LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Environnement, du Climat
et du Développement durable

Administration de l'environnement

Esch-sur-Alzette, 21 May 2021

Spatial Emissions Mapping of Luxembourg

1. Introduction

The present documentation describes the different methods used in 2021 for the gridding of the emissions 2019 of different pollutants (NOx (as NO_2), NMVOC, SOx (as SO_2), NH_3, $PM_{2.5}$, PM_{10}, BC[1], CO, Pb, Cd, Hg, PCDD/PCDF, PAHs, HCB, PCB) registered in Luxembourg. The gridding is done using the EMEP grid 0.1° x 0.1°.

The emissions, which have to be disaggregated, correspond to the national NFR sector emissions for the 15 pollutants aforementioned. These NFR sectors are grouped into different GNFR sectors (Gridding NFR sectors).

Concerning the GNFR sector F_RoadTransport, the emissions are distributed in a first step according to fuel sold, and in a second step according to fuel used.

Figure 1 shows a map of the Grand-Duchy of Luxembourg and the 51 cells of the EMEP grid which are covering the country. The shapefiles containing this grid are provided by the European Environment Agency. The coordinates of the 51 cells are prescribed and correspond to the center of the cells, whereas the FIDs belonging to them can be freely chosen.

The software used to work with is the Gridding Emission Tool for ArcGIS (*GRETA*) from AVISO.

The disaggregated values, as finally reported under CLRTAP, are summarized in the file *LU_CLRTAP-NEC_2021v2_annex_v_gridded_emissions_210506_fuelsold.xlsx* (according to fuel sold) an in the file *LU_CLRTAP-NEC_2021v2_annex_v_gridded_emissions_210506_fuelused.xlsx* (according to fuel used).
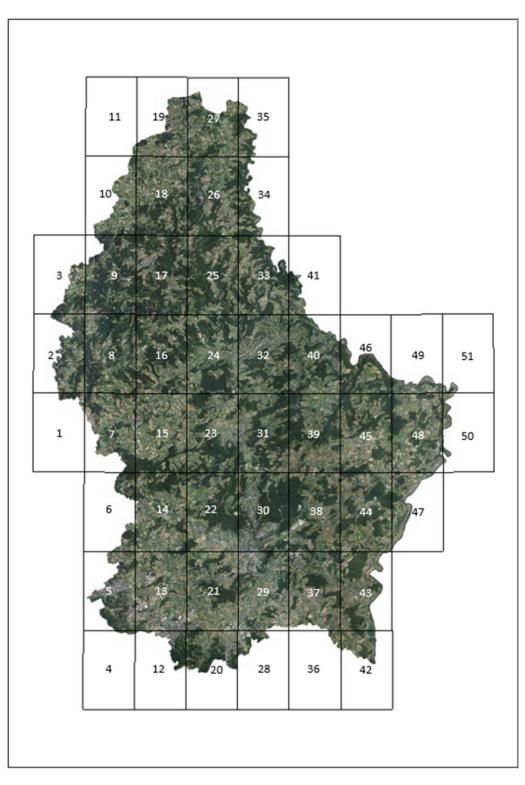
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[1] Not included in GRETA

Figure 1 - EMEP grid 0.1° x 0.1° for Luxembourg

2. Methodology and results for the different GNFR sectors

A_PublicPower

The emissions of the GNFR sector A_PublicPower correspond to the emissions of the NFR sector 1A1a (Public electricity and heat production).

The disaggregation of the total emissions of this sector is carried out using E-PRTR (European Pollutant Release and Transfer Register) database. The emissions are assigned to the corresponding PRTR point sources. The remaining amount of emissions are distributed proportionally over the cantons in which the power plants reside.
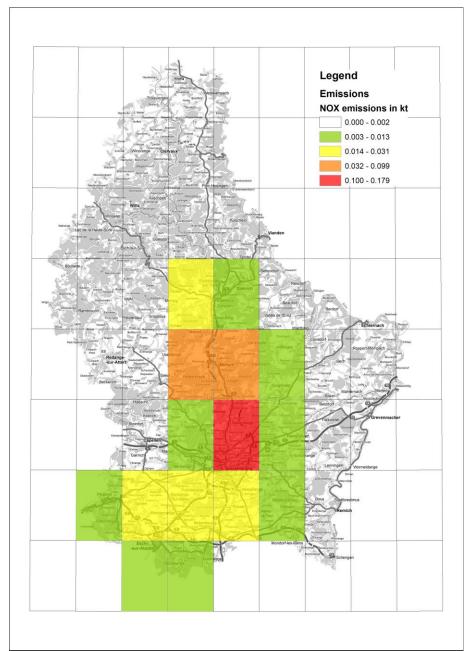

Figure 2 – NOX emission distribution of the GNFR sector A_PublicPower

B_Industry

The emissions of the GNFR sector B_Industry correspond to the sum of the emissions of the NFR sectors 1A2a (Stationary combustion in manufacturing industries and construction: Iron and steel), 1A2b (Stationary combustion in manufacturing industries and construction: Non-ferrous metals), 1A2c (Stationary combustion in manufacturing industries and construction: Chemicals), 1A2d (Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print), 1A2e (Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco), 1A2f (Stationary combustion in manufacturing industries and construction: Non-metallic minerals), 1A2gviii (Stationary combustion in manufacturing industries and construction: Other), 2A3 (Glass production), 2A5b (Construction and demolition), 2C1 (Iron and steel production), 2C3 (Aluminium production), 2D3b (Road paving with asphalt), 2H2 (Food and beverage industry), and 2K (Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)).

There is a separate distribution for the pollutants in the above-mentioned NFR sectors.
The distribution for 2D3b is performed considering the geometry of the road network and the annual mileage in Luxembourg.
For all other above-mentioned NFR sectors, the emissions are firstly distributed via PRTR point sources.
For each NFR sector, only the relevant companies are included in the distribution.

NFR sector	relevant NACE group
1A2a, 2A5b	1
1A2b, 2C3	2
1A2c	3
1A2d	4
1A2e, 2H2	5
1A2f	6
1A2gviii, 2K	1 to 12
2A3	7
2C1	8

Then, the number of companies per NACE sector is used at municipality level. Within the municipalities, emissions are allocated to the corresponding land use areas (OBS[2] 1.2.1.1.2, i.e. CLC[3] group 4 (mixed industrial and commercial areas, military, large buildings of public services)).
The deciding factor for the emission distribution is less the area used than the number of resident companies.

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[2] Occupation Biophysique du Sol
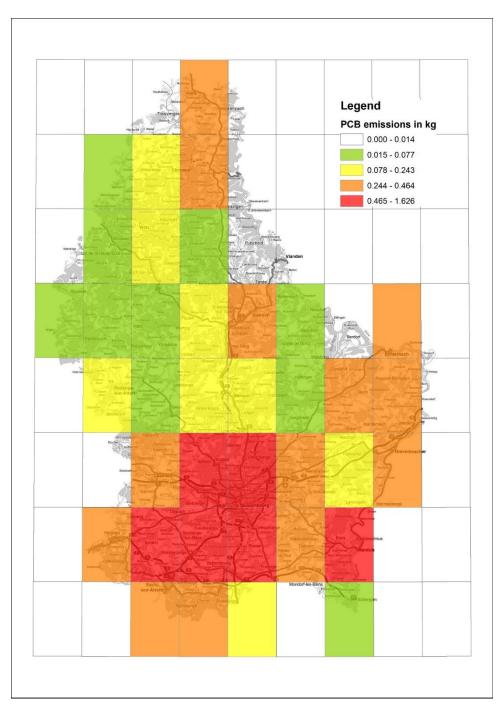[3] Corine Land Cover

Figure 3 – PCB emission distribution of the GNFR sector B_Industry

C_OtherStationaryComb

The emissions of the GNFR sector C_OtherStationaryComb correspond to the sum of the emissions of the NFR sectors 1A4ai (Commercial/institutional: Stationary), 1A4bi (Residential: Stationary) and 1A4ci (Agriculture/Forestry/Fishing: Stationary).

- The disaggregation of the total emissions of the sector 1A4ai is performed using the heating database. This heating database contains information about location and type of used heatings in Luxembourg. In addition to the type of use (private, commercial, public) and the municipality, the

energy source used as well as the power of the heating is indicated. This database was aggregated at community level. As a result, the total output of all privately used and not privately used heating systems was available for each municipality. This information was used as primary distribution parameter for the NFR sector 1A4ai. In the case of NFR sector 1A4ai only the not privately used heatings were taken into account. The share of heating output (in kW) per municipality in the total output of all non-privately used heating systems forms the distribution key. Afterwards the final step of spatial distribution to suitable land use areas (OBS 1.2.1.1.2 and OBS 1.2.1.2, i.e. CLC groups 4 and 5) takes place.

- As described for NFR sector 1A4ai, the heating database is used as primary distribution key for the disaggregation of the total emissions of the sector 1A4bi. In contrast to NFR sector 1A4ai, only privately used heating systems are taken into account in determining the distribution parameter. The second part of the spatial distribution is the subdistribution on areas containing residential buildings (OBS 1.1.1 to OBS 1.1.2.4, i.e. CLC groups 1 and 2).

- The disaggregation of the total emissions of the sector 1A4ci is done using an evaluation of the agricultural plants and wine estates per municipality and canton. The deciding factor is not the agricultural area but the number of farms, as the focus here is on the heaters within the buildings. Therefore, this proportional count of farms/wineries per municipality is the distribution key. The subsequent spatial subdistribution takes place via OBS 1.2.1.4 areas (CLC group 7).
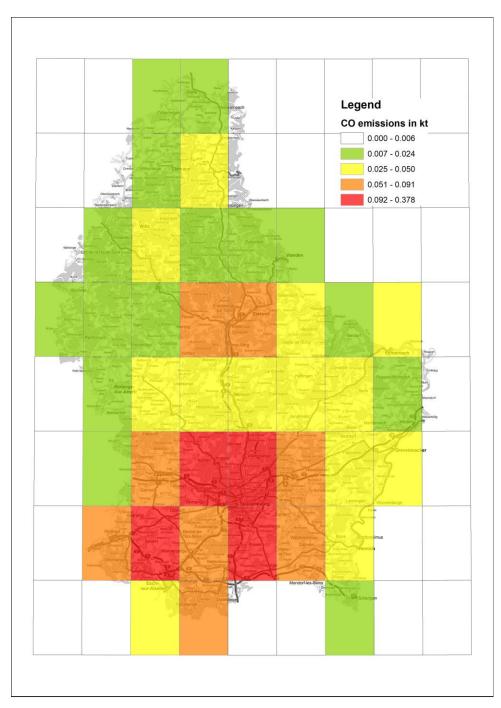
Figure 4 – CO emission distribution of the GNFR sector C_OtherStationaryComb

D_Fugitive

The emissions of the GNFR sector D_Fugitive correspond to the sum of the emissions of the NFR sectors 1B1a (Fugitive emission from solid fuels: Coal mining and handling), 1B2av (Distribution of oil products) and 1B2b (Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)).

- The disaggregation of the total emissions of the sector 1B1a is performed using the relevant NACE groups 13 and 14.

- The disaggregation of the total emissions of the sector 1B2av is done using two sources. 90 % of the emissions are distributed over the population per municipality (polygon of municipalities, CLC groups 2 to 5). Distribution of the remaining 10 % is based on the location of the filling stations (evenly distribution according to the point layer of petrol stations).

- The disaggregation of the total emissions of the sector 1B2b is performed using the heating database. For this NFR sector, only entries of the energy source "natural gas" were evaluated. The sum of the heating output (kW) provided per municipality was set in relation to the total heating output of "natural gas". This share per community is the main distribution parameter. Afterwards the final spatial distribution is done using OBS 1.1.1 to OBS 1.1.2.4 (CLC groups 1 and 2).
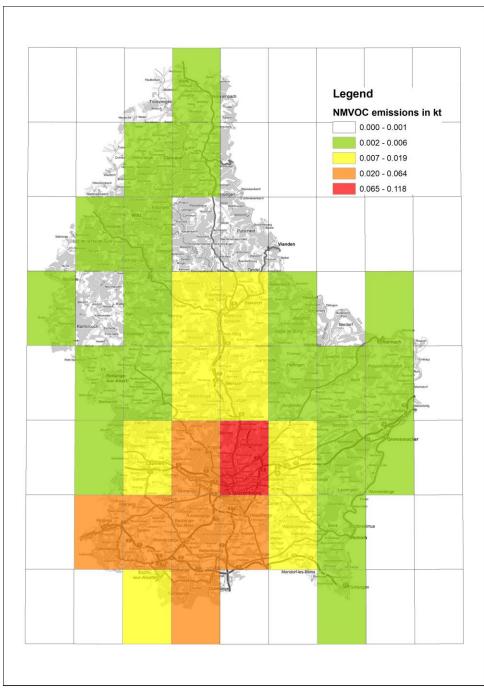

Figure 5 – NMVOC emission distribution of the GNFR sector D_Fugitive

E_Solvents

The emissions of the GNFR sector E_Solvents correspond to the sum of the emissions of the NFR sectors 2D3a (Domestic solvent use including fungicides), 2D3d (Coating applications), 2D3e (Degreasing), 2D3f (Dry cleaning), 2D3g (Chemical products), 2D3h (Printing), 2D3i (Other solvent use) and 2G (Other product use).

Total emissions of the sectors 2D3a, 2D3d, 2D3e, 2D3f, 2D3g, 2D3h, 2D3i and 2G are disaggregated using two different sources. 50 % of the emissions are distributed over the population per municipality. The distribution of the remaining 50 % is based on the number of employees in companies emitting solvents. The database containing then number of employees in NACE sectors emitting solvents was aggregated to municipality level. For some companies, there was no information on the number of employees. In these cases, the minimum number of employees was assumed to ensure the spatial distribution. The second part of the spatial distribution is the subdistribution across all building areas (OBS 1.1.1 to OBS 1.2.1.4, i.e. CLC groups 1 - 7), as small businesses are often located in residential areas.
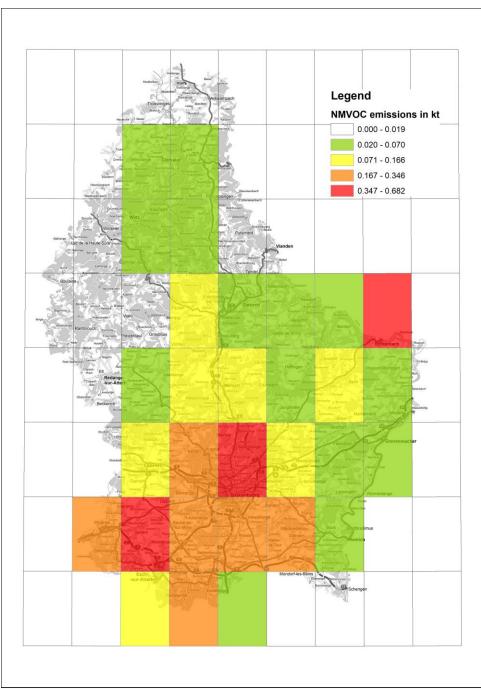
Figure 6 – NMVOC emission distribution of the GNFR sector E_Solvents

F_RoadTransport

The emissions of the GNFR sector F_RoadTransport correspond to the sum of the emissions of the NFR sectors 1A3bi (Road transport: Passenger cars), 1A3bii (Road transport: Light duty vehicles), 1A3biii (Road transport: Heavy duty vehicles and buses), 1A3biv (Road transport: Mopeds & motorcycles), 1A3bv (Road transport: Gasoline evaporation), 1A3bvi (Road transport: Automobile tyre and brake wear) and 1A3bvii (Road transport: Automobile road abrasion).

Total emissions in this sector are distributed according to the national road traffic model. Not only the geometry of the network is considered but also distribution parameters are derived using the average daily traffic per vehicle type.

- For the NFR sectors 1A3bi, 1A3bii, and 1A3biv, the mileage distribution of vehicle group "cars" is used for spatial distribution of the emissions.
- For the NFR sector 1A3biii, 1A3bvi, and 1A3bvii, the mileage distribution over yearly mileage of DTV (average daily traffic [Kfz/24h]) is used for spatial distribution of the emissions.
- For the NFR sector 1A3bv (Road transport: Gasoline Evaporation), the distribution is based on the number of inhabitants per municipality, as this serves as an indicator of the number of vehicles registered. Afterwards the final spatial distribution is done using CLC group 8 (OBS 1.2.2.1.1 and OBS 1.2.2.1.2).
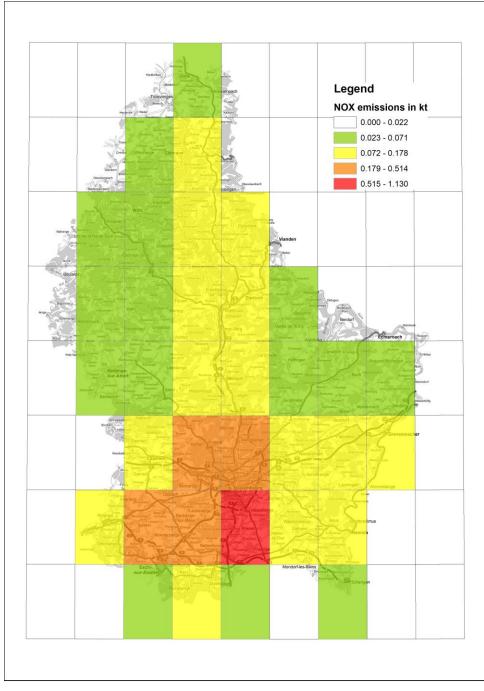

Figure 7 – NOX emission distribution of the GNFR sector F_RoadTransport

G_Shipping

The emissions of the GNFR sector G_Shipping correspond to the sum of the emissions of the NFR sectors 1A3di(ii) (International inland waterways) and 1A3dii (National navigation (shipping)).

The disaggregation of the total emissions of this sector is performed over the river Moselle. Therefore, the length of the river in the corresponding grid cells is determined. Based on the total length of the Moselle, the disaggregation of the total emissions of this sector can then be done.
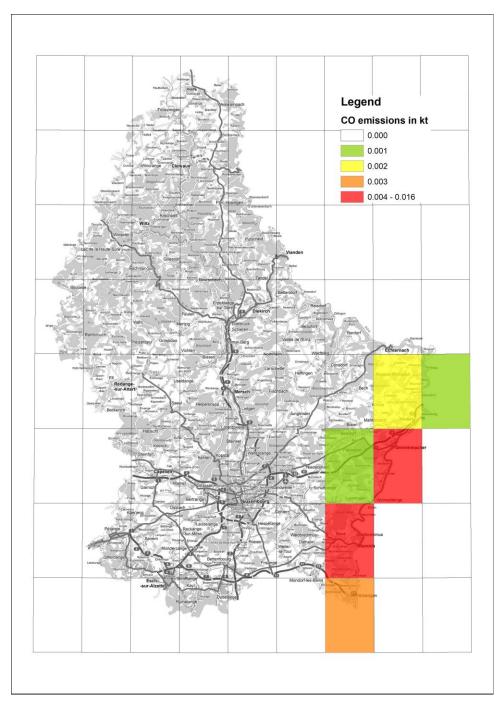

Figure 8 – CO emission distribution of the GNFR sector G_Shipping

H_Aviation

The emissions of the GNFR sector H_Aviation correspond to the sum of the emissions of the NFR sectors 1A3ai(i) (International aviation LTO (civil)) and 1A3aii(i) (Domestic aviation LTO (civil)).

The disaggregation of the total emissions of this sector is done on the basis of the detailed radar flight traces for all take-offs and landings in 2016 on the national airport of Luxembourg (Findel), and the linkage of the data with the flight schedules proportionately to the corresponding approach/departure routes.
52.4 % of the emissions are distributed to the funnels (climb and approach); the remaining 47.6 % are allocated to the airport area (taxiing and take-off/landing). In addition, the average emission proportion per segment as well as the average emission height per segment is taken into account.
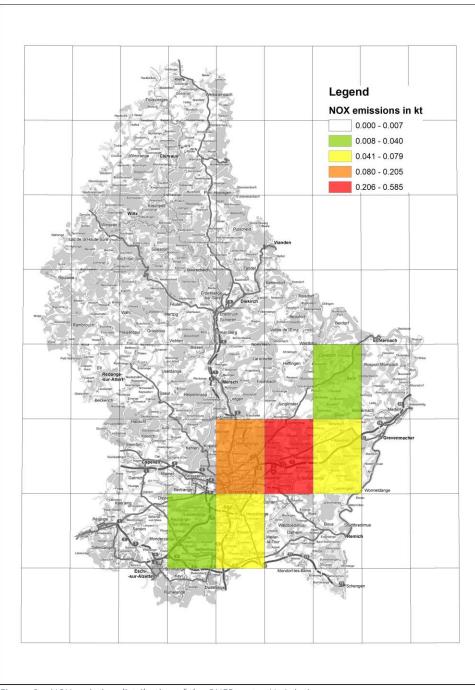

Figure 9 – NOX emission distribution of the GNFR sector H_Aviation

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I_Offroad

The emissions of the GNFR sector I_Offroad correspond to the sum of the emissions of the NFR sectors 1A2gvii (Mobile Combustion in manufacturing industries and construction), 1A3c (Railways), 1A4bii (Residential: Household and gardening (mobile)), 1A4cii (Agriculture/Forestry/Fishing: Off-road vehicles and other machinery) and 1A5b (Other, Mobile (including military, land based and recreational boats)).

- The disaggregation of the total emissions of the sector 1A2gvii is performed using the count of companies working in specific NACE sectors. Relevant NACE codes are the groups 13 and 14. The number of companies in groups 13 and 14 has been summed at the community level. This determines the proportionate distribution over affected communities. In the second step of the distribution, the allocation to the relevant OBS areas takes place. These are: industry (1.2.1.1.1), mining (1.3.1), earth deposit (1.3.2.1), heaps (1.3.2.2), industrial fallow (1.3.2.3) and construction sites (1.3.2.4). They are summarized to the previously defined CLC groups 3 and 12.

- The disaggregation of the total emissions of the sector 1A3c is done using the length proportion of the railway network for each grid.

- The disaggregation of the total emissions of the sector 1A4bii takes place in areas containing residential buildings. A measure of the level of emissions is the population of a municipality. Therefore, the distribution is based on the number of inhabitants. Subsequently, the spatial allocation to the relevant areas (OBS 1.1.1 to 1.1.2.4, i.e. CLC groups 1 and 2) is carried out.

- Total emissions of the sector 1A4cii are disaggregated over the number of agricultural holdings/wineries in line with the emissions of NFR sector 1A4ci (Agriculture/Forestry/ Fishing: Stationary). The subsequent spatial subdistribution takes place via OBS code 1.2.1.4 areas (CLC group 7).

- Total emissions of the sector 1A5b are evenly spread across all land use areas.
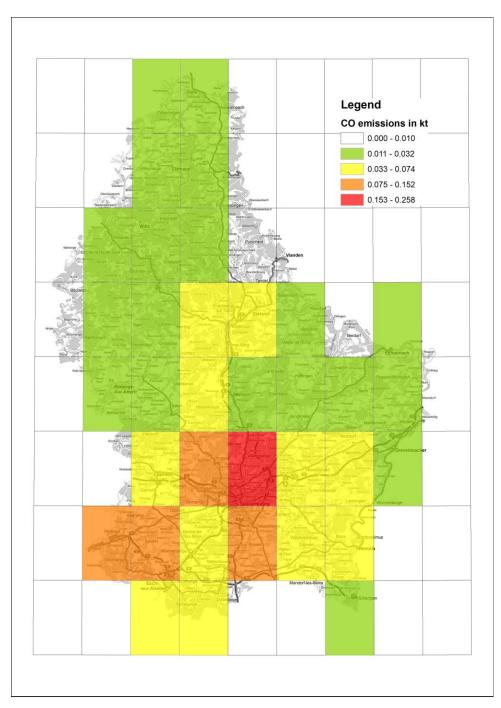
Figure 10 – CO emission distribution of the GNFR sector I_Offroad

J_Waste

The emissions of the GNFR sector J_Waste correspond to the emissions of the NFR sectors 5A (Biological treatment of waste - Solid waste disposal on land), 5B1 (Biological treatment of waste - Composting), 5B2 (Biological treatment of waste - Anaerobic digestion at biogas facilities), 5C1bv (Cremation), 5D1 (Domestic wastewater handling), 5D2 (Industrial wastewater handling) and 5E (Other waste).

Total emissions of this sector are disaggregated using the crematorium at Hamm as only point source. This crematorium is the only official source of emissions. The emission height is set to 10 m.
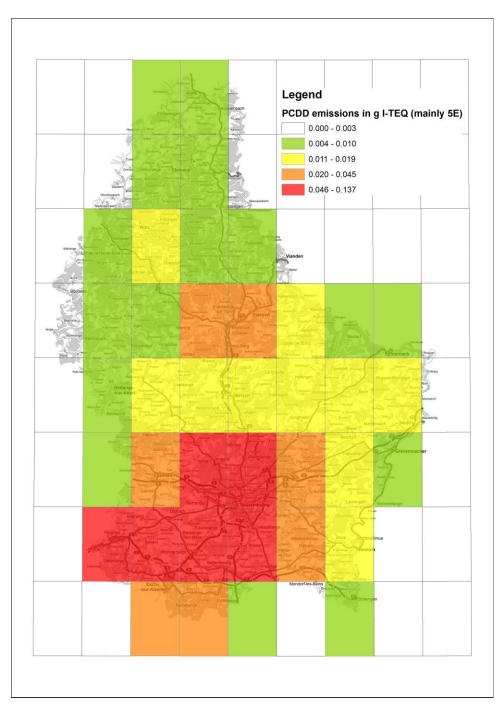
Figure 11 – PCDD emission distribution of the GNFR sector J_Waste

K_AgriLivestock

The emissions of the GNFR sector K_AgriLivestock correspond to the sum of the emissions of the NFR sectors 3B1a (Manure management - Dairy cattle), 3B1b (Manure management - Non-dairy cattle), 3B2 (Manure management - Sheep), 3B3 (Manure management - Swine), 3B4d (Manure management - Goats), 3B4e (Manure management - Horses), 3B4gi (Manure management - Laying hens), 3B4gii (Manure management - Broilers), 3B4giv (Manure management - Other poultry) and 3B4h (Manure management - Other animals).

- The disaggregation of the total emissions of the sectors 3B1a, 3B1b, 3B2, 3B3 and 3B4e is carried out on the municipalities using the livestock available at municipal level. The spatial distribution within a municipality then takes place over the CLC group 16 (humid and mesophilic grassland).

- The disaggregation of the total emissions of the sectors 3B4d, 3B4gi, 3B4gii, 3B4giv is performed only taking areas of the type commercial agriculture (OBS 1.2.1.4, i.e. CLC group 7) into account. Pre-distribution in municipalities takes place over the area share per municipality in relation to the total area of Luxembourg.

- The disaggregation of the total emissions of the sector 3B4h is performed only taking areas corresponding to the OBS classes 2.3.1.1 (humid grassland) and 2.3.1.2 (mesophilic grassland), i.e. CLC group 16. Pre-distribution in municipalities takes place over the area share per municipality in relation to the total area of Luxembourg
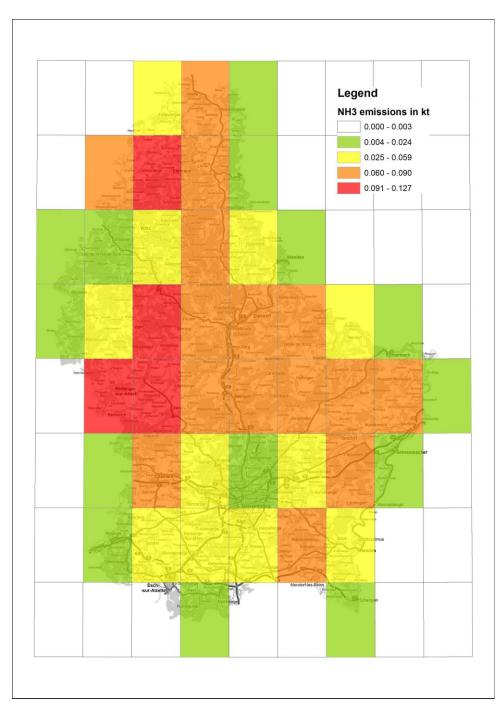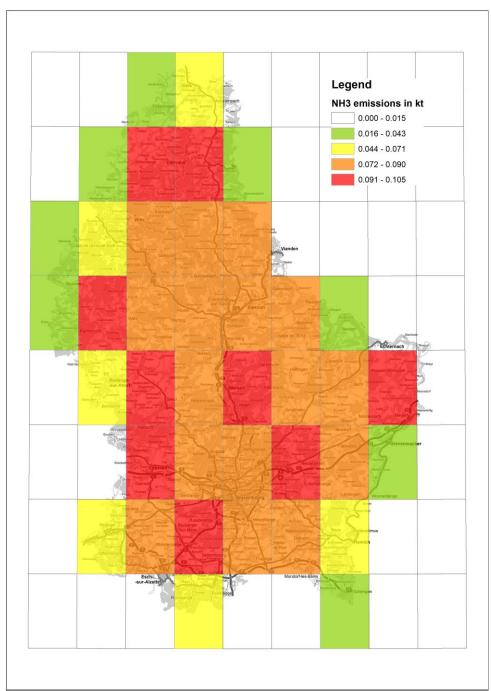
Figure 12 – NMVOC emission distribution of the GNFR sector K_AgriLivestock

L_AgriOther

The emissions of the GNFR sector L_AgriOther correspond to the sum of the emissions of the NFR sectors 3Da1 (Inorganic N-fertilizers (includes also urea application)), 3Da2a (Animal manure applied to soils), 3Da2b (Sewage sludge applied to soils), 3Da2c (Other organic fertilizers applied to soils (including compost)), 3Da3 (Urine and dung deposited by grazing animals), 3Da4 (Crop residues applied to soils), 3Dc (Farm-level agricultural operations including storage, handling and transport of agricultural products) and 3De (Cultivated crops).

Total emissions of this sector are disaggregated over areas corresponding to OBS 2.1.1.1, i.e. CLC group 14. Pre-distribution in municipalities takes place over the area share per municipality in relation to the total area of Luxembourg.

Figure 13 – NH3 emission distribution of the GNFR sector L_AgriOther

M_Other

The emissions of the GNFR sector M_Other are not applicable (NA) for Luxembourg.