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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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SUMMARY

In June 1995 and February 1996, a Health Hazard Evaluation was conducted at the Fish and Wildlife Service's (FWS) Chicago Port by the National Institute for Occupational Safety and Health (NIOSH). The evaluation was conducted in response to employee and management requests to NIOSH for assistance in evaluating worker exposures to residual pesticides on animal trophies imported into the United States. Approximately 80 FWS inspectors are involved in inspecting animal trophies at ports throughout the country. The FWS personnel inspect the contents of shipping containers to determine if there are endangered or internationally protected species present, and to compare the contents with the shipper's declaration. Typically, the trophies are partially prepared/preserved at the oversees location and are then sent to the U.S. for further processing. Various insecticides and fungicides may be applied to the hunting trophies to preserve them during preparation and shipment.

The NIOSH evaluation included the collection of bulk samples, personal breathing zone air samples, and area air samples for pesticide analysis. These samples were collected during routine trophy inspections which lasted approximately 20–40 minutes. A total of 15 bulk samples were collected from these shipments. All of the samples contained at least one of the following pesticides: lindane, carbaryl, fenitrothion, and/or DDT. One sample contained lindane, fenitrothion, and DDT. Personal breathing zone air samples collected on the follow–up visit did not contain detectable pesticide concentrations. This was not surprising given that only small amounts of lindane were detected on shipments inspected that day. Area air samples collected in the headspace of the shipping containers revealed primarily naphthalene, terpenes, and aliphatic hydrocarbons.

A potential health hazard exists from exposure to residual pesticides on animal trophies imported into the U.S. Because FWS inspectors must examine and handle the contents of the trophy shipments, skin contact with these residual pesticides is of primary concern. Although airborne pesticides were not found during the NIOSH evaluation, they could be present during inspections of more heavily contaminated materials. Recommendations are made in the report to prevent skin contact with animal trophies and to minimize the potential for aerosolization of particulate material and contamination of the surrounding environment.

Keywords: SIC 9512 (Land, Mineral, Wildlife, and Forest Conservation), pesticides, insecticides, animal trophies, hunting trophies, wildlife, taxidermy, lindane, fenitrothion, carbaryl, DDT.

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INTRODUCTION

In December 1994, the National Institute for Occupational Safety and Health (NIOSH) received employee and management requests for assistance in evaluating worker exposures to residual pesticides on animal trophies imported into the United States (U.S.). Environmental monitoring was performed at the Chicago port in June 1995 and February 1996. This report presents the results of the NIOSH evaluation and provides recommendations for minimizing exposures to potentially contaminated animal trophies.

BACKGROUND

There are approximately 80 Fish and Wildlife Service (FWS) inspectors in the U.S. At the time of the NIOSH site visits, five wildlife inspectors performed animal trophy inspections at the Chicago port. At this location, trophy shipments are most commonly received from Africa, Australia, and Asia. Trophy shipments are temporarily stored in the importing airline's warehouse until they are inspected, generally within a few days of arrival. FWS inspectors open the shipping containers to determine if there are any endangered or internationally protected species present, and to compare the contents with the items listed on the shipper's declaration.

In some cases the containers have previously been opened by U.S. Department of Agriculture inspectors. Shipments generally contain items that have been partially preserved at the original location (i.e., dry, salted hides), but may also contain fully–mounted or finished specimens. After passing inspection, the trophies are sent to a taxidermy facility in the U.S. for further processing. The number of trophy shipments received at the Chicago port is variable. Employees reported that two shipments are typically received per week during June, while greater than five shipments per week may be received during winter months. Various insecticides and fungicides may be applied to the trophies to preserve them during preparation and shipment. Preliminary analyses of bulk materials by FWS chemists indicated the presence of organochlorine, organophosphorus, and carbamate pesticides in some samples.

METHODS

Initial Evaluation

On June 19, 1995, three trophy shipments were inspected by a FWS inspector and supervisor. Bulk samples of particulate material were collected from each shipment. In some cases, a sample of loose particulate material was taken from the bottom of the container, while in other cases, the samples were scraped from the surface of the cape or skin. Additionally, some of the newspaper and sawdust packaging materials were sampled. A total of 11 samples were collected for pesticide analysis.

The largest sample (sample 003) was analyzed first to determine the most appropriate methods of analysis. A weighed portion of the sample (approximately one gram) was desorbed into 2 milliliters (mL) of a 9:1 toluene/acetone solution and rotated at 10 revolutions per minute (rpm) for one hour. Aliquots were then analyzed by gas chromatography using NIOSH Method 5600 (organophosphorus pesticides by flame photometric detection[1]), and EPA Method SW 846/8080 (organochlorine pesticides by electron capture detection[2]). Additionally, a one–gram sample of this material was sonicated in 5 mL of acetonitrile for two hours and an aliquot analyzed for carbamate pesticides by high pressure liquid chromatography (HPLC) with ultraviolet (UV) detection at 225 nm. The latter is an in–house method currently being evaluated by NIOSH. Because several unknown peaks were present in the chromatograms from the above analyses, a sample of this material was dissolved in toluene and analyzed by gas chromatography/mass spectrometry (GC/MS) for further identification.

The remaining 10 samples were analyzed by extracting them with methylene chloride and analyzing the extracts by GC/MS. Because carbamate pesticides can degrade in a gas chromatograph, a separate analysis was performed for carbamate pesticides by desorbing a weighed portion of the samples (from 4 to 187 milligrams) in 1.5 mL of acetonitrile. The solutions were sonicated for one hour, filtered, and aliquots analyzed by HPLC with UV detection at 225 nm and full scan (190 – 400 nm).

Sample 003 was also analyzed for elemental composition by NIOSH Method 7300 modified for microwave digestion of bulk samples.[3] This method determines the concentration of 28 elements (minerals and metals) by inductively coupled plasma emission spectrometry.

Follow–up Evaluation

On February 29, 1996, a follow–up evaluation was conducted to obtain additional bulk material samples for pesticide analysis and to assess the potential for inhalation exposures through personal breathing zone and area air samples. Four shipments were inspected by a FWS inspector on the follow–up evaluation. This included five shipping containers located in two warehouses.

Prior to the shipments being inspected, seven headspace air samples were collected in the five shipping containers (two were duplicates) by opening the crates just enough to place the sorbent tubes inside. The sorbent tubes contained three beds of sorbent materials (Carbopack Y, Carbopack B, and Carboxen 1003) attached to air sampling pumps via Tygon® tubing. The pumps were operated at 100 mL/minute. Samples were analyzed using an automated thermal desorption (ATD) system interfaced to a GC and mass selective detector (TD–GC–MSD). The sorbent tubes were desorbed in the ATD at 375^{N}F for 10 minutes prior to analyses.

A total of four bulk samples were collected. This included one composite sample in each shipping container with the exception of the container that held finished specimens. The latter did not contain any loose particulate material. Each sample was qualitatively analyzed for organophosphorus, organochlorine, and carbamate pesticides, and by GC/MS. Samples for organochlorine and organophosphorus pesticide screens were analyzed in accordance with NIOSH Method 5600 with modifications.[1] A weighed portion of the sample was desorbed into 4 mL of a 9:1 toluene/acetone solution and rotated for one hour. Aliquots were then analyzed by gas chromatography using flame photometric detection for the organophosphorus screen, and electron capture detection for the organochlorine screen. Because fenitrothion is not one of the pesticides included in the organophosphorus screening method, a separate analysis was conducted for this pesticide using GC with flame photometric detection. Samples for carbamate pesticide screens were analyzed as previously described using HPLC with UV detection at 225 nm.

Personal breathing zone air samples were collected on the FWS inspector during the entire time period that the work was performed. Separate air samples were collected at each warehouse. The air samples were collected using an OVS–2 tube attached to a personal air sampling pump calibrated at 1 liter per minute. These tubes contain a 13 millimeter diameter quartz filter for collecting the particulate fraction, followed by an XAD–2 sorbent material for collecting the vapor phase pesticides. The front and rear sections of the tubes were desorbed in 2 mL of a 9:1 toluene/acetone solution and agitated for one hour. Analysis for organochlorine pesticides (based on bulk material analyses) was performed using GC with electron capture detection in accordance with EPA Method 8080.[2]

EVALUATION CRITERIA

A summary of the primary health hazard data and pertinent chemical and physical properties for the pesticides detected by NIOSH can be found in Table 1.

RESULTS

Initial Evaluation

The two employees conducting the inspections wore disposable Tyvek® suits and shoe coverings, disposable nitrile gloves, and NIOSH–approved full–facepiece respirators equipped with particulate and organic vapor cartridges. The contents of the cartons were visually inspected, with each inspection taking less than 30 minutes.

Results of the pesticide analyses of bulk materials are shown in Table 2. Sample 003, powder taken from a lion's hide, was analyzed first and found to contain fenitrothion, lindane, and 4,4'–DDT. While chromatographic peaks were present at retention times matching several of the carbamate standards, the peaks could not be confirmed as carbamates (as opposed to false positives) due to the lack of confirmation by other means. For all samples analyzed subsequently, the carbamate analysis was modified to include a comparison of the UV spectra (full scan) for all peaks which eluted at the same time as the standards. Fenitrothion and DDT were found in a second sample of powder taken from shipment 1, but were not present in samples from shipments 2 and 3.

Carbaryl was detected in samples from shipments 2 and 3, and lindane was present in shipment 3. Only one of the powdered samples did not contain any detectable pesticides (sample 005); however, the amount of material available for analysis was very small, resulting in a high analytical limit of detection.

The elemental analysis of sample 003 revealed primarily calcium (13%); magnesium (6.3%); sodium (1.2%); aluminum (0.44%) phosphorous (0.31%) and iron (0.24%). Chromium was detected at a concentration of about 0.015%. Other metals such as lead, arsenic, and nickel were not detected; the LOD for these metals was about 6 micrograms per gram of sample, or 0.0006%.

During informal discussions with four FWS inspectors, employees expressed concern about headaches, eye and nose irritation, bad taste, and odors experienced during trophy inspections. Employees also expressed concern about discomfort experienced during summer months from the use of disposable Tyvek® suits and full–facepiece respirators. The use of respirators and disposable clothing was a new requirement for Region 3 FWS inspectors in early 1994.

Follow–up Evaluation

One employee conducted the trophy inspections at the two warehouses. The personal protective equipment ensemble was identical to that described earlier. The inspections took approximately 30 to 40 minutes.

Prior to the inspection, area air samples were collected in the headspace of the shipping containers for volatile organic chemicals (VOCs). The results showed low levels of VOCs, primarily naphthalene (a moth repellant and fungicide), C_{10}–C_{12} aliphatic hydrocarbons, terpene derivatives, and propane (most likely from the forklift trucks used in the warehouse). Low levels of acetone and toluene also were found on the air samples collected inside shipment number 1 (see Table 3). None of the pesticides detected in the initial evaluation were detected in these air samples.

Results of the pesticide analyses of bulk materials are shown in Table 3. Lindane was detected in the bulk samples from all four containers. The concentration of lindane (including the alpha, beta, and gamma BHC fractions) ranged from 0.06–0.46 microgram (µg) per gram of particulate material. None of the other pesticides on the screening panels were present in confirmable quantities; however, some unidentified peaks were present in the chromatograms. The GC/MS analyses revealed only the presence of alkanes in some samples. Fenitrothion was not detected in these samples above a limit of detection of 0.6 µg/sample.

Based on the bulk sample results, the personal breathing zone air samples collected on the FWS inspector were analyzed only for organochlorine pesticides. None of the organochlorine pesticides in the screening panel were found in the air samples. The limit of detection for lindane, the only pesticide identified in the bulk samples, was 0.005 μg/sample, which equates to a minimum detectable concentration of 0.13 microgram per cubic meter ($\mu g/m^3$) for a sample volume of 39 liters. For comparison purposes, the NIOSH recommended exposure limit (REL) and OSHA permissible exposure limit (PEL) are 500 $\mu g/m^3$ as a time–weighted average exposure over the workshift.

DISCUSSION AND CONCLUSION

The analytical results showed the presence of pesticides in all of the bulk samples collected by the NIOSH investigator. These results are consistent with those reported by the FWS Forensic Laboratory for bulk materials collected from the Dallas, Chicago, and Houston ports. All of the pesticides detected in the NIOSH survey were found in previous FWS shipments with the exception of DDT. This may be a new finding or may be the result of the increased sensitivity of the electron capture detector used in some of the NIOSH analyses.

Assessment of worker exposures to residual pesticides is complicated by the fact that information is not presently available on the specific types of insecticides and fungicides that are applied to animal trophies imported into the U.S. In addition, pesticides which are banned in our country, such as DDT, or those which have restricted usage in the U.S. may still be used in other countries. While the pesticides identified by NIOSH are consistent with those found previously by the FWS, there is no certainty that future shipments will not contain additional or different pesticides. Because many pesticides can be absorbed dermally and skin contact is considered an important route of exposure for most of the identified pesticides, the use of skin protection is particularly important when conducting trophy inspections. The disposable nitrile gloves worn by FWS inspectors did not sufficiently protect the workers from skin contact due to their short length.

On the follow–up survey, personal breathing zone air sampling was performed to assess the risk of inhalation exposure and to determine if the level of respiratory protection in current use is appropriate. However, the shipments inspected on the follow–up survey contained primarily rock salts and only small amounts of lindane. Thus, it is not surprising that the air samples did not contain detectable levels of pesticides. The air sampling results did not indicate the need for respiratory protection; however, it is possible that significant airborne exposures could occur if a shipment were more heavily contaminated. Because these results are limited to only two inspections, it is difficult to comment on the appropriateness of the existing level of respiratory protection used by inspectors. Additional air sampling may help address this concern. It is likely that the main airborne exposure would be to particulate rather than vapor–phase pesticides due to the relatively low vapor pressure of these pesticides and the fact that the shipments may be in transit for long periods of time before reaching the inspectors (weeks to months). The decision to use respiratory protection should be made with consideration to the average length of time it takes to conduct the inspections and the frequency of the inspections.

RECOMMENDATIONS

1. Ideally, a separate location or room with good general ventilation should be used for conducting animal trophy inspections.

2. Replace existing gloves with ones that provide better protection for exposed hand and arm surfaces and against sharp objects. Disposable nitrile gloves having a greater mil thickness and longer cuff length are available.

3. Consideration should be given to the use of

disposable Tyvek® aprons during trophy inspections in place of full Tyvek® suits to improve comfort and minimize the potential for heat stress in hot weather.

4. A disposable plastic tarp should be placed on the floor before removing the contents of the containers to minimize contamination of the surroundings. This tarp can be disposed after each inspection along with the disposable personal protective equipment.

5. Personal breathing zone air sampling should be conducted by the FWS to further evaluate the need for, and appropriate level of, respiratory protection.

6. Shippers should be required to identify the pesticides applied to each shipment. If this cannot be made a requirement for legal reasons, other means of obtaining this information should be explored. For example, historical shipping records could be reviewed and a prioritized listing made of the most common shipping agents and taxidermists in each region. Efforts could then be made to contact the individual taxidermy facilities to obtain additional information on products applied to the shipments before export.

7. Employees should be educated about pesticides, their health effects, and proper handling. The training should include the most likely pesticides (such as those identified by FWS and NIOSH) as well as the most toxic pesticides employees may encounter. It should include symptoms and physical effects that would allow FWS employees to identify an overexposure. It should also include training on the use of personal protective equipment to prevent or minimize exposures to pesticides. An example of the type of information that could be used in training is provided in the appendix.

8. Baseline red blood cell cholinesterase activity (RBC–ChE) should be measured on each FWS inspector at risk of exposure to organophosphorus and carbamate pesticides. Please see the appendix for additional information concerning RBC–ChE testing for workers without a baseline, and the frequency of periodic testing for workers exposed to organophosphorus insecticides. A knowledgeable medical practitioner should be consulted for assistance in establishing a biological monitoring program appropriate for FWS employees performing animal trophy inspections.

9. A method should be implemented for informing taxidermists who receive these shipments about known or possible contamination with pesticides. This could include a generic label applied by FWS inspectors stating that these trophy shipments may contain pesticide residues and that precautions may need to be taken to avoid exposure.

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Table 1 Chemical, Physical, and Health Hazard Data for Selected Pesticides U.S. Fish and Wildlife Service HETA 95–0074, 95–0080					
Substance	**CAS No.**	**Vapor Pressure (room temp)**	**NIOSH REL (mg/m^3)***	**OSHA PEL (mg/m^3)***	**Primary Health Effects**
Carbaryl	63–25–2	<0.00004 mm	5	5	An odorless, crystalline solid used as an insecticide. A short–acting cholinesterase inhibitor which can be absorbed through inhalation, skin absorption, and ingestion. See Appendix for more information on signs and symptoms of overexposure and medical monitoring of cholinesterase inhibiting pesticides. A carbamate pesticide.
DDT	50–29–3	0.0000002 mm	0.5	1	A white crystalline solid with an aromatic odor. This insecticide is banned in the U.S. but continues to be used oversees. It can be absorbed through inhalation, skin absorption, and ingestion. It affects the nervous system and when ingested in high doses causes paresthesias, tremor, and convulsions. Eye and skin irritation has resulted from heavy exposure to the dust. An organochlorine pesticide.
Fenitrothion	122–14–5	0.00006 mm	NA	NA	A brownish or yellow volatile oily liquid that may be formulated as a dust or wettable powder. It is used as an insecticide and acaricide. It can be absorbed through inhalation, skin absorption, and ingestion. See Appendix for more information on cholinesterase inhibiting pesticides. An organophosphorus pesticide.
Lindane	58–89–9	0.00001 mm	0.5	0.5	A crystalline solid with a musty odor. It is used as an insecticide and is in the organochlorine family. It can be absorbed through inhalation, skin absorption, and ingestion. Exposure to the vapor can result in eye and respiratory irritation, headaches, and nausea.

* The NIOSH recommended exposure limits (RELs) and OSHA permissible exposure limits (PELs) are expressed as time–weighted averages over an 8–hour (OSHA) or 10–hour (NIOSH) workshift.

mm = millimeter
mg/m^3 = milligrams per cubic meter
NA = not applicable
NIOSH REL = National Institute for Occupational Safety and Health recommended exposure limit
OSHA PEL = Occupational Safety and Health Administration permissible exposure limit

Table 2
Pesticide Composition of Bulk Materials
U.S. Fish and Wildlife Service
HETA 95–0074, 95–0080
June 19, 1995

Shipment No./ Shipping Agent/ Location	*Sample No.*	*Description*	*Pesticide Class* *Organo–phosphorous*	*Organo–chlorine*	*Carbamate*
(1) Tanzania Sarafis and Hunting Ltd./ Arusha, Tanzania	001	powder from baboon skin	fenitrothion	lindane, trace DDT	ND *
	002	sawdust from crate	ND	ND	ND
	003	powder from lion hide	fenitrothion	lindane, DDT	unconfirmed†
	004	newspaper packing material	ND	ND	ND
(2) Kuehne & Nagel Inc./ Windhoek, Namibia	005	powder from gemsbok tail‡	ND	ND	ND
	006	powder from Kudu cape	ND	ND	carbaryl
	007	powder from springbok cape and backskin	ND	ND	carbaryl
(2) Kuehne & Nagel Inc./ Windhoek, Namibia	008	powder from hartebeest skull	ND	lindane	carbaryl
	009	powder from oryx cape	ND	ND	carbaryl
	010	powder from skull	ND	lindane	carbaryl
	014	powder from bottom of box	ND	lindane	carbaryl

* ND = not detected.
† peaks were detected at appropriate retention times of standards but analysis was not performed at another wavelength for confirmation.
‡ sample size was very small (0.016 g) relative to all other samples above, thus detection limits for the analytes of interest were high.

Table 3
Pesticide Composition of Bulk Materials
U.S. Fish and Wildlife Service
HETA 95–0074, 95–0080
February 29, 1996

Shipment No./ Shipping Agent/ Location	*Sample No.*	*Description*	*Pesticide Class*		
			Organo–phosphorous	*Organo–chlorine*	*Carbamate*
(1) Trans African Taxidermists/ Mulderdrift, South Africa	1–3	Composite sample containing a rock salt material	ND ∗	Lindane	ND
(2) Trans African Taxidermists *or* Taxidermy Enterprises/ Bulawayo, Zimbabwe	4–6	Composite sample including paper, cardboard, and sawdust	ND	Lindane	ND
(3) Matabeleland Taxidermy/ Bulawayo, Zimbabwe	7–9	Composite sample containing a rock salt material and loose particulate	ND	Lindane	ND
(4) Trans African Taxidermists *or* Taxidermy Enterprises	10–12	Composite sample containing a rock salt material and loose sandy particulate	ND	Lindane	ND

∗ ND = not detected.

Appendix

Cholinesterase–inhibiting pesticides

Organophosphorus and carbamate pesticides have been detected in powder samples taken from animal trophy shipments. These pesticides can be absorbed by inhalation or through the skin. Although toxicity varies from chemical to chemical, they typically cause human illness by binding to and inhibiting acetylcholinesterase (A–ChE) at nerve endings. A–ChE is a cholinesterase (ChE) enzyme that breaks down and thus controls the amount of acetylcholine (a nerve impulse transmitter) available to send impulses from one cell to another. When A–ChE is inhibited, it cannot break down acetylcholine. Acetylcholine then accumulates at nerve endings, causing increased and continued nerve stimulation at those sites. The organophosphate–ChE bond is stable and largely irreversible. Therefore, recovery of A–ChE activity depends on the generation of new A–ChE. A–ChE inhibition, therefore, can sometimes last for months. On the other hand, the carbamate–ChE bond is rapidly reversible. The effects of carbamate poisoning, however, can be just as severe as those of organophosphorus poisoning.

Symptoms of moderate A–ChE toxicity include nasal and lung congestion, chest tightness, wheezing, shortness of breath, nausea, abdominal discomfort, and diarrhea. These symptoms may be confused with symptoms of viral infections (such as colds and influenza) or allergies. Other symptoms of A–ChE toxicity, such as increased tears and saliva, are unusual in viral infections and allergies. Therefore, overexposure to a ChE–inhibiting pesticide can sometimes be recognized by a characteristic pattern of symptoms that would not be expected from other illnesses. However, a reliable diagnosis can be made only after appropriate medical evaluation. The effects of severe overexposure, such as respiratory distress and seizures, are medical emergencies and require immediate evaluation and treatment.

ChE inhibition can be measured as decreases in ChE activity. Red blood cell–ChE (RBC–ChE), like ChE in nerve tissues, is an A–ChE. Its rate of generation nearly parallels that of A–ChE in nerve tissues, making it useful for monitoring exposure to ChE–inhibiting pesticides. A significant decrease in RBC–ChE activity indicates either a recent excessive exposure to a ChE–inhibiting pesticide or repeated exposures to organophosphorus insecticides in amounts sufficient to chronically depress ChE activity. Because the effects of overexposure to carbamate pesticides are short acting, past exposures would not be detected by biological monitoring.

Other types of ChEs, such as pseudocholinesterase (P–ChE, also known as plasma or serum ChE), are more sensitive to ChE inhibition. Thus, P–ChE activity can be clinically useful in monitoring cases of severe ChE inhibition. However, its use in monitoring workplace exposures is limited because P–ChE activity can return to baseline values within hours after removal from exposure (compared with weeks to months for RBC–ChE activity). Therefore, P–ChE values may not reflect the severity of toxicity unless blood specimens are obtained immediately after exposure. P–ChE activity can also be affected by factors unrelated to organophosphorus or carbamate exposure, including medical conditions such as liver disease.[1]

For employees with potential for occupational exposure during the manufacture and formulation of ChE–inhibiting pesticides, such as organophosphorus and carbamate pesticides, NIOSH recommends that RBC–ChE activity be measured.[2] The range of RBC–ChE activity varies considerably among individuals who have not been exposed to organophosphorus insecticides. Thus, an individual could experience a toxic decrease in RBC–ChE activity and still be within the range found in the general population ("normal" or reference range). For this reason, a single value within the laboratory's reference range should not be interpreted as a "normal" value. Instead, toxicity should be determined by comparing a given value with the individual's baseline value.

NIOSH defines an unacceptable exposure as a decrease in RBC–ChE activity to below 70% of the baseline value.[2]

NIOSH recommendations for biological monitoring of potentially exposed workers in the manufacture and formulation of ChE–inhibiting pesticides include a baseline measurement of RBC–ChE activity before potential for exposure begins.[2] For workers potentially exposed to organophosphorus insecticides, NIOSH recommendations also include periodic measurements at least annually thereafter.[2] NIOSH defines the pre–exposure baseline for RBC–ChE activity as the mean of two RBC–ChE determinations, each of which is derived from a separate sample of blood taken at least one day apart after a period of at least 60 days without known exposure to any ChE–inhibiting compounds. If the ChE determinations produce values differing by more than 15%, additional determinations on new samples should be performed until successive tests do not differ by more than 15%. Because RBC–ChE may not return to baseline within 60 days, determination of true pre–exposure values for currently exposed employees who do not have baseline results may not be possible. Measurements of periodic RBC–ChE activity should be made available as frequently as once a week for employees who are potentially exposed to ChE–inhibiting pesticides. The testing frequency may be initially increased to as often as every day, or, after three determinations, may be decreased to as infrequently as every eight weeks. The frequency should be based on the decision of a responsible medical practitioner after consideration of the following for each employee: (1) the toxicity of the pesticides to which the employee may be exposed; (2) the potential duration and concentration of the pesticide exposure; (3) the state of health of the employee; and (4) the results of previous RBC–ChE determinations. The biological monitoring program should be supervised by a physician, preferably by someone who is knowledgeable about measures to prevent workplace exposures as well as the health effects of pesticides.

The Biological Exposure Index (BEI) adopted by the American Conference of Governmental Industrial Hygienists (ACGIH) for exposure to organophosphorus chemicals is an RBC–ChE activity equal to 70% of an individual's baseline.[3] The BEI represents the level which is most likely to be observed in specimens collected from a healthy worker who has been exposed to chemicals to the same extent as a worker with inhalation exposure to the time–weighted average (TWA) Threshold Limit Value (TLV). BEIs apply to 8–hour exposures, five days per week. ACGIH regards biological monitoring as complementary to air monitoring and not for use as a measure of adverse effects or for diagnosis of occupational illness.[3]

For workers without a baseline RBC–ChE value, repeated tests have been recommended after removal from exposure to determine the level at which RBC–ChE values stabilize.[4,5] RBC–ChE values, however, may continue to increase for several months after last exposure. Therefore, RBC–ChE values should not be considered baseline until they have stabilized. To ensure validity, tests should be performed by the same laboratory using the same analytic method.

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