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Blue-Zone Technologies
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Dear Kipton:

Re. Review of Blue-Zone Calculations for Life Cycle Analysis

Introduction

Blue-Zone Technologies (Blue-Zone) calculated the greenhouse gas (GHG) emissions reduced using its primary product, Deltasorb® compared to existing practice of venting anesthetic gases to the atmosphere from hospital operating rooms. Anesthetic gases are used to put patients to sleep during surgery.

Anesthesia gases have a global warming potential (GWP) up to 2,000 times greater than carbon dioxide (CO_2) according to a research article in *Anesthesia Essays and Researchers* (2011, Jan-Jun; 5(1): 510).

The Deltasorb® technology system captures anesthetic gases from operating rooms in hospitals. The canister of Deltasorb® is then transported to Blue-Zone's processing facility in Toronto, Canada where the anesthestic gases are desorbed from the canister, distilled to USP grade as verified by Regulatory Agencies, and subsequently used as new generic anesthetics.

With this system, anesthetic gases can be used infinitely. The claim by Blue-Zone is that by capturing, processing, and reusing these anesthetics, they reduce the global warming contribution of the use of anesthetics.

Blue-Zone estimated the GHG emission reductions using the Deltasorb® technology system versus the practice of allowing aesthetic gases to vent to the atmosphere from the operating room. This letter serves as a critical review of their calculations and conclusions.

Quantity of anesthesia gas released in an operating room

Blue-Zone claims each Deltasorb® canister weighs approximately 5 kg and can capture approximately 350 ml (525 grams) of anesthesia gases, approximately the amount of anesthesia gases generated in an operating per week. The claim is based by a hospital survey by Blue-Zone through its anesthetic collection service that the average annual usage of anesthetics used per operating room is 19.2 litres.

Blue-Zone assumes 95% of the anesthetic gas used in an operating room is captured by the Deltasorb® canister. It also assumes an operating room is being used 52 weeks per year.

The quantity of anesthesia gas absorbed by a canister over the course of a week is entirely dependent how frequently the operating room is used.

Make-up of Anesthetic Gases

Blue-Zone bases its GHG comparison calculations on the claim that the weighted average of anesthetic gases used are in operating rooms are 29% Desflurane, 70% Sevoflurane, and 1% Isoflurane.

As the global warming potential (GWP) of the three anesthetic gases varies widely, it is important for any individual hospital to consider the gas it uses. Below is a table of common anesthetic gases and their respective GWP's.

Table 1: Global Warming Potential of Anesthetic Gases

Gas	**GWP20**[1]
Desflurane	6,810
Sevoflurane	440
Isoflurane	1,800

1. Mads Peter Sulbaek Andersen, Ole John Nielsen, and Jodi D. Sherman *Environmental Science & Technology* 2021 55 (15), 10189-10191 DOI: 10.1021/acs.est.1c02573

For a hospital to correctly calculate the quantity of GHG prevented from entering the atmosphere, they will need use the calculation below (see below).

CO_2e Prevented = [(Anesthetic Gas No.1 GWP from Table Above) x (Anesthetic Gas Concentration) + (Anesthetic Gas No. 2 GWP from Table Above) x Anesthetic Gas Concentration) +…] x (Amount of Gas Captured in Tonnes)

GHG Emissions Prevented from Capture

Blue-Zone claims that it prevents the release of 1.2 tonnes of carbon dioxide equivalent (CO_2e) for every 350 mL of anesthetic gas captured with the assumption that the gas is composed of 29% Desflurane, 70% Sevoflurane, and 1% Isoflurane. Based on my review, this calculation is accurate given the assumptions made.

GHG Emission from Transporting one Deltasorb cannister

Blue-Zone provides a table on the CO_2e emissions (in grams) per tonne of freight per kilometre transported. The table references a 2019 scientific paper. The emission factors in the table do not appear in the scientific paper. In response to this fact, Blue-Zone stated GHG emissions calculator for transportation provided at carboncare.org produces very similar results.

In the three case examples provided, the distances listed are one way from the City of Toronto, Canada which is the location Blue-Zone Deltasorb® canister desorption and distillation facility. The distances should be doubled, as there is shipping of cannisters from the facility to the hospital and back again after use.

For an individual hospital attempting to accurately assess the GHG generate transporting Deltasorb® canisters, they can use the following formula:

CO_2e emission from transport = 0.000001464 tonnes CO_2e / km (assuming use of average value from estimated via the CarbonCare website)

Emission from Processing one Deltasorb®

The estimation of GHG emissions from desorption and distillation are satisfactory. Blue-Zone uses emission factors on GHG emissions from electricity production and transmission from the U.S. EPA. They could have used emission factors published for Ontario which would have been more accurate and favourable, resulting in lower GHG emissions from this activity.

Example Journey of one Deltasorb Canister and its net Prevented GHG Emission

The formula used in calculating the GHG emissions prevented through the use of Blue-Zone Deltasorb® is correct. The actual example is off by a minor amount as the transportation distance was for a one-way trip and not a two-way trip.

Overall, in my professional opinion, the attached Appendix A report and supporting calculations provides a reasonably accurate assessment on the GHG emissions (expressed as CO_2e) avoided for a hospital using the Deltasorb® system to capture and have anesthetic gases reprocessed.

Sincerely,

John Nicholson, M.Sc., P.Eng.

Appendix A: GHG Footprint of Deltasorb® Canisters

GHG Emission Prevented by one Deltasorb®

Each Detasorb® is about 5kg and it is good for one OR for one week capturing 350ml (525g) of AA.
This is **1.2 metric tons of eCO_2* prevented by one Deltasorb® Canister**
*When weighted average of inhalation anesthetics used are 29% Desflurane, 70% Sevoflurane, and 1% Isoflurane

Blue-Zone's GHG Emission from Transporting one Deltasorb®

The following table shows the amount of eCO2 (in grams) emitted per metric ton of freight and per km of transportation:

Air plane (air cargo), average Cargo B747	500 g
Modern lorry or truck	60 to 150 g
Modern train	30 to 100 g
Modern ship (sea freight)	10 to 40 g
Airship (Zeppelin, Cargolifter) as planned	55 g

https://timeforchange.org/co2-emissions-shipping-goods

Case 1: Shipping one canister to France (Ocean Freight, 6,000km)

0.0012 metric tons of eCO_2 emitted

Case 2: Shipping one canister to Chicago (USA Ground, 845km)

0.00063 metric tons of eCO_2 emitted

Case 3: Shipping one canister to Peterborough (Ontario Ground, 114km)

0.000034 metric tons of eCO_2 emitted

Emission from Processing one Deltasorb® (Desorption)

Blue-Zone's desorption process uses 230 kwh of electricity to process 100 canisters. Therefore, 2.3 kwh of electricity per one canister. 2.3 kwh is equivalent to **0.002 metric tons of eCO2****
** US EPA GHG Calculator https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Emission from Recovering Anesthetics from one Deltasorb® (Distillation)

Blue-Zone's distillation process uses 75 kwh of electricity per day to process 50 L of recovered anesthetics for the purpose of manufacturing new generic anesthetic drugs. The distillation process takes 3-5 days to complete for desflurane and 5-8 days for sevoflurane.
50L can be prepared from processing (Desorption) 143 canisters. Therefore, 75 kwh/143 canisters = 0.52 kwh of electricity per canister per day. According to above US EPA GHG Calculator, **this is 0.0004 metric tons of eCO2. For Desflurane production: approx. 0.0016 metric tons of eCO2, for Sevoflurane production: approx. 0.0026 metric tons of eCO2.**

Example Journey of one Deltasorb® Canister and its net Prevented GHG Emission

Total emission prevented by one Deltasorb® canister for servicing a hospital in France, and producing Sevoflurane from captured anesthetics:

1.2 metric tons of eCO_2 (captured) - 0.0012 metric tones of eCO_2 (Transportation) - 0.002 metric tones of eCO_2 (Desorption) - 0.0026 metric tons of eCO2 (Distillation) = **1.194 metric tons of eCO2 Prevented**