

STRATEGIES USED IN THE SWEDISH DIOXIN SURVEY

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Introduction

The purpose of the Swedish dioxin survey was to determine sources, environmental concentrations and human intake of polychlorinated dibenzo-*p*-dioxins and furans (de Wit *et al.*, 1989; de Wit and Strandell, 1999). The survey also included analyses of several coplanar PCBs and polychlorinated naphthalenes in some samples. The survey took place from 1988 to 1993 and results from each year were used to design sampling for the next year.

Source-related samples

A major aim of the dioxin survey was to identify sources of PCDDs/PCDFs and if possible quantify their releases to the environment. Previous studies had indicated that municipal waste incinerators were a major source of PCDDs/PCDFs so these were not included in the survey as legislation was already in place to limit emissions of PCDDs/PCDFs from smoke-stack gases.

Source-related samples were chosen according to several different strategies. In some cases industries already known to emit PCDDs/PCDFs were studied further. In other cases, industries not studied previously were screened using samples from one or two individual plants. The industries with high concentrations were investigated further by taking samples from several more plants. Numerous other source-related samples were taken when other samples (sediment, biota, water) indicated the presence of PCDD/PCDF sources.

The second strategy for source-related sampling was to screen various types of industries that use processes or chemicals that were suspected of producing PCDDs/PCDFs. The industries in this screening included metallurgical industries, rubber production, pharmaceuticals production, cement and lime production, textile industry, dry cleaners and oil refineries. The results of the screening were used to plan sampling of more plants within the same type of industry.

Responsible administrators for different industry sectors at the Swedish Environmental Protection Agency (NV) helped to identify plants that could be of interest and the types of samples that would be most likely to contain PCDDs/PCDFs. In many cases, NV also contacted the local environmental authorities and the industry to facilitate sample collection. Local environmental authorities also helped identify local industries within their counties or cities that might be PCDD/PCDF sources.

A third strategy was to investigate industries where environmental samples such as fish or sediment indicated that a source of PCDDs/PCDFs could be present. In cases where samples were

taken during industrial processes, as much data as possible about the process at the sampling time point was collected.

Water

Leach water samples were taken from the drainage systems at several waste dumps, including waste dumps containing industrial solid wastes. Effluent water was collected from a number of different processes including pulp and paper manufacture, textile production, steel production and dry cleaning. Water streams into a sewage treatment plant in Stockholm were sampled in an attempt to identify and quantify PCDDs/PCDFs in sewage sludge. Different steps in the purification of drinking water with sodium hypochlorite at a water treatment plant in Gothenburg were also studied to determine if PCDDs/PCDFs could be created by this process.

Solid wastes

Sludge, dust, filter powder, ashes and slag are solid wastes produced by many industries. Samples of sludge were taken from sedimentation lagoons or other types of collection containers. In a few cases, sludge samples were collected from known deposition sites. Dust and filter powder samples were usually taken from bags or containers where they were collected. Slag was collected from smelter ovens. Distillation residue samples from dry cleaners were collected from the distillation waste collection tank connected to the fluid recycling system. Ashes from an illegal wire reclamation dump were collected directly from the surface of the ash pile.

Smoke-stack gases

Most smoke-stack gases were sampled according to Swedish Environmental Protection Agency (NV) guidelines (Jansson and Bergvall, 1987). Consultants specialized in taking such samples were used.

Products

Products of varying types were obtained from industries via contacts with NV administrators, local environmental authorities or by direct contacts with the industry in question. These included various paper pulps, plastic matting, chlorinated paraffins used in plastic matting, dishwasher machine soap, laundry soap, chlorine bleach, ethylene dichloride tar from PVC manufacture, PVC, chlorinated flocculation agents and asphalt.

Air sampling

To study long-range transport, high-volume air samples were collected from a weather station at the southern tip of the island of Gotland in the Baltic Sea Proper. A second air sampling station was set up temporarily in the northern part of Sweden.

Environmental samples

Biota

Previous studies have shown that chemical concentrations of organochlorines, such as PCBs and DDT in living organisms (Olsson *et al.*, 1978 ; Olsson and Reutergårdh, 1986 ; Bignert *et al.*, 1993 ; Bignert *et al.*, 1994) are affected by many different variables including age, size, sex, reproductive stage, time of year for collection, health status, geographic location and degree of biomagnification with each trophic level in the food web. Sampling of biota was therefore designed to establish if these factors also play a role in concentrations of PCDDs/PCDFs. Sampling also included testing tissue types.

In collaboration with the Swedish Museum of Natural History, well-described, representative samples were selected for analysis. In some cases, such as for the time-trend analyses, archived samples were obtained from the Environmental Specimen Bank at the Museum. In other cases, extra material was collected in connection with the current Swedish Environmental Monitoring Program. Sampling sites were chosen to represent background areas with no direct pollution sources.

Sediments

Deep core sediment samples were collected to study time-trends from both diffuse deposition and from nearby point sources. In addition, surficial sediment samples were collected to study diffuse and local sources. Surficial sediments were also collected from background areas to study long-range transport and air deposition. Some sediment samples were taken at the same sites as pike samples to be able to study possible relationships in congener patterns and concentrations between sediment and pike. Most surficial sediment samples were collected by the same person to ensure less variability caused by different sampling methods.

Soil

Soil samples were taken in the vicinity of two plastic waste fires. One accidental fire occurred at an industry dump for plastic matting waste at Tarkett AB, in Ronneby in 1990. Tarkett AB utilized chlorinated paraffins as plasticizers. Soil samples were taken at different distances and from different wind directions around the dump and the industry buildings. A reference sample was taken 12 kilometers north of the industry site.

In the second case, soil samples were taken around a dump for industrial waste near Valdemarsvik in 1990, where PVC plastic materials caught on fire and burned for 10 days. The wind blew from the same direction most of the time and smoke followed a valley close to the ground. Samples were taken at different distances and from different wind directions from the fire and included a reference sample 10 km northwest of the dump.

Food sampling

Previous to the survey, only a very few analyses of foodstuffs were available making it very difficult to estimate the dietary intake of PCDDs/PCDFs for humans. In collaboration with the

National Food Administration, food samples were chosen and prepared to cover the major suspected sources of PCDDs/PCDFs in the Swedish diet. These included dairy products, meat (beef, pork, lamb), chicken, eggs, fish (among others herring, salmon, plaice, mackerel, trout, whitefish, Arctic char). Results from the biological program were used for moose, reindeer, burbot liver and several fish species. The results were combined with information on average per capita intakes for various foodstuffs in order to calculate the average intake of PCDDs/PCDFs and coplanar PCBs in Sweden.

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