Ammonia and Ammonium Nitrate in Archives

Mašková, Ludmila
2016

AMMONIA AND AMMONIUM NITRATE IN ARCHIVES

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Keywords: Indoor environment, Indoor/outdoor ratio, Indoor source

INTRODUCTION

Ammonia in libraries and archives can damage stored materials such as pigments and metals (Grzywacz, 2006) and mediate microbial decomposition (Petushkova and Lyalikova, 1986). The aim of this study was to investigate concentrations and sources of ammonia in the indoor air of five different types of archives, and to establish the relationship between the indoor and outdoor environments.

EXPERIMENTAL SETUP

The measurements were carried out in five depositories located in four buildings in the Czech Republic, each representing a different outdoor environment: (1) the State Regional Archives in Třeboň (small town), (2) the Depository of the Research Library of South Bohemia in Zlatá Koruna (rural), (3) the Library in the Regional Museum in Teplice (industrial area), and (4) two depositories (Land Rolls – LR and New Vault – NV) in the National Archives in Prague (large city). The archives in Třeboň, Zlatá Koruna and Teplice are naturally ventilated, whereas the depositories in the Prague are equipped by ventilation and filtration systems. The sampling sites have already been described in details in previous publications (Mašková et al., 2015, Vichi et al., 2016).

Ammonia was collected by Analyst diffusive samplers (Marbaglass, Italy) during a 12-month period at every location. Sampling was performed on a monthly basis both indoors and outdoors. The analyses were done by an ion chromatography (Watrex Ltd., Czech Republic) with a SHODEX CD-5 conductivity detector. In parallel, measurements of particulate matter (PM) were performed on a daily basis during four intensive campaigns in different seasons of the year at every location. Particles from the indoor and outdoor air were collected by two Berner type Low Pressure Impactors (25/0.018/2, Hauke, Austria) and further the main ions were analysed by an ion chromatography (Dionex ICS-5000, Thermo Scientific, USA).

RESULTS AND CONCLUSIONS

Indoor concentrations of ammonia, in all archives, were usually higher than in the outdoor environment (Fig. 1). Similar results have been observed in many studies, and as a possible source decomposition of infiltrated ammonium nitrate the generation of gaseous ammonia and nitric acid was usually considered (Lunden et al., 2003, Andělová et al., 2010, López-Aparicio et al., 2011, Skytte et al., 2012, Talbot et al., 2016).

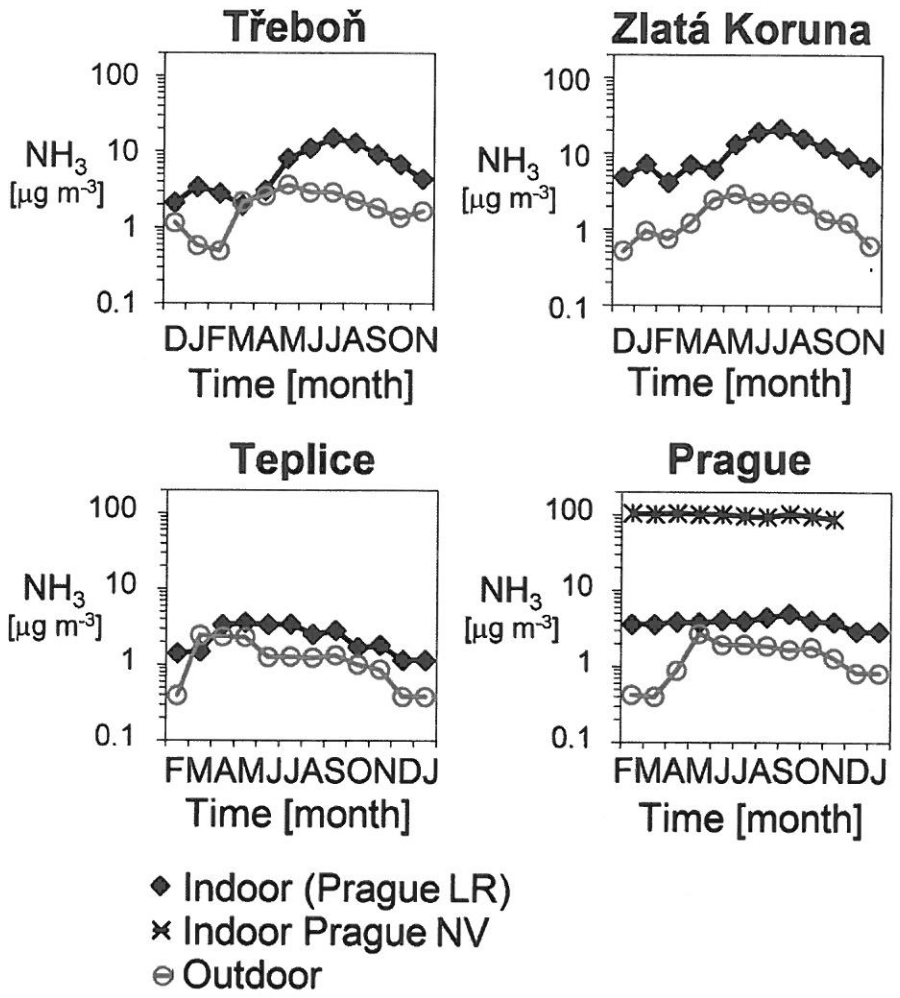

Fig. 1: Time behavior of ammonia concentrations in the indoor and outdoor environments

Concentrations of indoor ammonia from decomposition of ammonium nitrate were estimated. The results revealed that the penetration of ammonium nitrate and ammonia from outdoors can explain only approximately 20-80% of indoor ammonia levels in the naturally ventilated archives (Fig. 2). Moreover, in the depositories in Prague the ammonium nitrate contribution was negligible because the indoor PM concentrations were significantly reduced by the filtration system.

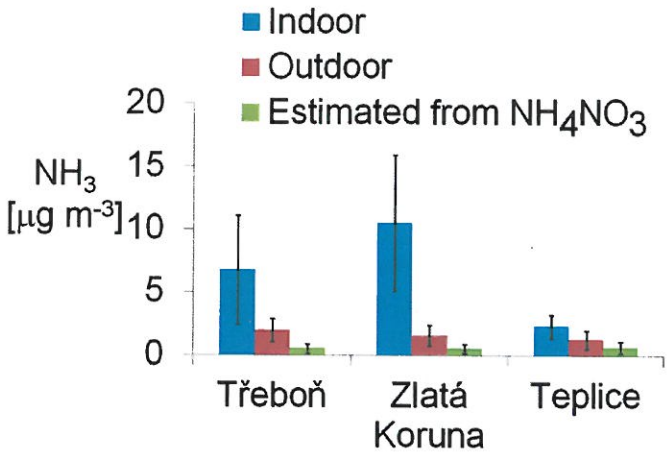

Fig. 2: Annual average indoor and outdoor concentrations of NH_3 and estimated NH_3 concentrations produced by decomposition of ammonium nitrate penetrated from outdoors (±standard deviation)

This indicates another source of ammonia in all of the archives. Typical indoor sources, such as cleaning products (Šišovič et al., 1987), metabolic activities of visitors (Dahlin et al., 1997), smoking (Morton and Laffoon, 2008), were absent. Therefore, emissions from the degradation of organic compounds, such as animal urine, a traditional mortar additive (Snow and Torney, 2014), or urea-based compounds used as concrete additives (Demirboga et al., 2014), were considered. To test this two passive NH_3 samplers were exposed in each depository. The first was exposed to the open indoor air while the second was exposed in parallel under a sealed glass cover. The results confirmed that the building material is the source of ammonia in all of the archives. Emissions from the building material also explained very high values of ammonia in the NV depository in Prague. The air quality in this depository was subsequently improved by employing filters for removing ammonia through the ventilation system. After three months the indoor ammonia concentrations decreased from the initial values approximately 100 μg m^{-3} to less than 1 μg m^{-3}.

ACKNOWLEDGEMENT

The work was supported by the Ministry of Culture of the Czech Republic under grant DF11P01OVV020.

REFERENCES

Andělová, L., Smolík, J., Ondráčková, L., Ondráček, J., López-Aparicio, S., Grøntoft, T., Stankiewicz, J. Characterization of Airborne Particles in the Baroque Hall of the National Library in Prague. *e-Preservation Sci.*, 7, 141-146, (2010).

Dahlin, E., Henriksen, J.F., Anda, O. Assessment of environmental risk factors in museums and archives. *Eur. Cult. Herit. Newsl. Res.*, 10, 94-97, (1997).

Demirboga, R., Karagöl, F., Polat, R., Kaygusuz, M.A. The effects of urea on strength gaining of fresh concrete under the cold weather conditions. *Construct. Build. Mater.*, 64, 114-120, (2014).

Grzywacz, C.M. Monitoring for gaseous pollutants. The Getty Conservation Institute: Los Angeles, USA, (2006).

López-Aparicio, S., Smolík, J., Mašková, L., Součková, M., Grøntoft, T., Ondráčková, L., Stankiewicz, J. Relationship of indoor and outdoor air pollutants in a naturally ventilated historical building envelope. *Build. Environ.*, 46, 1460-1468, (2011).

Lunden, M.M., Revzan, K.L., Fischer, M.L., Thatcher, T.L., Littlejohn, D., Hering, S.V., Brown, N.J. The Transformation of Outdoor Ammonium Nitrate Aerosols in the Indoor Environment. *Atmos. Environ.*, 37, 5633-5644, (2003).

Mašková, L., Smolík, J., Vodička, P. Characterisation of Particulate Matter in Different Types of Archives, *Atmos. Environ.*, 107, 217-224, (2015).

Morton, M.J., Laffoon, S.W. Cigarette smoke chemistry market maps under Massachusetts Department of Public Health smoking conditions. *Regulat. Toxicol. Pharmacol.*, 51 (1), 1-30, (2008).

Petushkova, J.P., Lyalikova, N.N. Microbiological degradation of lead-containing pigments in mural paintings. *Stud. Conserv.*, 31, 65-69, (1986).

Skytte, L., Rasmusen, K.L., Ryhl-Svendsen, M., Svensmark, B., Brimblecombe, P. Ammonia chemistry within Danish churches. *Sci. Total Environ.*, 417-418, 13-20, (2012).

Snow, J., Torney, C. Lime mortars in Traditional buildings. National Conservation Centre: Edinburgh, UK, (2014).

Šišovič, A., Šega, K., Kalinić, N. Indoor/outdoor relationship of ammonia concentration in selected office buildings. *Sci. Total Environ.*, 61, 73-77, (1987).

Talbot, N., Kubelová, L., Makeš, O., Cusack, M., Ondráček, J., Vodička, P., Schwarz, J., Ždímal, V. Outdoor and Indoor Aerosol Dynamics from Urban Background Measurements during Warm Season. *Atmos. Environ.*, 131, 171-184, (2016).

Vichi, F., Mašková, L., Frattoni, M., Imperiali, A., Smolík, J. Simultaneous Measurement of Nitrous Acid, Nitric Acid, and Nitrogen Dioxide by Means of a Novel Multipollutant Diffusive Sampler in Libraries and Archives. *Heritage Science*, 4(4), 1-8, (2016).