Monitoring of atmospheric $^{14}$CO$_2$ in the Czech Republic (CZ) and Hungary (HU)

Monitoring in the locality Prague-Bulovka started in 2001 (there was expected greater local change by Suess effect) and in the locality Koseicie in 2004, this locality is situated in relatively clear area without greater local anthropogenic sources of fossil CO$_2$. This monitoring was naturally aimed on [1].

1. Determination of reference $^{14}$C activity in the environment and its seasonal and annual changes in the localities with smaller and greater local anthropogenic influences, from fossil fuel combustion, on the base of Prague-Bulovka and Koseicie data comparison.

2. Find robust $^{14}$C reference parameters, which are minimally influenced by Suess effect (e.g. spring/summer $^{14}$C activities, $^{14}$CO$_2$ activity concentration).

3. Contribute to corrections for $^{14}$C dating of various types of samples with origin after 1960 (i.e. utilizing Calibomb). It can be supposed that great part of requested dating will be in the areas which can be charged by local and regional Suess effect.

4. In the Atomi the purposes of $^{14}$CO$_2$ monitoring was to detect the excess $^{14}$C in the vicinity of the pucks Nuclear Power Plant (NPP).

Sample processing

Sample processing: CO$_2$ is cumulated into sodium hydroxide solution. Samples from localities Prague-Bulovka and Koseicie are consequently treated in NPL by the way of benzene synthesis, how is described (Geptád-Polášek 1985). Measurement of benzene is performed by low-background liquid scintillation spectrometer QUANTULUS 1220. For calibration purpose is used "secondary" oncolic acid HOSII NIST (former NBS), standard reference material 4006a.

Likewise, activity concentration of atmospheric $^{14}$CO$_2$ was experimentally calculated and corrected for normalised gas conditions for locality Prague-Bulovka (in mBq/m$^3$). The calculation follows volumetric determination of total CO$_2$ carbon content in sodium hydroxide solution, yield of CO$_2$, sorption, and air volume normalised to standard conditions (0 °C, 1013.25 hPa). Calculated combined uncertainties involve these partial components: quantity of collected CO$_2$, normalised volume of sampled air, yield of CO$_2$, sorption, $^{14}$C activity determination (in Bq per gram of carbon, $^{14}$C correction is not performed).

In the Atomi differential $^{14}$C activity samplers were developed to obtain integrated samples for measuring of $^{14}$C [2]. The sampling period was 4 weeks, the flow rate of sampling was stabilized ca. 10 L h$^{-1}$. $^{14}$C was collected in the form of CO$_2$, then absorbed in trapping columns filled with 3 M NaOH solution. The absorption of CO$_2$ in the 3 M NaOH solution was 99.9% using a specially designed bubble-type trap. The activity of the samples was measured in the form of $^{14}$CO$_2$ using proportional counting method [1, 4]. The standard deviation of a single $^{14}$C measurement was $\pm 0.5\%$. $^{14}$CO$_2$ corrected $^{14}$C data are relative to NBS oncolic acid, corrected for decay [6].

Results

Results of $^{14}$C activity from monitoring stations Prague-Bulovka, Koseicie, B-24 (BH), and A-6 (HH), since 2001, are compared with data from monitoring stations Schauinsland in Germany (G), and on only small Suess effect, and Jungfraujoch in Switzerland (CH), high mountain clear monitoring station (cite?!!). However, data from Germany and Switzerland monitoring stations were available till end of year 2003, and July 2003, respectively.

Locality Prague-Bulovka is probably charged by greater local Suess effect from fossil fuel combustion. For this station and average of A6 and B24 were calculated differences from monthly average values utilizing Schauinsland and Jungfraujoch results.

Conclusions

- Maximum observed differences of $^{14}$C activity correspond to the autumn/winter seasons, dating cold part of year greater emissions of fossil carbon can be expected (heating). Contemporary the Suess effect is amplified by worse conditions for fossil CO$_2$ dissipation (atmospheric inversion). The observed differences are more prominent in comparison with temperature curve at the locality Prague-Bulovka. Observed $^{14}$C values from Koseicie observatory are not charged by such distinctive seasonal changes in comparison with Prague-Bulovka.

- During summer period observed differences are close/below level of significance, although in the vicinity of sampling locality Prague-Bulovka there is a frequent motorway (i.e. relatively stable source of fossil carbon during whole year). It indicates, that Calibomb dating of samples with carbon accumulation during summer season (botanic samples) can be influenced by local Suess effect only minimally also in the vicinity of greater fossil carbon sources. Samples cumulated also during cold period of year (e.g. carbonates, underground water) can be influenced by local Suess effect more extensively.

- Average values of $^{14}$C from Hungarian monitoring stations A-6 (close to a frequented main road) and B-24, which are close to Paks NPP indicate also seasonal changes caused by Suess effect. Calculated differences between Jungfraujoch and Schauinsland data indicate similar grouping like data from Prague-Bulovka, although amplitudes are distinctly smaller. Several observed values can be also partially influenced by small leakages of $^{14}$CO$_2$ from the NPP.

- Resulting data from monitoring stations Schauinsland and Koseicie in vicinity inserted to the activity monitored in Prague-Bulovka are charged by greater combined uncertainty (about 5%) with dominant component given by volumetric determination of carbonates quantity. Annual averages decreased from 54.4 (2002) to 53.3 mBq/m$^3$ (2005). The observed data of activity concentration do not reflect seasonal changes. Activity concentration of atmospheric $^{14}$CO$_2$ is not charged by Suess effect, i.e. number of $^{14}$C atoms per cubic meter of air is not influenced by addition of fossil carbon atoms.

References