-use pad
- Reusable (washable) pad (Uger pad)
- Menstrual cup (reusable)

The four options were investigated with respect to their environmental, economic, hygiene, comfort and social performance, with the environmental assessment taking the form of a comparative LCA.

The products were evaluated over their full life cycle, i.e., from raw material extraction and preparation, production and distribution (secondary packaging), through to use and disposal. For the single-use products, the use phase includes water and soap used in washing hands after changing products. For the menstrual cup, the use phase includes water for rinsing the cup, whilst for the reusable pad the use phase assumptions depend on the geography (assumed to be hand washed without detergent in India, but machine washed with detergent in the EU and US).

The functional unit was defined as menstrual protection for 50 women over one year. Assumptions relating to the number of menstrual days per year per women (52) and the number of product changes per day resulted in reference flows of 156 tampons, 208 single-use pads, 6 reusable pads and 0.1 cup per woman per year (with the cups having a reported lifespan of 10 years).

### Summary of results and conclusions

The **menstrual cup has the lowest potential environmental impacts of the four options**, regardless of geographic location. However, when the environmental impacts are considered alongside the economic and social aspects, the reusable pad is found to be the preferred option in the Indian context. Detailed analysis shows that:

- In the European and North American contexts, **the menstrual cup has** only about 1% of the impacts of the reusable pad (the worst performer in these geographical contexts), and between 3% to 30% of the impacts of the single-use pad (the next best

option in these geographical contexts). The large extent of the difference in impacts between the cup and the other options is due to the expected 10-year lifespan of the cup. This means that just one tenth of the material used to make and deliver the cup needs to be considered in the study to fulfil the reference flow (for the chosen functional unit of one year).

- **Tampons and pads have comparable impacts**, with the pad having marginally lower potential impacts in all three of the geographical contexts.
- The **reusable pad has the highest environmental impacts in the European and North American contexts**, attributed to the high use of raw materials (packaging), and water and detergent use in the use phase. **The reusable pad had potential impacts comparable to the cup in the Indian context** and significantly lower impacts than the single-use pad and tampon. The reusable pad's low impacts in the Indian context are attributed to the avoidance of packaging and transport, due to it being locally produced.
- For the **menstrual cup**, the cardboard packaging is the main contributor to the environmental impacts, regardless of geographic location, accounting for 73% to 99% of the potential impact across the impact categories considered. Washing the menstrual cup (by hand) is an important contributor to aquatic toxicity (with the use phase accounting for 26% of the ecotoxicity impact).
- For the **tampons and pads**, the environmental impacts arise predominantly from raw material extraction and production of the products and their packaging. With the packaging contributing 70% to 95% across the impact categories considered, and the product contributing 4% to 17%.
- The environmental impacts of the **reusable pad** were found to vary significantly with geographic location. The reusable "Uger" pads are produced in India, with both cotton and textile production taking place in India. The use of the reusable "Uger" pads in Europe and the USA therefore involves additional packaging as well as the long-distance transport associated with bringing them to these markets. The use phase (washing) is also an important determinant of impacts in the different geographical contexts. In India the reusable pads are assumed to be washed by hand without detergent, whilst in Europe and the USA they are assumed to be machine washed with detergent.

An **economic indicator**, the accessibility indicator, is also developed in the study. Defined as the ratio between the purchasing costs per year and the minimum hourly wage in that geographical location (the lower the ratio the more accessible the option), the **accessibility indicator shows the reusable cups to be more accessible than single-use pads and tampons in all geographical contexts**. In the European and North American contexts this is the case even

when the upfront cost of the cup is carried in a single year rather than being spread over the 10 years of use. However, in the Indian context, the reusable pad is found to be more accessible than the cup when the upfront costs are carried in a single year. The preference for the reusable “Uger” pad in the Indian context was reinforced further by the social analysis, in which the options were scored according to their social, comfort and hygiene aspects.

**Table 3: Summary table: Leroy, Y., Yannou, B., Murthy, L., Lallmahomed, A. and Bris, G. Y. (2016)**

		Products considered in study			
		Tampon	Single-use pad	Reusable pad	Cup
Study scope	Materials	Tampon: cotton; String: cotton; Packaging and notice: paper, cardboard and LDPE	Pad: non-woven polymer, cellulose, cellulose and polymer, silicone paper;		
	Functional unit	Menstrual protection for 50 women over a one-year period			
	Number per FU	7,800	10,400	300	5
	Weight (g)	Tampon (cotton): 2.5; Notice (paper): 1.536; String (cotton): 0.0176; Primary packaging (LDPE): 0.000276; Secondary packaging (cardboard): 12	Pad: 4.66; Primary and secondary packaging (LDPE): 4.67	Pad: 26.07; Packaging: 72.45	Cup: 26.88; Packaging: 20
	Life cycle stages	Cradle-to-grave (raw materials, production, distribution, use and disposal)			
Indicators	Region	Europe			
	End of life assumption	Product: Household waste; Packaging: 46% recycled	Product: Household waste; Packaging: 75% recycled	Product & packaging: Incineration	Product: Incineration; Packaging: 75% recycled
	Global warming				
	Aquatic eco toxicity				
	Ozone layer depletion				
	Carcinogens				

■ Highest relative impact     
 ■ In-between (neither highest nor lowest)     
 ■ Lowest relative impact



**Table 3: Summary table: Leroy, Y., Yannou, B., Murthy, L., Lallmahomed, A. and Bris, G. Y. (2016)**

		Products considered in study			
		Tampon	Single-use pad	Reusable pad	Cup
Indicators	Region	India			
	End of life assumption	Product & packaging: Landfill	Product & packaging: Landfill	Product & packaging: Landfill	Product: Landfill 10% and reuse 90%; Packaging: Landfill
	Global warming				
	Aquatic eco toxicity				
	Ozone layer depletion				
	Carcinogens				
Indicators	Region	USA			
	End of life assumption	Product: Household waste; Packaging: 50% recycled	Product: Household waste; Packaging: 50% recycled	Product and packaging: 37% recycled and 13% composted	Product: Incineration; Packaging: 50% recycled
	Global warming				
	Aquatic eco toxicity				
	Ozone layer depletion				
	Carcinogens				
Method	Impact 2002+				
Other comments	An economic indicator is added to complement the environmental assessment, based on the purchasing costs of each product and the minimum hourly wage per location. The social, hygienic and compost aspects are also considered in the study. A multi-criteria analysis and semi-aggregation process was conducted.				
Reviewed	Peer-reviewed conference proceedings				

■ Highest relative impact     
 ■ In-between (neither highest nor lowest)     
 ■ Lowest relative impact



The cup has the **lowest environmental impacts** regardless of **geographic location**; however, when **economic and social aspects** are considered alongside environmental impacts, the **reusable pad** is found to be the preferred option in the Indian context.

### 2.2.3 Comparative Life cycle assessment of menstrual products: Vilabrille Paz, C., Ciroth, A., Mitra, A., Birnbach, M. and Wunsch, N (2020)

This aim of this study is to provide the comparative environmental life cycle impacts of the menstrual cup, and tampons and pads made either of organic cotton or conventional materials like cellulose fibres and plastic materials.<sup>9</sup> A critical review by an external review panel has been conducted for this study; hence it is compliant with ISO 14040/44 for Life Cycle Assessment. The functional unit is defined as the collection of the amount of menstrual fluid that is expelled by an average menstruating person over a period of one year following the exchange frequency of products recommended by producers. The study identifies the use phase as a particular gap in previous LCAs and so looks at the full life cycles of each product (raw materials production, product manufacture, distribution, use, and end of life), with the following use phase inclusions:

- Conventional tampon: hand washing (water and soap) and toilet paper for disposal at every exchange;
- Organic tampon: hand washing (water and soap) and toilet paper for disposal at every exchange;
- Conventional pad: toilet paper for disposal of last pad in period, the remaining pads are wrapped in the single wrapper of the subsequently used pad;
- Menstrual cup: hand washing (water and soap) and cup washing (water and soap) at every exchange and cup sterilisation (water and energy) between periods.

The pad has the lowest use phase additions. This is because it is assumed that hands are washed anyways after using the toilet, thus the pad does not require additional hand washing (i.e., hands are not washed before the exchange, as with tampons and cup). Pads are not inserted into the body and the manufacturers do not state in their recommendation to wash hands prior to application. However, manufacturers' instructions included with menstrual cups and tampons recommend users to wash hands before application.

Two scenarios are analysed for sterilising the menstrual cup between periods – boiling the cup on the stove or placing it in a container and covering it with boiling water that has been boiled in an electric kettle.<sup>10</sup>

#### Summary of results and conclusions

The **menstrual cup is the strongly preferred option** from an environmental perspective. Furthermore, the **importance of the use phase to the life cycle impacts of menstrual cups and tampons** is clearly shown in this study. Detailed findings include:

- The **menstrual cup (kettle scenario) has the lowest impacts in all but one impact category** (marine eutrophication, in which it has the second-lowest impact). Sterilising the cup by boiling it on a stove results in higher water and electricity use than when sterilised using water boiled in a kettle. Nonetheless, even with the more impactful use scenario, the menstrual cup is still significantly preferred, having lower environmental impacts than the single-use options in 13 out of the 16 impact categories considered.



The cup is strongly preferred from an environmental perspective, even when sterilised in a less efficient manner or used for just one year, it remains the alternative with the lowest environmental impacts.

<sup>9</sup> By kind agreement of the authors and commissioners of this study, it has been made available for the meta-analysis before its official release and publication. The results for organic pads are not included in this summary and will be available in the publication.

<sup>10</sup> In a related study, both methods were shown in a laboratory study to provide an adequate level of sterilisation.

- For the menstrual cup, in both scenarios, the use phase is by far the most relevant life cycle stage, contributing greater than 95% to almost all of the impact categories. Electricity required in sterilising the cups accounts for this high use-phase contribution in the stove-top scenario (in which cups are sterilised by boiling them in a pot on the stove), along with soap production and wastewater treatment. The kettle scenario, in which the cups are sterilised by having water boiled in a kettle poured over them, requires significantly less electricity, and consequently has significantly lower impacts. In the kettle scenario, production of the soap used in washing the cup and hands between uses, is the process that contributes most to impacts. Wastewater treatment is also a significant contributor, depending on the impact category.
- Between the conventional pad, conventional tampon and organic tampon, the product that has the best environmental performance depends on the impact category, thus it is **not possible to state that any of them are consistently preferred in terms of environmental impact**. The organic tampon has lower impacts than the conventional tampon in ten categories (including climate change), but higher impacts in the six categories strongly affected by

organic cotton production (land use, terrestrial, marine, and freshwater eutrophication, acidification and freshwater ecotoxicity). The higher use phase impacts of the tampons account for their higher impacts than the conventional pads across most impact categories; the exception being resource use (both energy and minerals and metals) where the conventional pads have the highest impacts. For the tampons, both conventional and organic, the production of components is the most relevant life cycle stage for most impact categories, with the use phase (hand washing and toilet paper production) the most relevant in others. The absorbent core (viscose in the conventional tampon and organic cotton in the organic tampon) is the component that contributes the most to impacts.

- For the conventional pad the most relevant life cycle stage is the production of components, most notably the production of plastics and fluff pulp. Manufacturing is the highest contributor to some impact categories due to electricity consumption.
- Across all products, distribution, the shopping trip and end-of-life disposal (incineration) are less significant life cycle stages.



A very rigorous set of sensitivity analyses, data quality assessment, completeness and consistency checks allow a **high degree of confidence in the environmental preference for the menstrual cups.**

- **The most important parameters/assumptions affecting the environmental performance of the menstrual cup is the frequency of sterilisation, the amount of water and soap used when washing the cup and the wearing time.** Nonetheless, **the environmental preference for the cups was found to be robust.** Only when the cup is sterilised after every exchange (instead of washing with soap and water, as recommended by manufacturers) is it not the preferred option, and this only for the stove-top sterilisation (the cup remains the best option even when sterilised between every exchange if sterilisation is by pouring boiling water from a kettle). The lifetime of the cup was not found to be a very significant parameter, with the cup still having the lowest impacts even if used for only one year.
- **Hand washing (amount of soap and water used and the water temperature) along with the amount of toilet paper used are important parameters/assumptions affecting the environmental performance of tampons.** This is particularly the case for conventional tampons, where the production phase (raw materials) has a relatively higher contribution than the organic tampons to its life cycle impacts. The **high use-phase inputs of tampons (relative to pads) therefore see conventional tampons become the least preferred option.** In the organic tampons, the dataset used to model the production of organic cotton is also an important parameter.
- **The assumption that hands are only washed after exchanging a pad and not before (as for tampons and the cup) is an important one for the environmental performance of the pad.** If it is assumed that hands are washed before exchanging all products, then the pad becomes the least environmentally preferred option.



**Table 4: Summary table: Vilabrille Paz, C., Ciroth, A., Mitra, A., Birnbach, M., and Wunsch, N. (2020)**

		Products considered in study			
		Conventional single-use pad	Conventional tampon	Organic tampon	Menstrual cup
Study scope	Materials	Cellulose core (sulphate pulp) with SAP; PE top-sheet; rayon, PE, PP and polyester distribution layer, PP and PE back-sheet, adhesive; silicone release paper	Viscose core, nonwoven core cover (PE and PP), polyester string	Organic cotton (core and string)	Medical grade silicone
	Functional unit	The use of menstrual products by one menstruating person for one year			
	Number used	260	260	260	1/5 of a cup (cup lifetime of 5 years)
	Weight [grams]	5.00 [Pad 4.4, Wrapper (LDPE) 0.5, Plastic bag (LDPE) 0.1]	2.88 [Tampon 2.52, Wrapper (PE) 0.06, Leaflet and box 0.30]	3.71 [Tampon 2.89, Wrapper (PP) 0.09, Leaflet and box 0.72]	54.16 [Cup 11.37, Box 32.88, Bag (organic cotton) 7.45, Label and leaflet 2.46]
	Geographic region	Use in Germany			
	Life cycle stages	All, including use (toilet paper for disposal)	All, including use (hands washing and toilet paper for disposal)		All, including use (hands washing, cup washing cup sterilization on stove)
	End of life assumptions	Incineration			
Indicators	Land use				
	Water scarcity				
	Resource use, minerals and metals				
	Resource use, energy carriers				
	Climate change				
	Eutrophication terrestrial				
	Eutrophication marine				
	Eutrophication freshwater				
	Acidification terrestrial and freshwater				
	Ecotoxicity freshwater				
	Cancer human health effects				
	Non-cancer human health effects				
	Ionizing radiation, HH				
	Photochemical ozone formation, HH				
	Respiratory inorganics				
	Ozone depletion				
	Method	Environmental Footprint 2.0 (European Commission)			
Other comments	A rigorous ranking exercise to analyse the importance of assumptions and modelling decisions (analysed in sensitivity analyses) on the relative environmental performance of the options was undertaken. This exercise shows the environmental preference for the menstrual cup to be robust. Only under one scenario – when the cup is sterilised on the stove top between each exchange – is it not the best option.				
Reviewed	ISO compliant and peer-reviewed by a three-person expert review panel.				

■ Highest relative impact     
 ■ In-between (neither highest nor lowest)     
 ■ Lowest relative impact



# 03 Discussion and conclusions

The discussion and conclusions are provided in three sections. The first section provides a synthesis of the findings of the meta-analysis in terms of the potential environmental impacts of single-use menstrual products and their alternatives. The second section summarises the important aspects to be considered when interpreting LCA studies on single-use menstrual products and their alternatives. The final section provides guidance for policy makers when using LCA to develop policies that addresses the environmental concerns associated with menstrual products.

## 3.1 ENVIRONMENTAL IMPACTS OF SINGLE-USE MENSTRUAL PRODUCTS AND THEIR ALTERNATIVES

### 3.1.1 Comparison of single-use and reusable menstrual products

**The reusable menstrual cup has substantially lower environmental impacts than single-use menstrual products.** This was shown to be the case across all impact categories and regardless of the material from which the menstrual cup was produced (Weir, 2015; Leroy *et al.*, 2016; Hait and Powers, 2019; Vilabrille Paz *et al.*, 2020). The significantly lower impacts of the reusable cup relative to the single-use products – with the reusable cup having less than 1% of the impacts of the single-use options over a year of use in Hait and Powers (2019) and Leroy *et al.* (2016) – is due in part to its long life span (assumed to be 10 years in these studies). Nonetheless, the cup needs to be used only for one or two months for its environmental benefits relative to single-use tampons and pads to be realised. The “breakeven” point of the reusable cup made from silicone is between 12 (Weir, 2015) and 20 tampons (Hait and Powers, 2019). These studies didn’t include sterilising the cups monthly, as recommended by manufacturers, only including rinsing between uses. However, even when full use-phase impacts are considered (rinsing between uses and sterilising with boiling water monthly), the menstrual cup has a better environmental performance than single-use options, even when used for just one year (Vilabrille Paz *et al.*, 2020).

**The use phase of the menstrual cup constitutes its most significant environmental impacts,** which are likely to vary with different consumer habits. This is apparent even in the two studies covered in the meta-analysis that assumed the cup only to be rinsed in cold water between uses. Periodic sterilisation in boiling water, as recommended by the manufacturers, was not included in either study, nor was soap used in washing. The study by Vilabrille Paz *et al.* (2020) addresses this limitation, and finds the cup still to be strongly preferred to single-use pads and tampons,

albeit with the use phase playing an even more important role in the life cycle impacts of the cup.

The **packaging of the menstrual cup**, typically a cardboard box, was found to be **a significant contributor to the cradle-to-gate life cycle impacts of the menstrual cup for certain impact categories.** Many manufacturers include a fabric bag to store the cup in when it’s not in use, which adds to the packaging impacts.

Other reusable menstrual products are not well represented in the LCA literature, with only one of the studies considering a locally produced reusable pad in India. In this study the **environmental impacts of the reusable pad were found to be strongly dependent on the geographical context**, and in particular on how the pad is washed during its use phase (Leroy *et al.*, 2016). Although there is a lack of LCA studies on reusable pads and period underwear, it is reasonable to draw comparisons with the wider literature on baby nappies and adult incontinence products, as these are made of very similar absorbent materials (both the single-use and the reusable alternatives). A conclusion from a meta-analysis on nappy LCA studies is that **reusable nappies washed in a water and energy-efficient manner have lower environmental impacts than single-use nappies** (UNEP, 2021), **and this finding is likely to be true also of reusable menstrual pads and period underwear.**

An important insight that the above findings bring is that **the environmental impacts of reusable menstrual products (both cups and pads) are driven by consumer behaviour to a much larger degree than single-use products.** Consumers using reusable pads have strong leverage to reduce the environmental impacts, for example, in their choice of washing machine and wash temperature and by washing full loads, in their choice of detergent, and by line-drying their reusable products. Consumers using menstrual cups have strong leverage in whether they use a kettle or pot to sterilise the cup between uses (with the former having

significantly lower energy use and associated emissions), and even just placing a lid on the pot can considerably reduce energy use (Vilabrille Paz *et al.*, 2020). Using renewable energy will also substantially decrease use-phase impacts. However, for **single-use products, the environmental impacts fall largely outside of the influence of the consumer** (in the raw materials used in tampon and pad manufacture and in the waste-disposal practices of their municipality). However, across all options (single-use and reusable) the amount of water and soap, and the water temperature used to wash hands before and after changing products, are influential (Vilabrille Paz *et al.*, 2020).

### 3.1.2 Comparison of single-use menstrual products

For **single-use** menstrual products no product performs consistently better or worse across the studies included in the meta-analysis.

**Geographical context is important.** In a developing country context, locally made single-use pads were shown to be a better option than imported single-use pads. This was found to be the case not only with respect to environmental impacts, but also with respect to the affordability and social impacts of the single-use pads.

**Individual product variations and the use phase are also influential.** There is no consensus in comparing tampons and pads, with their relative environmental preference varying between and even within studies when different assumptions are made (e.g., thickness and source of absorbent material, consumer use habits, packaging, with or without applicator, applicator material etc.). The fact that pads come in a wide array of different absorbencies and that there is no standard indicating the amount of fluid they can absorb, makes comparisons difficult and compounds this lack of consensus. For tampons, the applicator is an important contributor to impacts, and tampons without an applicator are generally found to have lower impacts than pads (Mazgaj, Yaramenka and Oleksandra, 2006; Hait and Powers, 2019). An exception is Vilabrille Paz *et al.* (2020) in which the conventional pad has lower impacts than both the organic and conventional tampon. This is due to the inclusion of the use phase (hand washing and toilet paper used to wrap used tampons), which is assumed to be higher for tampons than pads (hand washing before and after exchange instead of just afterwards) (Vilabrille Paz *et al.*, 2020). Since no other studies include hand washing and Vilabrille Paz (2021) look at tampons without applicators, it is not possible to evaluate whether there is a trade-off

between applicator use and hand washing (surmising that using an applicator might reduce hand washing), and which one results in lowest impacts when using tampons.

**Product innovation can reduce impacts. For both single-use tampons and pads the raw materials used in their production account for the highest share of their environmental impacts.** Studies on absorbent hygiene products have shown significant reductions in environmental impacts in recent years with the design of lighter products and the introduction of superabsorbent polymers (Cordella *et al.*, 2015; Hait and Powers, 2019). Focussing on the design aspect of absorbent hygiene products, especially the absorbent material itself, is therefore the most important intervention for decreasing the environmental impacts of these products<sup>11</sup>. **Packaging design is also an important intervention point** for decreasing the environmental impacts of single-use menstrual products because of their tendency to be individually wrapped.

**Lighter products tend to have the better environmental profile simply due to less material requiring production and disposal.** This accounts to some degree for organic products having poorer relative environmental performance than expected when compared to conventional products, as the organic products tend to weigh more. This is because conventional products make use of super absorbent polymer (SAP), which allows a reduction in material consumption whilst keeping absorbency high. Nonetheless, the organic tampon was found to be generally preferred to the conventional tampon (owing to differences in the environmental impacts of organic cotton versus viscose compensating for its slightly higher weight) (Vilabrille Paz *et al.*, 2020).

**The end-of-life scenario has important implications for the environmental impacts** of single-use menstrual products. A study evaluating the end-of-life impacts of absorbent hygiene products found incineration (with energy recovery) to have higher potential climate impact than landfill disposal, but lower human health impacts and resource depletion (Arena, Ardolino and Di Gregorio, 2016). A novel recycling process for disposable absorbent menstrual products has potential to decrease impacts below those of incineration and landfill (Arena, Ardolino and Di Gregorio, 2016), but **social and hygiene constraints are such that achieving the recycling of single-use menstrual products is still likely to be a long way off.** In fact, contamination concerns with menstrual products currently prevent even the recycling of commonly recycled materials, such as cardboard tampon applicators (Peberdy, Jones and Green, 2019).

<sup>11</sup> See for example the EU Ecolabel requirements for absorbent hygiene products, the selection of which was informed by LCA studies (<https://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html>)



## 3.2 IMPORTANT ASPECTS IN LIFE CYCLE ASSESSMENTS OF SINGLE-USE MENSTRUAL PRODUCTS AND THEIR ALTERNATIVES

Based on the studies reviewed in the meta-analysis, the following aspects are identified that should be considered when undertaking and interpreting LCAs of menstrual products and their alternatives. These aspects include the following:

**Material type and weight:** The environmental impacts of menstrual products are influenced by the weight of the product and continued weight reduction results in a reduction of their impacts. This is largely because raw material production is consistently the largest contributor to environmental impacts. Consequently, further light weighting coupled with optimised material production and selection could further reduce the impacts of these products (Cordella *et al.*, 2015).

**Geographical context:** The environmental impacts of menstrual products have been shown to depend on the specific context. For example, Musaazi *et al.* (2015) and Leroy *et al.* (2016) found that locally-made pads (single-use and reusable, respectively) had a better environmental profile than comparable imported products. This is due to a number of factors, including using locally sourced raw materials, local consumer behaviour and reduced packaging and transportation requirements. In addition, these products were also more affordable and brought about greater positive social change than imported single-use products. Consumer behaviours can also vary by geography. Different social norms for example strongly affect the acceptability of the different options, especially tampons and menstrual cups.

**Behaviour of consumers:** The environmental impacts of both single-use and reusable menstrual products are dependent on assumptions related to their use. The frequency at which products are changed (duration of use) will differ with individual products and consumers. The frequency and manner in which reusable products are washed and the frequency and manner in which cups are sterilised, strongly affects their environmental impacts. Including the use phase is critical, not only for reusable products, but also for single-use products, where hand washing habits and the use of additional materials (such as toilet paper for wrapping single-use products prior

to disposal) contributes significantly to overall life cycle impacts (Vilabrille Paz *et al.*, 2020). Improved education and consumer guidance around the use of menstrual products to reduce their environmental impacts should, therefore, be promoted.

**Affordability and social acceptability are critical factors.** It is not surprising that of the few LCA studies that have been conducted on menstrual products the majority include some sort of cost and/or social impact evaluation. From the wider literature on menstrual products, it is also clear that cultural taboos and social norms, along with affordability and availability, are deciding factors when determining the products women choose to manage their menstruation (Borowski, 2011; Peberdy, Jones and Green, 2019). While quantification of these factors might not be possible within the scope of an LCA, these factors are too important to be left out of any recommendation on menstrual products<sup>12</sup>.

**Functional equivalence:** The menstrual products compared in the studies are comparable in terms of function and size (within product groups). However, they are less consistent in terms of other aspects related to their use, such as the need for access to toilet facilities with running water and acceptability of use. The functional equivalence of products with and without applicators is not discussed and might be relevant to consumers particularly when considering different single-use and reusable products.

**Choice of environmental impact indicators:** The purpose of LCA is to assess environmental impacts across all relevant indicators to better understand trade-offs and avoid burden-shifting. Related to this is the limitation of LCA in terms of the environmental category indicators included in impact assessment methods. Both tampons and pads have been found to contain chemicals identified as carcinogens, neurotoxins, hormone disruptors and reproductive toxicants (Scranton, 2013; ANSES, 2018; KEMI, 2018; WECF International, 2020)<sup>13</sup>. The LCA studies do not quantify the potential health impacts of these products although they are discussed in Hait and Powers (2019) and Weir (2015). **Impacts arising from chemicals in products are generally underestimated in LCA studies** due to gaps in data on the identity and quantities of chemicals used, as

<sup>12</sup> Aspects requiring action to drive change are well-summarised in #breakfreefromplastic and Zero Waste Europe's "The Bloody Manifesto" (Zero Waste Europe, 2020c). <https://zerowasteurope.eu/library/the-bloody-manifesto/>

<sup>13</sup> In a survey of 35 different menstrual products, covering sanitary towels, panty liners, tampons and menstrual cups, the Swedish Chemicals Agency (KEMI) analysed 62 chemical substances, finding 21 of these to be hazardous chemical substances ("hazardous chemical substances" includes both the chemical substances assessed to be hazardous and the substances suspected to be hazardous, based on the criteria for classification of hazardous substances within the EU). Nonetheless, the low concentrations of these substances in the products analysed led the report to conclude that the risk of negative health effects from exposure to chemical substances in menstrual products is low (KEMI, 2018) (Low concentrations in the KEMI report denoted concentrations of less than 0.1 % weight by weight). A study by the French Agency for Environmental and Occupational Health and Safety (ANSES) had similar conclusions, finding no cases of health thresholds being exceeded despite finding Carcinogenic, Mutagenic and Reprotoxic (CMR) substances, endocrine disruptors and skin-sensitising chemicals in menstrual products (ANSES, 2018).

well as gaps in the ability of LCA models to describe the effects arising from the toxicity of these chemicals when they get into the environment (Roos *et al.*, 2019). Although both tampons and pads are widely used globally, there is little understanding regarding the exposure to the various hazardous substances that have been found in them (Scranton, 2013; ANSES, 2018), as well the potential for


reusable products to avoid these potential health impacts. The potential for inappropriately disposed menstrual products to add to the impacts of marine plastic pollution is another aspect not covered by LCA studies.<sup>14</sup> This limitation is particularly significant in the comparison of conventional single-use period products with biodegradable products (e.g., from organic cotton).

### 3.3 IMPORTANT ASPECTS IN POLICY MAKING

This meta-analysis is not intended to provide definitive environmental guidance on the “best” menstrual product choice and in doing so promote policies that prohibit or limit the use of other alternatives. Rather, it serves to highlight important aspects that policy makers should consider when evaluating environmental information provided in the form of life cycle studies, to inform policy development that is context specific and locally relevant.

The most notable aspect, and one that is highlighted through the application of LCA, is that policies should **take a systems perspective**. LCA studies employ a systems perspective in the sense that they consider the life cycle of a product from resource extraction, production through use and end-of-life processes. For the “menstrual products system” it is especially important to recognise that it sits within a wider social and economic system of providing women a safe, accessible and effective way of managing menstruation. **Although shown to be environmentally preferred by a considerable margin, the reusable menstrual cup cannot be considered a viable alternative unless the wider social and economic system is able to accommodate it.** For example, cultural and religious taboos will need to be overcome. Sufficient infrastructure, such as access to running water, and privacy in the home, schools and places of work will need to be ensured.

The importance of the social and economic aspects is touched upon here but socio-economic aspects are not the focus of the report, which is on the environmental aspects of single-use menstrual products and their alternatives, specifically on insights obtained from taking a life cycle perspective. Zero Waste Europe’s “Policy recommendations to make menstrual products, nappies and wet wipes circular” provides wider policy recommendations in line with the EU Plastic Strategy and the Circular Economy Action Plan (Zero Waste Europe, 2020a), based on a review of legal measures to address the impacts of these products (Zero Waste Europe, 2020b). Policy recommendations to increase the uptake of reusable menstrual products include setting reuse targets, reducing or eliminating taxes on reusable products, introducing economic incentives for reusable products and reuse systems to overcome barriers to entry, and making availability of reusable products mandatory to at least the same extent as single-use products in retail outlets (Zero Waste Europe, 2020a). In a developing country context, equally important to the above measures to increase the uptake of reusable options is to provide infrastructure to enable the uptake. In particular, to ensure access to safe and hygienic facilities where women can exchange and wash products, including access to running water and soap. For example, governments could impose minimum standards and requirements for schools, workplaces and public buildings.

 Although shown to be environmentally preferred by a considerable margin, **the menstrual cup** cannot be considered a viable alternative **unless the wider social and economic system is able to accommodate it.**

<sup>14</sup> Projects are under way to develop models and methods to account for the impact of plastic pollution in the marine environment, such as the *MariLCA project*, which aims to integrate potential environmental impacts of marine litter into LCAs.

**Affordability and access to products are important considerations.** With the increasing prominence of menstrual protection being a human rights issue, more governments are taking action on the issue of “period poverty”. This has largely been in the form of rolling out free menstrual products to schools and colleges (Tingle and Vora, 2018; Specia, 2020), which gives governments considerable leverage in the procurement of menstrual products. Such **public procurement of menstrual products should be subject to sustainability criteria**, with governments opting for the **least environmentally detrimental option (informed by life cycle thinking) within the social and economic constraints of their context.** Similarly, government programmes that see menstrual products zero rated for VAT or given other tax benefits or subsidies should be subject to sustainability criteria. The EU Ecolabel on absorbent hygiene products<sup>15</sup> provides such sustainability criteria for single-use pads and tampons.

A finding of the meta-analysis is that, whilst the reusable menstrual cup is clearly preferred, there is no best environmental performer between pads (both single-use and reusable) and tampons. **Policy makers should be aware of differences in environmental impacts between and within product categories** and the reasons for these differences. Differences in aspects such as use habits, packaging, manufacturing location, and whether an applicator is included with the tampon, are likely to determine the preferred single-use option. With reusable pads, consumer washing habits are likely to be the determining factor.

There are relatively few LCA studies on menstrual products in the literature and further **studies in the specific geographical context should be undertaken before promoting a particular product.** Furthermore, the LCAs in the literature do not cover the full range of products available, such as organic pads and tampons, other reusable options such as period underwear and reusable pads, and recently emerged products such as reusable tampon applicators.

Notwithstanding the above, the following recommendations for policy can be drawn from the meta-analysis.

- 1. Policies must address the stigmatisation and lack of information prevalent around menstruation and menstrual products.**

There is a considerable lack of information around sustainable alternatives for managing menstruation, as well as little awareness of the environmental impacts of single-use menstrual products (Borowski, 2011; Tingle and Vora, 2018; Peberdy, Jones and Green, 2019). The reusable menstrual cup has substantially lower environmental impacts and is considerably more affordable in the long term than single-use products, but will remain a fringe product unless the taboos associated with its use are confronted. **Education campaigns and destigmatisation are therefore a crucial first aspect of any policy on menstrual products.**



<sup>15</sup> <https://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html>

This should include education in schools, as well as campaigns and peer-to-peer transfer of information. Social media is already playing a significant role in breaking the silence and spreading information on alternatives to single-use products (Cooper, 2018; Tingle and Vora, 2018). Nonetheless, far more will have to be done by policy makers, including addressing the “secrecy” and “shame” aspects that continue to be promoted in the marketing of single-use products (Weir, 2015; Hait and Powers, 2019; Peberdy, Jones and Green, 2019). Outreach and education will need to be the frontline of any policy to promote reusable menstrual cups, with research suggesting that those with a higher awareness of the impacts of single-use products are more likely to choose products that are less harmful to the environment (Peberdy, Jones and Green, 2019).

Information and studies on the health risks of menstrual products are woefully inadequate (Scranton, 2013). Under current regulations in most countries around the world, manufacturers are not required to disclose what is in the products. **Policies need to address the lack of transparency and require manufacturers to disclose all ingredients on labels.** Governments should set binding requirements for manufacturers to phase out hazardous chemicals

and eliminate carcinogenic, mutagenic and reprotoxic substances (CMRs) and endocrine disruptors from menstrual products. Companies should also be required to highlight allergens and skin-sensitising chemicals on labels, especially those intentionally added to products, such as fragrances.

**Further investigations on the health implications of menstrual products are needed.** This applies to both single-use and reusable products. There is especially a lack of understanding on the health risks due to exposure to toxins through direct and prolonged contact with mucous membranes (Scranton, 2013; ANSES, 2018). In addition, there is no understanding of potential cumulative and combined effects of exposure to low doses of chemicals like phthalates, bisphenols and pesticides residues, all of which have been found in tampons, pads and panty liners (WECF International, 2020). Trace amounts of hazardous chemicals, such as siloxanes, have also been found in various brands of menstrual cups (ANSES, 2018; Danish Consumer Council THINK Chemicals, 2018; KEMI, 2018). Furthermore, no studies are available on the potential health risks associated with improper use of menstrual products, for example, inadequate washing and sterilisation of menstrual cups or inadequate personal hygiene (hand washing).



## 2. Consumer behaviour must be considered when developing policies regarding menstrual products

**Policies must consider the potential for mismanagement of single-use products at end-of-life.** The end-of-life treatment of single-use menstrual products is a significant determinant of their overall environmental impacts. Furthermore, end-of-life impacts of single-use products are likely under-represented in LCA studies as expected rather than actual disposal is modelled. Beach clean-up data and consumer research shows that many users of single-use menstrual products are unaware that these products should not be flushed down toilets (Borowski, 2011; Cooper, 2018). This indicates that to a high, albeit unquantified degree, single-use menstrual products are not being landfilled or incinerated, which is how they are modelled in LCA studies, but instead enter the wastewater system, where they block drains and cause adverse environmental impacts. Therefore, it is important that the end-of-life fate of material is correctly and appropriately taken into account when designing policy for menstrual products. Limitations of existing infrastructure and technologies (as well as the potential of future technologies) must also be considered. **Education campaigns around the proper disposal of single-use menstrual products are required, together with holding manufacturers more accountable for the responsible disposal of their products.** Clear and unambiguous messaging on packaging/labelling should be mandatory, including information on the presence of plastics and chemicals, appropriate disposal options and waste disposal means to be avoided (Zero Waste Europe, 2020a).

The use phase is an important contributor to the life cycle impacts of both reusable and single-use products. Hand washing habits, including the amount of soap and water used, and the water temperature, are important factors influencing the environmental impacts of menstrual products. **Consumer education campaigns and product packaging should provide best practice guidelines on washing hands for good hygiene and lowest environmental impacts.** Similarly, **consumer education campaigns and product labelling should provide best practice guidelines on washing reusable pads, and washing and sterilising menstrual cups.**

## 3. Policies should be geographically adapted and account for likely future developments in materials and production processes.

**Policies must be culturally and socially adapted** and need to take into account country or region-specific characteristics of the consumer population that will be affected by the policy. For menstrual products, the choice of product is often dominated by social norms

as well as product availability. **Cost has a considerable influence on consumer decisions, especially for those on a low income** (Borowski, 2011). The menstrual cup, for example, has the lowest environmental impacts by a considerable margin and the lowest annualised costs (Weir, 2015; Hait and Powers, 2019). However, the upfront investment cost of the menstrual cup may be a deterrent for some consumers (Leroy *et al.*, 2016; Hait and Powers, 2019). In addition to cost, convenience and availability are important factors influencing purchasing decisions (Peberdy, Jones and Green, 2019). In certain contexts, practicability might be as important as cost and convenience. For example, a lack of access to toilet facilities with running water is a barrier to the uptake of reusable products.

**Many of the aspects that affect environmental performance are geographically dependent,** such as available feedstocks for bio-based materials, available power generation technology, consumer behaviour with regard to reusable alternatives and use habits, and available waste management systems and end-of-life practices. Menstrual products made from locally sourced materials were found to have environmental and social advantages in the local market, but these benefits did not necessarily extend to these products when exported. It is critical therefore that policy makers understand and appreciate the implications and feasibility of proposed policies in the context of geographical constraints.

The designs of tampons and pads have changed considerably over the years, particularly in terms of dematerialisation, the use of super absorbent polymers and a greater inclusion of bio-based materials. This may mean that current LCA studies will become outdated if further innovation is seen in these products and **policies should account for likely future developments in product designs, materials and production processes.**

**More recently developed technologies and materials may be at a disadvantage to other more established technologies** and materials due to their scale or lack of data availability. This is true of bio-based polymers and the potential for composting and recycling single-use menstrual products at end-of-life. Further LCA studies at a higher level of standardisation are required to fully unpack the benefits and trade-offs between bio-based and fossil-based polymers. Similarly, a greater number of consistent datasets covering more geographies are required to fully understand the benefits of alternative materials, such as organic cotton and bamboo.

Current LCA results may also change if future developments in energy, transport and waste management systems are incorporated. This means that **LCA studies should be current and regularly updated if they are to provide relevant policy advice.**

4. **Policies must recognise and manage trade-offs and risks of burden-shifting between environmental impacts.**

Care must be taken to recognise and manage the trade-offs between other quantified and unquantified environmental impacts. Cancer risks and risks to reproductive health due to CMR and endocrine-disrupting substances in products, allergies due to skin-sensitising chemicals, Toxic Shock Syndrome (TSS) and other bacterial infections are some of the health concerns associated with the use of menstrual products that are raised in the literature, but that are

not currently quantified in LCA studies (Borowski, 2011; Scranton, 2013; Weir, 2015; Cabrera and Garcia, 2019; Hait and Powers, 2019; WECF International, 2020). **Policies must therefore be based on several sources of information** and LCA results should be considered together with other sources of relevant information on health and environmental aspects. In addition to the above health concerns, relevant gaps in environmental impacts for menstrual products are impacts from chemicals (both incorporated in products and used in manufacturing), water pollution and adding to marine plastics due to flushing single-use menstrual products.



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