MANAGEMENT PLAN FOR THE USE OF MARINE TOXINS IN RESEARCH LABORATORIES

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ABSTRACT

In response to an increase in the use of marine toxins in the laboratory and a general lack of regulatory guidance for managing them, the following management plan provides an approach for properly managing marine toxins in the laboratory. The plan discusses why marine toxins are being increasingly used in laboratories as well as their possible health effects if not managed properly. Methods for transportation, handling, and storage are also discussed. Suggestions are given for appropriate and adequate controls and medical surveillance needs. Although many of the environmental implications, which will be discussed later, are currently unknown, suggestions for a waste management plan are also included. This management plan is an effective and thorough method for effectively managing marine toxins in the laboratory.

IMPLICATIONS

Currently, there are no regulations or guidelines available for the proper management of marine toxins. While there may be sufficient evidence that there should be something regulating these chemicals because they are so toxic to humans, the regulatory system is slow. Although marine toxins continue to be unregulated, their use in research laboratories continues to grow. As knowledge of their beneficial uses and medical importance grows, so does the need for their proper management. This management plan is a tool that provides guidance to laboratories that work with marine toxins so they can minimize the toxin's affects both in the workplace and on the environment.

INTRODUCTION

Marine toxins are some of the most toxic substances known to humankind; even very small amounts can be lethal. These toxins are commonly known to cause poisoning in people who consume infected marine organisms, such as fish or shellfish. Recently, there has been an increase in the use of marine toxins for research purposes. The human effects of marine toxin poisonings, as well as a variety of medical research applications, are two of the primary research applications. The neurotoxic compounds of the marine toxins are of particular importance to medicine. Their effects on specific ion channels in nerve and muscle membranes and their use in investigating the excitable properties of nerve cells is a major reason for the current interest in the toxins (1). Because marine toxin research is relatively new and human toxicity data are limited to accidental ingestion of contaminated shellfish, there is little to no regulatory guidance available to safely manage these extremely toxic substances. The purpose of this plan is to provide guidance for research laboratories that use marine toxins in the area of transportation, storage and handling, controls, medical surveillance, and waste storage and disposal. Although there are many marine toxins known, and even more being discovered, this plan will focus specifically on shellfish and ciguatera (fish) toxins, which seem to be most commonly used in research. This management plan should always be used in conjunction with any applicable federal, state or local laws.

TOXIN CHARACTERISTICS

All marine toxins are produced by microscopic dinoflagellates such as *Gambierdiscus toxicus* and *Gymnodinium breve* (2). Their primary danger to humans occurs when larger marine organisms feed on or filter these dinoflagellates. The toxins produced by the dinoflagellates bioaccumulate within a larger organism, such as a fish, which can be consumed by humans. Ingestion, of course, is not the only concern when they are used in the research laboratory. Any route through which the toxins can enter the bloodstream is of importance when trying to safely manage them. Although shellfish and ciguatera toxins can affect the human body differently, the primary toxic effect is to the neurological system (3).

Shellfish Toxins

There are a variety of shellfish toxins causing four types of shellfish poisoning. Paralytic shellfish poisoning (PSP), which is caused primarily by saxitoxin (from red tide algal blooms); diarrheic shellfish poisoning (DSP), caused by okadaic acid; neurotoxic shellfish poisoning (NSP), caused by brevetoxins; and amnesic shellfish poisoning (ASP), caused by domoic acid (4). All four of these toxins are harmful to humans and have been used in research applications.

Research Applications of Shellfish Toxins. Many marine toxins are used in the laboratory to study the toxin's mode of action in humans and marine life. For instance, saxitoxin and brevetoxin are used to study the cytotoxic effects of marine toxins on human embryonic cells (5). Many researchers are extremely interested in the medical research aspects of okadaic acid because it has been linked to multiple health risks. Okadaic acid, which has been found to induce oxidative stress in the brain, is attributed to being a cause in neuronal loss in Alzheimer's disease and is being studied in Alzheimer's research (6). It is also being studied in research laboratories as a possible tumor promoter in mice and rats (7). Domoic acid is often used in research laboratories to understand neurological response and cell death following exposure to a neurotoxin (8). Various amounts and concentrations of shellfish toxins are used in research. For example, brevetoxins are used in concentrations as small as 10 nanomolar (9). Okadaic acid is used in animal research studies in concentrations of 100 nanograms per kilogram of body weight (6). This information becomes important when we later discuss the doses and concentrations of shellfish toxins that are lethal or poisonous to humans. As shellfish toxins are studied and understood more, their research applications will inevitably increase. Although beneficial for science and research, increased use in the laboratory will only reinforce the need for proper management of these extremely hazardous substances.

Human Effects. Historically, the primary route of exposure to marine toxins has been from ingesting infected marine organisms. Many marine toxins have not been studied for their health effects beyond ingestion hazards; for that reason, appropriate precautions should be made so they are treated with absolute care. Any way the toxin can enter the bloodstream should be considered hazardous, including contact and inhalation exposure. Exposure to even minuscule amounts of saxitoxin includes symptoms of numbness, tingling and burning of the lips and skin, as well as giddiness, ataxia and fever (2). Severe poisoning may lead to general muscular incoordination, respiratory distress and death from respiratory failure (4). Okadaic acid affects the gastrointestinal system causing severe diarrhea, injury to intestinal mucosa (4), and has been implicated in an increase in digestive cancers among shellfish consumers (10). Exposure to brevetoxin causes incoordination, paralysis, and convulsion when ingested and has been shown to irritate the eyes and nasal passages, leading to coughing and asthma-like symptoms when inhaled (4). Domoic acid can cause loss of balance, nausea, headache, disorientation and vomiting when ingested, and can lead to permanent loss of short-term memory (4). Not all of the shellfish toxins are lethal to humans but those that are not can be severely debilitating. The degree of poisoning correlates directly with the dose a person is exposed to. Although lethal human doses are not known for all shellfish toxins, regulatory limits for consumption are set extremely low. For instance, the maximum permitted level of okadaic acid in shellfish that is considered safe for consumers is set at 16-20 micrograms per 100 grams of shellfish flesh (4). One hundred grams of shellfish is about the size of one meal. An ingested amount of brevetoxin as small as 70 nanograms can cause intoxication in humans (11). Generally, amounts and concentrations of shellfish toxins used in research are below levels that are harmful to humans. Nonetheless, only a small amount of toxin can cause human poisoning and caution must always be taken when working with any amount or concentration of shellfish toxins.

Ciguatera Toxins

Ciguatera toxins are a group of marine toxins that cause ciguatera poisoning from eating toxic salt-water fish. Ciguatera poisoning is a major concern in tropical areas where fish is the principal food source. The primary toxin in this group is ciguatoxin, but also includes tetrodotoxin.

Research Applications. The primary use for ciguatera toxins in the laboratory is medical research, but the reaction of living cells to poisoning by the toxins is studied as well. For instance, the affect of cituatoxin on the intestines of mice is studied to determine how the toxin affects victims of ciguatera poisoning (12). Ciguatera poisoning does not only affect humans; it can also affect fish populations. For that reason, the result of ciguatera poisoning in fish embryos is being researched (13). Tetrodotoxin, a marine toxin found in the puffer fish, is being extensively researched for its medical purposes. Currently, it's being studied in medical research laboratories as a possible long-term topical anesthetic (14). Additionally, tetrodotoxin has been found to curb narcotic cravings in laboratory animals and is consequently being used in drug dependence research (15). Ciguatoxin is used in various amounts for research and one research study used doses between 0.23 and 14 nanograms (12). Tetrodotoxin is used in one research study in amounts of 40 microliters in 0.1, 1, 10 millimolar concentrations (14). Again, this information becomes important when discussing the doses and concentrations of ciguatera toxins that are considered lethal or poisonous to humans.

Human Effects. Ciguatera toxin and tetrodotoxin are both potentially fatal toxins. Tetrodotoxin poisoning causes a variety of neurological symptoms, which include numbness, tingling of the lips and inner mouth surfaces, weakness, paralysis of the limbs and chest muscles, and a drop in blood pressure (16). Ciguatoxin causes both gastrointestinal and neurological symptoms. Gastrointestinal problems include vomiting, diarrhea, and severe abdominal pain and the symptoms can prove fatal (17). Neurological symptoms, which include myalgia, ataxia, vertigo, dizziness, auditory hallucinations, and muscular numbness, are more severe and can persist for months or even years (17). Concentrations of ciguatera toxins that can cause human poisonings are very low. Levels of only 0.1 ppb of one particular ciguatera toxin (CTX-1) can result in human poisoning (18). Tetrodotoxin can be lethal at doses of only 1-2 milligrams, about 1.4 ounces of fish (19). Comparing the lethal human doses of tetrodotoxin and the amounts used in research, laboratory workers aren't likely to be working with lethal human doses. One thing that must be kept in mind is that current data are based on acute exposure. Health effects from chronic exposure to ciguatera poisoning are unknown at this time. Knowing this, marine toxins should always be strictly controlled regardless of the doses or concentrations used in the laboratory.

TRANSPORTATION, STORAGE, AND HANDLING

Transportation

The Department of Transportation (DOT) is the governing body regulating the shipment of hazardous materials and it is important to ensure compliance when shipping marine toxins. Under the DOT definition, a poison is any substance that can kill, injure, or impair living organisms (20). This definition certainly describes the physiological nature of marine toxins. DOT definitions go further to distinguish between poisons by defining them as either poison A or poison B. Poison A chemicals are compressed gases and Poison B chemicals are any liquid or solid substances, other than Class A poisons or irritating materials, that are known to be so toxic to humans as to afford a health hazard during transportation, or that, in the absence of adequate data on human toxicity, are presumed to be toxic to humans (20). By the preceding definitions given, a marine toxin would be listed as Poison B for shipping and would carry the DOT placard 6.1, Poison.

Handling and Storage

Proper handling and storage of chemicals play a vital role in protecting against accidental spills or releases. The manner in which a chemical is stored and handled is dependent on what hazard or hazards the material carries. For instance, corrosive and flammable chemicals are considered hazardous and need proper handling and storage, but both can react very differently when exposed to a chemical that is basic. It is common knowledge that acidic materials cannot be stored with basic materials because they can violently react with each other. Marine toxins fall under the definition of a toxic chemical: any chemical that causes adverse health effects on living organisms (20). Toxic chemicals must be segregated from other chemicals and stored in a well-identified area that is cool, well-ventilated, and away from light, heat, acids, oxidizing agents, and moisture (20). In addition, storage areas must be properly labeled and must identify what types of chemicals are stored inside. Storage cabinets must be properly ventilated and should have a lip at the edge of each shelf to help stop spillage in case of leaks. While all hazardous chemicals warrant safe handling procedures, many chemicals have specific handling requirements to keep workers safe. For instance, it would obviously be dangerous to handle water-reactive chemicals with wet gloves. Toxic chemicals also need special attention when handling them. For instance, all experiments which involve toxic chemicals should be performed in an area designated for toxic chemical use, appropriate personal protective equipment (PPE) must always be worn to prevent skin contact, and reusable PPE must be properly decontaminated after each use (20). Unnecessary exposures and releases could be the unfortunate result of improper storage and handling of marine toxins.

CONTROLS

When working with toxic materials it is important to determine what measures must be taken to ensure the safety of the workers. Controls are a means of preventing exposures or overexposures to hazards. There are three types of controls, engineering controls, administrative controls, and PPE, listed in their selection priority. Engineering controls are physical controls put in place as a means to try to remove a hazard or prevent exposure from occurring. Administrative controls and PPE are personnel controls and are used when a hazard cannot be prevented or removed. Often, measuring worker exposure using sampling and analysis is an excellent method of determining exposure level and the adequacy of controls in place. This is accomplished to establish if workers are being exposed or overexposed to workplace hazards. Once the sampling is accomplished, the results are compared to a standard to find out if workers are being exposed above permissible limits. Unfortunately, there are currently no sampling methods for marine toxins and no exposure standards to compare them to. Because employee exposure is not measurable, preventing exposure becomes vital to a safe management plan.

Engineering Controls

Engineering controls are the first controls to be considered because they either remove a hazard or prevent it from occurring. The preferred sequence in deciding what engineering controls to use are: substitution of a less hazardous substance, segregation of hazardous processes, eliminating or reducing emissions by process modification, controlling exposure by means of ventilation, total enclosure of process, and partial enclosure of sources of air contamination and exhaust of the enclosure (21). Not all engineering controls apply for every laboratory setting. For instance, when working with marine toxins the nature of the work deals with researching the toxins themselves. For this reason, substitution would not be an option when selecting engineering controls.

Process Controls. Process controls involve making alterations to a process to prevent exposure or overexposure from occurring. Process modification and segregation of the hazardous process are two examples of process controls. Examples of process modification would be brush painting instead of spray painting or using an automatic degreasing machine instead of hand degreasing (21). Both of these modifications reduce or eliminate worker exposure. An example in a laboratory setting would be the use of an auto pipette machine to handle small amounts of chemicals in large batches during analysis. Segregating a process can remove a hazard entirely by placing either workers or hazardous chemicals in a controlled environment.

Ventilation. Laboratory ventilation is another important engineering control and includes general room ventilation and local exhaust ventilation. Local exhaust ventilation, in this case fume hoods, is a great way to control exposure at the source. If the hood is designed and used properly, the chemical is pulled away from the worker before it is inhaled. One of the primary factors affecting the adequacy of a laboratory hood is the face velocity. There have been various figures given from a variety of sources recommending safe and adequate working face velocity measurements. According to one source, face velocity should be between 75 and 150 feet per minute (fpm), or higher for highly toxic chemicals (17). Another source shows that face velocities in the 60-100 fpm range provided acceptable safe hood operating conditions (22). The most current American National Standards Institute Laboratory Ventilation Standard (ANSI Z9.5) states there is no recommended face velocity, but suggests a range of 80-120 fpm (23). The American Conference of Governmental Industrial Hygienists Ventilation Manual recommends only an acceptable minimum standard set at 60 fpm (22). Regardless of which flow rate is used, two things must be remembered. First, face velocity alone should not be used to determine if your workers are being protected against workplace hazards. Second, a fume hood’s adequacy and safety depends largely on maintenance of the hood and worker training. There are other types of qualitative measurement to indicate the adequacy of the hood flow such as smoke bombs or smoke sticks. Both provide a way to see if air is flowing into or out of the hood. Smoke sticks should be held outside of the hood and run along the work surface; all of the smoke should be pulled into the laboratory hood (22). A smoke bomb is placed in the hood and ignited; again, the direction of the smoke should be into the exhaust system and not into the work area (22). A hood that is properly designed to control worker exposure but not adequately maintained could be as dangerous as working on an open bench top. In addition, if workers are not trained on how to use the hood properly, they may be contributing to their own workplace exposures. Laboratory hoods will not maintain the same face velocity they started with over time; therefore, recurring checks should be performed to determine if the face velocity is changing. The Occupational Safety and Health Administration (OSHA) Laboratory Safety Standard (29 CFR 1910.1450) recommends hoods be equipped with a monitor to determine if the air is moving properly through the face of the hood (24). This is an immediate indication of inadequate airflow the laboratory worker can recognize without taking any measurements. Results from periodic face velocity measurements can be used to determine if there have been any changes in how the hood operates and if workers are being protected. General room ventilation is also important when discussing local exhaust ventilation because room air patterns can account for at least 50% of unsafe hood performance (22). Turbulence in the room can come from various sources such as worker movement or laboratory doors being open. It is also important for the laboratory to remain at a negative pressure in relation to the corridor and service space to prevent outward air migration (22). One of the most important aspects of determining what type of hood to use is to ensure a design engineer develops a system that is adequate to control the hazards that will be used in the hood. The scientists and researchers that will work in the laboratory should convey their specific needs to the engineer during the design process.

Administrative Controls

Administrative controls consist of things such as worker rotation, time limits, and employee training. Worker rotation and time limits are control methods usually used in work areas where workers are potentially exposed above the permissible exposure limit (PEL) set forth by OSHA. These methods of control are used only when all engineering controls have been exhausted. It is imperative to have an effective training program in place when working with hazardous materials. Proper training is not only crucial to an effective management plan, it is required by law. Under 29 CFR 1910.1450, Occupational Exposure to Hazardous Chemicals in Laboratories, employees must be trained on the hazards of the materials they will be working with at the time of or before the employee’s initial assignment (25). This training should include physical and health hazards of chemicals in the work area, emergency procedures, appropriate work practices, and use of personal protective equipment. As stated previously, part of this initial training should cover understanding the ventilation system, its limitations, as well as how to use it properly. This holds true for all engineering equipment. The most technologically advanced engineering controls can be in place, but if workers are unaware of how to properly use them they could be rendered useless. Suggestions for managing a training program in laboratories using marine toxins are listed in the Recommendations section.

Personal Protective Equipment

Although PPE is used only after all other methods of controls have been considered, it almost always plays some role in worker protection. Once determined that PPE will be needed, careful thought should be placed on selecting equipment that is adequate for the process and materials being used. OSHA's PPE Standard, 29 CFR 1910.132, should be used as a basis when developing a PPE management plan (26). 29 CFR 1910.132 provides information for general requirements. Additionally, there are regulations governing specific equipment use, such as 29 CFR 1910.134, Respiratory Protection. Before a worker is allowed to wear any type of PPE, he or she must be medically cleared to be physically able to wear the equipment. Equipment selection is the first step in a PPE plan and is based on the anticipated hazards of the work area. For example, if a process has an inhalation hazard, respiratory protection may be selected for worker protection. In addition, selection of a proper respirator cartridge is key. For example, an organic vapor cartridge will not protect against a particulate hazard such as asbestos. Once equipment is selected, employee training is crucial. The adequacy of PPE is fully dependent on the person wearing it and it could be useless if not properly maintained and cared for. Each piece of equipment may require specific maintenance, care, and cleaning instructions and workers should be adequately trained in all of these areas. It is also important to understand the limitations of the PPE that is selected. For instance, even if nitrile gloves provide protection against a particular chemical there will be a breakthrough time applicable at which point the chemical can reach the skin. When deciding whether to use disposable or reusable PPE, there is a waste issue to be concerned with. Disposable PPE, although more convenient, also creates more waste to dispose of. This can cause a financial burden when reusable gloves may suit the task just as well. All of these factors must go into managing an effective PPE program, but employee training may be the most crucial. All the time in the world can be put into the selection process, but if workers don't understand how to care for, use, and maintain the equipment it may not provide the protection that is needed. Laboratories that use marine toxins must also determine what PPE is necessary based on the chemical properties of not only the toxins, but also any additional chemicals used in the process. Suggestions for selection of PPE are given in the Recommendations section.

MEDICAL SURVEILLANCE

A medical surveillance plan is the foundation of a successful laboratory management plan. The entire purpose of the laboratory management plan is to prevent laboratory chemicals from causing harm to workers. The medical surveillance plan is an excellent way of regulating and monitoring worker health. A comprehensive medical surveillance plan would include pre-employment examinations, periodic medical examinations, emergency medical treatment, non-emergency medical treatment, medical record keeping, medical program review, and termination medical examination (20).

Signs of Acute and Chronic Exposure

Because most of the effects of marine toxin poisoning are known through food poisoning and because laboratory research is relatively new, there are little data on the chronic effects of most marine toxins. As previously stated, one exception to that is evidence that chronic exposure to okadaic acid through eating infected shellfish is linked to increases in digestive cancers. Many of the signs of acute exposure to marine toxins are gastrointestinal symptoms and could be mistaken for general flu-like symptoms. However, there are symptoms that seem to be unique to marine toxin poisoning and would be easily identified. Ciguatera poisoning, for example, can cause disturbances in thermal sensation, such as cold objects feeling hot, and a feeling of prickliness in the palms and soles of the feet (27). An interesting and hallmark symptom of tetrodotoxin and saxitoxin poisoning is tingling and burning sensations felt on the lips and tongue (28). A remarkable symptom of acute domoic acid poisoning is loss of short-term memory (4). All of the acute symptoms, and chronic if known, of marine toxin poisoning should be included in the laboratory's employee training program. Employee's who will work with the toxins must be aware of all of the possible symptoms of exposure, paying special attention to the unique signs.

Medical Monitoring Requirements

OSHA's Laboratory Standard, 29 CFR 1910.1450, gives instruction on how to handle medical consultation and examinations that are the result of an exposure. Employees who develop signs or symptoms of exposure to chemicals they work with must be allowed to see a physician at no cost to the employee (25). As previously stated, marine toxin poisoning can be hard to diagnose because many of the initial symptoms are general flu-like symptoms. This is where it is important for the employees to be trained and aware of the possible symptoms of marine toxin poisoning and to seek help immediately. Informing the physician of what chemicals are used in the workplace can possibly prevent an incorrect diagnosis of a worker. Diagnosis of ciguatera toxicity is usually made on clinical grounds; however, laboratory analysis by using an enzyme-linked immunosorbent assay test for the toxin or a high-pressure liquid chromatograph (HPLC) test can be performed on serum, plasma, and urine of the infected individuals (29). Additionally, analysis of paralytic shellfish poisoning caused by saxitoxin can be performed using receptor binding assay or HPLC (30). Although there is no specific antidote for ciguatoxin poisoning, studies show that treating patients with antihistamines and a 20% Mannitol solution produces a noticeable decrease in neurological and muscular dysfunctional symptoms (29). A medical examination and consultation plan should be put into place based on the specific needs and potential exposures of employees in the laboratory. Although it is important to have a plan of action on how to handle overexposures, an effective plan must be in place that evaluates the general health of the laboratory workers and gives a baseline of their health prior to, during, and at termination of employment.

WASTE

In 1976 the Resource Conservation and Recovery Act was passed which gave the Environmental Protection Agency the authority to control hazardous waste from “cradle to grave”. This control includes the generation, transportation, treatment, storage, and disposal of hazardous waste, and is translated in 40 CFR Subchapter I (31). In terms of generation, emphasis is placed on reducing or eliminating the amount of waste generated by making process changes such as substituting materials that are less hazardous or materials that can be recycled. When waste is generated, it must be properly managed with an effective waste management plan. Aside from how they affect fish populations, there is very little knowledge of the environmental effects of marine toxins. This poses a challenge when determining how to properly manage the waste.

Waste Characterization

There are various types of waste characterizations listed in 40 CFR Part 261 and they are defined in two categories: listed waste and characteristic waste. An example of characteristic waste is waste that exceeds the regulatory limits for lead or barium concentration. Waste that has a pH equal to or below 2 would be characterized as corrosive waste. An example of a listed waste is waste that comes from specific sources such as sludge from a wastewater treatment plant. Characterization of waste helps determine how the waste must be stored, transported, and disposed. Characterization can be based on analytical testing or the generator's knowledge of their waste (32). Because there are no regulatory limits for marine toxins in waste, the hazardous waste determination would be made based on generator's knowledge of the material. In terms of waste characterization, marine toxins fall under the acutely toxic category, which is waste that is found to be fatal to humans in low doses (32). Waste from processes that involve marine toxins will probably have additional chemicals mixed with them, which may carry additional hazard characterizations.

Waste Storage

Just as hazardous materials must be stored in a safe manner that protects people as well as the environment, hazardous waste must be treated with just as much care. Requirements for the storage of hazardous waste can be found in 40 CFR Part 262. Waste must be stored in a container compatible with the waste and in an environment that will keep the waste stable. For instance, highly corrosive and caustic chemicals that could corrode metal should not be stored in a metal drum. During storage, waste can accumulate for 90 days or less without having a permit (33). During this accumulation time, the waste must be labeled in accordance with federal regulations. For example, the date the accumulation began must be placed on the container, as well as any identification of the waste (33).

Waste Disposal

All hazardous waste offered for transport and disposal must have a properly completed manifest that contains an EPA identification number (33). 40 CFR Part 262 outlines the requirements for record keeping, labeling, placarding, as well as packaging hazardous waste offered for disposal (site). Companies that transport hazardous waste must comply with 40 CFR Part 263 and any applicable DOT regulations (34). Hazardous waste treatment plants receive their direction from 40 CFR Part 264 (35). When waste is being picked up for disposal, copies of the known material's material safety data sheets are supplied to the transporter. This will help the treatment and disposal plant to determine how to handle the waste. Most of the marine toxin material safety data sheets have a section for waste disposal that suggests mixing the waste with a combustible carrier and burning in a chemical incinerator (16, 36, 37). Unless a laboratory will treat or dispose of their waste on-site, attention should be focused on the storage, characterization, and proper documentation of the waste stream.

RECOMMENDATIONS

Storage

Marine toxins should be kept in a closed container that is properly labeled in accordance with 29 CFR 1910.1200 at all times. They should be stored in a chemical storage locker or cabinet and kept separate from other materials. The cabinet should be locked and only personnel who have been adequately trained in the hazards of the toxins should be allowed access. An inventory sheet should be kept to help track use of the chemical. Additionally, the storage cabinet should be properly ventilated outside the building.

Handling

Only workers who have been trained in the hazards of the toxins should handle them. Proper protective equipment must always be worn to prevent contact. Moreover, they should always be handled under a fume hood. General laboratory safe work practices also apply. Workers should always wash their hands after working with marine toxins, eating should not be permitted in the laboratory, and mouth pipetting should be prohibited.

Controls

Process Controls. Process controls will depend largely on how the toxins are being used in the laboratory. One suggestion would be to segregate the process so that workers are not exposed. Various types of safety pipettes can also be used that could minimize the risk involved when handling the toxins.

Ventilation: The scientist involved in the research project should give input to the ventilation design engineer and ensure the hood is designed to accommodate the project, to include an air movement monitor. If a new hood is not being built, modifications can be made, if needed, to an existing hood. Many figures were given for adequate face velocity measurements. The measurements suggested by the American National Standards Institute should be used because they are very current and reliable figures. Therefore, face velocity should be between 80 and 120 feet per minute. The fume hoods should be surveyed periodically to ensure the face velocity has not changed by a large degree. A change would be an indication that something is wrong with the mechanics of the hood and would warrant repair or further testing. Sash type and height is something that should also be considered. There are two types of sashes, vertical opening and horizontal opening. Which sash should be used is dependent on the type of work that will be done in a hood. Something to always keep in mind, though, is that lowering a sash will alter the face velocity of the hood and could cause turbulence.

Training: Workers who will work with marine toxins should be fully trained before they ever come in contact with the chemical. The training should cover any hazard information about the toxins, storage and handling procedures, procedures for proper operation of ventilation systems, and acute and chronic symptoms of exposure. Furthermore, there should be extensive and recurring training, if needed, in the personal protective equipment that will be used in the laboratory including proper care, maintenance, and storage procedures. Training must always be documented in accordance with 29 CFR Part 1020 (37).

Personal Protective Equipment: Due to the amounts and concentrations usually used in laboratories, and if local exhaust ventilation is used as well, respiratory protection would not be needed when working with marine toxins. If a laboratory should use doses and concentrations close to or above those that can cause human poisoning, respiratory protections should be considered. Gloves should be worn while working with or handling marine toxins, in order to prevent contact. Because there is a cost issue involved, the decision to use disposable or reusable gloves rests with each individual laboratory—as long as the material of the glove (nitrile, neoprene, etc.) is adequate for the chemicals being used. Because breakthrough times for specific marine toxins cannot be found through the manufacturer, the laboratory can determine this by placing an amount of toxin on the glove and recording the time it takes to breakthrough. Many of the research applications using marine toxins involve additional chemicals. Glove selection should be made based on the chemical used with the shortest breakthrough time for that glove. Additionally, lab coats or aprons should be worn to prevent contact to the skin and chemical goggles should be worn to prevent the chemicals from either burning the eye or entering the bloodstream through the eye. Employees should be trained to inspect each piece of PPE before it is worn and should not be used if inadequate. If disposable PPE is used, it should be placed in the hazardous waste container upon disposal if it has any chemicals on it.

Medical Surveillance

All employees should receive physicals before beginning work to not only establish a baseline of their health, but also to ensure they are physically able to wear the PPE required for the job. It would be preferable to employ a physician who is trained in occupational health as the worker's primary care physician. If that is not possible, the company physician should be briefed in the hazards and symptoms of exposure of marine toxins, as well as any other hazardous materials. All medical surveillance must be well documented and medical records must be maintained for at least 30 years after the termination of employment, in accordance with 29 CFR 1910.120 (38).

Waste

A separate waste management plan should be developed and managed by someone who is trained for hazardous waste management. The plan would include measures for storage, disposal, record keeping procedures, and emergency procedures. The waste should be stored in a closed container near the process. Because the waste is acutely hazardous, not more than one quart of waste can be accumulated at the generation site (33). All materials that are not decontaminated after working with marine toxins, such as disposable PPE items, must be disposed of in the hazardous waste storage container.

CONCLUSION: Laboratory use of marine toxins will inevitably increase as more information surfaces about their value to research. It is important that laboratories employ a comprehensive management plan that focuses on all aspects of properly controlling marine toxins. The plan should be reviewed and updated as new applicable information emerges concerning health and environmental risks. Elements of the management plan should be used in conjunction with the laboratory's chemical hygiene plan and all applicable federal, state, and local regulations.

ABOUT THE AUTHOR

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