Pomace waste management scenarios in Quebec – impact on greenhouse gas emissions

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ABSTRACT

During the management apple pomace wastes (apple juice industry) by different strategies, there is production of greenhouse gases (GHG) which must be taken into account. In this perspective, this study compares life cycle of GHG emissions from five waste management options of apple pomace comprising, incineration, landfill, composting, solid-state fermentation to produce high-value enzymes and animal feed using life cycle assessment (LCA) model. The results of the analysis indicated that of all the apple pomace management sub-models for a functional unit, solid-state fermentation to produce enzymes was the most effective method for reducing GHG emissions (906.81 tons CO2 eq. per year), while apple pomace landfill resulted in higher GHG emissions (1841 tons CO2 eq. per year). Thus, solid-state fermentation was a green and low GHG producing alternative which can be sustainable in terms of value-addition and environmental protection to manage different kinds of agro-industrial solid wastes in Quebec, such as apple pomace.

METHODS

GHG emissions from the waste collection and transportation

$$Et = \frac{N \times D \times C}{100} \times \frac{(C_{CO2} \times 44 + C_{N2O} \times 310 + C_{CH4} \times 23)}{1000}$$

*E*t =GHG carbon equivalence from collection and transportation of waste (kg CO_2 equivalent/year);
N = number of vehicles
D= distance between the industry and management site
C= fuel consumption/100 km= 35 L/100 km
Cig = GHGs emission coefficient (g/L of fuel, *g*: GHG types, such as CO_2, CH_4 and N_2O);
44 = Molecular weight of N_2O
23= Molecular weight of N

Incineration

$$CO_{2(x)} = CE_{CO2-2007} \times M_{Inc\ x\ /province}$$

$CE_{CO2-2007(y)}$= coefficient of CO_2 emission in 2007
$M_{Inc(y)}$ = total mass of incinerated waste in 2007

$$N_2O\ emissions = IWi \times EFi$$

N_2O Emissions = emissions of N_2O
IWi = volume of waste type *i* incinerated
EFi = emission factor of N_2O (kg N_2O/Gg of waste)

Landfill

$$GHG\ t = f \times 1.87 \times A \times C_0 \times k_1 \times e^{-K1 \times T}$$

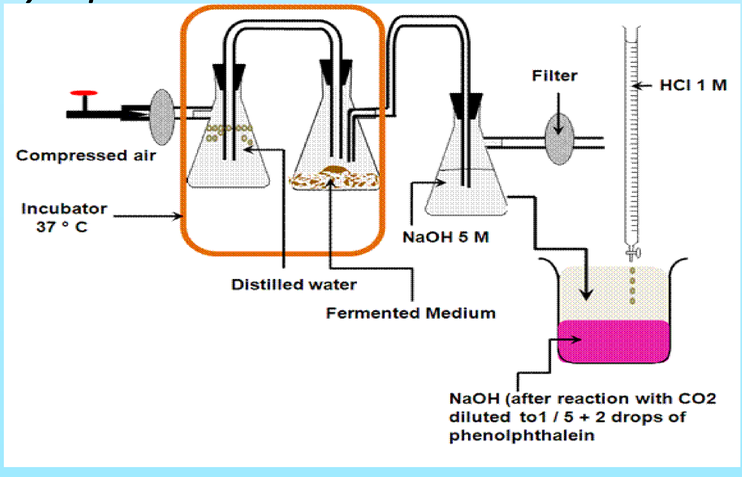
GHG = production of landfill gas,
f = factor of dissimilation (0.58)
1.87 = conversion facteur
A = quantity of wastes loaded into the incinerator
C0 = quantity of organic carbon in the waste
k1 = constant of degradation, 0.094 (per annum)
t = time elapsed since the waste deposit (year)

Animal feed

Coefficients of emission, or $CE_{(CE)T}$, in kg CH_4 per animal, per year

Year	Milking cow	Dairy cattle	Cattle	Calves
2006	135,2	73	60,4	48,3

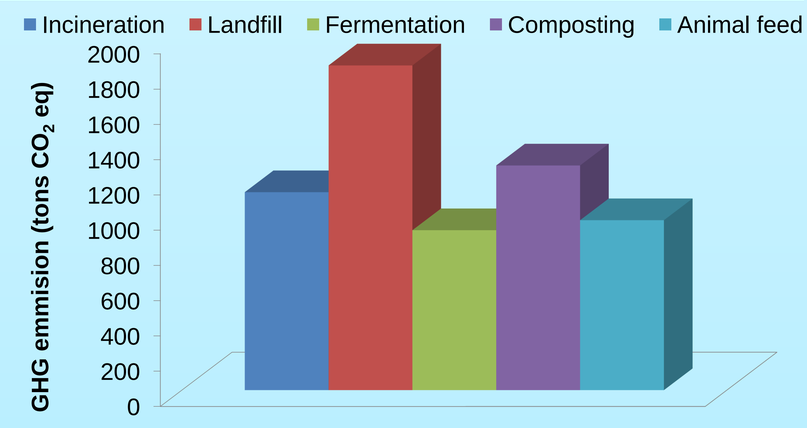
Enzyme production



RESULTS

GHG emissions during different scenarios of apple pomace management

Scenario (tons of CO_2 eq per year)	Animal feed	Landfill	Incineration	Enzyme production	Composting
GHG emissions during transportation	62.1	27.7	221.9	221.9	110.9
CO_2 emissions	N C	201.13	8498. 9	684.8	57.7
CH_4 emissions	901.2	1612.6	N C	N C	N C
N_2O emissions	N C	N C	50.24	N C	1105
Energy recovery	N C	N C	7649.01	N C	N C



Net GHGs emissions from various apple pomace waste management methods

CONCLUSION

The results obtained in this study showed that enzyme production (906.81 tons of CO_2 equivalent per year) and animal feed (963.384 tons of CO_2 equivalent per year) were the least polluting options of the environment in terms of GHG emissions followed by incineration (1122.1 tons of CO_2 equivalent per year), composting (1273 tons of CO_2 equivalent per year) and landfill (1841 tons of CO_2 equivalent per year).