Review of the consistency of PM, HM and POP emission factors – 4D Agricultural Soils

Chapter 4D of the GB contains PM_{10} and $PM_{2.5}$ emission factors (EFs) for agricultural field operations such as soil cultivating, harvesting etc.

Both tier 1 and tier 2 EFs are provided. The tier 2 emission factors are crop and climate specific while the tier 1 EFs are expressed simply as kg per ha.

Even though it is outside the scope of this work, the NMVOC EF has been reviewed due to the strange unit of the current tier 1 EF for NMVOC.

Assessment of consistency for PM emission factors

The GB contains tier 1 EFs for PM_{10} and $PM_{2.5}$ referenced to van der Hoek & Hinz (2007). However, it is not clear how the EFs have been derived. The reference provides EFs as shown below.

	Working step EF_{10} kg/ha			
Crop	Soil cultivation	Harvesting	Cleaning	Drying
Wheat	0.25	2.7	0.19	0.56
Rye	0.25	2.0	0.16	0.37
Barley	0.25	2.3	0.16	0.43
Oat	0.25	3.4	0.25	0.66

It is not possible based on the excerpt above to understand the derivation of an EF of 1.56 kg PM_{10} per ha.

The tier 2 EFs are also referenced to van der Hoek & Hinz (2007) and are divided into the same categories (Soil cultivation, harvesting, cleaning and drying) as in the reference as shown above. Furthermore, the tier 2 EFs distinguish between wet and dry climatic conditions.

For wet climatic conditions the values presented in the GB matches the reference for soil cultivation, cleaning and drying. However, for harvesting the EF is significantly lower in van der Hoek & Hinz (2007) than in the GB. There is no mention of grass in van der Hoek & Hinz (2007), wherefore it is not clear where these EFs originate from.

The information provided in annex 4 (Table A4-2) of the GB contains different values for soil cultivation than both the original reference (van der Hoek & Hinz, 2007) and the tier 2 EF tables.

Table A4-2 PM emission factors EF_{PM} for agricultural crop operations, in kg ha^{-1} PM.

Crop	Soil cultivation	Harvesting	Cleaning	Drying
Wheat	0.25	4.9	0.19	0.56
Rye	0.25	3.7	0.16	0.37
Barley	0.25	4.1	0.16	0.43
Oat	0.25	6.2	0.25	0.66

Table 3–3 Tier 2 EFs for agricultural crop operations, in kg ha^{-1} PM_{10}, wet climate conditions

Crop		Soil cultivation	Harvesting	Cleaning	Drying
			K		
	I	1	2	3	4
Wheat	1	0.25	0.49	0.19	0.56
Rye	2	0.25	0.37	0.16	0.37
Barley	3	0.25	0.41	0.16	0.43
Oat	4	0.25	0.62	0.25	0.66
Other arable	5	0.25	NA	NA	NA
Grass	6	0.25	0.25	0	0

Note: grass includes hay making only.

Table 3–4 Tier 2 EFs for agricultural crop operations, in kg ha^{-1} PM_{10}, dry climate conditions

Crop		Soil cultivation	Harvesting	Cleaning	Drying
			k		
	I	1	2	3	4
Wheat	1	2.25	2.45	0.19	0
Rye	2	2.25	1.85	0.16	0
Barley	3	2.25	2.05	0.16	0
Oat	4	2.25	3.10	0.25	0
Other arable	5	2.25	NA	NA	NA
Grass	6	2.25	1.25	0	0

Note: grass includes hay making only.

Table 3–5 Tier 2 EFs for agricultural crop operations, in kg ha^{-1} $PM_{2.5}$, wet climate conditions

Crop		Soil cultivation	Harvesting	Cleaning	Drying
			k		
	I	1	2	3	4
Wheat	1	0.015	0.02	0.009	0.168
Rye	2	0.015	0.015	0.008	0.111
Barley	3	0.015	0.016	0.008	0.129
Oat	4	0.015	0.025	0.0125	0.198
Other arable	5	0.015	NA	NA	NA
Grass	6	0.015	0.01	0	0

Note: grass includes hay making only.

Table 3–6 Tier 2 EFs for agricultural crop operations, in kg ha^{-1} $PM_{2.5}$, dry climate conditions

Crop		Soil cultivation	Harvesting	Cleaning	Drying
			k		
	I	1	2	3	4
Wheat	1	0.12	0.098	0.0095	0
Rye	2	0.12	0.074	0.008	0
Barley	3	0.12	0.082	0.008	0
Oat	4	0.12	0.125	0.0125	0
Other arable	5	0.12	NA	NA	NA
Grass	6	0.12	0.05	0	0

Note: grass includes haymaking only.

1 *Source of default EFs - Van der Hoek and Hinz (2007).*

The difference between the EFs for wet and dry climatic conditions is a factor of nine for soil cultivation and a factor of five for harvesting. It is neither described in the main GB chapter nor in annex 4 how these factors have been derived.

It should be determined how the EFs in the GB have been derived. Otherwise, the EFs should be changed to match the data presented in the reference used.

Assessment of the NMVOC emission factor

The current EF in the GB is provided in the strange unit kg per kg fertiliser-N applied. Furthermore, it is not possible to reproduce the EF from the reference provided.

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	4D	Agricultural Soils			
Fuel	NA				
Not estimated	NO_X, CO, SO_X, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP, SCCP				
Not applicable	TSP				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	5.95539E-09	kg kg^{-1} fertilizer-N applied	1.92E-10	8.51E-08	Steinbrecher et al (2008)
NH_3	0.084	kg kg^{-1} fertilizer-N applied	0.06	0.10	Harrison & Webb (2001)
PM_{10}	1.56	kg/ha	0.78	7.8	van der Hoek & Hinz (2007)
$PM_{2.5}$	0.06	kg/ha	0.03	0.3	van der Hoek & Hinz (2007)
NO	0.026	kg kg^{-1} fertilizer-N applied	0.005	0.104	Steinbrecher et al (2008)

There are few countries reporting NMVOC emissions from crops. In the national inventory Germany uses data by König et al. (1995). Other sources of NMVOC EFs are Lamb et al. (1993) and Winer et al. (1992). Annex 3 of the GB chapter also cites data from Dämmgen (in fact, Rösemann et al. (2011)). Rösemann et al. uses EFs developed by König et al. (1995).

Annex 3 states that the tier 1 EFs are based on the data from Germany, while the table in the main chapter refers to Steinbrecher et al. (2008). Furthermore, there is an error in table A3-1 of the GB concerning terpenes from grass. Also the equation and EF table in the annex fails to mention that the EFs provided are per hour, which significantly changes the resulting annual emissions.

König et al. (1995) does not mention whether the presented EFs are in NMVOC-C or NMVOC. The annex in the GB assumes that the data are NMVOC-C. However, the chosen constituents to convert the units are not always consistent with König et al. (1995), e.g. for aldehydes the annex uses formaldehyde (methanal) and acetaldehyde (ethanal), while the compound measured by König et al. is hexanal.

The EF for rye estimated by König et al. is significantly higher than the EF estimated for wheat. Also the EF for wheat is lower than other sources (Lamb et al., 1993 and Winer et al., 1992). The opposite is the case for rye where the EF is substantially higher. König states that the large difference in the emission rates between rye and wheat observed in the study is unclear. However, different stages of development might explain the differences in the observed emission rates. Rye was sampled a week before blossoming and during blossoming. Wheat was sampled 3 d after blossoming, the blossoms being washed off by heavy rain during the days prior to sampling. It might be that the emissions of alcohols in the non-blossoming rye were

already a result of the development of the blossoming stage while wheat with the blossoms washed off exhibited a largely reduced emission of BOVOCs (and terpenes). It might also be that the emission of alcohols is reduced after rains due to leaching of water soluble compounds during rainfall.

This could indicate that the EF for wheat by König et al. could be underestimated, while the EF for rye could be overestimated.

An approach for the tier 1 EF could be to use the average value for rye and wheat, since this also covers two different situations, i.e. shortly before blossoming and after blossoming (and after a rainfall).

References

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