Life Cycle Analysis of the Production of Three Hospital Preparations through an Advanced Pharmaco-Technical Eco-Audit

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Context and objective :

The environmental impact of pharmaceutical preparations is a crucial indicator for optimizing production methods in hospitals. **This study aims to compare the carbon footprint of two sterile hospital pharmaceutical preparations packaged in (i) glass vials (50 mL) and (ii) pouches (250 mL), and (iii) a non-sterile hospital preparation of capsules (size 4).**

Materials and Methods :

The carbon footprint (CF) of three hospital preparations (batches of 300 units) was calculated as the sum of the carbon emissions (CE) associated with the use of (i) pharmaceutical raw materials (active ingredients, excipients), (ii) single-use materials for packaging or pharmaceutical production, (iii) equipment used in the production processes, whether directly or indirectly involved in the preparation (electricity and water requirements for the washer-disinfector, depyrogenation oven, autoclave) or in maintaining a controlled environment (energy requirements for controlled atmosphere zones, CAZ). The CEs were calculated as follows $\mathbf{CE_1}$ = ∑ (masses used × carbon emission factors); $\mathbf{CE_2}$ = electrical energy demand (kWh/day) × 0.233 kg CO_2/kWh; $\mathbf{CE_3}$ = thermal energy demand (kWh/day) × 0.184 kg CO_2/kWh; $\mathbf{CE_4}$ = water demand (L) × 0.2 kg CO_2/L.

$\mathbf{CE = CE_1 + CE_2 + CE_3 + CE_4}$.

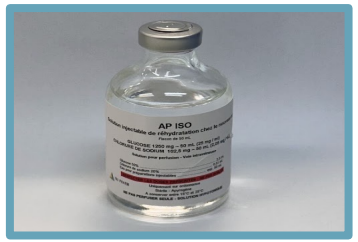

Figure 1: AP-ISO
Glucose 50%.....2.5 mL
Sodium Chloride 20%.....0.51 mL
PPI Water.....q.s. to 50 mL

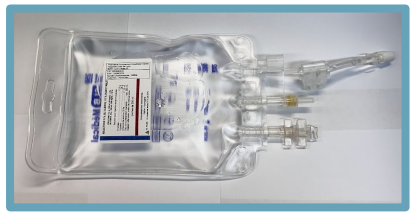

Figure 2: Fructose – Glycerol
Fructose 5%.....12.5 g
Glucose 10%.....25 g
Sodium Chloride 20%.....11.25 mL
PPI Water.....q.s. to 250 mL

Figure 3: Melatonin
Melatonin.....5 mg
Microcrystalline Cellulose.....70 mg

Results :

	AP ISO	Fructose Glycérol	Mélatonine
EC_1	25 kg CO_2	55 kg CO_2	1 kg CO_2
EC_2	27 kg CO_2	7 kg CO_2	7 kg CO_2
EC_3	3 kg CO_2	3 kg CO_2	3 kg CO_2
EC_4	76 kg CO_2	0 kg CO_2	0 kg CO_2
EC_{tot}	131 kg CO_2	65 kg CO_2	11 kg CO_2

Table 1: Distribution of carbon emissions by category for the hospital preparations studied.

Discussions :

The analysis showed that the CE1 (~25 kg CO_2) of glass preparations (50 mL) are low compared to the bags (~55 kg CO_2), while the $EC_{2\text{-}4}$ for glass preparations are significant (106 kg CO_2) due to the water and thermal treatment of CAZ and vials (CE_2: 7 kg $CO_{2\ CAZ}$ + 3 kg $CO_{2\ oven}$ + 3 kg $CO_{2\ washer}$ + 14 kg $CO_{2\ autoclave}$; CE_3: 3 kg $CO_{2\ CAZ}$; CE_4: 76 kg $CO_{2\ 380\ L\ water}$), resulting in a total CE for vials $\mathbf{CE_{vial}}$ **= 131 kg** $\mathbf{CO_2}$ and for pouches $\mathbf{CE_{pouches}}$ **= 65 kg** $\mathbf{CO_2}$. The CEs for capsule preparation consider CE_1 (1 kg CO_2); CE_2 (7 kg CO_2); CE_3 (3 kg CO_2); CE_4 (0 kg CO_2), resulting in a total CE for capsules $\mathbf{CE_{capsules}}$ **= 11 kg** $\mathbf{CO_2}$.

Conclusions :

The results indicate that the production of hospital preparations in glass vials present significant CEs due to the energy consumption required for washing, depyrogenation and sterilization of vials. The CE for pouches is two times lower than that for vials. Non-sterile hospital supplies in capsules have the lowest CE. These results highlight the importance of packaging and sterilization methods on the carbon footprint of hospital pharmaceutical preparations. The impact of the number of units per batch on the total CE will be evaluated in future studies .