ABSTRACT FROM

LIFE CYCLE ASSESSMENT OF SURGICAL DRAPES AND TAPES RESUSABLE AND DISPOSABLE

Environmental Clarity Inc. (E.Vozzola, M. Overcash, E.Griffing) - October 2018

paper edited by Roberto Riedo on behalf of the "Chainge Consortium" (Eurotape, van Dijk, Vetex, Christeyns, Rotecno)

PRELIMINARY OBSERVATIONS

Comparative life cycle studies by McDowell (1993), Carre (2008), van de Berghe and Zimmer (2010), Overcash (2012), and Vozzola (2018) compared reusable and disposable surgical gown systems. Studies by Jewell and Wentsel (2014) and Vozzola (2018) compared reusable and disposable isolation gown systems. All of these studies found that reusable medical textile systems provided substantially better environmental profiles than disposable systems. However, the previous literature has not typically included the environmental impacts of surgical drapes and tapes.

GOAL OF THE LIFE CYCLE ASSESSMENT

Eurotape, BV (on behalf of the "Change Consortium", composed of Eurotape, van Dijk, Vetex, Christeyns and Rotecno) commissioned Environmental Clarity, Inc. to quantify and compare the cradle-to-end-of-life environmental impacts of reusable and disposable surgical drape and tape systems. The objectives of the study were:

● to compare three environmental indicators (energy consumption, water consumption, and solid waste generation) and 11 environmental impacts from CML (Abiotic depletion (of minerals), Abiotic depletion of fossil fuels, global warming, ozone layer depletion, human toxicity, fresh water ecotoxicity, marine aquatic ecotoxicity, photochemical oxidation (smog formation), acidification, and eutrophication) of reusable and disposable surgical drapes and tapes

● to clearly show what parts of the life cycle are important to the result

●to provide a sensitivity analysis for important parameters.

Reusable and disposable surgical drape and tape systems were compared using life cycle guidelines set forth by the International Organization for Standardization (ISO) in ISO 14040 and ISO 14044 (ISO, 2006). The life cycle assessment results are intended to be used by the members of the "Change Consortium" to build and promote a sustainable pathway for textiles in the health care industry.

1. THREE ENVIRONMENTAL INDICATORS

● 1.1 - Natural Resource Energy (NRE) in MJ

Natural resource energy is the total energy of all fuels used to provide energy in a process and includes the higher heating value (HHV) of fuel combusted per unit of energy transferred to the process (efficiency) plus the energy used to deliver fuel to the point of use (often known as precombustion or delivered energy). A complete description of the types of energy included in this report, including the relationship between process energy and NRE, is given in the Life Cycle Inventory Analysis section below. The heating value of fuels combusted for energy is an indicator of environmental emissions, as the majority of environmental impacts often result from energy consumption.

● 1.2 - Blue Water Consumption in kg blue water

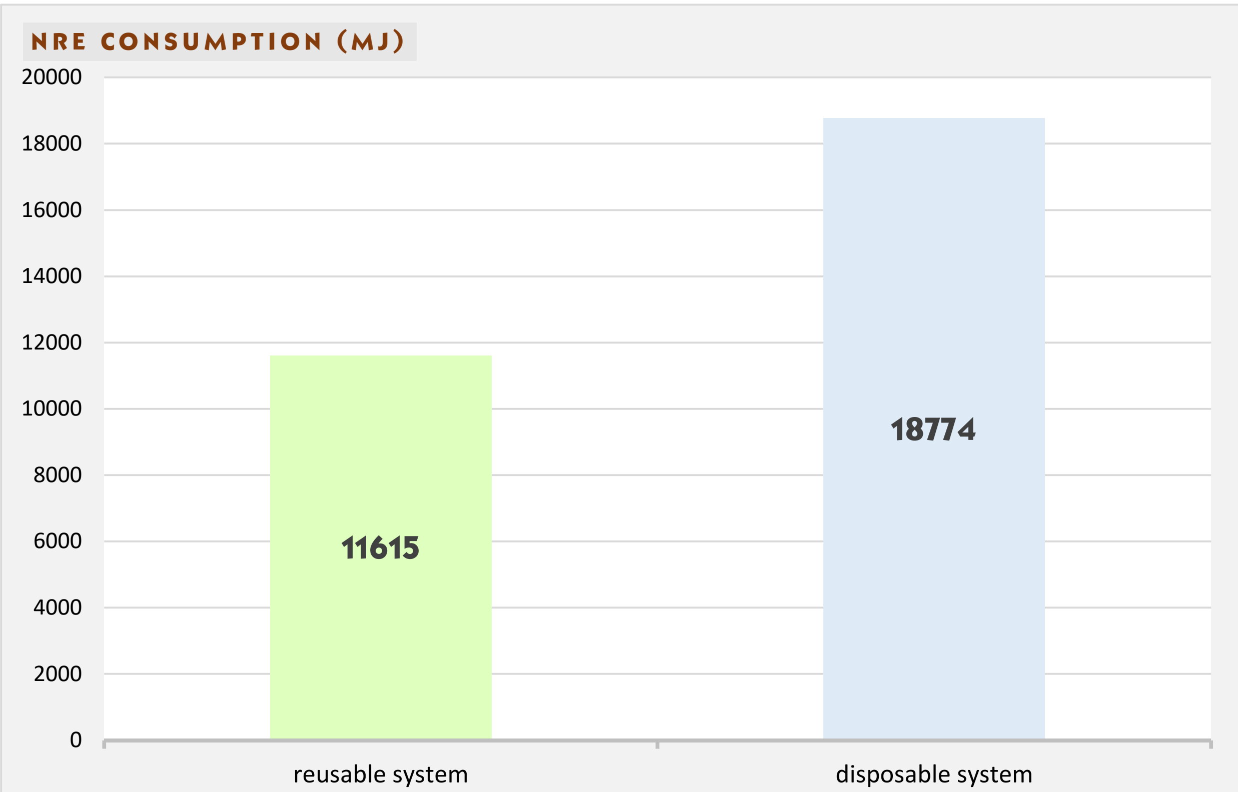
Blue water is the total of all water evaporated during production or physically incorporated into the product (Aviso et al., 2011). Thus, blue water does not include non-contaminated water returned to the environment (i.e. from steam heating or cooling water conditions) or contaminated water that is returned to the environment via a wastewater treatment process (i.e. from laundry).

● 1.3 - Solid Waste Generation as kg waste generated at point of use
Solid waste generation is the total solid waste generated at the health care facility using the surgical drapes and includes the drapes, tapes, biological waste on the drapes, and non-recycled packaging.

1.1 Natural Resource Energy Consumption (NRE in MJ)

	NRE in MJ per 1000 drape uses	
Life cycle stage	**reusable system**	**disposable system**
- drape manufacturing plus supply chain	2300	16260
- drape packaging plus supply chain	1801	2112
- tape manufacturing plus supply chain	305	186
- tape packaging plus supply chain	7.7	4.5
- laundry	5717	0
- sterilization	413	43
- use phase transport	1038	0
- end of life	33	168
TOTAL NRE	**11615**	**18774**
%	100	162

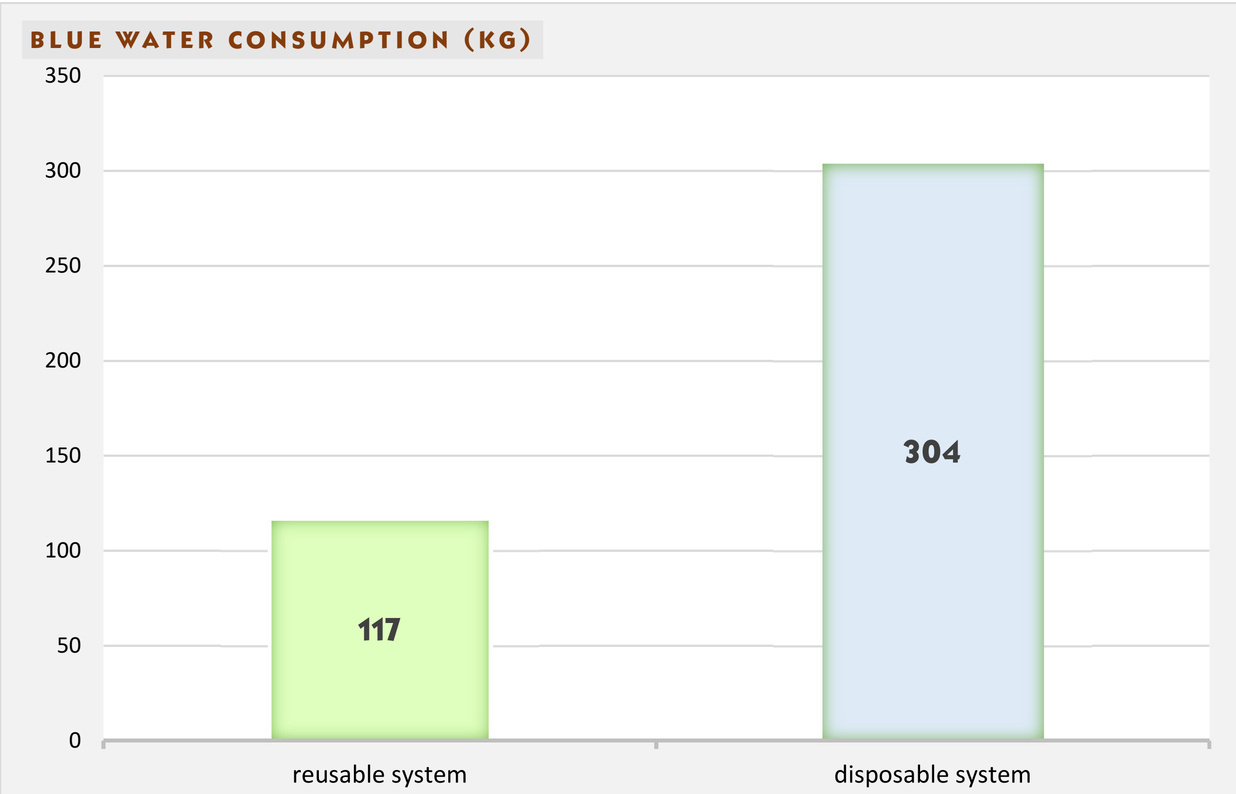
IMPROVMENT FROM SELECTING REUSABLE SYSTEM: 38%



1.2 Blue Water Consumption

Life cycle stage	reusable system	disposable system
	kg water use per 1000 drape uses	
- cooling water manufacturing	75.1	218
- steam manufacturing	76.9	85.8
- laundry reusable drapes; including recovered water	-35	0
TOTAL kg	**117**	**304**
%	100	260

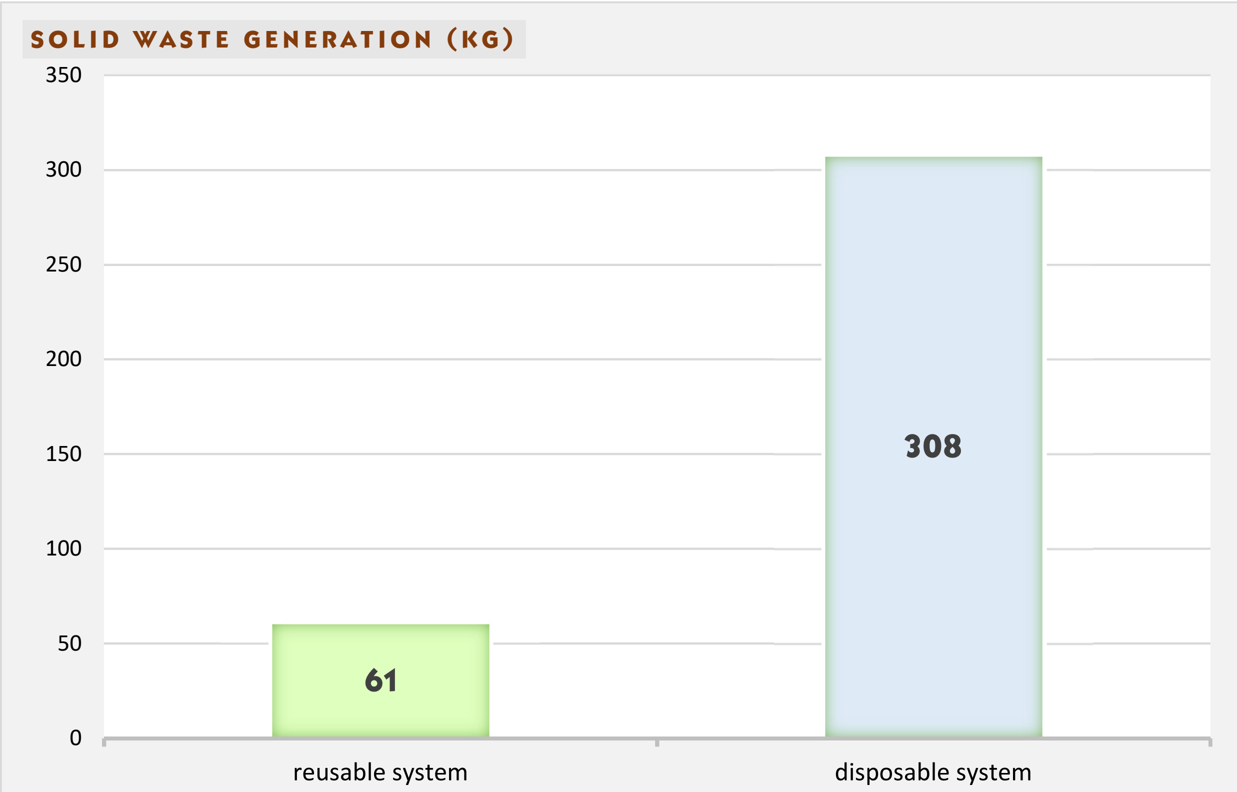
IMPROVMENT FROM SELECTING REUSABLE SYSTEM: 62%



1.3 Solid Waste Generation

Life cycle stage	kg waste per 1000 drape uses	
	reusable system	disposable system
- drapes	0	245
- drape packaging	58.1	57
- surgical tape	2.96	5.26
- tape packaging	0.038	0.022
- biological waste on drapes	0.01	0.643
TOTAL kg	**61**	**308**
%	100	504

IMPROVMENT FROM SELECTING REUSABLE SYSTEM: 80%



2. ELEVEN ENVIRONMENTAL IMPACT CATEGORIES

● Global warming potential (GWP) in kg carbon dioxide equivalent (kg CO_2eq)

Global warming potential, also known as greenhouse gas (GHG) emissions, is often dominated by energy use. The energy portion can be estimated using the representative ratio of 0.06 kg CO_2eq/MJ NRE combustion. However, this life cycle assessment included a more detailed calculation using the CML 3.01 (2013) methodology. The GWP is the carbon dioxide (and CO_2eq of other greenhouse gasses) produced from all combustion processes for energy production plus any process emissions. CML 3.01 assigns specific impact factors to each chemical emission (CO_2 = 1, methane = 25, nitrous oxide = 298, etc.).

● Abiotic depletion, kg antimony equivalent (kg Sb eq)

Abiotic depletion characterizes the use of non-fossil raw materials. More rare elements are given a higher equivalent factor. For example, gold is given a factor of 52 Sb eq. More widely available atoms are given a lower value.

● Abiotic depletion, fossil fuels, (MJ LHV)

Fossil abiotic depletion characterizes the consumption of fossil fuels. Each MJ low heat value (LHV) of fuel corresponds to 1 MJ of abiotic depletion.

● Ozone layer depletion (ODP), kg chlorofluorocarbon 11 equivalent (kg CFC-11 eq)

Ozone layer depletion quantifies damage to the ozone layer, by chemicals such as chlorofluorocarbons (CFCs). The characterization model is developed by the World Meteorological Organization (WMO).

● Human toxicity (HTP inf), kg 1,4-dichlorobenzene equivalents, (kg 1,4-DB eq)

Characterisation factors, expressed as Human Toxicity Potentials (HTP), are calculated with USES-LCA, describing fate, exposure and effects of toxic substances for an infinite time horizon.

● Fresh water ecotoxicity (FAETP inf)
● marine aquatic toxicity (MAETP)
● terrestrial ecotoxicity (TETP inf), kg 1,4-dichlorobenzene equivalents, (kg 1,4-DB eq)

Each of these impact categories is based on USES-LCA, describing fate, exposure and effects of toxic substances for an infinite time horizon.

● Photochemical oxidation (smog formation), kg ethylene equivalents (kg C2H4 eq)

Model developed by Jenkin & Hayman and Derwent

● Acidification, kg sulphur dioxide equivalents (kg SO2 eq)

Includes fate, average Europe total, A&B. Model developed by Huijbregts

● Eutrophication, kg phosphate equivalent (kg PO4—eq)

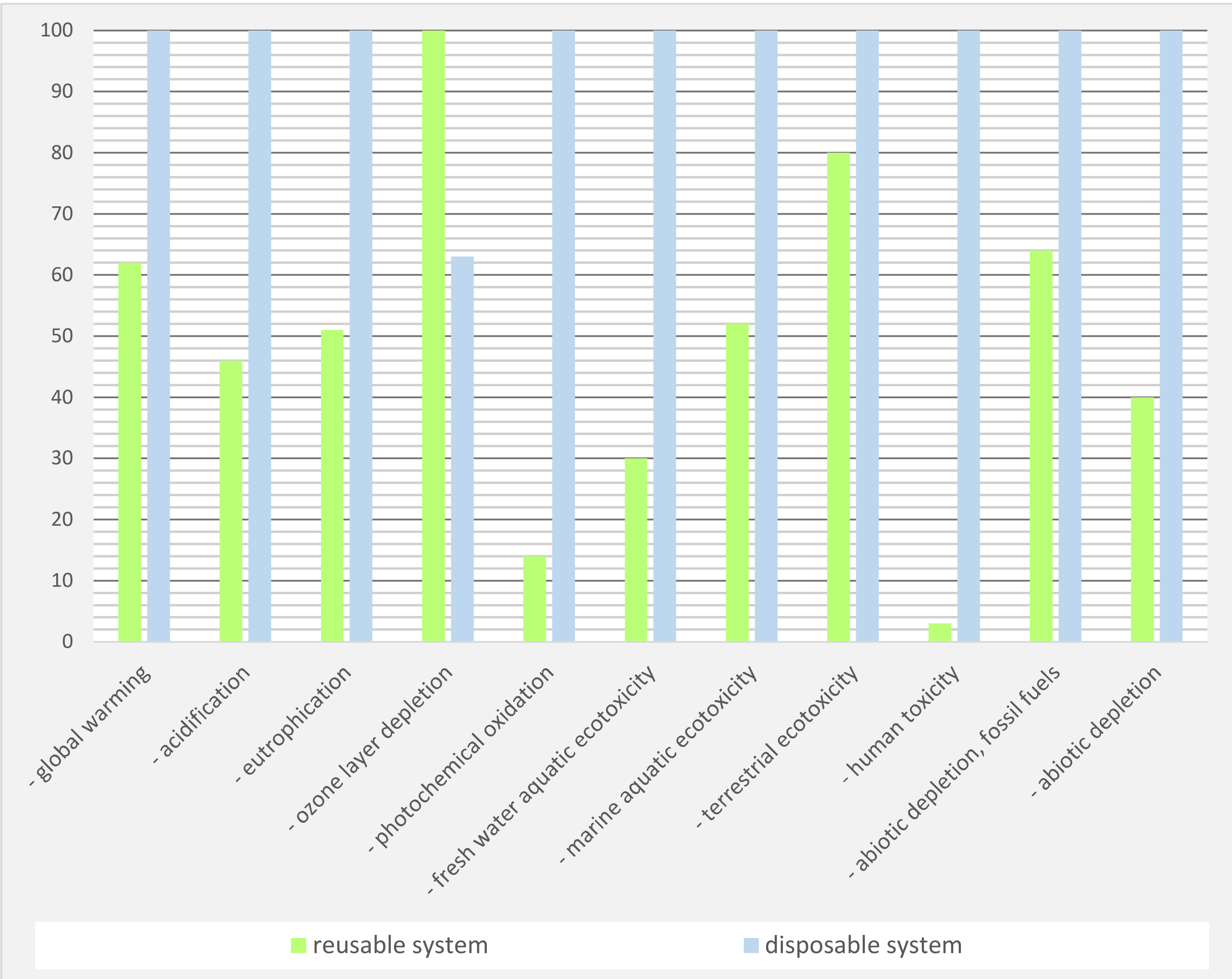
Describes fertilization of water systems. Model developed by Heijungs et al.

2.1 Cradle-to-end-of-life evaluations of reusable (60 cycles) and single use surgical drapes, environmental impacts, method CML*)

*) Centrum voor Milieukunde in Leiden, Holland

% reduction when selecting reusables drapes in comparison to disposable drapes

Parameter	
- global warming	38
- acidification	53
- eutrophication	48
- ozone layer depletion	-36
- photochemical oxidation	86
- fresh water aquatic ecotoxicity	69
- marine aquatic ecotoxicity	47
- terrestrial ecotoxicity	20
- human toxicity	97
- abiotic depletion, fossil fuels	36
- abiotic depletion	57



3. LIFE CYCLE INTERPRETATION

Reusable surgical drape systems outperformed disposable surgical drape systems in the carbon footprint and solid waste category. For the blue water use, the results are inconclusive as more data on operating room water carried by the drapes are needed. Thus, determining which drape system uses more blue water requires more measurements of the water content on soiled drapes from the operating room. For the impact assessment, the improvement from selecting reusable drapes was 20-60% in most categories. This is consistent with the NRE improvement of 38%. Four categories that differed significantly from this range are ozone layer depletion, human toxicity, photochemical oxidation and fresh water ecotoxicity. In the ozone layer depletion category, the reusable drapes had 36% greater impact than disposable drapes. This category was strongly influenced by process emissions of methyl chloride and chlorodifluoromethane. These chemicals are emitted in the production of ePTFE, which appears in the critical zone of reusable drapes and in the tape system. In the human toxicity category, the reusable drapes had a 97% reduction in impact relative to the disposable drapes. The large impact for disposable drapes in this category was dominated by ethylene oxide (ETO) emissions in the sterilization process.

Importance of drape weight

The LCI and LCIA results for the disposable surgical drape systems are highly dependent on the weight of the drape. For example, a 10% decrease in disposable drape weight results in about a 9% decrease in NRE consumption, water consumption, and solid waste generation. The weight of the reusable drape is also significant, since the laundry results are based on the weight of items laundered. Thus, a 10% decrease in reusable drape weight results in about a 8% decrease in NRE consumption and blue water consumption.

Importance of laundry efficiency

The LCI and LCIA results for the reusable surgical drape are highly dependent on the efficiency of the laundry process. For example, a 10% decrease in laundry energy consumption results in about a 5% decrease in NRE.

Production location of disposable drapes

About 10% of the NRE for disposable drapes was due to transport from Asia to Western Europe. If the gowns were produced in Europe, this would have a minor impact on the calculated improvement. The reusable drape system would still consume 32% less NRE than the disposable system. Reliable energy modules were not readily available for China. Thus, the results in this report were based on using European energy modules for both disposable and reusable drapes. As a sensitivity analysis, alternative scale-up factors for China were used to calculate NRE from process energies from gown and packaging materials. This resulted in an NRE of 26,000 MJ/1000 disposable gown uses. In this case, the net reduction in NRE for choosing reusable drapes would be 53%.

4. CONCLUSION

A LCI done using European energy modules and the CML impact method showed that the reusable drape system had lower environmental impacts in 10 of the 11 categories. Furthermore, the reusable drape system outperformed the disposable drape system in all the three environmental indicators studied within the present analysis.

There would appear to be increased environmental benefits for any textile items that are reusable versus disposable. Thus, adding the life cycle of other textile and non-textile items found in health care facilities (especially surgical gowns) would further strengthen the environmental benefits of reusable systems.