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Original Research Article

Extraction of Polychlorinated Biphenyls (PCB's) in Soil, Maize and Water Due to Disposal of Pharmaceuticals in Dumpsite within Lagos and Environ Using Gas Chromatography and Mass Spectromtry (GCMS): A Global Concern

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Abstract

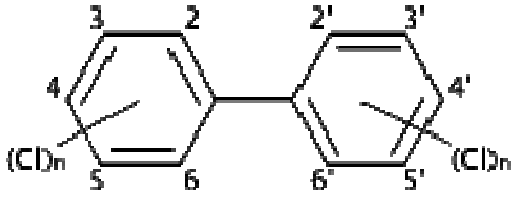
The Levels, distributions of mean concentrations of (PCB'S) classified under persistent organic pollutants POP in soil, Maize and water samples was determined using Gas Chromatography and Mass Spectrometer (GC-MS). A range of 27 PCB congeners with low, medium and high concentration were widely distributed and detected in all the analysed samples. The results obtained showed wide distribution of PCB's with high concentration at the control sites than dump site, which made control site more sup citable and exposure to chemical hazard. This however may lead to negative impact in the environment most especially schools, communities and farmland as the results are above their threshold values found in the literatures. The PCB 8 in water sample at Epe control site (13.15 ± 12.271) PCB 44 in water control site at Olusosun (0.012 ± 0.016) were considered to be high in all the sites.

Keyword: Dumpsites, Control site, Pollutant, wet and dry season

INTRODUCTION

Polychlorinated biphenyls (PCBs) is an organic chlorine compound with the formula $C_{12}H_{10-x}Cl_x$ which entered the environment through both use and disposal of solid pharmaceuticals waste among others. They belong to a family of chemicals formed by attaching one or more chlorine atoms to a pair of connected benzene rings, meaning it is a kind of organo halogenated contaminants (OCs) consisting of a total of 209 congeners composed by molecules with 1–10 chlorine atoms attached to the two rings of biphenyl (Erickson and Kaley, 2011; IARC, 2017) which can be formed with varying toxicological and chemical properties, this occur during their manufacture and use in industries.

Chemical structure of PCBs from IARC, 2016



Formula: $C_{12}H_{10-x}Cl_x$
Molar Weight: 326.4g/mol

Table 1. The TEFj for each dioxin-like PCB were those defined by the World

Dioxin-Like PCB	TEF's
PCB77	0.0001
PCB81	0.0003
PCB 105	0.00003
PCB114	0.00003
PCB 118	0.00003
PCB 123	0.00003
PCB126	0.1
PCB156	0.00003
PCB 157	0.00003
PCB 167	0.00003
PCB 169	0.3
PCB 189	0.00003

Health Organisation (WHO) in 2005

There are some of the organic hydrocarbons deposited during disposal of some unwanted pharmaceutical that decomposed into chemical compounds found in the soil (Donohue and Curtis 1996, Faulk et al, 1999). These organic compounds are considered pharmaceutical pollutants, they are persistent, bio accumulative and toxic contaminants in the environment and are stored in adipose tissues where liver is the primary site of metabolism (Alicia Cunningham, 2004). PCBs enter the body either by inhalation of air containing polychlorinated biphenyls, ingestion of contaminated food or water, or by dermal contact with polychlorinated biphenyls products. Disposal of products containing PCBs or application of contaminated sewage sludge to soils may also release them to the environment. A total of 12 PCBs congeners were defined as dioxin-like PCBs by the World Health Organization (WHO) in 2005, they were one of the first compounds listed as POPs in the Stockholm Convention on May 22, 2001, their environmental fate is complex and global in scale. Like many lipophilic toxins, PCBs bio magnify up the food chain e.g ducks can accumulate PCBs from eating fish and other aquatic life from contaminated rivers, and these can cause harm to human health or even death when eaten. The most commonly observed health effects in people exposed to extremely high levels of PCBs are skin conditions, such as chlorine and rashes, but these were known to be symptoms of acute systemic poisoning dating back to 1922. Studies in workers exposed to PCBs have shown changes in blood and urine that may indicate liver damage. In Japan in 1968, 280 kg of PCB-contaminated rice bran oil was used as chicken feed, resulting in a mass poisoning, known as Yushō disease, In 2013, the International Agency for Research on Cancer (IARC) classified dioxin-like PCBs as human carcinogens. Because of their longevity, PCBs are still widely in use, even though their manufacture has declined drastically since the 1960s, when a host of problems were identified. Because of PCBs' environmental toxicity and classification as persistent organic pollutants, PCB production was banned by United States federal law in 1978 and by the Stockholm Convention on Persistent Organic Pollutants in 2001. People living near incinerators, other PCB-disposal facilities, or PCB hazardous waste sites are at risk as they persist in the environment for significant periods of time. It is therefore possible that the presence of PCBs in the environment poses a long-term threat to wildlife on both a local and global scale. Some PCBs share a structural similarity and toxic mode of action with dioxins. The maximum allowable contaminant level in drinking water in the United States is set at zero, but because of the limitations of water treatment technologies, a level of 0.5 parts per billion is the de facto level.In environmental samples, PCB is calculated by multiplying the concentration of each individual dioxin-like PCB present in the sample (PCBj) by the respective TEFj (Drimal et al., 2016): TCDDeq= $\sum$ (Table 1)

PCB mixtures are resistant to acids, bases, oxidation, hydrolysis, and temperature change are found as colorless oily liquids or waxy solids. They are chemically very stable and unreactive, non-flammable and resistant to heat and "hydrophobic", so do not mix well with water. They do however dissolve readily in organic (carbon-containing) solvents. They can generate extremely toxic dibenzodioxins and dibenzofurans through partial oxidation. PCBs readily penetrate skin, PVC (polyvinyl chloride), and latex (natural rubber). Once PCBs are emitted at the atmosphere, they can reach into different media (water and sediments, vegetation, etc) being the soils an important reservoir (Ren et al., 2007). The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) allow a daily PCB intake of 6 µg/kg per day (AAP 2003). Table 2

Extraction using Ultrasonic bath for soil, maize and liquid-liquid extraction for water to determine PCB was implored within 0-20 cm depth at Abule-Egba, Epe,

Table 2. Standards, regulations, and recommendations for PCBs (AAP, 2003)

Agency	Focus	Level	Comments
OSHA	Air: workplace	1.0 mg/m^3 for PCBs with 42% Cl 0.5 mg/m^3 for PCBs with 54% Cl	Enforceable; TWA*, PEL[a] Both standards encompass all physical forms of aerosols, vapor, mist, sprays, and PCB-laden dust particles.
NIOSH	Air: workplace	1.0 µg/m^3	Advisory; TWA (10-hour)
EPA	Drinking water: environment	0.0005 ppm	Enforceable MCL[b]
FDA	Food: environment	0.2-3.0 ppm (all foods) 2.0 ppm (fish) 10 ppm (paper food-packaging materials)	Enforceable; Tolerance level
WHO FAO	Food: environment	6.0 µg/kg per day	Allowable daily intake

Olusosun, and Shagamu dumpsite and control sites. The mean concentrations of PCB in wet and dry season are presented in the results.

MATERIALS AND METHODS

Apparatus/Instrument

Rotary Evaporator, Separating funnels, Beakers (100cm^3), measuring cylinder (10cm^3),conical flask, vials, round bottom flask, burette (100cm^3), pipette, clamps, Spatula, Sensitive Weighing balance (capable of accurate weighing to 0.01 g.) ,Soil particles, water samples, Grinding Tools, Ultrasonic bath, Gas Chromatography Agilent 7890 A GC- µECD GC-MS, What man Filter paper (No.41).

Chemical / Reagents

Dichloromethane (DCM), Acetone by Agilent Technologies, authorised distributors in Nigeria, Hexane supplied by Synapse Technologies, Sodium Sulphate ($NaSO_4$) by Katchey Company limited, Distilled water by NAFDAC Laboratory, Chloroform/Ethyl Ether, Methylene, Helium Gas for GC-MS by Sigma-Aldrich (Agilent Technology)

Methods

Soil and maize extraction

The method EPA-3510C was adopted with some modifications. All extraction techniques used was validated by spiking (Wells, 1994). Extractions generally rely on favourable partition of PCBs from the sample into the extraction matrix. Repeated extractions yielded efficient results with the following steps:

A 20 g by weight of each soil sample was taken into a beaker. A 100ml of Acetone solvent was added to each sample. A 100ml of 30% Dichloromethane (DCM) was added to the sample in ratio was 1:1. A 5g of $NaSO_4$ was added to all the samples to remove any possible water in the soil in case some samples may contain water. A 30ml of DCM and Acetone was added to the samples to aid complex extraction. Samples were then arranged in Ultrasonic bath for 30minutes for extraction to take place using EPA Method 3550B (NOTE: The sound under the ultrasonic bath assist on the extraction process instead of shaking the samples in the beakers).The temperature of the Ultrasonic bath was maintained between 40^0 C-60^0 C for 30 minutes. The samples were filtered into a round bottom flask and 20-30g of $NaSO_4$ was added to remove water. Samples were dried by reducing large volume of solvent to 2ml using Rotary evaporator. A solvent switch was carried out by adding 2-5 ml hexane to aid instrument identification of the compounds. Extract was transferred into 2ml vial and stored in a refrigerator ready for GC-MS analysis.

Water (liquid-liquid extraction)

This procedure was adopted using US.EPA 3510C 1991 method. A seperatory funnel was used for liquid-liquid extraction to determine level of Persistent Organic Pollutants POP's in the samples such as Poly aromatic hydrocarbons PAH's and Polychlorinated biphenyls PCB's by the use of GC-MS instrument. The following steps were used:

A 100ml water + 50ml Dichloromethane in a separating funnel was added and shaken vigorously while expelling air at intervals by opening the ark so that it will not build in pressure and cause explosion. Ratio 1:1 was considered (for efficiency, start with 50ml water and 50ml DCM, and later added 50ml water/DCM). Sample

was allowed to settle. A 50ml of 30 % DCM was added to the same separating funnel to make up 100ml of DCM, which equate to ratio 1:1.Sample was vigorously shaken to expel air at interval to enable proper separation process to take place. The aqueous solution was allowed to settle on the clamp and opening the cap to enable the force of gravity to bring proper separation into aqueous and organic layers. A 20-30g of $NaSO_4$ was added in a filter paper in a round bottom flask and discards the solvent through the filter paper while trapping any possible water through the use of sodium sulphate. A Rotary evaporator was used to dry large volume of the sample to 2-3ml of the sample extract and was transferred in to 2ml vial using vacuum. Before the completion of drying, a solvent switch was carried by replacing DCM with 2-5ml hexane to each sample to complete the drying process. (Hexane solvent is recognized by GC-MS instruments for this type of analysis hence the need to do solvent switch).A 2ml of DAH's (Spike) was introduced into 50ml DCM. Sample extracts were stored in 2ml vial in refrigerator ready for GC-MS analysis. Table 3

RESULTS AND DISCUSSION

Figure 1-4a show the distribution of mean concentration of PCB in soil and maize at 0-20 cm depth within Abule-Egba, Epe, Olusosun, and Shagamu dump and control sites. The mean concentration of PCB 8 as shown in figure 5 in dry season at Abule-Egba dumpsite site was (0.059 ± 0.052ppm) but was not detected at control site while wet season active was significant detected at the control site (0.109 ± 0.154 ppm). In dry season at Epe, the concentration of PCB 8 in dumpsite and control site was not detected but present with a low concentration in wet season control site (0.035 ± 0.03 ppm) and above detection limit at active site (1.05 ± 0 ppm). Olusosun mean concentration of PCB 8 in active was not detected but present in a low concentration at control site (0.006 ± 0.009 ppm). A higher concentration was detected at active site in wet season (0.138 ± 0.195 ppm) as compare to control site, which was lower (0.1 ± 0.051 ppm).A comparitative mean concentration of PCB 8 in Shagamu active site in dry season was detected (0.199 ± 0.282 ppm) with wet season active site (0.568 ± 0.288ppm) but was not detected in dry season control site and was above detection limit in wet season control site (0.169 ± 0 ppm).The PCB 8 in maize sample was above detection limit (1.235 ± 0 ppm) but widely detected in figure 4 and 4a.Genarally,PCB 8 mean concentration was recorded higher at Shagamu in dry season active and wet season active site which attributed to high concentration at the site. Figure 12 showed distribution of PCB in water at control site at Epe during dry season, figure 6 with ID DEWWC03 showed water from borehole in a school at Epe with the presence of PCB's.

Figure 10, 13, 14 show the distribution of PCB in soil at 0-20 cm depth samples within Abule-Egba, Epe, Olusosun, and Shagamu dumpsites. The mean concentration of PCB 118 shown in figure 15 in dry season at Abule-Egba active site was (0.217 ± 0.29 ppm) and above detection limit at control site (0.024 ± 0 ppm) and low concentration in wet season active site (0.024 ± 0.028 ppm) and control site (0.055 ± 0.066 ppm).The PCB 118 detected in dry season at Epe active (0.031 ± 0.037 ppm) and control site (0.023 ± 0.024 ppm) were low but low but absent in wet season active site with low concentration at control site (0.219 ± 0.303 ppm).In Olusosun, PCB 118 mean concentration was detected low in dry season active (0.017 ± 0.015 ppm) and control site (0.014 ± 0.015 ppm) but was above detection limit in wet season active site (0.347 ± 0 ppm) with a very low concentration of PCB 118 detected at control site (0.063 ± 0.048 ppm). The PCB 118 concentration detected in dry season at Shagamu active site was the highest among all the four sites (0.237 ± 0.335 ppm) but absent dry season control site, wet season active site and above detection limit at control site (2.428 ± 0 ppm) that includes maize (0.332 ± 0 ppm).

Figure 7, 8, 9 show the distribution of PCB in water samples within Abule-Egba borehole, well, Epe river, borehole and well, Olusosun borehole, well and Shagamu dumpsites stream and borehole. The PCB 126 mean concentration as shown in figure 16 in dry season at Abule-Egba active site was not detected but found to be above detection limit at the control site (0.49 ± 0 ppm).In wet season active site, there was absence of PCB 126 compound but detected in a low concentration at the control site (0.108 ± 0.067 ppm).The mean concentration of PCB 126 was detected in dry season at Epe active site (0.185 ± 0.253 ppm) with a higher concentration as compare to all sites detected at the control site (0.398 ± 0.433 ppm).In wet season, the mean concentration in active site (1.256 ± 0 ppm) and control site(0.098 ± 0 ppm) were above detection limits. PCB 126 was not detected in wet season active site at Olusosun and was observed to be absent in dry season control site and wet season active site but with very low concentration detected In wet season control site (0.047 ± 0.012 ppm).The PCB 126 concentration in dry season at Shagamu active (0.007 ±0 ppm) and control site (0.112 ± 0 ppm),wet season control site (0.073 ± 0 ppm) were above detection limit while it was absent at wet season active site.

Figure 17 show the distribution of PCB 167 in soil at 0-20 cm depth samples within Abule-Egba, Epe, Olusosun, and Shagamu dumpsites. There was wide distribution of PCB 167 in all the study sites though with low concentrations. At Abule-Egba, a high mean concentration was detected in dry season active site (9.688 ± 10.869 ppm) but above detection limit at the control site (0.691 ± 0 ppm).A low mean concentration of

Table 3. PCB 8 (2,4'-Dichlorobiphenyl) concentration of soil by sampling sites

Site Location	Dry Season		Wet Season		
	Active (Mean ± SD)	Control (Mean± SD)	Active (Mean ± SD)	Control (Mean ± SD)	Control (Maize)
Abule-Egba	0.059 ± 0.052	0 ± 0	0 ± 0	0.109 ± 0.154	-
Epe	0 ± 0	0 ± 0	1.05 ± 0	0.035 ± 0.03	-
Olusosun	0 ± 0	0.006 ± 0.009	0.138 ± 0.195	1.235 ± 0	-
Shagamu	0.199 ± 0.282	0 ± 0	0.568 ± 0.288		

Soil sample ID: ESC01 (Epe)

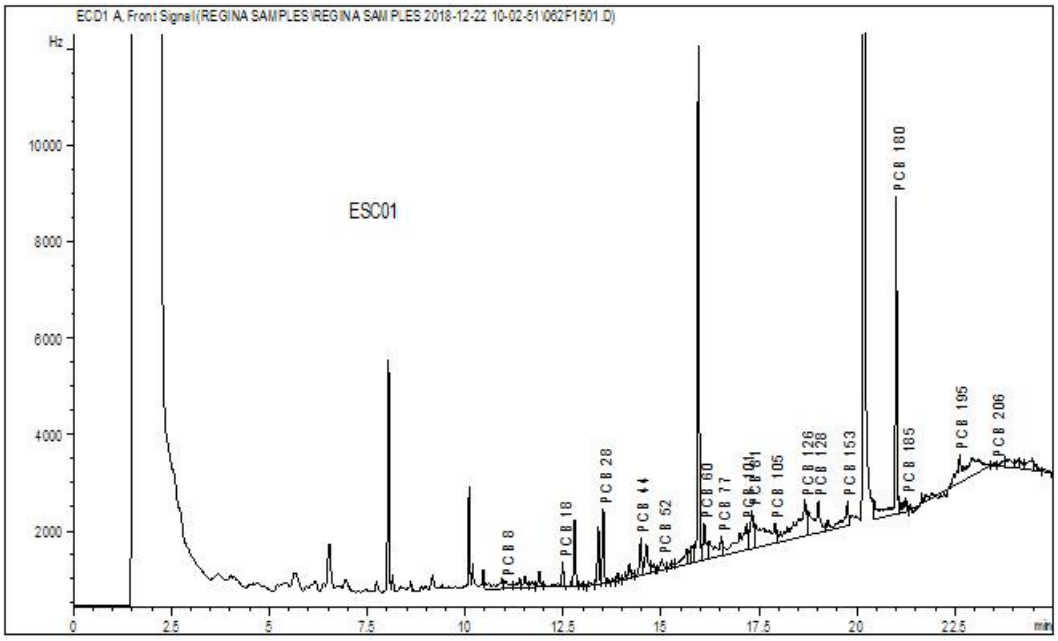


Figure 1. Soil sample ID: ESC01 (Epe)

Table 4. GC-MS Results for Sample ESC01

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	Sample ID
1	11.039	3.77298 e-5	4.74223 e-2	PCB 8	
2	12.448	4.15060 e-5	9.16355 e-2	PCB 18	
3	13.521	2.63873 e-5	1.30153 e-1	PCB 28	
4	14.479	4.19636 e-5	1.27525 e-1	PCB 44	
5	15.016	2.94284 e-5	4.31802 e-2	PCB 52	
6	16.103	3.80925 e-5	1.48558 e-1	PCB 60	
7	16.536	4.89202 e-5	2.79472 e-1	PCB 77	
8	17.176	1.30123 e-4	1.15798	PCB 81	
9	17.316	6.39046 e-5	3.38202 e-1	PCB 101	
10	17.901	5.97424 e-5	6.16853 e-1	PCB 105	
11	18.039	-	-	PCB 114	
12	18.259	-	-	PCB 118	
13	18.478	-	-	PCB 123	
14	18.667	5.26293 e-5	7.10155 e-1	PCB 126	
15	19.012	5.92718 e-5	4.93230 e-1	PCB 128	
16	19.325	-	-	PCB 138	
17	19.758	4.70849 e-5	2.38139 e-1	PCB 153	
18	19.933	-	-	PCB 156	
19	20.070	-	-	PCB 157	

Table 4. Continue

20	20.163	-	-	PCB 167
12	20.362	-	-	PCB 169
22	20.803	-	-	PCB 170
23	21.002	7.59662 e-5	1.77471	PCB 180
24	21.248	8.09721 e-5	1.88107 e-1	PCB 185
25	21.691	-	-	PCB 189
26	22.623	1.09576 e-4	1.43985	PCB 195
27	23.529	8.06308 e-5	2.60098 e-2	PCB 206

Table 5. GC-MS Results for Sample DAS 01

S/N	Retention time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.245	5.34130 e-5	9.57242 e-2	PCB 8	2,4'-Dichlorobiphenyl
2	12.339	4.93926 e-5	7.19226 e-1	PCB 18	2,2',5-Trichlorobiphenyl
3	13.511	2.72267 e-5	2.49952 e-1	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.474	4.58981 e-5	5.01022 e-1	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	15.044	3.78665 e-5	3.77331 e-1	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.084	3.92450 e-5	2.96502 e-1	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.737	5.05563 e-5	7.32004 e-1	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.158	7.49798 e-5	7.45544 e-1	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.462	1.31719 e-4	2.06353	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.896	6.06692 e-5	1.53886	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
11	17.972	5.91737 e-5	4.12569 e-1	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
12	18.221	4.06639 e-5	5.45873 e-1	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.426	6.14565 e-5	3.72513 e-1	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.620	5.26663 e-5	8.30256 e-1	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	19.057	6.02659 e-5	1.92487	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
16	19.500	3.48879 e-5	1.10370	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
17	19.746	3.82442 e-5	5.86730 e-1	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
18	19.883	8.66617 e-5	111.60194	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.169	7.79701 e-5	7.48508	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
20	20.277	6.24512 e-5	9.10614 e-1	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
21	20.438	6.54976 e-5	2.87672	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
22	20.912	7.56667 e-5	8.66136 e-1	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
23	21.101	1.28946 e-4	2.25248	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
24	21.461	-	-	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl

Table 5. Continue

25	21.634	6.94782 e-5	3.82246	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.618	1.10132 e-4	3.28856	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.129	1.29797 e-4	8.26862	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl

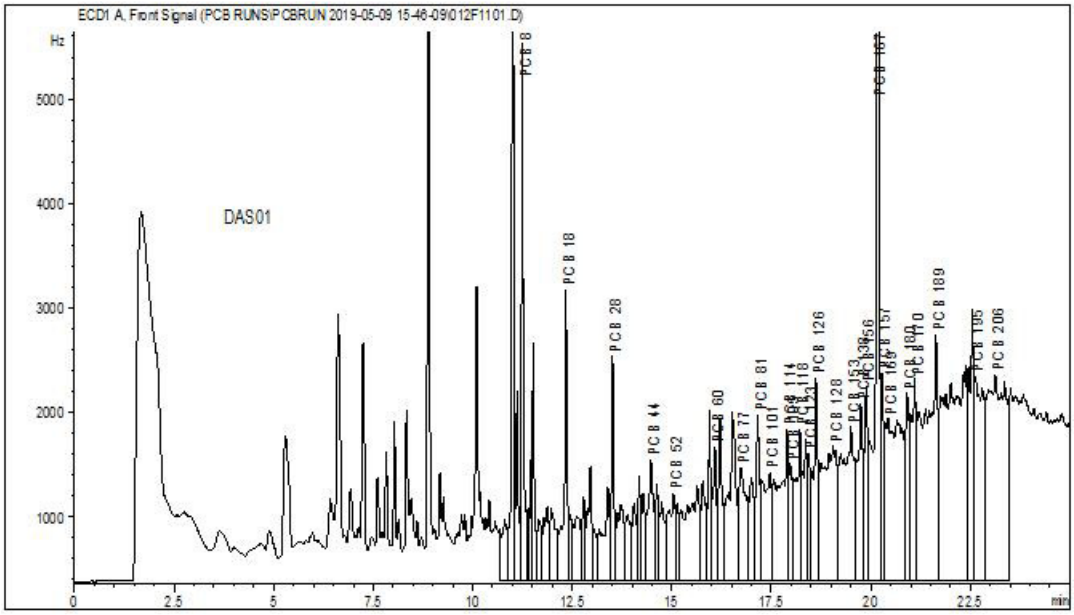


Figure 2. Soil sample ID: DAS01 (Abule-Egba)

Table 6. GC-MS Results for Sample DOS 02

S/N	Retention time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.209	0.00000	0.00000	PCB 8	2,4'-Dichlorobiphenyl
2	12.205	8.04731 e-6	3.86292 e-3	PCB 18	2,2',5-Trichlorobiphenyl
3	13.511	2.69878 e-5	1.98981 e-1	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.472	4.09351 e-5	1.04657 e-1	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	15.025	0.00000	0.00000	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.097	2.69885 e-5	1.85914 e-2	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.653	0.00000	0.00000	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.307	0.00000	0.00000	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.520	0.00000	0.00000	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.964	5.00802 e-5	5.63856 e-2	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
11	18.039	0.00000	0.00000	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
12	18.289	0.00000	0.00000	PCB 118	2,3',4,4',5-Pentachlorobiphenyl

Table 6. Continue

13	18.498	3.02851 e-5	1.20881 e-2	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.609	0.00000	0.00000	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	19.072	3.85027 e-5	1.98483 e-2	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
16	19.327	0.00000	0.00000	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
17	19.591	5.17212 e-4	7.83615 e-2	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.916	0.00000	0.00000	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.004	4.38808 e-5	1.07293 e-2	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
20	20.039	3.12026 e-5	5.59667 e-3	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
21	20.168	7.79487 e-5	6.04358	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
22	20.803	-	-	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
23	20.906	-	-	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
24	21.461	-	-	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl
25	21.691	-	-	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.617	1.10191 e-4	3.80158	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.121	1.29251 e-4	2.58877	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl

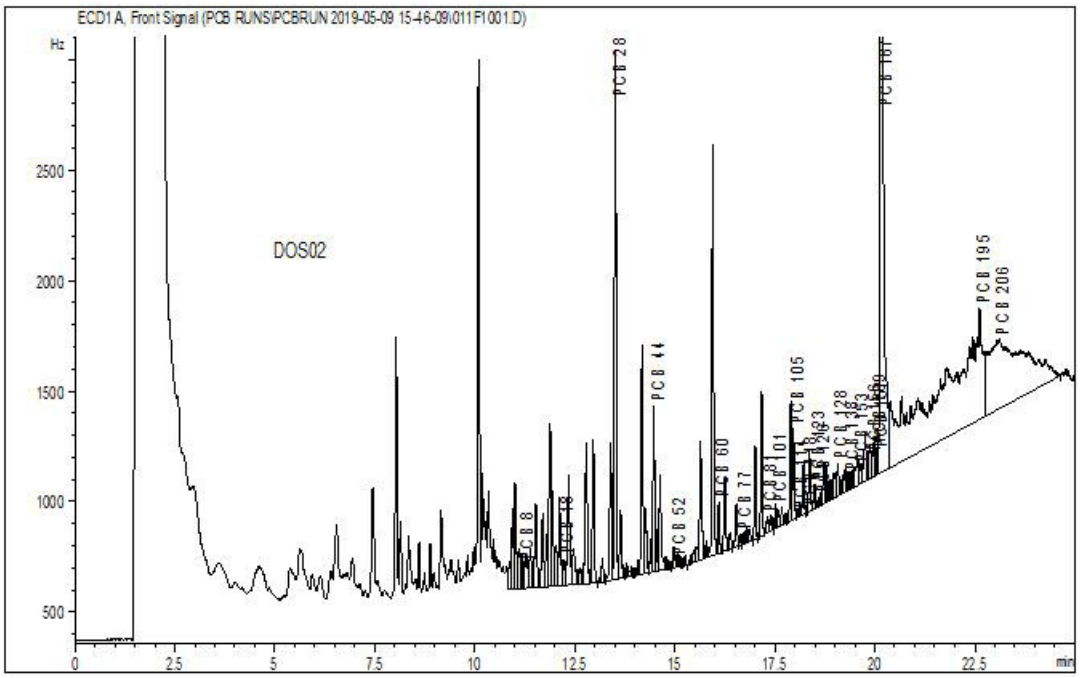


Figure 3. Soil sample ID: DOS02 (Olusosun)

Table 7. GC-MS Results for Sample SMO2

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	Sample ID
1	11.044	4.95151 e-5	2.06593 e-1	PCB 8	
2	12.354	4.89137 e-5	5.31613 e-1	PCB 18	
3	13.524	2.78155 e-5	6.45080 e-1	PCB 28	
4	14.482	4.64287 e-5	7.79215 e-1	PCB 44	
5	15.253	3.86142 e-5	7.90369 e-1	PCB 52	
6	16.105	3.91441 e-5	2.73316 e-1	PCB 60	
7	16.540	5.07075 e-5	8.55527 e-1	PCB 77	
8	17.177	7.63022 e-5	8.47636 e-1	PCB 101	
9	17.906	1.32956 e-4	5.07728	PCB 81	
10	17.974	5.93804 e-5	4.69426 e-1	PCB 105	
11	18.133	5.97474 e-5	5.10063 e-1	PCB 114	
12	18.228	4.05425 e-5	3.31926 e-1	PCB 118	
13	18.478	-	-	PCB 123	
14	18.586	-	-	PCB 126	
15	19.043	-	-	PCB 128	
16	19.312	3.87983 e-5	3.14190	PCB 138	
17	19.594	3.64345 e-5	6.91712 e-1	PCB 153	
18	19.757	8.54976 e-3	104.16340	PCB 156	
19	20.070	-	-	PCB 157	
20	20.165	7.78456 e-5	3.12615	PCB 167	
12	20.379	6.53349 e-5	1.22402	PCB 169	
22	20.803	-	-	PCB 170	
23	20.906	-	-	PCB 180	
24	21.349	8.41778 e-5	7.21286	PCB 185	
25	21.691	-	-	PCB 189	
26	22.237	1.10432 e-4	10.48095	PCB 195	
27	23.217	-	-	PCB 206	

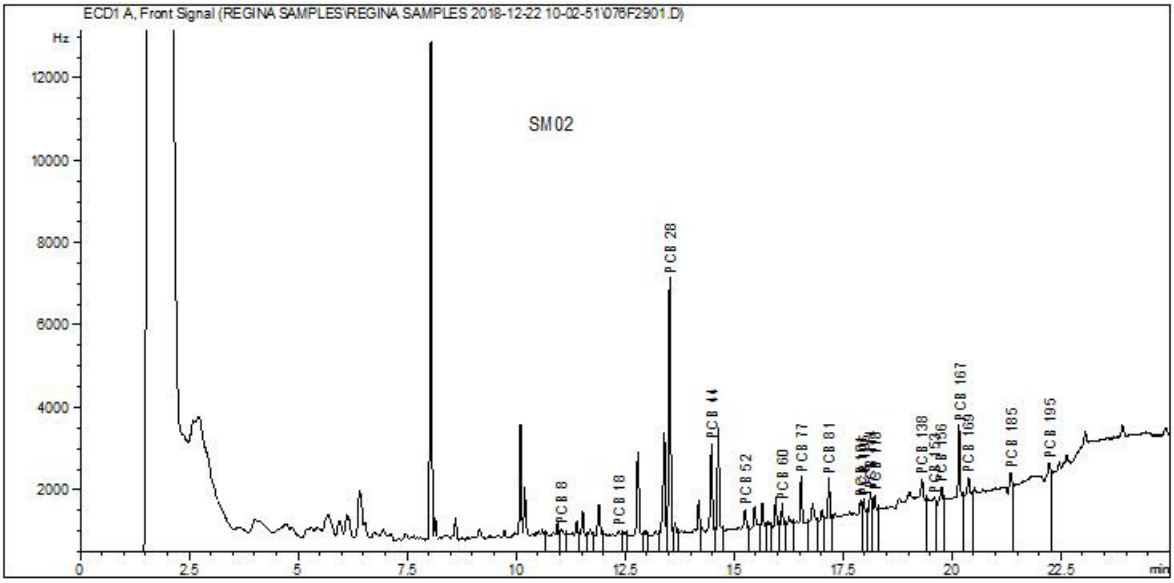


Figure 4. Maize sample ID: SM02 (Shagamu)

Table 8. GC-MS Results for Sample SMP02

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.233	5.36749e-5	1.23545	PCB 8	2,4'-Dichlorobiphenyl
2	12.066	4.97986e-5	1.01856	PCB 18	2,2',5-Trichlorobiphenyl
3	13.528	2.80122e-5	1.32551	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.489	4.73523e-5	12.31599	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	14.876	3.92692e-5	10.49357	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.148	4.03968e-5	4.82429	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.579	5.15023e-5	61648	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.227	8.73062e-5	39.63062	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.522	-	-	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.830	6.09071e-5	41.68911	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
11	18.039	-	-	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
12	18.259	-	-	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.374	6.35720e-5	10.33996	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.676	5.28752e-5	16.97361	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	19.043	-	-	PCB 129	2,2',3,3',4,5-Hexachlorobiphenyl
16	19.325	-	-	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
17	19.590	-	-	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.933	-	-	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.070	-	-	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
20	20.167	7.80346e-5	26.81275	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
21	20.280	6.55523e-5	5	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
22	20.803	-	25578	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
23	20.906	-	-	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
24	21.461	-	-	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl
25	21.691	-	-	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.692	-	-	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.217	-	-	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl

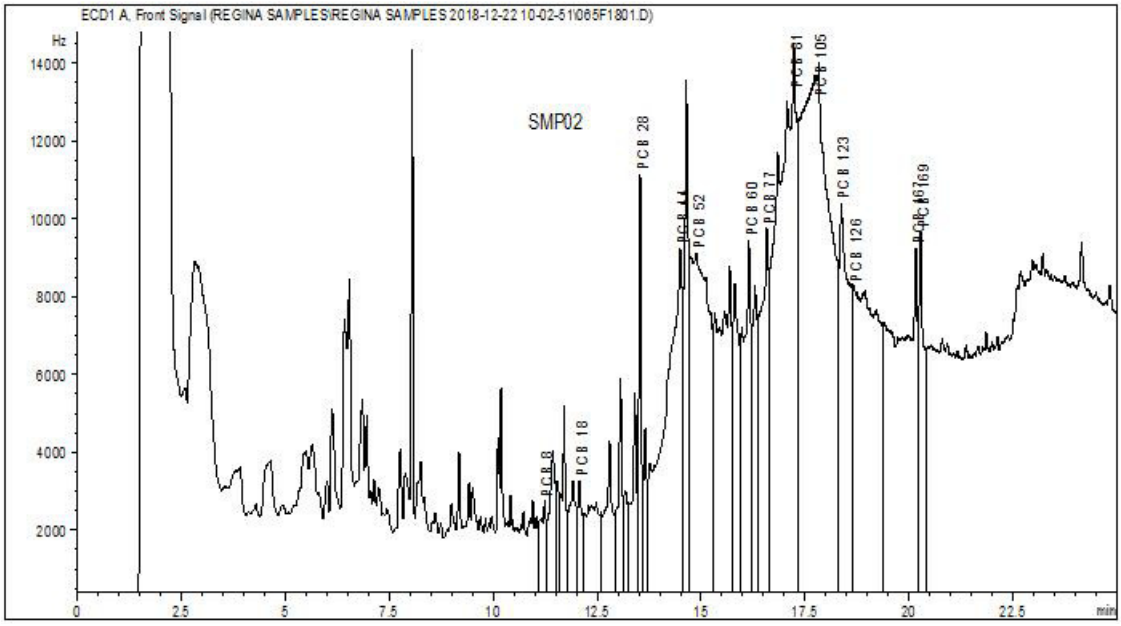


Figure 4a. Maize powder sample ID: SMP02 (Shagamu)

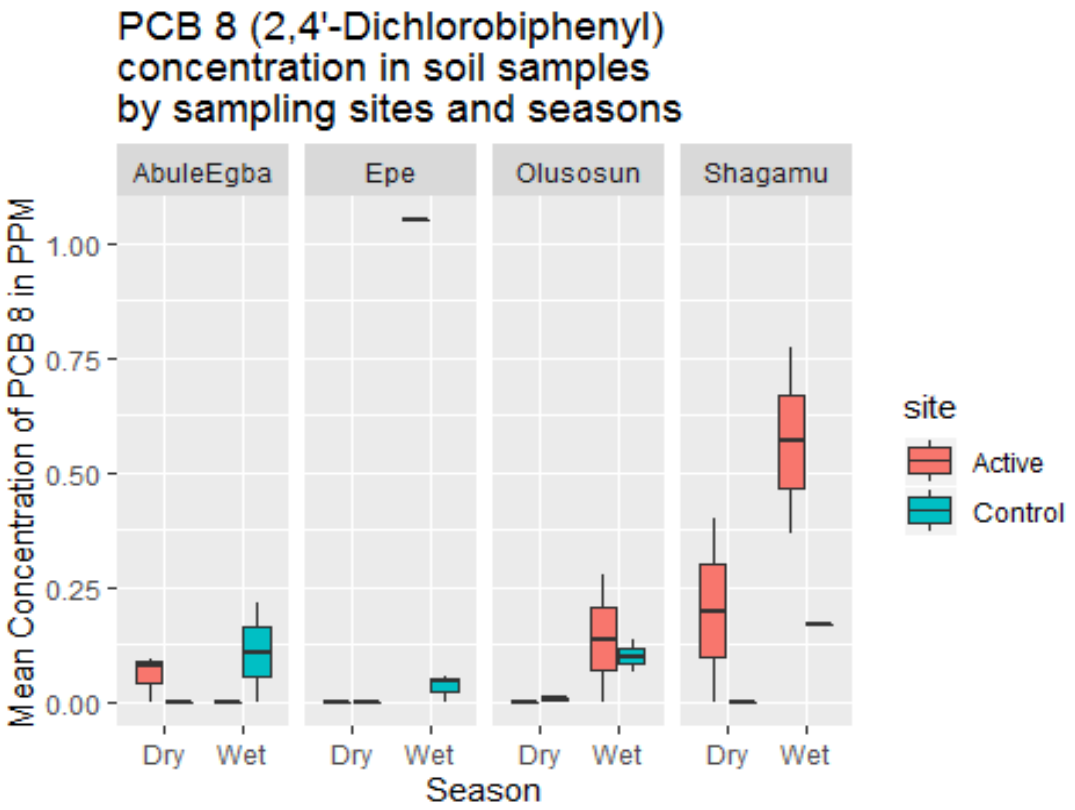


Figure 5. PCB 8 (2,4'-Dichlorobiphenyl) concentration of soil by sampling sites

Table 9. PCB 8 (2,4'-Dichlorobiphenyl) water concentration by sampling site (ppm)

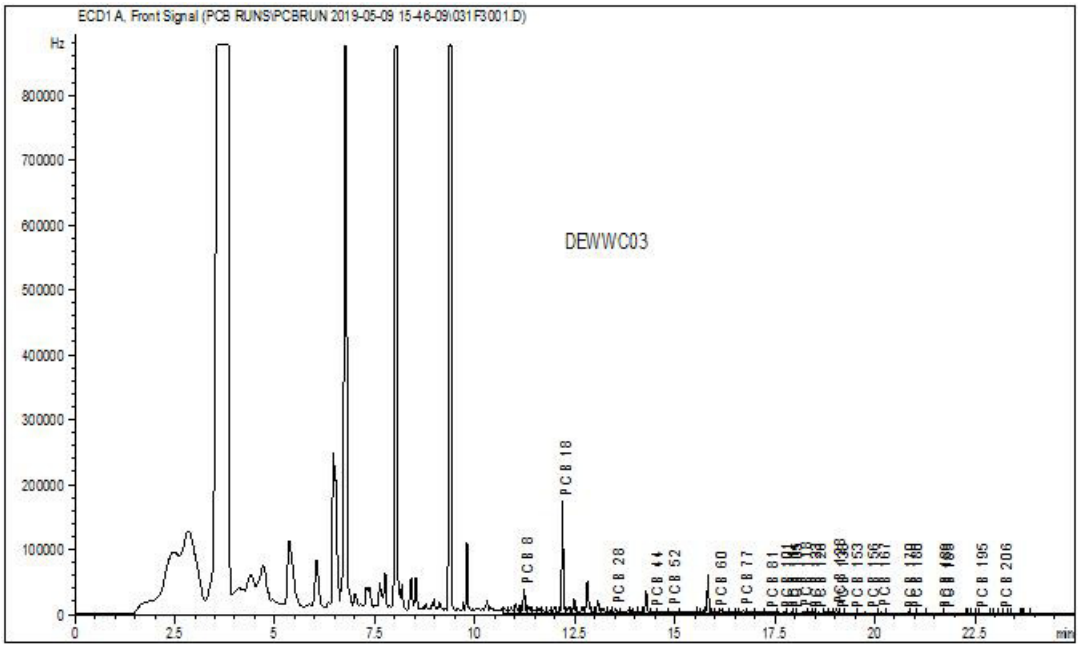
Site Location	Dry Season		Wet Season	
	Active(ppm) (Mean ± SD)	Control(ppm) (Mean ± SD)	Active(ppm) (Mean ± SD)	Control(ppm) (Mean ± SD)
Abule-Egba	0 ± 0	5.518 ± 0	-	0.054 ± 0.075
Epe	1.673 ± 2.366	3.887 ± 3.529	0 ± 0	0.104 ± 0
Olusosun	0 ± 0	-	-	0.012 ± 0.016
Shagamu	0.09 ± 0	2.627 ± 0	0.539 ± 0	0.002 ± 0

Table 10. Results for Sample DEWWC03

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.231	5.44284e-5	6.88984	PCB 8	2,4'-Dichlorobiphenyl
2	12.190	5.07593e-5	24.36490	PCB 18	2,2',5-Trichlorobiphenyl
3	13.511	2.79472e-5	9.84423e-1	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.472	4.65226e-5	8.62902e-1	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	14.936	3.88224e-5	1.12494	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.086	3.95753e-5	4.08829e-1	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.716	5.08892e-5	1.07137	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.386	8.04143e-5	1.40580	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.744	1.31107e-4	1.59036	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.892	5.93857e-5	4.02243e-1	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
11	17.971	5.78275e-5	2.27954e-1	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
12	18.222	4.06674e-5	5.56026e-1	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.466	6.03842e-5	2.45972e-1	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.589	5.23317e-5	3.27039e-1	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	19.039	6.00532e-5	1.16138	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
16	19.128	3.56900e-5	1.15599e-1	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
17	19.503	4.21286e-5	3.23516e-1	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.891	8.56555e-3	105.12489	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.070	-	-	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
20	20.159	7.68646e-5	5.52745e-1	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
21	20.362	-	-	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
22	20.828	1.27347e-4	1.02341	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
23	20.966	7.37314e-5	1.96463e-1	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
24	21.695	6.60213e-5	1.38241e-1	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl

Table 10. Continue

25	21.776	7.94638e-5	1.26637e-1	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.618	8.67953e-5	4.76569e-2	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.223	0.00000	0.00000	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl



Water sample ID: DEWWC03 (Epe)

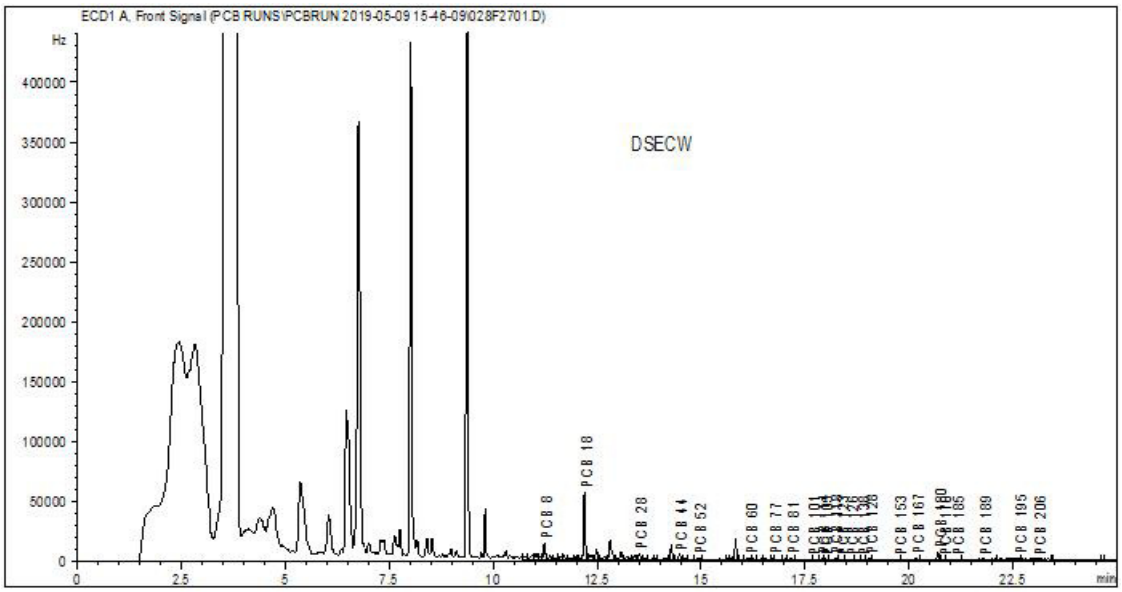
Figure 6. Borehole water control sample ID: DEWWC03 from secondary school (Epe)

Table 11. Results for Sample DSECW

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.231	5.41588e-5	2.62683	PCB 8	2,4'-Dichlorobiphenyl
2	12.190	5.06791e-5	8.46134	PCB 18	2,2',5-Trichlorobiphenyl
3	13.513	2.77727e-5	5.79896e-1	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.474	4.65748e-5	9.17409e-1	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	14.934	3.75995e-5	3.16660e-1	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.151	3.93596e-5	3.27946e-1	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.720	4.83492e-5	2.28028e-1	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.170	6.99569e-5	4.97367e-1	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.651	1.29142e-4	9.07978e-1	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.899	5.74871e-5	1.86828e-1	PCB 114	2,3,4,4',5-Pentachlorobiphenyl

Table 11. Continue

11	17.969	5.68416e-5	1.69969e-1	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
12	18.222	4.04287e-5	2.42334e-1	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.357	5.55420e-5	9.11953e-2	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.604	5.12956e-5	1.11715e-1	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	18.871	3.29875e-5	5.82363e-2	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
16	19.040	5.85341e-5	3.16730e-1	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
17	19.736	4.73165e-5	2.35553e-1	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.933	-	-	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.070	-	-	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
20	20.160	7.66022e-5	4.51681e-1	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
21	20.362	-	-	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
22	20.695	7.58770e-5	1.35314	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
23	20.827	1.02933e-4	8.95054e02	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
24	21.124	7.94988e-5	1.27622e-1	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl
25	21.790	6.84335e-5	4.35850e-1	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.620	1.08584e-4	7.13972e-1	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.085	1.20957e-4	2.12129e-1	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl



Water sample ID: DSECW (Shagamu community)

Figure 7. Borehole water sample ID: DSECW (Shagamu community)

Table 12. Results for Sample DOBW2

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.165	0.00000	0.00000	PCB 8	2,4'-Dichlorobiphenyl
2	12.300	0.00000	0.00000	PCB 18	2,2',5-Trichlorobiphenyl
3	13.510	2.44109e-5	5.76207e-2	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.471	3.52773e-5	4.81535e-2	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	14.980	0.00000	0.00000	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.096	0.00000	0.00000	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.634	0.00000	0.00000	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.311	0.00000	0.00000	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.521	0.00000	0.00000	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.967	0.00000	0.00000	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
11	18.050	0.00000	0.00000	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
12	18.214	6.37590e-6	4.71087e-4	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.364	4.29271e-5	2.75849e-2	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.610	7.00500e-6	5.28842e-4	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	18.949	0.00000	0.00000	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
16	19.253	0.00000	0.00000	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
17	19.635	5.84466e-4	7.77603e-2	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.944	0.00000	0.00000	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.159	7.71860e-5	7.59235e-1	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
20	20.305	5.09487e-5	2.40684e-2	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
21	20.377	0.00000	0.00000	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
22	20.796	5.04598e-5	1.50434e-2	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
23	20.998	0.00000	0.00000	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
24	21.442	5.34341e-5	1.32657e-2	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl
25	21.706	0.00000	0.00000	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.616	0.00000	0.00000	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.108	0.00000	0.00000	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl

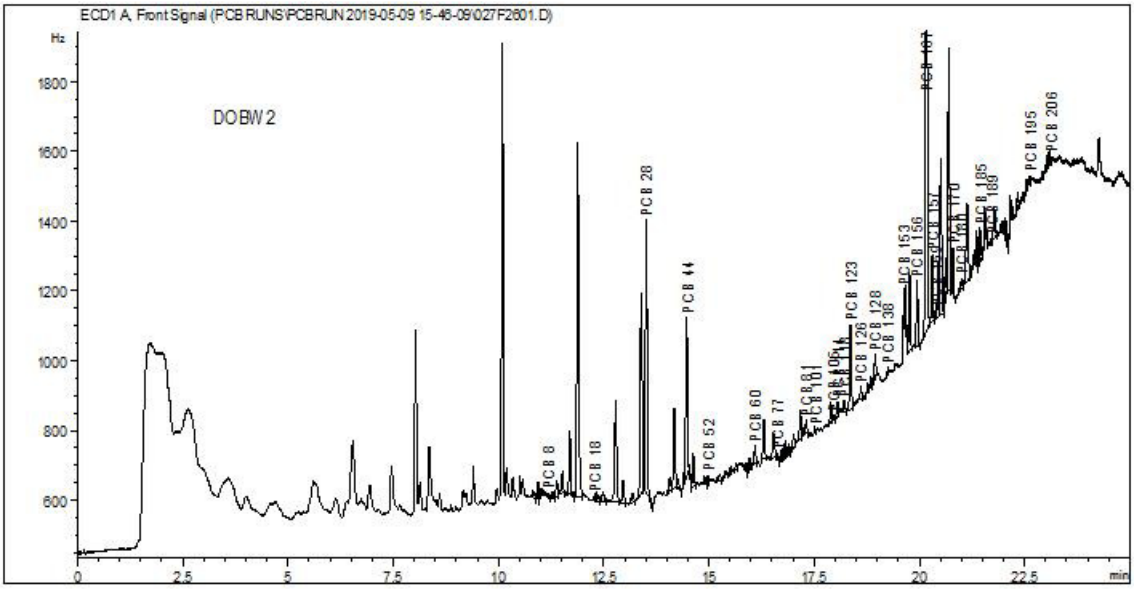


Figure 8. Borehole water sample ID: DOBW2 (Olusosun)

Table 13. GC-MS Results for Sample DOPSC02

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.280	0.00000	0.00000	PCB 8	2,4'-Dichlorobiphenyl
2	12.119	1.98510e-5	1.31630e-2	PCB 18	2,2',5-Trichlorobiphenyl
3	13.511	2.56194e-5	8.87812e-2	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.470	2.95407e-5	2.73823e-2	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	14.979	0.00000	0.00000	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.095	2.91138e-5	2.38072e-2	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.645	0.00000	0.00000	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.312	0.00000	0.00000	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.522	0.00000	0.00000	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.965	5.35858e-5	9.91506e-2	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
11	18.131	0.00000	0.00000	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
12	18.219	3.70762e-5	2.50026e-2	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.500	0.00000	0.00000	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.612	0.00000	0.00000	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	19.036	0.00000	0.00000	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
16	19.310	0.00000	0.00000	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
17	19.754	2.08568e-3	7.45921e-2	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.850	0.00000	0.00000	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl

Table 13. Continue

19	20.159	7.71715e-5	7.46727e-1	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
20	20.345	0.00000	0.00000	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
21	20.382	0.00000	0.00000	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
22	20.887	0.00000	0.00000	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
23	20.927	0.00000	0.00000	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
24	21.457	0.00000	0.00000	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl
25	21.700	0.00000	0.00000	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.705	0.00000	0.00000	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.180	0.00000	0.00000	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl

Table 14. GC-MS Results for Sample DAS03

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.280	0.00000	0.00000	PCB 8	2,4'-Dichlorobiphenyl
2	12.127	0.00000	0.00000	PCB 18	2,2',5-Trichlorobiphenyl
3	13.510	2.13265ee-5	2.77548e-2	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.470	2.21380e -5	1.45110e-2	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	14.984	0.00000	0.00000	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.242	0.00000	0.00000	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.548	0.00000	0.00000	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.311	0.00000	0.00000	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.525	0.00000	0.00000	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.964	0.00000	0.00000	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
11	18.039	-	-	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
12	18.215	0.00000	0.00000	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.367	0.00000	0.00000	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.586	-	-	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	19.023	0.00000	0.00000	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
16	19.254	0.00000	0.00000	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
17	19.590	-	-	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.844	0.00000	0.00000	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.070	-	-	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl

Table 14. Continue

20	20.159	7.11724e-5	8.88026e-2	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
21	20.390	1.71505e-6	1.42647e-4	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
22	20.796	0.00000	0.00000	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
23	20.908	0.00000	0.00000	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
24	21.585	0.00000	0.00000	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl
25	21.617	0.00000	0.00000	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.676	0.00000	0.00000	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.052	0.00000	0.00000	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl

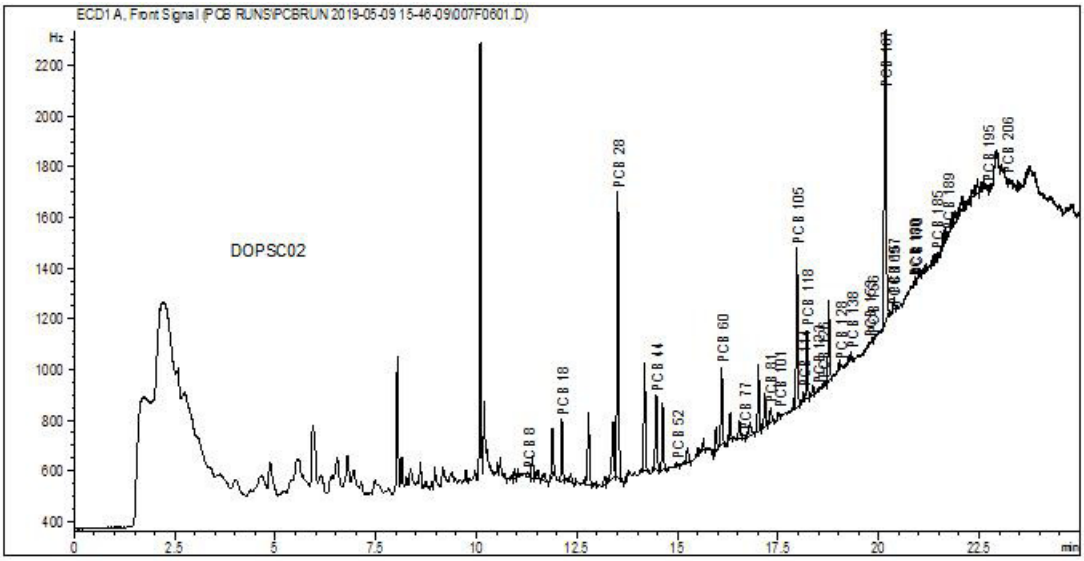


Figure 9. Borehole water Primary school sample ID: DOPSC02 (Olusosun)

Table 15. GC-MS Results for Sample DOS 03

S/N	Retention time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.164	0.00000	0.00000	PCB 8	2,4'-Dichlorobiphenyl
2	12.118	0.00000	0.00000	PCB 18	2,2',5-Trichlorobiphenyl
3	13.510	2.46673 e-5	6.24512 e-2	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.473	3.67153 e-5	5.68514 e-2	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	14.975	0.00000	0.00000	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.096	3.89392 e-5	2.35601 e-1	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.539	0.00000	0.00000	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.289	0.00000	0.00000	PCB 81	3,4,4',5-Tetrachlorobiphenyl

Table 15. Continue

9	17.524	0.00000	0.00000	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.967	0.00000	0.00000	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
11	18.020	0.00000	0.00000	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
12	18.219	3.76922 e-5	3.03705 e-2	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.500	0.00000	0.00000	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.666	2.29164 e-5	2.64861 e-3	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	18.920	0.00000	0.00000	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
16	19.251	0.00000	0.00000	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
17	19.556	3.10678 e-3	7.42053 e-2	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.919	0.00000	0.00000	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.049	5.41594 e-5	2.51206 e-2	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
20	20.071	4.54038 e-5	1.47034 e-2	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
21	20.162	7.77351 e-5	2.05882	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
22	20.803	-	-	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
23	21.121	7.60329 e-5	2.31175	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
24	21.446	8.36824 e-5	1.09550	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl
25	21.775	6.92679 e-5	1.50181	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.542	1.10185 e-4	3.73808	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.066	1.29719 e-4	6.30991	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl

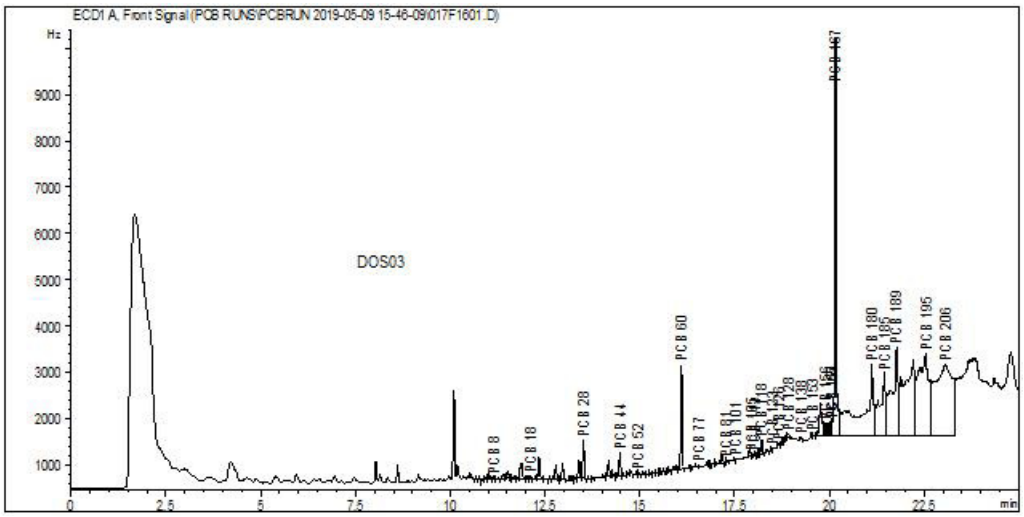


Figure 10. Soil Sample ID:DOS03 (Olusosun)

Table 16. GC-MS Results for Sample DACW 1

S/N	Retention time (min)	Amount/ Area	Amount (ppm)	Group name	IUPAC Name
1	11.230	5.43870 e-5	5.51788	PCB 8	2,4'-Dichlorobiphenyl
2	12.190	5.07491 e-5	19.66746	PCB 18	2,2',5-Trichlorobiphenyl
3	13.511	2.79773 e-5	1.11758	PCB 28	2,4,4'-Trichlorobiphenyl
4	14.472	4.66362 e-5	9.91018 e-1	PCB 44	2,2',3,5'-Tetrachlorobiphenyl
5	14.932	3.83668 e-5	5.82285 e-1	PCB 52	2,2',5,5'-Tetrachlorobiphenyl
6	16.083	3.92364 e-5	2.94375 e-1	PCB 60	2,3,4,4'-Tetrachlorobiphenyl
7	16.717	5.06722 e-5	8.23205 e-1	PCB 77	3,3',4,4'-Tetrachlorobiphenyl
8	17.386	8.14424 e-5	1.66217	PCB 81	3,4,4',5-Tetrachlorobiphenyl
9	17.744	1.29761 e-4	1.05159	PCB 101	2,2',4,5,5'-Pentachlorobiphenyl
10	17.892	1.29761 e-4	2.75742 e-1	PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
11	18.039	5.83415 e-5	-	PCB 114	2,3,4,4',5-Pentachlorobiphenyl
12	18.227	4.06333 e-5	4.69700 e-1	PCB 118	2,3',4,4',5-Pentachlorobiphenyl
13	18.362	6.03319 e-5	2.41896 e-1	PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
14	18.804	5.25145 e-5	4.89639 e-1	PCB 126	3,3',4,4',5-Pentachlorobiphenyl
15	19.039	5.98702 e-5	8.83791 e-1	PCB 128	2,2',3,3',4,4'-Hexachlorobiphenyl
16	19.125	3.29770 e-5	5.81155 e-2	PCB 138	2,2',3,4,4',5'-Hexachlorobiphenyl
17	19.503	4.96496 e-5	2.13410 e-1	PCB 153	2,2',4,4',5,5'-Hexachlorobiphenyl
18	19.765	3.72512 e-3	14.02582	PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
19	20.070	-	-	PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
20	20.159	7.71914 e-5	7.64060 e-1	PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
21	20.362	-	-	PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
22	20.826	1.25873 e-4	6.75393 e-1	PCB 170	2,2',3,3',4,4',5-Heptachlorobiphenyl
23	20.985	7.21493 e-5	1.18148 e-1	PCB 180	2,2',3,4,4',5,5'-Heptachlorobiphenyl
24	21.124	7.94845 e-5	1.27218 e-1	PCB 185	2,2',3,4,5,5',6-Heptachlorobiphenyl
25	21.694	6.78042 e-5	2.81765 e-1	PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
26	22.656	1.04680 e-4	2.32017 e-1	PCB 195	2,2',3,3',4,4',5,6-Octachlorobiphenyl
27	23.351	0.00000	0.00000	PCB 206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl

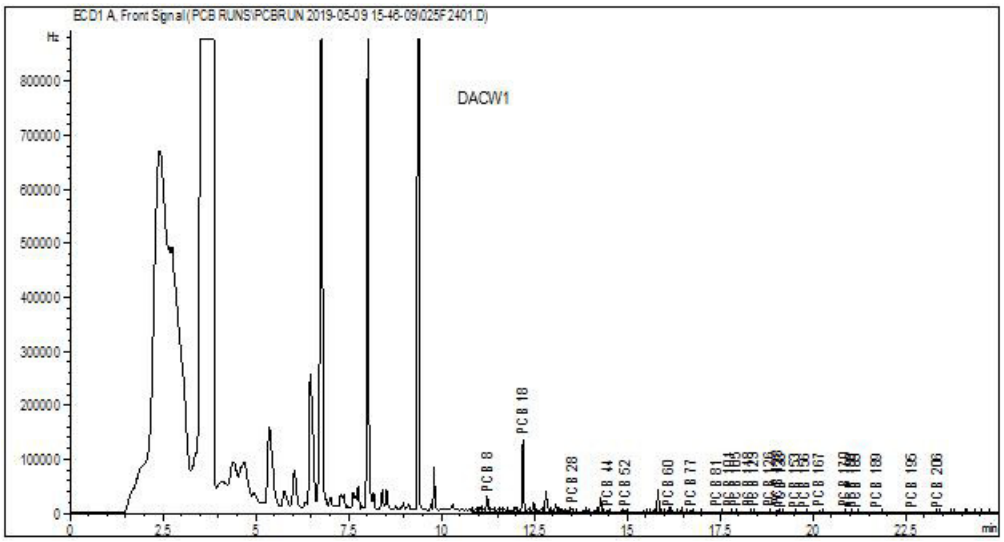


Figure 11. Water sample ID: DACW1 from community (Abule-Egba)

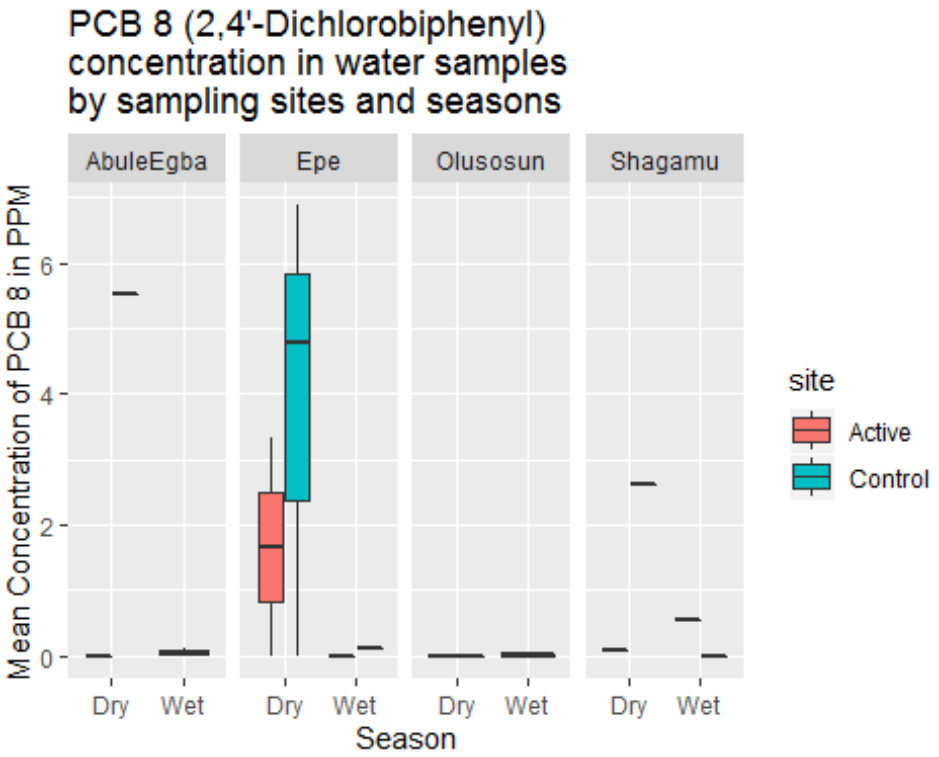


Figure 12. PCB 8 (2,4'-Dichlorobiphenyl) water concentration by sampling site (ppm)

Table 17. PCB 28 (2,4,4'-Trichlorobiphenyl) concentration of soil by sampling sites

Site Location	Dry Season		Wet Season		
	Active (Mean ± SD)	Control (Mean ± SD)	Active (Mean ± SD)	Control (Mean ± SD)	Control (Maize)
Abule-Egba	0.139 ± 0.111	0.081 ± 0	0.279 ± 0.087	0.193 ± 0.11	-
Epe	0.032 ± 0.045	0.086 ± 0.036	0.651 ± 0	0.23 ± 0.173	-
Olusosun	0.098 ± 0.089	0.185 ± 0.135	0.318 ± 0.39	0.195 ± 0.126	-
Shagamu	0.068 ± 0.019	0.082 ± 0	0.618 ± 0.637	0.207 ± 0	0.645 0

Table 18. GC-MS Results for Sample AS04

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	Sample ID
1	11.170	0.00000	0.00000	PCB 8	
2	12.199	0.00000	0.00000	PCB 18	
3	13.526	2.74783 e-5	3.40073 e-1	PCB 28	
4	14.487	3.82568 e-5	6.92081 e-2	PCB 44	
5	14.959	1.76812 e-5	1.18617 e-2	PCB 52	
6	16.107	3.73231 e-5	1.10023 e-1	PCB 60	
7	16.543	0.00000	0.00000	PCB 77	
8	17.319	0.00000	0.00000	PCB 81	
9	17.533	0.00000	0.00000	PCB 101	
10	17.977	0.00000	0.00000	PCB 105	
11	18.029	0.00000	0.00000	PCB 114	
12	18.232	2.57609 e-5	4.34802 e-3	PCB 118	
13	18.479	0.00000	0.00000	PCB 123	
14	18.634	1.49187 e-5	1.36104 e-3	PCB 126	
15	18.994	5.25360 e-5	7.39600 e-2	PCB 128	
16	19.364	0.00000	0.00000	PCB 138	
17	19.531	1.77780 e-4	8.98949 e-2	PCB 153	
18	19.972	0.00000	0.00000	PCB 156	
19	20.039	7.91804 e-6	8.20242 e-4	PCB 157	
20	20.168	7.71710 e-5e-6	7.46289 e-1	PCB 167	
12	20.392	3.18708 e-5	5.01949 e-3	PCB 169	
22	20.792	0.00000	0.00000	PCB 170	
23	21.046	0.00000	0.00000	PCB 180	
24	21.328	6.48648 e-5	2.55910 e-2	PCB 185	
25	22.074	6.43420 e-5	9.18195 e-2	PCB 189	
26	22.625	1.04546 e-4	2.26578 e-1	PCB 195	
27	23.217	-		PCB 206	

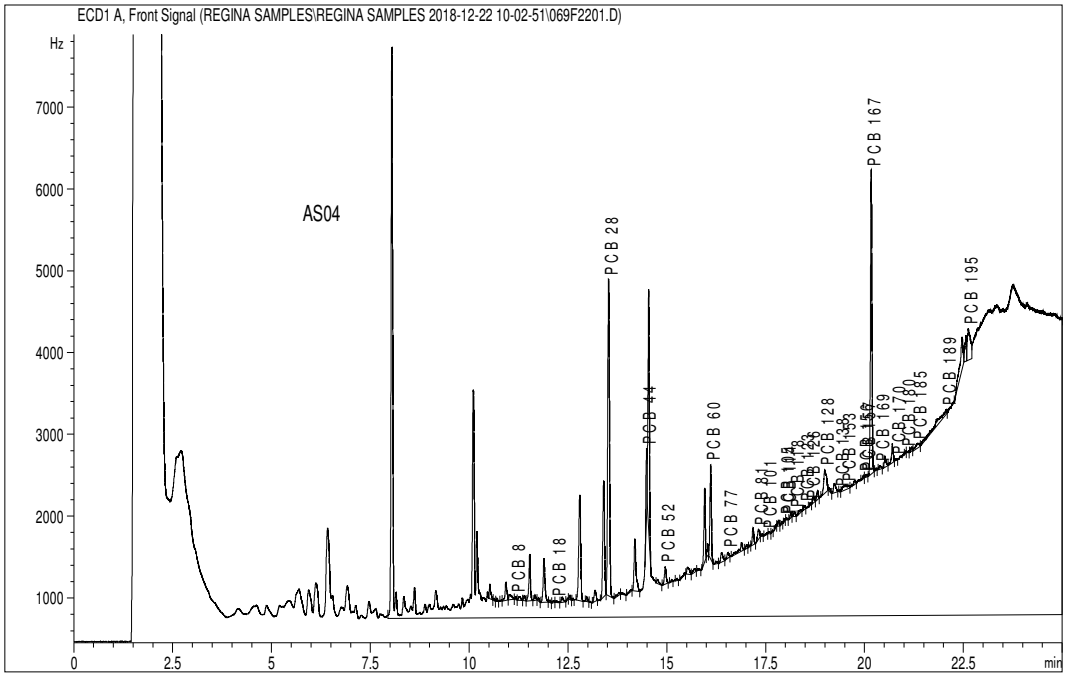


Figure 13. Soil sample ID: AS04 (Abule-Egba)

Table 19. PCB 28 (2,4,4'-Trichlorobiphenyl) concentration of soil by sampling sites

Site Location	Dry Season		Wet Season		
	Active(ppm) (Mean ± SD)	Control(ppm) (Mean ± SD)	Active(ppm) (Mean ± SD)	Control(ppm) (Mean ± SD)	Control(ppm) (Maize)
Abule-Egba	0.139 ± 0.111	0.081 ± 0	0.279 ± 0.087	0.193 ± 0.11	-
Epe	0.032 ± 0.045	0.086 ± 0.036	0.651 ± 0	0.23 ± 0.173	-
Olusosun	0.098 ± 0.089	0.185 ± 0.135	0.318 ± 0.39	0.195 ± 0.126	-
Shagamu	0.068 ± 0.019	0.082 ± 0	0.618 ± 0.637	0.207 ± 0	0.645 ± 0

Table 20. GC-MS Results for Sample OSC031

S/N	Retention Time (min)	Amount/ Area	Amount (ppm)	Group name	Sample ID
1	11.280	4.09863e-5	6.38420e-2	PCB 8	
2	12.214	3.62806e-5	5.12760e-2	PCB 18	
3	13.523	2.73396e-5	2.83874e-1	PCB 28	
4	14.483	4.68665e-5	1.41331	PCB 44	
5	15.101	2.47871e-5	2.47575e-2	PCB 52	
6	16.106	3.87974e-5	2.14901e-1	PCB 60	
7	16.541	4.99423e-5	4.58872e-1	PCB 77	
8	17.178	7.34480e-5	6.51165e-1	PCB 81	
9	17.902	1.28184e-4	7.47956e-1	PCB 101	
10	17.973	5.52369e-5	1.18574e-1	PCB 105	
11	18.134	5.67713e-5	1.54250e-1	PCB 114	
12	18.227	3.98020e-5	9.64063e-2	PCB 118	
13	18.337	5.62137e-5	1.00631e-1	PCB 123	
14	18.794	5.21984e-5	2.62945e-1	PCB 126	
15	19.043	-	-	PCB 129	
16	19.313	3.79871e-5	4.23480e-1	PCB 138	
17	19.590	-	-	PCB 153	
18	19.933	-	-	PCB 156	
19	20.070	-	-	PCB 167	
20	20.167	7.75660e-5	1.35047	PCB 169	
12	20.379	6.34490e-5	1.55441e-1	PCB 157	
22	21.002	6.93108e-5	6.70988e-2	PCB 170	
23	21.186	0.00000	0.00000	PCB 180	
24	21.457	0.00000	0.00000	PCB 185	
25	21.705	0.00000	0.00000	PCB 189	
26	22.705	0.00000	0.00000	PCB 195	
27	23.193	4.50085e-5	8.43694e-3	PCB 206	

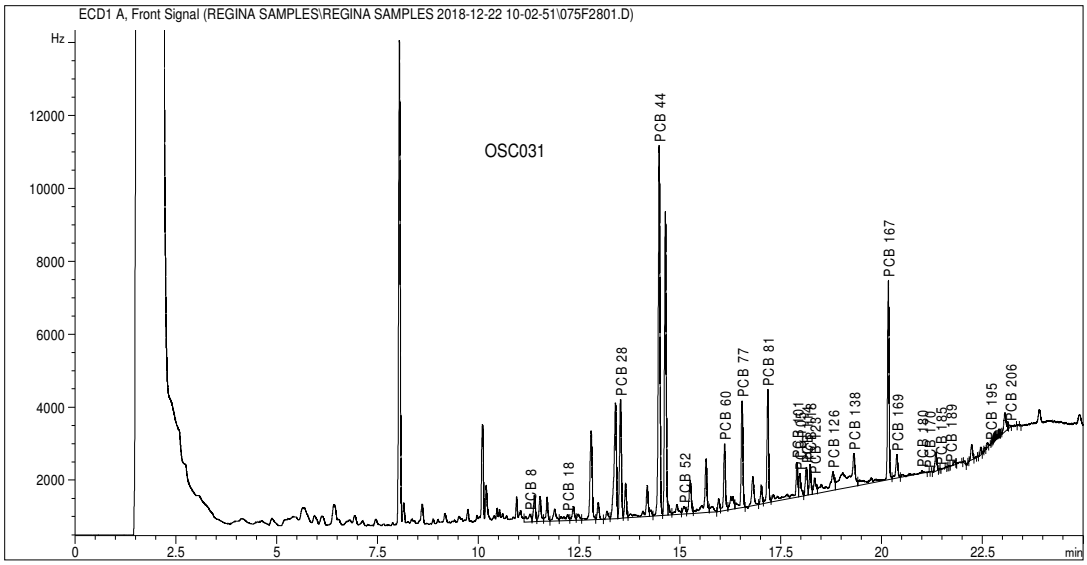


Figure 14. Soil sample ID:OSC031 ketu community (Olusosun)

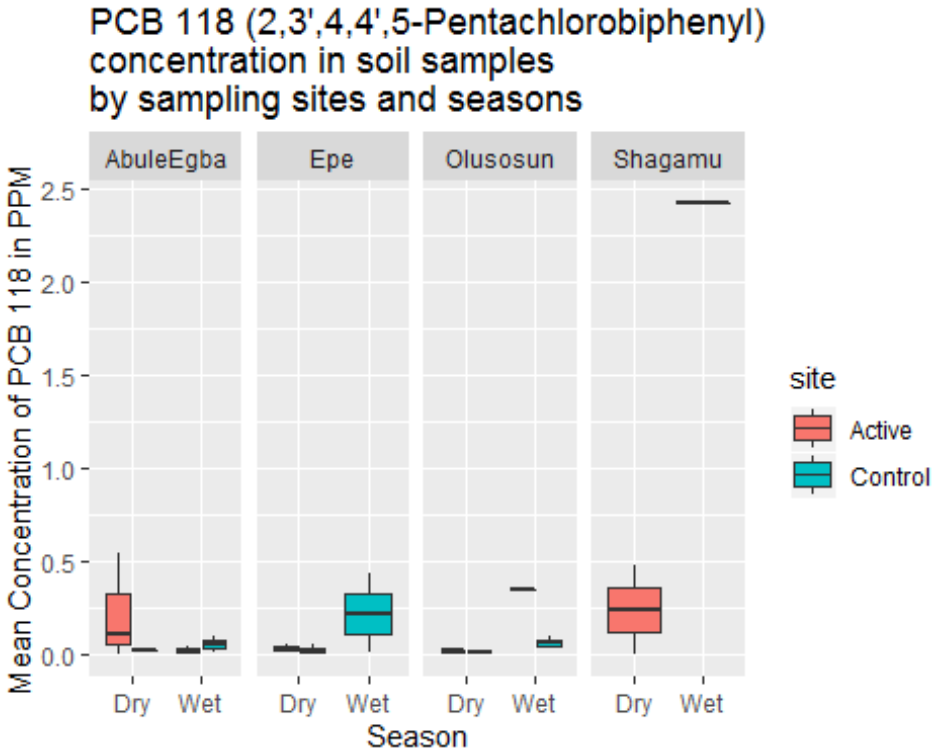


Figure 15. PCB 118 (2,3',4,4',5-Pentachlorobiphenyl) concentration by sampling sites (Soil)

Table 21. PCB 126 (3,3',4,4',5-Pentachlorobiphenyl) concentration of water by sampling sites

SiteLocation	Dry Season		Wet Season	
	Active(Mean ±SD)	Control(Mean± SD)	Active(Mean ±SD)	Control(Mean ±SD)
Abule-Egba	0 ± 0	0.49 ± 0	-	0.108 ± 0.067
Epe	0.185 ± 0.253	0.398 ± 0.433	1.256 ± 0	0.098 ± 0
Olusosun	0 ± 0	-	-	0.047 ± 0.012
Shagamu	0.007 ± 0	0.112 ± 0	-	0.073 ± 0

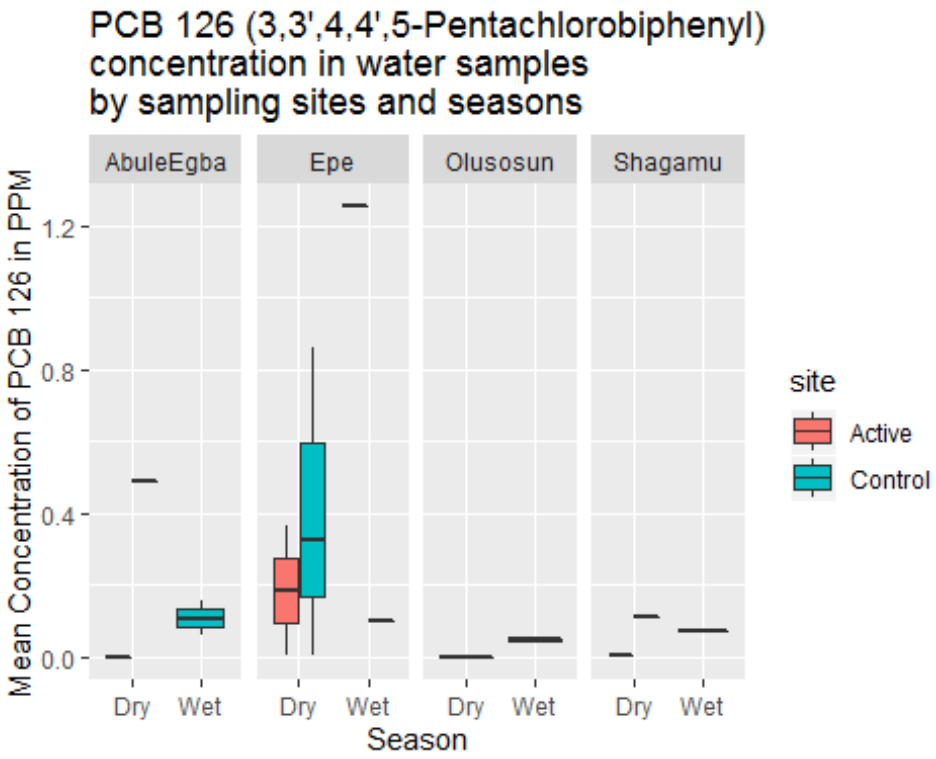


Figure 16. PCB 126 (3,3',4,4',5-Pentachlorobiphenyl) concentration of water by sampling sites

Table 22. PCB 167 (2,3',4,4',5,5'-Hexachlorobiphenyl) soil concentration by sampling sites

Site Location	Dry Season		Wet Season		
	Active(ppm) (Mean±SD)	Control(ppm) (Mean±SD)	Active (ppm) (Mean±SD	Control(ppm) (Mean±SD)	Control(ppm) (Maize)
Abule-Egba	9.688 ± 10.869	0.691 ± 0	0.673 ± 0.104	0.502 ± 0.578	-
Epe	0.666 ± 0.941	3.673 ± 5.658	-	0.181 ± 0.256	-
Olusosun	2.737 ± 3.024	1.144 ± 0.562	3.214 ± 3.925	0.541 ± 0	-
Shagamu	6.779 ± 3.131	2.612 ± 0	8.498 ± 10.689	-	3.126 ± 0

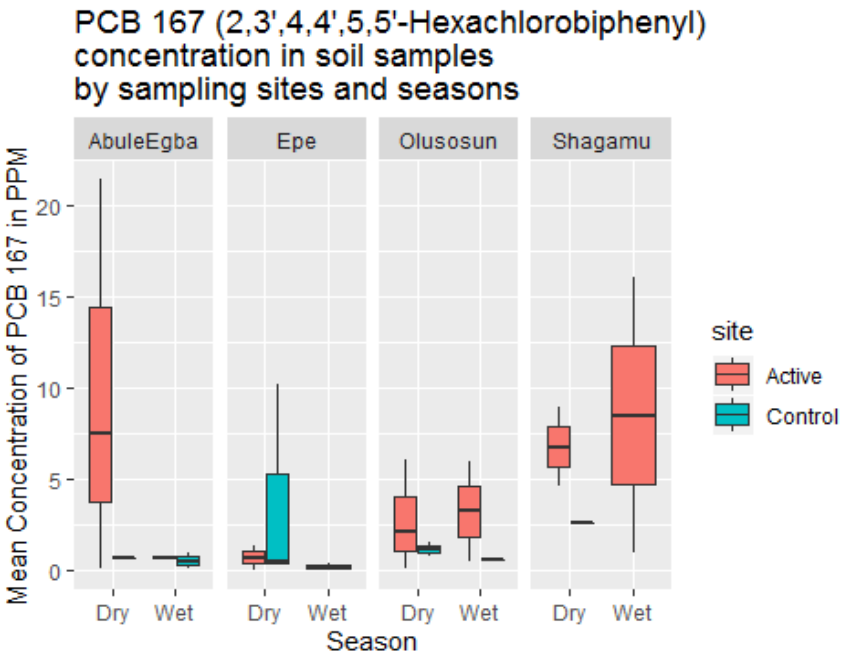


Figure 17. PCB 167 (2,3',4,4',5,5'-Hexachlorobiphenyl) soil concentration by sampling

Table 9. PCB 101 (2,2',4,5,5'-Pentachlorobiphenyl) water concentration by sampling sites

Site Location	Dry Season		Wet Season	
	Active(ppm) (Mean ± SD)	Control(ppm) (Mean ± SD)	Active(ppm) (Mean ± SD)	Control(ppm) (Mean ± SD)
Abule-Egba	0 ± 0	1.052 ± 0	-	0.084 ± 0
Epe	1.711 ± 2.419	1.751 ± 1.836	1.818 ± 0	-
Olusosun	0 ± 0	-	-	0.188 ± 0.213
Shagamu	0.091 ± 0	0.908 ± 0	1.292 ± 0	0.05 ± 0

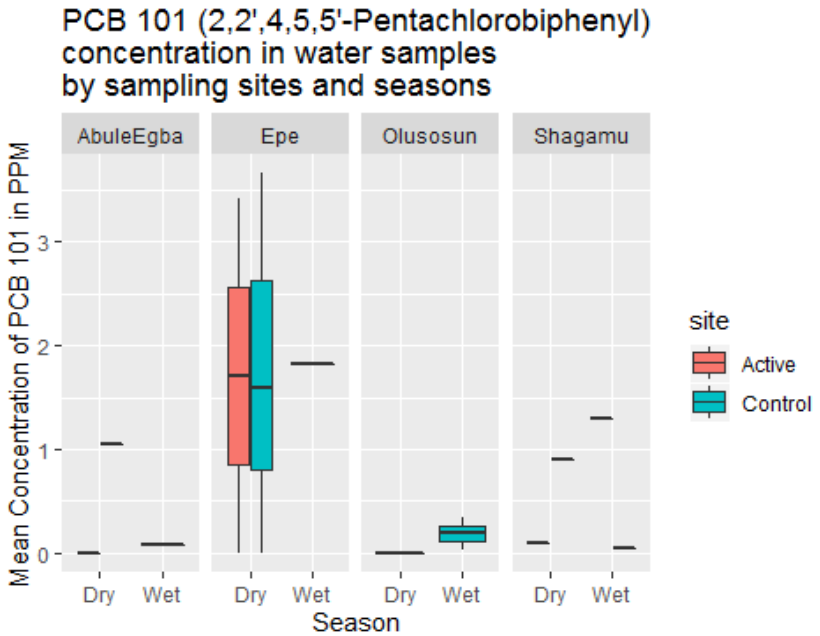


Figure 18. PCB 101 (2,2',4,5,5'-Pentachlorobiphenyl) water concentration by sampling sites

Table 24. MS Results for Reference Standard (Signal Point)

S/N	Retention Time (min)	Level signal	Amount (ppm)	Amount /Area	Group name	IUPAC Name
1	11.211	1	1.00000e-1	4.31864 e-5	PCB 8	2,4'-Dichlorobiphenyl
		2	2.00000 e-1	4.55306 e-5		
		3	5.00000 e-1	5.20551 e-5		
		4	1.00000 e-1	5.37706 e-5		
2	12.196	1	1.00000 e-1	4.05373 e-5	PCB 18	2,2',5-Trichlorobiphenyl
		2	2.00000 e-1	4.26644 e-5		
		3	5.00000e-1	4.84072 e-5		
		4	1.00000 e-1	5.00802 e-5		
3	13.574	1	1.00000 e-1	2.53374 e-5	PCB 28	2,4,4'-Trichlorobiphenyl
		2	2.00000 e-1	2.60611 e-5		
		3	5.00000 e-1	2.76138 e-5		
		4	1.00000 e-1	2.80227 e-5		
4	14.498	1.	1.00000 e-1	3.93375 e-5	PCB 44	2,2',3,5'-
		2.	2.00000 e-1	4.09468 e-5		Tetrachlorobiphenyl
		3	5.00000 e-1	4.57223 e-5		
		4	1.00000 e-1	4.68449 e-5		
5	15.012	1	1.00000 e-1	3.29602 e-5	PCB 52	2,2',5,5'-
		2	2.00000 e-1	3.47100 e-5		Tetrachlorobiphenyl
		3	5.00000 e-1	3.81309 e-5		
		4	1.00000 e-1	3.88930 e-5		
6	16.097	1	1.00000 e-1	3.60974 e-5	PCB 60	2,3,4,4'-
		2	2.00000 e-1	3.65569 e-5		Tetrachlorobiphenyl
		3	5.00000 e-1	4.02063 e-5		
		4	1.00000 e-1	4.00915 e-5		
7	16.634	1	1.00000 e-1	4.31152 e-5	PCB 77	3,3',4,4'-
		2	2.00000 e-1	4.50865 e-5		Tetrachlorobiphenyl
		3	5.00000 e-1	4.99351 e-5		
		4	1.00000 e-1	5.10321 e-5		
8	17.290	1	1.00000 e-1	3.69093 e-5	PCB 81	3,4,4',5-
		2	2.00000 e-1	3.41373 e-5		Tetrachlorobiphenyl
		3	5.00000 e-1	7.90641 e-5		
		4	1.00000 e-1	7.80403 e-5		
9	17.522	1	1.00000 e-1	9.54720 e-5	PCB 101	2,2',4,5,5'-
		2	2.00000 e-1	1.04943 e-5		Pentachlorobiphenyl
		3	5.00000 e-1	1.21650 e-5		
		4	1.00000 e-1	1.31304 e-5		
10	17.957	1	1.00000 e-1	5.15353 e-5	PCB 105	2,3,3',4,4'-
		2	2.00000 e-1	5.48065 e-5		Pentachlorobiphenyl
		3	5.00000 e-1	5.97743 e-5		
		4	1.00000 e-1	6.02693 e-5		
11	18.039	1	1.00000 e-1	5.25825 e-5	PCB 114	2,3,4,4',5-
		2	2.00000 e-1	5.50506 e-5		Pentachlorobiphenyl
		3	5.00000 e-1	5.97914 e-5		
		4	1.00000 e-1	6.05510 e-5		
12	18.259	1	1.00000 e-1	3.90799 e-5	PCB 118	2,3',4,4',5-
		2	2.00000 e-1	3.94912 e-5		Pentachlorobiphenyl
		3	5.00000 e-1	4.10926 e-5		
		4	1.00000 e-1	4.06826 e-5		
13	18.478	1	1.00000 e-1	5.23661e-5	PCB 123	2,3',4,4',5'-
		2	2.00000 e-1	5.65129 e-5		Pentachlorobiphenyl
		3	5.00000 e-1	6.28983 e-5		
		4	1.00000 e-1	6.27898 e-5		
14	18.586	1	1.00000 e-1	4.86801 e-5	PCB 126	3,3',4,4',5-
		2	2.00000 e-1	5.00076 e-5		Pentachlorobiphenyl
		3	5.00000 e-1	5.41645 e-5		
		4	1.00000 e-1	5.24159 e-5		

15	19.043	1	1.00000 e-1	5.26778 e-5	PCB 129	2,2',3,3',4,5-
		2	2.00000 e-1	5.40644 e-5		Hexachlorobiphenyl
		3	5.00000 e-1	5.98193 e-5		
		4	1.00000 e-1	6.00001 e-5		
16	19.325	1	1.00000 e-1	3.34085 e-5	PCB 138	2,2',3,4,4',5'-
		2	2.00000 e-1	3.51441 e-5		Hexachlorobiphenyl
		3	5.00000 e-1	3.87011 e-5		
		4	1.00000 e-1	3.84869 e-5		
17	19.590	1	1.00000 e-1	5.54627 e-5	PCB 153	2,2',4,4',5,5'-
		2	2.00000 e-1	6.24817 e-5		Hexachlorobiphenyl
		3	5.00000 e-1	6.32169 e-5		
		4	1.00000 e-1	3.21705 e-5		
18	19.933	1	1.00000 e-1	5.81077 e-5	PCB 156	2,3,3',4,4',5-
		2	2.00000 e-1	5.85307 e-5		Hexachlorobiphenyl
		3	5.00000 e-1	6.90366 e-5		
		4	1.00000 e-1	1.55710 e-5		
19	20.070	1	1.00000 e-1	5.72358 e-5	PCB 167	2,3',4,4',5,5'-
		2	2.00000 e-1	5.89551 e-5		Hexachlorobiphenyl
		3	5.00000 e-1	6.35232 e-5		
		4	1.00000 e-1	6.25090 e-5		
20	20.163	1	1.00000 e-1	6.81485 e-5	PCB 169	3,3',4,4',5,5'-
		2	2.00000 e-1	7.06592 e-5		Hexachlorobiphenyl
		3	5.00000 e-1	7.87998 e-5		
		4	1.00000 e-1	7.71208 e-5		
21	20.362	1	1.00000 e-1	5.74088 e-5	PCB 157	2,3,3',4,4',5'-
		2	2.00000 e-1	5.99070 e-5		Hexachlorobiphenyl
		3	5.00000 e-1	6.86723 e-5		
		4	1.00000 e-1	6.46208 e-5		
22	20.803	1	1.00000 e-1	1.01143 e-4	PCB 170	2,2',3,3',4,4',5-
		2	2.00000 e-1	1.08323 e-4		Heptachlorobiphenyl
		3	5.00000 e-1	1.21671 e-4		
		4	1.00000 e-1	1.28498 e-4		
23	20.906	1	1.00000 e-1	6.78944 e-5	PCB 180	2,2',3,4,4',5,5'-
		2	2.00000 e-1	6.99831 e-5		Heptachlorobiphenyl
		3	5.00000 e-1	7.74653 e-5		
		4	1.00000 e-1	7.54099 e-5		
24	21.461	1	1.00000 e-1	7.56712 e-5	PCB 185	2,2',3,4,5,5',6-
		2	2.00000 e-1	7.77298 e-5		Heptachlorobiphenyl
		3	5.00000 e-1	8.39932 e-5		
		4	1.00000 e-1	8.35599 e-5		
25	21.691	1	1.00000 e-1	6.29590 e-5	PCB 189	2,3,3',4,4',5,5'-
		2	2.00000 e-1	6.45361 e-5		Heptachlorobiphenyl
		3	5.00000 e-1	6.90699 e-5		
		4	1.00000 e-1	6.91059 e-5		
26	22.692	1	1.00000 e-1	9.82981 e-5	PCB 195	2,2',3,3',4,4',5,6-
		2	2.00000 e-1	9.63889 e-5		Octachlorobiphenyl
		3	5.00000 e-1	1.07559 e-4		
		4	1.00000 e-1	1.09543 e-4		
27	23.217	1	1.00000 e-1	1.09001e-4	PCB 206	2,2',3,3',4,4',5,5',6-
		2	2.00000 e-1	1.12394 e-4		Nonachlorobiphenyl
		3	5.00000 e-1	1.25769 e-4		
		4	1.00000 e-1	1.28508 e-4		

PCB 167 was detected in wet season control site (0.502 ± 0.578 ppm) but lower in active site (0.673 ± 0.104 ppm).The mean concentration in dry season at Epe active site was very low (0.666 ± 0.941 ppm) when compare to control site which was higher (3.673 ± 5.658 ppm) while it was absent in wet season active and low concentration at control site(0.181 ± 0.256 ppm). Olusosun active site in dry season was observed to have concentration of PCB 167 at a comparative value of (2.737 ± 3.024 ppm) in wet season active site but with a low concentration at control site (1.144 ± 0.562 ppm).In wet season at Olusosun active site,a low concentration of

PCB167 was detected (.214 ± 3.925 ppm) but was above detection limit at the control site (0.541 ± 0 ppm). The PCB 167 mean concentration in dry season at Shagamu was detected in active site with a value of (6.779 ± 3.131 ppm) and was above detection limit at control site (2.612 ± 0 ppm) while wet season active site has PCB 167 (8.498 ± 10.689 ppm), absent at control site and above detection limit in maize samples (3.126 ± 0).

CONCLUSION

The determination of Polychlorinated biphenyls PCB and the impact in the environment have been widely identified in the studied dumpsites as well as control sites. The Levels and distributions of mean concentrations of these organic compounds in soil, Maize and water samples were determined using Gas Chromatography and Mass Spectrometer (GC-MS). A range of 27 PCB congeners with low, medium and high concentration were detected and widely distributed in all the analysed samples as collected from four study sites. The results obtained in this study showed wide distribution of PCB's with high concentration at the control sites more than dump site, which made control areas to be susceptible to exposure to chemical hazard that could have a negative impact in the environment most especially schools, communities and farmland as the results showed that they are above their threshold values found in the literatures, this further means that the health risk assessment is high as the values obtained were not within safe limits. The EPA considered maximum contaminant level of PCB's in drinking water to be zero and enforceable MCL in public water system to be 0.0005ppm (EPA 2001) while FDA mandates tolerances of 0.2-3.0 ppm PCBs for all foods. The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) also allow a daily PCB intake of 6 µg/kg per day (AAP 2003).

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