Faculty of Fisheries and Marine Sciences & Technology
University of Ruhuna

Laboratory and Fieldwork safety guidelines

Rationale

Safety in the working environment is a relatively modern concept only developing in the last century. This issue is least discussed in developing counties. Although Sri Lankan law addresses the safety issues in working environments such as factories and industrial workplaces there are no specific guidelines for research and academic institutes.

Degree programme conducted by the Faculty of Fisheries and Marine Sciences & Technology (FMST) produces graduates with hands-on experience. Both degree programmes offered by the faculty practical based courses which are conduct in a laboratory or the field. Thus, ensuring safety in Laboratory and field is crucial although it is not addressed properly to date. Further, all currently conducted laboratory practicals are based on activities using chemicals or chemically preserved specimens (Formaldehyde) which can have both immediate and long-term effects on human health. Past Incidents of contacting chemicals with hands and eyes stress the immediate need for laboratory safety. Thus, risks associated with exposure to Hazardous chemicals, Electricity, Explosive chemicals, Glassware and sharp objectives and heat should monitor, assess, and minimize for the safety of students and staff. Since most of the fieldwork associated with the sea and freshwater environment risks related to these systems need to be identified and minimized. Past frequent incidents of injuries due to sea urchin spines and wave action should consider seriously. Most of the incidents are avoidable and safety issues have arisen due to the lack of knowledge on safety. Thus, there is an immediate need of formulating laboratory and field safety guidelines to ensure safety in the academic environment.

Objectives:

- To ensure the laboratory practical and fieldwork safely of students and staff
- To minimize the incidents associated with hazardous chemicals and other issues.

Implementation and sustainability Plan

1. Formulation of safety guidelines.
2. Implementation of Laboratory safety committee (for monitoring and action on incidents)
3. Implementation of an incident reporting system.
4. Implementation of a hazardous chemical waste disposal plan
5. A workshop will be conducted to train laboratory staff on the above issues.
6. Laboratory and Fieldwork workshop for students during the orientation programme.
7. Risks associated with each laboratory/fieldwork and safety precautions for each risk will be mentioned in each practical schedule. Thus, students are aware of the practical specific safety issues.

Laboratory and fieldwork safety guidelines

1. Storage /Handling and waste management of hazardous chemicals
2. Laboratory safety protocols
3. Field safety protocols

1. Storage /Handling and waste management of hazardous chemicals

1.1 Storage of hazardous chemicals

Chemicals need to be categorized according to the level of toxicity. A method will be developing to dispose of each chemical accordingly reducing the harmful effects to the environment and humans.

Proper storage of chemicals will be carried out with a colour code label according to the level of toxicity.There is a range of storage facilities suitable for chemicals in laboratories. But specifically, Material Safety Data Sheet (MSDS) for the substance must be referred to to determine safe storage conditions for each chemical. Following should be strongly concerned during the chemical storage.

- Store chemicals in a designated area.
- When storing chemicals side by side, make sure they are compatible and will not react to produce hazardous reactions.
- All chemical containers must be appropriately and clearly labeled with the name of the substance and hazard category.
- Replace defaced or accidentally removed suppliers or workplace labels in chemicals.
- Close caps and lids tightly before storing any chemical.
- Limit access to the storage area.
- Store the minimum store levels of hazardous chemicals that are reasonable for the level of usage in the lab.
- Pay attention to the expiry date and the date when the bottle is first to open should be clearly shown on the label.
- Do not store chemicals under the sink as they may leak, and some chemicals react when wet.
- Store large breakable containers (liquid chemicals) below the shoulder height.
- Wooden cabinets should not be used for the storage of oxidizing acids.
- Small quantities of dilute acids may be stored on the bench racks and side racks with appropriate labeling.
- Alkalis and flammable liquids are incompatible with acids and must store separately.
- A flammable solvent such as alcohol, toluene, hexane, etc: should only be stored in specified flammable solvent cabinets and such cabinets must be clearly labeled.
- Peroxides forming solvents by auto-oxidation such as diethyl ether, cyclohexene, glycol ethers, etc: should be stored away from light and heat with tightly secured caps.

Table of commonly used lab chemicals and chemicals incompatible with them are attached as annex 1.

1.2 Material Safety Data Sheets (MSDS)

A safety data sheet contains important data about physical and chemical properties of particular substance along with health and safety measures. It provides lab users with procedures for safe handling, storage, disposal of chemicals with specific protective equipment. Also, it includes relevant information on physical data such as melting point, boiling point flashpoint along with health measures including toxicity, health effects, first aid, and reactivity. So, MSDS is a written document produced by a chemical manufacturer or importer that includes communication of hazards and precautionary information including;

- Identification of substance, mixture and company, distributor.
- Identification of hazard.
- Information on composition or ingredients.
- First-aid measures.
- Fire - fighting measures.
- Accidental release measures.
- Storage and handling.
- Exposure control, personal protection.
- Physical and chemical properties.
- Stability and reactivity.
- Toxicological information.
- Disposal information.
- Transport information.
- Regulatory information.
- Others.

1.3 Grades of chemicals and reagents

1. **A.C.S grade:**
   Chemical grade of the highest purity and meets or exceed purity standards set by A.C.S (American Chemical Society)
2. **Guaranteed Reagent grade (GR):**
   Chemicals with high purity generally equal to A.C.S grade. Specifically used in many laboratory and analytical applications.
3. **AR grade**:
   Suitable for laboratory and general use.
4. **Primary standard grade:**
   Analytical reagent of exceptional purity specially manufactured for standardizing volumetric solutions and preparing reference standards.
5. **U.S.P grade:**
   A chemical grade of sufficient purity to meets or exceed the requirements of the U.S Pharmacopeia (U.S.P) and use in many laboratory purposes.
6. **N.F grade:**
   A grade of sufficient purity to meet or exceed the requirements of the National Formulary (N.F).

7. **Lab grade:**
   A chemical grade of relatively high quality, with an exact level of impurities. These are usually pure enough for educational laboratory works and the purity is not enough to be offered for food, drug, or medicinal use.
8. **Purified grade:**
   Also, referred to as pure or practical grade. Indicates good quality chemicals meeting no official standard. Can be used for educational laboratory applications and not pure enough for food, drug, and medicinal use.
9. **Technical grade:**
   Good quality chemicals for commercial and industrial purposes. Purity is not enough for food, drug, or medicinal use.

1.4 Chemical safety signs and labels.

Once a chemical has been classified under hazard classification, it must be communicated to a target audience. Labels and safety data sheets are the major tools for chemical hazard communication. These imply the hazardous properties of chemicals that may pose a health physical or environmental hazard during handling and usage. The following figure represents the labels with hazardous class.

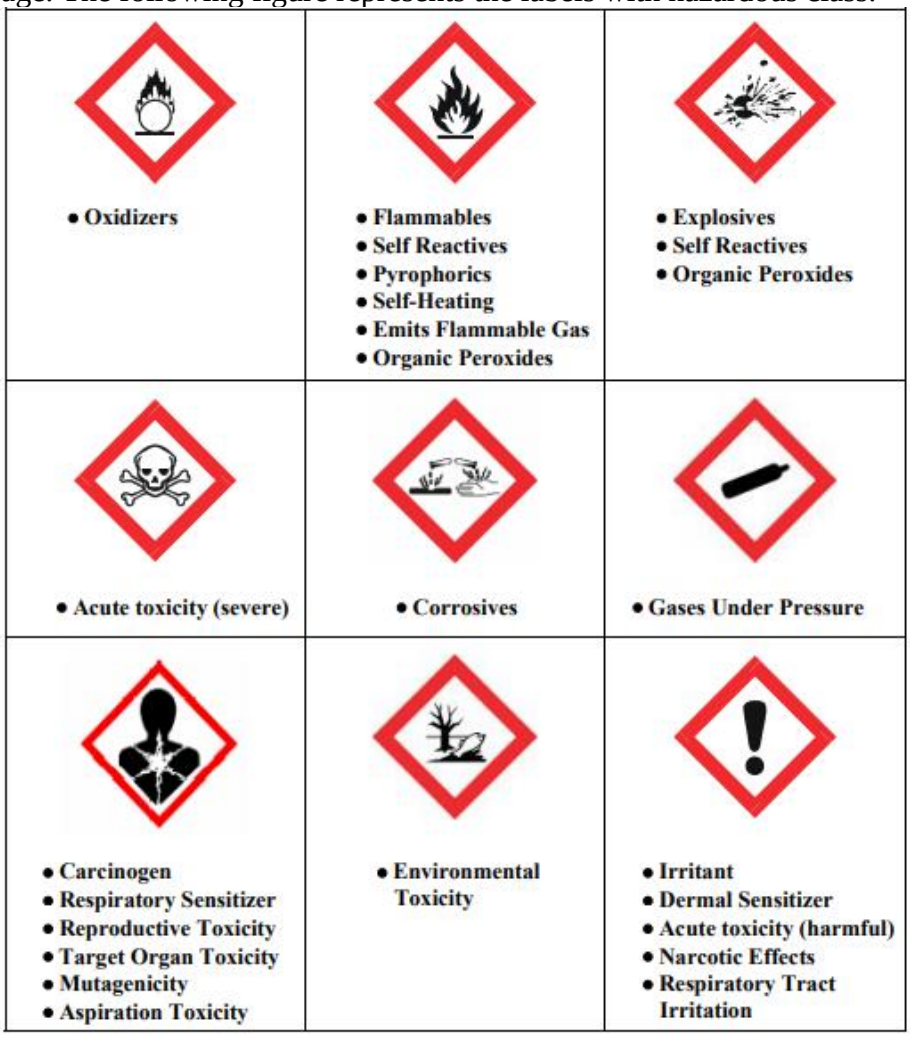

Figure 1: Labels with hazardous class

1.5 Chemical handling

Following rules should be followed to prevent the accidental contamination of reagents, chemicals, and solutions and to develop safe chemical handling practices.

- Handle containers safely to avoid damaging them.
- Do not use the contents of unlabeled containers.
- Do not dispose of flammable material in the trash.
- Do not eat or drink while handling the chemicals.
- Select the available best grade of chemical for analytical work.
- Whenever possible, pick from the smallest chemical container to get the desired quantity.
- Replace the top of the container immediately after removal of the reagent.
- Hold the stoppers of reagent bottles between your fingers and never set a stopper on the desktop.
- Never return any excess chemical reagent to a bottle, unless specifically advised.
- Use a clean and specific spatula to each container to take chemicals. Exchange of spatula will make contaminations.
- Handling chemicals should be done with great care, as many chemicals are toxic and hazardous. Thus, read the label on the bottle before handling them.

1.6 Laboratory waste management

Waste management is all the activities and actions required to manage waste from its inspection to its final disposal. This includes the collection, transport, disposal of waste together with monitoring and regulations.

Laboratory waste can mainly be classified into two major classes.

1. Hazardous waste
2. Nonhazardous waste and other waste

1.6.1 Hazardous waste

A chemical or chemical mixture that exhibits any corrosive, flammable, toxic, reactive, and persistent in the environment can be referred to as hazardous.

1.6.1.1 Hazardous waste accumulation.

Following should be concerned during the storage of hazardous chemical wastes in the laboratories.

- Accumulation of waste should be done in appropriate containers compatible with the waste. (flammable, corrosive, toxic, reactive, and persistent in the environment)
- It is acceptable to reuse containers that were used for other chemicals if they have been rinsed and the original labels have been defaced.
- Containers designed for solid chemicals should not be used for liquids.
- Use only containers that show no sign of damage or deterioration.
- Waste containers must remain closed, except when adding waste.
- Use spring-loaded funnels for adding waste frequently to waste containers.
- Do not fill the containers to the full capacity (not more than 3/4) to allow for pressure changes due to temperature changes.
- Do not keep the containers near sinks. (leakages may cause secondary contaminations)

- Store waste away from emergency equipment.
- Each container should carry a label to identify its content.
- Hazardous waste must not be stored in containers for more than one year.

1.6.1.2 Hazardous waste Disposal methods

After the proper accumulation of hazardous waste in laboratories, each laboratory should handover the accumulated waste to relevant authorities for treatment, recycling, and disposal.

- Recycling:
  The recycling process includes physical, chemical, and electrochemical separations. Major techniques involved in the recycling process are:
  - Distillation of solvent waste.
  - Dechlorination of halogenated, non-solvent waste.
  - Metal concentration techniques such as leaching, solvent extraction, ion exchange, precipitation, crystallization, and evaporation.

- Waste exchange:
  Certain waste that is not useful to the generator, maybe desired by another industry as a raw material. Waste exchangers help facilitate the process of transfer and recycling of waste.

- Disposal:
  Before the disposal of hazardous waste, physical, chemical, and detoxification treatment methods are involved. Disposal methods vary according to the type of waste. The most common disposal method is landfilling.

1.6.2 Nonhazardous waste and other waste

Nonhazardous waste includes all other waste that does not fit the definition of hazardous waste. Other wastes include sharps, broken glass, and general refuse.

- Handling of broken glassware:
  - All the broken glass and other sharp material should be placed in a broken glass container and it should be labeled properly.
  - Use leather gloves, broom, dustpan tongs, or other devices to pick up broken glassware.
  - Do not put the broken glassware into regular refuse containers.
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1.7 Chemical Spill or Laboratory Accident:

- Get out of immediate danger.
- If necessary, evacuate the building by pulling the nearest fire alarm.
- Always stay upwind of the spill (wind blowing from you towards spill).
- Contact the laboratory supervisor (contact info posted on the door).
- Do NOT attempt to clean up a chemical spill if you have not received proper training. It will be assessed by trained personnel who will ensure that proper clean-up techniques are employed. Offensive odors from ventilation systems should be reported as well.

2. Laboratory safety protocols

The major scope of implementing laboratory safety guidelines is to document a proper laboratory safety program to ensure a safe working environment. Thus, all the students and faculty members must adhere to all the safety methods and precautions addressed by these guidelines.

2.1 General laboratory safety

Following rules and regulations will assist to maintain a safe working environment in laboratories.

- No one is allowed to be in laboratories, without the permission of the laboratory in charge.
- No one is allowed to conduct any laboratory work, without supervision.
- No one is allowed to alter experimental procedures, except as instructed.
- Strongly recommended wearing closed-toe, closed-heel shoes that cover the entirety of the foot.
- It is mandatory to wear safety goggles at all times.
- Clothing that completely covers your arms and legs are highly recommended. Loose or torn clothing should be avoided.
- Dangling jewelry and finger rings or other tight jewelry should be avoided.
- Confine long hair while in the laboratory.
- Lab coats are required upon entering the laboratory.
- No food or drinks are allowed in the laboratory. This prohibition applies to the storage of food, consumption of food and beverages, and the use of medicine in the laboratory.
- Mobile phones are not allowed to keep and use during laboratory sessions.
- All should be aware to operate the nearest eyewash fountain, safety shower, and fire extinguisher.
- All experiments associated with poisonous gasses and vapors are required to conduct in the fume hood.
- Always use pipette fillers when handling hazardous chemicals such as strong acids, heavy metal solutions, etc. (in such cases, mouth sucking must never be used)
- Always keep the working area clean.
- All the reagent bottles must recap after use to avoid contamination.
- If you have personal health concerns and special health conditions (asthma, pregnancy, etc.), it is strongly recommended to consult your doctor and to get the concern before taking any laboratory session.
- It is mandatory to take great care when handling glassware and operating laboratory instruments and equipment.
- Wash your hands after removing the gloves and when leaving the lab. Do not touch items such as mobile phones, turning doorknobs, or do not use the elevator before washing hands.

2.2 Engineering controls to minimize hazards

Engineering controls are the things that are built or installed to separate people from chemical biological or physical hazards. This includes fume hoods, biosafety cabinets, exhaust ventilation, safety shields, and proper storage facilities.

2.2.1 Fume hoods

Fume hoods are a substantial infrastructure element for handling hazardous chemicals by preventing hazardous and odorous chemical exposure release to laboratory and laboratory users. Thus, they should not be misused for purposes such as garbage, storage of materials, etc.

A fume hood generally comprises,

- **Face:** space where air capture occurs.
- **Sash**: the glass "window" that moves through the hood face to protect the user and laboratory for the period in use.
- **Baffles**: positioned behind the hood and direct air in a suitable direction. It also can be regulated according to altering vapor densities of chemicals.
- **Ducts**: hood and ventilation system is attached by ducts and its exhaust to open air.
- **Airfoil**: positioned at the bottom front edge of the hood and is a vent that keeps a minimum gap open at all times and allows better, less turbulent airflow and better capture.

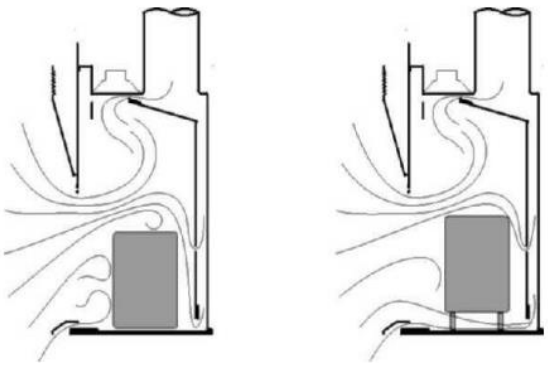
Figure 2: Front view of a fume hood

Before using a fume hood;

- Use only fume hoods that have appropriate face velocity.
- If the fume hood is out of service, it should not be used under any circumstances.

During the usage;

- Always work with the fume hood sash as low as possible (no higher than50 cm) (this increases the performance of the hood as well as safety during the experiments)
- Any lab apparatus should be raised at least 2.5 cm above the work surface of the hood, to improve the airflow in the hood. (figure 3)



(a) (b)

Figure 3 (a) poor placement of apparatus in fume hood; (b) good placement of apparatus in fume hood.

- Windows and doors should be kept closed within the lab to minimize the traffic in front of the hood when the hood is operational.
- In the case of a chemical spill, the area should be cleaned immediately.
- The working area and hood sash should be cleaned regularly.
- When working, only hands should be inside of the hood and never put your head inside a functioning laboratory hood, to monitor an experiment.
- All the equipment and other apparatus such as reagent bottles, beakers, distilled water bottles, etc: should not be stored in the hood.
- Fume hood sash should be kept closed when you are away from the hood or leaving the lab.

2.2.2 Eyewashes/showers

Emergency eyewashes and shower

All laboratories must have access to an eye washer and an emergency shower. Both must be readily accessible, free of obstructions, and within immediate proximity to hazard. The lid in the eyewash head must always be closed while not in use, to prevent dust particle accumulation.

How to use the eye washer:

- Push the relevant button, to flush the fluid from the conical head.
- Get your eyes directly in the flushing fluid.
- Keep your eyes open by holding your eyelids apart with your fingers.
- Gently roll your eyes from left to right and up and down to be sure that fluid is flushing all of the areas of your eyes.
- Continue flushing your eyes for 15 minutes.

How to use the emergency shower:

- Make your way to the emergency shower quickly.
- Pull down the handle or lever as soon as you get under the nozzle.
- Take off your clothes and any other possible contaminated items such as glasses or jewelry.
- Stand under the shower for at least 15 – 20 minutes, even if the water is very cold.
- Hold your eyelids open the entire time to rinse out your eyes.

Figure 4: Eyewash station

Figure 5: Emergency shower

2.2.3 Fire extinguisher

Fire extinguishers are based on the type of combustible and flammable materials in the lab. Fire extinguishers should be conspicuously located, wall-mounted, and easily accessible.
The following table describes the appropriate fire extinguisher, based on the situation.

Table 2 Classes of fire with an appropriate extinguisher.

Classes of fire	Type of extinguisher
Ordinary combustibles such as wood, paper, and cloth (class A)	Dry chemical or water
Flammable liquids such as gasoline, oil, and oil-based paint (class B)	Carbon dioxide or dry chemical
Energized electrical equipment including wiring, fuse boxes, circuit breakers, and machinery (class C)	Carbon dioxide or dry chemical
Combustible metal such as Al, Mg, or Na (Class D)	Special extinguisher (Dry power)

Figure 6: CO_2 fire extinguisher

2.3 Electrocution Hazards

Extension cords, outlets, and electrical tools are potential safety hazards in every laboratory. Damaged cords, outlets, and electrical tools that don't operate appropriately may cause serious safety risks due to electrocution. All extension cords and cables must be organized in the laboratory. They should not be tangled or crowded in the room or counters, or they may cause accidents. If cables are torn or damaged, laboratory authorities must be notified, and the damaged cords or electrical tools must be replaced immediately.

2.4 Personal protective equipment

Personal protective equipment (PPE) is intended to protect lab users, from workplace injuries and hazards, due to contact with chemicals, handling of machinery, and other workplace risks. PPE incorporates an assortment of equipment and clothing including goggles, lab coats, gloves, face shields, respirators, etc.
When performing any experiment or any operation, the appropriate PPE should be decided by considering the following factors.

- The nature of the hazard and the task.
- Chemicals being used.
- Routes of exposure to chemicals.
- The material the PPE is constructed.

2.4.1 Eye and face protection

Eye protection equipment should be worn at all times while working with hazardous chemicals, biological materials, or any physical hazards in the laboratory.
Eye and face protection equipment, which are commonly used in laboratory experiments are listed below.

Table 3 Eye and face protection equipment

Safety glasses	Splash goggles	Laser goggles	Face shields
Provide eye protection from moderate impact and particles associated with grinding, broken glass, and minor chemical splashes.	Provide adequate eye protection from hazards including potential chemical splashes, concentrated solutions, and during bulk chemical transfer.	Contains a lens with a filter or absorber and design to reduce light transmittance.	Provide additional protection for eyes and face in combustion together with safety glasses and safety goggles.
			

2.4.2 Hand protection

Most accidents involving hands and arms can be classified under four main hazard categories as chemicals, cuts, abrasions, heat, or cold. There are several types of gloves that protect against and opposes corruption. The correct utilization of hand protection can shield from potential chemical and physical hazards.

Selection of gloves is extremely important based on the task to perform and chemicals to handle. Some of these properties include permeability of glove material, the temperature of the chemical, type of possible physical hazards, the thickness of the glove material, amount of chemical that can be absorbed by the glove material, etc.

The following table depicts different glove types that are commonly used in general laboratory experiments.

Table 4 Different glove types

Glove type	Appropriate task
Latex gloves	Resistance to ketones, alcohols, caustics, and organic acids. 
Nitrile gloves	Resistance to alcohols, caustics, organic acids, and some ketones. 
Cryogenic gloves	Protect from extremely cold temperatures. 
Cut resistance gloves	Design to protect from cuts while working with sharp tools. 
Heat resistance gloves	Provide a high level of protection against high heat. 

2.4.3 Protective clothing

During laboratory experiments, lab coats protect skin and personal clothing from incidental contact and small splashes. Also wearing lab coats prevent the spread of contamination outside the lab. Thus, lab coats should be worn at all times during laboratory work.
When lab coats are in use, the following should be considered.

- Wear lab coats that fit properly.
- Lab coats should be worn fully buttoned or snapped with sleeves down.
- Wear lab coats when only in the laboratory during lab works.
- Remove lab coats when leaving the lab to go home, lunch, restroom, meetings, conference, etc.

Figure 7: a – a lab coat b – a lab apron

2.4.4 Respiratory protection

A respirator is a device designed to protect the wearer from inhalation of harmful substances. Proper usage of respirators will protect the wearer from fumes and smoke, harmful dust, gas and vapor, oxygen deficiency, and biological hazards.
Respirators must be cleaned and disinfected after each use.

2.5 Check-In and Check-Out System

- Keeping a record of the usage of laboratories and special equipment is extremely critical in terms of reducing safety risks. Each facility has a logbook to record a person's name, time of operation and those log files must be well-maintained and can be accessible all the time. Logbooks must be signed when checked in the lab and before checking out the lab.
- For safety reasons, students and faculty are encouraged to inform their colleagues or laboratory supervisors if they plan to work in the laboratory after business hours.

3. Fieldwork safety

Fieldwork activities may take place in unfamiliar surroundings these activities are diverse. The fieldwork environment may be potentially hazardous; therefore, it is necessary to plan and reduce the risk of injury or harm as far as is reasonably practicable.
All personnel always have a responsibility to work safely, taking reasonable care to protect their health and safety and that of fellow participants. Fieldwork associated with underwater activities all members should adhere to dive safety protocol by the FMST/University of Ruhuna. Following protocols needs to be followed during the fieldwork.

3.1 Weather forecast

Specifically, be aware of season and tide patterns before you go work in marine habitats.

3.2 Buddy system

A minimum of two people should be in attendance during the fieldwork. In some situations, and according to the level of risk, more people will be required.

3.3 Medical Conditions

All personnel involved in the fieldwork must be physically and mentally fit for the tasks required in the fieldwork. They must accept appropriate medical advice where relevant and disclose to the lecturer in charge of any limitation imposed by their health that may affect their ability to participate safely in any fieldwork activity. This obligation applies both before and during fieldwork. Information provided must be treated as confidential information, unless non-disclosure creates a risk to other participants.

3.3. Personal protection

All Personal involved in fieldwork must;

- Wear appropriate proactive clothing such as long sleeve/lucre/wet suites to cover the body to avoid high sunlight, animal bites/stings.
- Wear boots/covered shoes
- Wear life jackets if you are working in marine environments
- Be conscious about the environment (tides/high waves) and associated animals (annex II harmful marine organisms)

3.4 First Aid

- First aid kit is a must and contents of first aid kits need to reflect the types of hazards likely to cause injury
- At least one person in the field group should be qualified, first aid attendant

3.5 Using chemicals in the field

- Do not discard chemicals into the environment. Collect all used chemicals and bring them back to the laboratory for proper discard

3.6 Boat safety

All personnel in the boat must;

- always wear life jackets and protective shoes (boots/covered shoes) in the boat.
- be extra careful when handling equipment from the boats (e.g. plankton net, mini CTD, etc.)
- obey instructions given by the boat in-charge/skipper