Article

Human health impacts of aviation biofuel production: exploring the application of different life cycle impact assessment (LCIA) methods for biofuel supply chains

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Substance contribution analysis for each aviation biofuel alternative

Sugarcane-ATJ aviation biofuel

The substance contribution analysis reveals the key substances contributing to each impact category and key emissions to environmental compartments (i.e., air, water, and soil), as presented in **Tables S3-S7**. USEtox 2(r + i), ReCiPe 2016 (H), and TRACI show that HCT is predominantly caused by emissions of chromium VI to water compartment. Additionally, emissions of chromium VI to air and soil compartments; and nickel to air, water, and soil compartments also contribute to HCT. Further, HNCT is mainly attributed to the emissions of zinc to air, water, and soil compartments. Emissions of lead, mercury, and cadmium to air compartment; and barium to water compartment are also responsible for HNCT. These heavy metal emissions are mainly from the toxic chemicals used in sugarcane milling (e.g., phosphoric acid and polyacrylamide), and biofuel conversion (e.g., sulphuric acid, ammonia, and polyacrylamide). The use of fertilizers (e.g., urea, diammonium phosphate, potassium chloride, and ammonia) and pesticides (e.g., diuron and carbofuran) in sugarcane cultivation is also responsible for these emissions. Another main contributor is the use of primary energy processes such as diesel used in engine and for trash unbailing, electricity used for operations, and natural gas used for H_2 production. On the other hand, according to ReCiPe 2016 (H), IMPACT 2002+, and TRACI, FPM is primarily a result of emissions of ammonia, nitrogen oxides, PM2.5, and sulphur dioxide to air compartment. These emissions are primarily attributed to the use of fertilizers and pesticides in sugarcane production, and toxic chemicals and primary energy used in industrial processes. The combustion of aviation biofuel also contributes largely to the emissions of PM2.5 and nitrogen oxides. In respect to PS, ReCiPe 2016 (H) and TRACI indicate that the emissions of nitrogen oxides and nitrogen monoxide to air compartment are predominantly responsible. These emissions are mainly from sugarcane milling and biofuel conversion, due to the use of primary energy and toxic chemicals.

Eucalyptus-FP aviation biofuel

Based on USEtox 2(r + i), ReCiPe 2016(H), and TRACI, HCT of the eucalyptus-FP supply chain is predominantly attributed to the emissions of chromium VI to water compartments. In addition, emissions of nickel to water compartment, and chromium VI to air and soil compartments also account for HCT. Moreover, HNCT is primarily caused by emissions of zinc to water compartment. Next to this, emissions of mercury to air and water compartments, and zinc and cadmium to air compartment are also responsible for HNCT. These heavy metal emissions are mainly from feedstock production due to the use of fertilizers (e.g., superphosphate, potassium chloride, and ammonium sulphate), pesticides (e.g., glyphosate herbicide and sulfluramid formicide), and diesel in the field,

and from biofuel conversion due to ash disposal (assuming that ash is sent to landfill). On the other hand, according to ReCiPe 2016 (H), IMPACT 2002+, and TRACI, FPM is primarily a result of the emissions of ammonia, nitrogen oxides, PM2.5, and sulphur dioxid e to air compartment, while ReCiPe 2016 (H) and TRACI suggest that PS is predominantly caused by the emissions of nitrogen oxides, and nitrogen monoxide to air compartment. The emissions responsible for FPM are primarily from the use of fertilizers, pesticides, and diesel in feedstock production; and ash disposal in biofuel conversion. Combusting biofuel is a key contributor to the emission of nitrogen oxides. With regard to PS, the emissions of nitrogen oxides and nitrogen monoxide are mainly from feedstock production and biofuel combustion.

Macauba-HEFA aviation biofuel

According to USEtox 2(r + i), ReCiPe 2016 (H), and TRACI, HCT of the macauba-HEFA supply chain is predominantly attributed to the emissions of chromium VI to water compartment, followed by the emissions of nickel to water compartment; whereas HNCT is primarily caused by the emissions of zinc to air, water, and soil compartments, followed by the emissions of lead to air compartment. The emissions of mercury to air compartment, and cadmium to soil and air compartments are also responsible for HNCT. These heavy metal emissions are mainly from the use of primary energy in H_2 SMR process, ash disposal (assuming that ash is sent to landfill) in biofuel conversion, and the use of fertilizers (e.g., superphosphate and potassium nitrate), pesticides (e.g., pyrethroid), and diesel in feedstock production. On the other hand, according to ReCiPe 2016 (H), IMPACT 2002+, and TRACI, FPM is mainly a result of the emissions of ammonia, nitrogen oxides, PM2.5, and sulphur dioxide to air compartment, while ReCiPe 2016 (H) and TRACI suggest that PS is predominantly caused by the emissions of nitrogen oxides to air compartment. The emissions responsible for FPM are primarily from the use of fertilizers, pesticides, and diesel in feedstock production; primary energy used in H_2 SMR; and ash disposal in biofuel conversion. Biofuel combustion is a key contributor to the emission of nitrogen oxides. With regard to PS, the emissions of nitrogen oxides and nitrogen monoxide come predominantly from combusting biofuel.

Table S1. Life cycle inventory for the feedstock production phase, based on the functional unit of 1 L jet fuel.

Sugarcane-ATJ	Value	Unit	Eucalyptus-FP	Value	Unit	Macauba-HEFA	Value	Unit
Reference: [1, 2]]			**Reference:** [3, 4]			**Reference:** [5]		
Product			**Product**			**Product**		
Sugarcane	79	ton/ha	Eucalyptus		ton/ha	Macauba		ton/ha
Inputs			**Inputs**			**Inputs**		
Nutrients			**Nutrients**			**Nutrients**		
N (Urea, 45% N)	2.34E-02	kg	N (Urea, 45% N)	5.76E-03	kg	Urea (45% N)	2.56E-05	kg
P_2O_5 (Diammonium phosphate, 20% P_2O_5)	8.53E-03	kg	Ammonium sulfate (21,2% N)	2.31E-02	kg	Nitrogen fertilizer, as N	1.93E-01	kg
K_2O (Potassium chloride, 60% K_2O)	1.66E-02	kg	Superphosphate(18.5% P_2O_5)	3.33E-01	kg	Potassium chloride (58% KCl), fertilizer	2.56E-05	kg
Ammonia, steam reforming, liquid	1.65E-03	kg	K_2O (Potassium chloride, 60% K_2O)	1.58E-01	kg	Magnesium sulfate (11% MgO, 13% S), fertilizer	1.37E-05	kg
Monoammonium phosphate, as P_2O_5	6.12E-04	kg	Limestone (as calcium carbonate)	1.15E+00	kg	Phosphate fertilizer, as single superphosphate.	6.30E-02	kg
Monoammonium phosphate, as N	1.16E-04	kg	Mg	1.90E-02	kg	Potassium fertilizer, as K_2O.	2.31E-01	kg
Limestone, milled, loose	9.07E-02	kg	Water	4.90E+00	kg	Lime, at regional storehouse (soil in Brazil is low in Ca and Mg)	3.79E-01	kg
Gypsum, mineral, at mine	4.53E-02	kg	**Agrochemicals**			Water	1.54E+02	kg
Agrochemicals			Lubricants (oil and grease)	4.55E-05	kg	**Agrochemicals**		
Glyphosate	5.89E-05	kg	Glyphosate herbicide	8.88E-03	kg	Agricultural phytosanitary. Pyrethroid. Deltamethrin 2.5%.	5.98E-01	kg
Diuron, at regional storehouse/RER U	2.27E-05	kg	Sulfluramid formicide	6.45E-03	kg	Water. 500 L/ha for sprayer.	2.56E+02	kg
Carbofuran, at regional storehouse/RER U	9.52E-05	kg	**Transport**			Glyphosate, at storehouse. Isopropylammmonium salt.	7.35E-01	kg
Growth regulators (alachlor)	2.27E-05	kg	Diesel use transport to mill	8.27E-03	kg	2,4-D, herbicide, at storehouse. Isopropylammmonium salt + 2,4-D	2.45E-01	kg
Insecticides (Fenvalerat Pyrethroid)	9.07E-06	kg	**Energy resources**			Water. 500 L/ha for herbicide.	2.56E+02	kg
Herbicides	6.12E-05	kg	Diesel use in field	2.80E-01	kg	**Transport**		
Vinasse application			Electricity (seedling cultivation)	1.04E-02	MJ	Transport tractor and trailer.	2.40E+00	tkm
Vinasse pumping and storage system operation	9.47E-03	m^3	**Emissions to air**			Transport truck <10 t	1.54E-03	tkm
Vinasse aspertion system operation	1.42E-02	m^3	Ammonia [Inorganic emissions to air]	4.33E-03	kg	Transport. 28-t truck	2.05E+00	tkm
Machinery			Carbon dioxide [Inorganic emissions to air]	8.70E-01	kg	**Emissions to air**		
Harvester	9.91E-04	kg	Carbon monoxide [Inorganic emissions to air]	3.10E+00	kg	Ammonia [Inorganic emissions to air]	2.93E-02	kg
Tractor	1.73E-03	kg	Glyphosate particles	1.56E-02	kg	Carbon dioxide [Inorganic emissions to air]	5.37E-02	kg
Agricultural machinery, general, production	2.39E-03	kg	Nitrogen oxides [Inorganic emissions to air]	5.76E-04	kg	Nitrogen oxides [Inorganic emissions to air]	3.33E-03	kg
Diesel, at refinery	3.20E-02	kg	Nitrous oxide (laughing gas, nitrogen monoxide) [Inorganic emissions to air]	6.69E-03	kg	**Emissions to water**		
Transport			Particular matter	5.94E-04	kg	Glyphosate particles	1.10E-04	kg
Transport, lorry 16-32t, EURO3	2.66E-01	tkm	Sulphur dioxide [Inorganic emissions to air]	4.65E-04	kg	2,4-D, herbicide	3.68E-05	kg
Transport, lorry >32t, EURO3	5.80E-01	tkm	VOCNM [volatile organic compounds non-methane]	4.50E-03	kg			
Emissions to air			**Emissions to soil**					
Ammonia [Inorganic emissions to air]	9.02E-03	kg	Lubricants residue	1.36E-05	kg			
Benzene [Group NMVOC to air]	2.33E-07	kg	**Emissions to water**					

Benzo{a}pyrene [Group PAH to air]	9.59E-10	kg	Glyphosate particles [Pesticides to water]	8.30E-06	kg
Cadmium [Heavy metals to air]	3.20E-10	kg	Runoff surface (from P2O5)	6.34E-03	kg
Carbon dioxide [Inorganic emissions to air]	1.80E-01	kg	Runoff surface and percolation (from N)	5.76E-03	kg
Carbon monoxide [Inorganic emissions to air]	1.73E-04	kg			
Chromium [Heavy metals to air]	1.60E-09	kg			
Copper [Heavy metals to air]	5.44E-08	kg			
Hydrocarbons (unspecified) [Organic emissions to air (group VOC)]	9.59E-05	kg			
Methane [Organic emissions to air (group VOC)]	4.13E-06	kg			
Nickel [Heavy metals to air]	2.24E-09	kg			
Nitrogen oxides [Inorganic emissions to air]	1.36E-03	kg			
Nitrous oxide (laughing gas) [Inorganic emissions to air]	7.75E-04	kg			
Polycyclic aromatic hydrocarbons (PAH, carcinogenic) [Group PAH to air]	1.05E-07	kg			
Selenium [Heavy metals to air]	3.20E-10	kg			
Sulphur dioxide [Inorganic emissions to air]	3.24E-05	kg			
Zinc [Heavy metals to air]	3.20E-08				
Emissions to soil					
Cadmium [Heavy metals to agricultural soil]	4.28E-07	kg			
Carbofuran [Pesticides to agricultural soil]	9.39E-05	kg			
Chromium [Heavy metals to agricultural soil]	3.11E-06	kg			
Copper [Heavy metals to agricultural soil]	2.65E-06	kg			
Diuron [Pesticides to agricultural soil]	2.18E-05	kg			
Fipronil [Pesticides to agricultural soil]	8.93E-06	kg			
Glyphosate [Pesticides to agricultural soil]	5.78E-05	kg			
Hexazinone [Pesticides to agricultural soil]	6.35E-06	kg			
Lead [Heavy metals to agricultural soil]	5.71E-06	kg			
Nickel [Heavy metals to agricultural soil]	2.54E-06	kg			
Zinc [Heavy metals to agricultural soil]	1.76E-05	kg			
Emissions to water					
Carbofuran [Pesticides to fresh water]	1.43E-06	kg			
Diuron [Pesticides to fresh water]	3.31E-07	kg			
Fipronil [Pesticides to fresh water]	1.36E-07	kg			
Glyphosate [Pesticides to fresh water]	8.82E-07	kg			
Nitrate [Inorganic emissions to fresh water]	5.49E-03	kg			

Table S2. Life cycle inventory for the industrial production phase, based on the functional unit of 1 L jet fuel.

Sugarcane-ATJ	**Value**	**Unit**	**Eucalyptus-FP**	**Value**	**Unit**	**Macauba-HEFA**	**Value**	**Unit**
Reference: [1, 2]			**Reference:** [6]			**Reference:** [6]		
Outputs (co-products)			**Outputs (co-products)**			**Outputs (co-products)**		
Aviation biofuel	0.81	kg	Aviation biofuel	0.81	kg	Aviation biofuel	0.81	kg
Biodiesel	0.23	kg	Biodiesel	0.23	kg	Biodiesel	0.55	kg
Naphtha	0.11	kg	Naphtha	0.11	kg	Naphtha	0.27	kg
Propane	0.067	kg	**Inputs**			**Inputs**		
Inputs			Feedstock	17.92	kg	Feedstock	1.51	kg
Feedstock	17.92	kg	Natural gas	0.44	kg	Natural gas	0.29	kg
Water	22.43	kg	H_2O	0.018	kg	H_2O	0.44	kg
CaO (100%)	0.018	kg	**Emission to soil**			**Emission to soil**		
H_3PO_4 (15wt%)	0.0042	kg	Ash to landfill	0.0042	kg	Ash to landfill	0.59	kg
Polyacrylamide (Flocculant polymer, 1wt%)	0.053	kg						
NH4OH	0.023	kg						
H_2SO_4	1.88	kg						
Diesel for trash unbaling	0.38	kg						
Natural gas	0.22	kg						
Emission to soil								
Ash to landfill	7.24	kg						

Table S3. Top 20 substance contribution (in %) to HCT, resulting from different LCIA methods.

Sugarcane-ATJ supply chain															
	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		cases	Substance		kg 1,4-DCB	Substance		kg 1,4-DCB	Substance		kg C_2H_3Cl eq.	Substance		CTUh
	Total	All	9.68E-08	Total	All	4.80E+00	Total	All	6.89E-02	Total	All	6.43E-02	Total	All	1.43E-07
1	Chromium VI	Water	8.43E-08	Chromium VI	Water	4.67E+00	Chromium VI	Water	6.34E-02	Hydrocarbons, aromatic	Air	3.01E-02	Chromium VI	Water	1.02E-07
2	Nickel	Water	4.95E-09	Chromium VI	Soil	6.01E-02	Chromium VI	Air	1.77E-03	Benzo(a)pyrene	Air	2.59E-02	Chromium	Soil	2.54E-08
3	Benzo(a)pyrene	Air	2.97E-09	Chromium VI	Air	5.14E-02	Nickel	Air	1.36E-03	Hydrocarbons, aromatic	Water	4.13E-03	Chromium	Air	5.65E-09
4	Arsenic	Water	1.68E-09	Nickel	Water	1.04E-02	Nickel	Water	9.48E-04	Arsenic	Water	1.10E-03	Chromium	Water	4.54E-09
5	Chromium VI	Soil	5.97E-10	Nickel	Air	3.26E-03	Chromium VI	Soil	6.88E-04	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	1.03E-03	Arsenic	Water	1.88E-09
6	Mercury	Air	5.76E-10	Nickel	Soil	2.63E-03	Formaldehyde	Air	3.39E-04	PAH, polycyclic aromatic hydrocarbons	Air	7.79E-04	Nickel	Water	1.60E-09
7	Nickel	Soil	4.53E-10	Formaldehyde	Air	3.39E-04	Benzo(a)pyrene	Air	9.65E-05	Arsenic	Air	6.12E-04	Chromium VI	Soil	6.41E-10
8	Nickel	Air	3.77E-10	Mercury	Air	1.89E-04	Nickel	Soil	9.10E-05	Chromium	Air	3.27E-04	Mercury	Air	3.81E-10
9	Chromium VI	Air	2.29E-10	Mercury	Water	1.37E-04	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	5.60E-05	Arsenic	Soil	1.77E-04	Chromium VI	Air	2.93E-10
10	Arsenic	Air	1.36E-10	Lead	Soil	1.15E-04	Lead	Air	4.31E-05	PAH, polycyclic aromatic hydrocarbons	Water	3.88E-05	Nickel	Air	1.77E-10
11	Formaldehyde	Air	1.14E-10	Benzo(a)pyrene	Air	9.65E-05	Cadmium	Air	3.62E-05	Aldrin	Soil	2.57E-05	Nickel	Soil	1.46E-10
12	Lead	Air	8.64E-11	Lead	Air	6.17E-05	Mercury	Water	2.55E-05	Cadmium	Air	8.92E-06	Arsenic	Air	1.32E-10
13	Cadmium	Air	7.79E-11	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	6.03E-05	Benzene	Air	2.00E-05	Chromium VI	Air	8.53E-06	Formaldehyde	Air	1.15E-10
14	Cadmium	Water	3.62E-11	Cadmium	Air	5.96E-05	Furan	Air	1.25E-05	Formaldehyde	Air	7.00E-06	Cadmium	Air	5.35E-11
15	Cadmium	Soil	3.45E-11	Cadmium	Soil	2.84E-05	PAH, polycyclic aromatic hydrocarbons	Air	7.22E-06	Carbaryl	Soil	5.77E-06	Lead	Air	5.16E-11
16	Mercury	Water	2.79E-11	Cadmium	Water	2.18E-05	Cadmium	Soil	4.28E-06	Atrazine	Soil	4.67E-06	Benzo(a)pyrene	Air	2.51E-11
17	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	2.12E-11	Benzene	Air	2.00E-05	Lead	Water	3.84E-06	Ethane, 1,2-dichloro-	Water	3.53E-06	Mercury	Water	2.21E-11
18	Mercury	Soil	2.07E-11	Lead	Water	1.80E-05	Mercury	Air	3.79E-06	Phenol, pentachloro-	Air	2.87E-06	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	1.74E-11
19	Fluoranthene	Water	1.13E-11	Arsenic V	Water	1.79E-05	Cadmium	Water	2.86E-06	Carbaryl	Air	1.45E-06	Cadmium	Soil	1.35E-11
20	Lead	Soil	8.90E-12	Furan	Air	1.25E-05	Benzene, ethyl-	Air	2.66E-06	PAH, polycyclic aromatic hydrocarbons	Soil	8.52E-07	Mercury	Soil	1.13E-11
Eucalyptus-FP supply chain															
	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		cases	Substance		kg 1,4-DCB	Substance		kg 1,4-DCB	Substance		kg C_2H_3Cl eq.	Substance		CTUh
	Total	All	1,73E-07	Total	All	8,546251	Total	All	0,124002	Total	All	0,051101	Total	All	2,45E-07
1	Chromium VI	Water	1,48E-07	Chromium VI	Water	8,22E+00	Chromium VI	Water	1,12E-01	Hydrocarbons, aromatic	Air	0,03256	Chromium VI	Water	1,59E-07
2	Nickel	Water	1,34E-08	Chromium VI	Soil	1,54E-01	Chromium VI	Air	4,75E-03	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	0,00537	Chromium	Water	5,62E-08
3	Arsenic	Water	5,45E-09	Chromium VI	Air	1,38E-01	Nickel	Water	2,56E-03	Arsenic	Water	0,003656	Chromium	Air	1,49E-08
4	Chromium VI	Soil	1,53E-09	Nickel	Water	2,80E-02	Chromium VI	Soil	1,76E-03	Hydrocarbons, aromatic	Water	0,003516	Arsenic	Water	5,90E-09
5	Mercury	Air	1,02E-09	Nickel	Air	3,88E-03	Nickel	Air	1,65E-03	Benzo(a)pyrene	Air	0,002057	Nickel	Water	4,30E-09
6	Chromium VI	Air	6,13E-10	Mercury	Water	1,61E-03	Formaldehyde	Air	8,53E-04	Arsenic	Air	0,001498	Chromium VI	Soil	1,64E-09
7	Nickel	Air	3,93E-10	Formaldehyde	Air	8,53E-04	Mercury	Water	3,03E-04	PAH, polycyclic aromatic hydrocarbons	Air	0,001217	Chromium VI	Air	7,86E-10
8	Formaldehyde	Air	3,41E-10	Mercury	Air	3,50E-04	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	2,91E-04	Chromium	Air	0,000865	Mercury	Air	6,77E-10

9	Mercury	Water	3,32E-10	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	3,13E-04	Lead	Air	9,94E-05	Arsenic	Soil	0,000196	Chromium	Soil	4,42E-10
10	Arsenic	Air	3,12E-10	Lead	Air	1,42E-04	Cadmium	Air	3,68E-05	Ethane, 1,2-dichloro-	Water	5,26E-05	Formaldehyde	Air	3,43E-10
11	Benzo(a)pyrene	Air	2,13E-10	Cadmium	Water	8,80E-05	Benzene	Air	2,02E-05	PAH, polycyclic aromatic hydrocarbons	Water	3,39E-05	Arsenic	Air	3,02E-10
12	Lead	Air	1,90E-10	Cadmium	Air	8,00E-05	Cadmium	Water	1,22E-05	Chromium VI	Air	2,29E-05	Mercury	Water	2,62E-10
13	Cadmium	Water	1,55E-10	Lead	Water	3,00E-05	PAH, polycyclic aromatic hydrocarbons	Air	1,14E-05	Cadmium	Air	1,48E-05	Nickel	Air	1,78E-10
14	Cadmium	Air	1,20E-10	Benzene	Air	2,02E-05	Methane, tetrachloro-, CFC-10	Air	8,54E-06	Formaldehyde	Air	1,46E-05	Lead	Air	1,13E-10
15	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	1,12E-10	PAH, polycyclic aromatic hydrocarbons	Air	1,14E-05	Ethane, 1,2-dichloro-	Water	7,60E-06	Aldrin	Soil	1,35E-05	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	9,18E-11
16	Nickel	Soil	7,65E-12	Nickel	Soil	9,03E-06	Benzo(a)pyrene	Air	7,45E-06	Ethane, 1,2-dichloro-	Air	5,61E-06	Cadmium	Air	8,01E-11
17	Ethane, 1,2-dichloro-	Water	6,63E-12	Methane, tetrachloro-, CFC-10	Air	8,54E-06	Mercury	Air	6,74E-06	Phenol, pentachloro-	Air	3,30E-06	Cadmium	Water	1,41E-11
18	Benzene	Air	5,31E-12	Ethane, 1,2-dichloro-	Water	7,60E-06	Lead	Water	6,15E-06	Methane, tetrachloro-, CFC-10	Air	1,26E-06	Ethane, 1,2-dichloro-	Water	6,88E-12
19	Cadmium	Soil	5,05E-12	Benzo(a)pyrene	Air	7,45E-06	Ethane, 1,2-dichloro-	Air	5,77E-06	PAH, polycyclic aromatic hydrocarbons	Soil	8,98E-07	Lead	Water	6,63E-12
20	Arsenic	Soil	3,18E-12	Ethane, 1,2-dichloro-	Air	5,77E-06	Ethene, chloro-	Air	3,63E-06	Benzene	Water	5,78E-07	Benzene	Air	6,09E-12
Macauba-HEFA supply chain															
	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		cases	Substance		kg 1,4-DCB	Substance		kg 1,4-DCB	Substance		kg C_2H_3Cl eq.	Substance		CTUh
	Total	All	8,42E-08	Total	All	4,319942	Total	All	0,060524	Total	All	0,009448	Total	All	2,45E-07
1	Chromium VI	Water	7,66E-08	Chromium VI	Water	4,238418	Chromium VI	Water	0,057543	Hydrocarbons, aromatic	Air	0,005516	Chromium VI	Water	9,21E-08
2	Nickel	Water	4,64E-09	Chromium VI	Soil	0,046915	Nickel	Water	0,000889	Arsenic	Water	0,001346	Chromium	Air	8,20E-08
3	Arsenic	Water	1,35E-09	Chromium VI	Air	0,023466	Chromium VI	Air	0,000807	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	0,000643	Chromium	Water	2,44E-09
4	Chromium VI	Soil	4,66E-10	Nickel	Water	0,009714	Chromium VI	Soil	0,000537	Benzo(a)pyrene	Air	0,000636	Chromium	Soil	1,76E-09
5	Mercury	Air	4,61E-10	Nickel	Air	0,000698	Formaldehyde	Air	0,000308	PAH, polycyclic aromatic hydrocarbons	Air	0,000541	Nickel	Water	1,60E-09
6	Formaldehyde	Air	1,19E-10	Formaldehyde	Air	0,000308	Nickel	Air	0,000297	Arsenic	Air	0,000321	Arsenic	Water	1,49E-09
7	Chromium VI	Air	1,04E-10	Mercury	Air	0,000148	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	3,50E-05	Hydrocarbons, aromatic	Water	0,000228	Chromium VI	Soil	1,46E-09
8	Nickel	Air	7,05E-11	Mercury	Water	8,36E-05	Furan	Air	2,44E-05	Chromium	Air	0,00014	Mercury	Air	5,01E-10
9	Arsenic	Air	6,92E-11	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	3,77E-05	Lead	Air	2,30E-05	Arsenic	Soil	4,50E-05	Chromium VI	Air	3,03E-10
10	Benzo(a)pyrene	Air	6,66E-11	Lead	Air	3,30E-05	Mercury	Water	1,57E-05	Formaldehyde	Air	7,71E-06	Formaldehyde	Air	1,34E-10
11	Mercury	Soil	5,25E-11	Lead	Water	3,12E-05	Lead	Water	6,86E-06	Atrazine	Soil	5,66E-06	Arsenic	Air	1,21E-10
12	Cadmium	Soil	4,74E-11	Furan	Air	2,44E-05	Benzene	Air	6,50E-06	Aldrin	Soil	4,66E-06	Nickel	Air	6,71E-11
13	Lead	Air	4,59E-11	Cadmium	Soil	1,78E-05	Cadmium	Air	6,12E-06	Chromium VI	Air	3,89E-06	Mercury	Soil	3,19E-11
14	Fluoranthene	Water	2,35E-11	Cadmium	Air	1,42E-05	Cadmium	Soil	5,80E-06	Cadmium	Air	2,73E-06	Lead	Air	2,88E-11
15	Cadmium	Air	2,18E-11	Cadmium	Water	1,10E-05	PAH, polycyclic aromatic hydrocarbons	Air	4,94E-06	PAH, polycyclic aromatic hydrocarbons	Water	2,49E-06	Cadmium	Soil	2,74E-11
16	Cadmium	Water	1,93E-11	Benzene	Air	6,50E-06	Mercury	Air	3,04E-06	Phenol, pentachloro-	Air	9,70E-07	Cadmium	Air	2,54E-11
17	Mercury	Water	1,72E-11	PAH, polycyclic aromatic hydrocarbons	Air	4,94E-06	Methane, tetrachloro-, CFC-10	Air	2,40E-06	PAH, polycyclic aromatic hydrocarbons	Soil	8,28E-07	Mercury	Water	1,44E-11
18	Lead	Soil	1,68E-11	Methane, tetrachloro-, CFC-10	Air	2,40E-06	Benzo(a)pyrene	Air	2,31E-06	Ethane, 1,2-dichloro-	Water	5,90E-07	Furan	Air	1,36E-11
19	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	1,33E-11	Benzo(a)pyrene	Air	2,31E-06	Cadmium	Water	1,53E-06	Trifluralin	Soil	5,80E-07	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	1,31E-11
20	Furan	Air	1,25E-11	Formaldehyde	Water	1,23E-06	Formaldehyde	Water	1,23E-06	Methane, tetrachloro-, CFC-10	Air	3,55E-07	Lead	Soil	1,09E-11

Table S4. Top 20 substance contribution HNCT, resulting from different LCIA methods.

Sugarcane-ATJ supply chain															
	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		cases	Substance		kg 1,4-DCB	Substance		kg 1,4-DCB	Substance		kg C_2H_3Cl eq.	Substance		CTUh
	Total	All	3,84E-07	Total	All	6,22E+02	Total	All	1,70E+00	Total	All	8,17E-02	Total	All	6,02E-07
1	Arsenic	Water	1,25E-07	Zinc	Water	4,83E+02	Zinc	Water	1,47E+00	Zinc	Soil	4,11E-02	Zinc	Water	2,29E-07
2	Mercury	Air	6,82E-08	Zinc	Soil	1,28E+02	Lead	Air	5,16E-02	Arsenic	Water	1,15E-02	Arsenic	Water	1,39E-07
3	Zinc	Water	4,70E-08	Zinc	Air	7,51E+00	Zinc	Air	3,93E-02	Arsenic	Air	6,14E-03	Zinc	Air	6,45E-08
4	Lead	Air	3,03E-08	Barium	Water	1,70E+00	Zinc	Soil	2,81E-02	Cadmium	Soil	6,01E-03	Zinc	Soil	5,73E-08
5	Zinc	Air	2,34E-08	Vanadium	Air	5,36E-01	Fipronil	Soil	1,61E-02	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	5,20E-03	Mercury	Air	4,51E-08
6	Cadmium	Air	1,80E-08	Vanadium	Water	4,16E-01	Carbofuran	Soil	1,51E-02	Barium	Water	3,01E-03	Lead	Air	1,81E-08
7	Zinc	Soil	1,67E-08	Barium	Soil	2,84E-01	Barium	Water	1,29E-02	Arsenic	Soil	1,84E-03	Cadmium	Air	1,13E-08
8	Barium	Water	1,00E-08	Thallium	Water	2,42E-01	Cadmium	Air	1,08E-02	Ammonia	Air	1,51E-03	Arsenic	Air	8,13E-09
9	Cadmium	Water	9,71E-09	Lead	Soil	1,38E-01	Mercury	Water	1,03E-02	Barium	Soil	6,84E-04	Barium	Water	6,90E-09
10	Cadmium	Soil	9,27E-09	Mercury	Air	7,66E-02	Vanadium	Air	6,09E-03	Zinc	Water	6,78E-04	Cadmium	Soil	3,62E-09
11	Arsenic	Air	8,54E-09	Lead	Air	7,41E-02	Barium	Soil	6,09E-03	Molybdenum	Air	6,59E-04	Mercury	Water	2,61E-09
12	Mercury	Water	3,29E-09	Mercury	Water	5,54E-02	Carbon disulfide	Air	5,80E-03	Antimony	Air	5,44E-04	Lead	Soil	2,48E-09
13	Lead	Soil	3,12E-09	Chromium VI	Water	3,59E-02	Acrolein	Air	4,88E-03	Zinc	Air	3,71E-04	Carbofuran	Soil	1,97E-09
14	Mercury	Soil	2,45E-09	Cadmium	Air	3,24E-02	Lead	Water	4,62E-03	Copper	Soil	2,74E-04	Vanadium	Water	1,64E-09
15	Vanadium	Water	1,16E-09	Barium	Air	3,11E-02	Cadmium	Soil	3,91E-03	Lead	Soil	2,66E-04	Lead	Water	1,45E-09
16	Molybdenum	Air	1,02E-09	Cadmium	Soil	2,60E-02	Vanadium	Water	3,89E-03	Nickel	Soil	2,53E-04	Mercury	Soil	1,34E-09
17	Barium	Soil	9,55E-10	Lead	Water	2,16E-02	Cadmium	Water	2,64E-03	Carbofuran	Soil	2,48E-04	Cadmium	Water	8,93E-10
18	Vanadium	Air	7,79E-10	Cadmium	Water	2,00E-02	Lead	Soil	1,76E-03	Antimony	Water	2,44E-04	Vanadium	Air	8,29E-10
19	Antimony	Water	6,53E-10	Fipronil	Soil	1,61E-02	Mercury	Air	1,42E-03	Benzene	Air	1,48E-04	Antimony	Water	6,81E-10
20	Lead	Water	6,09E-10	Carbofuran	Soil	1,51E-02	Acephate	Soil	1,32E-03	Cadmium	Air	1,37E-04	Barium	Soil	6,61E-10
Eucalyptus-FP supply chain															
	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		cases	Substance		kg 1,4-DCB	Substance		kg 1,4-DCB	Substance		kg C_2H_3Cl eq.	Substance		CTUh
	Total	All	9,64E-07	Total	All	1,15E+03	Total	All	4,17E+00	Total	All	9,91E-02	Total	All	1,46E-06
1	Arsenic	Water	4,04E-07	Zinc	Water	1,11E+03	Zinc	Water	3,43E+00	Arsenic	Water	3,80E-02	Zinc	Water	5,33E-07
2	Mercury	Air	1,21E-07	Zinc	Air	3,05E+01	Glyphosate	Air	2,20E-01	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	2,71E-02	Arsenic	Water	4,36E-07
3	Zinc	Water	1,10E-07	Zinc	Soil	4,61E+00	Zinc	Air	1,57E-01	Arsenic	Air	1,50E-02	Zinc	Air	2,52E-07
4	Zinc	Air	9,39E-08	Barium	Water	2,27E+00	Mercury	Water	1,23E-01	Barium	Water	3,15E-03	Mercury	Air	8,01E-08
5	Lead	Air	6,64E-08	Vanadium	Water	1,15E+00	Lead	Air	1,19E-01	Zinc	Water	2,62E-03	Lead	Air	3,97E-08
6	Cadmium	Water	4,15E-08	Thallium	Water	7,81E-01	Cadmium	Air	1,99E-02	Zinc	Soil	2,22E-03	Mercury	Water	3,10E-08
7	Mercury	Water	3,91E-08	Mercury	Water	6,50E-01	Carbon disulfide	Air	1,77E-02	Arsenic	Soil	2,04E-03	Arsenic	Air	1,99E-08
8	Cadmium	Air	3,03E-08	Barium	Soil	2,50E-01	Barium	Water	1,75E-02	Mercury	Water	1,56E-03	Cadmium	Air	1,93E-08
9	Arsenic	Air	2,09E-08	Glyphosate	Air	2,20E-01	Cadmium	Water	1,12E-02	Zinc	Air	1,50E-03	Zinc	Soil	1,29E-08
10	Barium	Water	1,36E-08	Vanadium	Air	2,08E-01	Vanadium	Water	1,08E-02	Cadmium	Water	1,50E-03	Barium	Water	9,36E-09
11	Zinc	Soil	5,54E-09	Lead	Air	1,71E-01	Zinc	Soil	1,05E-02	Molybdenum	Air	6,67E-04	Cadmium	Water	3,78E-09
12	Vanadium	Water	3,20E-09	Mercury	Air	1,42E-01	Lead	Water	7,38E-03	Barium	Soil	6,01E-04	Vanadium	Water	3,45E-09
13	Antimony	Water	1,83E-09	Cadmium	Water	8,09E-02	Barium	Soil	5,35E-03	Antimony	Air	5,88E-04	Lead	Water	2,33E-09
14	Glyphosate	Air	1,60E-09	Chromium VI	Water	6,33E-02	Thallium	Water	4,08E-03	Antimony	Water	5,11E-04	Antimony	Water	1,91E-09
15	Cadmium	Soil	1,36E-09	Cadmium	Air	5,98E-02	Acrolein	Air	2,91E-03	Ammonia	Air	2,53E-04	Glyphosate	Air	1,26E-09
16	Thallium	Water	1,12E-09	Barium	Air	3,78E-02	Mercury	Air	2,56E-03	Cadmium	Air	2,28E-04	Thallium	Water	1,22E-09
17	Molybdenum	Air	1,03E-09	Lead	Water	3,60E-02	Vanadium	Air	2,38E-03	Benzene	Air	1,59E-04	Carbon disulfide	Air	1,10E-09
18	Molybdenum	Water	1,01E-09	Carbon disulfide	Air	1,77E-02	Barium	Air	1,58E-03	Glyphosate	Air	1,38E-04	Molybdenum	Water	7,67E-10
19	Lead	Water	9,72E-10	Molybdenum	Water	1,13E-02	Beryllium	Air	1,34E-03	Chromium	Air	1,28E-04	Cadmium	Soil	7,23E-10
20	Lead	Soil	8,74E-10	Nickel	Water	5,40E-03	Molybdenum	Air	1,07E-03	Selenium	Water	1,20E-04	Molybdenum	Air	6,69E-10

Macauba-HEFA supply chain															
	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		cases	Substance		kg 1,4-DCB	Substance		kg 1,4-DCB	Substance		kg C_2H_3Cl eq.	Substance		CTUh
	Total	All	3,14E-07	Total	All	5,29E+02	Total	All	1,76E+00	Total	All	3,22E-02	Total	All	5,33E-07
1	Arsenic	Water	1,00E-07	Zinc	Water	5,19E+02	Zinc	Water	1,62E+00	Arsenic	Water	1,40E-02	Zinc	Water	2,51E-07
2	Mercury	Air	5,45E-08	Zinc	Air	4,81E+00	Zinc	Soil	4,78E-02	Zinc	Soil	4,92E-03	Arsenic	Water	1,08E-07
3	Zinc	Water	5,18E-08	Zinc	Soil	3,84E+00	Lead	Air	2,76E-02	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	3,25E-03	Zinc	Soil	5,58E-08
4	Zinc	Soil	2,50E-08	Barium	Water	3,54E-01	Zinc	Air	2,56E-02	Arsenic	Air	3,22E-03	Zinc	Air	4,04E-08
5	Lead	Air	1,61E-08	Vanadium	Water	3,47E-01	Lead	Water	8,24E-03	Ammonia	Air	2,54E-03	Mercury	Air	3,59E-08
6	Zinc	Air	1,50E-08	Thallium	Water	1,52E-01	Mercury	Water	6,36E-03	Cadmium	Soil	9,49E-04	Lead	Air	9,61E-09
7	Cadmium	Soil	1,28E-08	Mercury	Air	6,01E-02	Cadmium	Soil	5,27E-03	Molybdenum	Air	5,56E-04	Cadmium	Soil	6,80E-09
8	Mercury	Soil	6,21E-09	Lead	Air	3,96E-02	Cadmium	Air	3,72E-03	Antimony	Air	5,24E-04	Arsenic	Air	4,27E-09
9	Lead	Soil	5,90E-09	Lead	Water	3,75E-02	Vanadium	Water	3,24E-03	Arsenic	Soil	4,68E-04	Cadmium	Air	3,55E-09
10	Cadmium	Air	5,57E-09	Mercury	Water	3,38E-02	Carbon disulfide	Air	3,08E-03	Copper	Soil	3,20E-04	Mercury	Soil	3,41E-09
11	Cadmium	Water	5,18E-09	Vanadium	Air	3,35E-02	Acephate	Soil	2,85E-03	Barium	Water	3,18E-04	Lead	Soil	2,91E-09
12	Arsenic	Air	4,48E-09	Chromium VI	Water	3,26E-02	Barium	Water	2,78E-03	Zinc	Air	2,38E-04	Lead	Water	2,59E-09
13	Barium	Water	2,15E-09	Barium	Air	3,03E-02	Acrolein	Air	2,12E-03	Zinc	Water	1,32E-04	Mercury	Water	1,61E-09
14	Mercury	Water	2,03E-09	Barium	Soil	1,96E-02	Cadmium	Water	1,40E-03	Dimethoate	Soil	1,16E-04	Barium	Water	1,48E-09
15	Lead	Water	1,09E-09	Cadmium	Soil	1,64E-02	Barium	Air	1,24E-03	Antimony	Water	1,11E-04	Vanadium	Water	1,04E-09
16	Vanadium	Water	9,65E-10	Cadmium	Air	1,11E-02	Mercury	Air	1,13E-03	Benzene	Air	5,67E-05	Molybdenum	Air	5,58E-10
17	Molybdenum	Air	8,61E-10	Cadmium	Water	1,01E-02	Molybdenum	Air	8,87E-04	Selenium	Water	4,81E-05	Antimony	Air	5,54E-10
18	Copper	Soil	5,94E-10	Molybdenum	Water	5,28E-03	Thallium	Water	7,93E-04	Barium	Soil	4,72E-05	Cadmium	Water	4,72E-10
19	Antimony	Air	5,12E-10	Copper	Water	4,13E-03	Beryllium	Air	5,76E-04	Cadmium	Air	4,19E-05	Molybdenum	Water	3,58E-10
20	Arsenic	Water	3,14E-07	Zinc	Water	5,29E+02	Zinc	Water	1,76E+00	Arsenic	Water	3,22E-02	Zinc	Water	5,33E-07

Table S5. Top 10 substance contribution FPM, resulting from different LCIA methods.

Sugarcane-ATJ supply chain												
	ReCiPe 2016(E)	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.
	Total	All	1,25E-02	Total	All	1,25E-02	Total	All	8,07E-03	Total	All	3,63E-03
1	Ammonia	Air	7,08E-03	Ammonia	Air	7,08E-03	Ammonia	Air	3,58E-03	Ammonia	Air	1,96E-03
2	Nitrate	Air	1,31E-08	Nitrogen oxides	Air	2,19E-03	Nitrogen oxides	Air	2,53E-03	Particulates, < 2.5 um	Air	1,00E-03
3	Nitrogen dioxide	Air	1,40E-06	Sulfur dioxide	Air	1,82E-03	Particulates, < 2.5 um	Air	1,01E-03	Sulfur dioxide	Air	3,85E-04
4	Nitrogen monoxide	Air	3,86E-04	Particulates, < 2.5 um	Air	1,01E-03	Sulfur dioxide	Air	4,89E-04	Nitrogen oxides	Air	1,44E-04
5	Nitrogen oxides	Air	2,19E-03	Nitrogen monoxide	Air	3,86E-04	Nitrogen monoxide	Air	4,45E-04	Particulates, > 2.5 um, and < 10um	Air	1,26E-04
6	Particulates, < 2.5 um	Air	1,01E-03	Sulfur trioxide	Air	8,69E-06	Particulates, < 10 um	Air	6,54E-06	Carbon monoxide, fossil	Air	1,96E-06
7	Sulfur dioxide	Air	1,82E-03	Nitrogen dioxide	Air	1,40E-06	Carbon monoxide	Air	3,85E-06	Carbon monoxide	Air	1,31E-06
8	Sulfur monoxide	Air	1,77E-08	Sulfur oxides	Air	2,68E-08	Sulfur trioxide	Air	2,36E-06	Nitrogen dioxide	Air	9,18E-08
9	Sulfur oxides	Air	2,68E-08	Sulfur monoxide	Air	1,77E-08	Nitrogen dioxide	Air	1,62E-06	Carbon monoxide, biogenic	Air	8,06E-08
10	Sulfur trioxide	Air	8,69E-06	Nitrate	Air	1,31E-08	Sulfur monoxide	Air	3,55E-09	N.A.	N.A.	N.A.
Eucalyptus-FP supply chain												
	ReCiPe 2016(E)	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.
	Total	All	1,07E-02	Total	All	1,07E-02	Total	All	8,00E-03	Total	All	3,65E-03
1	Ammonia	Air	1,19E-03	Sulfur dioxide	Air	3,81E-03	Nitrogen oxides	Air	2,41E-03	Particulates, < 2.5 um	Air	1,99E-03
2	Nitrate	Air	1,69E-08	Nitrogen oxides	Air	2,08E-03	Particulates, < 2.5 um	Air	1,99E-03	Sulfur dioxide	Air	8,03E-04
3	Nitrogen monoxide	Air	1,59E-03	Particulates, < 2.5 um	Air	1,99E-03	Nitrogen monoxide	Air	1,83E-03	Particulates, > 2.5 um, and < 10um	Air	3,89E-04
4	Nitrogen oxides	Air	2,08E-03	Nitrogen monoxide	Air	1,59E-03	Sulfur dioxide	Air	1,03E-03	Ammonia	Air	3,31E-04
5	Particulates, < 2.5 um	Air	1,99E-03	Ammonia	Air	1,19E-03	Ammonia	Air	6,03E-04	Nitrogen oxides	Air	1,37E-04
6	Sulfur dioxide	Air	3,81E-03	Sulfur oxides	Air	1,84E-08	Particulates	Air	1,31E-04	Carbon monoxide	Air	2,68E-06
7	Sulfur oxides	Air	1,84E-08	Nitrate	Air	1,69E-08	Carbon monoxide	Air	7,86E-06	Carbon monoxide, fossil	Air	1,34E-06
8	Sulfur trioxide	Air	3,81E-10	Sulfur trioxide	Air	3,81E-10	Particulates, < 10 um	Air	6,49E-06	Carbon monoxide, biogenic	Air	4,03E-07
9	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	Sulfur trioxide	Air	1,03E-10	N.A.	N.A.	N.A.
10	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Macauba-HEFA supply chain												
	ReCiPe 2016(E)	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.	Substance		kg PM2.5 eq.
	Total	All	1,53E-02		All	1,53E-02	Total	All	9,30E-03	Total	All	4,32E-03
1	Ammonia	Air	1,19E-02	Ammonia	Air	1,19E-02	Ammonia	Air	6,04E-03	Ammonia	Air	3,32E-03
2	Nitrate	Air	1,27E-08	Nitrogen oxides	Air	2,08E-03	Nitrogen oxides	Air	2,41E-03	Particulates, < 2.5 um	Air	6,65E-04
3	Nitrogen dioxide	Air	4,06E-09	Particulates, < 2.5 um	Air	6,65E-04	Particulates, < 2.5 um	Air	6,65E-04	Sulfur dioxide	Air	1,38E-04
4	Nitrogen monoxide	Air	1,26E-06	Sulfur dioxide	Air	6,53E-04	Sulfur dioxide	Air	1,76E-04	Nitrogen oxides	Air	1,37E-04
5	Nitrogen oxides	Air	2,08E-03	Nitrogen monoxide	Air	1,26E-06	Particulates, < 10 um	Air	6,49E-06	Particulates, > 2.5 um, and < 10um	Air	5,96E-05
6	Particulates, < 2.5 um	Air	6,65E-04	Nitrate	Air	1,27E-08	Carbon monoxide	Air	3,32E-06	Carbon monoxide	Air	1,13E-06
7	Sulfur dioxide	Air	6,53E-04	Sulfur oxides	Air	9,40E-09	Nitrogen monoxide	Air	1,45E-06	Carbon monoxide, fossil	Air	1,09E-06
8	Sulfur oxides	Air	9,40E-09	Sulfur trioxide	Air	6,27E-09	Nitrogen dioxide	Air	4,70E-09	Carbon monoxide, biogenic	Air	5,64E-08
9	Sulfur trioxide	Air	6,27E-09	Nitrogen dioxide	Air	4,06E-09	Sulfur trioxide	Air	1,70E-09	Nitrogen dioxide	Air	2,67E-10
10	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table S6. Top 20 substance contribution PS, resulting from different LCIA methods.

Sugarcane-ATJ supply chain												
	ReCiPe 2016(E)	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		kg NOx eq.	Substance		kg NOx eq.	Substance		kg C2H4 eq.	Substance		kg O3 eq.
	Total	All	2,37E-02	Total	All	2,37E-02	Total	All	1,19E-03	Total	All	5,53E-01
1	Nitrogen oxides	Air	1,99E-02	1-Butanol	Air	2,16E-11	NMVOC, non-methane volatile organic compounds, unspecified origin	Air	8,80E-04	Nitrogen oxides	Air	4,94E-01
2	Nitrogen monoxide	Air	3,48E-03	1-Butene	Air	3,04E-13	VOC, volatile organic compounds	Air	1,39E-04	Nitrogen monoxide	Air	5,63E-02
3	NMVOC, non-methane volatile organic compounds, unspecified origin	Air	2,64E-04	1-Pentene	Air	8,29E-11	Pentane	Air	3,55E-05	VOC, volatile organic compounds	Air	1,65E-03
4	Pentane	Air	1,29E-05	1-Propanol	Air	4,13E-08	Butane	Air	2,53E-05	Nitrogen dioxide	Air	2,14E-04
5	Butane	Air	7,98E-06	2-Butene, 2-methyl-	Air	3,98E-14	Hexane	Air	1,66E-05	Carbon monoxide	Air	2,05E-04
6	Hexane	Air	5,03E-06	2-Methyl-1-propanol	Air	3,88E-11	Propane	Air	1,34E-05	Pentane	Air	1,16E-04
7	Propane	Air	3,78E-06	2-Propanol	Air	2,44E-08	Xylene	Air	1,14E-05	Xylene	Air	8,47E-05
8	Ethene	Air	3,06E-06	2-Propenal, 2-methyl-	Air	8,59E-12	Toluene	Air	1,02E-05	Butane	Air	8,19E-05
9	Propene	Air	2,86E-06	4-Methyl-2-pentanone	Air	1,33E-13	Ethene	Air	8,44E-06	Propene	Air	7,97E-05
10	Toluene	Air	2,56E-06	Acetaldehyde	Air	5,50E-07	Hydrocarbons, aromatic	Air	8,39E-06	Ethene	Air	7,62E-05
11	Heptane	Air	1,94E-06	Acetic acid	Air	2,09E-07	Heptane	Air	7,97E-06	Formaldehyde	Air	7,30E-05
12	Hydrocarbons, aromatic	Air	1,39E-06	Acetone	Air	3,88E-08	Propene	Air	7,53E-06	Toluene	Air	6,37E-05
13	Methanol	Air	1,30E-06	Acrolein	Air	1,02E-07	Ethane	Air	5,47E-06	Furan	Air	4,42E-05
14	Formaldehyde	Air	1,29E-06	Aldehydes, unspecified	Air	6,40E-09	Benzene	Air	4,39E-06	Hexane	Air	4,33E-05
15	Ethane	Air	1,28E-06	Benzaldehyde	Air	-2,76E-08	Hydrocarbons, aliphatic, alkanes, unspecified	Air	4,18E-06	Propane	Air	3,64E-05
16	Benzene	Air	7,25E-07	Benzene	Air	7,25E-07	Formaldehyde	Air	4,03E-06	Chlorine	Air	2,85E-05
17	Acetaldehyde	Air	5,50E-07	Benzene, 1,2,3-trimethyl-	Air	1,08E-11	Methanol	Air	3,63E-06	Methanol	Air	1,84E-05
18	Butene	Air	3,47E-07	Benzene, 1,2,4-trimethyl-	Air	3,90E-11	Butene	Air	1,77E-06	Acetaldehyde	Air	1,81E-05
19	Benzene, ethyl-	Air	2,83E-07	Benzene, 1,3,5-trimethyl-	Air	8,97E-12	Acetaldehyde	Air	1,76E-06	Heptane	Air	1,64E-05
20	Acetic acid	Air	2,09E-07	Benzene, ethyl-	Air	2,83E-07	Benzene, ethyl-	Air	1,22E-06	Benzene	Air	1,44E-05
Eucalyptus-FP supply chain												
	ReCiPe 2016(E)	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		kg NOx eq.	Substance		kg NOx eq.	Substance		kg C2H4 eq.	Substance		kg O3 eq.
	Total	All	3,38E-02	Total	All	3,38E-02	Total	All	3,81E-03	Total	All	7,27E-01
1	1-Butanol	Air	5,23E-12	Nitrogen oxides	Air	1,89E-02	VOC, volatile organic compounds	Air	2,05E-03	Nitrogen oxides	Air	4,69E-01
2	1-Pentene	Air	1,81E-11	Nitrogen monoxide	Air	1,43E-02	NMVOC, non-methane volatile organic compounds, unspecified origin	Air	1,58E-03	Nitrogen monoxide	Air	2,32E-01
3	1-Propanol	Air	2,62E-08	NMVOC, non-methane volatile organic compounds, unspecified origin	Air	4,72E-04	Pentane	Air	2,97E-05	VOC, volatile organic compounds	Air	2,43E-02
4	2-Butene, 2-methyl-	Air	1,84E-14	Pentane	Air	1,08E-05	Butane	Air	2,15E-05	Chlorine	Air	6,49E-04
5	2-Methyl-1-propanol	Air	2,76E-12	Butane	Air	6,76E-06	Hexane	Air	1,54E-05	Carbon monoxide	Air	4,19E-04
6	2-Propanol	Air	6,30E-08	Hexane	Air	4,66E-06	Xylene	Air	1,42E-05	Formaldehyde	Air	1,52E-04
7	4-Methyl-2-pentanone	Air	6,89E-14	Propane	Air	3,32E-06	Hydrocarbons, aliphatic, alkanes, unspecified	Air	1,22E-05	Xylene	Air	1,06E-04
8	Acetaldehyde	Air	1,15E-06	Ethene	Air	2,73E-06	Propane	Air	1,18E-05	Pentane	Air	9,76E-05
9	Acetic acid	Air	2,12E-06	Formaldehyde	Air	2,69E-06	Toluene	Air	9,49E-06	Butane	Air	6,95E-05
10	Acetone	Air	3,75E-08	Toluene	Air	2,38E-06	Hydrocarbons, aromatic	Air	9,07E-06	Ethene	Air	6,75E-05

11	Acrolein	Air	6,22E-08	Acetic acid	Air	2,12E-06	Formaldehyde	Air	8,40E-06	Toluene	Air	5,95E-05
12	Aldehydes, unspecified	Air	1,66E-08	Propene	Air	1,98E-06	Ethene	Air	7,51E-06	Propene	Air	5,44E-05
13	Benzaldehyde	Air	1,68E-08	Ethane	Air	1,58E-06	Ethane	Air	6,74E-06	Acetic acid	Air	4,46E-05
14	Benzene	Air	7,79E-07	Heptane	Air	1,54E-06	Acetic acid	Air	6,51E-06	Hexane	Air	4,00E-05
15	Benzene, ethyl-	Air	2,31E-07	Hydrocarbons, aromatic	Air	1,50E-06	Heptane	Air	6,32E-06	Acetaldehyde	Air	3,79E-05
16	Butadiene	Air	6,48E-12	Methanol	Air	1,20E-06	Propene	Air	5,21E-06	Propane	Air	3,20E-05
17	Butane	Air	6,76E-06	Acetaldehyde	Air	1,15E-06	Benzene	Air	4,72E-06	Methanol	Air	1,71E-05
18	Butene	Air	2,78E-07	Benzene	Air	7,79E-07	Acetaldehyde	Air	3,70E-06	Benzene	Air	1,55E-05
19	Cumene	Air	5,04E-08	Methyl ethyl ketone	Air	4,38E-07	Methanol	Air	3,35E-06	Ethane	Air	1,53E-05
20	Cyclohexane	Air	2,22E-11	Butene	Air	2,78E-07	Methyl ethyl ketone	Air	1,43E-06	Heptane	Air	1,30E-05

Macauba-HEFA supply chain

	ReCiPe 2016(E)	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**	**TRACI**	**Compart.**	**Unit**
No	Substance		kg NOx eq.	Substance		kg NOx eq.	Substance		kg C2H4 eq.	Substance		kg O3 eq.
	Total	All	1,90E-02	Total	All	1,90E-02	Total	All	3,50E-04	Total	All	4,71E-01
1	1-Butanol	Air	2,76E-11	Nitrogen oxides	Air	1,89E-02	NMVOC, non-methane volatile organic compounds, unspecified origin	Air	1,67E-04	Nitrogen oxides	Air	4,69E-01
2	1-Pentene	Air	1,68E-10	NMVOC, non-methane volatile organic compounds, unspecified origin	Air	5,02E-05	VOC, volatile organic compounds	Air	1,39E-04	VOC, volatile organic compounds	Air	1,65E-03
3	1-Propanol	Air	8,70E-09	Nitrogen monoxide	Air	1,13E-05	Ethene	Air	7,43E-06	Nitrogen monoxide	Air	1,84E-04
4	2-Butene, 2-methyl-	Air	6,96E-14	Ethene	Air	2,70E-06	Formaldehyde	Air	4,44E-06	Carbon monoxide	Air	1,77E-04
5	2-Methyl-1-propanol	Air	1,58E-08	Formaldehyde	Air	1,42E-06	Xylene	Air	3,72E-06	Furan	Air	8,60E-05
6	2-Propanol	Air	1,74E-08	Pentane	Air	1,13E-06	Pentane	Air	3,10E-06	Chlorine	Air	8,47E-05
7	2-Propenal, 2-methyl-	Air	2,24E-12	Propene	Air	9,25E-07	Toluene	Air	3,03E-06	Formaldehyde	Air	8,05E-05
8	4-Methyl-2-pentanone	Air	2,30E-14	Toluene	Air	7,60E-07	Propene	Air	2,44E-06	Ethene	Air	6,68E-05
9	Acetaldehyde	Air	4,76E-07	Butane	Air	6,81E-07	Butane	Air	2,16E-06	Xylene	Air	2,79E-05
10	Acetic acid	Air	3,36E-07	Hexane	Air	5,14E-07	Ethane	Air	2,07E-06	Propene	Air	2,54E-05
11	Acetone	Air	3,41E-08	Ethane	Air	4,84E-07	Hydrocarbons, aliphatic, alkanes, unspecified	Air	1,92E-06	Monoethanolamine	Air	2,21E-05
12	Acrolein	Air	4,50E-08	Acetaldehyde	Air	4,76E-07	Hexane	Air	1,70E-06	Toluene	Air	1,90E-05
13	Aldehydes, unspecified	Air	4,97E-09	Propane	Air	4,23E-07	Benzene	Air	1,68E-06	Acetaldehyde	Air	1,56E-05
14	Benzaldehyde	Air	1,22E-08	Acetic acid	Air	3,36E-07	Hydrocarbons, aromatic	Air	1,54E-06	Pentane	Air	1,02E-05
15	Benzene	Air	2,77E-07	Methanol	Air	3,30E-07	Acetaldehyde	Air	1,53E-06	Acetic acid	Air	7,07E-06
16	Benzene, 1,2,3-trimethyl-	Air	2,81E-12	Benzene	Air	2,77E-07	Propane	Air	1,50E-06	Butane	Air	7,00E-06
17	Benzene, 1,2,4-trimethyl-	Air	1,02E-11	Hydrocarbons, aromatic	Air	2,54E-07	Acetic acid	Air	1,03E-06	Benzene	Air	5,51E-06
18	Benzene, 1,3,5-trimethyl-	Air	2,34E-12	Nitrate	Air	1,18E-07	Methanol	Air	9,24E-07	Methanol	Air	4,71E-06
19	Benzene, ethyl-	Air	3,31E-08	Heptane	Air	1,13E-07	Heptane	Air	4,62E-07	Ethane	Air	4,68E-06
20	Butadiene	Air	2,18E-10	Ethanol	Air	9,61E-08	Ethanol	Air	3,06E-07	Hexane	Air	4,41E-06

Table S7. Top 20 substance contribution HH, resulting from different LCIA methods.

Sugarcane-ATJ supply chain												
	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**
No	Substance		DALY	Substance		DALY	Substance		DALY	Substance		DALY
	Total	All	2,15E-06	Total	All	2,79E-04	Total	All	2,06E-05	Total	All	6,07E-06
1	Chromium VI	Water	9,70E-07	Zinc	Water	1,10E-04	Carbon dioxide	Air	6,30E-06	Ammonia	Air	2,51E-06
2	Arsenic	Water	3,56E-07	Carbon dioxide	Air	8,48E-05	Water, turbine use, unspecified natural origin, BR	Raw	5,43E-06	Nitrogen oxides	Air	1,77E-06
3	Mercury	Air	1,91E-07	Zinc	Soil	2,92E-05	Ammonia	Air	4,45E-06	Particulates, < 2.5 um	Air	7,04E-07
4	Zinc	Water	1,27E-07	Carbon dioxide, fossil	Air	2,39E-05	Water, turbine use, unspecified natural origin, CH	Raw	3,81E-06	Sulfur dioxide	Air	3,42E-07
5	Lead	Air	8,27E-08	Chromium VI	Water	1,55E-05	Water, river, RoW	Raw	2,58E-06	Nitrogen monoxide	Air	3,11E-07
6	Zinc	Air	6,31E-08	Water, turbine use, unspecified natural origin, BR	Raw	5,43E-06	Water, turbine use, unspecified natural origin, RoW	Raw	2,41E-06	Zinc	Soil	1,15E-07
7	Nickel	Water	5,77E-08	Ammonia	Air	4,45E-06	Water, turbine use, unspecified natural origin, CN	Raw	2,30E-06	Hydrocarbons, aromatic	Air	8,43E-08
8	Cadmium	Air	4,94E-08	Water, turbine use, unspecified natural origin, CH	Raw	3,81E-06	Carbon dioxide, fossil	Air	1,77E-06	Benzo(a)pyrene	Air	7,26E-08
9	Zinc	Soil	4,51E-08	Water, river, RoW	Raw	2,58E-06	Nitrogen oxides	Air	1,40E-06	Arsenic	Water	3,53E-08
10	Benzo(a)pyrene	Air	3,41E-08	Water, turbine use, unspecified natural origin, RoW	Raw	2,41E-06	Sulfur dioxide	Air	1,14E-06	Arsenic	Air	1,89E-08
11	Barium	Water	2,71E-08	Water, turbine use, unspecified natural origin, CN	Raw	2,30E-06	Water, river, RER	Raw	1,02E-06	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	1,74E-08
12	Cadmium	Water	2,66E-08	Zinc	Air	1,71E-06	Water, turbine use, unspecified natural origin, FR	Raw	7,65E-07	Cadmium	Soil	1,68E-08
13	Cadmium	Soil	2,54E-08	Nitrogen oxides	Air	1,40E-06	Particulates, < 2.5 um	Air	6,33E-07	Hydrocarbons, aromatic	Water	1,16E-08
14	Arsenic	Air	2,46E-08	Sulfur dioxide	Air	1,14E-06	Water, turbine use, unspecified natural origin, CA	Raw	5,45E-07	Barium	Water	8,43E-09
15	Mercury	Water	9,20E-09	Water, river, RER	Raw	1,02E-06	Water, turbine use, unspecified natural origin, US	Raw	4,53E-07	Arsenic	Soil	5,65E-09
16	Lead	Soil	8,54E-09	Water, turbine use, unspecified natural origin, FR	Raw	7,65E-07	Water, turbine use, unspecified natural origin, RU	Raw	4,02E-07	Carbon-14	Air	5,28E-09
17	Chromium VI	Soil	6,87E-09	Particulates, < 2.5 um	Air	6,33E-07	Zinc	Water	3,34E-07	Particulates, < 10 um	Air	4,58E-09
18	Mercury	Soil	6,84E-09	Water, turbine use, unspecified natural origin, CA	Raw	5,45E-07	Water, turbine use, unspecified natural origin, AT	Raw	3,21E-07	Carbon monoxide	Air	2,70E-09
19	Nickel	Soil	5,28E-09	Water, turbine use, unspecified natural origin, US	Raw	4,53E-07	Nitrogen monoxide	Air	2,46E-07	PAH, polycyclic aromatic hydrocarbons	Air	2,18E-09
20	Nickel	Air	4,40E-09	Methane, biogenic	Air	4,15E-07	Methane, biogenic	Air	2,18E-07	Barium	Soil	1,91E-09
Eucalyptus-FP supply chain												
	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**
No	Substance		DALY	Substance		DALY	Substance		DALY	Substance		DALY
	Total	All	4,59E-06	Total	All	3,69E-04	Total	All	1,31E-05	Total	All	6,04E-06
1	Chromium VI	Water	1,71E-06	Zinc	Water	2,53E-04	Water, turbine use, unspecified natural origin, RoW	Raw	5,66E-06	Nitrogen oxides	Air	1,69E-06
2	Arsenic	Water	1,15E-06	Carbon dioxide	Air	4,65E-05	Water, turbine use, unspecified natural origin, CN	Raw	4,48E-06	Particulates, < 2.5 um	Air	1,39E-06
3	Mercury	Air	3,39E-07	Chromium VI	Water	2,73E-05	Carbon dioxide	Air	3,45E-06	Nitrogen monoxide	Air	1,28E-06
4	Zinc	Water	2,97E-07	Carbon dioxide, fossil	Air	2,40E-05	Sulfur dioxide	Air	2,39E-06	Sulfur dioxide	Air	7,18E-07
5	Zinc	Air	2,54E-07	Zinc	Air	6,96E-06	Water, turbine use, unspecified natural origin, FR	Raw	2,31E-06	Ammonia	Air	4,23E-07
6	Lead	Air	1,81E-07	Water, turbine use, unspecified natural origin, RoW	Raw	5,66E-06	Water, turbine use, unspecified natural origin, SE	Raw	2,13E-06	Arsenic	Water	1,17E-07

7	Nickel	Water	1,56E-07	Water, turbine use, unspecified natural origin, CN	Raw	4,48E-06	Carbon dioxide, fossil	Air	1,78E-06	Particulates	Air	9,14E-08
8	Cadmium	Water	1,14E-07	Sulfur dioxide	Air	2,39E-06	Water, turbine use, unspecified natural origin, BR	Raw	1,72E-06	Hydrocarbons, aromatic	Air	9,12E-08
9	Mercury	Water	1,09E-07	Water, turbine use, unspecified natural origin, FR	Raw	2,31E-06	Water, turbine use, unspecified natural origin, AT	Raw	1,41E-06	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	9,10E-08
10	Cadmium	Air	8,31E-08	Water, turbine use, unspecified natural origin, SE	Raw	2,13E-06	Nitrogen oxides	Air	1,33E-06	Arsenic	Air	4,63E-08
11	Arsenic	Air	5,99E-08	Water, turbine use, unspecified natural origin, BR	Raw	1,72E-06	Particulates, < 2.5 um	Air	1,25E-06	Hydrocarbons, aromatic	Water	9,85E-09
12	Barium	Water	3,67E-08	Water, turbine use, unspecified natural origin, AT	Raw	1,41E-06	Nitrogen monoxide	Air	1,02E-06	Barium	Water	8,82E-09
13	Chromium VI	Soil	1,76E-08	Nitrogen oxides	Air	1,33E-06	Water, turbine use, unspecified natural origin, ES	Raw	9,80E-07	Zinc	Water	7,34E-09
14	Zinc	Soil	1,50E-08	Particulates, < 2.5 um	Air	1,25E-06	Water, turbine use, unspecified natural origin, CH	Raw	9,62E-07	Arsenic	Soil	6,26E-09
15	Vanadium	Water	8,64E-09	Zinc	Soil	1,05E-06	Water, turbine use, unspecified natural origin, RU	Raw	9,07E-07	Zinc	Soil	6,22E-09
16	Chromium VI	Air	7,09E-09	Nitrogen monoxide	Air	1,02E-06	Water, turbine use, unspecified natural origin, US	Raw	8,83E-07	Benzo(a)pyrene	Air	5,76E-09
17	Antimony	Water	4,94E-09	Water, turbine use, unspecified natural origin, ES	Raw	9,80E-07	Zinc	Water	7,82E-07	Carbon-14	Air	5,60E-09
18	Nickel	Air	4,58E-09	Water, turbine use, unspecified natural origin, CH	Raw	9,62E-07	Ammonia	Air	7,49E-07	Carbon monoxide	Air	5,50E-09
19	Glyphosate	Air	4,32E-09	Water, turbine use, unspecified natural origin, RU	Raw	9,07E-07	Water, turbine use, unspecified natural origin, DE	Raw	7,24E-07	Radon-222	Air	4,74E-09
20	Formaldehyde	Air	3,93E-09	Water, turbine use, unspecified natural origin, US	Raw	8,83E-07	Water, turbine use, unspecified natural origin, IT	Raw	7,18E-07	Particulates, < 10 um	Air	4,54E-09

Macauba-HEFA supply chain

	USEtox 2 (r+i)	**Compart.**	**Unit**	**ReCiPe 2016(E)**	**Compart.**	**Unit**	**ReCiPe 2016(H)**	**Compart.**	**Unit**	**IMPACT 2002+**	**Compart.**	**Unit**
No	Substance		DALY	Substance		DALY	Substance		DALY	Substance		DALY
	Total	All	1,82E-06	Total	All	1,87E-04	Total	All	1,40E-05	Total	All	6,63E-06
1	Chromium VI	Water	8,81E-07	Zinc	Water	1,18E-04	Ammonia	Air	7,52E-06	Ammonia	Air	4,24E-06
2	Arsenic	Water	2,87E-07	Carbon dioxide	Air	3,26E-05	Water, turbine use, unspecified natural origin, CN	Raw	2,79E-06	Nitrogen oxides	Air	1,68E-06
3	Mercury	Air	1,52E-07	Chromium VI	Water	1,41E-05	Carbon dioxide	Air	2,42E-06	Particulates, < 2.5 um	Air	4,65E-07
4	Zinc	Water	1,40E-07	Carbon dioxide, fossil	Air	8,20E-06	Water, turbine use, unspecified natural origin, RoW	Raw	2,04E-06	Sulfur dioxide	Air	1,23E-07
5	Zinc	Soil	6,75E-08	Ammonia	Air	7,52E-06	Nitrogen oxides	Air	1,33E-06	Arsenic	Water	4,30E-08
6	Nickel	Water	5,41E-08	Water, turbine use, unspecified natural origin, CN	Raw	2,79E-06	Carbon dioxide, fossil	Air	6,08E-07	Hydrocarbons, aromatic	Air	1,54E-08
7	Lead	Air	4,39E-08	Water, turbine use, unspecified natural origin, RoW	Raw	2,04E-06	Water, turbine use, unspecified natural origin, US	Raw	5,45E-07	Zinc	Soil	1,38E-08
8	Zinc	Air	4,06E-08	Nitrogen oxides	Air	1,33E-06	Methane, biogenic	Air	4,90E-07	Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	Air	1,09E-08
9	Cadmium	Soil	3,50E-08	Zinc	Air	1,10E-06	Water, turbine use, unspecified natural origin, RU	Raw	4,26E-07	Arsenic	Air	9,91E-09
10	Mercury	Soil	1,74E-08	Methane, biogenic	Air	9,31E-07	Particulates, < 2.5 um	Air	4,18E-07	Particulates, < 10 um	Air	4,54E-09
11	Lead	Soil	1,61E-08	Zinc	Soil	8,75E-07	Sulfur dioxide	Air	4,10E-07	Cadmium	Soil	2,66E-09
12	Cadmium	Air	1,53E-08	Water, turbine use, unspecified natural origin, US	Raw	5,45E-07	Zinc	Water	3,69E-07	Carbon monoxide	Air	2,33E-09
13	Cadmium	Water	1,42E-08	Water, turbine use, unspecified natural origin, RU	Raw	4,26E-07	Water, turbine use, unspecified natural origin, FR	Raw	2,75E-07	Benzo(a)pyrene	Air	1,78E-09
14	Arsenic	Air	1,29E-08	Particulates, < 2.5 um	Air	4,18E-07	Water, turbine use, unspecified natural origin, CH	Raw	2,71E-07	Molybdenum	Air	1,56E-09

15	Barium	Water	5,79E-09	Sulfur dioxide	Air	4,10E-07	Water, turbine use, unspecified natural origin, CA	Raw	2,29E-07	PAH, polycyclic aromatic hydrocarbons	Air	1,52E-09
16	Mercury	Water	5,67E-09	Dinitrogen monoxide	Air	2,82E-07	Water, turbine use, unspecified natural origin, IN	Raw	2,00E-07	Antimony	Air	1,47E-09
17	Chromium VI	Soil	5,37E-09	Water, turbine use, unspecified natural origin, FR	Raw	2,75E-07	Chromium VI	Water	1,91E-07	Radon-222	Air	1,47E-09
18	Lead	Water	2,97E-09	Carbon dioxide, land transformation	Air	2,72E-07	Water, turbine use, unspecified natural origin, SE	Raw	1,90E-07	Arsenic	Soil	1,44E-09
19	Vanadium	Water	2,61E-09	Water, turbine use, unspecified natural origin, CH	Raw	2,71E-07	Water, turbine use, unspecified natural origin, BR	Raw	1,76E-07	Carbon-14	Air	1,43E-09
20	Molybdenum	Air	2,32E-09	Water, turbine use, unspecified natural origin, CA	Raw	2,29E-07	Water, turbine use, unspecified natural origin, AT	Raw	1,49E-07	Nitrogen monoxide	Air	1,02E-09

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