Wind Directional Sampling for Ambient Air Monitoring of PCDD/F

Gisela Dörr*, Tobias Schwotzer*, Hans-Jörg Wildanger#, Otto Hutzinger*°, Maximilian Swerev°, Hermann Nordsieck°
*Chair of Ecological Chemistry and Geochmistry, University of Bayreuth, D-95440 Bayreuth, Germany
CIL Computer im Labor GmbH, Kastanienweg 21, D-66386 St.Ingbert, Germany
° BIfA Bayerisches Institut für Abfallforschung, Am Mittleren Moos 46B, D-86167 Augsburg, Germany

INTRODUCTION

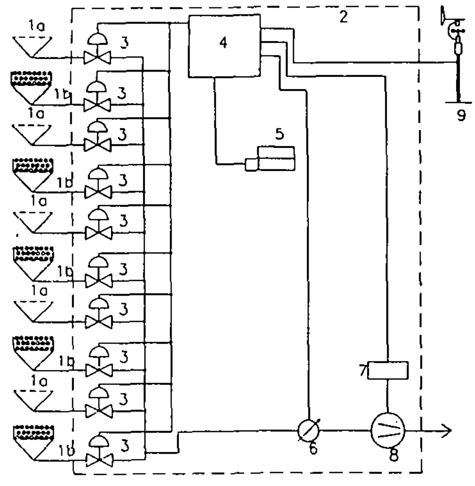
Ambient air monitoring often leads to the question which sources contribute to the levels of the pollutants. Today some approaches are used for source apportionment:
- Meteorological data (wind speed and direction) and the concentrations during several sampling periods are correlated. The coincidence of high levels and a particular wind direction indicates a specific emission source in this area[1-3].
- For larger areas backward trajectories of the air masses at the sampling point are calculated to clarify the origin of the pollutants[4].
- A more sophisticated tool for source-reconciliation is the Chemical Mass Balance (CMB) method. It is based on the comparison of the substance patterns or fingerprints at the emission sites and in the ambient air samples by a multivariate regression model[3,5].
- Also statistical methods like Principal Component Analysis and Factor Analysis have been successfully applied to differentiate between emission sources[3,4].

These methods do not exclude each other but can be combined efficiently for the interpretation of ambient air data.
Because the sampling is the crucial step in all source apportionment studies, recently, some efforts were done to get more information in this step by directional sampling techniques. The principle is that air of different wind directions is sampled separately on several sampling heads. The wind direction is registered and the corresponding sampling head is activated automatically. Directional samplers for particulate matter were developed and used by the University of Hamburg in a research project for monitoring contaminant fluxes in the North sea[6], by the Warren Spring Laboratory in England to rank emissions sources like metal works[7,8] and by C.A.Pio in Portugal at an industrial site[9].
Here we describe a system for directional sampling of gaseous and particulate compounds and its application in an ambient air monitoring study of PCCD/F levels in Augsburg, Germany.

DESCRIPTION OF THE WIND DIRECTIONAL SAMPLING STATION (WDS)

The sampling station consists of a sampling unit with a temperature sensor and the sampling heads, a wind mast (7 m) with sensors for wind speed and direction and a box that contains the pump, the mass flow meter, the switching valves for the sampling heads, the electronics and as the control and registrating device, a computer (Fig. 1).
The WDS can operate up to ten sampling heads. The sampling angle of each head can be chosen independently between 0-360°. If two sampling heads are set at the same sector (e.g. one for metals on particles, the other one for organic substances) they are connected alternately in intervals to the

Fig.1: Schematic diagram of the WDS
(1 Sampling heads 2 Box 3 Valves 4 System electronics 5 Computer 6 Mass flow meter 7 Frequency modulator 8 Pump 9 Wind sensors)

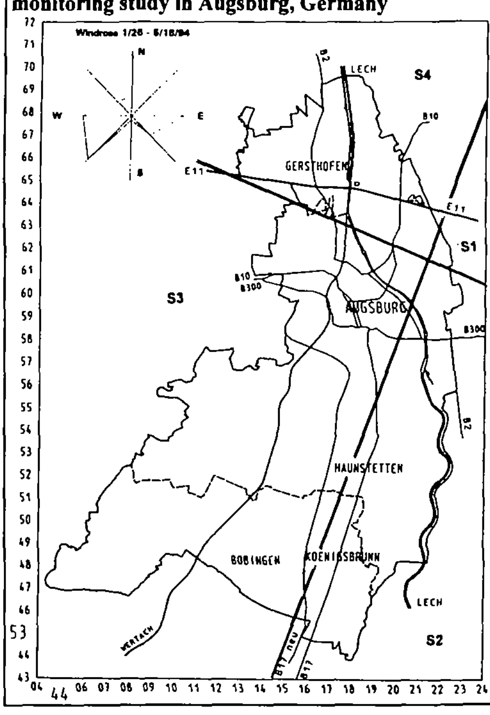


pump. The activation of the sampling heads is done by diaphragm valves that are switched by compressed air. A frequency modulated pump gives an infinitely variable volume flow (20 -500 l /min).
The automatic (=unattended) operation of the WDS is controlled by a computer program. In this program the parameters for the directional sampling like upper / lower wind speed, sampling angle, volume flow, distance to a source for each sampling head and system intervals are fixed. While the station is running automatically, data calculated for a selected time period like wind vector, temperature, sampled volume of each sampling head and error messages of the system are stored continuously in a result file. The wind data are processed by the program as Cartesian coordinates, the check for activating the right sampling head is done by vector addition of the wind vectors during a certain time period. Also a manual operation mode is available for testing the different functions and parts of the WDS. Robustness of the unattended WDS operation is enhanced by a battery supply during power interruption and program routines for restarting automatic sampling or for a stepwise reduction of the volume flow if the set value can not be reached anymore.
The WDS is especially useful to investigate the origin of low concentrated contaminants that need a long sampling duration. In conventional sampling, stable meteorological conditions are not always given during a longer sampling episode. The WDS has the advantage to be not constrained to a continuous episode, a sample will normally correspond to several shorter episodes of identical meteorological conditions. Therefore, the personnel and analytical input of the conventional method where a high sampling frequency is required to connect sample levels and wind data is reduced enormously. Thus, the WDS is the easy way to get reliable directional data.

WDS MONITORING STUDY

A monitoring study of about half a year (1/26/94 - 5/18/94) was conducted with the

Fig 2: Sectors and Windrose during the WDS monitoring study in Augsburg, Germany



WDS at the rim of the city of Augsburg, Germany. During a monitoring study with 7 conventional stations in the year 1992 ambient air levels of PCDD/F were higher at this site where the WDS was positioned.

The wind rose was divided in four sectors of 90° (Fig. 2). Sampling was performed in the range 0.8 - 10 m/s wind speed. For the calms (= sector 0, undefined wind direction, wind speed < 0.8 m/s) a fifth sampling head was installed.

Fig.3: [PCDD/F] of the sectors and sampling periods

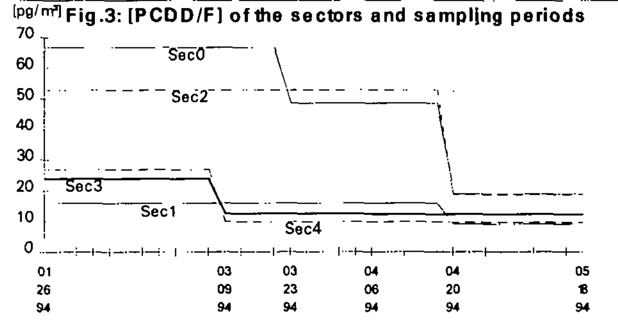
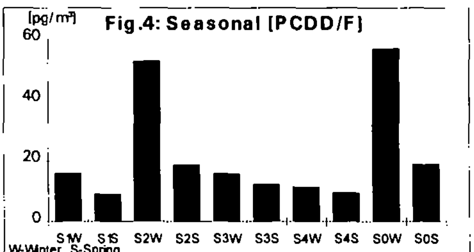


Figure 3 shows the PCDD/F (= sum of homologs) levels of the different sectors during the monitoring period. The sampling periods of the sectors were of different length because some wind directions were preferred (Fig.2). and others rare In general the PCDD/F concentrations were elevated in winter and fell off in spring. Apparently, the levels of sectors 0 and 2 surpassed the ones of the other directions. For easier comparison identical sampling periods were defined in combining the periods to a winter (until 4/20/94) and a spring sample (Fig.4). It was confirmed that there was a confined local source for PCDD/F in sector 2, presumably nearby the position of the WDS, because the calm levels were high, too. The drop of the PCDD/F levels from winter to spring differed depending on the sector and it was more pronounced in the sectors 2 and 0 (Fig.5). This may be related to seasonal emissions in the sectors, i.e. a more active source in winter is indicated by a higher drop of the PCDD/F concentrations. These winter emissions could be due to some kind of residential heating. Schatowitz et al. reported high emissions of PCDD/F when waste wood or household waste was burnt in a household or wood stove[10]. Burning of such material in a garden house area nearby the WDS seemed to be quite possible. Naturally, also meteorological conditions like a low boundary layer associated with certain wind directions could partly account for the different seasonal changes in the sector levels.

Fig.4: Seasonal [PCDD/F]



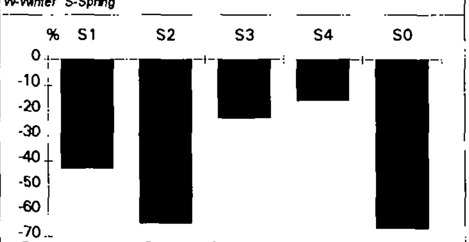


Fig.5: Drop of [PCDD/F] between winter and spring

The homolog patterns of the samples were compared to an averaged homolog pattern of the monitoring. A simple ranking and rating scheme was used for this purpose. It was established that the pattern of the winter samples of sector 0 and 2 deviated from the typical winter pattern and also from the averaged pattern of the monitoring. The homolog pattern in spring of all sectors exhibited a higher similarity than in winter.

In Table 1 the wind frequency and the contributions to the PCDD/F levels at the WDS site for the whole monitoring period is listed. Also this calculation showed that sector 2 transported a higher portion of PCDD/F to the WDS site than would be expected by the frequency of wind from this direction. Mutually, the contributions of the other sectors were reduced in relation to their frequency.

Table 1: Wind frequency and PCDD/F contributions of the sectors

Sector	1	2	3	4
Wind frequency %	17.7	12.9	50.8	18.6
Contribution % to [PCDD/F]	10.8	38.7	40.0	10.5

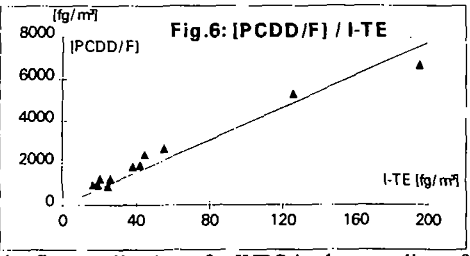


Fig.6: [PCDD/F] / I-TE

For the I-TE similar results as for the PCDD/F were found. In the air samples the PCDD/F and I-TE values showed a good correlation (r= 0.935) (Fig.6).

CONCLUSIONS

A wind directional sampling station (WDS) was developped. The WDS was used in a monitoring study for PCDD/F levels in ambient air which is the first application of a WDS in the sampling of organic pollutants. All over the sampling periods the WDS functioned without problems in the unattended automatic mode. By comparing the levels and the homolog pattern of the WDS samples it was possible to localize the area where higher emission of PCDD/F originated from. Burning of waste wood and household waste for residential heating was considered as the possible source of a confined local impact. Thus, monitoring by a WDS is the method of choice for localizing or controlling emission sources.

ACKNOWLEDGEMENT

We thank the Bavarian State Ministry for State Development and Environmental Affairs for funding this research program.

REFERENCES

1) R M Smith, P O'Keefe, D R Hilker,. K M Aldous, S H Mo, R M Stelle (1989): Ambient air and incinerator testing for PCDD/F by low resolution mass spectrometry, *Chemosphere* **18**, 585-592

2) R M Smith, P W O'Keefe, K Aldous, S Connor, P Lavin, E Wade (1990),: Continuing atmospheric studies of PCDD/F in New York area, *Chemosphere* **20**, 1447-1453

3) C W Sweet, S J Vermette, S Landsberger (1993): Sources of toxic trace elements in urban air in Illinois, *Environ. Sci. Technol.* **27**, 2502 - 2510

4) P Masclct, S Pistikopoulos, S Beync, G Mouvier (1988): Long range transport and gas / particle distribution of PAH at a remote site in the Mediterranean Sea, *Atmos. Environ.* **22**, 639 - 650

5) R M Kamens, C K Li (1993): The use of PAH as source signatures in receptor modeling, *Atmos. Environ.* **27A**, 523 - 532

6) J Sündermann - Ed. (1994): Circulation and contaminat fluxes in the North Sea, Springer, 159-168

7) J L Barnett; P Clayton; B J Davis (1987): Fugitive emissions - a directional sampler for particulates, Warren Spring Laboratory, Stevenage

8) P Clayton; B J Davis, (1993): Directional sampling as a means of assessing the contribution of fugitive emissions to ambient pollutant levels; Couling, S. (Ed.): Measurement of airborne pollutants; Butterworth-Heineman, Oxford

9) C A Pio; M S Viana (1991) Directional sampling of air pollutants using a wind sensor / microcomputer system; *Environ.Technol.* **12**, 407-412

10) B Schatowitz, G Brandt, F Gafner, E Schlumpf, R Bühler, P Hasler, T Nussbaumer (1993): Dioxin emissions from wood combustion, *Organohalogen Compounds*. **11** ,307-310