In The Red: A private economic cost and qualitative analysis of environmental and health implications for five menstrual products

Submitted by:
Caitlyn Shaye Weir, BSc Combined Honours,
Environmental Science and Gender and Women Studies, Dalhousie University (2015)

April 3rd , 2015

With the generous support of:

Project Co-Supervisor, Dr. Tarah Wright,
Associate Professor of Environmental Science, Dalhousie University

and

Project Co-Supervisor, Dr. Peter Tyedmers
Professor and Director for the School of Resource and Environmental Studies, Dalhousie University

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Acknowledgements:

I would like to thank Nathan Ayer, PhD candidate, for compiling the environmental indicators per kilogram of raw material (Table 46).

Abstract

Almost all women menstruate at some point in their lives, and as such there is a large and constant market for menstrual products. The objective of this research is to collect and present existing data about the impact of menstrual products and to identify research gaps. This project will explore the explicit cost differences between five menstrual products, as well as the externality costs on environment and health associated with each menstrual product. A private cost analysis of five menstrual products was conducted, directly comparing the cost to a woman using a single product for one, five and ten years of menstruation. A qualitative unpriced input description was then offered for each menstrual product, and a meta-analysis of external costs related to environment, resource and health were gathered. This data was analyzed by directly comparing the private costs and the externality costs of each product. The most economical menstrual products for a temporal lens of one menstrual cycle, one year and five years or more, are tampons without applicators, sea sponge and the reusable menstrual cup respectively. The environmental externalities of product raw materials show that for a temporal scale of one unit and one cycle or longer, the products with the least environmental effect are the tampon without applicator and the reusable menstrual cup respectively. The health externalities of each product show there to be no researched negative impacts from menstrual cups, one researched negative impact from the sea sponge, and four researched negative impacts from tampons. This project identified a range of research, most notably the lack of cost-benefit analysis or lifecycle analysis of menstrual products, and the dated health research.

1.0 Introduction

According to the 2011 population census, women consist of approximately 51% of the Canadian population (Statistics Canada, 2013). Almost all women menstruate at some point in their lives, and as such there is a large and constant market for menstrual products. Sales in 2013 for feminine hygiene and incontinence products were $3.4 billion in North America, and are set to rise to $3.7 billion by 2016 (Progressive Grocer, 2014). Individual women who use mainstream menstrual products (i.e. single use, disposable tampons and/or sanitary pads) are likely to spend a lot of money over the course of a lifetime. There is also a large volume of mainstream menstrual products disposed of during a woman's lifetime. Women use approximately 12,000 to 15,000 non-reusable menstrual products in their lifetime, amounting to between 250 and 300 pounds of waste per woman (Borowski, 2011). In addition to cost and waste volume, there are the effects of the lifecycle of menstrual products, from raw materials to manufacturing and transportation of goods, on the environment and the impact from using menstrual products on human health.

Research has been done about the social perceptions of menstruation and the effects of those perceptions about menstruation on women and their choice of menstrual product (e.g. Kissling, 2006; Brumberg, 1997; Del Saz-Rubio & Pennock-Speck, 2011). Likewise, research studies have been completed exploring the effects of menstrual products on vaginal health (e.g. Yang et al., 2001; Tierno & Hanna, 1994; North & Oldham, 2011). However, very little academic literature has been published exploring the possible environmental effects of menstrual product production, use and disposal (Appendix C). Specifically, there is a lack of information about whether reusable products such as menstrual cups, which are marketed as green alternatives to non-reusable products, are in fact more environmentally friendly than mainstream menstrual products. Menstrual product companies have advertising that states their products are "Easy on the earth. Easy on the Wallet" (Softcup, 2015), are "eco-friendly" with "no waste and no chemicals" (DivaCup, 2015) or that there is "one pound less waste" than other brands (o.b., 2015). Are these claims true? Are menstrual products environmentally friendly? Which menstrual have the least amount of environmental impact? This research begins to explore the environmental effects of menstrual products and provides a starting point for future research about the environmental effects of menstrual products.

There are two possible methods with which to proceed to conduct an analysis of the complete impact of menstrual products: cost benefit analysis and lifecycle analysis. Cost benefit analysis (CBA) is a tool to compare the social costs and benefits of products or ventures through the categories of monetized, quantified but unmonitized and unquantified effects. It is typically used to

evaluate, but can be used to compare products (Treasury Board of Canada, 2007). Lifecycle Analysis (LCA) is used as a tool to evaluate the true impact of a product by taking into consideration the impacts from material harvesting and fabrication, the manufacturing process, transportation, packaging, use and disposal (Vink et al., 2002). LCA uses measurable indicators to predict the effect on the environment. Although both the CBA and LCA frameworks would provide substantial insight into the full impacts of menstrual products, there is not enough time to conduct a conclusive study using either method within the context of this project. Instead, this project provides a private cost analysis of five insertable menstrual product options including two tampons, two menstrual cups and one sea sponge, of which some products are representative of reusable and non-reusable options. In addition, this project describes qualitatively the general lifecycle of each product, the quantitative environmental impacts from product materials and health implications associated with each of the five insertable menstrual products chosen.

The history of menstruation and menstrual management has an effect on the current manner in which menstruation is socially perceived and studied. The medicalization of menstruation has led to store bought sterile products and created an economic demand, which in turn has driven product advertisements and public perceptions of menstruation (Brumberg, 1997; Al-Khalidi, 2000; Kissling, 2006). The social perceptions about women's bodies as sexual objects have fueled the market for menstrual products further by promoting insecurities about the female body and menstruation (Fahs, 2014). Studies show that the messages propagated by advertisements reinforce feelings of shame and embarrassment about menstruation, which continues to drive the market and product evolution (Del Saz-Rubio & Pennock, 2009; Havens & Swenson, 1988; Simes & Berg, 2000).

Canadian women spend $840 million dollars on menstrual products annually, which amounts to about $85 per woman (CBC, 2015). Although this is not much cost in comparison to other consumer products, it is a gendered cost shouldered by women, who typically have less disposable income (Bennett, 2006). Since menstrual product life spans vary, it is difficult to compare product cost to one another. Many studies speculate that reusable products such as menstrual cups would be more economical (e.g. Karnacky, 1962; Cheng et al. 1995; Borowski, 2011). However, Howard et al. (2009) is the only study found to date that provides calculated data to investigate such a claim. Influences affecting choice of menstrual product include: peer and family opinion (Oster & Thornton, 2012; Omar et al., 1997), product marketing that steers women to choose the dominant brands (Evagelidis & Levav, 2013) or to use justification when purchasing (Sela et al., 2009), low product cost for low income women (Jacob et al., 2014; Pedrini & Ferri, 2014; Smith et al., 2009),

and social factors, such as political awareness, social capital, level of education and age (Torgler at al., 2006).

Vaginal health indicators have been more thoroughly researched since the concern of Toxic Shock Syndrome surfaced in the 70's and 80's. The link between *Staphylococcus aureus* growth and Toxic Shock Syndrome has been widely accepted (Friedrich, 1985; Tierno & Hanna, 1994). The release of dioxins from menstrual products has been a more recent concern (Shin & Ahn, 2009; Yang et al., 2011; DeVito & Schecter, 2002). Friedrich (1981) and Karnacky (1962) illustrate that vaginal mucous can be altered by menstrual products, which can lead to vaginal ulcers. Tierno & Hanna (1994), Smith et al. (1982) and Karnacky (1962) found that certain menstrual products have been found to amplify the growth of *S. aureus*. There are many studies about vaginal health and the effects of menstrual products on vaginal health, however, there were no reviews or meta-analyses found compiling the current research.

There has been an increase in scientific studies of the effect of menstrual products on individual health with the discovery of Toxic Shock Syndrome, a reaction to a toxin released by the bacteria *Staphylococcus aureus* (Tierno & Hanna, 1994; Karnacky, 1962; Smith et al, 1982; North & Oldham, 2011), however, the scholarly study of menstrual products' effects on health, resource and environment remain few. There are a few studies specific to lifecycle analysis of menstrual products: Davidson (2012) narrates the qualitative lifecycle of a disposable tampon, but does not quantify any of the inputs or outputs; Mazgaj et al. (2006) conduct a comparative life-cycle analysis of a pad and a tampon; and Borowski (2011) elaborates with statistics about waste production as a result of menstruation.

There is a lack of information about the lifecycle of reusable menstrual products, and there is no research found elaborating on the costs and benefits of menstrual products. Likewise, there is no evidence of a study comparing the externalities of reusable and non-reusable products. There is no research found comparing the private cost of menstrual products, and no study elaborating the methods for a private cost analysis from which to template this research. In addition, the studies conducted by Mazgaj et al. and Borowski are not published or peer-reviewed studies, which further demonstrates the need for more research in the area of menstrual products.

Background Context and Definitions

Most women menstruate at some point in their lives. Menarche can occur anywhere between the ages of 8 and 15, and menopause typically between the ages of 45 and 55 (USDHH, 2012). A

menstrual cycle lasts on average 3 to 7 days, occurring once every 21 to 35 days, during which a woman sheds approximately 2 ounces of menstrual fluid (USDHH, 2012). Menstrual products are designed either to absorb the menstrual fluid outright, or to contain it for later removal. Depending on the type of menstrual product chosen, a woman may be disposing of the product after use or disinfecting it for her next menstrual cycle.

Tampons consist of absorbent fibres such as cotton, rayon or polyester, either bleached or unbleached, and are one-use disposable. Tampons may come with an applicator of cardboard or hard plastic. The applicators are one-use disposable. This study uses the Tampax brand compact regular tampon with plastic applicator and the o.b. brand regular tampon without applicator. Both brands of tampons have a maximum life time of four to eight hours before disposal (Mazgaj et al., 2006; Tampax, 2015; o.b., 2015). For this project, an average life span of six hours was assumed (Czerwinski, 1996; Chase et al., 2007).

Menstrual cups are pliable, funnel shaped devices used to contain menstrual fluid until it is removed and rinsed by the wearer. They can be non-reusable or reusable for either one menstrual cycle or for 10 or more years, depending on the brand. Non-reusable cups are made with a combination of polyurethane and soft polymer plastic while reusable cups can be made from medical grade silicone or tree rubber (Howard, 2011; North & Oldham, 2011; DivaCup, 2015; Softcup, 2015). This study uses the Softcup brand non-reusable menstrual cup, which has a maximum life time of 12 hours before disposal, and the DivaCup brand reusable menstrual cup, which has a minimum life span of one year and a reported life span of up to ten years (DivaCup, 2015).

Sea sponges are an ocean dwelling organism that are harvested to be used as a menstrual product and are reusable for six months to a year. Sponges are harvested from the ocean, leaving the roots to allow for regeneration of the organism. This study uses the Sea Pearls sea sponges from Jade and Pearl, with an assumed lifetime of six months (Jade and Pearl, 2015).

Due to the limited data in the study of menstrual products, data from comparable equivalents of the menstrual products mentioned was necessary. Products of comparable equivalents are a different brand of insertable menstrual management with the same materials, or a similar material used in the vagina for a purpose other than for menstruation.

In the context of this project, resource and environmental effects are any direct impacts on organic and inorganic organisms, ecosystems and cycles, excluding humans. Health effects are direct effects of the use of a menstrual product on the body of the individual using the product. Unpriced inputs in the context of this thesis mean the inputs not reflected in the actual cost of a product: the

unreflected costs on the environment and on personal health which are a direct outcome of the harvest or creation of raw materials, the processing and assembly of products, the transportation, the inputs from the use of the product and the method of disposal. For example, this may include the carbon dioxide equivalent emitted as a result of the raw materials of the products chosen.

In this thesis, the terms woman and women are used to describe all individuals who menstruate, regardless of gender identity. Female pronouns are used in conjunction with the terms woman and women.

Project Overview

The goal of this project is to make a direct comparison of private costs of five menstrual products, and their resource, environmental and health implications. My research question is: with regards to five distinct brands, are there differences in private cost and product associated environmental and health implications between menstrual products? My project assess five menstrual products: the o.b. tampon, Tampax compak tampon, Softcup menstrual cup, DivaCup menstrual cup and Sea Pearls sea sponges. My research question was addressed by: (1) assessing the private economic costs of the five insertable menstrual products, both reusable and non-reusable, and (2) assessing the associated unpriced resource, environmental and health implications of each product.

The research question was addressed using a private cost analysis of five menstrual products for the duration of one year, five years and ten years. For the purpose of this study, only insertable menstrual products were examined, specifically Tampax compak regular tampon, o.b. regular tampon, SoftCup non-reusable menstrual cup, DivaCup reusable menstrual cup and Sea Pearls sea sponges. Although products vary slightly by brand, insertable menstrual products are categorized in general groups based on product design, reusability and methods of disposal. With respect to the unpriced cost of externalities, only preliminary qualitative data was gathered; quantitative data was collected where possible.

Research questions were addressed in two ways. (1) A private cost analysis of the five selected menstrual products was conducted, directly comparing the cost to a woman using one product for one, five and ten years of menstruation. (2) A qualitative lifecycle description for each menstrual product, followed by an analysis of primary material impacts in the form of abiotic depletion measured in antimony equivalent, fossil fuel depletion measured in megajoules, global warming potential measured in carbon dioxide equivalent, acidification measured in sulfur dioxide equivalent and eutrophication measured in phosphate equivalent, in addition to the waste produced for each

product. Next, the health implications of each product was compiled and presented, including product correlation with Toxic Shock Syndrome as measured by the proliferation of *S. aureus*, dioxin release from products, vaginal mucosal alterations and vaginal ulcers as a result of product use. This data was analyzed using a direct comparison of cost, environmental effects and health implications of each product.

2.0 Literature Review

Menstruation is a topic entrenched in history that influences the way in which it is spoken about and navigated in the present. Academic studies about menstruation, social perceptions of the female body, advertisements and economics of menstruation all stem from the same history and as such are deeply entwined with one another. To understand the influences on menstrual product choices and the unpriced health, resource and environmental inputs for each product, it is necessary to explore the history of menstruation and the subsequent studies to date. This research will add to scholarly research about menstruation and commence to fill a void in lifecycle analyses for menstrual products.

History of Menstrual Management: Commodification and Commercialization

Store bought menstrual products are a recent endeavor and an invention of the 20th century. Before women purchased menstrual products from stores, they would use the material available to them, most often in the form of old cloth and rags (e.g. Kissling, 2006; Charlesworth, 2001; Brumberg, 1997). With research into germs and increasing sterility in medicine came the medicalization of menstruation. Brumberg (1997), Oinas (1998), Al-Khalidi (2000) and Kissling (2006) describe how menstruation became a hygiene concern. Girls began getting information about menarche from doctors instead of female family members, and the doctors would endorse sterile store bought products under the label of hygiene. Doctors put medical pressure on girls and their families to acquire sterile products, which led to social division of class between families who could afford store bought products and those who could not. Typically, immigrant families were unable to afford menstrual products and were socially pressured to purchase products to conform to North American culture. The popularization of store bought menstrual products came from the medicalization of the female body and bodily functions, and the discovery of germs, microbes and sanitation. The shift of menstruation from the private sphere of the household to the public sphere of medicine allowed for menstruation to become a public good in the economy, which allowed popular thought to become shaped by product advertisers.

Medical endorsement of sterile menstrual products led to advertisements for menstrual products in mainstream media. Public advertisements provide an archive of societal perceptions on subjects not openly discussed, such as menstruation. The patterns that emerge from menstrual product commercials show themes of shame and dirtiness. Del Saz-Rubio and Pennock (2009), Havens and Swenson (1988), and Simes and Berg (2000) show agreement between the following

messages of advertisements: silence and shame about menstruation; embarrassment about menstruation; avoiding getting 'caught' menstruating through odour, leaking, lack of participation in daily and physical activities, and by not being sexy; women as always dirty, emphasizing on the hygiene of pads and tampons, adding deodorants and perfumes into menstrual products and the hygiene of tampon applicators. Fahs (2014) notes the negative perceptions about menstruation with evidence from discussion about sex during menstruation. The main message of advertisements has been to heighten insecurities and maintain feelings of shame towards menstruation so women purchase products to remedy them. Messages of insecurity about menstruation in advertising have directed the purchase of menstrual products to remedy the perceived problems with menstruation, which influences the types of menstrual products purchased.

Menstrual cups and tampons were invented around the same time, yet tampons became the main choice of menstrual product. Studies have been conducted to determine the viability of menstrual cups for menstrual flow management. The results of the few studies conducted have significant agreement about the barriers women face and the benefits they enjoy when using menstrual cups. Pena (1967), Cheng et al. (1995), Day (2012), Koks et al. (1997), North and Oldham (2011), and Stewart et al. (2010) all found that barriers to menstrual cup use were due to leakage, lack of comfort, cramping, poor fit, inconvenient to empty and difficulty when inserting and removing the cup; the benefits women in these studies noted were odour control, comfort and dryness. Grose and Grabe (2014), analyzed menstrual products from the standpoint of Objectification Theory, which states that women are monitored from the outside as objects of sexual desire to the point where they begin to self-monitor as objects. Jackson and Falmagne (2013) argued that since menstruation is perceived as dirty, women feel as though their bodies are dirty, which negates the image of the ideal "feminine body" sought by the male gaze, making women feel insecure and inferior. From the standpoint of Objectification Theory and the male gaze, menstrual cup uptake will be difficult because it involves women becoming intimate with their own bodies and being comfortable with themselves, which is impossible to do as objects of sexual desire. According to advertisements about menstruation, women are meant to feel insecure and ashamed of menstruating, which is also a barrier to using menstrual cups since they require confidence and intimacy with one's body.

Given the data collected from the studies of menstrual cup uptake, having to touch one's labia and vagina while manipulating the cup, and having to touch menstrual fluid was a barrier across all of the studies (e.g. Karnacky, 1962; Cheng et al., 1995; Koks et al., 1997; North & Oldham, 2011).

This could in part explain the reluctance to switch from less intimate methods of menstrual management, such as tampons with applicators. Fahs (2014) conducted a study and found that women have negative feelings about their genitals, with common themes arising showing the vagina as dirty and gross, needing maintenance, and as unknown and unnatural. A main influencing factor on women's feelings about their vaginas was the approval and appreciation of men, relaying back into the Objectification Theory and women self-monitoring themselves as sexual objects (Roberts et al., 2002; Roberts & Water, 2004; Jackson & Falmagne, 2013; Grose & Grabe, 2014). These barriers to menstrual cup uptake directly influence the types of products purchased. The studies conducted about menstrual cup uptake show agreement about the barriers and benefits women perceive. Objectification Theory shows agreement with the messages of insecurity in advertisements. If Objectification Theory and messages in advertisements are a cause of barriers for menstrual cup uptake, then social perception has shaped the purchasing of menstrual products.

Tampons and menstrual cups were invented at the same time yet tampons became the more popular product, and menstrual cups were forgotten for a number of years (Karnacky, 1962). There has been a recent resurgence of popularity of menstrual cups. No studies researching the re-emergence of menstrual cups have been found to date. However, market research suggests that market trends emerge as a direct result of the desires of the consumer. Given that menstrual cups have been around for so long, and that they've only gathered noticeability recently, it can be assumed that they are emerging out of the consumers desires for what the reusable menstrual cups can uniquely offer, which are reusability, lack of chemicals and environmental awareness. There are no peer-reviewed studies to support this claim.

Private Cost Implications

Canadian women spend $840 million dollars on feminine hygiene products a year, which is approximately $85 dollars per woman per year (CBC, 2015). Howard et al. (2011), calculated that in 2009 approximately $40 dollars was spent by a woman in Vancouver annually on menstrual products. Compared to other expenses, the price of menstrual products is not very much annually, however, these small costs add up over time. The cost of menstrual products is also necessary to consider since it is a gendered purchase that only affects women, who typically have less disposable income (Bennett, 2006). The price of menstrual products becomes important when compounded with other gendered purchases, such as make-up, and the overall increase in price for women on comparable products, such as deodorant and soaps (Duesterhaus et al., 2011). The disproportionate

economic purchases of menstrual products by an economically discriminated population makes the private cost of menstrual products important. In addition to assessing gendered costs, projecting future costs is an important aspect when comparing costs to compare decisions with different timelines and potential outcomes based on social time preferences (Winpenny, 1995). To project future costs, prices of goods must be inflated, to reflect the change in the strength of currency, and discounted, to equate future costs into present value (Winpenny, 1995).

Influences on Product Choice

Women's choice of menstrual product is swayed by a combination of factors. The common factors affecting choice of product is peer opinion, product marketing and product cost. The environment is also a factor depending on individual attributes.

Peer Opinion

One study was found exploring the effects of peer opinion on menstrual cup uptake. Oster and Thornton (2012) conducted a study of menstrual cup uptake in Nepal, judging the effect of peer influence on product uptake. They found that girls in the study with more peers using the cup were quicker to adopt the technology, and that the effect of peers was not in hearing about the technology but in understanding how to use it. Britton (1996) found that family, peers and school teachers were the primary sources through which girls learned about menstruation, however, data collected by Koff and Rierdan (1995) showed that although girls emphasized the importance of a mother's support when learning about menstruation, the learning of how to use menstrual products should be done by friends. Some market studies found that women were more likely to use the same products as their mothers and female relatives (Omar et al., 1997). Overall, there is evidence to support the influence of peer opinion on menstrual product choice.

Product Marketing

In addition to the public perception of menstrual products, product labels and marketing have an effect on purchasing tendencies. Sela et al. (2009) found that consumers chose products that were easier to justify when given larger sets of options from which to choose. Menstrual products have many brands, absorbencies, materials, and age-specific marketing that creates a large set of products from which to choose. Such a large set could lead to consumers using justification, such as familiarity with product use, as a means to choose a product, instead of considering all of the product inputs and outputs. Evagelidis and Levav (2013) discovered that when there is brand dominance in a given set of products, the consumer is less likely to choose products based on their predetermined preferred product attributes and instead choose the dominant product. Within the menstrual product

industry, there are four main brands of tampons and pads that are the dominant brands; brands for menstrual cups and sea sponges are much less dominant. Given this study, consumers may compromise their product prominence, for example minimal effects on the environment, in favour of dominant brands. Larceneux et al. (2011) established that products labeled as organic were perceived as more environmentally friendly and of better quality. Often, an extension of organic labels are the terms 'green' and 'environmentally friendly'. Using these terms in conjunction with menstrual products, as the menstrual cups and the sea sponge often do, may lead consumers to believe the products have minimal affects on the environment without any evidentiary support.

Product Cost

Menstrual products vary in cost, with reusable products generally being more expensive than non-reusable products, which acts as a barrier for some women. Product cost and income are important factors when considering consumer behaviour. Pedrini and Ferri (2014), Smith et al. (2009) and Jacob et al. (2014) show agreement that people of lower income are less likely to buy more expensive products, which in the context of menstruation would mean that non-reusable products would be favoured. Pedrini and Ferri (2014) deduced that socially conscious consumers were more likely to be of higher income with post secondary education. Smith et al. (2009) concluded that consumer income had an effect on a consumer decision to buy organic produce, which is generally more expensive than non-organic produce. Jacob et al. (2014) postulated that the cost of a product is a driving factor in menstrual product choice for impoverished and low-income women based on their study of women in Mumbai. Environmentally conscious products are typically more expensive than other products, and as such people of low-income would be less inclined to purchase them. The difference between the cost of reusable and non-reusable products varies widely, which is a factor when women consider which menstrual products to purchase. Private cost is an important factor in product choice, and as such is useful to compare between brands.

Environment

There were no studies found that identified the influence of the environment on the purchase of menstrual products, however there were studies that explored the influence of the environment on overall purchase of consumer goods. Torgler et al. (2006) describe several factors that increase the likelihood of a consumer to consider the environmental impact wen making decisions. Political interest, political awareness and social capital affect choice toward environmental conservation positively, whereas age negatively correlates with environmental protection. People who are married, people of higher income, people with jobs and people with formal education have been shown to

correlate with higher environmental protection. Some studies explored by Torgler at al. (2006) show that women have more concern for the health of the environment, whereas other studies show no difference in environmental protection between men and women. Welsh et al. (2010) describe an under-rating of the utility from more environmentally friendly products and an over-rating of the costs associated with environmentally friendly products, which means that in retrospect, consumers derived less pleasure from their purchase decisions when the less environmentally friendly product was chosen, even if the environmental product was more expensive in comparison to competing products. This study also shows that when faced with a purchasing decision, the cost of the product has a greater affect on the purchase decision than consideration for environmental health.

The drivers for women's choice are a combination of peer opinion, product marketing, cost and environment. This information is useful in situating the private cost analysis of the proposed research and explaining potential factors for difference in product choice.

Life Cycle Analysis of Menstrual Products

Life cycle analyses are not common for menstrual products, and as such no clear comparison can be drawn between them. Vink et al. (2003) describe the life cycle of NatureWorks™, a broadly utilized polylactide used in non-woven menstrual products such as pads. Musaazi et al. (2013) present a life cycle analysis of menstrual products available in Uganda, comparing, *Libresse*, a menstrual pad purchased at a discount from non-governmental organizations (NGO's) and local product *Makapads*, made for Africans by Africans and sold by the women of the local area. Musaazi analyzes the life cycle from both the social (SLCA) and environmental (ELCA) views to find that the social implications are similarly important to the environment when considering sustainability. Davidson (2012) qualitatively outlines one possible lifecycle for a tampon without going into detail about numeric lifecycle implications. Mazgaj et al. (2006) is the only study found to date that compare the life cycle of a *Libresse* pad and an o.b. tampon. Although this is a beneficial study, it is not peer-reviewed literature. Overall, the studies conducted focus on non-woven disposable products and are too few for a sufficient comparison. This further supports the need for more studies on the environmental impact of menstrual products.

Environment and Menstrual Products

The production of consumer goods influences the environment from the harvesting or creation of materials, to the production and transportation, to the use and the disposal. Consumer products, such as menstrual products, contribute to negative impacts on the environment during the

products lifecycle. Common effects on the environment are global warming potential, fossil fuel depletion, eutrophication, acidification, abiotic depletion, land use and waste.

Global warming potential

Global warming potential is important to measure because it directly impacts global climate, which indirectly impacts the human environment. Global warming potential is measured by the radiative forcing effects of greenhouse gases emitted to the environment, such as carbon dioxide, methane, halocarbons, water vapour and nitrogen oxides (Tester et al., 2012). Schlesinger and Bernhardt (2013) emphasize the importance of the carbon cycle, noting the chemical properties of carbon dioxide and methane that contribute to the greenhouse gas effect. Humans have been adding more carbon to the carbon cycle and increasing the amount of carbon found in the atmosphere, oceans and soils (Schlesinger & Berhardt, 2013). According to Rockström et al. (2009), a vital planetary boundary to respect is atmospheric carbon dioxide (CO_2) concentration and radiative forcing. According to palaeo-climatic data, the planet did not promote the formation of ice on the planet surface until atmospheric CO_2 concentrations dropped to 450ppm and less, prompting the authors to set a boundary of 350ppm as an acceptable level at which anthropogenic activity can continue. Due to the increase of greenhouse gas emissions, global warming potential, measured in CO_2 equivalent, is an effective measure to estimate the global atmospheric greenhouse gas loading.

Fossil fuel and abiotic depletion

The depletion of abiotic and fossil fuel reserves is important to monitor because they are not easily renewed and the more they are depleted, the less opportunity there is to utilize them (van Oers et al., 2002). This indicator is important to monitor due to their long term regeneration process. Fossil fuel depletion is linked closely with global warming potential because the burning of fossil fuel releases greenhouse gases to the atmosphere.

Acidification

Acidification is an important indicator to monitor because it affects the pH of the environment, such as soils and water. Acidifying compounds can be released to the atmosphere and deposited on ecosystems through precipitation. Once in the ecosystem, it can have negative effects. Acidification of soils has a negative impact on the growth of flora by depleting the soil phosphorus and magnesium (Schlesinger & Berhardt, 2013), and on soil microbes, which have a sensitive pH range (Masters & Ela, 2008). Acidification of water has negative impacts on marine life by altering the pH of the water, which affects the binding properties of chemical compounds and the structure

formation of proteins (Rockström et al., 2009). Coral reefs are the most sensitive areas that will be affected by ocean acidification, however, significant changes to one marine species can have drastic changes on the food web and the local ecology of an area. Likewise, the ocean becomes less efficient as a CO_2 as the pH decreases (Schlesinger & Bernhardt, 2013; Rockström et al., 2009). Acidification has a positive correlation with eutrophication and nutrient loading of environments (Schlesinger & Bernhardt, 2013). It is also related to global warming potential because as acidification increases, pH decreases and methane producing bacteria begin to flourish and create a positive feedback loop (Masters & Ela, 2008). The acidification indicator used in LCA measures the acidification to the global environment rather than the acidification to a particular area. Changes in acidification will affect all ecosystems differently. The LCA measure does not predict which ecosystem will be acidified, however, it is still important to monitor since all environments are connected through global cycles (Schlesinger & Bernhardt, 2013).

Eutrophication

Eutrophication refers to the loading of the environment with available nitrogen (N) and phosphorus (P). In particular, eutrophication leads to nutrient rich water environments that result in algae blooms (Schlesinger & Bernhardt, 2013; Masters & Ela, 2008). While in bloom, the algae make it difficult for marine life to obtain radiation from the sun. Once the algae die and settle to the bottom of the waterway, they then proceed to anaerobically decompose, depleting the biologically available oxygen in the waterway (Mitch & Gosselink, 2007). After the depletion of oxygen, the algae begin to decompose anaerobically, releasing methane, a very potent greenhouse gas. The LCA indicator for eutrophication measures the eutrophication potential of the global environment rather than the eutrophication of a particular ecosystem. Some ecosystems are more sensitive to eutrophication than others. The LCA measure does not predict which ecosystem will become loaded with nutrients, however, it is important to estimate the rate of eutrophication as an indicator of water ecosystem health.

Land use

Land-system change is named as an important planetary boundary by Rockström et al. (2009) because land use change has been the largest driver of ecosystem and biodiversity loss, which reinforce one another in a positive feedback loop. Land use change also has the potential to alter global systems on a hydrological scale, which in turn can have an effect on the global scale.

Consumer products have the possibility of affecting a change in land use, from an undisturbed state to one that could damage the local ecosystem and initiate biodiversity loss.

Waste

The use of consumer goods creates waste in the form of compost, recycling or garbage. Menstrual products create between 250 and 300 pounds of waste per woman in the United States (Borowski, 2011). Menstrual products will either be disposed of in the garbage, where it will be landfilled, or in the toilet where it will be filtered out or get released to a waterway. Once disposed of, the menstrual product may begin to breakdown, depending on the material. Ashley et al. (2005) estimate that 2.5 million tampons are flushed down the toilet daily in the U.K. The amount of waste would vary with the lifespan of the product and the reusability. Non-reusable products, such as tampons would generate more waste than reusable products such as the DivaCup or Sea Pearls.

Menstruation and Vaginal Health

A woman's choice in menstrual product can have an effect on her health as some products encourage bacterial growth and release toxins into the body. To understand the unpriced costs related to health during menstruation, it is important to understand the microbiology and toxicology researched about menstrual products. Vaginal mucous is important in maintaining a balanced bacterial environment (Valore et al., 2002; Aroutcheva et al., 2001). The interruption or absorption of vaginal mucous can lead to an imbalanced pH and vaginal ulcers (Karnacky, 1962). Menstruation provides bacteria with an ideal habitat for growth. The vagina and vulva provide bacteria with an environment in which to thrive, a food source in the form of menstrual fluid, and oxygen. Although bacteria grow more efficiently with oxygen, they can still proliferate at a slower rate in anoxic conditions.

Toxic Shock Syndrome is caused by a toxin excreted during growth of *Staphylococcus aureus*. Menstrual products have been reported to act as a vector for bacteria (Friedrich, 1985) and amplify the production of *S. aureus* (Tierno and Hanna, 1994). Karnacky (1962) did a study that compared the growth of bacteria on a menstrual pad, tampon and menstrual cup. He found that the pad harboured the most bacteria, followed by the tampon and finally the menstrual cup. Smith et al. (1982) collected data on the proliferation of bacteria in the vagina during menstruation, comparing the difference in colonization between women who used tampons and those that use sea sponges. It was found that sea sponges had higher counts for each of the studied 18 bacteria counts than those on the tampon. The Softcup, a brand of one-use menstrual cup, had no effect on colonization of *S.*

aureus and did not increase the colonization of bacteria associated with vaginosis (*Giardia vaginalis* and *Bacteriodes* spp.), vulvovaginitis (*Candida* and other yeast) and urinary tract infections (*Eschirichia coli*). Normal vaginal bacteria, *Lactobacillus,* were maintained during use of the cup (North and Oldham, 2011).

In addition to bacteria is the presence of toxins in menstrual products. Dioxins are a group of chemicals found in paper and wood products that bio-accumulate in fat tissue and are linked to cancer (Archer et al., 2005; Shin & Ahn, 2009; Yang et al., 2011). Dioxins are a by-product of the bleaching of tampons. New bleaching technologies have significantly decreased the presence of dioxins in tampons, but there are still small amounts present. Small amounts would typically not be a concern except that tampons come into contact with some of the most absorbent tissue in the human body, and when combined with bio-accumulation, dioxins from tampons can become a large problem. There is contradictory evidence about the danger from dioxins in menstrual products. Yang et al (2011) researched the long-term menstrual effects of two polychlorinated aromatic hydrocarbons on young women: dibenzo-p-dioxins and dibenzo-furans. They found that women had earlier menarche along with reduced menstruation length with prolonged menstrual bleeding. Shin & Ahn (2009) found that levels of dioxin were low in tampons from the United States, but that even low levels would be a concern. Alternatively, DeVito and Schecter (2002) and Archer et al. (2005) found that dioxin exposure from tampons were well below the FDA standard for exposure.

Menstrual product choice can have an effect on women's health by inhibiting the growth of bacteria and reducing the absorption of toxins. Understanding the microbiological and toxicity related aspects of menstrual products are important to understanding the unpriced costs to health and wellness.

Conclusion

Perceptions and research of menstruation has been shaped by the complex history and stigma surrounding women and menstruation. There have been an increasing number of recent studies about menstruation and menstrual products, but none so far as to describe the life cycle of reusable menstrual products. There are not enough peer-reviewed sources to adequately compare the life cycle of reusable and non-reusable menstrual products. This research is a starting point for life cycle analyses of menstrual products.

3.0 Methods

Women require menstrual products to manage menstrual fluid, either with reusable or non-reusable products. Each menstrual product has a different lifespan which amounts to a different private cost. Each product is also composed of different materials, which amount to different environmental inputs and different health implications. This study will be analyzing five menstrual products and assumes each product to provide equal menstrual protection.

This thesis will address research questions in two ways. (1) A private cost analysis of the five selected menstrual products was conducted, directly comparing the cost to a woman using one product for one, five and ten years of menstruation. (2) A qualitative lifecycle description for each menstrual product, followed by an analysis of primary material impacts in the form of abiotic depletion measured in antimony equivalent, fossil fuel depletion measured in megajoules, global warming potential measured in carbon dioxide equivalent, acidification measured in sulfur dioxide equivalent and eutrophication measured in phosphate equivalent, in addition to the waste produced for each product. Next, the health implications of each product was compiled and presented, including product correlation with Toxic Shock Syndrome as measured by the proliferation of *S. aureus*, dioxin release from products, vaginal mucosal alterations and vaginal ulcers as a result of product use. This data was analyzed using a direct comparison of cost, environmental effects and health implications of each product.

Product Selection and Scope

There are innumerable types, brands and absorbencies of menstrual products. This project compares five specific menstrual products.

- o.b. tampon: This tampon is a rayon/cotton blend of regular absorbency with no applicator. This product is FDA approved and has a lifespan of six hours (Fig 1, a).
- Tampax compak tampon: This tampon is a rayon/cotton blend of regular absorbency with a plastic applicator. This product is FDA approved and has a lifespan of six hours (Fig 1, b).
- Softcup menstrual cup: This menstrual cup is made of polyurethane and kraton polymer plastic and is non-reusable. This product is FDA approved and has lifespan of 12 hours (Fig 1, c).
- DivaCup menstrual cup: This menstrual cup is medical grade silicone and is reusable for multiple cycles. This product is FDA approved and has a lifespan of one year, however, there

have been multiple accounts of the DivaCup lasting ten years. The life spans of this product will be used as the functional time unit (Fig 1, d).

- Sea Pearl sea sponges: These are sea sponges harvested from the ocean. They are not FDA approved, and as such are not able to be marketed as a menstrual product, but are sold for such purpose. They have a lifespan of 6 months per sponge (Fig 1, e).

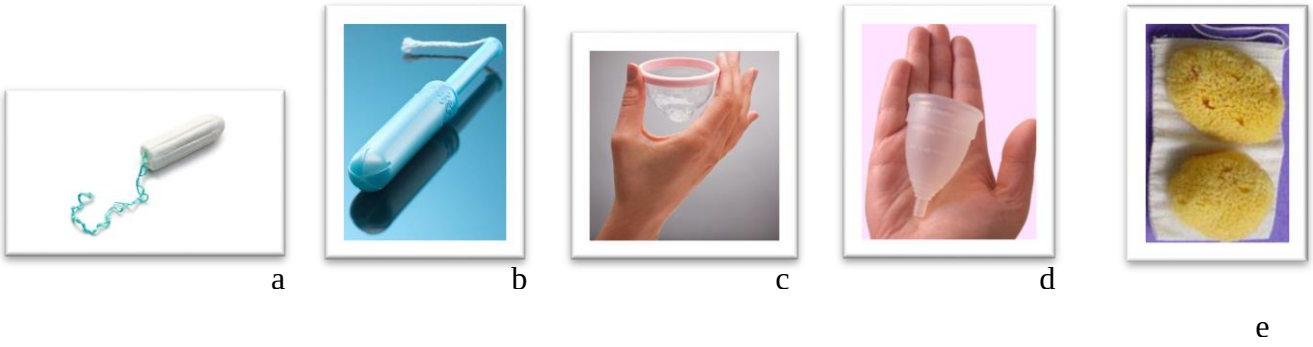

Fig 1. a. o.b.regular tampon. b. Tampax compak regular tampon c. Softcup d. DivaCup e. Sea Pearls

These five products were chosen to represent a wide range of lifespans, from six hours to ten years and a range of unpriced inputs; two tampons were chosen to compare differences in unpriced inputs due to applicators. These five products were also chosen to represent both non-reusable and reusable products that are available for purchase; two tampons were chosen because they appear to be the most popular menstrual product on the market (Czerwinski, 1996; Omar et al., 1997) and two menstrual cups were chosen to represent non-reusable and reusable cups that are available for purchase at pharmacy stores. Sea sponges were chosen as a fifth option because the product site maintains that they are a sustainable option when compared to tampons and cups.

Menstrual Cycle Assumptions

Menstrual cycles range in duration and frequency per year (USDHH, 2012). For this project menstrual cycles are described as light, average and heavy (Table 1).

Table 1. Menstrual cycle duration and frequency

Title of Cycle	Days of Duration	Frequency per Year
Light	3	12
Average	5	13
Heavy	7	13

The number of menstrual products used per cycle, and used per year have been estimated from the menstrual cycle duration and frequency (Table 1) and the product lifespan. It is assumed that each product is used for the entire duration of menstrual cycle and for the all menstrual cycles during the year (Appendix B).

Financial Cost Data Collection

Prices and number of units per package for Tampax Compak regular tampon, o.b. regular tampon, Softcup and DivaCup were collected at selected pharmacy stores. Four pharmacy stores were used to collect data on the two brands of tampons and the two brands of menstrual cups. These stores were chosen because they sell four of the five products. The following stores were used for data collection:

- Lawtons Pharmacy 5991 Spring Garden Rd, Halifax, NS, Canada
- Lawtons Pharmacy 5665 Spring Garden Rd, Halifax, NS, Canada
- Shoppers Drug Mart 5524 Spring Garden Rd and, Halifax, NS, Canada
- Shoppers Drug Mart 6139 Quinpool Rd, Halifax, NS, Canada

The price of the sea sponges were collected from the product website since they are not available for purchase in stores. They are available at http://jadeandpearl.com/sea-pearls-reusable-sea-sponges/#.VHoIoIdlTNY. Given the limited timeframe of this project, only the physically accessible area in which data can be collected was considered.

Any applicable taxes were applied to the final price of each product. In the context of this project, tax was 15%HST. The final price was divided by number of units per package. Shipping and handling and tax was calculated into the cost of the Sea Pearls, and the cost then divided by the individual units per package. The product costs collected over the timeframe were then averaged and the average cost per unit used for final analysis. Data collection was repeated two times a week for four weeks, between the dates of Nov 12th and Dec 12th 2014. The price per unit of all data collected

for each product was averaged over the four weeks and was used as the base cost of product for the analysis of future costs.

The cost of solely using one product for one, five and ten years was calculated. The cost was be calculated for a light, an average and a heavy menstrual cycle (Table 1) based on the number of products used per cycle and number of products used per year (Appendix B). One year was chosen as the lower end because this is the recommended lifespan of the longest-lived product and ten years was chosen as the upper-end because that is the experienced lifespan of the longest-lived product, the DivaCup. Five years was chosen a halfway point between the lower and upper end of the timescale.

The future cost of products was calculated using inflation and discounting.
Inflation rates were assumed to be increasing at a constant rate every year, which were calculated using the average change in inflation from the past four years of the Canadian Price Index (CPI). The average change in inflation used for the calculations of this project was 1.775% per year (Appendix A). Inflation was compounded on the product cost each year after the first year of purchase.

Discounting was applied to the cost after inflation. Three discounting factors will be applied to the costs: 5% to reflect low discounting, 15% to reflect medium discounting and 60% to reflect high discounting. The low discounting factor was chosen based on the average annual discounting of consumer goods, the medium inflation is based on the long term, governmental discounting factor, and the high discounting factor was chosen based on an assumption of high social cost (Bruce, 2007).

Qualitative Unpriced Input Data Collection

Peer-reviewed articles, databases, grey literature, unpublished projects and product websites and publicity that outline any resource, environment or health effects from the five menstrual products or comparable equivalents of each menstrual product was gathered. The five products were compared using the average menstrual flow (Table 1) with a functional unit of one year, assuming sole use of one product for that time period (Appendix B).

Menstrual products were separated and sorted by raw material, then weighed using an AccuLab V200 scale with a capacity of 200g and readability of 0.01g. The average mass per material per unit was calculated. If there were more than one material listed for a particular use (ex: cotton string and polyester string), it was assumed that each material was equally represented in the final product. The mass per material of menstrual product was then multiplied by the environmental impact value. All material impacts were then summed for a total environmental impact score per unit of menstrual product. Data from lifecycle assessments of product materials was gathered from

lifecycle databases. All data sets used were from the Ecoinvent 2.2 database (www.ecoinvent.ch) and all environmental impacts were calculated using the CML - IA Baseline method (http://cml.leiden.edu/software/data-cmlia.htm). Environmental impacts were presented per kilogram of raw material.

The following resource and environmental impacts from menstrual products were considered:

- Abiotic depletion measured in kilograms of antimony equivalent (kg Sb eq.)
- Fossil fuel depletion measured in megajoules (MJ)
- Global warming potential measured in kilograms of carbon dioxide equivalent (kg CO_2 eq.)
- Acidification measured in kilograms of sulfur dioxide equivalent (kg SO_2 eq.)
- Eutrophication measured in kilograms of phosphate equivalent (kg PO_4 eq.)

A Boolean search was conducted using the terms and the databases in Appendix C. An excel spreadsheet for gathered health implications was created. The effects mentioned in the articles relevant to health were listed and then grouped according to relevance and similarities.

The following health implication from menstrual products were considered:

- Correlation with Toxic Shock Syndrome as measured by the proliferation of *Staphylococcus aureus*
- Amount of dioxins released to the vagina
- Recorded correlation with vaginal mucosal alterations, ulcers and pH balance.

The list of unpriced impacts has been narrowed according to the available literature and information from product materials and the Ecoinvent 2.2 database. The unpriced inputs have also been narrowed according to what can be accomplished given the limited timeframe of this project.

The mass of menstrual product per unit was used to calculate the waste for an average menstrual cycle for sole use for one year. The waste per year was presented for one woman and for the Canadian population of average menstruating age (Appendix E, Table 56). It was assumed that one product was used solely for that time period and that the population of women that fall between the ages of 13 and 50 were menstruating (USDHH, 2012).

Analysis

Products were directly compared based on private cost, environmental effects of the product materials and the health implications. Private cost data was analyzed according to the most economical product choice for the temporal scale per unit, per cycle, per year, per 5 years and for 10 years. Products were compared based on the least environmental impacts for a temporal scale per unit, per cycle and per year. Health implications were compared based on the least amount of negative health impacts per product, as described in the literature. Patterns in the data, gaps in research, areas of contradiction and any other apparent trends were described.

Limitations and Delimitations

A limitation of this study is that it is based on the cost of living in Halifax, NS, in particular the Halifax Peninsula. Another limitation is the amount of literature available about product lifecycle, cost benefit analyses, and the limited research about menstrual sea sponges. The delimitations of this study include the short timeframe, which does not allow for a true CBA or LCA. As well, the product choice was narrowed according to what could be analyzed during the limited timeframe of this project and according to product availability in Halifax.

4.0 Results

Private Cost:

The cost per unit of menstrual product is $0.26 for o.b., $0.31 for Tampax, $0.93 for Softcup, $13.23 for Sea Pearls and $40.81 for DivaCup (Fig 2). The three non-reusable products cost significantly less than the two reusable products.

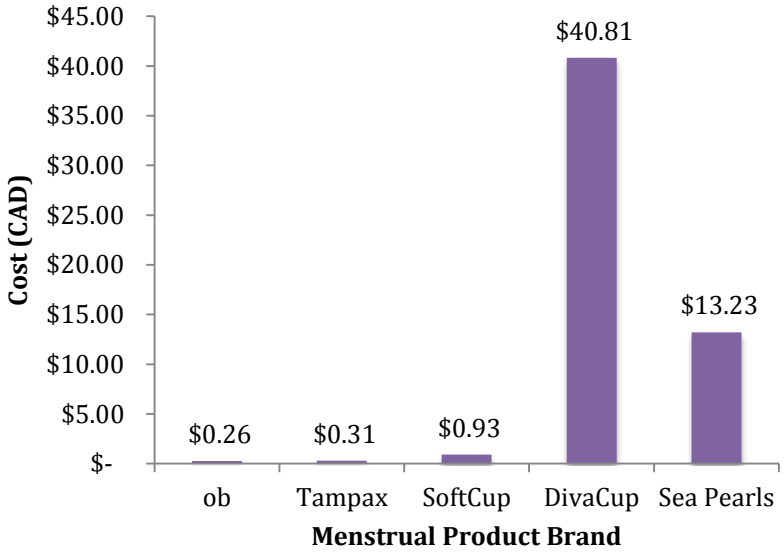

Fig 2. The average cost of menstrual product per unit, in Canadian dollars.

For a temporal scale of one cycle, the cost for the three non-reusable menstrual products increases as the duration of menstruation increases. For the two reusable menstrual products, there is no relationship between the cost for products and the duration of menstruation (Fig 3). The cost of the two reusable menstrual products does not change with an increase in duration of menstruation. Excluding the DivaCup, the cost for menstrual products is comparable for a light menstrual cycle, however, there is increasing disparity in cost between the non-reusable and the reusable menstrual products as menstrual cycle duration increases. At this temporal scale, the cost of the DivaCup is significantly higher than all other menstrual products considered (Fig 3).

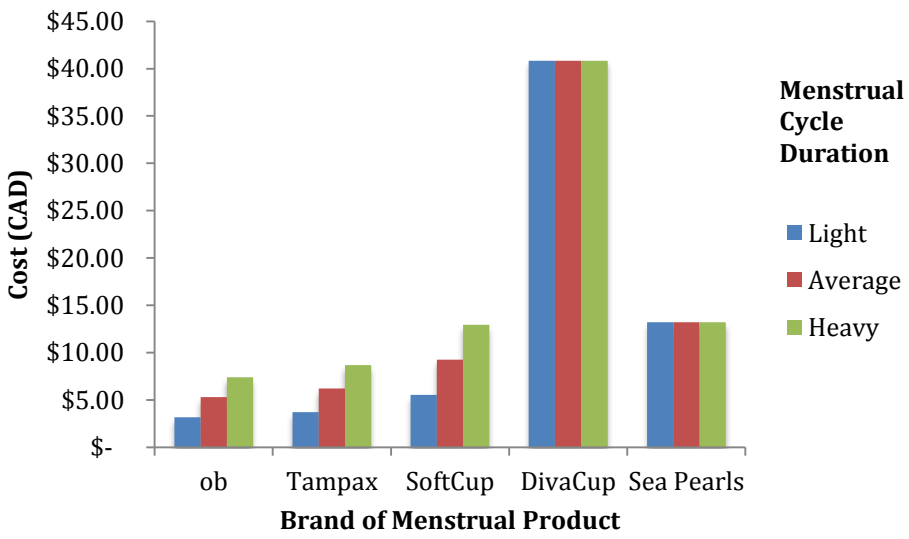

Fig 3. The cost of menstrual product for one menstrual cycle, in Canadian dollars.

For a temporal scale of one year, the private cost of purchasing reusable menstrual products remains the same with increasing menstrual cycle duration, whereas the non-reusable menstrual product cost increases. The yearly cost for a light menstrual cycle duration is comparable between all menstrual products. The most economical option for all menstrual cycle durations is the Sea Pearls. The cost for non-reusable menstrual products is more expensive than reusable products for the average and heavy menstrual cycle durations (Fig 4).

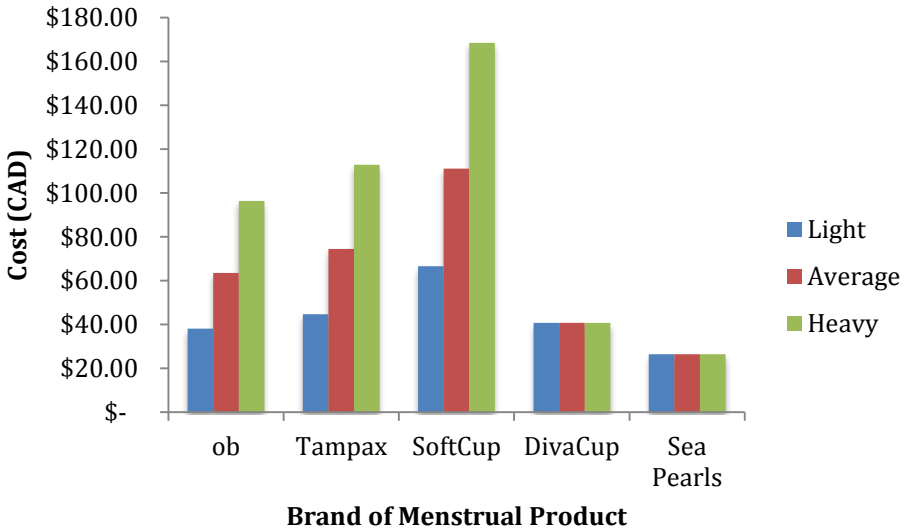

Fig 4. The cost of menstrual product for one year, in Canadian dollars.

Figures 5, 6 and 7 illustrate the product cost for the five menstrual products using the functional time units of one year, five years and ten years. Figure 5 represents a discount rate of 5%, figure 6 represents a discount rate of 15% and figure 7 represents a discount rate of 60%.

The cost for non-reusable menstrual products increase with increasing duration of menstrual cycle and with increasing years of use. The reusable menstrual products show less variation in cost over time. The 5% discount rate shows a large difference in price between the reusable and non-reusable menstrual products (Fig 5), whereas the highest discount rate of 60% shows less difference in cost (Fig 7). The discount rate of 60% shows nearly identical costs for menstrual products bought for five years as menstrual products bought for ten years (Fig 7).

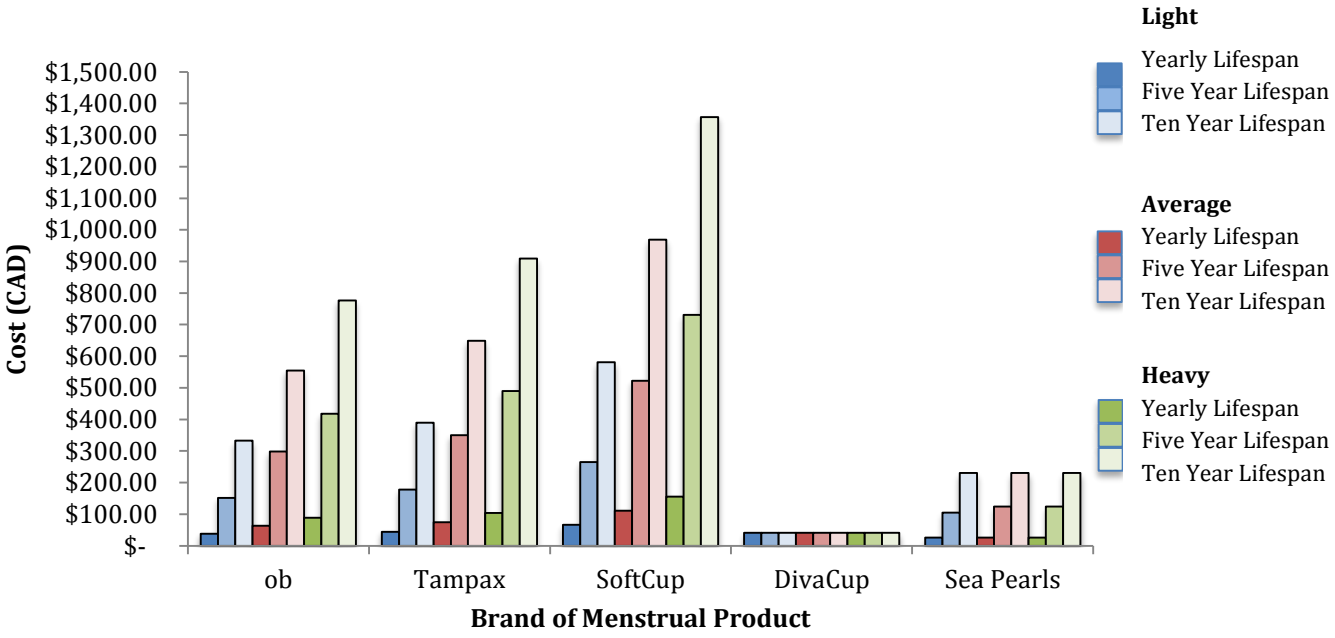

Fig 5. Comparison of the cost of menstrual products with functional time unit of one, five and ten years for light, average and heavy duration, with 5% discount factor in Canadian dollars.

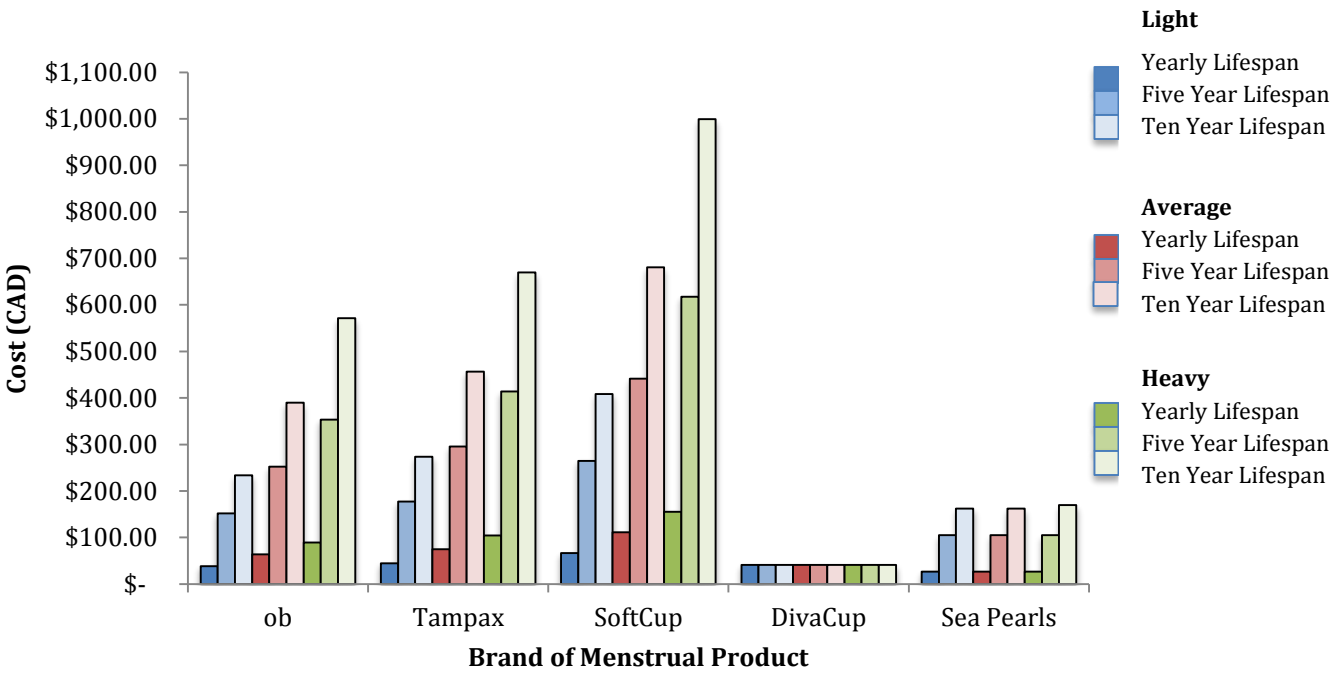

Fig 6. Comparison of the cost of menstrual products with functional time unit of one, five and ten years for light, average and heavy duration, with 15% discount factor in Canadian dollars.

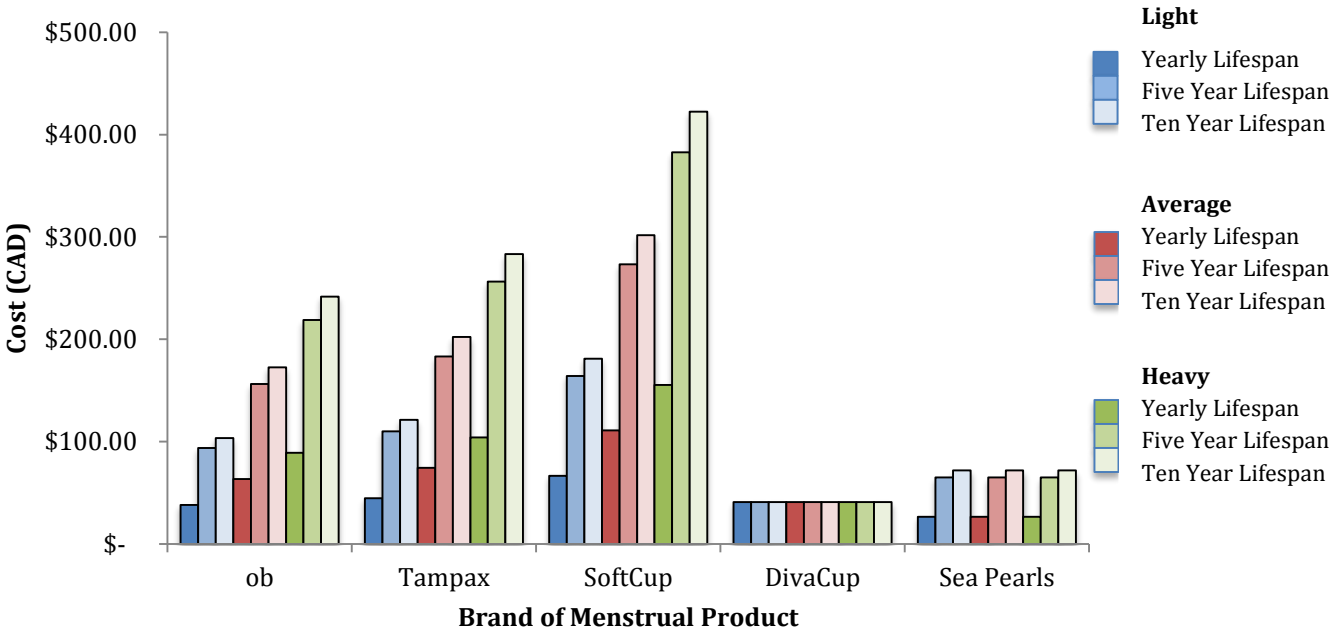

Fig 7. Comparison of the cost of menstrual products with functional time unit of one, five and ten years for light, average and heavy duration, with 60% discount factor in Canadian dollars.

Figures 8, 9 and 10 illustrate the product cost of the five menstrual products using a functional time unit of ten years, with an annual replacement of the DivaCup, replacement at five years and no replacement for ten years. Figure 8 represents a discount rate of 5%, figure 8 represents a discount rate of 15% and figure 9 represents a discount rate of 60%.

The product cost for four out of the five products remains the same when the functional time unit is ten years, with variation in cost associated with menstrual cycle duration. The DivaCup is comparable in cost to the non-reusable menstrual products for a light menstrual cycle duration. The difference between annual replacement of the DivaCup and replacement after five years is significant, whereas the difference in cost between replacement after five years and no replacement for ten years is minimal. The increasing discount rate makes the difference between the cost of non-reusable products and reusable products less pronounced (Fig 8, 9, 10).

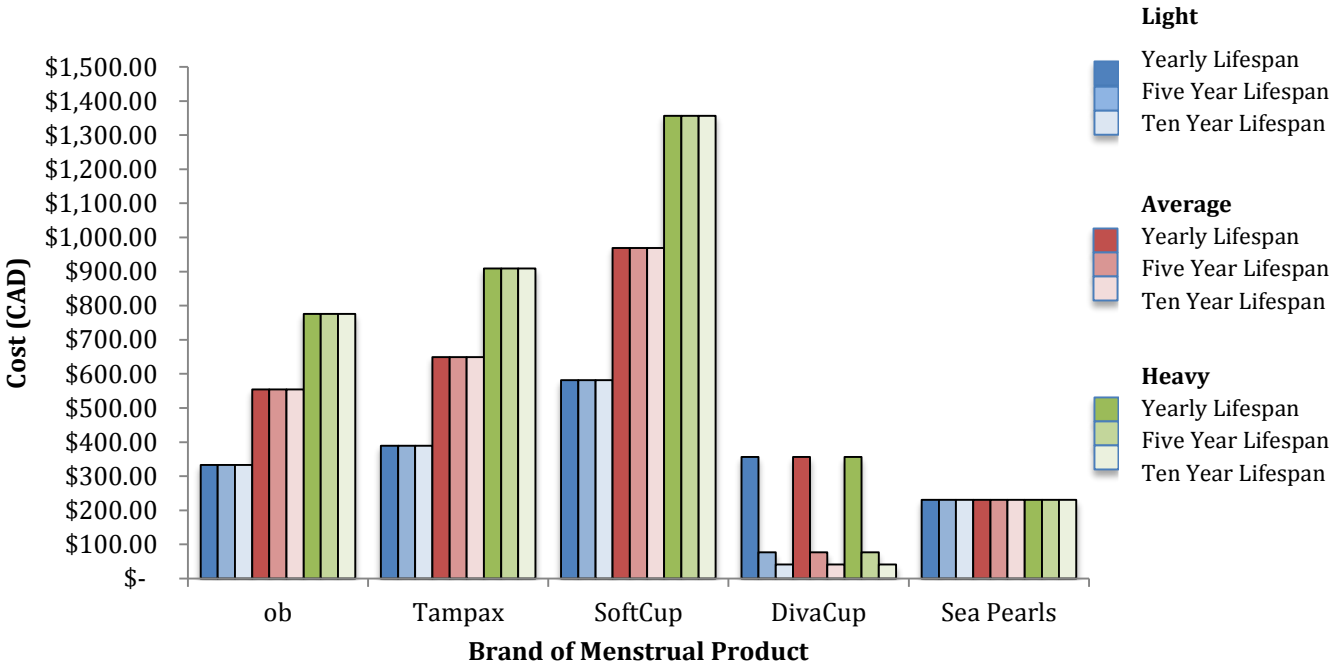

Fig 8. Comparison of the cost of menstrual products with functional time unit of ten years using three lifespans of DivaCup (being replaced every year, every five years, and ten years) for light, average and heavy duration, with 5% discount factor in Canadian dollars.

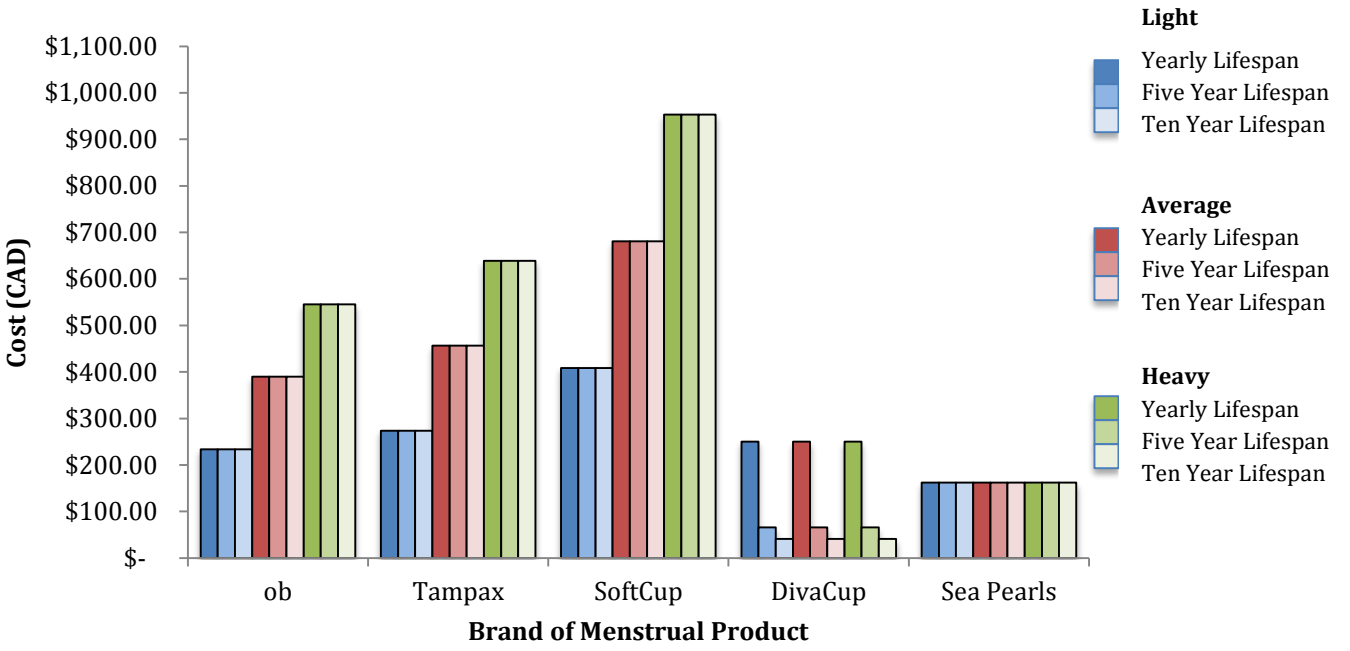

Fig 9. Comparison of the cost of menstrual products with functional time unit of ten years using three lifespans of DivaCup (being replaced every year, every five years, and ten years) for light, average and heavy duration, with 15% discount factor in Canadian dollars.

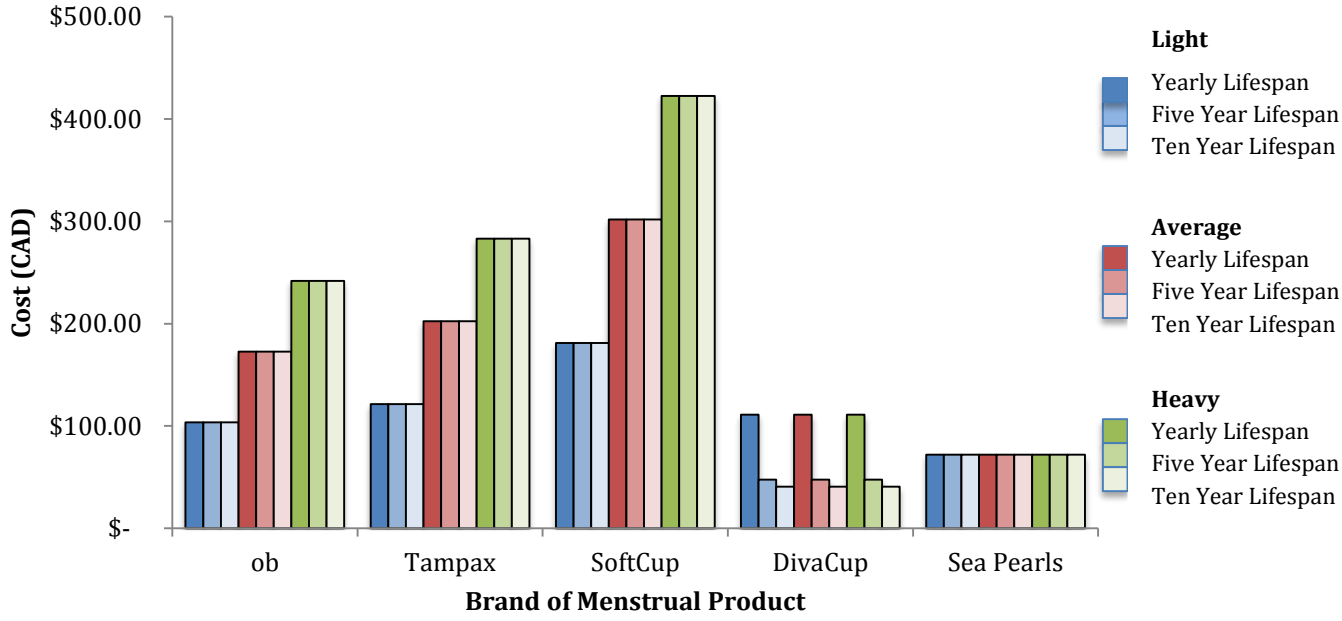

Fig 10. Comparison of the cost of menstrual products with functional time unit of ten years using three lifespans of DivaCup (being replaced every year, every five years, and ten years) for light, average and heavy duration, with 60% discount factor in Canadian dollars.

Qualitative Environmental and Health Implications:

Qualitative Lifecycle Description

The following lifecycle descriptions provide a qualitative assessment of each products potential lifecycle to illustrate the range of inputs and outputs for which could not be accounted in this project.

o.b Tampon

The raw materials, cotton fiber, rayon fiber, cotton string, polyester string and polypropylene string, are first gathered and then transported to the assembly factory. At the factory, the raw materials are processed, reformed or altered, and assembled to form the tampon. The tampon is then individually packaged in polypropylene and the individual tampons packaged together in a box. Packaging requires further materials of cardboard. The packaged product is then transported to the various stores for purchase. After purchase, the products are used, and then either disposed of in the garbage, in which case it would be taken to landfill, or flushed down the toilet where it will travel through the waste water facility, pipes and eventually into a waterway if not filtered out during the process (Davidson, 2012; Mazgaj et al, 2006; o.b., 2015).

Tampax Compak Tampon

The raw materials, cotton, rayon, polyester, are first gathered and then transported to the assembly factory. At the factory, the raw materials are processed, reformed or altered, assembled to form the tampon. Next, each tampon is inserted into a polyethylene applicator. The tampon is then packaged individually in polypropylene, then individual tampons packaged together in a box. Packaging requires further materials of cardboard. The packaged product would then be transported to the various stores for purchase. After purchase, the products are used, and then disposed of either in the garbage, in which case it would be taken to landfill, or flushed down the toilet where it will travel through the waste water facility, pipes and eventually into a waterway if not filtered out during the process (Davidson, 2012; Mazgaj et al., 2006; Tampax, 2015).

Softcup

The raw materials for Softcup are polyurethane and kraton polymer. The raw materials are transported to the production factory where they are processed and formed, then assembled to form a

Softcup. Individual cups are then packaged using polypropylene and individual cups packaged together in a cardboard box. The final packaged product is then transported to stores, where they are sold to customers. After use, SoftCups are disposed of in the garbage, which would then be taken to a landfill.

DivaCup.

The raw material for a DivaCup is medical grade silicone. Materials are first transported to the assembly factory, where the liquid silicone is shaped into the DivaCup form and vulcanized at high heat to retain the shape. The product is then individually packaged in cardboard, and transported to the retail stores where they are bought. During a DivaCup's lifetime, it may be boiled, which has energy and water inputs, or it may be rinsed out, which amounts to more water inputs. The final disposal is in the garbage, where it will end up in a landfill (DivaCup, 2015).

Sea Pearls

Sea Pearls are sea sponges, harvested from either the Mediterranean, Atlantic or Caribbean oceans by a scuba diver. The roots are left intact to allow for regrowth. The harvested sponges are sent to a store to be washed, cut and shaped into spheres. The finished product is put into a fabric bag, and then shipped to customers directly. Sea Pearls are compostable, however, some may end up in the garbage and finally a landfill, or flushed down the toilet and into the local wastewater treatment plant (Jade and Pearl, 2015).

Environmental Implications

The following environmental indicators were calculated based on the raw materials of each product. Information for the raw materials of o.b., Tampax, Softcup and DivaCup were available; the raw materials information for the Sea Pearls was not available, therefore results for Sea Pearls are absent.

Abiotic Depletion

Based on a single unit of menstrual product, the o.b. tampon has the least amount of abiotic depletion at 0.015 g Sb eq., followed next by Tampax at 0.027g, the SoftCup with 0.046g and finally DivaCup at 0.068g (Fig. 11). When compared temporally based on cycle, the DivaCup has the least amount of abiotic depletion at 0.68 g Sb eq., followed by o.b., Softcup and lastly Tampax (Fig 12). There is only one DivaCup used per cycle, so there is no change in the abiotic depletion based on

cycle duration. The o.b., Tampax and Softcup have increased abiotic depletion with increasing cycle duration. When compared temporally for a year, the DivaCup produces the least amount of abiotic depletion, followed by o.b., Softcup and lastly Tampax (Fig 13). Since the DivaCup has a minimum lifecycle of one year, the abiotic depletion from the materials remain the same for one unit as well as for one year.

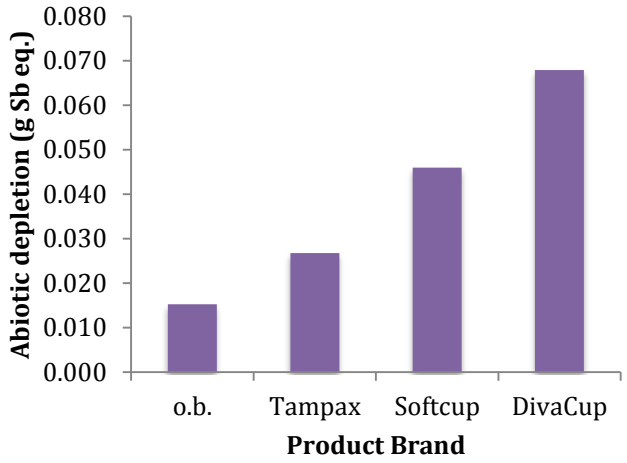

Fig 11. Abiotic depletion for four menstrual products materials per unit, g Sb eq.

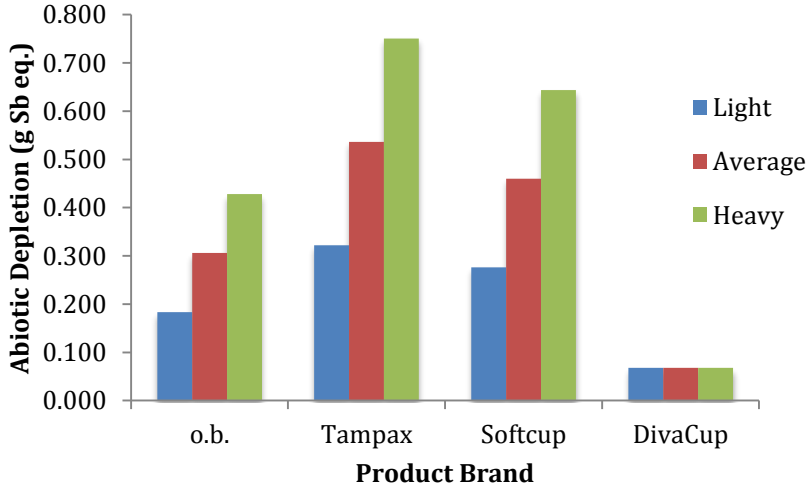

Fig 12. Abiotic depletion for four menstrual product materials per cycle, in g Sb eq.

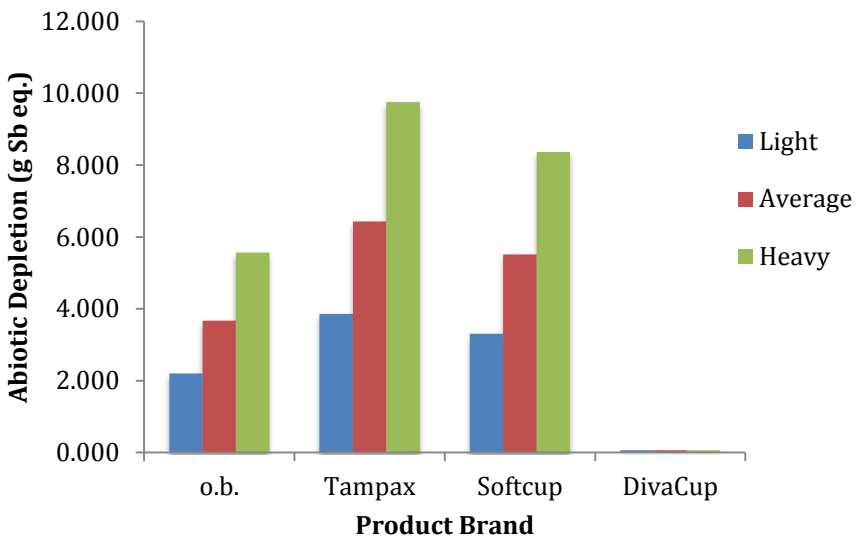

Fig 13. Abiotic depletion of four menstrual product materials per year, in g Sb eq.

Fossil Fuel Depletion

With a temporal scope of one unit, the o.b. produces the least amount of fossil fuel depletion at 83.95 MJ, followed by Tampax with 457.30 MJ, Softcup with 582.69 MJ, and DivaCup with 738.44 MJ (Fig 14). For a temporal scope of one cycle, the o.b. and DivaCup are comparable for a light duration. Overall, the DivaCup produces the least amount of fossil fuel depletion, followed by o.b., Softcup and then Tampax (Fig 15). Temporally for a year, the DivaCup has the least amount of fossil fuel depletion, followed by o.b., Softcup, then Tampax (Fig 16). Since the DivaCup has a lifespan of at least one year, the fossil fuel depletion from the materials remain the same for one unit, one cycle and for one year.

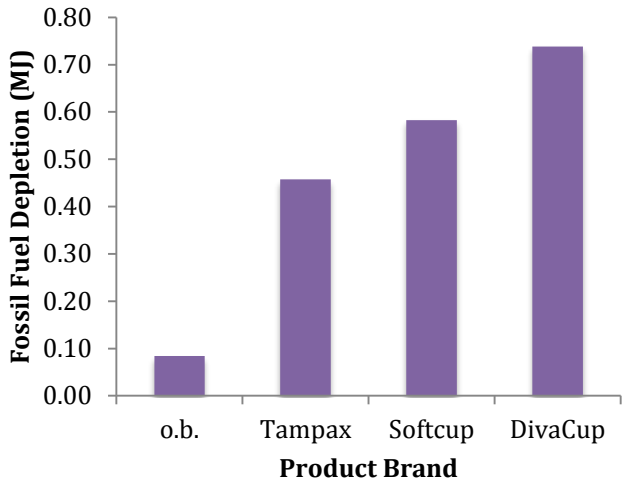

Fig 14. Fossil fuel depletion of four menstrual product materials per unit, in MJ.

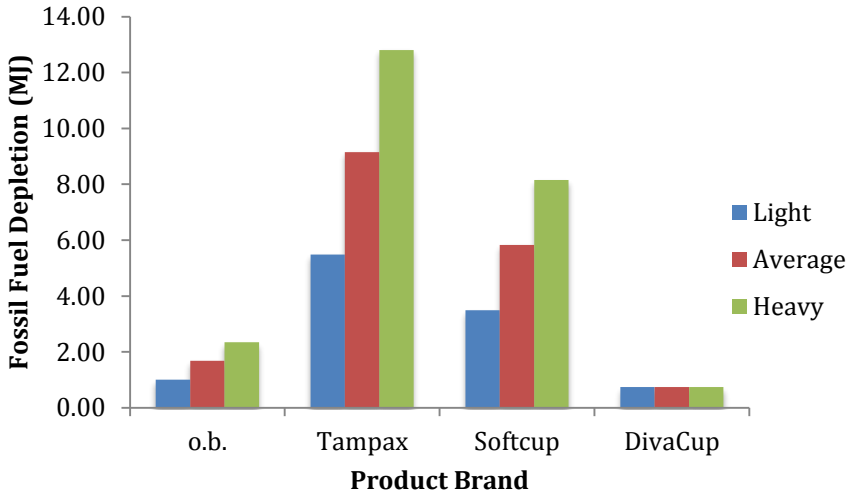

Fig 15. Fossil fuel depletion for four menstrual product materials per cycle, in MJ.

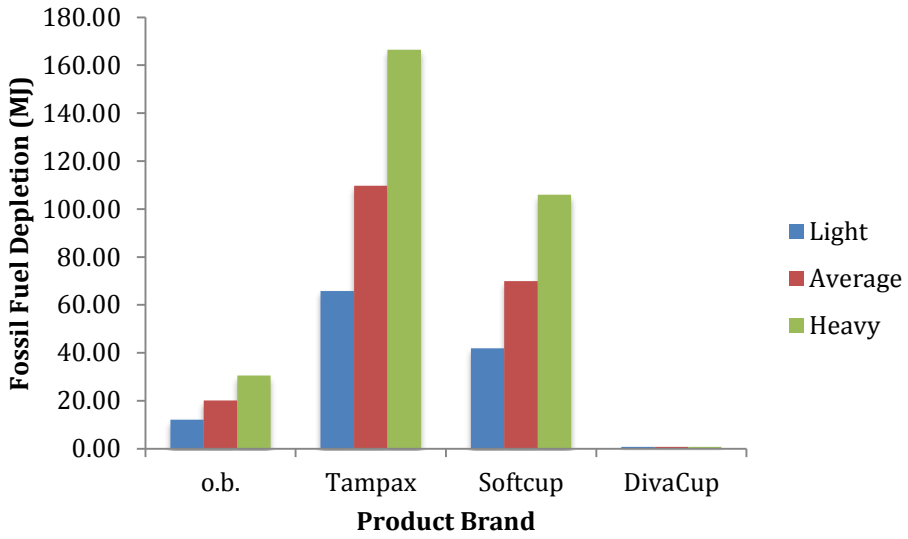

Fig 16. Fossil fuel depletion for four menstrual product materials per year in MJ.

Global Warming Potential

On a single unit basis, the o.b. produces the least amount of global warming potential at 6.49 kg CO_2eq, followed by Tampax at 21.90 kg, Softcup with 26.83 kg and lastly DivaCup with 39.86 kg (Fig 17). When compared for one cycle, the DivaCup has the least amount of global warming potential, followed by o.b., Softcup then Tampax (Fig 18). For a functional time unit of one year, the DivaCup produces the least amount of global warming potential followed by o.b., Softcup then Tampax (Fig 19). The global warming potential from the DivaCup remains the same for one unit, one cycle and one year.

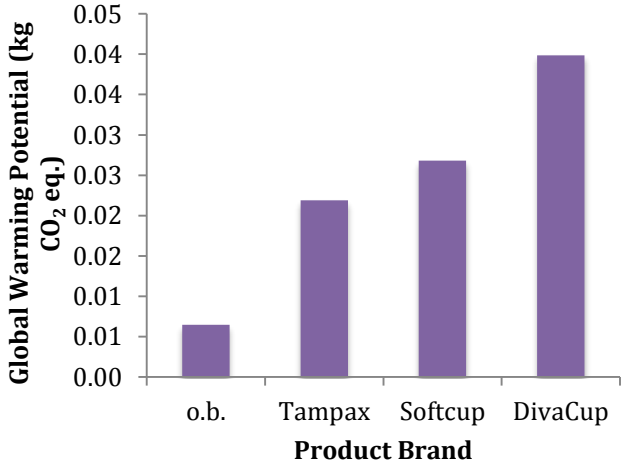

Fig 17. Global warming potential for four menstrual product materials per unit, in kg CO_2 eq.

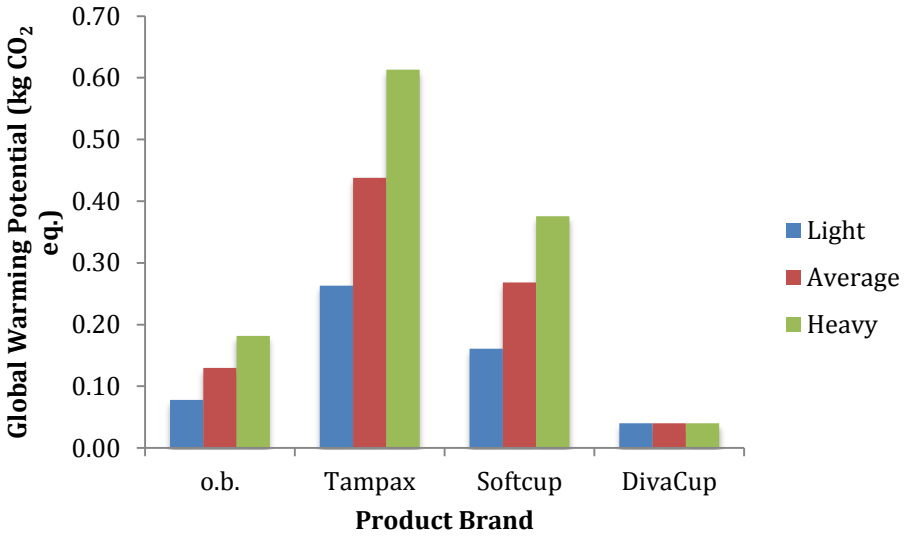

Fig 18. Global warming potential for four menstrual product materials per cycle, in kg CO_2 eq.

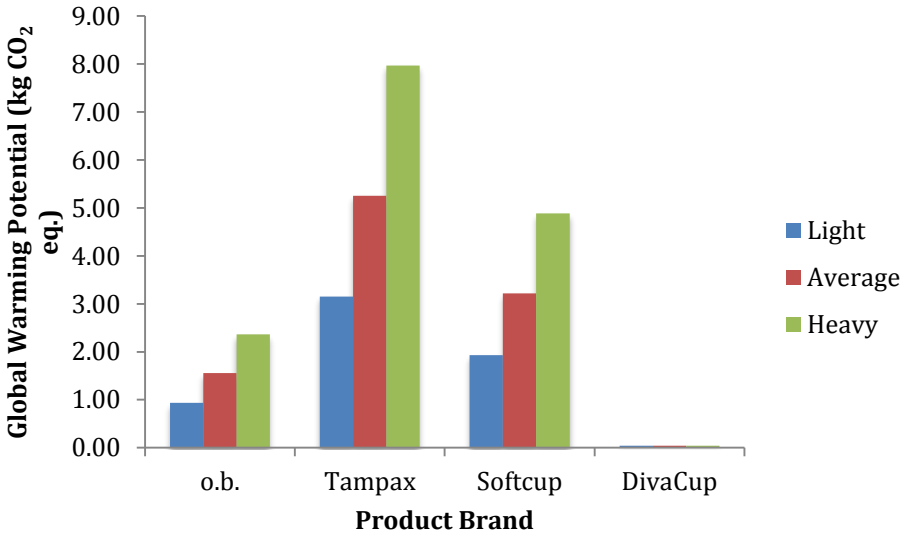

Fig 19. Global warming potential for four menstrual product materials per year, kg CO_2 eq.

Acidification

For a single unit of menstrual product, the o.b. produces the least amount of acidification with 59.35 g SO_2 eq., followed by Tampax at 111.01 g, Softcup 111.87g, and finally DivaCup with the highest at 151.51g (Fig 20). On a temporal scale of one cycle, the DivaCup has the least amount of acidification, followed by Softcup, o.b. and lastly Tampax (Fig 21). For a temporal scale of one year,

the DivaCup materials produce the least amount of acidification, followed by Softcup, o.b., and finally Tampax (Fig 22). The acidification from the DivaCup remains the same for one unit, one cycle and one year.

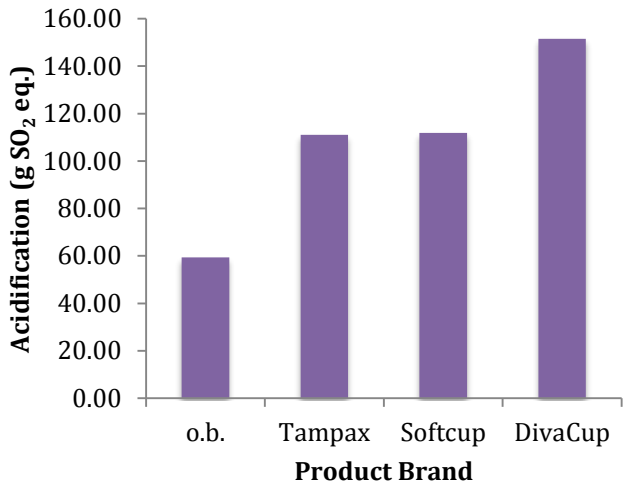

Fig 20. Acidification of four menstrual product materials per unit, in g SO_2 eq.

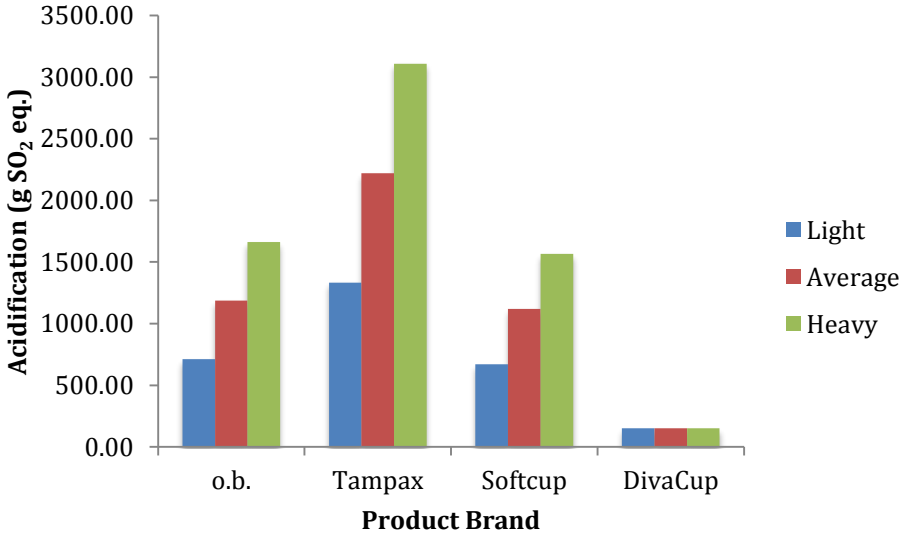

Fig 21. Acidification of four menstrual product materials per cycle, in g of SO_2 eq.

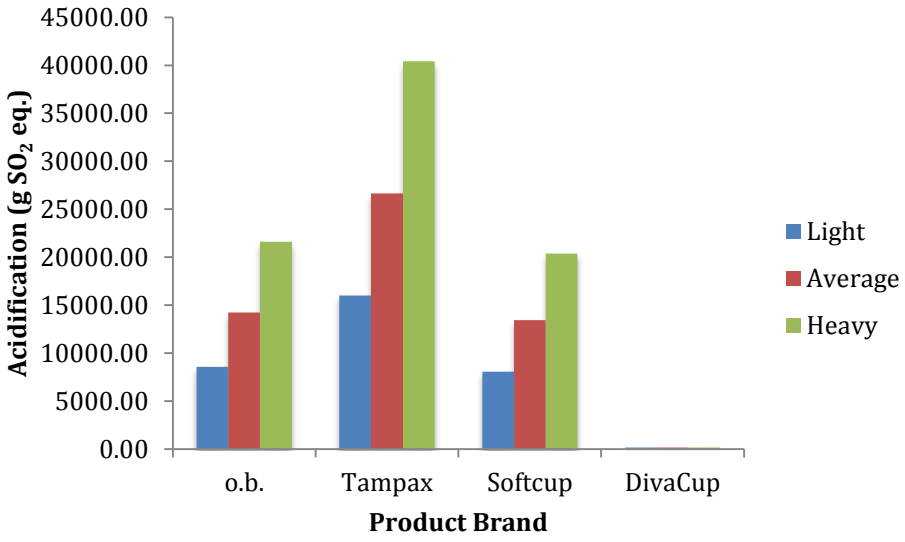

Fig 22. Acidification of four menstrual product materials per year, in g SO_2 eq.

Eutrophication

For a scale of one unit of menstrual product, the Softcup has the least amount of eutrophication at 24.21 g PO_4 eq., followed by o.b. with 25.96 g, Tampax with 42.75 g, and lastly DivaCup with 44.57 g (Fig 23). For a temporal scale of one cycle, the DivaCup produces the least amount of eutrophication, followed by Softcup, o.b., and then Tampax (Fig 24). For a temporal scale of one year, the DivaCup produces the least amount of eutrophication, followed by Softcup, o.b., and then Tampax (Fig 25). The eutrophication from the DivaCup remains the same for one unit, one cycle and one year.

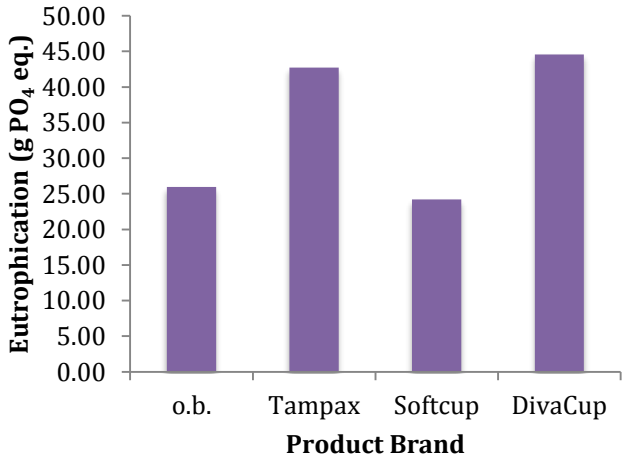

Fig 23. Eutrophication of four menstrual product materials per unit, in g PO_4 eq.

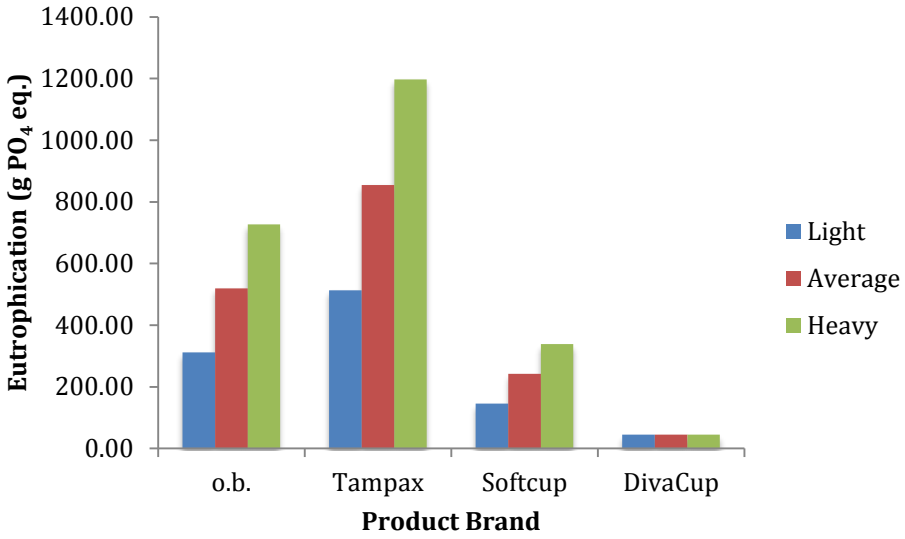

Fig 24. Eutrophication of four menstrual product materials per cycle, in g PO_4 eq.

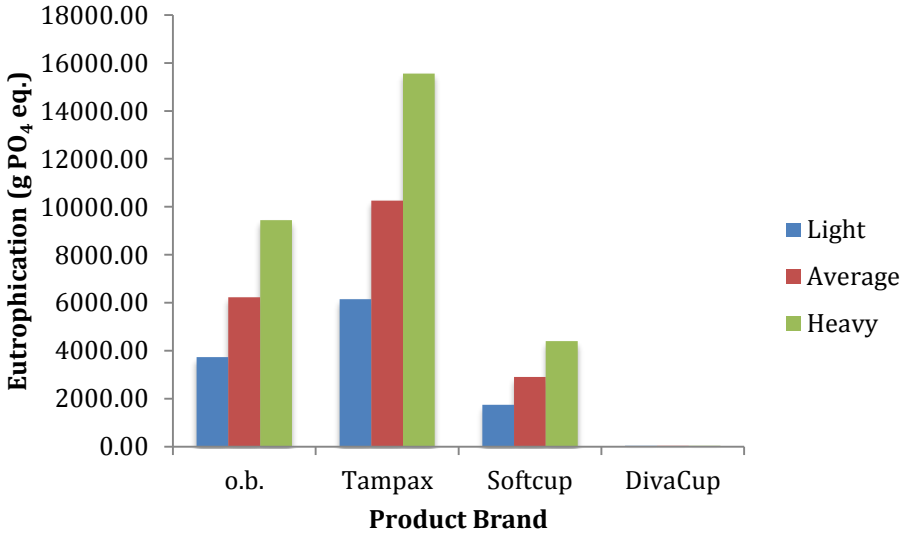

Fig 25. Eutrophication of four menstrual product materials per year, in g PO_4 eq.

Waste

Per woman, the Divacup produces the least amount with 0.01kg of waste per year followed by o.b. with 0.38kg, Softcup with 0.81kg and Tampax with 1.34kg (Table 2). The amount of menstrual product waste produced by the Canadian population, in terms of sole use of one product, is 112,630kg of DivaCups, 2,888,120kg of o.b. tampons, 6,176,688kg of Softcups and 10,223,272kg of Tampax tampons and applicators (Table 2). Information was not available for the Sea Pearls because they were not available for purchase in the study area.

Table 2. Mass of menstrual product weight for average menstrual duration.

Brand	Mass per menstrual product unit (g)	Number of products used per year	Total kilograms of waste per woman per year	Total kilograms of waste for women in Canada per year
o.b.	1.57167	240	0.38	2888120.44
Tampax	5.56333	240	1.34	10223272.57
Softcup	6.7225	120	0.81	6176688.12
DivaCup	14.71	1	0.01	112630.57
Sea Pearls	---	2	---	---

Health Implications

Staphylococcus aureus Proliferation

During proliferation, *S. aureus* releases TSST-1, a toxin that causes Toxic Shock Syndrome. Both brands of tampons produced TSST-1 under laboratory testing, with o.b generating 9.3 μg/ml and Tampax generating 4.0 μg/ml (Tierno & Hanna, 1994). The Today contraceptive sponge, which is a close approximation to Sea Pearls, generated 3.0 μg/ml. Smith et al. (1982) found that there was more growth of *S. aureus* on sea sponges when compared to tampons, while Borowski (2011) states that there is no risk of TSS with sea sponges.

Karnacky (1962) and North & Oldham (2011) found that there was almost no growth of *S. aureus* on menstrual cups. The Softcup website states that there are not enough studies to date to confidently state whether there is bacterial growth with their product (Softcup, 2015).

Dioxins

There is contradictory evidence about the presence of dioxins in tampons. Shin & Ahn (2007) and Yang et al. (2011) state that there is a small release of dibenzo-p-dioxins and dibenzo-furans during the breakdown of cotton and rayon from tampon products inside the vagina, which results in the absorption of dioxins to the body. However, DeVito and Schecter (2002) and Archer et al. (2005) tested the release of dioxins from tampons and diapers and found that there is insignificant release of dioxins as compared to the dioxin guideline of the FDA. The Tampax website found that there are no dioxins in Tampax tampons as described from a self-monitoring study (Tampax, 2015). There are no recorded studies about the release of dioxin for menstrual cups or sea sponges.

Muscosal Alterations

Friedrich (1981) found a positive correlation between the use of tampons and vaginal mucosal alterations. Karnacky (1962) did not find any mucosal alterations with menstrual cups. The Softcup website states that there are no mucosal alterations (Softcup, 2015). There are no studies discussing any mucosal alterations of sea sponges.

pH

Karnacky (1962) found no change in vaginal pH with the use of menstrual cups. The Softcup website states that their product does not cause changes to vaginal pH (Softcup, 2015). There are no studies directly linking tampon use or sea sponge use and changes in vaginal pH.

Ulcers

There is a positive correlation between tampon use and vaginal ulcers (Friedrich, 1981). The Softcup website states that there is no correlation between Softcup use and vaginal ulcers (Softcup, 2015). There are no studies exploring a link between sea sponges and vaginal ulcers.

Table 3. Health impacts collected from academic research and product websites.

	Health Indicator				
	S. aureus	**Dioxins**	**Mucosal Alterations**	**pH**	**Ulcers**
o.b.	9.3 µg/ml of TSST-1 produced in laboratory setting (Tierno & Hanna, 1994)	Releases dibenzo-p-dioxins and dibenzo-furans during the breakdown of the cotton/rayon, and these are absorbed by the vaginal wall and bioaccumulate in fat. (Shin & Ahn, 2007; Yang et al., 2011) Exposure to dioxins insignificant. (DeVito & Schecter, 2002; Archer et al., 2005)	Positive correlation for mucosal alterations. (Friedrich, 1981)		Positive correlation with vaginal ulcers. (Friedrich, 1981)
Tampax	4.0 µg/ml of TSST-1 produced in laboratory setting (Tierno & Hanna, 1994)	Releases dibenzo-p-dioxins and dibenzo-furans during the breakdown of the cotton/rayon, and these are absorbed by the vaginal wall and bioaccumulate in fat. (Shin & Ahn, 2007; Yang et al., 2011) Exposure to dioxins insignificant. (DeVito & Schecter, 2002; Archer et al., 2005) No dioxin found in tampons (Tampax website, internal monitoring results)	Positive correlation for mucosal alterations. (Friedrich, 1981)		Positive correlation with vaginal ulcers. (Friedrich, 1981)
Softcup	~0 in two separate clinical studies. (North and Oldham, 2011; Karnacky, 1962) Not enough studies to date to confidently give an answer (SoftCup website)	Not applicable. (SoftCup website)	No change in mucosal structure. (Karnacky, 1962) No mucosal alterations. (SoftCup website)	No change (Karnacky, 1962; SoftCup website)	No correlation with vaginal ulcers. (SoftCup Website)
DivaCup	~0 in two separate clinical studies. (North and Oldham, 2011; Karnacky, 1962)	Not applicable. (DivaCup website)	No change in mucosal structure. (Karnacky, 1962)	No change in vaginal pH. (Karnacky, 1962)	
Sea Pearls	3.0 µg/ml of TSST-1 produced in laboratory setting. (Tierno & Hanna, 1994) More *S. aureus* than tampon users (Smith et al., 1982) No risk for TSS. (Borowski, 2011)				

5.0 Discussion

This research was spurred by the question, are menstrual products that are marketed as "green" have fewer environmental impacts as compared to other brands? Upon investigation, it was found that there is little research exploring the environmental impacts of menstrual products. Neither an LCA or CBA could be found, which led to an investigation of private cost, environmental impacts and health implications of menstrual products. The following section will discuss the results of the private cost data, the raw material environmental impact data, the health implication data, a gender analysis of the effect of social perceptions followed by the effect of marketing on menstrual products.

Cost

The private cost of goods is a main factor in consumer choice (Smith et al., 2009; Jacob et al., 2014; Ferri, 2014). Menstrual products have widely differing life spans, which make the cost difficult to compare across product brands. The projected cost data collected for this study equates the product lifespans to allow for a cost comparison. Cost data results will be discussed in three parts: the first section expands on the cost of products for up to one year of product purchase since this data did not require further manipulation; the second section focuses on the cost of products for more than one year, which required the application of inflation and discounting; lastly, the implications of the private cost data will be discussed.

On a single unit comparison, the non-reusable products were significantly more economical than the reusable products; the same is true for a cycle comparison, which means that if women are purchasing products for one cycle at a time, the most economical choice is the non-reusable products. The cost of reusable menstrual products remains constant over varying cycle durations since both the DivaCup and Sea Pearls have a lifespan greater than one cycle, whereas the cost of non-reusable products is dependent on cycle duration. For a temporal comparison of one year, the reusable products become the most economical, during which for a light duration cycle there is a comparable cost for o.b., Tampax and DivaCup, however, once the cycle duration increases, the cost of tampons increases as well. If cost were the only factor in a woman's decision when purchasing menstrual products, then it could be assumed that reusable products would be the most popular products, however, studies conducted in research settings show that women prefer tampons (Czerwinski, 1996; Omar et al., 1997), which illustrates that there is more than cost affecting menstrual product choice.

Cost data projected greater than one year were subject to inflation and compared at three different discount rates. The cost projection ends at ten years since this is the experienced lifespan on

a DivaCup. At a discount factor of 5%, the difference between the non-reusable and reusable products varies at approximately the same rate between one, five and ten years, during which time the reusable menstrual products are the most economical products. The cost of the DivaCup if used for more than one year becomes pronounced as the most economical menstrual product, followed by the Sea Pearls. For a discount rate of 15%, the disparity in cost between reusable and non-reusable menstrual products becomes less pronounced, but is still vast. The DivaCup remains the most economical choice for the five and ten year cost projection. For a 60% discount rate, the differences between the five and ten year cost projection become almost negligible. The difference in investing in a DivaCup for five or ten years becomes less drastic than with the previous discounting rates, although it is still the most economical choice among the products compared. The discounting factors affect the future costs of non-reusable menstrual products more than reusable menstrual products, and affect the furthest projected costs the most. The ten year cost projection at varying discount rates show that even at vastly different rates of social cost, the most economical products are the reusable products.

The cost differences between purchasing one unit, and purchasing products for ten years is a very large. The most economical product varies with the temporal scale. If a woman has a short time horizon and is only concerned with purchasing products for the current cycle, then tampons are the most economical choice. If instead, a woman decides to project her purchasing for a year, then the Sea Sponge would be the most economical choice. However, if a woman decides to project her purchases for the next five or ten years, then a DivaCup would be the most economical choice, regardless of time preference.

If women prefer to use tampons to menstrual cups (e.g. Cheng et al., 1995; Koks et al., 1997; Howard et al., 2011; North & Oldham, 2011), then according to the private cost data, women will be spending more money on purchasing tampons regardless of time horizon. Studies suggest that although cost is the most important factor when purchasing a menstrual products, product familiarity, the environment, comfort, convenience and health all play a role in the final decision (e.g. Stewart et al., 2010; Day, 2012). Sela et al. (2009) describe how large subsets of options lead people to choose an option based on a simple justification, such as cost or convenience. Evangelidis and Levav (2013) found that brand dominance can sway product choice away from less prominent brands despite personal interests in things like low cost. Studies such as Sela et al. (2009) and Evangelidis and Levar (2013) suggest that contrary to the data of this study, women may have a longer time horizon than one cycle, but are persuaded by brand dominance and large ranges of options to remain with

what is most familiar to them. Unaccounted for in the consumer choice studies are the influence of peer and family opinion. Koff and Rierdan (1995) and Oster and Thornton (2012) found that peers had a large influence in the use and adoption of menstrual products. Likewise, Britton (1996) emphasizes the role of peers, family and teachers in the understanding about menstruation and menstrual products in young women. Social perceptions, which also play a significant role in product choice, are not well addressed in the consumer choice studies. Social perceptions will be addressed separately later in the discussion.

Howard et al. (2011) included private cost in their comparison study between tampons and menstrual cups. They found that the cost for a DivaCup was comparable to tampons for one year of menstruation, and speculated that if the DivaCup was used for more than one year, there would be significant economic savings. The cost projection for this study expanded on the speculations of Howard et al. (2011) and confirmed that the DivaCup was comparable in cost to tampons on the time horizon of one year, and that the economic savings of using the DivaCup for more than one year is significant. There were slight differences in cost collection between studies, which did not impact a direct comparison between results. Howard et al. (2011) collected data on one day from one location whereas for this study cost was averaged over one month from four locations. Additionally, although the cost data from Howard et al. (2011) was from 2009 in Vancouver, BC, it is consistent with the cost data collected for this study from Halifax, NS, in 2014.

There is gap in the literature about the true costs and benefits of menstrual products. This study had to assume that benefits for each product were comparable, which in actuality is not true. A CBA would account for differences in products benefits and costs, such as effectiveness of menstrual fluid retention, comfort, ease of use, accessibility of product, monetary value of environmental impacts, monetary value of health implications, in addition to private economic cost. A CBA would allow for easier comparison between products and provide more information on which consumers can base their decisions.

Environmental

There are many considerations to account for when considering the environmental impact of each menstrual product. Only five environmental indicators were chosen to compare the menstrual product materials: abiotic depletion, fossil fuel depletion, global warming potential, acidification and eutrophication. These five indicators were used as a proxy for the larger environmental impacts of the menstrual products. Tampax is comprised equally of cotton/rayon and plastic, whereas o.b. is

almost solely cotton/rayon and Softcup is solely plastic. DivaCup is comprised of silicon. Unfortunately sea sponge was not found in the lifecycle databases on material indicators, so it cannot be compared to the other menstrual products.

On a single unit basis, the DivaCup had the most environmental impact in every category, however, once products were compared temporally for one cycle and for one year, the DivaCup had the lowest environmental impact; since one unit can be reused, the input for one unit, one cycle and one year is the same. For the non-reusable menstrual products, on a temporal scale of one cycle and one year, Tampax had the most abiotic and fossil fuel depletion, followed by Softcup and then o.b. The common factor between Tampax and Softcup is the plastic components, which is a component not used greatly in the o.b tampon. This means that abiotic depletion and fossil fuel depletion are likely related to the amount of plastic used in a menstrual product. Similarly, Tampax had the highest global warming potential, followed by Softcup and then o.b., which likely means that global warming potential is linked to the use of plastic in menstrual products. Tampax had nearly double the acidification and eutrophication potential of o.b and Softcup. This shows that acidification and eutrophication are affected almost identically for cotton/rayon products as they are for plastics. It also explains why o.b. and Softcup had comparable values since they are comprised of cotton/rayon and plastic respectively.

The data gathered for environmental impacts were based solely on raw materials, neglecting other sources of outputs such as land use, transportation, at plant assembly, use and method of disposal. The tampons have an effect on land use from the growing of cotton. It is estimated that 2.4% of the world's arable land is used for cotton growing, and requires a lot of water and pesticides to grow (Bevilacqua et al., 2014). The harvesting process is mostly mechanized, which has further fuel, manufacturing and operating outputs from the machinery (Mazgaj et al., 2006; Bevilacqua et al., 2014). After assembling and processing the tampons at the plant, there are transportation inputs for the transportation to stores. Once used, there are waste outputs form tampons; there is volume occupied in landfills, or filtering costs at wastewater plants (Borowski, 2011). These inputs and outputs all have an effect on the environment, which is not accounted for in the analysis of raw material from tampons.

The medical grade silicone for the DivaCup starts as a liquid and is molded into the menstrual cup at high heat to make it retain its form (DivaCup, 2015), which would have outputs from operating machinery and the fuel needed to provide the heat for the vulcanization process. After production, the menstrual cup is transported to stores, which has further outputs from the burning of

fossil fuel. During use of the DivaCup, there may be outputs from the heat required for boiling of water for disinfecting each month. Likewise, there will be water inputs from rinsing the cup between uses. Final disposal requires the product to be transported to a landfill where it will occupy a certain volume.

The Softcup does not specify the exact process of fabrication. Assuming that the polyurethane and kraton polymer are mold injected, there will be inputs from the operation of machinery and the solidification process for each plastic. Likewise, there may be an energy component to the assembly of the polyurethane and kraton polymer if the plastics are fused together. Once assembled and packaged, there will be outputs from transportation in the form of fossil fuel burning. After use, the Softcups will need to be transported to a landfill, where they will occupy a certain volume.

The Sea Pearls require specific habitat, with particular water temperature, nutrients and sunlight, which are all passive inputs from the environment. Only sponges that are five inches or larger are harvested, which means there is a time component to production (Jade and Pearl, 2015). The sponges are harvested by a diver, which has outputs in the form of equipment, boat transportation to harvesting sites and any potential risks to the divers health. Once harvested, the sponges are formed into smaller spheres by hand, and then shipped to customers (Jade and Pearl, 2015), which involves the input of fuel to the transportation source, which likely includes planes since they are an international company.

Comparatively, there are only land use considerations for the tampons and for the sea sponges; the cotton requires active tending with water and fertilizer, whereas the sea sponges are passively tended with nutrients from the ocean. The tampons and menstrual cups both have assembly outputs at the factory, which require electricity from a fuel source. The cotton for tampons requires bleaching and washing, which produces wastewater. The menstrual cups require heat for the silicone or plastics to retain the form of the cups, which requires a fuel source. Outputs from transportation of each of these products will vary, depending on the fuel used, the method of transportation, the distance travelled and the size of shipments. Final disposal of products to the landfill have different outputs in the form of volume, degradation and leachate production (Ashley et al., 2005). According to the calculations from this study, the DivaCup produces the least amount of waste as compared to the other products. The Sea Pearls were not available to weigh, however, given the difference in weight and density between natural sponge material and silicone, the sea sponges likely have less volume of waste. Howard et al. (2011) calculated that 771 248 400 non-reusable products would be disposed of annually in Canada. Borowski (2011) cited that disposable menstrual products account

for between 250 and 300 pounds of waste per woman. The waste calculations for this report do not consider the possible degradation potential of each material. For example, the Sea Pearls are a compostable material (Jade and Pearl, 2015), whereas Softcup consist partly of polyurethane, which does not easily degrade (Gu, 2003; Restrepo-Florez et al., 2014). Tampons will produce a higher volume of waste compared to reusable menstrual products, but plastics are generally more difficult to degrade than cotton. Since sea sponges can be composted (Jade and Pearl, 2015), they will produce some greenhouse gases when decomposing. These potential inputs and outputs from the lifecycles of each product are incomplete and estimated where information was lacking. The potential outputs from the lifecycles are meant to illustrate the range of environmental effects that were not considered in this report, and give some perspective to the environmental impacts from raw materials.

There was very little information about the lifecycles of the menstrual products chosen for this project. Mazgaj et al. (2006) compared the lifecycle of an o.b. tampon and a pad. Their results about the environmental impacts of an o.b. tampon were presented in terms of different environmental indicators and were relative to the pad and therefore no absolute values were available. For these reasons, the data presented by Mazgaj et al. (2006) cannot be compared to this study. There are no peer-reviewed resources about the lifecycle of menstrual products, which is a gap in the research. There is also limited information about the production process of the menstrual cups and the sea sponge. The lifecycle of menstrual products would be useful to fully understand the environmental impact and to compare the inputs and outputs of each product. Over half the population menstruates, so menstrual products are a continuing need in our society and as such, will continue to have an impact on the environment. This information would be useful for consumers to know if they are concerned with their effect on the environment, and to keep companies accountable for their products' effects.

The environmental impacts from raw material show that the DivaCup has the least amount of environmental effect due to the fact that it is reusable. The waste produced in a year also confirms that the reusability of the DivaCup greatly reduces waste when compared to the non-reusable products. The environmental data is limited by the fact that the Sea Pearls were not included in the data analysis. This data is also limited by the lack of information about the lifecycle for each product. The environmental impacts from the raw materials of the menstrual products provides a portion of the environmental impact of menstrual products, but only a small portion. A full lifecycle analysis of each product would provide better comparison between products.

Health

Health implications from menstrual products have been a public concern since the 1980's (). Most research focuses on one aspect of vaginal health; no articles were found reviewing the state of menstrual product effect on vaginal health. Literature exploring vaginal health and menstrual products are discussed below for product correlation with toxic shock syndrome, product release of dioxins, and product correlations with vaginal mucous alterations, vaginal ulcers and alterations of pH. The implications of menstrual products and vaginal health are then discussed, followed by the identification of gaps in research.

Toxic Shock Syndrome (TSS) is the main concern in the literature with regards to menstrual products. It is understood in the literature that *Staphylococcus aureus* produces the toxin TSST-1 during growth in the vagina. Differences in bacterial growth are attributed to differences in growth medium. It is believed that tampons act as a vector, but also provide a warm, moist and nutrient rich environment for the bacteria. The o.b. tampon showed a growth of 9.3 μg/ml of TSST-1 in laboratory experiments, while Tampax showed a growth of 4.0 μg/ml (Tierno & Hanna, 1994), which implies that using Tampax would result in less bacterial growth. Similarly, the sea sponge also acts as a vector for *S. aureus*. Tierno and Hanna (1994) found that the Today sponge, analogous to the Sea Pearls, resulted in 3.0 μg/ml of TSST-1. Borowski (2011) lists no risk for TSS as an advantage to sea sponges, although Smith et al. (1982) found in a comparison study between tampon users and sea sponge users that there were more bacteria on the sea sponges. It was hypothesized by Smith et al. (1982) that due to the fact that the sponge gets reused, that bacteria previously present would be reintroduced to the vagina. The advantage to tampons was that they are sterile and any bacteria introduced to the vagina could be avoided by hand hygiene before and after tampon insertion, particularly with tampons that have applicators (Smith et al., 1982). Karnacky (1962) and North and Oldham (2011) explored the growth of *S. aureus* on menstrual cups and found there to be approximately zero. Karnacky (1962) stipulated that the material of menstrual cups made it difficult for the bacteria to attach and grow. They also believe that the seal of the menstrual cup produces a nearly anaerobic environment, which would limit the oxygen available and inhibit substantial bacterial growth. Assuming analogous hand hygiene practices, it would seem that the menstrual cups would result in the lowest probability of TSS, followed by tampons with applicators, tampons with applicators and finally sea sponges.

There is contradictory research about the presence, type and relevance of dioxins in tampons. Shin and Ahn (2007) and Yang et al. (2011) state that all paper products release dioxins during material breakdown, which is problematic with tampons because they are in contact with sensitive and delicate membranes of the vagina, and once absorbed bioaccumulate in fat. They identified dibezo-p-dioxins and dibenzo-furans in tampons, and concluded that the risk of dioxin exposure from tampons is a concern. DeVito and Schecter (2002) and Archer et al. (2005) did separate studies comparing the levels and types of dioxin in tampons and found that none of the most problematic dioxins were present, and the dioxins present were in much lower concentrations than the FDA standard. They concluded that there is no concern of dioxin exposure from tampons. With regards to the four dioxin studies, it was not possible to compare results between studies because the brand names of the tampons are coded within the results and there are no comparable statistics between studies. The Tampax website also states that their testing shows no dioxins in Tampax tampons (Tampax, 2015). Since dioxins are associated with the breakdown of paper products, dioxin exposure is not applicable to Softcup or DivaCup. It can be extrapolated that there is no risk of dioxin exposure from Sea Pearls due to the material. There is contradictory evidence presented by the studies on dioxins in menstrual products; Shin and Ahn (2007) and Yang et al. (2011) both report that there is a little dioxin release from tampons and that it is a concern, whereas DeVito and Schecter (2002) and Archer et al. (2005) both report that dioxin release from tampons is significantly less than the FDA standard and is not of concern. No conclusions can be drawn from the available literature.

Vaginal mucous is important in providing a protective layer to the vaginal membranes and keeping a balanced pH, which in turn maintains a balanced bacterial community (Aroutcheva et al., 2001). Vaginal mucous also provides a system with which the vagina can maintain a clean environment (Valore et al., 2002). Alterations in vaginal mucous can result in infections, such as yeast infections, and ulcers, which can increase the likelihood of infection and transmission of sexually transmitted infections (Friedrich, 1981). Since tampons are designed to absorb fluid, they invariably absorb vaginal mucous as well, which can lead to an imbalance in the vagina. Friedrich (1981) found that there was a positive correlation between tampon use and mucosal alterations and ulcers. Karnacky (1962) found that there were no changes in vaginal mucous structure with the use of menstrual cups, and that the vaginal pH stayed relatively the same when the menstrual cup was in use as compared to when it was not in use. There were no studies found exploring any connections between menstrual cup use and vaginal ulcers. There were no studies found that explored any

relationships between sea sponges and vaginal mucosal alterations, pH or ulcers, however, due to the absorbent nature of the sea sponge, it can be assumed that there would be some alteration of mucosal structures. According to the available literature, it would seem that menstrual cups produce the least amount of effects to vaginal mucous and pH.

The information for the health implications of menstrual products was collected from existing academic literature. From the collection of the health information, it is clear that there are some gaps in research that can be addressed. Most notable is the lack of research about the personal health implications of Sea Pearls or for sponges for use in the vagina. There was no literature found addressing changes in vaginal mucous, vaginal ulcers or vaginal pH. Tierno and Hanna (1994) and Smith et al. (1982) were the only studies describing the rates of TSST-1 release during use of sponges in controlled setting. The research gaps surrounding sea sponges probably arise from the fact that they are not FDA approved, and as such, not monitored by the FDA. In general, the research found about vaginal health impacts from menstrual products were dated, with studies in some areas no more recent than the 1980's; the only research found that was relatively recent was about dioxins. Another notable research gap found was the contradictory information about dioxin release from tampons. Research in the area of dioxin release from menstrual products should be expanded.

Social Perceptions and Gender

The social perceptions of menstruation guide the way in which menstruation is navigated in advertising and in everyday life. There are conflicting messages about menstruation: menarche is to be celebrated, but menstruation needs to be kept secret; motherhood is respectful, but menstruation is dirty; menstruation is natural, but women must manage and control their menses (Britton, 1996; Charlesworth, 2001). These conflicting notions about menstruation and the female body lead to insecurities and reinforce the need for women to participate in social scripts about menstruation, lest they be treated with less respect due to menses (Roberts et al., 2002). There is a positive feedback loop between advertising for menstrual products and social perceptions of menstruation; taboos are broadcasted widely in advertising which further stigmatize menstruation, which then reinforce taboos in a cyclical manner. Common themes from advertising include menstruation as dirty, shameful and something that needs to be concealed (Del Saz-Rubio & Pennock, 2009; Havens & Swenson, 1988; Simes & Berg, 2000). Through emphasizing these insecurities, menstrual product companies reinforce the need for their products to manage menstruation. In particular, social perceptions influence the purchasing of products. Women are made to feel as objects of sexual desire and begin

to self-monitor themselves as objects of the male gaze (Grose & Grabe, 2014). Many of the prevailing themes from advertising reinforce the dichotomy between being sexy and menstruating; it is impossible to feel dirty and shameful while simultaneously feeling sexually confident. Likewise, being viewed as an object becomes a barrier to intimacy with one's body, which is essential for use of some menstrual products such as menstrual cups. A prevailing barrier to using menstrual cups as cited by menstrual cup uptake studies has been labeled the "ick" factor, which is related to the need to come into contact with menstrual fluid (Stewart et al., 2010; North & Oldham, 2011; Borowski, 2011). The "ick" factor and objectification of women's bodies would lead women to purchase menstrual products that distance themselves from their menstruation, such as tampons with applicators. It is evident that women purchase a lot of tampons with applicators since Tampax, a dominant brand, only offers tampons with applicators. In terms of product cost, the health or environmental implications of given menstrual products, social perceptions will be a dominant factor in women's product choice since social perceptions indicate how a woman must proceed in order to be accepted.

Marketing

The original motivation behind this research was to begin to discern whether the products that are marketed as "green" have less environmental impacts. Softcup's marketing states, "Easy on the Earth. Easy on the wallet" and "no mess sex," intimating that only this product can provide menstrual protection during sex (Softcup, 2015). In comparison to the cost of o.b., Tampax, DivaCup and Sea Pearls, Softcup is the most expensive product. The environmental impact of the raw materials shows that both the DivaCup and o.b. have less impact than the Softcup. From this study it would seem that Softcup's advertising claims are misinformed. DivaCup's website states that their product is "eco-friendly" with "no waste and no chemicals" (Divacup, 2015). According to the environmental impact of the raw materials, the DivaCup has the largest environmental impact per product when compared to the o.b., Tampax and Softcup, however, the environmental impacts become significantly less per cycle and per year of use, since only one cup is used. This study does not account for all environmental impacts, but if the raw materials are a proxy for environmental impact, then the DivaCup has very little effect on the environment. There is some waste from the packaging of the DivaCup, from the disposal, but in comparison to the other products, waste is also negligible. The literature does not show any chemical release from the DivaCup. According to this study, DivaCup's advertising seems well informed. The o.b. website claims that o.b. saves up to one pound of waste as

compared to applicator brands (o.b., 2015). According to the data observed in this study, o.b.'s advertising seems well informed. Tampax and Sea Pearls did not advertise any environmental or health benefits from their products. Aside from the examples above, most advertising focuses on social taboos and reinforcing social perceptions about menstruation rather than the externality benefits of their products. From the information gathered in this study, the DivaCup and o.b. are well informed about the environmental effects and health implications of their products, whereas the Softcup's advertising seems misinformed.

6.0 Conclusion

The motivation for this research was to investigate and compare the cost, environmental and health implications of menstrual products. The cost analysis projected the private economical cost of five menstrual products for ten years, and found that the most economical product choice depended on the time horizon of the consumer; on a unit and cycle basis, the o.b. tampon was most economical, on a year time scale, the Sea Pearls were most economical, whereas the DivaCup was found to be most economical for any time scale greater than one year. The environmental effects of product raw material were described using five environmental indicators. It was found that based on raw materials, the o.b. tampon had the least environmental effect per unit, and the DivaCup had the least environmental effect for one cycle and for one year. The environmental indicator data set did not include the raw material of sea sponge, and as such, the Sea Pearls were not included in the comparison. The mass of waste produced for one year was calculated per product, and it was found that the DivaCup had the least amount of waste. The Sea Pearls were not available for purchase, so they were not included in the waste calculations. The health implications from menstrual products on the body of the consumer were gathered from existing literature. It was found that the menstrual cups had the least amount of health effects. During the research of this project, it was found that there is limited academic research exploring the private cost and environmental effects of menstrual products. Specific to private cost, there were no studies linking consumer behaviour studies and the effect of social perceptions about gender and menstruation on menstrual product choice. This study begins to fill a research gap by equating time horizons of menstrual products to compare economic cost. However, only five of numerous menstrual products were compared in this study, making the overall comparison incomplete. As far as could be found, current research is lacking a cost benefit analysis, which would allow for easier comparison between menstrual products. This project

provides an initial insight into environmental implications of product raw materials and the waste produced, but does not expand on other areas of product lifecycle outputs. Within the literature found about environmental effects, there were few articles exploring the environmental effects of menstrual products with no peer-reviewed academic sources that explored the effects of insertable menstrual products. There were few studies exploring the waste produced by menstrual products. Health implications were more thoroughly researched, however, the articles found are dated and areas of research in the field of dioxins are contradictory. There is no health literature found on sea sponges used for menstruation. Overall, this project provides an initial compilation of results for a few considerations women might have before purchasing insertable menstrual products. There are many gaps in research within the context of menstruation identified in this project, most notably in the area of cost-benefit analysis, lifecycle analysis and dated studies about the effect of menstrual products on vaginal health. Menstruation is prevalent among the Canadian population, and the true effects and impacts from menstrual products should be more carefully studied to help empower decisions of consumers when purchasing products.

References

Al-Khalidi, A. (2000). "The greatest invention of the century": menstruation in visual and material culture. In M. Andrews and M. M. Talbot (Eds), *All the World and Her Husband: Women in Twentieth-Century Consumer Culture* (pp. 65-81). New York, NY: Cassell.

Archer, J.C., Mabry-Smith, R., Shojaee, S., Threet, J., Eckert, J.J., & Litman, V. (2005). Dioxin and furan levels found in tampons. *Journal of Women's Health, 14(4),* 311-315.

Aroutcheva, A., Gariti, D., Simon, M., Shott, S., Farrow, J., Simoes, J., Gurguis, A. & Faro, S. (2001). Defense factors of vaginal lactobacilli. *American Journal of Obstetrics and Gynecology, 185(2),* 375-379.

Ashley, R., Blackwood, D., Souter, N., Hendry, S., Moir, J., Dunkerley, J.,…& Goldie, P. (2005). Sustainable disposal of domestic sanitary waste. *Journal of Environmental Engineering, 131(2),* 206-215.

Bennett, J. (2006). Less money than a man would take. *History Matters: Patriarchy and the Challenge of Feminism,* 102-109.

Bevilacqua, M., Ciarapica, F.E., Mazutto, G. & Paciarotti, C. (2014). Environmental analysis of a cotton yarn supply chain. *Journal of Cleaner Production, 82,* 154-165.

Borowski, A. (2011). *Are American women turning to reusable and greener menstrual products due to health and environmental pollution concerns.* (Unpublished Masters dissertation). Retrieved from RIT Scholar Works. Paper 544.

Britton, C. (1996). Learning about the curse: An Anthropological perspective on experiences of menstruation. *Women's Studies International Forum, 19(6),* 645-653.

Bruce, C. (2007). *Selecting the discount rate*. Retrieved from http://www.economica.ca/ew01_3p3.htm.

Brumberg, J.J. (1997). Sanitizing Puberty: The American Way to Menstruate. In *The Body Project: An Intimate History of American Girls* (pp. 27-56). Toronto: Random House of Canada.

CBC. (2002). *Politician attacks tampon tax*. Retrieved from http://www.cbc.ca/news/canada/politician-attacks-tampon-tax-1.314989.

Charlesworth, D. (2001). Paradoxical constructions of self: Educating young women about menstruation. *Women and Language, 24(2),* 13-20.

Chase D.J., Schenkel, B.P., Fahr, A-M. & Eigner, U. (2007). A prospective, randomized, double-blind study of vaginal microflora and epthelium in women using a tampon with an aperture film cover compared with those in women using a commercial tampon with a cover of nonwoven fleece. *Journal of Clinical Microbiology, 4(45),* p1219-1224. doi:10.1128/JCM.02156-06

Cheng, M., Wilanksy, D., Kung, R., Shime, J., & Hannah, M. (1995). Menses cup evaluation study. *Fertility and Sterility, 64*(3), 661-663.

Czerwinski, B. S. (1996). Adult feminine hygiene practices. *Applied Nursing Research, 9*(3), 123-129. doi:http://dx.doi.org.ezproxy.library.dal.ca/10.1016/S0897-1897(96)80218-7

Davidson, A. (2012). Narratives of menstrual product consumption: Convenience, culture or commoditization? *Bulletin of Science, Technology & Society, 10(6), 1263-1293.*

Del Saz-Rubio, M. M., & Pennock-Speck, B. (2009). Constructing female identities through feminine hygiene TV commercials. *Journal of Pragmatics, 41*(12), 2535-2556. doi:http://dx.doi.org.ezproxy.library.dal.ca/10.1016/j.pragma.2009.04.005

DeVito, M.J. & Schecter, A. (2002). Exposure assessment to dioxins from tampons and diapers. *Journal of Environmental Health Perspectives, 110 (1),* 23-28.

Diva International Inc. (2015). *DivaCup.* Retrieved from http://divacup.com.

Evanglelidis, I. & Levav, J. (2013). Prominence versus dominance: How relationships between alternatives drive decision strategy and choice. *Journal of Marketing Research, L,* 753-766.

Fahs, B. (2014). Genital panics: Constructing the vagina in women's qualitative narratives about pubic hair, menstrual sex, and vaginal self-image. *Body Image, 11*(3), 210-218. doi:http://dx.doi.org.ezproxy.library.dal.ca/10.1016/j.bodyim.2014.03.002

Farage, M.A. (2006). A Behind-the-scenes look at safety assessment of feminine hygiene pads. *Annals of New York Academy of Science, 1092, 66-77.*

Friedrich, E. (1981). Tampon effects on vaginal health. *Clinical obstetrics and gynecology,* 24(2).

Grose, R. G., & Grabe, S. (2014). Sociocultural attitudes surrounding menstruation and alternative menstrual products: The explanatory role of self-objectification. *Health Care for Women International, 35*(6), 677-694. doi:10.1080/07399332.2014.888721

Gu, J-D. (2003). Microbiological deterioration and degradation of synthetic polymeric materials: recent research advances. *International Biodeterioration and Biodegradation, 52,* 69-91.

Havens, B & Swenson, I. (1988). Imagery associated with menstruation in advertising targeted to adolescent women. *Adolesence, 23(89), 89-97.*

Howard, C., Rose, C. L., Trouton, K., Stamm, H., Marentette, D., Kirkpatrick, N., . . . & Paget, J. (2011). FLOW (finding lasting options for women): Multicentre randomized controlled trial comparing tampons with menstrual cups. *Canadian Family Physician Medecin De Famille Canadien, 57*(6), e208-15.

Hwa Shin, J. & Gyong Ahn, Y. (2007). Analysis of polychlorinated dibenzo-p-dioxins and dibenzo-furans in sanitary products of women. *Tectile Research Journal, 77(8), 597-603.*

Jacob, I., Khanna, M., & Yadav, N. (2014). Beyond poverty: A study of diffusion & adoption of feminine hygiene products among low income group women in mumbai. *Procedia - Social and Behavioral Sciences, 148*(0), 291-298. doi:http://dx.doi.org.ezproxy.library.dal.ca/10.1016/j.sbspro.2014.07.045

Jackson, T.E., & Falmagne, R.J. (2013). Women wearing white: Discourses of menstruation and experiences of menarche. *Feminism and Psychology, 23(3),* 379-398.

Jade and Pearl. (2015). *Sea Pearls Reusable Sea Sponges*. Retrieved from http://jadeandpearl.com/sea-pearls-reusable-sea-sponges/.

Karnacky, K. (1962). Internal menstrual protection with rubber menstrual cup. *Obstetrics and Gynecology, 19*(5), 688-&.

Kissling, E.A. (2006). *Capitalizing on the Curse: The Business of Menstruation.* Boulder, Colorado: Lynne Rienner Publishers.

Koff, E. & Rierdan, J. (1995). Preparing girls for menstruation: Advice from adolescent girls. *Adolescence, 30(120),* 795-811.

Koks, C. A., Dunselman, G. A., de Goeij, A. F., Arends, J. W., & Evers, J. L. (1997). Evaluation of a menstrual cup to collect shed endometrium for in vitro studies. *Fertility and Sterility, 68*(3), 560-564.

Larceneux, F., Benoit-Moreau, F., & Renaudin, V. (2011). Why might organic labels fail to influence consumer choices? Marginal labelling and brand equity effects. *Journal of Consumer Policy, 35,* 85-104.

Liswood, R. (1959). Internal menstrual protection - use of a safe and sanitary menstrual cup. *Obstetrics and Gynecology, 13*(5), 539-543.

Masters, G.M. & Ela, W.P. (2008). *Introduction to Environmental Engineering and Science.* Upper Saddle River NJ: Pearson Education Inc.

Mazgaj, M., Yaramenka, K., & Malovana, O. (2006). *Comparative life cycle analysis of sanitary pads and tampons.* (Unpublished dissertation). Retrieved from https://xa.yimg.com/kq/groups/15953006/101965068/name/Sanitary

Mitsch, W.J. & Gosselink, J.G. (2007). *Wetlands, fourth edition.* Hoboken NJ: John Wiley and Sons.

Musaazi, M. K., Mechtenberg, A. R., Nakibuule, J., Sensenig, R., Miyingo, E., Makanda, J. V., . . . & Eckelman, M. J. Quantification of social equity in life cycle assessment for increased

sustainable production of sanitary products in Uganda. *Journal of Cleaner Production*, (0) doi:http://dx.doi.org.ezproxy.library.dal.ca/10.1016/j.jclepro.2013.10.026

North, B. B., & Oldham, M. J. (2011). Preclinical, clinical, and over-the-counter postmarketing experience with a new vaginal cup: Menstrual collection. *Journal of Womens Health, 20*(2), 303-311. doi:10.1089/jwh.2009.1929

o.b. (2015). *o.b.*http://www.ob-tampons.com/

Oinas, E. (1998). Medicalization by whom? Accounts of menstruation conveyed by young women and medical experts in medical advisory columns. *Sociology of health and illness, 20(1),* 52-70.

Omar, H., Aggarwal, S., & Perkins, K. (1997). Tampon use in young females. *Journal of Pediatric and Adolescent Gynecology, 10*(3), 171. doi:http://dx.doi.org.ezproxy.library.dal.ca/10.1016/S1083-3188(97)70249-3

Oster, E. & Thornton, R. (2012). Determinants of technology adoption: Peer effects in menstrual cup-uptake. *Jounal of European Economic Association, 10(6), 1263-1293.*

Pedrini, M., & Ferri, M. (2014). Socio-demographical antecedents of responsible consumerism propensity. *International Journal of Consumer Studies, 38,* 127-138.

Pena, E. (1962). Menstrual protection - advantages of menstrual cup. *Obstetrics and Gynecology, 19*(5), 684-&.

Progressive Grocer. (2014). Feminine hygiene and incontinence products. *Progressive Grocer, 93(7),* 18.

Restrepo-Florez, J-M., Bassi, A. & Thomson, M.R. (2014). Microbial degradation and deterioration of polyethylene: a review. *International Biodeterioration and Biodegradation, 88,* 83-90.

Roberts, T.A & Water, P.L. (2004). Self-Objectification and that "Not so fresh feeling". *Women and Therapy, 27(3),* 5-21.

Roberts, T.A., Goldenberg, J.L., Power, C. & Pyszczynski, T. (2002). "Feminine Protection": The effects of menstruation on attitudes towards women. *Psychology of Women Quarterly, 26,* 131-139.

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S.III, Lambin, E.…& Foley, J. (2009). Planetary Boundaries: Exploring the safe operating space for humanity. *Journal of Ecology and Society, 14 (2).*

Schlesinger, W.H. & Berhaerdt, E. (2013). *Biogeochemistry: An analysis of global change.* Oxford, UK: Elsevier.

Sela, A., Berger, J., & Liu, W. (2009). Variety, vice and virtue: How assortment size influences option choice. *Journal of Consumer Research, 35,* 941-951.

Shin, J.H. & Ahn, Y.G. (2007). Analysis of polychlorinated dibenzo-p-dioxins and dibenzo-furans in sanitary products of women. *Textile Research Journal, 77(8),* 597-603.

Simes, M.R., & Berg D.H. (2000). Surreptitious learning: Menarche and menstrual product and advertisement. *Health Care for Women Internation, 22, 455-469.*

Smith et al. (1982). Bacterial flora of the vagina during the menstrual cycle; Findings in users of tampons, napkins and sea sponges. *Annals of Internal Medicine, 96(2),* 948-951.

Smith, T. A., Huang, C. L. & Lin, B-H. (2009). Does price or income affect organic choice? Analysis of U.S. fresh produce users. *Journal of Agricultural and Applied Economics, 41(3),* 731-744.

Softcup. (2015). *Instead Softcup*. Retrived from http://softcup.com/

Statistics Canada. (2013). *Age (131) and Sex (3) for the Population of Canada and Forward Sortation Areas, 2011 Census.* Retrieved from http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/tbt-tt/Rp-eng.cfm?LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GID=0&GK=0&GRP=1&PID=102009&PRID=0&PTYPE=101955&S=0&SHOWALL=0&SUB=0&Temporal=2011&THEME=88&VID=0&VNAMEE=&VNAMEF=

Stewart, K., Greer, R., & Powell, M. (2010). Women's experience of using the mooncup. *Journal of Obstetrics and Gynaecology, 30*(3), 285-287. doi:10.3109/01443610903572117

Tampax. (2015). *Tampax*. Retrieved from http://tampax.com/en-us

Tester, J.W., Drake, E.M., Driscoll, M.J., Golay, M.W. & Peters, W.A. (2012). *Sustainable Energy: Choosing Among Options, second edition.* Massachusetts: Massachusetts Institute of Technology.

Tierno, P. M., & Hanna, B. A. (1994). Propensity of tampons and barrier contraceptives to amplify *staphylococcus aureus* Toxic shock syndrome toxin-I. *Infectious Diseases in Obstetrics and Gynecology, 2*(3), 140-145. Retrieved from http://search.proquest.com/docview/733498031?accountid=10406

Torgler, B., & Carcia-Valinas, M.A. (2006). The determinants of individuals' attitudes towards preventing environmental damage. *Journal of Ecological Economics, 63, 536-552.* doi:10.1016/j.ecolecon.2006.12.013

Treasury Board of Canada. (2007). *Canadian Cost Benefit Analysis Guide: Regulatory preposals.* Retrieved from http://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf

US Department of Health and Human Services Office on Women's Health. (2012). *Menstruation and the menstrual cycle factsheet.* Retrieved from http://www.womenshealth.gov/publications/our-publications/fact-sheet/menstruation.html#moreInfo .

Valore, E.V., Park, C.H., Igreti, S.L. & Ganz, T. (2002). Antimicrobial components of vaginal fluid. *American Journal of Obstetrics and Gynaecology, 187(3),* 561-568.

van Oers, L., de Koning, Guinee, A. & Huppes, G. (2002) *Abiotic resource depletion in LCA.* Retrieved from http://www.leidenuniv.nl/cml/ssp/projects/lca2/report_abiotic_depletion_web.pdf

Vink, E. T. H., Rábago, K. R., Glassner, D. A., & Gruber, P. R. (2003). Applications of life cycle assessment to NatureWorks™ polylactide (PLA) production. *Polymer Degradation and*

Stability, 80(3), 403-419. doi:http://dx.doi.org.ezproxy.library.dal.ca/10.1016/S0141-3910(02)00372-5

Welsh, H. & Kuhling, J. (2010). Pro-environmental behaviour and rational consumer choice: Evidence from surveys of life satisfaction. *Journal of Economic Psychology, 31, 405-420.* doi:10.1016/j.joep.2010.01.009

Winpenny, J.T. (1995). Dealing with Time. In *The Economic Appraisal of Environmental Projects and Policies: a Practical Guide* (pages of chapter). Location: OECD

Yang, C., Huang, T., Lin, K., Kuo, P., Tsai, P., & Guo, Y. L. (2011). Menstrual effects among women exposed to polychlorinated biphenyls and dibenzofurans. *Environmental Research, 111*(2), 288-294. doi:10.1016/j.envres.2010.11.011

Appendices

Appendix A: Inflation Calculations

Estimate of average inflation using the Canadian Price Index.

Table 4. Information for calculation of average CPI.

Year	CPI	Δ previous year %
2009	114.4	0.3
2010	116.5	1.8
2011	119.9	2.9
2012	121.7	1.5
2013	122.8	0.9

Δ % Average CPI = (0.3+1.8+2.9+1.5+0.9)/5
= 1.775%

Appendix B: Menstrual Product Quantity Calculations

Estimate of number of menstrual products needed per cycle duration

Table 5. Number of o.b regular tampons needed per cycle and per year, based on a product lifespan of six hours.

	Days of Duration	Number of products per 1 cycle	Frequency per Year	Number of products per year
Light	3	12	12	144
Average	5	20	12	240
Heavy	7	28	13	364

Table 6. Number of Tampax Compak regular tampons needed per cycle and per year, based on a product lifespan of six hours.

	Days of Duration	Number of products per 1 cycle	Frequency per Year	Number of products per year
Light	3	12	12	144
Average	5	20	12	240
Heavy	7	28	13	364

Table 7. Number of SoftCup non-reusable menstrual cups needed per cycle and per year, based on a product lifespan of 12 hours.

	Days of Duration	Number of products per 1 cycle	Frequency per Year	Number of products per year
Light	3	6	12	72
Average	5	10	12	120
Heavy	7	14	13	182

Table 8. Number of DivaCup reusable menstrual cups needed per cycle and per year, based on a product lifespan of 1 year.

	Days of Duration	Number of products per 1 cycle	Frequency per Year	Number of products per year
Light	3	1	12	1
Average	5	1	12	1
Heavy	7	1	13	1

Table 9. Number of Sea Pearls sea sponges needed per cycle and per year, based on a product lifespan of 6 months.

Menstrual Cycle	Days of Duration	Number of products per 1 cycle	Frequency per Year	Number of products per year
Light	3	1	12	2
Average	5	1	12	2
Heavy	7	1	13	2

Appendix C: Databases and Search Terms

Databases:
Environmental Science Pollution Management
Web of Science
GreenFILE
Science Direct
EconLit
STOR
Gender Studies Database
WorldCat
Business Source Complete
ABI Inform Global

Search Terms:
Menstruation
menstrual products
feminine hygiene
feminine hygiene products
tampon
menstrual tampon
feminine hygiene tampon
menstrual cup
feminine hygiene cup
menstrual sponge
feminine hygiene sponge
menstrual management

All search terms were searched in correlation with environment, impacts, health, environmental impacts, lifecycle analysis and cost benefit analysis, in each database above.

Appendix D: Cost Results and Data Tables

Cost Results

Table 10. Menstrual product cost for one year of use at three discount factors for three menstrual cycle durations.

		Product				
Cycle	**Discount**	**o.b.**	**Tampax**	**Softcup**	**DivaCup**	**Sea Pearls**
Light	5%	$38.12	$44.65	$66.62	$40.81	$26.45
	15%	$38.12	$44.65	$66.62	$40.81	$26.45
	60%	$38.12	$44.65	$66.62	$40.81	$26.45
Average	5%	$63.53	$74.41	$111.03	$40.81	$26.45
	15%	$63.53	$74.41	$111.03	$40.81	$26.45
	60%	$63.53	$74.41	$111.03	$40.81	$26.45
Heavy	5%	$88.94	$104.18	$155.44	$40.81	$26.45
	15%	$88.94	$104.18	$155.44	$40.81	$26.45
	60%	$88.94	$104.18	$155.44	$40.81	$26.45

Table 11. Menstrual product cost for five years of purchase at three discounting rates for three menstrual cycle durations.

		Product				
Cycle	**Discount**	**o.b.**	**Tampax**	**Softcup**	**DivaCup**	**Sea Pearls**
Light	5%	$179.23	$209.94	$313.25	$40.81	$124.37
	15%	$151.50	$177.47	$264.80	$40.81	$105.13
	60%	$93.83	$109.91	$164.00	$40.81	$65.11
Average	5%	$298.71	$349.90	$522.08	$40.81	$124.37
	15%	$252.50	$295.78	$441.33	$40.81	$105.13
	60%	$156.39	$183.19	$273.34	$40.81	$65.11
Heavy	5%	$418.19	$489.87	$730.92	$40.81	$124.37
	15%	$353.51	$414.09	$617.86	$40.81	$105.13
	60%	$218.94	$256.47	$382.67	$40.81	$65.11

Table 12. Menstrual product cost for ten years of purchase at three discount rates for three menstrual cycle durations.

		Product				
Cycle	**Discount**	**o.b.**	**Tampax**	**Softcup**	**DivaCup**	**Sea Pearls**
Light	5%	$332.57	$389.56	$581.26	$40.81	$230.78
	15%	$233.75	$273.82	$408.55	$40.81	$162.21
	60%	$103.60	$121.36	$181.08	$40.81	$71.90
Average	5%	$554.28	$649.27	$968.77	$40.81	$230.78
	15%	$389.59	$456.36	$680.92	$40.81	$162.21
	60%	$172.67	$202.27	$301.80	$40.81	$71.90
Heavy	5%	$775.99	$908.98	$1,356.27	$40.81	$230.78
	15%	$571.64	$669.61	$999.11	$40.81	$170.01
	60%	$241.74	$283.18	$422.52	$40.81	$71.90

Table 13. Menstrual product cost for ten years with an annual replacement of the DivaCup for three discounting factors for three menstrual cycle durations.

		Product				
Cycle	**Discount**	**o.b.**	**Tampax**	**Softcup**	**DivaCup**	**Sea Pearls**
Light	5%	$332.57	$389.56	$581.26	$356.11	$230.78
	15%	$233.75	$273.82	$408.55	$250.30	$162.21
	60%	$103.60	$121.36	$181.08	$110.94	$71.90
Average	5%	$554.28	$649.27	$968.77	$356.11	$230.78
	15%	$389.59	$456.36	$680.92	$250.30	$162.21
	60%	$172.67	$202.27	$301.80	$110.94	$71.90
Heavy	5%	$775.99	$908.98	$1,356.27	$356.11	$230.78
	15%	$571.64	$669.61	$999.11	$250.30	$170.01
	60%	$241.74	$283.18	$422.52	$110.94	$71.90

Table 14. Menstrual product cost for ten years with replacement of the DivaCup after five years for three discounting factors for three menstrual cycle durations.

		Product				
Cycle	**Discount**	**o.b.**	**Tampax**	**Softcup**	**DivaCup**	**Sea Pearls**
Light	5%	$332.57	$389.56	$581.26	$76.84	$230.78
	15%	$233.75	$273.82	$408.55	$65.85	$162.21
	60%	$103.60	$121.36	$181.08	$47.50	$71.90
Average	5%	$554.28	$649.27	$968.77	$76.84	$230.78
	15%	$389.59	$456.36	$680.92	$65.85	$162.21
	60%	$172.67	$202.27	$301.80	$47.50	$71.90
Heavy	5%	$775.99	$908.98	$1,356.27	$76.84	$230.78
	15%	$571.64	$669.61	$999.11	$65.85	$170.01
	60%	$241.74	$283.18	$422.52	$47.50	$71.90

Table 15. Menstrual product cost for ten years with no replacement of the DivaCup for three discounting factors for three menstrual cycle durations.

		Product				
Cycle	**Discount**	**o.b.**	**Tampax**	**Softcup**	**DivaCup**	**Sea Pearls**
Light	5%	$332.57	$389.56	$581.26	$40.81	$230.78
	15%	$233.75	$273.82	$408.55	$40.81	$162.21
	60%	$103.60	$121.36	$181.08	$40.81	$71.90
Average	5%	$554.28	$649.27	$968.77	$40.81	$230.78
	15%	$389.59	$456.36	$680.92	$40.81	$162.21
	60%	$172.67	$202.27	$301.80	$40.81	$71.90
Heavy	5%	$775.99	$908.98	$1,356.27	$40.81	$230.78
	15%	$571.64	$669.61	$999.11	$40.81	$170.01
	60%	$241.74	$283.18	$422.52	$40.81	$71.90

Cost Data

Table 16. Cost of five menstrual products for a light menstrual cycle, based on the annual replacement of the Diva Cup with inflation applied, including tax and shipping where applicable, in Canadian dollars.

			Time (yrs)									
Product Brand	**Price per Unit**	**Price per cycle**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	0.264691667	$3.18	$38.12	$38.79	$39.48	$40.18	$40.89	$41.62	$42.36	$43.11	$43.88	$44.66
Tampax	0.310057341	$3.72	$44.65	$45.44	$46.25	$47.07	$47.90	$48.75	$49.62	$50.50	$51.40	$52.31
Softcup	0.925257143	$5.55	$66.62	$67.80	$69.00	$70.23	$71.48	$72.74	$74.04	$75.35	$76.69	$78.05
DivaCup	40.8135	$40.81	$40.81	$41.54	$42.28	$43.03	$43.79	$44.57	$45.36	$46.16	$46.98	$47.82
Jade and Pearl	13.225	$13.23	$26.45	$26.92	$27.40	$27.88	$28.38	$28.88	$29.39	$29.92	$30.45	$30.99

Table 17. Cost of five menstrual products for a light menstrual cycle, based on the annual replacement of the Diva Cup with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**Present Value (PV) of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$332.57	$38.12	$36.94	$35.81	$34.71	$33.64	$32.61	$31.61	$30.64	$29.70	$28.79
Tampax	$389.56	$44.65	$43.28	$41.95	$40.66	$39.41	$38.20	$37.03	$35.89	$34.79	$33.72
Softcup	$581.26	$66.62	$64.57	$62.59	$60.67	$58.80	$57.00	$55.25	$53.55	$51.91	$50.31
DivaCup	$356.11	$40.81	$39.56	$38.34	$37.17	$36.03	$34.92	$33.85	$32.81	$31.80	$30.82
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 18. Cost of five menstrual products for a light menstrual cycle, based on the annual replacement of the Diva Cup with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**Present Value (PV) of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$233.75	$38.12	$33.73	$29.85	$26.42	$23.38	$20.69	$18.31	$16.21	$14.34	$12.69
Tampax	$273.82	$44.65	$39.51	$34.97	$30.95	$27.39	$24.24	$21.45	$18.98	$16.80	$14.87
Softcup	$408.55	$66.62	$58.96	$52.18	$46.18	$40.87	$36.17	$32.01	$28.33	$25.07	$22.19
DivaCup	$250.30	$40.81	$36.12	$31.97	$28.29	$25.04	$22.16	$19.61	$17.35	$15.36	$13.59
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 19. Cost of five menstrual products for a light menstrual cycle, based on the annual replacement of the Diva Cup with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**Present Value (PV) of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$103.60	$38.12	$24.25	$15.42	$9.81	$6.24	$3.97	$2.52	$1.61	$1.02	$0.65
Tampax	$121.36	$44.65	$28.40	$18.07	$11.49	$7.31	$4.65	$2.96	$1.88	$1.20	$0.76
Softcup	$181.08	$66.62	$42.38	$26.95	$17.15	$10.91	$6.94	$4.41	$2.81	$1.79	$1.14
DivaCup	$110.94	$40.81	$25.96	$16.51	$10.50	$6.68	$4.25	$2.70	$1.72	$1.09	$0.70
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Table 20. Cost of five menstrual products for a light menstrual cycle, based on the replacement of the Diva Cup after five years with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$332.57	$38.12	$36.94	$35.81	$34.71	$33.64	$32.61	$31.61	$30.64	$29.70	$28.79
Tampax	$389.56	$44.65	$43.28	$41.95	$40.66	$39.41	$38.20	$37.03	$35.89	$34.79	$33.72
Softcup	$581.26	$66.62	$64.57	$62.59	$60.67	$58.80	$57.00	$55.25	$53.55	$51.91	$50.31
DivaCup	$76.84	$40.81	$-	$-	$-	$36.03	$-	$-	$-	$-	$-
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 21. Cost of five menstrual products for a light menstrual cycle, based on the replacement of the Diva Cup after five years with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$233.75	$38.12	$33.73	$29.85	$26.42	$23.38	$20.69	$18.31	$16.21	$14.34	$12.69
Tampax	$273.82	$44.65	$39.51	$34.97	$30.95	$27.39	$24.24	$21.45	$18.98	$16.80	$14.87
Softcup	$408.55	$66.62	$58.96	$52.18	$46.18	$40.87	$36.17	$32.01	$28.33	$25.07	$22.19
DivaCup	$65.85	$40.81	$-	$-	$-	$25.04	$-	$-	$-	$-	$-
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 22. Cost of five menstrual products for a light menstrual cycle, based on the replacement of the Diva Cup after five years with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$103.60	$38.12	$24.25	$15.42	$9.81	$6.24	$3.97	$2.52	$1.61	$1.02	$0.65
Tampax	$121.36	$44.65	$28.40	$18.07	$11.49	$7.31	$4.65	$2.96	$1.88	$1.20	$0.76
Softcup	$181.08	$66.62	$42.38	$26.95	$17.15	$10.91	$6.94	$4.41	$2.81	$1.79	$1.14
DivaCup	$47.50	$40.81	$-	$-	$-	$6.68	$-	$-	$-	$-	$-
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Table 23. Cost of five menstrual products for a light menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b	$332.57	$38.12	$36.94	$35.81	$34.71	$33.64	$32.61	$31.61	$30.64	$29.70	$28.79
Tampax	$389.56	$44.65	$43.28	$41.95	$40.66	$39.41	$38.20	$37.03	$35.89	$34.79	$33.72
Softcup	$581.26	$66.62	$64.57	$62.59	$60.67	$58.80	$57.00	$55.25	$53.55	$51.91	$50.31
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 24. Cost of five menstrual products for a light menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$233.75	$38.12	$33.73	$29.85	$26.42	$23.38	$20.69	$18.31	$16.21	$14.34	$12.69
Tampax	$273.82	$44.65	$39.51	$34.97	$30.95	$27.39	$24.24	$21.45	$18.98	$16.80	$14.87
Softcup	$408.55	$66.62	$58.96	$52.18	$46.18	$40.87	$36.17	$32.01	$28.33	$25.07	$22.19
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 25. Cost of five menstrual products for a light menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of all expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
OB	$103.60	$38.12	$24.25	$15.42	$9.81	$6.24	$3.97	$2.52	$1.61	$1.02	$0.65
Tampax	$121.36	$44.65	$28.40	$18.07	$11.49	$7.31	$4.65	$2.96	$1.88	$1.20	$0.76
SoftCup	$181.08	$66.62	$42.38	$26.95	$17.15	$10.91	$6.94	$4.41	$2.81	$1.79	$1.14
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Table 26. Cost of five menstrual products for an average menstrual cycle, based on the annual replacement of the Diva Cup with inflation applied, including tax and shipping where applicable, in Canadian dollars.

			Time (yrs)									
Product Brand	**Price per Unit**	**Price per Cycle**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$0.26	$5.29	$63.53	$64.65	$65.80	$66.97	$68.16	$69.37	$70.60	$71.85	$73.13	$74.43
Tampax	$0.31	$6.20	$74.41	$75.73	$77.08	$78.45	$79.84	$81.26	$82.70	$84.17	$85.66	$87.18
Softcup	$0.93	$9.25	$111.03	$113.00	$115.01	$117.05	$119.13	$121.24	$123.39	$125.58	$127.81	$130.08
DivaCup	$40.81	$40.81	$40.81	$41.54	$42.28	$43.03	$43.79	$44.57	$45.36	$46.16	$46.98	$47.82
Jade and Pearl	$13.23	$13.23	$26.45	$26.92	$27.40	$27.88	$28.38	$28.88	$29.39	$29.92	$30.45	$30.99

Table 27. Cost of five menstrual products for an average menstrual cycle, based on the annual replacement of the Diva Cup with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$554.28	$63.53	$61.57	$59.68	$57.85	$56.07	$54.35	$52.68	$51.06	$49.50	$47.98
Tampax	$649.27	$74.41	$72.13	$69.91	$67.77	$65.68	$63.67	$61.71	$59.82	$57.98	$56.20
Softcup	$968.77	$111.03	$107.62	$104.32	$101.11	$98.01	$95.00	$92.08	$89.25	$86.51	$83.85
DivaCup	$356.11	$40.81	$39.56	$38.34	$37.17	$36.03	$34.92	$33.85	$32.81	$31.80	$30.82
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 28. Cost of five menstrual products for an average menstrual cycle, based on the annual replacement of the Diva Cup with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$389.59	$63.53	$56.22	$49.76	$44.03	$38.97	$34.49	$30.52	$27.01	$23.91	$21.16
Tampax	$456.36	$74.41	$65.86	$58.28	$51.58	$45.65	$40.40	$35.75	$31.64	$28.00	$24.78
Softcup	$680.92	$111.03	$98.26	$86.96	$76.96	$68.11	$60.28	$53.35	$47.21	$41.78	$36.98
DivaCup	$250.30	$40.81	$36.12	$31.97	$28.29	$25.04	$22.16	$19.61	$17.35	$15.36	$13.59
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 29. Cost of five menstrual products for an average menstrual cycle, based on the annual replacement of the Diva Cup with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$172.67	$63.53	$40.41	$25.70	$16.35	$10.40	$6.62	$4.21	$2.68	$1.70	$1.08
Tampax	$202.27	$74.41	$47.33	$30.11	$19.15	$12.18	$7.75	$4.93	$3.14	$1.99	$1.27
Softcup	$301.80	$111.03	$70.63	$44.92	$28.58	$18.18	$11.56	$7.35	$4.68	$2.98	$1.89
DivaCup	$110.94	$40.81	$25.96	$16.51	$10.50	$6.68	$4.25	$2.70	$1.72	$1.09	$0.70
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Table 30. Cost of five menstrual products for an average menstrual cycle, based on replacement of the Diva Cup after five years with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$554.28	$63.53	$61.57	$59.68	$57.85	$56.07	$54.35	$52.68	$51.06	$49.50	$47.98
Tampax	$649.27	$74.41	$72.13	$69.91	$67.77	$65.68	$63.67	$61.71	$59.82	$57.98	$56.20
Softcup	$968.77	$111.03	$107.62	$104.32	$101.11	$98.01	$95.00	$92.08	$89.25	$86.51	$83.85
DivaCup	$70.45	$40.81	$-	$-	$-	$29.64	$-	$-	$-	$-	$-
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 31. Cost of five menstrual products for an average menstrual cycle, based on replacement of the Diva Cup after five years with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$389.59	$63.53	$56.22	$49.76	$44.03	$38.97	$34.49	$30.52	$27.01	$23.91	$21.16
Tampax	$456.36	$74.41	$65.86	$58.28	$51.58	$45.65	$40.40	$35.75	$31.64	$28.00	$24.78
Softcup	$680.92	$111.03	$98.26	$86.96	$76.96	$68.11	$60.28	$53.35	$47.21	$41.78	$36.98
DivaCup	$55.13	$40.81	$-	$-	$-	$14.31	$-	$-	$-	$-	$-
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 32. Cost of five menstrual products for an average menstrual cycle, based on replacement of the Diva Cup after five years with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$172.67	$63.53	$40.41	$25.70	$16.35	$10.40	$6.62	$4.21	$2.68	$1.70	$1.08
Tampax	$202.27	$74.41	$47.33	$30.11	$19.15	$12.18	$7.75	$4.93	$3.14	$1.99	$1.27
Softcup	$301.80	$111.03	$70.63	$44.92	$28.58	$18.18	$11.56	$7.35	$4.68	$2.98	$1.89
DivaCup	$41.83	$40.81	$-	$-	$-	$1.02	$-	$-	$-	$-	$-
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Table 33. Cost of five menstrual products for an average menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$554.28	$63.53	$61.57	$59.68	$57.85	$56.07	$54.35	$52.68	$51.06	$49.50	$47.98
Tampax	$649.27	$74.41	$72.13	$69.91	$67.77	$65.68	$63.67	$61.71	$59.82	$57.98	$56.20
Softcup	$968.77	$111.03	$107.62	$104.32	$101.11	$98.01	$95.00	$92.08	$89.25	$86.51	$83.85
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 34. Cost of five menstrual products for an average menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$389.59	$63.53	$56.22	$49.76	$44.03	$38.97	$34.49	$30.52	$27.01	$23.91	$21.16
Tampax	$456.36	$74.41	$65.86	$58.28	$51.58	$45.65	$40.40	$35.75	$31.64	$28.00	$24.78
Softcup	$680.92	$111.03	$98.26	$86.96	$76.96	$68.11	$60.28	$53.35	$47.21	$41.78	$36.98
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 35. Cost of five menstrual products for an average menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars

		Time (yrs)									
Product Brand	**PV of Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$172.67	$63.53	$40.41	$25.70	$16.35	$10.40	$6.62	$4.21	$2.68	$1.70	$1.08
Tampax	$202.27	$74.41	$47.33	$30.11	$19.15	$12.18	$7.75	$4.93	$3.14	$1.99	$1.27
Softcup	$301.80	$111.03	$70.63	$44.92	$28.58	$18.18	$11.56	$7.35	$4.68	$2.98	$1.89
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Table 36. Cost of five menstrual products for a heavy menstrual cycle, based on an annual replacement of the Diva Cup with inflation applied, including tax and shipping where applicable, in Canadian dollars.

			Time (yrs)									
Product Brand	**Price per Unit**	**Price per Cycle**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$0.26	$7.41	$88.94	$90.52	$92.12	$93.76	$95.42	$97.11	$98.84	$100.59	$102.38	$104.20
Tampax	$0.31	$8.68	$104.18	$106.03	$107.91	$109.83	$111.78	$113.76	$115.78	$117.83	$119.93	$122.05
Softcup	$0.93	$12.95	$155.44	$158.20	$161.01	$163.87	$166.78	$169.74	$172.75	$175.82	$178.94	$182.11
DivaCup	$40.81	$40.81	$40.81	$41.54	$42.28	$43.03	$43.79	$44.57	$45.36	$46.16	$46.98	$47.82
Jade and Pearl	$13.23	$13.23	$26.45	$26.92	$27.40	$27.88	$28.38	$28.88	$29.39	$29.92	$30.45	$30.99

Table 37. Cost of five menstrual products for a heavy menstrual cycle, based on annual replacement of the Diva Cup for ten years with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$775.99	$88.94	$86.20	$83.56	$80.99	$78.50	$76.09	$73.75	$71.49	$69.29	$67.17
Tampax	$908.98	$104.18	$100.98	$97.88	$94.87	$91.96	$89.13	$86.40	$83.74	$81.17	$78.68
Softcup	$1,356.27	$155.44	$150.67	$146.04	$141.56	$137.21	$132.99	$128.91	$124.95	$121.11	$117.39
DivaCup	$356.11	$40.81	$39.56	$38.34	$37.17	$36.03	$34.92	$33.85	$32.81	$31.80	$30.82
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 38. Cost of five menstrual products for a heavy menstrual cycle, based on annual replacement of the Diva Cup for ten years with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$545.42	$88.94	$78.71	$69.66	$61.65	$54.56	$48.28	$42.73	$37.82	$33.47	$29.62
Tampax	$638.90	$104.18	$92.20	$81.60	$72.21	$63.91	$56.56	$50.05	$44.30	$39.20	$34.70
Softcup	$953.29	$155.44	$137.57	$121.75	$107.75	$95.36	$84.39	$74.68	$66.10	$58.49	$51.77
DivaCup	$250.30	$40.81	$36.12	$31.97	$28.29	$25.04	$22.16	$19.61	$17.35	$15.36	$13.59
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 39. Cost of five menstrual products for a heavy menstrual cycle, based on annual replacement of the Diva Cup for ten years with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$241.74	$88.94	$56.57	$35.99	$22.89	$14.56	$9.26	$5.89	$3.75	$2.38	$1.52
Tampax	$283.18	$104.18	$66.27	$42.15	$26.81	$17.06	$10.85	$6.90	$4.39	$2.79	$1.78
Softcup	$422.52	$155.44	$98.88	$62.89	$40.01	$25.45	$16.19	$10.30	$6.55	$4.17	$2.65
DivaCup	$110.94	$40.81	$25.96	$16.51	$10.50	$6.68	$4.25	$2.70	$1.72	$1.09	$0.70
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Table 40. Cost of five menstrual products for a heavy menstrual cycle, based on the replacement of the Diva Cup after five years with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$775.99	$88.94	$86.20	$83.56	$80.99	$78.50	$76.09	$73.75	$71.49	$69.29	$67.17
Tampax	$908.98	$104.18	$100.98	$97.88	$94.87	$91.96	$89.13	$86.40	$83.74	$81.17	$78.68
Softcup	$1,356.27	$155.44	$150.67	$146.04	$141.56	$137.21	$132.99	$128.91	$124.95	$121.11	$117.39
DivaCup	$70.45	$40.81	$-	$-	$-	$29.64	$-	$-	$-	$-	$-
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 41. Cost of five menstrual products for a heavy menstrual cycle, based on the replacement of the Diva Cup after five years with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$545.42	$88.94	$78.71	$69.66	$61.65	$54.56	$48.28	$42.73	$37.82	$33.47	$29.62
Tampax	$638.90	$104.18	$92.20	$81.60	$72.21	$63.91	$56.56	$50.05	$44.30	$39.20	$34.70
Softcup	$953.29	$155.44	$137.57	$121.75	$107.75	$95.36	$84.39	$74.68	$66.10	$58.49	$51.77
DivaCup	$55.13	$40.81	$-	$-	$-	$14.31	$-	$-	$-	$-	$-
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 42. Cost of five menstrual products for a heavy menstrual cycle, based on the replacement of the Diva Cup after five years with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$241.74	$88.94	$56.57	$35.99	$22.89	$14.56	$9.26	$5.89	$3.75	$2.38	$1.52
Tampax	$283.18	$104.18	$66.27	$42.15	$26.81	$17.06	$10.85	$6.90	$4.39	$2.79	$1.78
Softcup	$422.52	$155.44	$98.88	$62.89	$40.01	$25.45	$16.19	$10.30	$6.55	$4.17	$2.65
DivaCup	$41.83	$40.81	$-	$-	$-	$1.02	$-	$-	$-	$-	$-
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Table 43. Cost of five menstrual products for a heavy menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 5% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$775.99	$88.94	$86.20	$83.56	$80.99	$78.50	$76.09	$73.75	$71.49	$69.29	$67.17
Tampax	$908.98	$104.18	$100.98	$97.88	$94.87	$91.96	$89.13	$86.40	$83.74	$81.17	$78.68
Softcup	$1,356.27	$155.44	$150.67	$146.04	$141.56	$137.21	$132.99	$128.91	$124.95	$121.11	$117.39
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$230.78	$26.45	$25.64	$24.85	$24.09	$23.35	$22.63	$21.93	$21.26	$20.61	$19.98

Table 44. Cost of five menstrual products for a heavy menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 15% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$545.42	$88.94	$78.71	$69.66	$61.65	$54.56	$48.28	$42.73	$37.82	$33.47	$29.62
Tampax	$638.90	$104.18	$92.20	$81.60	$72.21	$63.91	$56.56	$50.05	$44.30	$39.20	$34.70
Softcup	$953.29	$155.44	$137.57	$121.75	$107.75	$95.36	$84.39	$74.68	$66.10	$58.49	$51.77
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$162.21	$26.45	$23.41	$20.72	$18.33	$16.23	$14.36	$12.71	$11.25	$9.95	$8.81

Table 45. Cost of five menstrual products for a heavy menstrual cycle, based on no replacement of the Diva Cup for ten years with inflation applied and 60% discount factor, including tax and shipping where applicable, in Canadian dollars.

		Time (yrs)									
Product Brand	**PV of Future Expenditures**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
o.b.	$241.74	$88.94	$56.57	$35.99	$22.89	$14.56	$9.26	$5.89	$3.75	$2.38	$1.52
Tampax	$283.18	$104.18	$66.27	$42.15	$26.81	$17.06	$10.85	$6.90	$4.39	$2.79	$1.78
Softcup	$422.52	$155.44	$98.88	$62.89	$40.01	$25.45	$16.19	$10.30	$6.55	$4.17	$2.65
DivaCup	$40.81	$40.81	$-	$-	$-	$-	$-	$-	$-	$-	$-
Jade and Pearl	$71.90	$26.45	$16.82	$10.70	$6.81	$4.33	$2.75	$1.75	$1.11	$0.71	$0.45

Appendix E: Environmental Impacts Results and Data Tables

Table 46. Five indicators of impacts for 1 kg of primary material.

Material	Amount	Abiotic Depletion (kg Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg PO_4 eq.)	Process Used
Cotton	1 kg	8.82E-06	30.7	3.06	0.0252	0.0231	Cotton fibres, at plant US
Cotton string	1 kg	2.14E-05	132	14.3	0.138	0.0401	Yarn, cotton, at plant GLO
Polypropylene	1 kg	5.74E-08	70.4	1.97	0.0062	0.000672	Polypropylene, granulate, at plant RER
Polypropylene string	1 kg	1.39E-06	141	7.58	0.0301	0.0158	Polypropylene, granulate, at plant RER, fleece production, PET RER
Polyester	1 kg	1.49E-05	107	7.46	0.0188	0.0104	Polyester resin, unsaturated, at plant RER
Polyester string	1 kg	1.62E-05	178	13.1	0.0427	0.0255	Polyester resin, unsaturated, at plant RER, fleece production, PET RER
Silicon	1 kg	4.62E-06	50.2	2.71	0.0103	0.00303	Silicone product, at plant RER
Rayon	1 kg	1.24E-05	61.1	4.8	0.0535	0.0122	Viscose fibres, at plant GLO
Polyethylene (Injection Moulded)	1 kg	8.53E-07	91.8	3.26	0.0115	0.00343	Polyethylene, HDPE, granulate, at plant RER, Injection Moulding RER
Polyurethane	1 kg	4.31E-06	88.2	4.31	0.0177	0.00383	Polyurethane, flexible foam, at plant RER
Kraton polymer	1 kg	7.15E-05	109	4.48	0.0295	0.00841	Tube insulation, elastomere, at plant DE
Sea Sponge	**Not available**						

Notes on the abbreviations for the above table

- "at plant" means that environmental impacts are from extraction of raw materials, some transport, and manufacturing of the product, up to the gate of the plant
- "RER" means European average data
- "GLO" means global average data
- "DE" means Germany
- For some of the materials used, a combined a process for manufacturing the raw material (e.g. polyester) with a processing step to simulate the production of the product (e.g. polyester string)
- "HDPE" and "PET" are plastic types
- "US" is United States data

Environmental Impacts Results

Table 47. Environmental indicators for four menstrual products for one unit.

	Abiotic Depletion (g Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (Kg CO_2 eq.)	Acidification (g SO_2 eq.)	Eutrophication (g PO_4 eq.)
o.b.	0.015	83.95	6.49	59.35	25.96
Tampax	0.027	457.3	21.9	111.01	42.75
Softcup	0.046	582.69	26.83	111.87	24.21
DivaCup	0.068	738.44	39.86	151.51	44.57

Table 48. Environmental Indicators for four menstrual products for a functional time unit of one cycle for three cycle durations.

		Abiotic Depletion (g Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (g SO_2 eq.)	Eutrophication (g PO_4 eq.)
Light	o.b.	0.184	1.01	0.08	712.20	311.57
	Tampax	0.322	5.49	0.26	1332.14	512.96
	Softcup	0.276	3.50	0.16	671.19	145.26
	DivaCup	0.068	0.74	0.04	151.51	44.57
Average	o.b,	0.306	1.68	0.13	1186.99	519.29
	Tampax	0.536	9.15	0.44	2220.23	854.94
	Softcup	0.460	5.83	0.27	1118.66	242.10
	DivaCup	0.068	0.74	0.04	151.51	44.57
Heavy	o.b.	0.428	2.35	0.18	1661.79	727.00
	Tampax	0.750	12.80	0.61	3108.32	1196.91
	Softcup	0.644	8.16	0.38	1566.12	338.94
	DivaCup	0.068	0.74	0.04	151.51	44.57

Table 49. Environmental indicators for four menstrual products for a functional time unit of one year for three cycle durations.

		Abiotic Depletion (g Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (g SO_2 eq.)	Eutrophication (g PO_4 eq.)
Light	o.b.	2.203	12.09	0.93	8546.35	3738.87
	Tampax	3.859	65.85	3.15	15985.66	6155.56
	Softcup	3.310	41.95	1.93	8054.33	1743.11
	DivaCup	0.068	0.74	0.04	151.51	44.57
Average	o.b.	3.671	20.15	1.56	14243.91	6231.45
	Tampax	6.432	109.75	5.26	26642.76	10259.26
	Softcup	5.517	69.92	3.22	13423.89	2905.19
	DivaCup	0.068	0.74	0.04	151.51	44.57
Heavy	o.b.	5.568	30.56	2.36	21603.27	9451.03
	Tampax	9.755	166.46	7.97	40408.19	15559.88
	Softcup	8.367	106.05	4.88	20359.57	4406.20
	DivaCup	0.068	0.74	0.04	151.51	44.57

Environmental Impacts Data

Table 50. Calculation on five environmental impacts for four menstrual products for a single unit.

Product	Materials	Mass per Unit (kg)	Abiotic Depletion (kg Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg PO_4 eq.)
o.b,	rayon fibre	6.73E-04	8.34E-09	4.11E-02	3.23E-03	3.60E-05	8.20E-06
	cotton fibre	6.73E-04	5.93E-09	2.06E-02	2.06E-03	1.69E-05	1.55E-05
	polypropylene	1.48E-04	8.51E-12	1.04E-02	2.92E-04	9.20E-07	9.97E-08
	cotton string	2.61E-05	5.59E-10	3.45E-03	3.73E-04	3.60E-06	1.05E-06
	polyester string	2.61E-05	4.23E-10	4.65E-03	3.42E-04	1.11E-06	6.66E-07
	polypropylene string	2.61E-05	3.63E-11	3.68E-03	1.98E-04	7.86E-07	4.13E-07
Tampax	rayon	6.17E-04	7.65E-09	3.77E-02	2.96E-03	3.30E-05	7.52E-06
	cotton	6.17E-04	5.44E-09	1.89E-02	1.89E-03	1.55E-05	1.42E-05
	polypropylene	4.45E-04	2.55E-11	3.13E-02	8.77E-04	2.76E-06	2.99E-07
	polyester	6.17E-04	9.19E-09	6.60E-02	4.60E-03	1.16E-05	6.41E-06
	cotton string	8.33E-05	1.78E-09	1.10E-02	1.19E-03	1.15E-05	3.34E-06
	polyethylene	3.19E-03	2.72E-09	2.92E-01	1.04E-02	3.66E-05	1.09E-05
Softcup	polyurethane	5.47E-03	2.36E-08	4.82E-01	2.36E-02	9.68E-05	2.10E-05
	polypropylene	9.40E-04	5.40E-11	6.62E-02	1.85E-03	5.83E-06	6.32E-07
	kraton polymer	3.13E-04	2.23E-08	3.41E-02	1.40E-03	9.22E-06	2.63E-06
DivaCup	silicone	1.47E-02	6.80E-08	7.38E-01	3.99E-02	1.52E-04	4.46E-05

Table 51. Calculation of five environmental impacts for four menstrual products for a light cycle duration and a temporal scale of one cycle.

Product	Materials	Mass per Unit (kg)	Abiotic Depletion (kg Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg PO_4 eq.)
o.b.	rayon fibre	8.07E-03	1.00E-07	4.93E-01	3.87E-02	4.32E-04	9.85E-05
	cotton fibre	8.07E-03	7.12E-08	2.48E-01	2.47E-02	2.03E-04	1.86E-04
	polypropylene	1.78E-03	1.02E-10	1.25E-01	3.51E-03	1.10E-05	1.20E-06
	cotton string	3.13E-04	6.71E-09	4.14E-02	4.48E-03	4.32E-05	1.26E-05
	polyester string	3.13E-04	5.08E-09	5.58E-02	4.10E-03	1.34E-05	7.99E-06
	polypropylene string	3.13E-04	4.36E-10	4.42E-02	2.38E-03	9.43E-06	4.95E-06
Tampax	rayon	7.40E-03	9.18E-08	4.52E-01	3.55E-02	3.96E-04	9.03E-05
	cotton	7.40E-03	6.53E-08	2.27E-01	2.26E-02	1.86E-04	1.71E-04
	polypropylene	5.34E-03	3.07E-10	3.76E-01	1.05E-02	3.31E-05	3.59E-06
	polyester	7.40E-03	1.10E-07	7.92E-01	5.52E-02	1.39E-04	7.70E-05
	cotton string	1.00E-03	2.14E-08	1.32E-01	1.43E-02	1.38E-04	4.01E-05
	polyethylene	3.82E-02	3.26E-08	3.51E+00	1.25E-01	4.40E-04	1.31E-04
Softcup	polyurethane	3.28E-02	1.41E-07	2.89E+00	1.41E-01	5.81E-04	1.26E-04
	polypropylene	5.64E-03	3.24E-10	3.97E-01	1.11E-02	3.50E-05	3.79E-06
	kraton polymer	1.88E-03	1.34E-07	2.04E-01	8.40E-03	5.53E-05	1.58E-05
DivaCup	silicone	1.47E-02	6.80E-08	7.38E-01	3.99E-02	1.52E-04	4.46E-05

Table 52. Calculation of five environmental impacts for four menstrual products for an average cycle duration and a temporal scale of one cycle.

Product	Materials	Mass per Unit (kg)	Abiotic Depletion (kg Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg PO_4 eq.)
o.b.	rayon fibre	1.35E-02	1.67E-07	8.22E-01	6.46E-02	7.20E-04	1.64E-04
	cotton fibre	1.35E-02	1.19E-07	4.13E-01	4.12E-02	3.39E-04	3.11E-04
	polypropylene	2.97E-03	1.70E-10	2.09E-01	5.84E-03	1.84E-05	1.99E-06
	cotton string	5.22E-04	1.12E-08	6.89E-02	7.47E-03	7.21E-05	2.09E-05
	polyester string	5.22E-04	8.46E-09	9.30E-02	6.84E-03	2.23E-05	1.33E-05
	polypropylene string	5.22E-04	7.26E-10	7.36E-02	3.96E-03	1.57E-05	8.25E-06
Tampax	rayon	1.23E-02	1.53E-07	7.54E-01	5.92E-02	6.60E-04	1.50E-04
	cotton	1.23E-02	1.09E-07	3.79E-01	3.77E-02	3.11E-04	2.85E-04
	polypropylene	8.90E-03	5.11E-10	6.27E-01	1.75E-02	5.52E-05	5.98E-06
	polyester	1.23E-02	1.84E-07	1.32E+00	9.20E-02	2.32E-04	1.28E-04
	cotton string	1.67E-03	3.57E-08	2.20E-01	2.38E-02	2.30E-04	6.68E-05
	polyethylene	6.37E-02	5.43E-08	5.85E+00	2.08E-01	7.33E-04	2.18E-04
Softcup	polyurethane	5.47E-02	2.36E-07	4.82E+00	2.36E-01	9.68E-04	2.10E-04
	polypropylene	9.40E-03	5.40E-10	6.62E-01	1.85E-02	5.83E-05	6.32E-06
	kraton polymer	3.13E-03	2.23E-07	3.41E-01	1.40E-02	9.22E-05	2.63E-05
DivaCup	silicone	1.47E-02	6.80E-08	7.38E-01	3.99E-02	1.52E-04	4.46E-05

Table 53. Calculation of five environmental impacts for four menstrual products for a heavy cycle duration and a temporal scale of one cycle.

Product	Materials	Mass per Unit (kg)	Abiotic Depletion (kg Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg PO_4 eq.)
o.b.	rayon fibre	1.88E-02	2.33E-07	1.15E+00	9.04E-02	1.01E-03	2.30E-04
	cotton fibre	1.88E-02	1.66E-07	5.78E-01	5.76E-02	4.75E-04	4.35E-04
	polypropylene	4.15E-03	2.38E-10	2.92E-01	8.18E-03	2.58E-05	2.79E-06
	cotton string	7.31E-04	1.56E-08	9.65E-02	1.05E-02	1.01E-04	2.93E-05
	polyester string	7.31E-04	1.18E-08	1.30E-01	9.58E-03	3.12E-05	1.86E-05
	polypropylene string	7.31E-04	1.02E-09	1.03E-01	5.54E-03	2.20E-05	1.16E-05
Tampax	rayon	1.73E-02	2.14E-07	1.05E+00	8.29E-02	9.24E-04	2.11E-04
	cotton	1.73E-02	1.52E-07	5.30E-01	5.28E-02	4.35E-04	3.99E-04
	polypropylene	1.25E-02	7.15E-10	8.77E-01	2.45E-02	7.73E-05	8.37E-06
	polyester	1.73E-02	2.57E-07	1.85E+00	1.29E-01	3.25E-04	1.80E-04
	cotton string	2.33E-03	4.99E-08	3.08E-01	3.34E-02	3.22E-04	9.36E-05
	polyethylene	8.92E-02	7.61E-08	8.19E+00	2.91E-01	1.03E-03	3.06E-04
Softcup	polyurethane	7.66E-02	3.30E-07	6.75E+00	3.30E-01	1.36E-03	2.93E-04
	polypropylene	1.32E-02	7.55E-10	9.26E-01	2.59E-02	8.16E-05	8.84E-06
	kraton polymer	4.38E-03	3.13E-07	4.77E-01	1.96E-02	1.29E-04	3.68E-05
DivaCup	silicone	1.47E-02	6.80E-08	7.38E-01	3.99E-02	1.52E-04	4.46E-05

Table 54. Calculation of five environmental impacts for four menstrual products for a light cycle duration and a temporal scale of one year.

Product	Material	Mass per Unit (kg)	Abiotic Depletion (kg Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg PO_4 eq.)
o.b.	rayon fibre	9.68E-02	1.20E-06	5.92E+00	4.65E-01	5.18E-03	1.18E-03
	cotton fibre	9.68E-02	8.54E-07	2.97E+00	2.96E-01	2.44E-03	2.24E-03
	polypropylene	2.14E-02	1.23E-09	1.50E+00	4.21E-02	1.32E-04	1.44E-05
	cotton string	3.76E-03	8.05E-08	4.96E-01	5.38E-02	5.19E-04	1.51E-04
	polyester string	3.76E-03	6.09E-08	6.69E-01	4.93E-02	1.61E-04	9.59E-05
	polypropylene string	3.76E-03	5.23E-09	5.30E-01	2.85E-02	1.13E-04	5.94E-05
Tampax	rayon	8.88E-02	1.10E-06	5.43E+00	4.26E-01	4.75E-03	1.08E-03
	cotton	8.88E-02	7.83E-07	2.73E+00	2.72E-01	2.24E-03	2.05E-03
	polypropylene	6.41E-02	3.68E-09	4.51E+00	1.26E-01	3.97E-04	4.31E-05
	polyester	8.88E-02	1.32E-06	9.50E+00	6.62E-01	1.67E-03	9.24E-04
	cotton string	1.20E-02	2.57E-07	1.58E+00	1.72E-01	1.66E-03	4.81E-04
	polyethylene	4.59E-01	3.91E-07	4.21E+01	1.50E+00	5.27E-03	1.57E-03
Softcup	polyurethane	3.94E-01	1.70E-06	3.47E+01	1.70E+00	6.97E-03	1.51E-03
	polypropylene	6.77E-02	3.88E-09	4.76E+00	1.33E-01	4.20E-04	4.55E-05
	kraton polymer	2.25E-02	1.61E-06	2.45E+00	1.01E-01	6.64E-04	1.89E-04
DivaCup	silicone	1.47E-02	6.80E-08	7.38E-01	3.99E-02	1.52E-04	4.46E-05

Table 55. Calculation of five environmental impacts for four menstrual products for an average cycle duration for a temporal scale of one year.

Product	Material	Mass per Unit (kg)	Abiotic Depletion (kg Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg PO_4 eq.)
o.b.	rayon fibre	1.61E-01	2.00E-06	9.86E+00	7.75E-01	8.63E-03	1.97E-03
	cotton fibre	1.61E-01	1.42E-06	4.95E+00	4.94E-01	4.07E-03	3.73E-03
	polypropylene	3.56E-02	2.04E-09	2.51E+00	7.01E-02	2.21E-04	2.39E-05
	cotton string	6.27E-03	1.34E-07	8.27E-01	8.96E-02	8.65E-04	2.51E-04
	polyester string	6.27E-03	1.02E-07	1.12E+00	8.21E-02	2.68E-04	1.60E-04
	polypropylene string	6.27E-03	8.71E-09	8.84E-01	4.75E-02	1.89E-04	9.90E-05
Tampax	rayon	1.48E-01	1.84E-06	9.04E+00	7.10E-01	7.92E-03	1.81E-03
	cotton	1.48E-01	1.31E-06	4.54E+00	4.53E-01	3.73E-03	3.42E-03
	polypropylene	1.07E-01	6.13E-09	7.52E+00	2.10E-01	6.62E-04	7.18E-05
	polyester	1.48E-01	2.21E-06	1.58E+01	1.10E+00	2.78E-03	1.54E-03
	cotton string	2.00E-02	4.28E-07	2.64E+00	2.86E-01	2.76E-03	8.02E-04
	polyethylene	7.64E-01	6.52E-07	7.02E+01	2.49E+00	8.79E-03	2.62E-03
Softcup	polyurethane	6.56E-01	2.83E-06	5.79E+01	2.83E+00	1.16E-02	2.51E-03
	polypropylene	1.13E-01	6.47E-09	7.94E+00	2.22E-01	6.99E-04	7.58E-05
	kraton polymer	3.75E-02	2.68E-06	4.09E+00	1.68E-01	1.11E-03	3.15E-04
DivaCup	silicone	1.47E-02	6.80E-08	7.38E-01	3.99E-02	1.52E-04	4.46E-05

Table 56. Calculation of five environmental impacts for four menstrual products for a heavy cycle duration for a temporal scale of one year.

Product	Material	Mass per Unit (kg)	Abiotic Depletion (kg Sb eq.)	Fossil Fuel Depletion (MJ)	Global Warming Potential (kg CO_2 eq.)	Acidification (kg SO_2 eq.)	Eutrophication (kg PO_4 eq.)
o.b.	rayon fibre	2.45E-01	3.04E-06	1.50E+01	1.17E+00	1.31E-02	2.99E-03
	cotton fibre	2.45E-01	2.16E-06	7.52E+00	7.49E-01	6.17E-03	5.65E-03
	polypropylene	5.40E-02	3.10E-09	3.80E+00	1.06E-01	3.35E-04	3.63E-05
	cotton string	9.50E-03	2.03E-07	1.25E+00	1.36E-01	1.31E-03	3.81E-04
	polyester string	9.50E-03	1.54E-07	1.69E+00	1.25E-01	4.06E-04	2.42E-04
	polypropylene string	9.50E-03	1.32E-08	1.34E+00	7.20E-02	2.86E-04	1.50E-04
Tampax	rayon	2.24E-01	2.78E-06	1.37E+01	1.08E+00	1.20E-02	2.74E-03
	cotton	2.24E-01	1.98E-06	6.89E+00	6.87E-01	5.66E-03	5.19E-03
	polypropylene	1.62E-01	9.30E-09	1.14E+01	3.19E-01	1.00E-03	1.09E-04
	polyester	2.24E-01	3.34E-06	2.40E+01	1.67E+00	4.22E-03	2.33E-03
	cotton string	3.03E-02	6.49E-07	4.00E+00	4.34E-01	4.19E-03	1.22E-03
	polyethylene	1.16E+00	9.89E-07	1.06E+02	3.78E+00	1.33E-02	3.98E-03
Softcup	polyurethane	9.96E-01	4.29E-06	8.78E+01	4.29E+00	1.76E-02	3.81E-03
	polypropylene	1.71E-01	9.82E-09	1.20E+01	3.37E-01	1.06E-03	1.15E-04
	kraton polymer	5.69E-02	4.07E-06	6.20E+00	2.55E-01	1.68E-03	4.78E-04
DivaCup	silicone	1.47E-02	6.80E-08	7.38E-01	3.99E-02	1.52E-04	4.46E-05

Waste

Table 57. Population of women of average menstruating age in Canada (Stats Can, 2011)

Age	Population
12 to 14	572990
15 to 24	2140965
25 to 34	2196405
35 to 44	1109735
45 to 50	1636640
Total	**7656735**

Table 58. Mass of menstrual product waste, in kilograms and pounds, for an average menstrual duration per year for one woman and for population of women of menstruating age in Canada.

Brand	Mass per menstrual product unit (g)	Number of products used per year	Total kilograms of waste per woman per year	Total pounds of waste per woman per year	Total kilograms of waste for women in Canada per year	Total pounds of waste for women in Canada per year
o.b.	1.57167	240	0.38	0.83	2888120.44	6353864.97
Tampax	5.56333	240	1.34	2.94	10223272.57	22491199.66
Softcup	6.7225	120	0.81	1.77	6176688.12	13588713.87
DivaCup	14.71	1	0.01	0.03	112630.57	247787.26
Sea Pearls		2	0.00	0.00	0.00	0.00