

# MONITORING OF POLYCHLORINATED BIPHENYLS (PCBs) IN SEDIMENT FROM A DAM IN NORTHERN PRETORIA, SOUTH AFRICA

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**Abstract** - Polychlorinated biphenyls (PCBs) are a class of toxic persistent organic pollutants (POPs) in the environment. The objective of this study was to analyse 6 indicator PCBs (28, 52, 101, 138, 153 and 180) in sediment samples from a selected dam and compare the results to environmental guidelines. Samples were taken once monthly from September 2015 to August 2016. The samples were extracted and cleaned up with a silica gel column before analysis by GC-MS. 4 of the 6 PCBs- 28, 52, 101 and 138- were detected in sediment samples from April-August.  $\Sigma$  PCBs concentrations of 17.40-18.50  $\mu\text{g}/\text{kg}$  found for samples taken from May-July is slightly higher than 50 % of the guideline limit of 34.1  $\mu\text{g}/\text{kg}$  for total PCBs for sediment in a freshwater ecosystem. This poses a potential risk to humans who consume fish from the dam. Continual monitoring of these pollutants is necessary for risk assessing the environmental health of this water body.

**Keywords** - Environmental monitoring, PCBs, sediment, GC-MS, guideline limits.

## I. INTRODUCTION

Polychlorinated biphenyls (PCBs) are one of several classes of chemicals which are regarded as persistent organic pollutants (POPs) in the environmental. These chemicals have long half-lives in sediment, air, soil, and biota and are characterized by being highly halogenated, having low water solubility and high lipid solubility [1]. These pollutants are also semi-volatile [2] thus allowing them to be transported in the atmosphere for long distances before they are deposited. These characteristics; persistence, bioaccumulation, toxicity, and long-range environmental transport distinguish POPs from many other organic pollutants [3]. Due their lipophilicity, POPs can accumulate in the fatty tissues of organisms. This bioaccumulation poses a health risk to both humans and animals; several POPs have been reported to be hormone disrupters which can alter the normal functioning of the endocrine and reproductive systems in humans and wildlife [4]. Measures have been taken to attempt to eliminate these pollutants globally, the most significant of these being the Stockholm Convention ratified internationally in 2001 with a mandate to phase out the production and use of 12 kinds of POPs (the so-called "dirty dozen") including PCBs. There is no history of PCB production in South Africa. However, the predominant electrical power producer Eskom [5] still utilizes PCB-containing dielectric fluids in equipment such as transformers and capacitors for insulation and thermal cooling [5].

Sediment and water are regarded as major environmental sinks for POPs through which these pollutants enter the food chain wherein humans and wildlife are exposed mainly via feeding on aquatic foodstuff such as fish and drinking contaminated water [6]. The monitoring of POPs in water bodies is

therefore of considerable importance. The Bon Accord dam is an earth filled dam located in the Onderstepoort area in the northern part of Pretoria, South Africa. It has a catchment area of about 315  $\text{km}^2$  and was constructed in 1923 mainly for the irrigation of neighbouring farms. It is currently also used for activities such as fishing and speed-boating. This study was aimed at monitoring contamination levels of PCBs in this selected dam.

## II. EXPERIMENTAL DETAILS

### 2.1. Sampling and sample preparation

A stainless steel grab sampler was used to collect samples by digging sediment from three points in the dam about 10 m from the banks. The GPS coordinates of the three points are A (25.624686°S, 28.193326°E), B (25.624045°S, 28.193821°E), and C (25.627560°S, 28.194041°E). Samples were taken once monthly during the period September 2015 to August 2016. 10-g sediment samples were Soxhlet extracted with 200 mL of a 1:1 acetone/hexane mixture using a procedure similar to that described in the EPA Method 1668C [7]. For clean-up the extract, concentrated to 1 mL under a stream of nitrogen gas, was introduced to a silica gel column and eluted with 25 mL hexane; the eluent was then concentrated to a final volume of 0.1 mL in a test tube.

### 2.2. GC-MS analysis and method validation

Extracts were analysed for PCBs with a GC-quadrupole MS (GCMS-QP 2010 SE, Shimadzu) using a US EPA recommended DB-1 column [7] (EPA, 2010). An isotopically labelled PCB- MBP 52 (2, 2', 5, 5'-Tetrachloro[13C12]biphenyl, Wellington Laboratories)- was added to the calibration standard (a mix of 6 indicator PCBs- 28, 52, 101, 138, 153, 180- at 10  $\text{ng}/\mu\text{L}$  each, Sigma-Aldrich) and samples

as internal standard before analysis. Experimental parameters used for analysis were as follows. GC: 270 °C splitless injection, 1 µL injection volume, 75-150-270 °C temperature programme, helium baseline 5.0, 40 cm/sec average velocity, 2 mL/min constant column flow, 128.7 kPa column pressure, 75 °C oven. MS: 290 °C interface, 180 °C ion source, 2.5 min solvent delay. The method was validated by analysing a certified reference material for the 6 indicator PCBs in sediment- CRM SQC072-50G, Sigma-Aldrich- and comparing the results to the acceptance limits for their recoveries.

### III. RESULTS AND DISCUSSION

#### 3.1. Method validation

Table 1 shows the concentration of PCBs determined from analysis of the CRM (expressed as µg/kg dry weight) and their respective acceptance limits; all the values lie within the acceptance limits, validating the method used in this study.

#### 3.2. PCBs in sediment samples

No PCBs were detected in any of the water samples collected at the same time as sediments (data not shown here), and no PCBs were detected in the sediment samples from September-March. 4 of the 6

analysed indicator PCBs-28, 52, 101 and 138- were detected in some sediment samples, as shown in Table 2. Each value represents the mean for 3 samples, with each sample analysed in triplicate. PCB 28 was detected from April to August 2016 ranging from 1.67-6.74 µg/kg. PCB 52 was detected in July at 2.15. PCBs 101 and 138 were detected from April-July at 5.88-6.27 and 2.59-5.77 µg/kg, respectively.

**Table 1: Determined PCBs for the CRM**

PCB Concentration (µg/kg)	Determined limits* (µg/kg)	Acceptance
28	393.04	133-474
52	77.46	52.2-138
101	239.71	207-454
138	50.88	21.2-75.9
153	69.24	38.8-139
180	229.91	134-478

\*Acceptance limits based on US EPA Inter-laboratory Study Results (Sigma-Aldrich Certificate of Analysis, 2014)

**Table 2: Levels of PCBs in sediment from the Bon Accord dam.**

Month	Concentration of PCB±SD (n= 3) (µg/kg)						
	28	52	101	138	153	180	Σ
PCBs							
Sep 2015- Mar 2016	nd	nd	nd	nd	nd	nd	nd
Apr 16.83	4.95±0.91	nd	6.27±0.46	5.61±0.97	nd	nd	
May 17.92	6.74±0.63	nd	5.94±0.99	5.25±0.68	nd	nd	
Jun 18.50	6.71±0.16	nd	6.02±0.74	5.77±0.29	nd	nd	
Jul 17.40	6.76±0.32	2.17±0.34	5.88±0.43	2.59±0.07	nd	nd	
Aug 2016	1.67±0.25	nd	nd	nd	nd	nd	1.67

nd: not detected

The Σ PCBs concentration of 17.40-18.50 µg/kg found for samples taken from May-July is slightly higher than 50 % of the guideline limit of 34.1 µg/kg for total PCBs for sediment in a freshwater ecosystem [8]. Although this appears to pose a potential risk to humans who eat fish from this dam,

the levels are much lower than those reported for studies in countries where, unlike South Africa, PCB

containing chemicals were manufactured prior to the global banning of these POPs (as seen in Table 3).

**Table 3: Comparison to other studies.**

Country	Σ PCBs (µg/kg)	Reference
South Africa	nd-18.50	This study
Tunisia	0.8-14.6	[9]
USA	4.18-4601	[10]
Italy	1-899	[11]
UK	36-1409	[12]

## CONCLUSION

PCBs have been detected in sediment from the Bon Accord dam at levels slightly higher than the recommended guideline limit of 34.1 µg/kg. This poses a concern regarding the sediment quality and by extension the environmental health of this ecosystem. Further monitoring of more congeners is required to obtain a fuller profile of PCBs in the dam. It can be concluded that this dam is moderately polluted with PCBs.

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