

Environmental emissions of apple fruits exported from Japan to Taiwan

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Appendix A of

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1. Emissions factors of fossil fuels

Table S1 Emission factors of use of fossil fuels

Energy source	CO ₂ (kg CO ₂ / MJ)	CH ₄ (10 ⁻⁶ kg CH ₄ / MJ)	N ₂ O (10 ⁻⁶ kg N ₂ O / MJ)	Source
Light oil (Diesel)	0.0741	10	0.6	IPCC, 2006, Table 2.5
Heavy oil (Residual fuel oil)	0.0774	10	0.6	IPCC, 2006, Table 2.5
Petroleum	0.0733	10	0.6	IPCC, 2006, Table 2.5

2. Emissions from application of fertilizers and pesticides

2.1. Emissions of nitrous components from application of fertilizer

IDEA ver.2 Database contains “Nitrogen emissions to water” and “N₂O emissions to air” related to application of fertilizer (See Table S2). Please note that there is lack of data about NH₃ emission to air and phosphorus emission to water from application of fertilizer in the IDEA data base.

2.2 Emissions from application of pesticides

We calculate the emissions of pesticide and disinfectant as 10 % is emitted to air, 85 % to soil, and 5 % stays on the plant according to Audsley et al. (2003) as applied in, among others, Goossens et al. (2017). The MiLCA software ver2 contain no data related to the emission of herbicide to air. Therefore, in the calculation of the herbicide, 95 % to soil, and 5 % stays on the plant was assumed.

Table S2 Emissions from application of fertilizers and pesticides (rescaled to the FU of 1 g of fresh apple)

Description	Value	Unit	Source
Nitrogen emissions to water from application of fertilizer	Cannot be disclosed ²⁾	kg-N/ kg-fresh apple	IDEA ver.2 Database ¹⁾
N ₂ O emissions to air from application of fertilizer	Cannot be disclosed ²⁾	kg-N ₂ O/ kg-fresh apple	IDEA ver.2 Database ¹⁾
Emission of pesticide (carbaryl) to air	Cannot be disclosed ²⁾	kg/ kg-fresh apple	IDEA ver.2 Database ¹⁾
Emission of disinfectant (captan) to air	Cannot be disclosed ²⁾	kg/ kg-fresh apple	IDEA ver.2 Database ¹⁾
Emission of pesticide (carbaryl) to soil	Cannot be disclosed ²⁾	kg/ kg-fresh apple	IDEA ver.2 Database ¹⁾
Emission of disinfectant (captan) to soil	Cannot be disclosed ²⁾	kg/ kg-fresh apple	IDEA ver.2 Database ¹⁾
Emission of herbicide to soil	Cannot be disclosed ²⁾	kg/ kg-fresh apple	IDEA ver.2 Database ¹⁾

1) IDEA ver.2 Database (Inventory Database for Environmental Analysis), accessed through MiLCA software ver. 2.2 (AIST and SuMPO, Japan).

2) The data utilization rules of the IDEA database prohibit the directly use of the values in any publications.

3. Heavy metal emissions from fertilizer use

The heavy metal emissions to soil and water from fertilizer use were calculated using the formulae listed in the study of Goossens et al. (2017). The input data of heavy metal emissions to soil and groundwater were referred from the previous study (Goossens et al., 2017) considering with the average yield (20.0 t apple / ha) from IDEA ver.2 Database (AIST and SuMPO, Japan). The obtained data are listed in the following Table S3.

Table S3 Heavy metal emissions from fertilizer use

Description	Value	Unit	Source
Cadmium from fertilizer to soil	0.316065795	mg / kg-fresh apple	Goossens et al., 2017
Copper from fertilizer to soil	0.441641031	mg / kg-fresh apple	Goossens et al., 2017
Zinc from fertilizer to soil	8.627637811	mg / kg-fresh apple	Goossens et al., 2017
Lead from fertilizer to soil	1.745485986	mg / kg-fresh apple	Goossens et al., 2017
Nickel from fertilizer to soil	1.002744414	mg / kg-fresh apple	Goossens et al., 2017
Chromium from fertilizer to soil	3.014377137	mg / kg-fresh apple	Goossens et al., 2017
Mercury from fertilizer to soil	0.00551849	mg / kg-fresh apple	Goossens et al., 2017
Cadmium from fertilizer to groundwater	0.0025	mg / kg-fresh apple	Goossens et al., 2017
Copper from fertilizer to groundwater	0.18	mg / kg-fresh apple	Goossens et al., 2017
Zinc from fertilizer to groundwater	1.65	mg / kg-fresh apple	Goossens et al., 2017
Lead from fertilizer to groundwater	0.03	mg / kg-fresh apple	Goossens et al., 2017
Nickel from fertilizer to groundwater	0	mg / kg-fresh apple	Goossens et al., 2017
Chromium from fertilizer to groundwater	1.06	mg / kg-fresh apple	Goossens et al., 2017
Mercury from fertilizer to groundwater	0.000065	mg / kg-fresh apple	Goossens et al., 2017

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