Supplementary material

Environmental lifecycle assessment to address the hotspots in natural rubber manufacturing; a case study with information gathered from Concentrated latex manufacturing in Sri Lanka

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**Table S1.** Representative processes in Eco invent v3.

|  |  |
| --- | --- |
| Process in concentrated latex manufacture | Representative process in Eco invent v3 |
| Diammonium phosphate or Diammonium hydrogen phosphate | Diammonium phosphate {RoW}| market for diammonium phosphate | APOS, U |
| Zinc oxide  | Zinc oxide {GLO}| market for | APOS, U |
| Ammonia | Ammonia, anhydrous, liquid {RoW}| market for ammonia, anhydrous, liquid | APOS, U |
| Sulfuric acid | Sulfuric acid {RoW}| market for sulfuric acid | APOS, U |
| Lauric acid | Fatty acid {GLO}| market for | APOS, U |
| Water supply  | Water pump operation, electric {RoW}| water pump operation, electric | APOS, U |
| Electricity  | Electricity, medium voltage {LK}| market for electricity, medium voltage | APOS, U |
| Wastewater treatment | Wastewater, average {RoW}| treatment of, capacity 1.1E10l/year | APOS, U |
| Transportation of latex | Transport, freight, lorry 3.5-7.5 metric ton, euro3 {RoW}| market for transport, freight, lorry 3.5-7.5 metric ton, EURO3 | APOS, U |

**Table S2.** Emission inventory of some selected pollutants per 1 tonne of concentrated latex. ZnO, and DAHP refer to Tetramethyl thiuram disulfide, Zinc oxide.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Environmental impact/pollutants  |  Unit | Total | DAHP | ZnO | Ammonia | Sulfuric acid | Lauric acid  | Transportation  | Water | Electricity | Wastewater treatment |
| *Abiotic depletion* |
| Tellurium | mg | 62.12 | 12.44 | 0.12 | 1.40 | 37.65 | 0.23 | 7.67 | 0.20 | 1.45 | 0.96 |
| Silver | mg | 215.04 | 32.31 | 0.29 | 2.87 | 99.88 | 0.74 | 75.40 | 0.19 | 1.84 | 1.51 |
| Copper | g | 181.76 | 35.77 | 0.36 | 6.01 | 105.80 | 0.74 | 24.93 | 0.62 | 4.46 | 3.08 |
| Gold | mg | 4.50 | 0.62 | 0.02 | 0.26 | 1.04 | 0.04 | 2.42 | 0.00 | 0.04 | 0.06 |
| Lead | g | 35.48 | 6.11 | 0.03 | 0.25 | 19.97 | 0.15 | 8.43 | 0.01 | 0.25 | 0.28 |
| Zinc | g | 159.82 | 27.85 | 0.13 | 1.13 | 90.89 | 0.70 | 36.67 | 0.06 | 1.12 | 1.27 |
| *Abiotic depletion (fossil fuels)* |
| Oil, crude | kg | 42.57 | 0.50 | 0.01 | 0.30 | 0.41 | 0.06 | 33.80 | 0.02 | 7.18 | 0.28 |
| Coal, hard | kg | 35.04 | 1.35 | 0.05 | 4.47 | 0.58 | 0.11 | 8.99 | 0.08 | 18.66 | 0.76 |
| Gas, natural | m3 | 10.89 | 1.66 | 0.07 | 4.20 | 0.71 | 0.06 | 3.42 | 0.09 | 0.39 | 0.28 |
| *Global warming (GWP100a)* |
| CO2 | kg | 218.41 | 7.84 | 0.29 | 19.57 | 2.93 | 3.50 | 119.53 | 0.46 | 60.82 | 3.47 |
| CH4 | g | 219.90 | 18.50 | 0.81 | 48.04 | 7.76 | 1.24 | 109.88 | 0.84 | 25.68 | 7.16 |
| N2O | g | 6.69 | 0.18 | 0.01 | 0.18 | 0.17 | 0.96 | 1.68 | 0.02 | 2.35 | 1.14 |
| *Ozone layer depletion*  |
| Halon 1301 | mg | 2.09 | 0.03 | 0.00 | 0.02 | 0.02 | 0.00 | 1.65 | 0.00 | 0.35 | 0.01 |
| Halon 1211 | ｵg | 115.43 | 38.50 | 2.13 | 27.89 | 3.43 | 2.09 | 33.41 | 1.58 | 2.19 | 4.21 |
| CFC-10 | ｵg | 312.76 | 24.61 | 0.74 | 7.49 | 40.54 | 9.02 | 111.85 | 0.59 | 30.38 | 87.54 |
| HCFC-22 | mg | 2.89 | 0.20 | 0.01 | 0.18 | 0.06 | 0.02 | 2.09 | 0.01 | 0.11 | 0.21 |
| *Human Toxicity* |
| Thallium | mg | 365.81 | 65.10 | 0.78 | 10.53 | 187.97 | 1.57 | 56.37 | 1.28 | 35.75 | 6.47 |
| Nickel | mg | 440.35 | 54.58 | 0.60 | 13.49 | 152.13 | 1.59 | 112.45 | 1.07 | 98.86 | 5.58 |
| Nitrogen oxides | kg | 1.01 | 0.02 | 0.00 | 0.03 | 0.02 | 0.00 | 0.71 | 0.00 | 0.21 | 0.02 |
| Sulfur dioxide | g | 801.35 | 58.48 | 0.71 | 33.71 | 137.16 | 2.13 | 185.84 | 1.60 | 364.23 | 17.50 |
| Ammonia | g | 12.06 | 1.69 | 0.02 | 0.43 | 1.09 | 1.59 | 2.50 | 0.02 | 0.97 | 3.76 |
| Particulates, < 2.5 um | g | 93.14 | 4.90 | 0.20 | 3.22 | 3.63 | 1.90 | 52.49 | 0.79 | 22.21 | 3.79 |
| *Photochemical oxidation* |
| SO2 | g | 801.35 | 58.48 | 0.71 | 33.71 | 137.16 | 2.13 | 185.84 | 1.60 | 364.23 | 17.50 |
| CO | g | 287.47 | 9.85 | 0.41 | 11.59 | 6.25 | 1.40 | 231.13 | 0.29 | 16.54 | 10.00 |
| CH4 | g | 219.90 | 18.50 | 0.81 | 48.04 | 7.76 | 1.24 | 109.88 | 0.84 | 25.68 | 7.16 |
| NOx | kg | 1.01 | 0.02 | 0.00 | 0.03 | 0.02 | 0.00 | 0.71 | 0.00 | 0.21 | 0.02 |
| NMVOC | g | 120.96 | 3.35 | 0.15 | 5.14 | 3.06 | 0.38 | 99.06 | 0.14 | 7.63 | 2.06 |
| A*cidification* |
| SO2 | g | 726.68 | 58.48 | 0.71 | 33.71 | 137.16 | 2.13 | 185.84 | 1.60 | 364.23 | 17.50 |
| NOx | kg | 1.01 | 0.02 | 0.00 | 0.03 | 0.02 | 0.00 | 0.71 | 0.00 | 0.21 | 0.02 |
| NH3 | g | 12.06 | 1.69 | 0.02 | 0.43 | 1.09 | 1.59 | 2.50 | 0.02 | 0.97 | 3.76 |
| *Eutrophication* |
| Phosphate | g | 185.09 | 23.82 | 0.30 | 14.45 | 17.58 | 0.57 | 36.98 | 0.93 | 57.37 | 33.09 |
| Nitrogen oxides | kg | 1.01 | 0.02 | 0.00 | 0.03 | 0.02 | 0.00 | 0.71 | 0.00 | 0.21 | 0.02 |
| Nitrate | g | 576.50 | 2.75 | 0.11 | 4.44 | 1.64 | 51.57 | 12.72 | 0.28 | 17.95 | 485.05 |
| Ammonium, ion | g | 111.69 | 0.13 | 0.00 | 0.12 | 0.13 | 0.08 | 0.73 | 0.00 | 0.14 | 110.37 |
| COD  | kg | 1.28 | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.44 | 0.00 | 0.40 | 0.36 |

**Table S3.** Impact assessment results per processing 1 tonne of concentrated latex

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Impact category | Unit | Diammoniam phosphate | Zinc oxide | Ammonia | Sulfuric acid | Lauric acid | Water supply  | Electricity  | Wastewater treatment | Transportation of field latex | Total Impact  |
| Abiotic depletion  | kg Sb eq | 7.208×10-4 | 7.585×10-6 | 9.078×10-5 | 2.125×10-3 | 1.644×10-5 | 1.041×10-5 | 7.603×10-5 | 5.775×10-5 | 6.621×10-4 | 3.767×10-3  |
| Abiotic depletion (fossil fuels) | MJ | 1.054×102 | 4.235 | 2.409×102 | 5.452×101 | 7.028 | 6.171 | 6.696×102 | 3.821×101 | 1.755×103 | 2.818×103  |
| Global warming (GWP100a) | kg CO2 eq | 8.426 | 3.189×10-1 | 2.097×101 | 3.220 | 3.804 | 4.939×101 | 6.257×101 | 4.131 | 1.232×102 | 2.271×102  |
| Ozone layer depletion  | kg CFC-11 eq | 6.570×10-7 | 2.639×10-8 | 4.414×10-7 | 3.015×10-7 | 6.031×10-8 | 2.687×10-8 | 4.341×10-6 | 2.441×10-7 | 2.027×10-5 | 2.637×10-5  |
| Human Toxicity | kg 1,4-DB eq | 2.396×101 | 4.157×10-1 | 7.482 | 6.067×101 | 1.031 | 7.247×10-1 | 3.050×101 | 7.946 | 4.874×101 | 1.815×102  |
| Photochemical oxidation | kg C2H4 eq | 3.641×10-3 | 6.119×10-5 | 2.663×10-3 | 6.895×10-3 | 1.864×10-3 | 9.144×10-5 | 1.008×10-2 | 1.927×10-3 | 1.904×10-2 | 5.472×10-2  |
| Acidification | kg SO2 eq | 8.455×10-2 | 1.257×10-3 | 5.460×10-2 | 1.786×10-1 | 6.786×10-3 | 2.445×10-3 | 5.429×10-1 | 3.546-×10-2 | 5.841×10-1 | 1.491  |
| Eutrophication | kg PO43-eq | 2.865×10-2 | 4.468×10-4 | 1.918×10-2 | 2.119×10-2 | 7.909×10-3 | 1.117×10-3 | 9.63×10-2 | 1.326×10-1 | 1.427×10-1 | 4.501×10-1  |