COMPARISON OF THE RESPONSE OF PCB FIELD TEST METHODS TO DIFFERENT PCB AROCLORS

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ABSTRACT

Polychlorinated biphenyls (PCB) are one of several environmental analytes that are not composed of single compounds but rather groups of related compounds. Because the analyst is looking for a number of different compounds, he or she must be aware of exactly what a particular analytical technique is detecting. To evaluate how well several popular field methods (2 immunoassays and one chemical method) can test over the range of possible Aroclors, a study was performed where each of the three methods was used to test a broad range of available Aroclors. Results show that on the lower chlorinated Aroclors (e.g. 1221) and the more highly chlorinated Aroclors (e.g. 1268) the chemical method may be off by a factor of three and the immunoassay methods by a factor of 100. Analysts using these techniques, therefore, should know ahead of time exactly what Aroclors they are dealing with or should implement proper correction factors to eliminate the chance of false negative results.

INTRODUCTION

Several methods currently exist to test for PCBs in all soil samples. The most established and most quantitative is gas chromatography (GC), usually capitalizing on the high sensitivity of the electron capture detector (SW-846 method 8080). GC is an excellent technique for quantifying PCBs because it separates out different congeners and quantifies them individually, alerting the analyst to any Aroclor mixtures or weathering that may have occurred while the PCBs have been exposed to the environment.

Field screening methods usually do not quantify individual compounds when testing for PCBs but make an estimate based on one or more characteristics of the target analyte. Therefore, field testing methods may give results that differ from other test methods even though they are operating exactly as designed. Three such field methods were compared on soils contaminated with a variety of Aroclors to see how they would respond in relation to each other. Two of the methods tested are immunoassay (IA) based tests (Millipore EnviroGard™, Ensys PCB RISc™) and one is a chemical based testing device (Dexsil L2000 PCB Analyzer™).

BACKGROUND

Immunoassay based test kits (ELISA) that are currently available for PCB analysis are specific devices that are designed to test exclusively for PCBs. When an animal is immunized to produce antibodies for PCBs, it is injected with a derivative of a single or several PCB congeners, but not all 209. Therefore, the antibodies that it produces will be sensitive to specific congeners, but not to all PCBs. For instance, if antibodies are produced to respond to 3,4,3′, 4′ tetrachlorobiphenyl, the test kit that utilizes this antibody will be highly sensitive to 3,4,3′,4′, tetrachlorobiphenyl but less sensitive to PCBs that contain different numbers of chlorine atoms or have chlorine atoms at different locations on the biphenyl molecule. As a result of this variation in sensitivity to different PCB congeners, the analyst using IA test kit may obtain vastly different responses to different Aroclors.

The L2000 PCB Analyzer is not based on an immunoassay, but instead, chemically detects the presence of PCBs by analyzing the sample for total organic chlorine and translates the amount of chlorine detected into ppm PCBs. All PCBs contain some chlorine and therefore, if the percent chlorine in the PCB being analyzed is

known, the amount of PCB present can be easily quantified. The percent chlorine contained in a specific Aroclor is usually given by the last two numbers in the four digit Aroclor designation, e.g. Aroclor 1260 is composed of 60% chlorine. Aroclors vary in chlorine content from 21 to 68 percent. This means that for a given concentration of PCB amount of chlorine will vary by about a factor of three.

Because both the IA methods and L2000 method may vary in response among Aroclors, a study was designated to determine what that variation might be. If the analyst is testing at a specific level for a certain Aroclor, then what levels of the other Aroclors would need to be present to avoid a false negative? — or to avoid a false positive?

PREPARATION

Each field method was purchased or calibrated to test for Aroclor 1242 at a level of 2 ppm. The following Aroclors were included in the study:

1221 1232 1016 1242 1248 1254 1260 1268

Neat standard from General Electric (1254, 1260), Ultra Scientific (1268), Analabs (1248, 1242, 1016), Monsanto (1232), and Chem Services (1221) were used to make standard in hexane at a level of 1000 ug/g.

A standard soil was made by mixing 6 kg dried clay wit 2 kg dried sand after passing each through a 850 um sieve. The mixture was then tumbled overnight to assure uniformity. The mixture was analyzed by method 8080 to assure that it was PCB free. Soil standard were prepared by placing 200 g of soil on an aluminum pan and spiking with the appropriate amount of PCB in hexane standard. Enough additional hexane was added to form a slurry. Samples were mixed and allowed to dry over night in a fume hood. Samples were then placed in glass jars and tumbled for four hours to assure uniformity.

Soil samples were prepared at the following concentrations:

Aroclor	Concentration (ug/g)
1221	40, 200
1232	20
1016	5
1242	2, 5
1248	1, 2
1254	5
1260	10
1268	10, 100

PROCEDURE

Each field test was run according to the instructions supplied by each manufacturer. All the Aroclors were run on each test and the PCB concentration in each soil was adjusted and reanalyzed until a result was obtained that gave a response equal to or just greater than the response obtained from 2 ppm of Aroclor 1242. Soil samples were initially tested at concentrations determined from the “detection limit” information provided by each manufacturer. The levels at which the L2000 was tested were simple to calculate because the percent chlorine of each Aroclor is well known. The levels for the IA kits were more difficult to choose because predicting the response of the kits to various Aroclors is not straightforward. This involved an iterative process of lowering or raising the PCB concentrations until a response equal to or greater than that of 2 ppm 1242 was obtained. PCB concentrations below those in the originally prepared soil samples were made by cutting the soil samples with the appropriate amount of blank soil to arrive at the final concentration. For example, a 6 ppm 1232 sample was prepared by mixing 3 g of 20 ppm 1232 standard with 7 g of blank soil.

RESULTS

For each of the eight Aroclors tested, Table 1 lists the PCB concentration that was required to yield a response equal to that of 2 ppm Aroclor 1242. For both of the IA kits, a level of 40 ppm 1221 was required to yield a positive test result. The L2000 pro-

vided a positive result at 4 ppm of the same Aroclor. The most sensitive Aroclors for the Millipore test were 1248 and 1254 which yielded positive results at 0.9 ppm. The most sensitive Aroclor for the Ensys test was 1260 which resulted in a positive test at a level of only 0.4 ppm. The L2000 exhibited the greatest sensitivity to the most highly chlorinated Aroclor, 1268, and gave a positive response at a level of 1.2 ppm.

Table 1

Aroclor	Millipore	Ensys	L2000
1221	40	40	4
1232	7	3	2.6
1016	3	3	2
1242	2	2	2
1248	0.9	1.1	1.8
1254	0.9	0.7	1.6
1260	1.5	0.4	1.4
1268	25	3	1.2

The sensitivity ratios for each method, defined as the ratio of the concentrations required to yield a positive test between the most sensitive and least sensitive of the Aroclors, was determined to be the following:

For the Millipore test 1221:1248=40:0.9=45

For the Ensys test 1221:1260=40:0.4=100

For the L2000 test 1221:1268=4:1.2=3.3

This means, that depending on the method, a specific test may require that one type of PCB be at a concentration 100 times greater (Ensys) than another type in order to yield the same response. This ratio should remain a constant for each method and will not vary with a change in calibrating Aroclor or concentration.

CONCLUSION

What are the consequences of these results? Suppose an analyst is field testing for PCBs at a site known to contain a variety of Aroclors, some of them partially weathered. The regulator has states that the site must be cleaned up to a level of PCBs no greater than 2 ppm. Now the analyst has a decision to make. If he or she uses an immunoassay test should the test be calibrated using the most sensitive Aroclor, least sensitive Aroclor, or something in between? By calibrating on the Aroclor with the highest sensitivity, (1248 ir 1254 for Millipore and 1260 for Ensys) if Aroclor 1221 is present, the test will not yield a positive result until the level reaches 90 ppm for the Millipore test or 200 ppm for the Ensys test meaning that there is a very high probability of obtaining a false negative. If the analyst chooses to calibrate on the least sensitive Aroclor (1221) in an effort to avoid false negatives, then false positives would result for anything above a level of 0.045 ppm 1254 for the Millipore test and for anything above 0.02 ppm 1260 for the Ensys test. The odds of obtaining a false positive result are huge! If an Aroclor with an average sensitivity is chosen, then the false positive/false negative debate is split down the middle and the potential for either one is still quite high.