PCB-LEVELS IN AIR AT A FORMER PCB STORAGE AREA

Löthgren C-J[1], Viberg T[2], Jameson M[1], Eriksen H[1]

[1]SAKAB AB, Norrtorp, S-692 85 Kumla, Sweden; [2]Vattenfall Power Consultant AB, Box 1046, 611 29 S-Nyköping, Sweden

Abstract

Air inside a former PCB storage was sampled as a part of an environmental monitoring program. Although no activity was taking place in the storage, the concentrations inside the storage were elevated compared to reference measurements outside the storage and to results found in the literature. New measurements performed after cleaning of the storage showed even higher levels. Two core samples from the concrete floor in the storage showed that PCB had penetrated 30 mm into the concrete. It is believed that the thorough cleaning with high-pressurized water uncovered new concrete surfaces with higher concentrations of PCBs, which then led to an increased vaporization back into the air inside the storage.

Introduction

Polychlorinated biphenyls (PCBs) have been widely used in many electric applications. Their excellent thermal stability and high dielectric constant made them very suitable for insulating and cooling media in transformers and capacitors.[1] On the other hand, their stability made them nearly undegradable if they were emitted into the environment. It was found that PCBs were accumulating in sea mammals (e.g. seals in the baltic sea) with reproductive disorder as a consequence.[2] The environmental risks connected with the handling of PCBs, led to restrictions in many countries during the 1970s. In Sweden the use of PCBs have been prohibited since 1993.[3]

The SAKAB plant in Kumla, Sweden was built in 1983 as a national centre for the treatment of hazardous waste. From the start of operation, PCB-containing waste has been received, stored and treated in the high temperature rotary kiln situated at the plant. Actually, the safe treatment of Swedish PCB-waste was one of the reasons for building the plant. With time the amounts of PCBs received at the plant have decreased and today nearly no waste in Sweden contain PCB in high concentrations. Because of the environmental and health risks associated with PCB-handling, the air in the PCB storage area has been sampled and analyzed for PCB-congeners every second year since 1994. In the measurement performed 2005 the levels inside the storage were still higher than outside even though no PCB was handled at that time. This paper reports results from activities made to investigate the cause of the elevated levels.

Materials and Methods

The storage investigated is built as a shelter with walls on three sides and with the fourth side open to the surroundings. The sample equipment was placed inside the storage, one meter above the concrete floor. A sketch of the sampling set-up is shown in Fig. 1. Air was pumped through a cartridge filled with XAD 2, at a flow rate of 10 dm^3/minute. At both ends of the cartridge a quartz filter was applied to keep the XAD in place. The air inside the storage was sampled in three campaigns, November 2005, May 2006, and August 2006. Each campaign lasted seven days. Between the sampling campaigns the

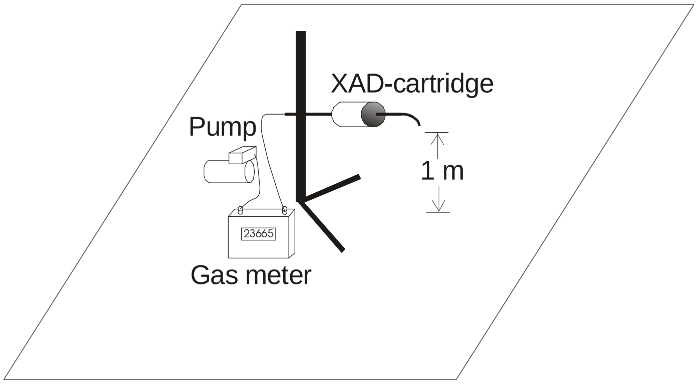

Figure 1: Set-up of sampling equipment inside the PCB storage

shelter was cleaned with high-pressure water washing (200 bar).

Simultaneously with the first campaign in November 2005, PCB was also sampled at a reference point in Hallsberg, appr. 15 km from the plant. The reference point was chosen to reflect the background concentration in the region around SAKAB.

When a sampling campaign was completed the cartridge was sent to an external laboratory for analyses. All cartridges were analyzed for the following PCB-congeners: TriCB#28, TeCB-#52, PeCB#101, PeCB#118, HxCB#138, HxCB#153, and HpCB#180. In September 2006 two core samples from the concrete floor in the storage were taken out. The cores were cut in 15 mm thick slices (cf. Fig. 2). Each slice was analyzed for the same PCB-congeners as the air samples.

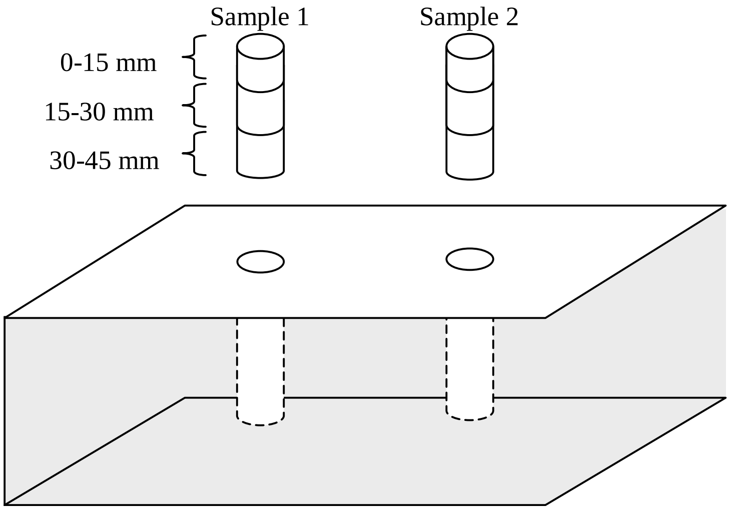

Figure 2: Illustration of the samples from the concrete floor in the PCB storage

Results and Discussion

The results from the air measurements in the storage and at the reference point are presented in table 1. The concentration of total PCBs inside the storage in the first campaign (82 ng/m^3) should be compared with the concentration at the reference point (0.08 ng/m^3). The concentration at the reference point is within the span reported by Lee et al.[4]

Table 1: Results from the air measurements inside the PCB storage and at the reference point. Concentrations are given in ng/m^3 dry gas. The relative amount of each congener measured is written to the right of each concentration. The average air temperature during the sampling period is given at the bottom of the table

	Campaign 1		**Campaign 2**		**Campaign 3**		**Reference point**	
PCB#28	59.5	72.3%	77.0	72.3%	86	53.8%	0.035	44.9%
PCB#52	8.5	10.3%	12.5	11.7%	27	16.9%	0.007	9.0%
PCB#101	4.1	5.0%	4.2	3.9%	11	6.7%	0.006	7.7%
PCB#118	1.9	2.3%	1.6	1.5%	4	2.5%	0.006	7.7%
PCB#138	3.0	3.7%	4.0	3.7%	10	6.1%	0.01	12.8%
PCB#153	4.4	5.4%	6.5	6.1%	15	9.2%	0.0095	12.2%
PCB#180	0.7	0.8%	0.9	0.9%	1	0.8%	0.0055	7.1%
Total PCB	**82.4**		**106.5**		**160**		**0.078**	
Temp (°C)	8.6		10.4		16.4		8.6	

The large discrepancy between the storage and the reference point caused some concern at the company since no activities were taken place in the storage anymore. This was the reason for the thorough cleaning that was performed before the second campaign. It was suspected that the major part of the PCBs originated from contaminated dust inside the storage. However, the concentrations in the second campaign were higher than in the first one. The storage was cleaned once again, this time with hot water and a standard industrial degreasing agent (Industrirent) that was supposed to increase the solubility of any PCBs adsorbed on surfaces in the storage. Still, the concentrations in the third campaign were even higher than before.

The clear trend of rising concentrations inside the storage indicates that the actual cleaning should be the cause to the increased levels. Even though the measurements were performed at different seasons the mean air temperature during the sampling periods only differed 8°C. The analyses of the two core samples showed that PCBs had penetrated appr. 30 mm into the concrete floor. The results from the core samples are presented in table 2.

Table 2: PCB concentrations in the core samples from the PCB-storage (mg/kg). The slices are measured from the top, cf. Fig 2.

	Core 1			**Core 2**	
	0-15 mm	15-30 mm	30-45 mm	0-15 mm	15-30 mm
PCB#28	<0.05	<0.05	<0.05	0.22	<0.05
PCB#52	<0.05	<0.05	<0.05	0.13	<0.05
PCB#101	0.13	0.055	<0.05	0.097	<0.05
PCB#118	0.12	0.051	<0.05	0.1	<0.05
PCB#138	0.33	0.17	<0.05	0.18	<0.05
PCB#153	0.32	0.15	<0.05	0.19	<0.05
PCB#180	0.15	0.074	<0.05	0.11	<0.05
Total PCB	**3.9**	**1.9**	**n.d.**	**5.4**	**n.d.**

Pizzaro et al[5] tested several cleaning methods for PCB-contaminated concrete, but none of the methods tested gave a long term effect. After some time, which was dependent on the method used, the concentration on the concrete surface was as high as before the cleaning. In this study the concentrations in air above the concrete surface even increased after cleaning. Since the cleaning was performed with high pressure washing, it is plausible that a thin layer of the concrete surface was removed during the washing. This revealed a new surface with new open pores, from which the PCB could evaporate. The second washing was even more intensive and consequently the emissions increased further.

Due to the low activity in the storage during the last years it is possible that the PCBs in the first few µm of the concrete surface already had evaporated so that this thin layer in reality made up a resistance for the transport of PCBs into the air. When the layer was removed or decreased during the washing, the transport resistance decreased and the evaporation increased. To verify this a much finer cutting of the core samples is required or an adequate numerical model for the diffusion and evaporation should be developed.

The relative concentrations (fingerprints) from the measurements show a larger fraction of PCB#28 in campaign two and three (cf. table 1). PCB#28 is a tri-chlorinated congener and a large fraction of this relatively light molecule in the air indicate that the evaporation process is in an early stage. It can further be seen that the fingerprints from the storage and from the reference point differ. The reference point has a larger fraction of hexa and hepta chlorinated congeners compared to the storage. Probably the fingerprint at the reference point reflects the background composition in the region and the fingerprint inside the storage the composition of the handled material.

Already two core samples show that the penetration depth in the floor is varying. In a report from a remediation at a Canadian military base PCB was found 50 – 100 mm down in the concrete at one location, but at another location at the same facility, PCB was found 750 mm below the surface offloor.[6] Also Pizzaro et al reported varying penetration depths.[5] For SAKAB this information indicate that more sampling of the floor is needed before any decisions about removing the concrete floor can be taken. Though the concentrations inside the storage are elevated compared to background, all the values are below the Swedish threshold limit value for working environment.[7]

Acknowledgements
The analyses work for the concrete samples by AnalyCen and for the air samples by Al-Contol is acknowledged.

References

[1] *Ullmans Encyclopedia of Industrial Chemistry*: Wiley-VCH Verlag GmbH & Co., 2001.
[2] Bernes C. *Persistent Organic Pollutants, a Swedish View of an International Problem* Monitor Vol. 16: Swedish EPA Stockholm 1998.
[3] Swedish Ministry of the environment SFS 1985:837, 1985.
[4] Lee W.-J., Lewis S. J. L., Chen Y.-Y., Wang Y.-F., Sheu H.-L., Su C.-C., Fan Y.-C. *Atmos. Environ.* 1996; 30:2371.
[5] Pizarro G. E. L., Dzombak D. A., Smith J. R. *Environmental Progress* 2002; 21:47.
[6] Poland J. S., Mitchell S., Rutter A. *Cold Regions Science and Technology* 2001; 32:93.
[7] Arbetsmiljöverket AFS 2005:17, 2005.