A PROPOSED MANUAL OF STANDARDS AND POLICIES FOR SCHOOL CHEMISTRY LABORATORY MANAGEMENT

MENCHU CORONEL-LUZANO
Researcher

Doctor of Philosophy
Major in Educational Management

Arnel T. Sicat, Ph.D.
Adviser

Abstract

This qualitative study ultimately aims to develop a proposed Chemistry laboratory guide for instructors, students, laboratory heads, and technicians. Pertinent data were gathered from six selected Chemistry laboratory heads from notable higher education institutions in the National Capital Region, which have been awarded high accreditation levels by prestigious accrediting bodies. In place of a face-to-face interview, participants opted to submit their detailed responses through electronic means. These were content analyzed guided by the objectives of the study. Findings reveal their best practices and most beneficial procedure in the upkeep of Chemistry laboratories for education which this study made use of as a basis for the development of the proposed Chemistry Laboratory Guide. Though participants vary in terms of their specific policies and practices on proper storage and handling of chemicals, reduction and minimization of chemical usage, chemical waste reduction, and proper handling and segregation of used chemicals/wastes, they are commonly guided by international standards in performing the aforementioned procedures. Prevailing international laws on chemical management and standards trusted by highly acclaimed worldwide organizations were also reviewed to substantiate findings and supplement needed information for the development of the proposed output. This study strongly recommends the utilization of the proposed Chemistry laboratory guide to help all users of Chemistry laboratories to work efficiently and safely, preventing possible harm and hazards that may otherwise result from lack of proper guidance.

Keywords: chemistry laboratory practices, standards and policies, chemical management, Chemistry Laboratory Guide

INTRODUCTION

The laboratory is an important facility of science instruction where different kinds of chemicals are used. It is used by the teacher to help students learn about chemistry where students are exposed to chemicals, doing experiments by manipulating them through procedures, and interpreting a laboratory result that requires scientific thinking. One of the major problem areas observed in most colleges and universities is the management of chemistry laboratories, specifically on chemical usage, storage, and disposals of chemical wastes. Improper management of chemicals poses health and safety risks to students and employees. This can also lead to unintended chemical discharge, which may inflict damage to the environment. Improper chemical discharges into sanitary sewer lines or on-site waste treatment systems (which include septic tanks) can have adverse effects on rivers, streams, and groundwater. Chemical releases and spills can also contribute to air pollution. Spills to the ground can ultimately result in long-term harm to the land and cause significant remediation costs. These concerns fall under Pollution Prevention Act which means proper management and source reduction minimizes chemical wastes production (United States Environmental Protection Agency Memorandum, 1992).

Among the primary concerns of school laboratories, aside from teaching students, is preventing and minimizing accidents and injuries. There are differences that should be recognized when developing prudent and realistic safety programs for teaching institutions where every policy is custom-fit for every school. Developing safety consciousness, conducting risk assessment, and forming wise and careful laboratory practices should be an integral part of every laboratory. Academic institutions must have this essential and unique responsibility of keeping everybody safe from harm.

Laboratory personnel which includes student assistants, laboratory supervisors, teachers, and students, as well as those who handle chemicals, must have basic if not complete knowledge on safe chemical storage, proper utilization, and disposal. Each of these people has an important role to play in chemical handling and should be aware that wise management cannot only minimize risks to humans and to the environment but also minimize the costs of acquiring chemicals. A crucial component of chemical education at every level is a basic attitude and habit of prudent behavior in the laboratory so that safety is valued and ensured at all times in all laboratory activities. In this way, "safety first" becomes an internalized attitude, not just an external expectation driven by institutional rules (Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, 1995). Every chemistry laboratory chemical wastes used and disposed of in the trash bin or on the sink go directly to the soil or water that can contaminate or pollute as these get absorbed deeper into the ground.

This study aims to promote awareness, awaken the sense of responsibility and concern among students, teachers, laboratory technicians, and school administrators. This study aims to determine the current best laboratory practices of other universities so that a benchmark on how to manage school chemistry laboratories in accordance with environmental policies be established, which may improve laboratory practices and ultimately create or formulate an integral laboratory management manual. The areas of concern in every school's laboratory that are observed as part of good laboratory management are the reduction of chemical usage and waste production, proper chemical storage, segregation, and handling. The last among the areas of concern is how the laboratory managers handle, store, segregate chemical waste, including treatment and disposal that may harm laboratory personnel and the environment if not handled correctly.

The proposed output of the study is a manual that would improve chemistry laboratory management that observes integral and clear standards, policies, and guidelines on laboratory chemicals storage, usage, and minimization of used and waste production, management, and disposals.

Proper and safe management of chemicals in laboratories must begin before the chemicals are delivered. This means that the laboratory managers must prepare the laboratory room and storage and identify the possible harm or danger that chemicals may cause, and they must know the proper way on how to store them. Responsible chemical management is critical to controlling a variety of environmental, health, and safety issues within any school. Knowing what materials are present in schools and how they are used, stored, and discarded will enable one to understand the issues associated with these substances. Properly recognizing and controlling the hazards inherent to these materials will enhance one's ability to create a safe school with minimal environmental liabilities (Chemical Management Resource Guide for School Administrators, 2010).

All chemistry instructional laboratory experiments are tested and modified to minimize hazardous waste generated by microscaling and the amount of chemicals used or by making substitutions with less hazardous or non-hazardous chemicals and doing a demonstration of experiments. They are also evaluated for clarity and performance. Carefully planned experiments provide laboratory workers confidence in adopting procedures on working with chemicals, like preparation, use, and disposals, which posed no danger or harm both to health and to the environment.

These experiments are useful not only among college-level instructors but also for senior high school instructors for integrating into their curricula the reduction in the generation of small quantities of hazardous waste from chemistry laboratories. In connection to this, in order to prevent laboratory pollution, information will be gathered based on the best management practices, chemical purchasing policies, training, and specific laboratory practices of school laboratory managers of some notable higher educational institutions.

The most fundamental process in school chemistry laboratories is storing, using, and disposing of chemicals. However, schools vary in treating different types of reagents. There are chemicals that are used in school, chemicals used in industries as well as medical and pharmaceutical companies. These chemicals they use and store can cause a harmful reaction if not handled safely and properly. This is how the Occupational Safety and Health Administration (OSHA) in the United States work by recognizing the unique characteristics of the laboratory workplace. This agency tailored a standard for occupational exposure to hazardous chemicals in laboratories. This standard is often referred to as the "Laboratory Standard" (OSHA Fact Sheet, 1991). Under this standard, every school laboratory is required to develop policies and guidelines which would address the specific hazards to personnel and students' health as well as the environment. It is necessary to understand the requirements of the standard, the evaluation of the current safety, health, and environmental practices, and the assessment of the hazards of every chemical stored and used. Inspections and inventory are conducted on a regular basis, set by the laboratory technician, either every end of the school year or every semester, to assess potential hazards.

According to NERC Health and Safety Guidance (2010), storing chemicals in laboratory stockrooms requires a number of considerations on health and safety factors. A separate isolated storage room for chemicals is one of the keys to good laboratory management. The laboratory, including the storage room, should be designed and constructed to prevent persistent contamination through impermeability, chemical resistance, and ease of cleaning. To help provide safe storage of laboratory chemicals, three principles can be applied to segregate incompatible chemicals from each other; to separate hazardous chemicals from unsuitable conditions for reasons of their toxicity, flammability, or reactivity and to provide adequate ventilation which will remove or dilute malodorous, noxious, toxic or flammable vapors and prevent their build-up (OSHA Lab Standard,1910.1450).

There are many chemicals that are incompatible with each other and, therefore, must not be stored in the same storage shelves. Improper storage of chemicals is the cause of many laboratory accidents. Each chemical stored must have an accompanying Material Data Safety Sheet (MDSS) that lists the substance's physical and chemical data, known toxicity, flammability or reactivity properties, incompatibilities, health effects as well as how the chemical behaves in fire, an accidental exposure incident, how spills are treated and the government regulation for its proper transportation, storage, and disposals. The MSDS must be readily available when needed, and a written training plan with information on training sessions and dates for all employees working with these chemicals is also required (General Guidelines for Storage and Management of Laboratory Chemicals, 2015).

Under the OSHA Hazard Communication Standards (2012), chemical distributors must evaluate the potential hazards their chemicals pose. They must appropriately label chemicals and provide for the consumer an MSDS for each chemical. They must also include how the chemical behaves in fire, how to handle an accidental exposure incident and how spills are treated as indicated in the MSDS. School administrators must train their laboratory personnel on how to handle them and have an MSDS readily available for each chemical. The storage of chemicals should be simple and organized in such a way as to minimize possible hazards. A suggested system for categorizing chemicals is to use color. The chemical classification groups include sulphuric acid and nitric acids, corrosive acids, corrosive bases, flammables, and non-hazardous chemicals. Chemical manufacturers and businesses utilizing hazardous chemicals must use color codes to identify and group chemicals according to hazard and class: red for flammable, yellow for reactive and oxidizing, blue signifies health hazard, white for corrosive, gray or green for moderately hazardous (ChemAlert Storage Code Fisher Scientific Inc., 2015). Many commercially-provided chemicals are manufactured with color-coded labels to make this task much easier, and so it is suggested to color code the label of each type of chemical according to its classification. Each chemical has an associated storage color code, and chemicals should only be stored with other chemicals of the same color code.

STORAGE GROUPS (ChemAlert Storage Code Fisher Scientific, Inc.)	
RED	It must be in inflammable storage (for chemicals that readily burn). Store separately only with other flammable chemicals.
GREY	It is used by Fisher (instead of green). Reagent presents no more than a moderate hazard in any category. For general chemical storage with no particular storage hazard
BLUE	It is toxic or a health hazard (for chemicals that are poisonous). Chemical is hazardous to health if ingested, inhaled, or absorbed through the skin. Store separately in a secure area.
YELLOW	It is for reactive/oxidizing chemicals that undergo spontaneous chemical reactions or readily react with other chemicals). It may react violently with water, air, or other chemicals. Store separate from combustible and flammable reagents.
GREEN	It is for corrosives – alkaline for chemicals (like strong acids and bases) that destroy tissue by chemical action. A reagent presents no more than a moderate hazard in any category. Keep in general chemical storage.
WHITE	It is for corrosives – acids for chemicals (like strong acids and bases) that destroy tissue by chemical action. It may be harmful to the eyes, mucous membranes, and skin. Store separately from combustible and flammable chemicals.

For schools with large storage areas or stock rooms, codes are used for classifying functional classes of chemicals. The organic and inorganic chemicals are separated, with sub-groups further separated. Related and functional storage groups are listed according to Prudent Practices and the shelf storage codes adopting "I" for inorganic compounds and "O" for organic compounds (The Prudent Practices in the laboratory, 1995). Below are tables containing a sample of storage codes.

Storage Codes	Related And Functional Storage Groups	Storage Codes	Related And Functional Storage Groups
I-1	Metals and hydrides	O-1	Organic acids anhydrides and peracids
I-2	Halides, sulfates, sulfites, thiosulfates, phosphates and halogens	O-2	Alcohols, glycols, - amines, - amides, - imines and imides
I-3	Amides, nitrates (except ammonium nitrate), nitries, and azides	O-3	Hydrocarbons, esters, and aldehydes
		O-4	Amines, - imines and pyridine
I-4	Hydroxides, oxides, silicates, carbonates and carbon	O-5	Ethers, ketones, halogenated hydrocarbons, and ethylene oxide
I-5	Sulfides, selenides, phosphides, carbides, and nitrides	O-6	Epoxy compounds ad isocyanates
		O-7	Organic peroxides, hydroperoxides, and azides
I-6	Chlorates,perchlorates,chlorites,hypochlorites and peroxides	O-8	Sulfides, polysulfides, sulfoxides, and nitriles
		O-9	Phenols and cresol
I-7	Arsenates, cyanides, and cyanates		
I-8	Borates, chromates, manganates, and permanganates		
I-9	Inorganic acids		
I-10	Sulfur, phosphorus, arsenic, and phosphorus Pentoxide		

Storage Codes	Inorganic Shelves	Storage Codes	Organic Shelves
I-1 & I-10	Sulfur, Phosphorus, Arsenic, Metals, and Hydrides (Store All Away From Water!)	O-1	Dry And Dilute Organic Acids, Anhydrides, and Peracids
I-2	Halides, Sulfates, Sulfites, Thiosulfates, Phosphates and Halogens	O-5 & O-7	Organic Peroxide and Azides
I-5 & I-7	Sulfides, Selenides, Phosphides, Carbides, Nitrides, Arsenates and Cyanides	O-6 & O-8	Epoxy Compounds, Isocyanates, Sulfides, Sulfoxides, and Nitriles
I-4	Dry Hydroxides, Oxides, Silicates, and Carbonates	O-9	Miscellaneous Organics: Powdered And Alcohol-free Stains and Indicators
I-3, I-6 & I-8	Nitrates, Nitrites, Borates, Chromates, Manganates, Permanganates, Chlorates, Chlorites, and Inorganic Peroxide		Flammable Storage Cabinet – Hydrocarbons, Ethers, Ketones, Amines, Halogenated Hydrocarbons, Aldehydes, Alcohols, Glycols, Phenol, Cresol, Combustible Organic Acids, and Combustible Anhydrides
I-9	Corrosive Acid Storage Cabinet – Inorganic Acid and Nitric Acid Stored Separately In This Or Another Cabinet		Corrosive Base Storage Cabinet Or Cupboard– Concentrated Liquid Inorganic Hydroxides

Based on the Laboratory Safety Design Guide of U.S. (2012), chemical shelves or cabinets can be constructed from materials such as solid wood, pressed wood, plywood, metal, or polyethylene. They may be coated with protective paints or epoxy to further protect the construction materials. Inexpensive cabinets and shelves may cause problems if used in ways they were not intended, like the fabricated cabinet made by some carpenters who lack proper information about the effect of chemicals. For example, it is not advisable to use a solid metal cabinet in the chemical storage room because of the corrosive nature of the chemicals. In any case, an ordinary shelf is made with a glass lining placed as protection for the wooden cabinet.

Simply placing chemicals on the shelves is not sufficient under the Occupational Safety and Health Administration (OSHA) requirements. Chemical shelves must be secured on the wall or mounted on the floor and should have antiroll-off lips. Overcrowding is not permitted when storing chemicals on the shelves. These must not exceed eye level in terms of height. In case of storing beyond eye level, these should be limited only with small secondary reagent bottles. A step ladder or stool should be available. Storing chemicals on the open floor is avoided.

According to Harris (2010), basic chemical segregation and storage principles are essential. Chemicals are stored and segregated according to hazard classifications or chemical families.

Class of Chemical	Recommended Storage Method	Examples	Incompatibilities
Compressed gases – Flammable	Moist free, low temperature, and away from oxidizing chemicals, secured against the wall or bench	Hydrogen, methane, acetylene, and propane	Oxidizing and toxic Compressed gases, oxidizing solid
Compressed gases – Oxidizing	Moist free, low temperature, away from combustible gases and liquids, secured against the wall or bench	Oxygen, Chlorine, and Bromine	Flammable gases
Compressed gases – Poisonous	Moist free, low temperature, away from combustible gases and liquids, secured against the wall or bench	Carbon monoxide, Hydrogen sulfide, and Nitrogen dioxide	Flammable and /or oxidizing gases
Corrosives – Acids	Store separately on acid-proof shelves, separate from oxidizing acids (i.e., chromic, nitric, sulfuric, and perchloric acids) from organic acids	Acetic acid, Phenol, Sulfuric acid, Chromerge, Nitric acid, Perchloric acid, Chromic acid, and Hydrochloric acid	Flammable liquids flammable solids, bases, and oxidizers
Corrosives – Bases	Hydroxides are placed in polyethylene bottles inside anti-corrosive shelves.	Ammonium hydroxide, Sodium hydroxide, Calcium hydroxide	Flammable liquids oxidizers, poisons, acids
Flammable Liquids	Away from open flame and inside fireproof shelves, combustible liquids are placed inside combustible proof cabinets or shelves	Acetone, Benzene, Diethyl ether, Methanol, Ethanol, Toluene, Glacial acetic acid	Acids, bases, oxidizers, and poisons
Flammable Solids	Away from open flame, moist free and low temperature. Separate from oxidizers and flammable liquids	Phosphorus, yellow Calcium carbide Picric acid, Benzoyl peroxide	Acids, bases, oxidizers, and poisons
Class of Chemical	**Recommended Storage Method**	**Examples**	**Incompatibilities**
General Chemicals - Non-reactive	Laboratory benches or shelves. Below eye level preferably, lined with glass and behind glass doors	Agar Sodium chloride Sodium bicarbonate Most non-reactive salts	Carbon tetrachloride, carbon dioxide, water

Oxidizers	Spill-proof trays inside storage shelves and away from flammable and combustible materials	Ammonium persulfate Ferric chloride Iodine Sodium hypochlorite Benzoyl peroxide Potassium permanganate Potassium dichromate The following are generally considered oxidizing substances: Peroxides, perchlorates, chlorates, nitrates, bromates, superoxides.	Separate from reducing agents, flammables, and combustibles.
Poisons/Toxic Compounds	Well ventilated and moist free area, Placed in secondary chemical-resistant containers and in accordance with the hazardous nature of the chemical	Aniline Carbon tetrachloride Chloroform Cyanides Heavy metals compounds, i.e., cadmium, mercury, osmium Oxalic acid Phenol Formic acid	Flammable liquids, acids, bases, and oxidizers.
Water-Reactive Chemicals	Moist free, low temperature, and away from water fire sprinkler	Sodium metal Potassium metal Lithium metal Lithium aluminum hydride	Separate from all aqueous solutions and oxidizers.
Carcinogen	Label all containers as "Cancer Suspect Agents" Store according to the nature of the hazard	Benzidine Beta-naphthylamine Benzene Methylene chloride Beta-propiolactone	Strong acids Non-flammable chlorinated solvent
Teratogens	Label all containers as "Suspect Reproductive Hazard" Store according to the nature of the hazard	Lead and mercury compounds Benzene Aniline	Corrosives, oxidizers, water treatment chemicals(citric, nitric acid, caustic soda)
Peroxide-Forming Chemicals	Store in air-lock vacuum containers in a dark, cool and moist area. Follow storage standards.	Ether (diethyl and isopropyl), Tetrahydrofuran Acetaldehyde Acrylonitrile	
Strong Reducing Agents	Moist free, well ventilated, and away from other chemicals	Acetyl chloride Thionyl chloride Maleic anhydride Ferrous sulfide	

The stock, the laboratory, and the preparation room are separate areas that are part of the storage facility. Laboratory personnel, including the laboratory instructor, must be familiar with the setting of where each substance is stored, located, and prepared. The shelves should be clearly labeled. It is a good practice to color code the storage area to help ensure that removed chemicals are returned to their proper places. Each chemical has an associated storage color code, and chemicals should only be stored with other chemicals of the same color code. One must store chemicals away from drains so they will not accidentally enter the local sewer system. In addition, one must not prepare or mix solutions in the chemical storage area.

CHED Memorandum Order 18 Series 2007 congruent with Safe Storage of Laboratory Chemicals (2015) and DepEd Order 48, s. 2006 identified that the right temperature, ventilation, segregation, and identification are important when storing chemicals. Chemicals should not be stored on the lab bench, fume hoods, or on the floor due to the possible danger of being knocked off and resulting in a spill. Chemical trays should never be placed with reagent bottles along the aisle or floor. Laboratories should try to only keep as much as possible the minimum quantity of chemicals necessary as specified in NFPA 45 and OSHA (Safe Storage of Laboratory Chemicals, 2015).

The storage of chemicals on bench tops should be kept to a minimum to help prevent clutter and spills and to allow for adequate working space, especially when preparing requested chemicals for every class. When ordering new chemicals, laboratories should only order enough stock needed for the experiment or the quantity that will be used within one or two years at most. This also means that knowledge of the different experiments is needed in order to identify and calculate the amount of chemicals needed. Fume hoods are also used to store chemicals like the volatile reagents that are used during experiments. Excessive storage of chemicals in fume hoods must be avoided, which hinders airflow, reduce working space, and increase the tendency of spillage, fire, or explosion (Safe Storage of Laboratory Chemicals, 2015).

The Occupational Safety and Health Administration (OSHA) is an agency of the U.S. Department of Labor. It was established under the Occupational Safety and Health Act in 1970. The primary purpose of OSHA is to develop and enforce regulations and to ensure a safe working environment in public and private organizations' components. Based on these regulations, storage of chemicals requires the proper MSDS documentation, storage area, and chemical segregation by class.

OSHA requires hard copy and on-site availability of the Material Safety Data Sheets (MSDS) for all chemicals in use and in storage. This manual usually accompanies the purchased chemical. CHED Memorandum Order (CMO) 18, s. 2007 specified that one should never use or handle chemicals without reading and understanding the MSDS of a particular chemical to be used. One must indicate the chemical properties, classification, safe handling and storage procedures, and potential hazards. The hard copies are to be arranged alphabetically in a designated file and stored in a place and should be accessible (OSHA Chemical Storage Requirements, 1995). Every school must have a chemical list to evaluate the hazards of chemical compounds or chemical constituents they have in stock. This is important for anyone who needs information in assessing the risks and inventory of chemicals. Through the use of a search tool, one can easily find the chemical by name, its exposure and safety hazards, the environmental toxicity as well as the common experiments.

According to OSHA Hazard Communication and CMO 18, s. 2007, all chemical containers must have proper labeling. The prepared solutions also should be properly labeled according to OSHA regulations. The original chemical container should include chemical name, manufacturer, potential hazard information, date of receipt, date opened, and expiration date. If laboratory personnel transfer a certain amount in smaller reagent bottles, a compatible reagent bottle must be available with the chemical name written or pasted on it. If chemical formulas, abbreviations, or acronyms are used, then there has to be a key or list of the chemical names that are accessible for the laboratory assistance and teachers. If a label is starting to fall off or becomes degraded from a chemical container, the container needs to be re-labeled for everyone's safety.

OSHA emphasizes that every person working in the laboratory, especially the laboratory assistants, must be fully trained on how to label chemicals using the system and how to read the label. Training must be done when a new person begins working in the laboratory when new chemicals are introduced and should occur on a regular basis, like every semester when new lab assistance is deployed.

When working with chemicals, chemical safety goggles, gloves, and lab coats should be the first pieces of equipment on the list (Environmental Health & Safety, 2014). Personal Protective Equipment (PPE) is necessary in handling chemicals for the protection of every personnel and student (DepEd Order 48, s. 2006). Advanced experiments sometimes require special equipment, such as a fume hood. Experiments that require the use of special safety equipment may require that working in the laboratory of a teacher or mentor.

According to the Environmental Health and Safety (2014), there is a need for proper training of personnel and students on the handling of chemicals and products containing chemicals that will help prevent accidents; thus, reducing exposure to harmful chemicals. Training at various levels should be provided for all school employees and students on basic chemical hygiene, storage and handling procedures, and how to respond in the event of a chemical spill or accident.

The excessive and unwise use of chemicals produces uncontrollable chemical waste. Reduction of waste starts with wise use of chemicals. The American Chemical Society (1993) recognized the need for minimizing chemical waste and has publications called "Less is better; buy only what you need and use all of what you buy." "Less is better" outlines the practical waste minimization concepts. There are three primary ways of waste minimization: the Environmental Protection Agency (2014) has placed them in the following hierarchy: source reduction, recycling, and treatment. Hierarchy is an order of hazardous substances management options according to their possible environmental detrimental effects.

Microscaling reduces the amount of chemical usage, particularly the amount of waste produced as well the generation of pollution to the environment. Microscale procedures use smaller quantities of reagents which reduce cost and may result in smaller quantities of waste

(Laboratory Waste Minimization and Pollution Prevention, 2014). There is this specific field of microscale chemistry, which means miniature experiments particular for instructional laboratory classes are implemented (UPD-DChE Waste Management System, 2004). Most macroscale experiments can be easily scaled-down and still achieve the same results. It is better for students to work in teams. For example, pairing students or merging groups of students can reduce the amount of chemicals that will be used. Pairing also teaches students to work together, interact and be open-minded, which are good values to be learned in the laboratory area. Demonstration of the experiment is also a good option, rather than having it with the whole class. Actual laboratory experiments are important in exploring and further understanding experiments to a certain degree, alternatives such as instrumental analysis, computer simulation, or even videos. Commercial and industrial laboratories opt to choose instrumentation and simulation rather than wet chemistry, where people do an actual experiment using different chemicals whenever possible. In higher education institutions, a computer simulation may greatly decrease the number of chemicals and, at the same time, reduce the amount of waste generated. In research development, experiments are always repeated, allowing researchers or students to work and optimize experiments on the computer instead of actual hands-on or wet chemistry in full scale.

Source reduction is the most suitable technique in minimizing chemical waste production. This process does reduce not only the amount of chemical usage but also the production and effect of chemical waste on the environment (Pollution Prevention Act of US Congress, 1990). Together with good chemical management, replacement or substitution of hazardous chemicals into less harmful and following proper laboratory and experiment protocol must be achieved by the laboratories (U.S. EPA Green Chemistry Program). Good chemical management involves dealing not only controlling the number of chemicals used but also means purchasing only the amount of chemicals to be used in the planned experiments. Good laboratory procedures mean preparing only the amount of solutions needed for the work anticipated. Wise purchasing decision results in effective waste reduction.

A starting point for waste minimization is efficiency in the use of resources. If a teacher places emphasis on sparing with the use of chemical usage or their resources (such as water or electricity), students will be more likely to pay attention to these resources as well.

Another approach is to minimize waste through recycling. Waste material is used for another activity or experiment, treated or reclaimed for another process is called recycling. After minimizing waste generation through source reduction, the next most preferable options are recycling and re-using (The Pollution Prevention Act of by US Congress, 1990). These can occur at a number of points in the chemical use cycle. Used chemicals will be maintained in their containers and must be secured in a storage area until such time that they are either re-used in a laboratory procedure or re-classified as waste for disposal. When used chemicals become reclassified as hazardous waste, their containers will be re-labeled as such and segregated according to classes for disposal based on Environmental Protection Agency categories. According to the Federal Law, the properties of chemical waste that pose hazards are as follows:

Ignitable	Materials capable of causing fire
Corrosive	Aqueous solutions with a pH less than or equal to 2 or greater than or equal to12.5
Reactive	Substances that are unstable, explosive, water-reactive, or generate toxic gases
Toxic	Substances that are harmful to human health such as Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, and Silver

Note that these definitions are unique, especially the definition of waste having the characteristic of toxicity (EPA's Regulations in the Code of Federal Regulations, 40 CFR). Another alternative process is chemical replacement. Replacing hazardous chemicals in laboratories with non-hazardous (or at least less-hazardous) chemicals is an important source reduction technique (U.S. EPA Green Chemistry Program). Using less harmful chemicals in place of hazardous chemicals avoids hazardous waste problems. Substitution can sometimes be done in combination with scaling down the amount of chemicals used in experiments at the same time, save money. Substitution has been achieved by a number of secondary schools, as well as introductory college chemistry courses. They have created laboratory experiments that rely on chemicals and compounds that can be available and purchased at the local grocery store rather than from a chemical supplier.

The responsibility of the chemistry laboratory does not end in waste reduction but also with waste management and disposal, which aims to maximize safety and minimize environmental impact. Waste minimization in the laboratory does not necessarily require major changes in the way experiments are run. Some basic efforts to be more efficient and careful with experimental procedures can substantially reduce the amount of waste generated.

Practicing waste minimization and pollution prevention are environmental responsibilities. Reducing wastes at the source is the most effective step towards eliminating wastes that would otherwise be released to the environment. Waste minimization and pollution prevention help ensure schools in meeting the legal requirements. There are laws that govern waste disposal. Many schools may be violating some of these laws. The best way to comply with these laws is to not generate waste in the first place.

Reduction of chemical usage and waste must be practiced in schools. Despite good practices, these are not enough because there are chemicals stored in the laboratory that are expired and unfitted for use. These are toxic and highly reactive agents that can cause harm to the laboratory personnel. These are the chemicals that are purchased in excessive amounts, stored incorrectly, and disposed of improperly. In addition to these unused chemicals, many schools accumulate the chemical waste from laboratory experiments for years.

The last of the three methods is treatment. The most common treatment is elementary neutralization which does not require any regulatory law. Other kinds of treatment may involve chemical, physical, or biological methods. The treatment method requires the training of personnel and securing a permit from environmental agencies. However, if treatment is conducted in the laboratory as part of an experimental or analytical procedure, a special permit is not required.

Stressing the importance of these approaches to students would help instill in them habits that will be of value to the rest of their lives, whether in the laboratory, on the job, or even at home. According to DENR Implementing Rules and Regulations of Republic Act 6969 (1992), the waste generator shall be responsible for the proper management and disposal of the hazardous waste and shall bear the cost of the proper storage, treatment, and disposal of hazardous waste (DAO 36 Series 2004). "Waste Generator" means a person, company, or institution who or which generates or produces, through any commercial, industrial, or trade activities hazardous wastes. It may choose to handle some or all of these responsibilities with the presence of in-house personnel, or it may have a contract with professional waste management firms.

Forty percent of generated wastes by the laboratory are from unused and unfitted chemicals that are mostly stored in the laboratories, and the accumulation of chemical waste may cause problems to everyone and may be difficult and expensive to dispose-off (The American Chemical Society, 2000). The school must choose among the suppliers who support wastes minimization. The institution must find a company that can deliver small amounts of chemicals and can accept and receive unused and expired chemicals at the same time.

The Occupational Safety and Health Administration (OSHA) promulgated a final rule for occupational exposure to hazardous chemicals in laboratories, also known as the OSHA Lab Standard. Included in the standard is the requirement that all employees covered by the standard must carry out the provisions of a Chemical Hygiene Plan (CHP). The OSHA priorities are as follows: (1) develop chemical safety programs that protect the health and well-being of students, faculty, staff, and visitors; (2) develop programs to minimize chemical hazards and chemical wastes; (3) provide guidance for the safe handling, storage, and disposal of chemicals used on campus; (4) dispose of chemical wastes in an environmentally sound and cost-effective manner; and, (5) assist the campus community in complying with federal, state and local regulations.

Wastes must be classified and categorized according to hazard so that these will be handled and managed accordingly (EPA's Regulations in the Code of Federal Regulations (40 CFR). Placing chemicals on proper containers as to type or class according to the OSHA

Laboratory Standards is necessary to determine chemical waste regulation. Putting a proper label on the reagent bottle, waste type, ID number, group, date collected, disposal, and treatment is a must.

Wise management of chemicals starts upon acquiring and purchasing the chemicals. The usage, storage, disposal, and impact to the environment are necessary to be considered to protect the health and safety of the laboratory personnel, especially during waste collection, storage, and disposal (Prudent Practices in the Laboratory (1995). Waste management, in particular, focuses on processing waste after it is created, concentrating on re-use, recycling, and conversion of any energy that can be generated from the waste rather than eliminating the creation of waste in the initial phases of production. On the other hand, waste minimization involves efforts to minimize resource and energy use during activities or experiments.

An international policy is created that places importance on source reduction as the most necessary approach in preventing and reducing chemical pollution. An order of priority and importance is given to lessen chemical waste production and the negative impact on health and the environment (The Pollution Prevention Act of by US Congress, 1990).

Source reduction	Pollution should be prevented or reduced at the source whenever feasible.
Recycling	Pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible.
Treatment	Pollution that cannot be prevented or recycled should be treated in an environmentally-safe manner whenever feasible.
Disposal	Disposal or other releases into the environment should be employed only as a last resort and should be conducted in an environmentally-safe manner.

Prudent waste management methods include involvement and commitment by the administrators to develop and support a waste minimization program. The program should involve training and developing laboratory personnel to be good in planning waste minimization strategies and identifying source reduction options. Improving regulatory requirements and compliance with government policies are among the management initiatives in promoting pollution prevention.

Unlike other waste generator institutions that have only particular types of waste generated, the chemistry laboratory produces mixed waste that is generated from the different chemicals used in their experiments. It is often difficult to find a facility that can manage different types or categories of chemical waste, which is a common problem of most schools and universities. Storing wastes should follow many of the same practices used for storing virgin chemicals. That is, wastes should be clearly labeled. They should be grouped and segregated according to type, and they should be tracked while leftover reagents and reaction products should be placed in marked containers at the end of each laboratory session. Broken glass should be placed in its own marked container. Used chemicals shall be classified into the following categories (School Laboratory Chemical Hygiene and Safety Plan):

Flammable	Ignitable: Materials capable of causing fire. • A liquid chemical with less than 60°C ignitable temperature (flashpoint) (e. g. Acetone, Methanol) • A solid that is combustible when in contact with air or friction can undergo a spontaneous chemical change which can result in burning under standard temperature and pressure (e. g., Benzoyl Peroxide). • A substance that is an ignitable compressed gas or oxidizer is an ignitable waste (e. g. Propane, Hydrogen Peroxide).
Reactive • **Water Reactive** • **Air Reactive**	A chemical that is normally unstable and undergoes violent chemical change without introducing any incompatible substances when it exceeds its normal storage conditions Can react violently when contact with water and form potentially explosive mixtures Can be release dangerous or toxic gases, vapors, or fumes in a certain amount that is dangerous to health
Toxic	Substances that are harmful to human health such as arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.
Corrosive	A waste chemical is corrosive if it has a pH of less than 2 or greater than 12.5 (Note that a chemical is not allowed to be poured down the drain if it has a pH of less than 5.5 or greater than 12).

School Laboratory Chemical Hygiene and Safety Plan suggested that containers shall be labeled with the following information:

• Used-chemical category
• Name of chemical(s) in the container
• Approximate percentage of each chemical (if mixed)
• Date prepared
• Name of the teacher or room number

Planning and analyzing waste chemical treatment and disposal for the newly procured chemical is so important to minimize laboratory expenses on waste management and disposals. These minimize costs and manage laboratory waste most efficiently. It is important to consider treatment and disposal options as early as possible.

Chemicals are harmful if not handled properly. They may cause problems with long exposures and cause different health problems affecting all systems of the body. A toxic substance is any substance that could be harmful to living things (American Chemical Society, 2000). Complex relationships exist between a substance and its physiological effect in humans. In very minimal amount, some used chemicals may be disposed of into the sink, provided that one has done some treatment like dilution before draining it down the sewer.

Not all used liquid chemicals are permitted to be diluted and be drained into the sewer because there are chemicals that cause harm or danger, if not to people but to the environment. Most chemicals can actually cause damage both to the environment and to humans. Chemicals that are allowed for sewer disposal must be biodegradable and with a low toxicity level in aqueous solutions. Chemical wastes which are allowed to be disposed of in the sewer include used buffer solution, treated mineral acids and bases, and diluted water-soluble organic solvents like alcohol (Prudent Practices in the Laboratory, 2014).

Chemistry laboratories are often sources of hazardous chemical waste that can pollute the environment and can cause harmful effects to humans and other living organisms that are exposed to toxic chemical waste. However, all laboratories managers can make efforts in order to make it safe for students, teachers, and laboratory technicians, particularly regarding storage, usage, and disposals of chemical waste generated in every experiment. Minimizing the use of chemicals and reducing the number of toxic chemical wastes can be very advantageous economically, for this will reduce the cost of chemical purchasing and help save the environment from further contamination and destruction by chemical waste. This effort can be concentrated on chemicals or wastes reduction, as well as re-use techniques. It can also be of great help if the right information regarding waste reduction, waste management, handling, storage, and segregation is disseminated and practiced in the laboratory.

The primary aim of this study is to develop a proposed manual of standards and policies for school chemistry laboratory management. Specifically, it seeks to: (1) describe the existing practices of credible HEIs in managing their chemistry laboratories in terms of storage, handling, minimization, waste storage, and disposal; (2) map-out the gaps in the management of school chemistry laboratories based on the analysis of the existing practices of the HEIs when compared with the local mandates (CMOs), governing rules and international standards.

As teachers or professors in line with the field of laboratory management involving chemicals or reagents, ensuring safety and providing solutions to problems in the laboratory, and working together with the laboratory technicians, are important aspects of educational management.

As stated in Occupational Safety and Health Administration (OSHA) that, "Every school laboratory is required to produce and formulate policies and guidelines that will address hazards on students, personnel and the environment. The present study runs congruent to the aforementioned OSHA requirement as it aims to contribute to (1) identifying the proper and safe ways of storing and handling chemical reagents (chemical storage); (2) describing how lab managers reduce or minimize chemical usage and excessed chemical, as well as toxic chemical waste generated in the laboratory; (3) determining how laboratory managers handle and segregate chemical waste; and (4) identifying the proper and safe ways of handling and disposing of chemical waste.

METHOD

The study adopted the qualitative method using content analysis and benchmarking approaches to describe the different existing chemistry laboratory practices of six notable Higher Education Institutions in the National Capital Region, which have been awarded high accreditation levels by prestigious accrediting bodies and pick up the practices that best adhere to the standard. Prevailing international laws on chemical management and standards were also reviewed, and content was analyzed to substantiate the findings and supplement the needed information for the development of the proposed manual of standards and policies for school chemistry laboratory management. Benchmarking through observation and anecdotal recording on laboratory practices was done during the visit in the selected HEIs. These HEIs offer chemistry subjects both for medical (medical technology, pharmacology, nursing, dentistry) and non-medical courses (civil and industrial engineering).

Ethical protocols in the conduct of the school visit were properly observed. A letter of permission signed by the Director of CHED Region 3 was accomplished to allow the researcher to conduct data gathering in the form of interviews among the chemistry laboratory-in-charge or head of the HEIs. After the permission was approved by the authorities, the benchmarking was scheduled during their convenient time. Informed consent forms were distributed to and signed by the participants. Said consent forms (Appendix V) contained the assurance clause of adherence to keeping data gathered confidential and respecting the right and freedom of the participant to withdraw from participation at any time during the conduct of the study. The six (6) select participants were given copies of the interview questions to give them time to reflect on the questions. In place of a face-to-face interview, participants opted to submit their detailed responses through electronic means. These responses were content analyzed guided by the objectives of the study. Following is the profile of the participants:

Table 1
Profile of participants according to age, years in service, and position

Participants	Age	Years in Service	Position
1	28	6	Assist. Prof 2 (Lab Teacher)
2	52	20	Lab Technician
3	49	18	Chair(Chemistry)
4	40	10	Lab Technician
5	29	5	Lab Instructor
6	31	4	Assist. Lab Tech

Questions in the interview guide were developed based on the conditions observed in the chemistry laboratory that needed immediate attention and improvement and on the existing chemistry laboratory practices, standards, and safety practices of international bodies.

After retrieving the responses, the data were summarized and categorized into technical laboratory themes. The common responses were considered to be the best and the most beneficial procedures in the upkeep of Chemistry laboratories for education.

The data gathered and literature review were used as a source of inputs for the drafting of the proposed manual of standards and policies for school chemistry laboratory management.

FINDINGS

The findings of the study are presented according to the sequence of the problems in the earlier section. The order of presentation is as follows: existing practices of credible HEIs on (1) proper and safe ways of storing and handling chemical reagents; (1.1) storage and handling of chemicals, (1.2) Segregation of chemicals, (1.3) storage cabinet materials, (1.4) labeling of chemical shelves, (1.5) safety handling and storing chemicals; (2) reduction and minimization of chemical usage and excessed chemicals ; (2.1) proper usage/utilization of chemicals, (2.2) minimization (chemical usage and waste production), (3) segregation of chemical waste; and, (4) proper and safe ways of disposing of chemical waste; and tables that are derived from gap analysis between the management of school chemistry laboratories of the existing practices of the HEIs and local mandates (CMOs), governing rules and international standards.

After reading, tabulating, and categorizing the respondents' answers, it was discovered that the best existing practices of the different universities could become models or benchmarks in upgrading the laboratory practices and chemical management. These include storage, utilization, and disposal. Based on the findings, a Chemistry Laboratory Guide Manual was developed. This will be useful in managing a chemistry laboratory. The said manual may be revisited in order to be updated with the latest trends.

Proper and Safe Ways of Storing and Handling Chemical Reagents

Storage and handling of chemicals. Allocate separate rooms for storage. The need for a separate room for storage prevents accidents like spills, bottle container breakage, and chemical fume inhalation, especially highly-volatile chemicals. There is a need to fabricate shelves to secure chemicals safely. Storing chemicals does not end in placing chemicals in a separate room. A secured and safe storage shelf is required to place chemicals with an anti-slip or anti-roll-off lid. It must be secured-mounted on the wall or on the floor. Chemicals produce certain chemical reactions when exposed to extreme conditions like temperature. It is generally ideal for placing chemicals in a cool, dry place. One participant (P4) commented: "Store chemical in cool temperature not exceeding 32^0 C". Other participants (P1 and P6) stated that chemicals must be stored in a place with good air circulation. Participants 1 and 5 stated that chemicals must be stored away from direct sunlight.

Table 2 emphasizes that in storing chemicals, all the participants confirm the allocation of a separate room for storage. They further supported fabricating shelves that would let the chemicals stay safe and secured. Regarding temperature provided in storing chemicals, the participants had this common practice of keeping the storage room and shelves for chemicals to be cool and dry. One of them (P2) specified the temperature to be at 32^0C, while two of them (P1 and P6) would also require proper air circulation or ventilation.

Table 2
Participants' current practices on storing chemicals

Storing Chemicals	P1	P2	P3	P4	P5	P6
a. Storage	Stockroom (not accessible for students) Chemical rack /cabinet	Stock room Reagent shelves with lid	Stock room(sepa-rate room) rack/open cabinet	Isolated place/room away from students lid cabinet	Stockroom Wall mount shelves	Small room to separate chemicals(to be safe) Open shelves with built-in anti-slip lid
b. Temperature	Away from the sun good ventilation	Cool, dry place	Low temperature	Cool temperature not exceeding 32^0	Away from the direct sunlight	Cool, dry place with good air circulation (ventilation)

Segregation of chemicals. Segregate chemicals according to compatibility, class, or type (P1, P2, P4, and P5). Most of the chemicals are reactive. When stored with unlike or incompatible chemicals, they might cause a violent reaction that may harm or endanger the laboratory personnel. Store chemicals according to class or type. It is recommended to segregate chemicals according to the subject. Chemicals may be segregated, whether they are used in organic or inorganic chemistry. Also, one must segregate chemicals using color codes. After classifying chemicals according to type or class, color codes are pasted on the body reagent bottles for identification.

Table 3 shows the practices on chemical segregation or separation inside the storage room. All six participants confirmed that chemicals must be stored according to compatibility as well as segregated according to type or class. One of them (P2) emphasizes that chemicals must be segregated according to types like oxides, hydroxides, nitrates, sulfates, acids, and base. Another participant (P3) elaborated that segregation must be done using color-coded labels for flammable, non - flammable, corrosive, non-corrosive, acids, bases, and also segregated as to they are organic or inorganic according to another participant (P6).

Table 3
Participants' current practices on segregation of chemicals

	P1	P2	P3	P4	P5	P6
Segregation/ Separation of Chemicals in the Stockroom	Group according to compatibility	Segregated according to type (oxides, hydroxides, nitrates, sulfates, acids, and bases)	Segregated according to the subject: Colored coded label (flammable, Non-flammable, corrosive, non-corrosive, acids, bases, etc.	Separated according to the type of chemical based on compatibility	Separated according to the type of chemical group chemicals based on compatibility	Separated according to the subject (those used in inorganic, organic, etc.)

Storage cabinet materials. Use of wood cabinets/shelves lined with glass. The use of shelves or cabinets that are anti-corrosive or anti-rust is mostly recommended. Wooden shelves lined with glass are commonly used. It is ideal to use stainless steel. Stainless steel cabinets may also be used, but it is not a common practice.

Table 4 shows that all participants recommend wood as a material to be used for the shelved cabinets for storing chemicals, specifically lined with glass (P1, P5, and P6). While two of the participants, specifically participant 2, recommended both stainless steel and wood, and participant 3 also recommended wood and rust-proof metal.

Table 4
Participants' current practices on the type of material used for storage cabinets

	P1	P2	P3	P4	P5	P6
Storage cabinets (materials used)	Wood panel lined with glass	Stainless and wood	Wood and rust-proof metals	Wooden	Glass-lined cabinet	Wooden/ glass

Labeling of Chemical Shelves. Participants expressed a unified practice, that labels must be color-coded according to type or class (P1-P5). Color codes are used and pasted on the shelves as a guide in returning and placing back on their group or class. Original labels are retained or copied and pasted on the cabinets (P1). Labels on the original container must be copied and pasted on shelves for security and safety purposes. Moreover, having warning signs pasted on chemical shelves as a precautionary measure may prevent any harm or accidents. (P5).

Table 5 presents data about the proper labeling of storage bottles of chemicals that are placed on the chemicals shelves in the stockroom. All participants agreed that chemicals must be labeled and color-coded for proper identification. Participant 1 emphasized that original labels must be retained, copied, and pasted.

Table 5
Participants' current practices on labeling reagent bottles and shelves

	P1	P2	P3	P4	P5	P6
Labeling: Reagent bottles and chemical shelves	Original labels are retained, copied, pasted on the cabinets	Proper label according to type, kind, and use of color-coded labels	Color-coded labels (acids, bases, oxides, etc.)	Color-coded labels (types/class)	Label according to categories and use Must have warning signs	Traditional label; the name of chemical attached in the bottle

Safety in handling and storing of chemicals. There is a need for Material Safety Data Sheet (MSDS) on chemicals shelves (P1, P3, P4, and P6). MSDS must be located near or on the shelves for easy access. One must have knowledge and practice of basic laboratory safety rules (P2-5). The basic laboratory safety rules in the laboratory must be practiced all the time for the safety of the students, that is, before, during, and after the experiment. One must work only with the presence of the instructor (P2). Working with the presence of a laboratory instructor may prevent any accident or damage.

Table 6 presents data about safety in handling and storage. Participants practice safety measures by having Material Safety Data Sheet (MSDS) ready at hand or placed on the shelves for reference. The participants always make sure that knowledge and practice on safety rules and regulations are implemented at all in the laboratories.

Participants 1, 3, 4, and 6 put emphasis on the importance of MSDS. On the other hand, participants 2 and 5 proposed the knowledge and practice of basic safety rules and regulations in the laboratory; another point by Participant 2 is to work only with the presence of a laboratory instructor.

Table 6
Participants' current practices on safety in handling and storing chemicals

	P1	P2	P3	P4	P5	P6
Safety in handling and storing chemicals	MSDS (material safety data sheet)posted for easy access	Avoid handling chemicals with bare hands; Work only in the presence of an authorized person; Practice basic safety rules and regulations	Proper information regarding handling chemicals safely	Always use the proper and required attire in the lab(lab gowns, goggles, facemask, gloves, and head cap)	Safety measures and use of protective gears	Proper knowledge and background in handling different chemicals

Reduction and Minimization of Chemical Usage and Excessed Chemicals

The proper use of any reagents in the laboratory will minimize the production of chemical waste in such a way that it reduces the potential harm to the environment.

Proper usage/utilization of reagents. The practice of using a separate clean, dry spatula for every solid reagent (P3, P4, and P5) as well as a separate pipette or dropper for every liquid reagent (P3, P4, and P5). It is advised to use clean containers (P6). The use of clean secondary containers, clean and dry spatula for solid reagents, and as well as a clean and dry pipette or dropper for liquid reagents will prevent the contamination of reagents during the experiment. One must get only the exact amount needed (P6). Getting only of what is needed as indicated from the experiment procedures will decrease or lessen the amount of reagents used and, at the same time, will decrease or lessen the amount of chemicals generated. One must know all precautionary measures before performing experiments (P1). It is important to read the experiment to know the chemicals to be used and to know how to handle these chemicals properly to prevent any harm or accident. It is highly recommended to practice "FIFO" (First In, First Out) (P2). Having knowledge of the expiration date of the chemicals stored in the laboratory is important. This is in order to be able to control and prevent chemicals from being used for experiments. It is advisable to utilize chemicals that are about to expire than those chemicals with a longer period of expiration dates.

Table 7 shows the current practices on proper utilization of reagents and chemicals during experiments and proper handling of chemical wastes. Participants practice the use of specific spatula for particular dry solid reagents and pipette for every liquid reagent. Older stocks must be utilized first to prevent waste of soon-to-expire chemicals. To save chemicals from contamination, participants 3, 4, and 5 practice the use of separate spatula for each dry solid (crystalline and powder) chemicals. A separate pipette for each liquid chemical or reagent is used. Participant 2 practices "FIFO" (first in, first out) in use or release of chemicals to prevent expiration of old stock chemicals and waste of chemicals. Participant 1 emphasizes the importance of precautionary measures prior to the execution of the experiment to prevent waste and accidents. Participant 6 is very particular with the use of clean containers and exact measurements for every reagent used.

Table 7
Participants' current practices on proper usage and utilization of reagents

	P1	P2	P3	P4	P5	P6
Proper usage/ utilization of reagents during experiments	Always prevent contamina-tion; Make sure you know all the precautiona-ry measures before performing the experiment	FIFO (First in, First out) to prevent expiration of reagents; Know the data information sheet regarding safety handling	Use of pipette and spatula to prevent contamina-Tion; Get only the exact amount	Instruct students on how to handle and always measure as stated on the procedures	Use a spatula for solid and dropper or pipette for the liquid to prevent contamina-tion and wasting of chemicals	Use clean containers; Make sure to get only the exact amount to prevent so much waste

Minimization (chemical usage and waste production). Microscaling is a way of minimizing or reducing the amount of chemicals to be used in the laboratory. Release only the amount of chemicals needed based on the experiment procedures.

There is a need for recycling and setting aside unused prepared chemicals. One must keep and set aside prepared chemicals that were not used for a particular experiment by the previous class. These can be used again by another class performing the same experiment. It is advisable to release only what is needed. One must issue chemicals only if when needed for a specific experiment. Table 8 presents the results on how to control the amount of chemicals used in the chemistry laboratory. All of the participants are unanimous in their response that the practice of microscaling is the best in reducing chemical waste in the laboratory.

Participants 1, 2, and 3 practice microscaling, a technique that reduces the amount of chemicals given to students in performing experiments. Participants 4 and 5 practice recycling unused prepared chemicals from the previous class. Participant 5 prepares only what is needed from the request of the laboratory teacher. Participant 6 practices releasing only what is needed based on the experiment procedures.

Table 8
Participants' current practices on minimization (Chemical usage and waste production)

	P1	P2	P3	P4	P5	P6
Controlling the amount of chemicals used	Give only a small amount or give only what is needed (micro-scaling)	Minimize the amount of chemicals used by means of having a demo experiment (micro-scaling)	Prepare only small or exact amounts based on how much is needed in the experiment (micro-scaling)	Based on the amount needed for certain experiments; Recycle unused prepared reagents for the next class	Prepare only what is needed from the request of the teacher; Set aside unused prepared chemicals for another class	Release only what is needed based on the experiment procedures

Segregation of chemical waste. Place or collect used chemicals in bottles secured with caps. Used chemicals must be collected and placed on clean bottles with a cap to prevent spillage. Proper identification is pasted on bottle containers. Proper labeling of waste bottles according to name, class, or type for safety reasons.

Table 9 shows the management of used and excess reagents after the experiment. For the unused prepared chemicals, the laboratory technician is the one responsible and liable for it. All participants practice setting aside and keeping the unused or excess prepared chemicals but not for longer periods. On the use and categorization of chemical waste, all the participants stressed collecting chemical waste separately in a bottle with a cap. Labels are placed on the bottle with the name, type, and classification of chemicals and the date collected. These bottles are placed in a separate room or shelves temporarily until the supplier collects them.

Table 9
Participants' current practices on waste management

	P1	P2	P3	P4	P5	P6
Management of used chemicals and excess reagents after the experiment.	Set aside but not for a longer period (Let suppliers collect the used chemicals/ waste); Set aside excess reagent for future needs	Place in a container with a label(classifi-cation, name, and date); Indicate if hazardous or not; Keep excess unused reagents for the next class	Put in a bottle with a cap and put a label (identify the reagent); Place in a safe location in the stockroom; Keep excess materials	Collect and set aside (in a safe place); Set aside unused reagents for future needs	Have specifically labeled bottles and place them in a place where it is safe until they are collected for disposal; Keep the excess for another class	Collect them in a bottle with a cap and put them in a safe place; Put identification (name and type of reagent) then dispose of it properly

Proper and safe ways of disposal of chemical waste. Dispose of chemical waste according to MSDS (P2 and P6). MSDS gives all the important information needed about any chemical like description, IUPAC name, and common name, other components for compounds, safety measures in handling, first aid in case of accidental inhalation and spillage, and proper ways of disposal.

Dispose of chemicals according to risk level and environmental law (P2). Different types of chemicals have different strengths and effects on the environment and living organisms. Disposing chemicals directly into the environment is strictly prohibited, especially to those classified with a high risk of potentially damaging the environment. Dilute used liquid chemicals before draining down the sink (P1 and P5). Some chemicals are allowed to be disposed into the drain (in small amounts), provided that they are diluted to reduce the strength of concentration. It is advised to contact the supplier for collection and disposal. (P1, P3, and P4). The best way to dispose of chemicals is to tie up with the chemical supplier. The school-in-charge of chemicals must have a Memorandum of Agreement upon purchasing of chemicals. This will cover the collection or retrieval of expired, unused prepared, and waste chemicals. Another option is to contract out with a chemical waste collector and treatment agent to collect and treat school laboratory chemical waste. This is a company that collects and treats chemical waste according to type. Their personnel are well-trained and licensed to do so.

Table 10 shows the findings of current practices on the management of chemical waste. Participants 1 and 5 use the dilution method prior to disposals. For less hazardous chemicals, it is advised to dilute with water before draining down the sink. Participants 2 and 6 put emphasis on referring first to the MSDS for proper waste management and disposal. All six participants practice labeling and identifying the kind of chemicals collected, segregated, and set aside. As practiced, the manner of disposal is according to the safety standards of the environmental protection law. Participants 1, 3, and 5 prefer to call or contact their supplier for the collection and disposal of their chemical waste. For schools with hospitals like Participant 3, their chemical waste is collected and disposed of together with their hospital wastes by an accredited company.

Table 10
Participants' current practices on proper and safe ways of disposal of waste chemicals

	P1	P2	P3	P4	P5	P6
Manage-ment of waste chemicals	Less hazardous chemicals dilute with water before draining down the sink; Let suppliers collect the used chemicals and waste	Dispose of chemicals according to their risk level; Dispose of according to environmental protection law; Refer to MSDS for proper disposal	Waste chemicals are labeled for proper disposal, collected together with the hospital waste	Collect and set aside (in a safe place); Contact supplier to get chemicals for disposals)	Less harmful chemicals and for small amounts; It may be drained down into the sink with running water	Dispose of properly according to MSDS

Development of the Proposed Manual

This portion exhibits how the manual evolved from the findings of this study (Table 11) and is based on international and local sources. The matrices show how the practices and standards revealed the gaps (Table 12) and imperatives necessary for integration in the manual.

Matrices in the Development of Guidelines and Policies on Chemistry Laboratory Management

This table presents the current laboratory practices of the participants in their respective school laboratories that are verified from existing laboratory standards both from international and local sources. Gaps are identified from their verified practices based on standards which are also a vital part of laboratory management.

Table 11
Practices, gaps, and standards (local and international)

PRACTICES	STANDARDS		GAP
	INTERNATIONAL	LOCAL	
a. Stock room • Separate, isolated storage room for chemicals only • Temperature and ventilation • With wall mount shelves • Anti-roll lip or lid	• Abbott Chemical Storage Standards (2014) • National Environment Research Council (NERC) Health and Safety Guidance (2010) • NFPA 45 and OSHA (Safe Storage of Laboratory Chemicals (2015) • Occupational Safety and Health Administration(OSHA)Laborato-ry Standards(1991)	• CMO 18 s2007 • DOLE:DO 136-14	•Cold storage •Well-illuminated • Built-in shelves not exceeding 1.90 meters in height
b. Segregation • Color-coded labels • According to class, type or compatibility • According to the subject, and chemical families or group	• ChemAlert Storage Code Fisher Scientific Inc., (2015) • The Prudent Practices in the Laboratory (1995) • Harris; Chemical Storage Guidelines. 2010	• CMO 18 s2007 • DOLE:DO 136-14	
c. Storage cabinet material • Wooden material lined with glass and stainless metal	• The Environmental Health and Safety Department (2012) • the Laboratory Safety Design Guide of U.S. (2012)		• Storage shelves coated/lined with epoxy or polyethylene
d. Reagent bottle labeling • Original labels are retained, copied, pasted on the cabinets • Proper label according to type, kind, and use of color-coded labels Traditional label; the name of chemical attached	• OSHA Hazard Communication Standards (1995)	• DOLE: DO 136-14	• Relabeling of fallen old labels • Using acronyms and Abbreviation • Training assistant on how to read and label chemicals • Warning signs or symbols • Labeling of secondary containers
e. Safety in handling and storage • Practice basic safety rules and regulations. • Always use PPE's • MSDS (material safety data sheet)posted for easy access • Proper information regarding handling chemicals safely	• International Labour Organization(ILO) Code of Practice Safety in the Use of Chemicals at Work (1993) • Environmental Health & Safety (2014) • International Labour Organization(ILO) Code of Practice Safety in the Use of Chemicals at Work (1993)	• CMO 18 s2007 • DepEd Order 48 s 2006	• Training of personnel and lab assistants • Chemical spills management • Emergency protocols • Limitation of storage on fume hood and laboratory benches • Safety symbols/sign • Chemical tracking system for inventory

• Knowledge and background in the proper handling of chemicals			• No chemicals should be stored above eye level and avoid top shelf
PRACTICES	**STANDARDS**		**GAP**
	INTERNATIONAL	**LOCAL**	
f. Proper usage/ utilization of reagents during experiments • Know all the precautionary measures before performing the experiment, never handle chemicals with bare hands • To prevent the expiration of reagents, practice FIFO. • Get only the exact amount to prevent so much waste • Use of clean pipette and spatula to prevent contamination.	• Occupational Safety and Health Administration (OSHA) Laboratory Standard • American Chemical Society (1993) • International Labour Organization • (ILO) Code of Practice Safety in the Use of Chemicals at Work (1993)	• •DepEd Order 48 s 2006 • UPD-DChE Lab Health and Safety and Environment Management System	chemical storage. • Corrosive chemical and liquid chemicals must not be stored above waist level
g. Controlling amount of chemicals used • Microscaling • Re-use and recycle unused prepared reagents • Prepare and release only what is needed based on the experiment procedures • Set aside excess reagents for future needs(next class)	• Laboratory Waste Minimization and Pollution Prevention (2014) • The Pollution Prevention Act of by US Congress (1990)	• UPD-DChE Waste Management System	
h. Management of used and excess chemicals • Collect and put in containers with cap • Put proper label or identification(name, type, classification, data collected) • Set aside but not for a longer period • Let chemical suppliers collect used chemicals or chemical waste	• Occupational Safety and Health Administration (OSHA) Laboratory Standard • Pollution Prevention Act by US Congress (1990	• CMO 18 s2007 • DENR AO 36 s 2004	

This table presents the verified findings from the existing standards and their page to which they are located in reference to the proposed manual.

Table 12
Findings and manual mapping

Findings	Standards	Manual Part/ Page
a. Stock room • Separate, isolated storage room for chemicals only • Temperature and ventilation • With wall mount shelves Anti-roll lip or lid	• Isolated area with strictly limited access for laboratory personnel only. • Ventilation is necessary for achieving the necessary air exchange and can be very useful for storerooms. • Room temperature must be cool and do not exceed 32^{0}C • Built-in shelves must be securely mounted on the wall or floor • Shelves height must not exceed two meters • Shelves must have an anti-roll lip or lid • Good lighting is needed for proper illumination	1.1 Manner of Chemical Storage; page 14
b. Segregation • Color-coded labels • According to class, type or compatibility • According to the subject, and chemical families or group	• Chemicals are classified, segregated, and shelved according to compatibility (class, type, or families by using color codes). • Incompatible chemicals must be stored separately	1.3 Segregation/Separation of chemicals container; page 16
c. Storage cabinet material • Wooden material lined with glass and stainless metal	• Storage shelves must be made up of highly corrosive resistant material like wood coated/lined with epoxy or polyethylene or lined with glass and stainless steel that are highly resistant to corrosion and chemical reaction	1.2 Storage shelves/racks; page 14-15
d. Reagent bottle labeling • Original labels are retained, copied, pasted on the cabinets • Proper label according to type, kind, and use of color-coded labels • Traditional label; the name of chemical attached on the bottle	• Retain the original label of chemicals on their containers. • For secondary containers, the label must be similar to the original container. • Use an appropriate reagent bottle for every type of chemical. • Use color codes in labeling • Old and degraded labels must be relabelled • Warnings signs must be included in the label of the reagent bottles	1.4 Reagent containers/bottle labelling; page 18

Findings	Standards	MANUAL PART/ PAGE
e. Safety in handling and storage • Practice basic safety rules and regulations. • Always use PPE's • MSDS (material safety data sheet)posted for easy access • Proper information regarding handling chemicals safely • Knowledge and background in the proper handling of chemicals	• Basic rules and regulations or SOP in the laboratory • Read and understand the MSDS before the experiment	2. Handling of Chemicals Proper Utilization of chemicals; pages 18-19
f. Proper usage/ utilization of reagents during experiments • Know all the precautionary measures before performing the experiment, never handle chemicals with bare hands • To prevent the expiration of reagents, practice FIFO. • Get only the exact amount to prevent so much waste • Use of clean pipette and spatula to prevent contamination	• Use a clean and dry spatula for solid(powder and crystalline)reagents • Use of clean and dry pipette and aspirator for liquid reagents	2. Handling of Chemicals A. Proper Utilization of chemicals; Pages 18-19
g. Controlling amount of chemicals used • Microscaling • Reuse and recycle unused prepared reagents • Prepare and release only what is needed based on the experiment procedures • Set aside excess reagents for future needs(next class)	•Prepare the exact amount of chemicals needed •Set aside and place in clean and dry reagent bottles unused and excess chemicals and recycle for the next class • Have a demonstration experiment for the class instead of performing by the many groups	2. Handling Chemicals B. Management of Unused or Excess Chemicals; page 19 3. Minimization of Chemical Usage and Chemical ` A. Wastes; page 20
h. Waste management and disposal • Label waste chemicals for proper disposal • Contact supplier for collection and disposal of chemical waste • Dispose of chemical waste according to risk level • Dispose of chemical waste according to environmental protection law • Refer to MSDS for proper disposal • For a small amount of less hazardous chemicals, dilute with water before draining down the sink.	• For a small amount of less hazardous chemical refer to MSDS for dilution • Treatment of waste chemicals must be according to risk level and environmental protection law • Contact supplier or Transporter to collect the chemical waste for disposal and treatment • Select proper container compatible with the chemical waste	1. Storing and Segregation Chemical Wastes. B. Disposals of chemical wastes; page 21

Findings	Standards	MANUAL PART/ PAGE
h. Waste management and disposal • Label waste chemicals for proper disposal • Contact supplier for collection and disposal of chemical waste • Dispose of chemical waste according to risk level • Dispose of chemical waste according to environmental protection law • Refer to MSDS for proper disposal • For a small amount of less hazardous chemicals, dilute with water before draining down the sink.	f. For a small amount of less hazardous chemical refer to MSDS for dilution g. Treatment of waste chemicals must be according to risk level and environmental protection law h. Contact supplier or Transporter to collect the chemical waste for disposal and treatment i. Select proper container compatible with the chemical waste	2. Storing and Segregation Chemical Wastes. B. Disposals of chemical wastes; page 21

DISCUSSION

A manual for laboratory experiments is important in any chemistry laboratory of an academic institution. It is a must-have for every laboratory head, student, or teacher who performs experiments using chemicals. Based on the requirements and recommendations of the OSHA, every laboratory must have a Laboratory Manual of Guidelines and Policies, aside from the Manual of Experiments. The Basic Laboratory Rules and Regulations must be followed and discussed with students to ensure the safety of everyone. However, managing a chemistry laboratory does not end there. Many areas of concern need to be given attention, aside from the basic information being tackled during laboratory orientation on the first day of class.

There are different areas of concern that this study was able to look into. The findings showed that the current practices of the participants might be considered as standards in managing a chemistry laboratory in schools, colleges, and universities.

Data show that the participants were unanimous in the practice of having an adequate and standard storage room which is a primary requirement in any chemistry laboratory as attested by qualified participants of this study. It appears that the storage room is a basic requisite for any laboratory. This practice adheres to the recommendation of the National Environment Research Council (NERC) Health and Safety Guidance (2010) and is congruent with Abbott Chemical Storage Standards (2014) that storing chemicals in laboratory stockrooms requires a number of considerations on health and safety factors. The question now lies on how adequate and fitting a storage facility for chemical reagents is as used in educational and instructional purposes.

The storage room for chemical reagents in chemistry laboratories among colleges and universities is a separate facility from the laboratory itself. This study considered that the stock or storage room must be properly ventilated and temperature-controlled with wooden shelves. The participants shared their experienced that integrating the storage into the laboratory itself is not a good practice. In fact, several hazards were cited, such as contamination, breakage, health dangers, and discomfort, among others. Storing chemicals within the lab area or even proximate to the work area has been considered a high-risk factor.

In Abbott for Chemical Storage Standards (2014), chemicals should not be stored in an area or room where students and teachers regularly stay. In addition, the storage area has to be physically isolated from where the laboratory experiments are conducted. Not everybody is allowed to have access to this facility.

It can be considered as best practice to have an exclusive storage room for chemicals apart from the laboratory itself. It is a basic requirement for schools offering courses that involve laboratory works using chemicals and other hazardous substances. Negligence to this practice would endanger not only health and orderliness but also the lives of those people, students, and teachers alike, who conduct learning activities in the laboratory.

Storing chemicals inside an isolated stockroom is not the only requirement for the safe keeping of chemicals. The participants gave similar and common responses in terms of the quality of the storage shelves. It is also important to emphasize that chemicals must be segregated or grouped in shelves according to type or compatibility. The use of color-coded labels is recommended for classifying and identifying chemicals.

It is a requirement to place a chemical on shelves where they are categorized or classified in order to have easy access in locating and getting chemicals as well as ease in returning the chemicals after use. Though this may not be the most important among the reasons why chemicals must be segregated, it is the standard that must be followed. It is not accepted or strictly not recommended to place or put incompatible chemicals side by side, for this may cause chemical reactions and may lead to possible harm or danger like the formations or production of harmful fumes, exothermic reaction, or worst can cause a violent reaction like an explosion.

It is important to know the type of chemicals in the laboratory, how and where to store them to prevent any accident or chemical reaction. It is a good practice that school management sends laboratory personnel to seminars and training so that they will be equipped with the proper knowledge and skills needed to become good laboratory custodians. It is advisable that chemical distributors must evaluate and classify chemicals with appropriate identification or labels on the containers. It is important to have a Materials Safety Data Sheet which provides information about the chemical substance, its proper storage, physical and chemical properties, flammability, toxicity, spillage, and accidental exposure.

It is highly suggested that the storage of chemicals should be simple and organized in such a way as to minimize possible hazards. The suggested system for categorizing chemicals is to use color code (ChemAlert Storage Code Fisher Scientific Inc., 2015).

ChemAlert Storage Color Codes Fisher Scientific Inc.

STORAGE GROUPS (ChemAlert Storage Code Fisher Scientific Inc.)	
RED	It must be in inflammable storage (for chemicals that readily burn). Store separately only with other flammable chemicals.
GREY	It is used by Fisher (instead of green). Reagent presents no more than a moderate hazard in any category. For general chemical storage with no particular storage hazard
BLUE	It is toxic or health hazard (for chemicals that are poisonous). Chemical is hazardous to health if ingested, inhaled, or absorbed through the skin. Store separately in a secure area.
YELLOW	It is for reactive/oxidizing chemicals that undergo spontaneous chemical reactions or readily react with other chemicals). It may react violently with water, air, or other chemicals. Store separate from combustible and flammable reagents.
GREEN	It is for corrosives – alkaline for chemicals (like strong acids and bases) that destroy tissue by chemical action. A reagent presents no more than a moderate hazard in any category. Keep in general chemical storage.
WHITE	It is for corrosives – acids for chemicals (like strong acids and bases) that destroy tissue by chemical action. It may be harmful to the eyes, mucous membranes, and skin. Store separately from combustible and flammable chemicals.

It is not enough to put chemicals in an isolated storage room as a standard requirement for proper chemical storage. It is also very important to know and identify what type or kind of chemicals are stored. Chemicals must be classified according to kind or type in order to place them according to their classification for ease of locating and returning before and after use. The most important reason is to prevent violent chemical reactions

The type and quality of the storage shelves must also follow global standards. Most participants agreed on wood as the ideal type of materials to be used on chemical shelves. Few recommended using stainless steel metals in addition to wooded shelves lined with glass.

As observed among recommended wooden shelves, there are times that when chemical reactions occur due to chemical spills, such may cause discoloration on the surface of the shelves. To protect the shelves from a chemical spill, laboratory personnel lined the shelves' rack with glass to prevent any reaction to the painted wooden shelves. However, stainless steel shelves may not be common, yet some laboratories use these to identify and classify chemicals that are non-corrosive chemicals.

It was stated in The Environmental Health and Safety Department and Laboratory Safety Design Guide of U.S. (2012) that chemical shelves or cabinets can be constructed from materials such as solid wood, pressed wood, plywood, metal, or polyethylene. They may be coated with protective paints or epoxy to further protect the construction materials. Inexpensive cabinets and shelves may cause problems if used in ways they were not intended, like the fabricated cabinet made by some carpenters, where they lack proper information about the effect of chemicals. In any case, if an ordinary shelf was made, a glass lining must be placed as protection for the wooden cabinets. It is not advisable to use a solid metal cabinet in the chemical storage room because of the corrosive nature of the chemicals.

Reagent bottles (chemical bottles) must be labeled using color codes for proper identification (the type and name of the chemical). Respondents put emphasis that original labels must be retained, copied, and pasted on the chemical shelves. Aside from the color codes, there must be warning signs for any possible harm or danger that the chemical may cause if improperly handled.

The shelves should be clearly labeled. It is a good practice to color code the storage area to help ensure that excess chemicals are returned to their proper places. Each chemical has a storage color code, and chemicals should only be stored with other chemicals of the same color code. In shelving chemicals, it is important to put identification or label according to the type or kind of chemical they belong to in order to prevent harmful chemical reactions in the storage room.

Proper labeling with the name and type of chemical must be pasted or written on the reagent bottle for ease of locating and returning chemicals before and after experiments. It is also a requirement to label the shelves. Color codes may be used in classifying and identifying the type of chemicals and are placed on particular shelves. It is also important to have an MSDS on the shelves for proper chemical handling, precautionary measures, and storage. Chemicals are grouped and classified according to class or family. They are placed in approved safety containers and stored on shelves separately according to chemical class or family. The classification includes health hazards, corrosion, flammable or combustible, reaction to air or water, oxidizers, cryogens, and peroxide forming. These groups of chemicals must not be stored near each other. They must be stored away or separate from incompatible classes.

Chemical manufacturers and businesses utilizing hazardous chemicals must use color codes to identify and group chemicals according to hazard and class: red for flammable, yellow for reactive and oxidizing, blue signifies health hazard, white for corrosive. Gray or green for moderately hazardous as stated in ChemAlert Storage Code Fisher Scientific Inc., (2015).

Safety rules and regulations should be followed as standard operating procedures when working in the laboratory. It is a must to know and practice basic laboratory safety rules at all times (International Labor Organization (ILO) Code of Practice Safety in the Use of Chemicals at Work, 1993). Students are not allowed to work without the supervision or presence of a laboratory instructor as part of lab rules and regulations to prevent accidents. Participants put emphasis on the availability of MSDS as a guide on proper handling and storage of chemicals.

It is a must for students working in the laboratory or taking chemistry laboratory class to know and practice the basic safety rules and regulations by wearing personal protective equipment such as laboratory gowns to protect their bodies and clothing from chemical spills and face masks to prevent inhalation of chemical fumes, goggles for eye protection, to prevent any harm and accidents that may happen during experiments. The MSDS serves as a bible for chemistry laboratory personnel. It is a guide and reference for any information needed for all chemicals used in the experiments.

Chemical spills on a small scale are common in the laboratory, and it is essential to know the hazard level of every chemical stored in the stockroom. A chemical spill plan control can vary according to the complexity of the laboratory and the level of danger or harm the chemicals can cause. During activities and preparations, chemical spills can be avoided by developing and implementing suitable helpful laboratory practices that considerably lessen the occurrence and like the hood of spills. According to the proponents of the Task Force on Laboratory Waste Management American Chemical Society (1995), every laboratory generates wastes and spills, which can certainly and seriously disrupt laboratory operation if handled inappropriately. Controlling and reducing the number of chemicals prepared and released in the stock room is the primary solution in minimizing and controlling the production of chemical waste generated in the laboratory.

The participants were unanimous in their answers regarding the practice of microscaling in controlling the amount of chemicals prepared and used by the students in their experiments. An exact amount of pre-weighed chemicals are prepared to prevent or minimize waste chemicals. A demo experiment is another method of microscaling that also minimizes the amount of chemicals used and minimizes the production of chemical waste. Recycling prepared and unused chemicals is another method of controlling the amount of chemicals used, where previously prepared unused chemicals for one class are set aside and used again for another requesting chemistry class.

Excessive and unwise use of chemicals produces or generates chemical waste. Waste reduction starts with the wise use of chemicals. The American Chemical Society (2014) recognized the need for minimizing chemical waste and has a publication called, “Less is better; buy only what you need and use all of what you buy.”

The most desirable method of waste minimization is source reduction, which reduces the impact of chemical waste release to the environment to the greatest extent. This is any activity that reduces or eliminates the generation of chemical waste at the source. Laboratories can accomplish this by good chemical management, the substitution of less hazardous materials, and good laboratory procedures. Good chemical management means purchasing only the amount of chemicals needed in the planned experiments. Good laboratory procedures include preparing only the amount of solutions needed for the work anticipated.

Proper handling of chemicals during the experiment is also an important area of concern in the practice of good laboratory management. Chemicals must be handled with care to prevent contamination and end up as chemical waste. For the unused prepared chemicals, the laboratory technicians are the ones responsible and accountable for it.

To save chemicals from contamination, the majority of the respondents practice the use of a separate, clean and dry spatula for dry solid (crystalline and powder) chemicals. Hence, it is necessary to know the type of solid compound to be used for the proper spatula. Metal spatulas are not recommended to be used for acidic compounds and other compounds that react with metals; instead, use porcelain spatula. A separate pipette for each liquid chemical or reagent is used. Participants practice “FIFO” (first in, first out) in use and release of chemicals to prevent the expiration of older stock of chemicals. Participants were very particular with the use of clean containers. They make sure that reagents to be used in experiments are measured exactly of what is indicated on the experiment procedure. It is important to follow the precautionary measures prior to conducting the experiment in order to prevent waste and accidents.

All participants practice setting aside and keeping the unused or excess prepared chemicals, but not for a longer period of time. On the use and categorization of chemical waste, all respondents emphasized the collection of chemical waste separately in a bottle with a cap. Labels are placed on the bottle with name, type, classification of chemicals, and date collected. These bottles are placed temporarily in a separate room or shelves until the supplier collects them. The unused reagents are kept for the need of the next class.

Wastes accumulated from the experiment are classified and categorized according to hazard so that they will be handled and managed accordingly. Placing chemicals on proper containers as to type or class according to the OSHA Laboratory Standards is necessary to determine chemical waste regulation. Putting a proper label on the reagent bottle, waste type, ID number, group, date collected, disposal, and treatment is a must. For leftover, unused reagents and reaction products (used chemicals) should be placed in marked containers at the end of each laboratory session. Used chemicals (waste) shall be classified into the following categories as indicated in the EPA and School Laboratory Chemical Hygiene and Safety Plan.

Classification of used chemicals based on the School Laboratory Chemical Hygiene and Safety Plan

Flammable	Ignitable: Materials capable of causing fire. • A liquid chemical with less than 60°C ignitable temperature (flashpoint) (e. g. Acetone, Methanol) • A solid that is combustible when contact with air or friction can undergo a spontaneous chemical change which can result in burning under standard temperature and pressure (e. g. Benzoyl Peroxide). • A substance that is an ignitable compressed gas or oxidizer is an ignitable waste (e. g. Propane, Hydrogen Peroxide).
Reactive • **Water Reactive** • **Air Reactive**	A chemical that is normally unstable and undergoes violent chemical change without introducing any incompatible substances when it exceeds its normal storage conditions Can react violently when contact with water and form potentially explosive mixtures Can be release dangerous or toxic gases, vapors, or fumes in a certain amount that is dangerous to health
Toxic	Substances that are harmful to human health such as arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.
Corrosive	A waste chemical is corrosive if it has a pH of less than 2 or greater than 12.5 (Note that a chemical is not allowed to be poured down the drain if it has a pH of less than 5.5 or greater than 12).

Participants have agreed that less hazardous chemicals must be diluted with water before draining down the sink. They emphasized the need to refer to the MSDS for proper waste management and disposal of every chemical type. All participants practice labeling and identifying the kind of chemicals collected, segregated, and set aside. The manner of disposal is based on the recommendation of safety standards of the environmental protection law. Participants 1, 3, and 5 noted that they contacted their supplier for the collection and disposal of their chemical wastes. For schools with hospitals, their chemical wastes are collected and disposed of together with their hospital wastes.

In the Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (NERC, 1995), the best strategy for managing laboratory waste is to maximize safety and minimize environmental impact and consider the objectives of prudent management from the time of chemical purchase. Prudent management of these wastes is necessary to protect the health and safety of all laboratory personnel who handle, process, and store the waste for disposal. It also minimizes the potential of harm to public health and the environment.

Unlike other waste generator institutions that have only a particular type of waste generated, a chemistry laboratory produces mixed waste that is generated from the different chemicals used in experiments. It is often difficult to find a facility that can manage different types or categories of chemical wastes, which is a common problem of most schools and universities.

Based on the analysis of the findings, laboratory heads and the laboratory-in-charge have a commonality in their answers. Their current laboratory practices serve as a guide in developing laboratory safety guidelines and policies in managing the use of chemicals in the chemistry laboratory. Since different schools have different needs, their guidelines are designed and guided by the international laws and policies of government agencies and some private environmental agencies. Though there are existing laboratory rules and regulations, knowing this information would help improve and upgrade laboratory policies and guidelines. It would establish standards that would be nationally and internationally accepted.

Chemicals are stored in a separate room which is not accessible to students to prevent accidents. Also, chemicals must be placed in shelves or racks that have protective lids that ideally mounted on the wall or floor for security and safety. Chemicals must be stored in a cool, dry place and away from the sun and not be stored on the floor, laboratory bench, or in fume hoods. It is advisable not to prepare or mix solutions in the chemical storage area. The storage area must be separate from the preparation area.

The segregation and separation of chemicals inside the stockroom are done according to compatibility. Chemicals must be segregated according to types while the group is according to subjects. The storage of chemicals should be simple and organized in order to minimize possible hazards, as stated in The Prudent Practices in the Laboratory (1995).

Wooden cabinets with shelves, which are made from the same materials used in storage cabinets, serve as divisions and are lined with glass. Rust-proof metals (stainless) may also be used but are not strongly recommended.

Labeling of chemicals must be according to color code for proper identification. Original labels must be retained or copied and pasted on the chemical shelves. Aside from the color codes, there must be warning signs for any possible harm or danger that the chemical may cause if improperly handled (ChemAlert Storage Code Fisher Scientific Inc., (2015) for categorizing chemicals is to use color code). The shelves should be clearly labeled. Color codes at the storage area must be visible to help ensure that chemicals are returned to their proper places after use.

One must store chemicals together based on their hazard class and must store each class separate from other chemical families. Chemical families are toxics/health hazards, corrosives, oxidizers, pyrophoric or air reactive, water-reactive, explosives, peroxide-forming chemicals, flammables, and combustibles. Chemicals are to be stored in approved safety containers; incompatible chemicals should not be stored with or used near each other (The Prudent Practices in the Laboratory 1995).

The Material Safety Data Sheet (MSDS) is important for the safety of handling chemicals. It emphasizes the knowledge of its chemical properties, components, handling storage, and disposals. The practice of basic safety rules and regulations in the laboratory is part of the standard operating procedure. When working with chemicals, personal protective equipment (PPEs) like chemical safety goggles, gloves, and laboratory coats should be the first pieces of equipment on the list. Another important point is to work only in the presence of a laboratory instructor.

Microscaling reduces the amount of chemicals released and given to students to be used in performing experiments. The exact amount of pre-weighed or pre-measured chemicals are prepared to minimize chemical usage and generation of waste chemicals (Laboratory Waste Minimization and Pollution Prevention, 2014). A demo experiment is another method of microscaling that also minimizes the amount of chemicals used and minimizes the production of chemical waste at the same time. Recycling prepared, or unused chemicals is a method of controlling the amount of chemicals used, where previously prepared, unused chemicals for one class are set aside and used again for another requesting chemistry class having the same experiment or will be needing the same reagents.

The best way to save chemicals from contamination during preparation and experiments is through the use of a separate spatula for each solid or powdered chemical. A separate pipette for each liquid chemical or reagent is used. The use of clean secondary containers and practicing exact measurements of every reagent are best practices to save and prevent chemical contamination.

Practice "FIFO" (first in, first out) in the use and release of chemicals to prevent the expiration of old stock chemicals and waste of chemicals (ILO Code of Practice Safety in the Use of Chemicals at Work, 1993). Know the importance of precautionary measures prior to the execution of the experiment to prevent waste and accidents.

For the unused prepared chemicals, the laboratory technician is the one responsible and liable for it. Practice setting aside and keeping the unused or excess prepared chemicals but not for a longer period for the next experiment or for the next class.

For used and categorized as chemical waste, all respondents emphasized the collection of chemical waste separately in a bottle with a cap. Labels are placed on the bottle with the name, type, and classification of chemicals and the date collected. These bottles are placed in a separate room or shelves temporarily until the supplier collects them.

The dilution of water-soluble liquid chemical wastes is a recommended method prior to the disposal of used liquid chemicals (Prudent Practice in the Laboratory: Handling and Disposal of Chemicals, 1995). Less hazardous chemicals are diluted with water before draining down the sink. The MSDS must be referred first for proper waste management and disposal. Practice labeling and identifying the kind of chemicals collected, segregated, and to be set aside. Disposal must be according to the safety standards of the environmental protection law. One must contact suppliers for the collection and disposal of chemical waste and for schools with hospitals. Chemical wastes must be collected and disposed of, together with their hospital wastes.

In terms of chemical storage facilities, findings reveal that for safety purposes, chemicals are stored in a separate room, which is not accessible to students (National Environment Research Council; Health and Safety Guidance, 2010). This is to prevent accidents. Table 2 shows that all six participants stated that chemicals must be stored in a separate room that is not accessible to students. Also, the six respondents mentioned that chemicals must be placed on a shelf or a rack. Three out of the six participants emphasized that shelves must have protective lids. On the other hand, participant five mentioned that shelves must be mounted on the wall for security and safety. An open area for storing chemicals may pose a danger, especially when students are free to enter. According to Billie Abbott (2000), chemicals should not be stored in an area or room where students and teachers regularly frequent. The chemical storage area must be secured with a lock and key for controlled access. It supports the measures adopted by the participants of this study, particularly their standard practices. The chemical storage should be well-lit and ventilated. This includes forced ventilation from floor to ceiling. Chemical storage shelving needs to be strongly secured to the wall or floor, contain a raised lip, and be at or below eye level for easy access. It is advisable to store chemicals away from drains so they will not accidentally enter the local sewer system.

In storing chemicals, there are important factors to consider because chemicals react when exposed to extreme temperatures. The right temperature, ventilation, segregation, and identification are important when storing chemicals. Chemicals should not be stored on the floor, laboratory bench, or in fume hoods. It is advised not to ever store or consume food or drink in the chemical storage area, nor prepare or mix solutions in the chemical storage area; there must be a separate preparation area.

According to NERC Health and Safety Guidance (2010), it is important to know the type of chemicals to store, how and where these are to be stored. Under the OSHA Hazard Communication Standards, chemical distributors must evaluate the hazards the chemicals pose. Chemicals must be appropriately labeled before giving it to the consumer. A Material Data Safety Sheet (MSDS) for each chemical listing the substance's known toxicity, flammability, or acidic or caustic properties must be considered. This will also include how chemicals behave in fire, accidental exposure incidents, and how spills are treated. The school administrator must train their workers on how to handle them and have an MSDS readily available for each chemical. The storage of chemicals should be simple and organized to minimize possible hazards. A suggested system for categorizing chemicals is to use color code (ChemAlert Storage Code Fisher Scientific Inc., 2015).

ChemAlert Storage Code Fisher Scientific Inc., 2015

RED	Inflammable storage Store separately only with other flammable chemicals.
GREY	General chemical storage. No particular storage hazard - Reagent presents no more than a moderate hazard in any category.
	Toxic or health hazard Chemical is hazardous to health if ingested, inhaled, or absorbed through the skin. Store separately in a secured area.
YELLOW	Reactive/Oxidizing chemicals May react violently with water, air, or other chemicals. - Store separate from combustible and flammable reagents.
GREEN	Corrosives – alkaline Reagent presents no more than a moderate hazard in any category. - For general chemical storage.
WHITE	Corrosives – acids It may be harmful to the eyes, mucous membranes, and skin. Store separately from combustible and flammable chemicals.

The type or quality of materials used for the storage shelves or cabinets must also follow standards. Not all of the materials may be used for the construction of chemical shelves. There are ready-made chemical shelves that are expensive. For a school with no budget for a fabricated one, they can also construct their own, but it may need to adhere to standards.

The Environmental Health and Safety Department (2012) stated that chemical shelves or cabinets could be constructed from materials such as solid wood, pressed wood, plywood, metal, or polyethylene. They may be coated with protective paints or epoxy to further protect the construction materials. Inexpensive cabinets and shelves may cause problems if used in ways they were not intended, like the fabricated cabinet made by some carpenters who lack proper information about the effect of chemicals. For example, it is not advisable to use a solid metal cabinet in the chemical storage room because of the corrosive nature of the chemicals. In any case, an ordinary shelf was made, glass lining must be placed as protection for the wooden cabinet.

Table 5 presents data about the proper labeling of storage bottles of chemicals that are placed on the chemical shelves in the stockroom. All of the six participants said that chemicals must be labeled using a color code for proper identification. Participant 1 emphasized that original labels must be retained, copied, and pasted on the chemical shelves. Participant 5 said, aside from the color codes, there must be other warning signs detailing any possible harm or danger that the chemical may cause if improperly handled.

The shelves should be clearly labeled (Prudent Practice in the Laboratory, 1995). It is a good practice to also color code the storage area to help ensure that removed chemicals are returned to their proper places. Each chemical has an associated storage color code, and chemicals should only be stored with other chemicals of the same color code.

Chemicals are grouped and classified according to class or family, placed in approved safety containers, and stored in shelves separately according to chemical class or family. The classification includes health hazards, corrosion, flammable or combustible, reaction to air or water, oxidizers, cryogens, and peroxide forming. These groups of chemicals must not be stored near each other. They must be stored away or separate from incompatible classes. Chemical manufacturers and businesses using hazardous chemicals use color codes to identify and group chemicals according to hazard and class: red for flammable, yellow for reactive and oxidizing, blue signifies health hazard, white for corrosive, and gray or green for moderately hazardous. One must store chemicals together by their hazard class and store each class separately from other chemical families (ChemAlert Storage Code Fischer Scientific).

Table 6 presents data about safety in handling and storage. Participants 1, 3, 4, and 6 put emphasis on the importance of the Material Safety Data Sheet (MSDS). On the other hand, Participants 2 and 5 stressed the knowledge and practice of basic safety rules and regulations in the laboratory. Another point raised by Participant 2 is to work only in the presence of a laboratory instructor by respondent 2. The Occupational Safety and Health Administration (OSHA) is an agency of the U.S. Department of Labor, established under the Occupational Safety and Health Act in 1970, which considered this safety practice.

The primary purpose of OSHA is to develop and enforce regulations to ensure a safe working environment in public and private organizations. It requires hard copy and on-site availability of the Material Safety Data Sheets (MSDS) for all chemicals in use. Entries should be kept alphabetically arranged in a designated file or binder and stored in a place that is easily accessible both for teachers and laboratory assistants. Chemicals purchased are usually accompanied by literature that specifies the chemical properties, classification, safe handling, storage procedures, and potential hazards. When working with chemicals, safety goggles, gloves, and laboratory coats should be the first pieces of equipment on the list.

Table 7 presents results on how to control the amount of chemicals used in the chemistry laboratory. Participants 1, 2, 3, and 6 practice microscaling, a technique that reduces the amount of chemicals released and given to students in performing experiments. The exact amount of pre-weighed or measured chemicals is prepared to prevent or minimize waste chemicals. A demo experiment is another method of microscaling that also minimizes the amount of chemicals used and minimizes the production of chemical waste at the same time. Recycling of prepared and unused chemicals is another method of controlling the amount of chemicals used, where previously prepared unused chemicals for one class are set aside and used again for another requesting chemistry class.

Table 8 presents results on current practices of the participants regarding the proper utilization of reagents and chemicals during experiments. It also includes the practice of proper handling of chemical wastes is practice. To save chemicals from contamination, Participants

3, 4, and 5 practice the use of separate spatula for each dry solid (crystalline and powder) chemical. A separate pipette for each liquid chemical or reagent is used. Participant 2 practices “FIFO” (first in, first out) in use or release of chemicals to prevent expiration of old stock chemicals and waste of chemicals. Participant 1 emphasizes the importance of precautionary measures prior to the execution of the experiment to prevent waste and accidents. Participant 6 is very particular with the use of clean containers and exact measurements of every reagent used.

The most favorable method of waste minimization is source reduction. This reduces the impact of chemical wastes on the environment to the greatest extent. Excessive and unwise use of chemical produces chemical wastes. Waste reduction starts with the wise use of chemicals. The American Chemical Society recognized the need for minimizing chemical waste and has a publication called “Less is better; buy only what you need and use all of what you buy.” This is an activity that reduces or eliminates the generation of chemical waste at the source. Laboratories can accomplish this by good material management, the substitution of less hazardous materials, and good laboratory procedures. Good chemical management means purchasing only the amount of chemicals you plan to use. Good laboratory procedures include preparing only the amount of solutions needed for the work anticipated.

Table 8 presents the management of used and excess reagents after the experiment. For the unused prepared chemicals, the laboratory technicians are the ones responsible and liable for it. All participants practice setting- aside and keeping the unused or excess prepared chemicals but not for a longer period. For used and categorized as chemical waste, all participants emphasized collecting chemical waste separately in a bottle with a cap. Labels are placed on the bottle with name, type, and classification, and date collected. These bottles are placed in separate rooms or shelves temporarily until the supplier collects them.

Wastes must be classified and categorized according to hazards so that they will be handled and managed accordingly. Placing chemicals on proper containers as to type or class according to the OSHA Lab Standards is necessary to determine chemical waste regulation. Putting a proper label on the reagent bottle: waste type, ID number, group, date collected, disposal, and treatment is a must. For leftover, unused reagents and reaction products (used chemicals) should be placed in marked containers at the end of each laboratory session. Used chemicals (waste) shall be classified into the following categories EPA categories):

Flammable	Ignitable: Materials capable of causing fire. • A liquid chemical with less than 60°C ignitable temperature (flashpoint) (e. g. Acetone, Methanol) • A solid that is combustible when contact with air or friction can undergo a spontaneous chemical change which can result in burning under standard temperature and pressure (e. g. Benzoyl Peroxide). • A substance that is an ignitable compressed gas or oxidizer is an ignitable waste (e. g. Propane, Hydrogen Peroxide).

Reactive • **Water Reactive** • **Air Reactive**	A chemical that is normally unstable and undergoes violent chemical change without introducing any incompatible substances when it exceeds its normal storage conditions Can react violently when contact with water and form potentially explosive mixtures Can be release dangerous or toxic gases, vapors, or fumes in a certain amount that is dangerous to health
Toxic	Substances that are harmful to human health such as arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.
Corrosive	A waste chemical is corrosive if it has a pH of less than 2 or greater than 12.5 (Note that a chemical is not allowed to be poured down the drain if it has a pH of less than 5.5 or greater than 12).

Like newly delivered procured chemicals that are treated with the utmost care, chemical wastes are also handled properly to prevent accidents and spills. The current practice of respondents in the management of chemical waste is through the use of dilution methods prior to disposal.

Table 9 shows the results of current practices about the management of chemical wastes. Participants 1 and 5 use the dilution method prior to disposals. Less hazardous chemicals are diluted with water before draining down the sink. Participants 2 and 6 put emphasis on referring first to the MSDS for proper waste management and disposal. All of the six participants practice labeling and identifying the kind of chemicals collected, segregated, and set aside. Manner of disposal must be according to the safety standards of the environmental protection law. Participants 1, 3, and 5 contact their suppliers for the collection and disposal of their chemical waste. For schools with hospitals like Participant 3, their chemical waste is collected and disposed of together with their hospital wastes.

According to Prudent Practices in the Laboratory (1995), the best strategy for managing laboratory waste aims to maximize safety and minimize environmental impact and consider these objectives from the time of chemical purchase. Prudent management of these wastes is necessary to protect the health and safety of all laboratory personnel who handle, process, and store the waste for disposal and to minimize the potential of harm to public health and the environment.

Unlike other waste generator institutions that have only a particular type of waste generated, the chemistry laboratory produces mixed waste that is generated from the different chemicals used in their experiments. It is often difficult to find a facility that can manage different types or categories of chemical waste, which are the common problems of most schools and universities.

Proclamation of the US Pollution Prevention Act (1990) offered regulated relief to academic institutions from some pre-requisites related to on-site management. This allows academic institutions to be given additional time to transfer waste from laboratories to the central deposit. Ample time is essential in making waste identification and urges laboratory cleanouts for not fully occupied or filled waste bottles not exceeding 55 gallons.

Based on findings, the current laboratory practices of the participant-HEIs, which they have been implementing in their respective laboratories, conform to the standards of laboratory management by international laws and policies. Matrices are constructed based on the current laboratory practices of the participants and on the international laws and guidelines involving different areas on managing chemistry laboratories. This is basically to map the gap between the existing HEIs‘practices on laboratory management and international laws and universal policies, and other areas of concern. The matrices show how the practices and standards can fill the gaps and imperatives necessary for the integration of the manual.

Table 11 presents the current laboratory practices of the participants in their respective school laboratories that are verified from existing laboratory standards, both international and local. All areas concerned with chemical management from storage, segregation, minimization, and waste management verify the standards vis-a-vis the participant HEIs' best laboratory practices and international standards.

International companies, namely Abbott Chemical Storage Standards, National Environment Research Council (NERC) Health and Safety Guidance, NFPA 45, and OSHA (Safe
Storage of Laboratory Chemicals and Occupational Safety and Health Administration (OSHA) Laboratory Standards together with the standards and policies set by CHED Memorandum Order (CMO) 18, s. 2007 and the Department of Labor and Employment Department Order (DOLE: DO) 136-14. Accordingly, the stock room must be separated and isolated from the rest of the laboratory for the safekeeping of chemicals and for the safety of students and personnel as well. The temperature must be controlled, and it must be well ventilated. Chemicals should be stored in chemical shelves with a protective anti-roll off the lip, and they must be made from wooden material lined with glass. Segregation of chemicals by color codes according to compatibility designed by ChemAlert Storage Code Fisher Scientific Inc. (2015) affirmed by The Prudent Practices in the Laboratory (1995). Subject and chemical families are a very crucial part of chemical management, as stated by The Environmental Health and Safety Department (2012) and The Laboratory Safety Design Guide of U.S. (2012). As with storage, labels of the reagent bottles must remain and be kept intact as suggested by OSHA Hazard Communication Standards and by DOLE: DO 136-14.

The use of personal protective equipment (PPE) knowledge or background of basic handling of the chemicals and availability of MSDS as a guide for any important information are needed in proper chemical usage. The Occupational Safety and Health Administration (OSHA) Laboratory Standard Practice, American Chemical Society (1993), and International Labour Organization (ILO) Code of Practice Safety in the Use of Chemicals at Work (1993) suggest the practice of minimization and proper chemical utilization. This is also true with DepEd Order 48 s 2006 and by UPD-DChE Lab Health and Safety and Environment Management System. Microscaling, reuse, recycling of prepared and unused reagent and the practice of First In First Out (FIFO) policy among stored chemicals in order to prevent waste and cost reduction are indicated in proper chemical management of The Pollution Prevention Act of by US Congress (1990) and the CHED Memorandum Order (CMO) 18, s. 2007 and

DENR Administrative Order (AO) 36, s. 2004. Waste chemicals like the unused chemical must also be well taken care of and must follow the rules in managing and dealing with chemical wastes to prevent harm and danger both to humans, animals, and to the environment as per order by Laboratory Waste Minimization and Pollution Prevention (2014), The Pollution Prevention Act of by US Congress (1990) together with University of the Philippines Department of Chemical Engineering (UPD-DChE) Waste Management System. Finally, for the collection, treatment, and disposal of chemical waste, both local and international laws, UPD-DChE WMS, DENR Implementing Rules, and Regulations of Republic Act 6969 (1992), The American Chemical Society (2000), Prudent Practices in the Laboratory (2014) DAO 36, s. 2004 (Hazardous Waste Management) suggests similar practice in chemical waste management that disposal of chemicals in the sink is strictly prohibited. Dilution of small quantities of liquid chemicals that are less harmful is a must and should disposal cannot be avoided, compliance with what is stated.

Table 12 presents the gaps in the current laboratory practices of the participants in their respective school laboratories that were checked based on existing laboratory standards, both international and local sources. Gaps were identified from their verified practices based on standards which are also a vital part of laboratory management.

On the area of storage/stock room, cold storage of chemicals was not mentioned by the participants, as well as the proper illumination and chemical shelves, which must not exceed 1.9 meters in height. These are important factors required by international standards like Abbott Chemical Storage Standards (2014), National Environment Research Council (NERC) Health and Safety Guidance (2010), NFPA 45 and OSHA (Safe Storage of Laboratory Chemicals (2015), OSHA Laboratory Standards (1991) that must be met by all chemicals laboratory and CMO 18, s. 2007 and DOLE: DO 136-14. In addition, a gap on chemical shelves was not mentioned by the participants. It is recommended that aside from lining it with a glass, painting or coating it with epoxy or polyethylene to protect against chemical reactions that might damage the shelves. This is also recommended by The Environmental Health and Safety Department (2012) and by The Laboratory Safety Design Guide of U.S. (2012).

In the area of reagent bottle relabeling, the use of acronyms must be elaborated. Relabeling of fallen original labels and labeling of secondary containers were not mentioned by the participant HEIs as well as the need for training of laboratory assistants on proper posting labels and warning symbols on the containers and shelves. These areas of concern not emphasized by the participants are among the gaps as proven by both international and local standards on chemical management such as Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (1995), Occupational Safety and Health Administration (OSHA) Laboratory Standard and the Department of Labor and Employment Department Order (DOLE: DO) 136-14.

In safe handling and storage of chemicals, these are the standard rules and policies that are not mentioned by the participant HEIs which are also a crucial part of managing a laboratory: training of personnel and lab assistants, chemical spills management, emergency protocols, limitation of storage on fume hood and laboratory benches, safety symbols/sign, chemical tracking system for inventory. It is recommended that no chemicals should be stored above eye level and avoid top-shelf chemical storage. Corrosive chemical and liquid chemicals must not be stored above waist level. These recommendations are clearly presented by different international companies regarding chemical management, namely by Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (1995), Environmental Health & Safety (2014), International Labor Organization Code of Practice Safety in the Use of Chemicals at Work (ILO 1993).

Table 13 presents the findings together with the gap on how they are placed on the proposed manual in reference to its content:(a) stock room: separate, isolated storage room for chemicals only, temperature, illumination and ventilation, with wall mount shelves anti-roll lip or lid are placed or located at section1.3; (b) manner of chemical storage and segregation, color-coded labels according to class, type or compatibility and according to subject and chemical families or group are place or located at section1.5; (c) segregation /separation of chemicals container; (d) storage cabinet material: wooden material lined with glass and stainless metal are place or located at section1.4; (e) storage shelves/racks, labeling, reagent containers/bottle labeling located at section1.6; (f) safety in handling and storage: located at section 2. (g) proper usage/ utilization of reagents during experiments at located at section 2; (h) controlling amount of chemicals used; proper utilization of chemicals located at section 2.1; (i) management of unused (excess) and used reagents (waste) located at section 4; and, (j) handling and disposing chemical waste (waste disposals) located at section 5 of the manual.

CONCLUSION

The overall analysis of the findings points out the need for a written chemistry laboratory manual of standards for use by a laboratory technician, faculty, and students, for which this study is primarily aimed. Appendix A presents the draft of the proposed manual of standards and policies for the school chemistry laboratory, which is derived from the salient findings of the study and which is recommended for further evaluation by the experts toward its eventual publication and utilization.

OVERALL RECOMMENDATIONS

The study recommends the utilization of the proposed manual in managing chemistry laboratories in school, specifically on storage, segregation, and handling of chemicals, minimization, handling, segregation, and storage of chemical waste.

Other aspects or areas that need attention, aside from the chemical management that may be recommended for further studies, are:

1. Training of the laboratory personnel, which include lab technicians, assistants, and teachers on:
    a. Chemical waste treatments
    b. Chemical waste disposals
2. Emergency procedures like Chemical Spills Management
3. Understanding Material Data Safety Sheet
4. Health and Risk assessments of stored chemicals
5. Green Chemistry: Substitution of harmful chemicals used in experiments into less hazardous ones.

References

American Chemical Society. (1993). Less is better: Laboratory chemical waste management for waste reduction (2nd Ed.) Washington, DC. Retrieved August 16, 2014 from http://infohouse.p2ric.org/ref/33/32432.pdf.

Chemical Management Resource Guide for School Administrators, 2010. Retrieved September 5, 2014 from www.epa.gov/oppt/pubs/chemmgmt/resourceguide.pdf.

Chemical Spill Management Guidelines 2012 November page 3. Retrieved May 20, 2014 from http://www.uow.edu.au/content/groups/public/@web/@ohs/documents/doc/uow136688.pdf.

ChemAlert Storage Code on Fisher chemical and Fischer Bioreagents Scientific Inc. (2014).Retrieved July 16, 2015 from https://www.fishersci.com/us/en/scientific-products/special-offers-and-programs/chemical-stockroom.html#tab2.

Chemical Stockroom Handbook: Essentials & Storage Guidelines (2015).Retrieved December 6, 2015 from https://www.fishersci.com/content/dam/fishersci/en_US/documents/programs/scientific/brochures-and-catalogs/guides/fisher-chemical-chemical-stockroom-handbook-guide.pdf.

Commission on Higher Education Memorandum Order 18 Series 2007.

Department of Education Order 48 Series of 2006; Safety Manual for Laboratory Sciences in Secondary Schools, 2006.

Department of Chemical Engineering, University of the Philippines; Laboratory Waste Management, 2010

Department of Environment and Natural Resources (DENR) Department Administrative Order (DAO) 36 Series of 2004, "Procedural Manual DAO 92-29". Retrieved April 19, 2016 from https://www.scribd.com/doc/37394031/DAO-2004-36-Procedural-Manual-Title-III-of-DAO-92-29-Hazardous-Waste-Management.

Department of Environment and Natural Resources DENR Implementing Rules and Regulations of Republic Act 6969; Section 24.4-5 Series 1992. Retrieved March 2, 2014.

Department of Environmental Health and Safety: Chemical and Hazardous Materials Safety, April 2012. Retrieved May 14, 2015 from http://www.utdallas.edu/ehs.

Drain Disposal Restrictions for Chemicals; Office of the EH&S and the Laboratory Operations and safety Committee (2013). Retrieved April 20, 2016 from http://ehs.berkeley.edu/sites/default/files/lines-of-services/workplace-safety/draindisposal.pdf.

Environmental Health & Safety: Laboratory safety manual and chemical hygiene plan of University of California, 2014. Retrieved June 1, 2014 from http://www.ehs.ucsb.edu/.

Environmental Protection Agency (EPA). Retrieved August 16, 2014 from http://infohouse.p2ric.org/ref/32/31760.pdf.

EPA Compliance Fact Sheet, Revision 1 (199): Guide to Laboratory Sink/Sewer Disposal of Wastes. Retrieved April 19, 2016 from http://www.vanderbilt.edu/viibre/chemical waste-sewer-disposal.pdf.

Flinn Scientific, Inc. retrieved Jan 3, 2016 from http://www.flinnsci.com/safety-supplies/products/signs-safety/.

General Guidelines for Storage and Management of Laboratory Chemicals, 42. Retrieved March 4, 2014 from http://safetyservices.ucdavis.edu/snfn/safetynets/snml/sn42/sn42 Revised on 12/21/15

GHS Chemical Hazard Labels; Globally Harmonized System of Classification and Labelling of Chemicals (GHS) 2007 . Retrieved April 11, 2015 from https://www.osha.gov/dsg/hazcom/global.html.

Harris, Jeffrey. Chemical Storage Guidelines. (2010). Retrieved June 11, 2014 from http://www.cmu.edu/ehs/newsletters/lifeline/chemical-storage-guidelines.html.

Hazardous Chemical Waste Management Reference Guide for Laboratories (1998). Retrieved June 11, 2014 from Department of Environmental Health and Safety, http://web.stanford.edu/dept/EHS/prod/enviro/waste/guide/refguide.pdf.

Indiana University Environmental Health and Safety (2016). Retrieved January 10, 2015 from https://protect.iu.edu/environmental-health/occupational-health/hazard-communication.html.

International Labor Organization (ILO): Your health and safety in the work place; Chemicals in the work place (1993). Retrieved June 11, 2014 from http://www.ilo.org/safework/info/instr/WCMS_113080/lang--en/index.html.

Keck Graduate Institute Chemical Spill Response Institute of Applied Sciences, 2011.Retrieved March 12 2014 from http://www.kgi.edu/faculty-and-research/laboratory-safety/chemical-waste-management/spill-response-plan.

"Laboratory Standard" (OSHA Fact Sheet; 1991). Retrieved August 1, 2014 from https://www.osha.gov/Publications/laboratory/OSHAfactsheet-laboratory-safety-osha-lab-standard.pdf.

Laboratory Waste Minimization and Pollution Prevention: A Guide for Teachers. Retrieved August 18, 2014 from http://infohouse.p2ric.org/ref/01/text/00779/ch04.html 1996.

Methanex Corporation (2013). Retrieved September 5, 2013 from www.labchem.com/tools/msds/msds/VT430.pdf.

National Environment Research Council (2010). Health and Safety Guidance Version 1.1 2010. Retrieved September11, 2014 from http://www.nerc.ac.uk/about/policy/safety/procedures/guidance-trade-union/.

NFPA 45 and OSHA. Safe Storage of Laboratory Chemicals (2007). Retrieved June 16, 2014 from https://chemcareasia.wordpress.com/2007/06/14/safe-storage-of-laboratory-chemicals/.

OSHA Hazard Communication Standards. Retrieved Mar 20, 2012 from http://www.usfosha.com/new-OSHA-hazard-communication-standards.aspx.

Pollution Prevention Act of 1990 by US Congress. Retrieved July 10, 2014 from http://www2.epa.gov/p2/pollution-prevention-act-1990.

Prudent Practices in the Laboratory by the National Research Council's Committee on Hazardous Substances in the Laboratory, (1995). Retrieved August 20, 2014 http://www.nap.edu/catalog/4911/prudent-practices-in-the-laboratory-handling and disposal-of.

Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards. Retrieved November 18, 2014 from http://www.ncbi.nlm.nih.gov/books/NBK55885/.

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (1995). Retrieved June 20, 2014 from http://infohouse.p2ric.org/ref/28/27559.pdf.

Safety in Academic Chemistry Laboratories, American Chemical Society, 2003, Volume 1. Retrieved July 1 2014 from www.epa.gov/epaoswer/osw/conserve/clusters/schools/index.htm

Safety, Health and Wellbeing. Retrieved May 14, 2015 from http://www.safety.uwa.edu.au/1758286.

The storage and handling guidelines found in Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (2011 page 96).Retrieved September 10, 2014 from http://www.ncbi.nlm.nih.gov/books/NBK55868/.

United States Environmental Protection Agency: Memorandum May 28, 1992. Retrieved May 28, 2014 from http://www2.epa.gov/p2.