Ammonia emissions from transport in the Czech Republic

J. Dufek, V. Adamec, J. Jedlička
Transport Research Centre, Lisenska 33a, 636 00 Brno, Czech Republic

ABSTRACT

In the 2004 year the Czech national transport-related emissions inventory was added on the next pollutant – ammonia (NH_3). The of ammonia emissions in exhaust gases were not measured in the Czech Republic yet. That is why, the emission factors from international Emissions Inventory Guidebook were used as input data. The final emissions were calculated according to the Czech national methodology for emissions calculation from transport.

From the calculated results it is evident that the total mass of ammonia increased rapidly. The car transport is the dominant producer of ammonia. The results reflect the differences in emission factors because newer cars fulfillimig EURO standards emit up to 50-times more ammonia than older cars. Thus the gradual modification of vehicle fleet results in year-to-year increasing of ammonia emissions, from 77 tons in 1990 to almost 2000 tonnes in 2003.

KEYWORDS

ammonia, emissions, modelling, consumption, emission factor

EMISSION FACTORS

Ammonia emissions have not still been measured in the Czech Republic. That is why the emission factors published in the last Emission Inventory Guidebook were used as input data for the calculation. The results of European projects COST 319, MEET a EMEP/CORINAIR aimed to the emission calculation are summarised in this handbook. The used emission faxtors are the same for the urban, rural and highway regime and they are displayed in the Table 1.

Table 1 Used ammonia emission factors ($mg.km^{-1}$)

Vehicle category	**urban**	**rural**	**highway**
Passenger cars and Light Duty vehicles			
- gasoline conventional (not fulfilling EURO limit values)	2	2	2
- gasoline fulfilling EURO I – III limits	70	100	100
- diesel	1	1	1
Heavy Duty Vehicles			
- mass between 3,5 – 7,5 tons	2	2	2
- mass exceeding 7,5 tons	3	3	3
Motorcycles			
< 50 cm^3	1	1	1
> 50 cm^3 (2-stroke, 4-stroke)	2	2	2

INPUT DATA FOR THE FUEL CONSUMPTION CALCULATION

The special emission calculation methodology developed in Transport Research centre was used to calculate fuel consumption of ondividual transport modes. The methodology uses fuel consumtion as the activity expression (top-down approach) but also annual milleages per 1 vehicle at selected categories. Thus it is a combination of bottom- up and top – down approaches. The main input data are fuel consumption anf transport performances.

Table 2. Fuel consumption in the Czech Republic

Type of vehicle	Year												
	1990	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Natural gasoline	9,5	103,7	320,4	621,3	782,1	1 010,3	1 210,8	1 172,7	1 390,0	1 562,3	1 974,4	1 976,0	2 107,7
lead gasoline	1 174,5	1 192,3	1 097,2	1 022,3	893,3	836,5	726,5	610,0	583,0	355,5	-	-	-
Avgas	8,0	12,0	8,0	8,0	9,0	3,4	5,0	6,0	2,6	2,8	3,2	3,0	3,1
Total of gasoline	1 192,0	1 308,0	1 425,6	1 651,6	1 684,4	1 850,1	1 941,0	1 788,7	1 975,6	1 920,6	1 977,6	1 979,0	2 110,8
Kerosine	256,0	232,0	174,1	138,1	177,2	156,1	148,5	160,0	189,0	189,0	181,7	202,4	240,4
Diesel	2 275,1	1 906,0	1 682,5	1 685,6	1 982,9	2 285,3	2 239,6	2 275,0	2 232,0	2 393,1	2 668,4	2 659,3	3 046,0
Bio diesel	•	•	•	•	25,0	30,0	170,0	180,0	178,0	228,3	207,5	230,0	256,7
LPG	•	•	•	•	1,6	5,0	8,2	12,0	61,0	62,1	72,4	92,0	97,8
CNG	•	1,3	1,2	2,4	3,2	3,4	3,8	4,5	5,3	4,9	4,9	4,9	5,0
Total (except CNG)	3 723,1	3 446,0	3 282,2	3 475,3	3 871,1	4 326,6	4 508,6	4 415,7	4 635,6	4 793,1	5 107,6	5 162,7	5 751,7

• data is not *available*
- sale was stopped

The significant growth sell of diesel oil, which has a negative impact on the emission balance, is still continuing. Positive can be asses the consumption of alternative fuels (Liquid Petroleum Gas (LPG), Compress Natural Gas (CNG) and bio-diesel). Also can be presume the increasing consumption of alternative fuels.

Table 3. Passenger transport performance in the Czech Republic [bil. passenger-km]

Transport mode	Year												
	1990	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Car transport	39,90	44,30	49,00	51,70	54,50	57,90	59,00	59,73	62,35	63,92	63,41	65,23	67,30
Public road	12,34	10,14	9,09	8,20	7,67	6,32	5,80	8,68	8,65	9,35	10,61	9,63	8,89
Road total	**52,24**	**54,44**	**58,09**	**59,90**	**62,17**	**64,22**	**64,80**	**68,41**	**71,00**	**73,27**	**74,02**	**74,86**	**76,19**
Rail electric	8,58	7,41	5,22	5,11	4,96	5,09	5,41	4,95	4,91	4,27	4,35	4,87	4,92
Rail diesel	4,78	4,35	3,33	3,37	3,06	3,02	2,31	2,07	2,05	3,03	2,95	1,72	1,59
Rail transport *Total*	**13,36**	**11,76**	**8,55**	**8,48**	**8,02**	**8,11**	**7,72**	**7,02**	**6,96**	**7,3**	**7,3**	**6,59**	**6,52**
Air transport	**2,18**	**2,42**	**2,25**	**2,60**	**3,03**	**3,17**	**3,52**	**3,68**	**4,34**	**5,85**	**6,4**	**6,9**	**7,1**
Inland waterway	**0,003**	**0,005**	**0,006**	**0,003**	**0,010**	**0,010**	**0,010**	**0,008**	**0,008**	**0,008**	**0,008**	**0,008**	**0,008**

Table 4. Freight transport performance in the Czech Republic [billion tonne–km]

Transport mode	Year												
	1990	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Road total	**16,82**	**20,25**	**25,26**	**29,81**	**32,50**	**34,55**	**40,64**	**33,91**	**36,96**	**39,03**	**40,26**	**45,06**	**46,56**
Public road	8,81	12,51	16,72	19,76	22,90	24,47	30,78	24,49	26,04	31,36	34,21	37,78	39,12
Road on own account	8,01	7,74	8,54	10,05	9,60	10,08	9,86	9,42	10,93	7,67	6,05	7,28	7,45
Railway	**41,14**	**31,11**	**25,14**	**22,70**	**25,50**	**22,46**	**20,97**	**18,76**	**16,71**	**17,30**	**16,88**	**15,77**	**15,85**
Electric traction	34,81	26,48	21,59	19,43	20,66	19,10	18,68	16,90	14,37	15,57	14,91	13,91	14,12
Motor traction	6,33	4,63	3,55	3,27	4,84	3,36	2,29	2,63	2,34	1,73	1,97	1,86	1,72
Air	**0,06**	**0,08**	**0,03**	**0,03**	**0,03**	**0,03**	**0,05**	**0,06**	**0,03**	**0,04**	**0,03**	**0,03**	**0,04**
Inland waterways	**1,41**	**1,34**	**1,22**	**1,18**	**1,23**	**1,35**	**0,70**	**0,82**	**0,91**	**0,77**	**0,61**	**0,54**	**0,52**

The presented traffic volumes are based on the national traffic census on road infrastructure network in 1990, 1995 and 2000. The given non-traffic volumes: rail, inland waterways and air are taken from the special databases.

In passenger transport volumes and performances a permanent increase in individual passenger transport (IAD) and air transport. The number of passengers are slightly increased to the rail electric traction and the other hand are broken down passenger transport on the diesel traction. The public road (buses) transport volume are slightly decreased.

Due to the increase of transport demands, the road freight transport performances were permanently growing in the 1990 – 2003 period. This trend still continus after entrance the Czech Republic into European Union (May, 2004), because fall off detailed check-up of heavy goods vehicle in the borders and vehicle will realise more journeys under same time than before entrance. Growth of road freight transport is proved as in the public transport as the transport "on own account". Freight railway performance on the electric traction is slightly increased in 2003 after decreasing during the last years.

RESULTS

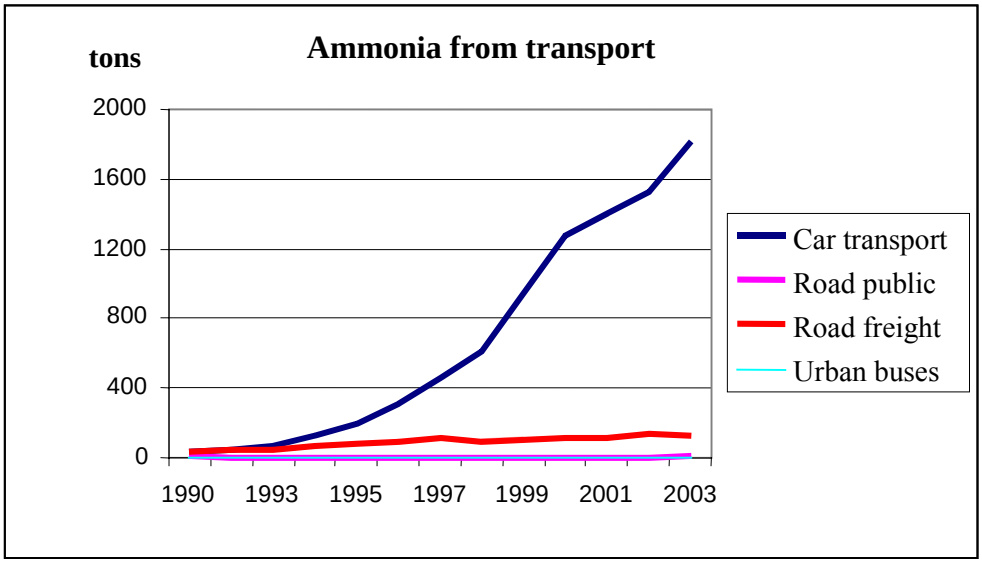
Ammonia emission factors were recalculated to the unit of $mg.kg^{-1}$ fuel and consequently installed to the model of emission calculation from transport. This model contains the algoritms of the Methodology of the calculation of air polluting emissions from transport. The results for individual years are in Table 5, as the annual emissions from 1990.

Table 5 The results of ammonia emissions balance from transport in the Czech Republic (tons per year)

Transport mode	Year												
	1990	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Car transport	33,8	51,4	73,9	122,2	193,8	313,3	462,4	609,2	947,2	1275,3	1406,2	1533,7	1816,0
Road public	6,2	4,4	3,7	3,3	3,8	3,7	3,3	4,7	4,6	5,1	5,7	5,4	6,4
Road freight	29,0	40,4	42,6	72,0	80,0	90,5	110,0	87,4	104,8	110,4	115,5	132,5	122,7
Urban buses	2,1	1,7	1,6	1,4	1,7	2,1	2,0	2,1	2,2	2,5	2,7	2,6	3,1
Rail diesel	5,6	3,7	2,4	2,0	2,9	3,1	2,6	2,7	2,4	2,1	2,3	2,2	2,6
Water	0,5	0,4	0,3	0,3	0,4	0,5	0,3	0,3	0,3	0,3	0,2	0,2	0,2
Air	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total	77,2	102,0	124,5	201,1	282,5	413,1	580,5	706,4	1061,5	1395,6	1532,6	1676,6	1951,0

It is evident that total mass of ammonia from transport in the Czech Republic has increased since 1990. Passenger cars are the most dominant in the ammonia emissions production. The resuts reflects the differences in emission factors between newer and older vehicles. The newer cars fulfilling the EURO limits emit till 50-times more ammonia than older ones. Thus the gradual change of Czech vehicle stock causes the significant increase of the ammonia even though the limited pollutants like carbon monoxide (CO), nitrogen oxides (NOx) and hydrocarbons (C_XH_Y) has decreased. Accorning to the calculation the ammonia emission mass from transport increades from 77 in 1990 to almost 2 thousands tonnes in 2003. The growing tendency is showed in Figure 1.

Fig. 1 . The ammonia emission from different transport modes in the Czech Republic



The comparison of the different transport modes contribution to total ammonia transport – related emission is evident on the Figures No. 2 and No. 3.

Fig. 2. Share of NH_3 in 1990

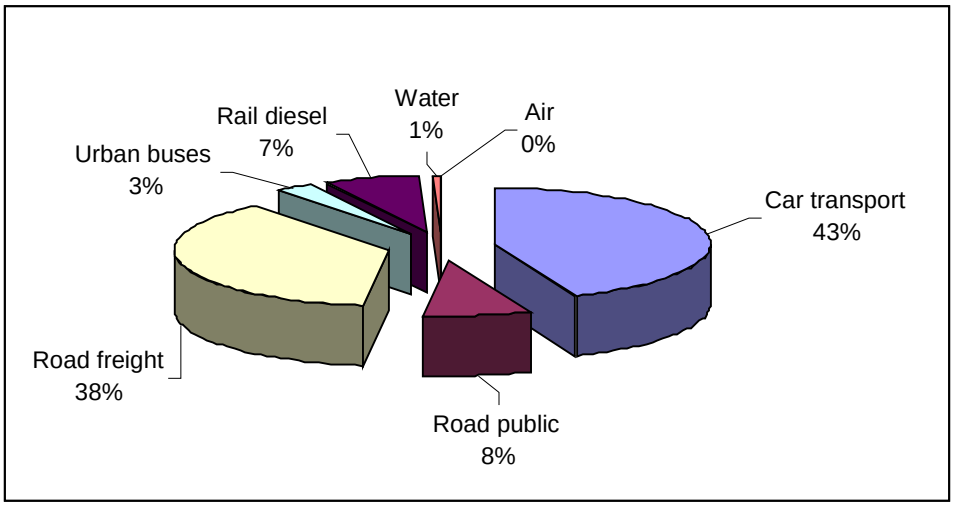
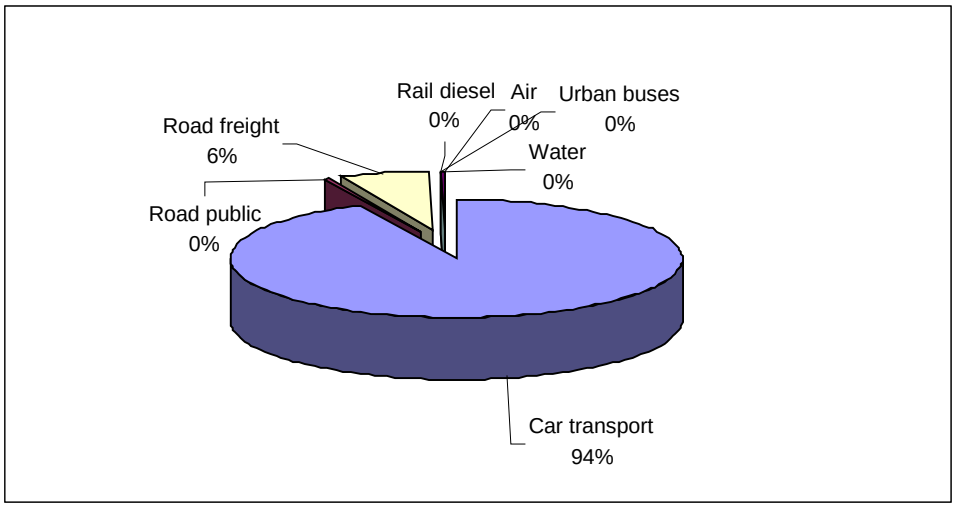


Fig. 3. Share of NH_3 in 2003



According to the calculations, the passenger cars are more and more dominant. The impact of car transport on the ammonia emissions has increased from 43 % in 1990 to 94 % in 2003. The impact of non road transport on ammonia emissions is now almost negligible.

Although the increase of ammonia emissions look treateningly, it is only a small part of the total NO_X – emission. Now the NH_3 creates 2 % of the total NO_X emissions, as is in Figures 4 and 5:

Figure 4: Percentage of NH_3 in 1990

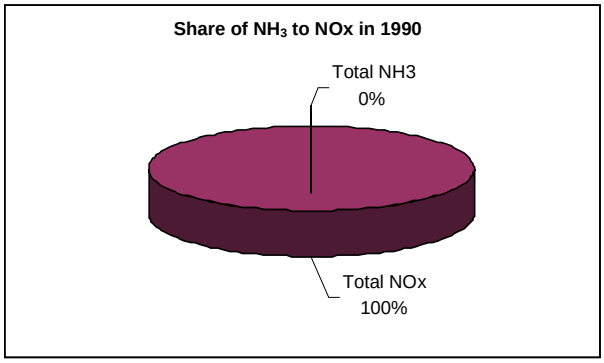
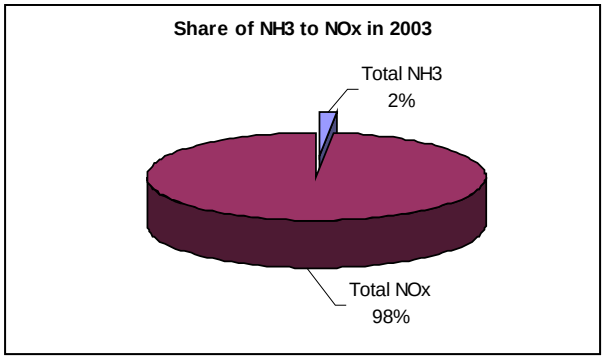


Figure 5: Percentage of NH_3 in 2003



UNCERTAINTIES

The main uncertainity resulted from the fact that no ammonia measurement in exhaust gases has been performed in the Czech Republic. The emission factors come from international databank and do not reflect the specific emission situation of Czech cars and lorries .

CONCLUSIONS

There will be an effort of the authors to continue in the project and to ensure the relevant measurement of ammonia in exhaust gases, in order to have the result more exact. Concerning this field, the appropriate sampling and analysis methodology will be selected and performed.

AUTHOR CONTACT

Jiri Dufek
Section of Environment
Transport Research Centre
Lisenska 33a
636 00 Brno
Czech Republic
Tel.: +420 541 633 717
Fax: +420 541 633 742
E-mail: Dufek@cdv.cz