PERSISTENT ORGANIC POLLUTANTS (POPs) CONTAMINATED SITES IN GHANA: SCREENING AND DETERMINATION OF LEVELS OF POLYCHLORINATED BIPHENYLS (PCBs) IN SELECTED POSSIBLE PCB-CONTAINING EQUIPMENT AND ENVIRONMENTAL SAMPLES

Adu-Kumi, S[1]; Ephraim, J. H.[2]; Asamoah, K. A.[2]
[1]Environmental Protection Agency, P. O. Box MB 326, Accra, Ghana; [2]Kwame Nkrumah University of Science and Technology, Department of Chemistry, Kumasi, Ghana.

Introduction

The Stockholm Convention on Persistent Organic Pollutants (POPs)[1] encourages countries which are Parties to the Convention to develop appropriate strategies for identifying sites contaminated by twelve chemicals currently listed in its Annexes, namely: aldrin, chlordane, dichlorodiphenyltrichloroethane (DDT), dieldrin, dioxins, endrin, furans, hexachlorobenzene (HCB), heptachlor, mirex, polychlorinated biphenyls (PCBs) and toxaphene. In Ghana there is inadequate institutional and regulatory framework for the management of contaminated sites.[2] Some of the difficulties in the development of suitable legislation include: inadequate capacity to draft and promulgate such legislation; fragmented nature of responsibility for the sound management of chemicals and contaminated sites; inadequate data and information that normally underpins such legislation; and high cost of such an undertaking. Currently there is inadequate capacity to identify contaminated sites and inadequate technical expertise to conduct laboratory analysis of POPs contaminated samples. The general nature of contaminated sites of concern includes such areas as the workplace, surface water and air where victims of exposure are unaware of the presence and the consequent harmful effects of POPs. Priority areas of concern include the following: the immediate surroundings of transformers installed before 1972; municipal waste dumps countrywide; open water discharges in the main industrial cities and towns, pesticides contaminated sites such as areas where pesticides containers were buried in the past or areas around former organochlorine formulation plants and irrigation sites. In this paper we report the results of screening of PCBs in selected possible PCB-containing equipment (mainly transformers) countrywide using the Clor-N-Oil 50 PCB Screening test kit. GC-μECD was employed to analyse twenty-two (22) transformer oils and environmental samples (soils and leaves) in the vicinity of these selected transformers which belong to the Electricity Company of Ghana (ECG), in Kumasi, Ghana[3], for PCBs as Aroclors 1260, 1248, 1221 and Congeners 118, 138 and 180.

Materials and Method

One thousand and forty-five (1045) units of possible PCB containing equipment were selected throughout Ghana. The country was grouped into 12 zones in line with the 10 geographical regions, for the purposes of the inventory. Samples were collected in specially designed tubes and stored in appropriate containers, bearing in mind the potential for possible contamination. Sampling was categorized as pre 1972, 1972 to 1985 and post 1985 (see table 1). Each category was based on the status of equipment (i.e. in use or out of use). The Clor-N-Oil 50 PCB Screening test kit was used for the analysis. The test kit works on the principle of chlorine determination. Since PCBs are chlorine-based materials, the test kit is able to detect them. However, the test cannot distinguish between any other chlorine-containing compounds such as trichlorobenzene which may also be found in transformer oil. These compounds may cause a result known as a "false positive", i.e. the oil will indicate the presence of over 50 ppm PCBs, but when analyzed by gas chromatography will show a value less than 50 ppm. The test also works on the principle of chloride detection. Therefore, contamination by salt (sodium chloride), sea water, perspiration, etc, will give a false positive result and further testing in a laboratory (e.g. gas chromatography) will be necessary.

Twenty-two (22) transformer oil samples analyzed for PCBs as Aroclors 1260, 1248, 1221 and Congeners 118, 138 and 180. Out of the 22 transformer oil samples, 20 were from functional 2^{o} transformers in operation at time of sampling. The two other samples were from a Transformer Maintenance Workshop. Selected transformers whose oils

were analyzed were manufactured between 1961 and 1977.

Representative soil, plantain leaf and transformer oils were collected from 23 selected sites in Kumasi. Soil samples were taken within a depth of about 15cm from the soil surface and within a radius of 10m around transformers (for transformer site samples) whilst the Maintenance Workshop sediment/soil samples were collected at about, 2cm depth. Samples were air dried for three weeks, ground, sieved to 2mm mesh size, bagged in labeled polyethylene bags and stored at room temperature until extraction. Similarly, plantain leaf samples were also taken within a 2.4m height range and within a radius of 10m around transformers (for transformer site samples) and Case Farm representative samples taken between 42m and 60m distances from the ECG transformer maintenance workshop. Leaf samples were air dried for three weeks, ground to almost powder, bagged in polyethylene bags and stored at room temperature until extraction. Agilent Technologies 6890N series GC-μECD equipped with a 7683 series Automatic Liquid Sampler and operated with the Chemstation version N.1 was used for the PCB analyses. The extraction, purification and analysis methods are described elsewhere.[3,4,5,6,7]

Results and Discussion

Screening Results and Classification of PCBs

Out of a total of 1045 possible PCB-containing equipment (mainly transformers) sampled and screened 14.74% of equipment tested positive with the PCB screening kit. That means such equipment contain PCBs greater than 50ppm. The majority of the equipment sampled that tested positive, as expected, were transformers manufactured before 1972 (5.36%) (see Table 1). 2.11% tested equipment contained pure PCB oil. The quantity of PCB contaminated equipment is not however decreasing after 1984 as expected. This is probably due to cross contamination through filtration process of mineral oil and topping up with PCB-contaminated mineral oil.

Aroclors (1260, 1248 and 1221) and PCB congeners (118, 138 and 180) in Transformer Oils

PCBs were detected in the transformer oils. The median Aroclor 1260 concentration in the 23 transformer oils for a range of $<0.2816 \mu g g^{-1}$ to 516.443 $\mu g g^{-1}$, was $<0.2816 \mu g g^{-1}$. The levels of Aroclors 1248 and 1221 in the transformer oils were below the Method Detection Limits of 0.1650ppm and 0.2520ppm respectively. PCB congener 180 in transformer oil samples had a range of $<0.2887 \mu g g^{-1}$ to 528.4401 $\mu g g^{-1}$ and a median value of $<0.2887 \mu g g^{-1}$. PCB 118 and PCB 138 had ranges of $<0.2923 \mu g g^{-1}$ to $465.9035 \mu g g^{-1}$ and $<0.2915 \mu g g^{-1}$ to $567.0558 \mu g g^{-1}$ respectively.

Aroclors 1260, 1248 and 1221 in Soils from Transformer Sites

Aroclors 1260, 1248 and 1221 were not detected in any of the soils from the sites of the 20 transformers which were in use and from the Transformer Maintenance Workshop at Adum. This is largely due to the insensitivity of available analytical instrument. The peaks of the soil samples did not tally with any of those of the standards of the above Aroclors. Their concentration levels were recorded as, below Method Detection Limit (MDL). For example the level of Aroclor 1260 in Roman Catholic Girls- soil sample was: $<0.2816 \mu g g^{-1}$, where $0.2816 \mu g g^{-1}$ is the MDL of Aroclor 1260.

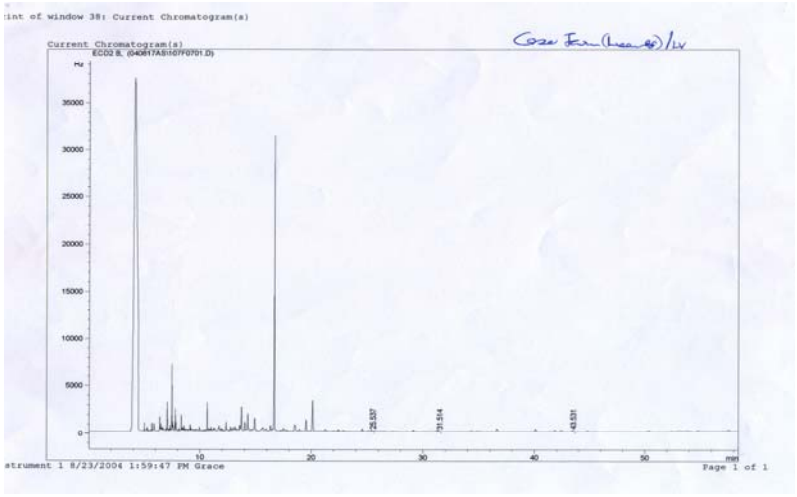
PCB Congeners 118, 138 and 180 in Soils from Transformer Sites

No detectable levels were registered at Method Detection Limits (MDLs) of $0.2923 \mu g g^{-1}$ for PCB118; $0.2915 \mu g g^{-1}$ for PCB138; and $0.2887 \mu g g^{-1}$ for PCB180, again largely due to the insensitivity of available analytical instrument.

PCBs as Congeners and Aroclors in Leaf and Soil Samples from the Case Study and Control Farms

No PCBs as Aroclors or Congeners were detected in leaf and soil samples analysed, for the detection limit of the method used (see table 2 below). See Figure 1 (Chromatogram of a Leaf Sample from the Case Study Farm)

Figure 1: Chromatogram of a Leaf Sample from the Case Study Farm



Conclusion

A number of sites have been identified as potential contaminated sites in Ghana. Priority areas of concern include the immediate surroundings of transformers particularly those installed before 1972 and many of these are located in sensitive areas which pose potential threats to human health and the environment. Lack of analytical capacity among others is however hampering serious analytical work in the country. The sensitivity of analytical techniques available is depicted in the analysis of samples outlined in the case studies presented in the current paper.

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Table 1: Result of PCB Classification and Period of Manufacture

PCB Classification	Period of Manufacture	PCB Test	Total PCB Test	% Total
Mineral Oil	< 1972	< 50 ppm	268	25.65%
	> 1984	< 50 ppm	359	34.35%
	1972-1984	< 50 ppm	163	15.60%
	Unknown	< 50 ppm	99	9.47%
PCB Contaminated Mineral Oil	< 1972	> 50 ppm	49	4.69%
	> 1984	> 50 ppm	42	4.02%
	1972-1984	> 50 ppm	30	2.87%
	Unknown	> 50 ppm	11	1.05%
PCB oil	< 1972	> 50 ppm	7	0.67%
	> 1984	> 50 ppm	8	0.77%
	1972-1984	> 50 ppm	4	0.38%
	Unknown	> 50 ppm	3	0.29%
Unknown	< 1972	< 50 ppm	1	0.10%
	> 1984	< 50 ppm	1	0.10%

Table 2: Concentration Levels of PCBs as Aroclors and Congeners (118, 138, and 180) in Plantain Leaves within 10m Radius of a Selected Transformer (Roman Catholic Girls I/D), Case Farm and Control Farm

Sample Matrix	Transformer Site	Aroclor 1260/ μgg^{-1} x 10^{-2}	Aroclor 1248/ μgg^{-1} x 10^{-2}	Aroclor 1221/ μgg^{-1} x 10^{-2}	PCB 118/ μgg^{-1} x 10^{-2}	PCB 138/ μgg^{-1} x 10^{-2}	PCB 180/ μgg^{-1} x 10^{-2}
Leaves	Roman Catholic Girls I/D	<28.16[a]	<16.50[b]	<25.20[c]	<29.23[d]	<29.15[e]	<28.87[f]
Leaves	Case Farm	<28.16[a]	<16.50[b]	<25.20[c]	<29.23[d]	<29.15[e]	<28.87[f]
Leaves	Control Farm	<28.16[a]	<16.50[b]	<25.20[c]	<29.23[d]	<29.15[e]	<28.87[f]

[a,b,c,d,e,f]The Method of Detection Limits (MDL) for Aroclor 1260, Aroclor 1248, Aroclor 1221, PCB 118, PCB 138, and PCB 180 are 0.2816 μgg^{-1} , 0.1650 μgg^{-1}, 0.2520 μgg^{-1}, 0.2923 μgg^{-1}, 0.2915 μgg^{-1}, and 0.2887 μgg^{-1} respectively.