Emissions from field burning of agricultural wastes (NFR 4F)

Consistency of the emission factors

Currently the GB references 4 different sources for the emission factors (EFs). Jenkins et al. (1996) is used as a reference for all main pollutants and particles except for NH_3 where Lee & Atkins (1994) is used. For PCDD/F an emission factor from UNEP is applied and for heavy metals the GB references Xinghua et al. (2007).

The study by Jenkins et al. is reported both in a report (Jenkins et al., 1996a), and the results are also published in several articles (Jenkins et al., 1996b, Turn et al., 1997).

The data recorded by Jenkins et al. also includes element analysis of the particulate matter. This therefore also includes EFs for heavy metals and BC.

The data from Jenkins et al. are older than the data from Xinghua et al., however for e.g. wheat the sample size is almost identical, i.e. 2 in Jenkins et al. (1996a) and 3 in Xinghua et al.

It should therefore be considered to change reference for the EFs for heavy metals to Turn et al. to ensure the consistency of the emission factors.

In the tables below is a comparison of the current heavy metal EFs in the GB for wheat and maize from Xinghua et al. and the EFs derived for wheat and maize from Turn et al.

	Wheat		Maize	
mg/kg	Xinghua et al	Turn et al.	Xinghua et al	Turn et al.
Pb	0.6300	0.1100	1.100	0.007
Cd	0.0270	0.8800	0.070	0.036
Hg	0.0080	0.1400	0.008	0.028
As	0.0460	0.0064	0.069	0.013
Cr	0.2200	0.0800	0.220	0.100
Cu	NA	0.0730	NA	0.054
Ni	0.3200	0.0520	0.034	0.036
Se	0.0130	0.0200	0.059	0.028
Zn	0.0280	0.5600	0.028	0.840

It can be seen that for some pollutants there is large differences between the two references while for other metals there is relatively good agreement.

Turn et al. presents EFs for metal taken for PM_{10} and $PM_{2.5}$, while Xinghua et al. only provides the speciation for $PM_{2.5}$. Based on the original data (Jenkins et al., 1996a) that are the basis for Turn et al., it is possible to correct for the particles greater than PM_{10} by assuming a similar chemical composition. The difference between the data reported in Turn et al. and what can be calculated based on Jenkins at al. (1996a) is shown in the table below.

mg/kg	Derived from Jenkins et al. 1996a	Turn et al.
Pb	0.1105	0.1100
Cd	0.8948	0.8800
Hg	0.1421	0.1400
As	0.0065	0.0064
Cr	0.0819	0.0800
Cu	0.0744	0.0730
Ni	0.0529	0.0520
Se	0.0206	0.0200
Zn	0.5754	0.5600

However, the question is whether the assumption of a similar chemical composition of the larger particles is valid, and whether it is worth the extra effort considering the already high uncertainties of the EFs.

The tier 1 EFs in the GB seems to be taken as the EFs for rice burning. This seems improbable in Europe. This could be changed either by using the predominant crop, e.g. wheat or taking an average of the data for the four crops included.

The current EF tables in the GB only contain an EF for the sum of 4 PAHs. However, in Jenkins et al. (1996b) data are available to include EFs for the four different PAHs included in the reporting to CLRTAP.

Recommendations

To enhance consistency it is proposed that the EFs for heavy metals in the GB are changed to Turn et al.

Where the EF calculated by Turn et al. is lower for PM_{10} than for $PM_{2.5}$, e.g. Pb from maize burning, it is suggested to use the $PM_{2.5}$ emission factor.

It is considered reasonable that the tier 1 EFs are changed from EFs for rice burning to the EFs for wheat burning.

It is proposed to include EFs for the four different PAHs in the EF tables for both tier 1 and tier 2.

Black carbon

The study by Jenkins et al. (1996a) also covered BC (calculated as EC). The results are reported by Turn et al.

EC - mg/kg			
Rice	Wheat	Barley	Maize
500	800	1200	750

Values for PM_{10} used

Several other sources provide information on EFs for BC. Some of the values available from literature are shown in the table below.

mg/kg	Turn et al. (EC)[1]	Xinghua et al. (EC)[1]	Sahai et al. (BC)[1]	Venkataraman et al. (BC)[1]	Kanokkanjana & Garivait (BC)	Cao et al. (BC)[1]	Liousse et al.[2] (BC)	Andreae & Merlet (BC)[1]
Rice	500			170[3]		520	600	
Wheat	800	490	160			520	910	
Barley	1200							
Maize	750	350			500-560	780	700	
Unspecified								690

Most of the literature available reports BC emission factors in the same range except for Sahai et al. and Venkataraman et al., where the EFs reported are markedly lower. Turn et al. and Xinghua et al. do not report on BC but on EC. Considering that the contribution from OC to the BC could be relevant for the combustion of biomass, it is possible that it is an underestimation to consider that BC equals EC. However, when comparing the available data presented in the table above, it seems that the available EFs are in the same range regardless of whether it is reported as EC (Turn et al. and Xinghua et al.) or as BC (e.g. Cao et al. and Liousse et al.)

Recommendations

To maintain the highest level of consistency between the emission factors for BC and the emission factors for the other pollutants covered, it is suggested to use the EFs reported by Turn et al. in the GB.

[1] The reference also contains information on OC.
[2] The paper distinguishes between developed and developing countries. Values for developed countries selected.
[3] Straw used as fuel.

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