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ORGANIC CHEMICAL WASTE MANAGEMENT IN CHEMISTRY LABORATORY BY EFFECTIVE DISPOSAL FOR BETTER ENVIRONMENT AND SOCIETY

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ABSTRACT

Chemicals are an Important source for manufacturing different products. It is an important contributor to the GDP and employment. A chemical waste is any material left off after manufacturing of any product in laboratories or industries and if not disposed properly may cause harm to the human health and environment . Some toxins such as arsenic, lead, mercury remains in environment for many years and accumulates. Humans and animals absorb these harmfull chemicals into the body after they eat fish or other prey . The different types of chemical waste includes acid and bases , volatile chemicals and heavy metals . The characteristics of these waste are ignitable , corrosive and can cause toxic infections . Therefore these waste need to treated effectively before disposal into sewage . Treatment of these waste includes salt formation, neutralization of acid and base , collection in different containers , recycling and evaporation. So by this method the chemicals can be reused and can save the environment by proper disposal. If we use harmless chemicals, there is no need for additional treatment for disposal and can lower the cost. The below study depicts the types and different treatments of organic chemical waste in detail.

KEYWORDS: Chemical waste, treatment, reused, cost.

INTRODUCTION

The environmental impact caused by teaching and research with regard to chemical waste is of increasing concern, and attempts to solve the issue are being made. Education and research-related institutions, in most laboratory and non-laboratory activities, contribute to the generation of small quantities of waste, many of them highly toxic. Of this waste, some is listed by government agencies who are concerned about environmental pollution: disposal of acids, metals, solvents, chemicals and toxicity of selected products of synthesis, whose toxicity is often unknown. This project work presents an assessment of the problem and identifies possible solutions, indicating pertinent laws, directives and guidelines; examples of institutions that have implemented protocols in order to minimize the generation of waste; harmonization of procedures for waste management and waste minimization procedures such as reduction, reuse and recycling of chemicals.

Dealing correctly with laboratory wastes is an important issue for all who manage or are employed in chemical laboratories. This Note outlines best practice in managing wastes from chemical laboratories in the context of relevant statutory controls. It stresses both the need to assess the risks to health or safety in handling wastes, and the need to protect the wider environment. Laboratory waste management is a broad subject. This Note does not pretend to be a full or definitive guide nor does it address issues such as microbiological or medical wastes.

Many chemical reagents are purchased and used for education, experiments or research in academic laboratories. These reagents are used in relatively small quantities and remaining leftover chemicals are seen to enter directly into the sink. While going through the history of chemical waste management in chemistry laboratories of our college it was observed that no such plan for effective disposal of these chemicals was carried out. It was observed that the number of experiments from 1st semester to final semester involves use of organic chemicals in large amount and the remaining chemicals that were leftover after performing experiments were disposed by directly throwing them into sink. This procedure leads to various hazardous effects such as corrosion of pipe lines of sink for example Concentrated acids, explosion due to reactive chemicals, ignitability of flammable liquids example Acetone, ethanol, methanol etc. Toxic chemicals when absorbed or ingested may

cause harmful effects. These chemicals when disposed directly to the sink may exposed to nature through drainage system which can be harmful to society and human health and may also affect the global warming by water pollution. Also this practise of direct disposal leads to unwanted wastage of chemicals which can be reused after treating them. Hence to control these effects the effective disposal procedures were need to be carried out. This chemical waste management procedure includes treatment of different types of chemicals such as neutralization of acid and base, salt formation, evaporation of volatile waste

Direct entry of chemicals into environment may also lead to environmental pollution. Chemical pollution is defined as increase in our environment of chemical pollutants that are not naturally present there or are found in amounts higher than their natural background values. Chemical pollution can be caused by variety of chemicals and can involve variety of health problems. Various chemical pollutants may accumulate in the aquatic sediments over longer periods of time. This means that, if no tests are performed, chemical pollution in the ocean water could cause mild or deadly chemical intoxification in humans after the consumption of contaminated seafood. However, there are prevention systems we are adopting so as to prevent this chemical pollution through this project.

The following information is commonly required by treatment disposal facilities before they will consider handling unknown materials:

- Physical description,
- Water reactivity,
- Water solubility,
- pH and possibly also neutralization, information,
- Ignitability (flammability),
- Presence of oxidizer,
- Presence of sulfides or cyanides,
- Presence of halogens,
- Presence of radioactive materials,
- Presence of biohazardous materials, and
- Presence of toxic constituents

2. Background of The Work

- The overriding principle governing the prudent handling of laboratory waste is that no activity should begin unless a plan for the disposal of nonhazardous and hazardous waste has been formulated.
- Reactive wastes are unstable under normal conditions. They can cause explosions, toxins, fumes, gases or vapours when heated.
- The environmental impact of chemical waste produced by teaching and research is a topic that has been of great concern and discussion.
- The main purpose behind this project to minimize the wastage of chemicals by recycling them through proper treatment and to control their harmful effects to the environment.
- So in this project I want to aware all of you about the best disposal treatment for chemcials and hazardous waste so that there should not be any harm to environment by the hands of our college.
- Hence with the help of this project we are introducing the process of controlling chemical waste in our laboratories so that the students will understand and will adopt this effective disposal system for environmental safety.

3. Hazardous Chemicals Normally Found In Our Laboratories Are As Follows

1. Chemical wastes generated in research laboratories, and during teaching activities,
2. Old chemical agents, considered an institutional liability, often difficult to identify and abandoned in the laboratory,
3. Chemical agents surpassing their expiration date and therefore in need of re-evaluation of their effectiveness, and need for disposal,
4. Bottles of chemicals without labels or with wrong or unreadable labels,
5. Material in a state of deterioration or in packages which are deteriorated, or damaged,
6. Unknown residues in chemicals containers,
7. Laboratory waste such as paper towels and rags,
8. Personal protective equipment: aprons, glasses, masks, gloves contaminated with harmful biological, chemical or radioactive material,
9. Non-recyclable batteries and gas cylinders,
10. Photographic film processing solutions,
11. Pesticides, equipment containing toxic compounds, different types of waste oils, used solvents, Thinner, oil remover, wood preservers,
12. Formaldehyde, formalin, acrylamide waste in liquid or gel form,
13. Mercury and other metals with high toxicity,

Defunct electronics, computers and thermometers,
Sharp devices such as: needles, syringes, chromatography needles, Pasteur pipettes, tips,
Bleach, ammonia, cleaning solvents, liquid wood polish,
Chemical bottles (glass and plastic) empty but contaminated
Contaminated broken (or damaged) laboratory glass,
Mercury-contaminated, broken (or damaged) thermometers,
Carcinogenic and radioactive chemicals, pathogenic microorganisms.

4. Definition of Characteristic Waste

According to federal law, the properties of chemical waste that pose hazards are as follows

Ignitability

Ignitable materials are defined as having one or more of the following characteristics:

1. Liquids that have a flash point of less than 60 °C (140 °F) or some other characteristic that has the

potential to cause fire;
2. Materials other than liquids that are capable, under standard temperature and pressure, of causing fire by friction, adsorption of moisture, or spontaneous chemical changes and, when ignited, burn so vigorously and persistently that they create a hazard;
3. Flammable compressed gases, including those that form flammable mixtures;
4. Oxidizers that stimulate combustion of organic materials.
5. Ignitable materials include most common organic solvents, gases such as hydrogen and hydrocarbons, and certain nitrate salts.

Corrosivity

Corrosive liquids have a pH ≤ 2 or pH ≥ 12.5 or corrode certain grades of steel. Most common laboratory acids and bases are corrosive. Solid corrosives, such as sodium hydroxide pellets and powders, are not legally considered by RCRA to be corrosive.

However, trained laboratory personnel must recognize that such materials are extremely dangerous to skin and eyes and must be handled accordingly.

Reactivity

The reactivity classification includes substances that are unstable, react violently with water, detonate if exposed to some initiating source, or produce toxic gases. Alkali metals, peroxides and compounds that have peroxidized, and cyanide or sulfide compounds are classed as reactive.

Toxicity

Toxicity is established through the toxicity characteristic leaching procedure (TCLP) test, which measures the tendency of certain toxic materials to be leached (extracted) from the waste material under circumstances assumed to reproduce conditions of a landfill. The TCLP list includes a relatively small number of industrially important toxic chemicals and is based on the leachate concentration, above which a waste is considered hazardous. Failure to pass the TCLP results in classification of a material as a toxic waste. The TCLP test is primarily for solid materials; liquids are typically evaluated on a straight concentration basis. TCLP analyses are usually performed by environmental testing laboratories.

6. Types of Chemical Waste

We have gone through organic chemistry record/ manuals from first semester to eight semester and observed that most of the organic chemistry practical's involved the following common types of chemical:

Table 1: Types of chemical waste in organic chemistry lab.

Acid and base	Volatile chemicals	Heavy metal containing chemicals
Formic acid, acetic acid,	Acetone, methanol, ethanol,	Arsenic, barium, copper, lead,
hydrochloric acid, sulphuric	toluene, xylene, benzene.	mercury.
acid, sodium hydroxide,		
ammonia, potassium		
hydroxide.		

7. Treatment

As mentioned above there are so many organic waste from organic chemistry lab and it is difficult to take all at a time that why we categorized majorly in three groups and out of which we have decided to go with acid base chemical waste.

7.1 Collecting In Container

Obtain a container that will not deteriorate when the acids is added to it.

1. Most strong acids will degrade glass and metal, but will not react with plastics so make sure you obtain the correct container for your acid. The acid should already be stored in such a container, but you will need a second container for diluting and neutralizing the acid.
2. Make sure the container can hold at least twice the volume of solution as the amount of acid you have. This allows you enough space for diluting and neutralizing the acid.

Figure 1: For this experiment three different containers with above mentioned type are collected and labelled as follows.

Volatile chemicals Organic chemicals Acid and base

7.2 Reduction

In the process of waste reduction at source, the goal is to

facilitate any activity that reduces or eliminates the generation of hazardous chemical waste. This activity can be implemented with good management when acquiring materials; when replacing toxic material with less harmful ones, and with good laboratory practice. Here are some suggestions that allow the reduction of waste at source are as follows:

- Implement a policy of minimizing waste in the university research and students practice laboratory, and train all those involved in these activities. The reduction at the source can be achieved through improvement of methods or processes and replacement of ineffective equipment. In educational institutions, this is not always possible, but one should consider using more modern extraction techniques, such as solid phase extraction, or supercritical fluid, to minimize waste by using smaller volumes of organic solvents,
- Do not mix dangerous classes of waste with non-hazardous ones
- Centralize the acquisition of chemicals, and biological and radiation materials,
- Dating all received material, thus facilitating earlier use of the oldest ones,
- Make an inventory of purchased and used chemical agents in the laboratory: maintain a file containing their location, which should be updated annually. This facilitates the reduction of the quantity stored, and avoids the purchase of unnecessary material,
- Provide employees with updated MSDS - Material Safety Data Sheet of the chemicals used in laboratories,
- Acquire any chemical, biological and radiation materials in the least possible amount. The motto of the American Chemical Society (2008), is "Less is better", it is safe and environmentally correct to buy less material, use less and, ultimately, dispose of less, allowing a reduction in risk of accidents, fires, or harm to human health, and at the same time reduces costs,
- Purchase the equipment needed for immediate use and avoid purchasing materials in large quantities, even it seems to be economically advantageous, since stocking can be expensive, or dangerous, and may lead to products exceeding their expiration date. A significant part of disposal done by universities is related to the purchase of unnecessary equipment,
- Label all reagents to allow their ready identification. Borrow material from other labs, or buy it in small quantities. There is a successful story about a chemicals redistribution program at the University of Wisconsin - Madison, which has existed since 1980. About 30% of excess chemical purchased for each quarter are redistributed by the university, which allows an economy of $ 10-20,000.00 on disposal of chemicals for the university. Thus, the institution donates chemicals to those who need them and at the same time, reduces the amount to be discarded, and all benefit from this type of procedure,
- Consider the possibility of testing in micro-scale, using new glassware and techniques that reduce quantities used to milligrams, which yields many benefits such as lower costs, since small-scale experiments using fewer solvents and other agents are generally processed more quickly, because it is faster to heat or cool small volumes, reduces exposure to harmful agents and reduces harmful emissions. However, please note that this technique can only be implemented to achieve the analytical proposed objective,
- Consider the alternative of presentations/demonstrations on video, computer modeling and simulations, which eliminate environmental impacts, as substitutes for laboratory tests in the classroom. These multimedia simulations allow the student to observe more complex procedures than would be possible in traditional activities in the laboratory,
- consider prior separation of reagents and weighing in the laboratory, avoiding contamination of several rooms and environments,
- Avoid using reagents containing toxic metals such as lead, chromium, arsenic, mercury, barium, silver, cadmium and selenium,
- Do not use sulfochromic solutions: substitute them for less toxic solutions such as biodegradable detergents like Alconox or Pierce RBS35. Evaluate the possibility of using hot water and detergent for cleaning glass, instead of solvents,
- Always keep the laboratory clean and in order,
- Discard waste for disposal in the sink leading to the sewage system. Some organic and inorganic compounds may be discarded in the sewage system, in quantities of 100g and diluted 100 times. Generally, water-soluble organic compounds which have lower boiling temperature of approximately 50ºC should not be discarded in this manner. Some compounds are hydrophilic, when present at levels up to 3% and have low toxicity.
- The compounds listed below are readily biodegradable and can be discarded in the sink:-

Organic compounds

Alkyl alcohols with less than 5 carbon atoms: *t*-myl alcohol; Alkanediols with less than 8 carbon atoms: glycerol, sugars alcoxi alkanes with less than 7 carbon atoms: *n*- C4H9OCH2CH2OCH2CH2OH, 2-Chloroethanol.

Aldehydes

Aliphatic compounds with less than 5 carbon atoms,

Amides

RCONH2 and RCONHR with less than 5 carbon atoms; RCONR2 with less than 11 carbon atoms,

Amines

aliphatic compounds with less than 7 carbon atoms; aliphatic diamines with less than 7 carbon atoms,

benzilamina, pyridine carboxylic acids: alkanoics acids with less than 6 carbon atoms; hydroxy alkanoics acids with less than 6 carbon atoms; amino alkanoic acid with less than 7 carbon atoms; class of ammonia salts , sodium and potassium salts of the acids mentioned above, with less than 21 carbon atoms; chloralkanoic acid with less than 4 carbon atoms,

Esters
Esters with less than 5 carbon atoms; isopropyl acetate. The compounds that have unpleasant odor, such as dimethylamine, 1,4-butanediamine, butyric and valeric acid, must be neutralized and their salts should be discarded in the sink into sewage drain diluted with at least 1,000 volumes of water; Ketones with less than 6 carbon atoms,

Nitriles
Acetonitrile, Propionitrile,

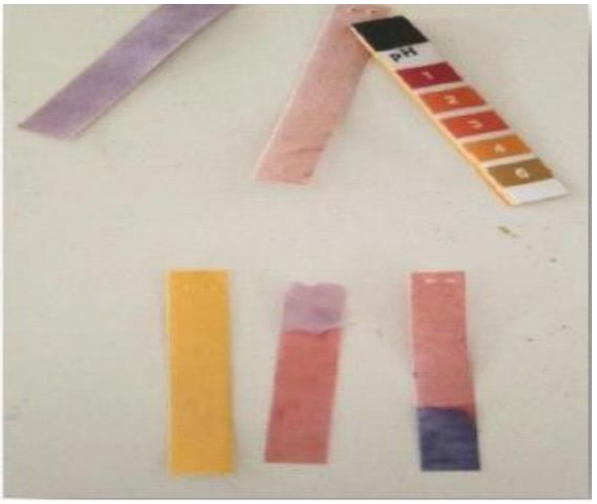
Sulfonic acid
Sodium or potassium salts of these acids are acceptable.

7.3 TEST OF PH

Treatment for acid and base
Test the pH of the acid with the pH or litmus paper.

Pre-treatment to acid base container
pH strips can be obtained from a science supply catalogue.

To determine how much neutralizing solution we need, we must know the pH of the acid we are trying to neutralize Check the pH by pH paper.



7.4 Neutralization of Acid And Base

The most common treatment is to neutralize highly acidic or alkaline solutions, leading to a desirable pH of 6 to 9. Thus, if this solution does not contain other toxic compounds it can be treated as regular trash and discarded in the sewage. Strong acids or bases must be neutralized before being released into the sewage, including those with the following cations: Al3+, Ca2+, Fe2+, Fe3+, H+, K+, Li+, Mg2+, Na+, (NH4)+, Sn2+, Sr2+, Ti3+, Ti4+, Zr2+; and anions: (BO3)3-, (B4O7)2-, Br-, (CO3)2-, (HSO3)-, (OCN)-, (OH)-, I-, (NO3)-, (PO4)3-, (SO4)2-, (SCN)-, Zn2+.

Acid base titrations are done to find the amount of acid and base by neutralizing acid or base with an acid and base of known concentration. During this neutralization process the acid base reacts to form water , salt and heat. This salt is then analysed by different methods for its reuse.

7.5 REUSE AND RECYCLING

Chemicals not only can be recycled, they also can be reused. Through "industrial symbiosis," spent chemicals from one industrial process can become feedstock for another. For instance, ferric chloride, the by-product of

steel pickling in hydrochloric acid, can be used for water treatment processes.

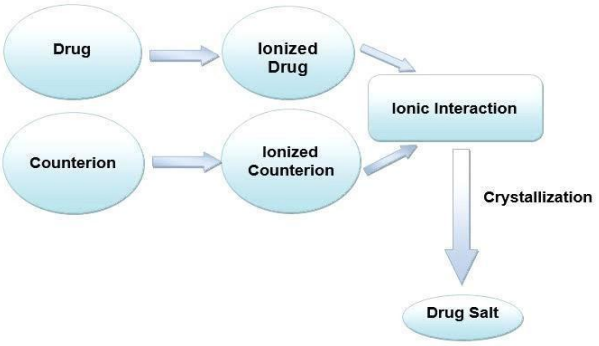
Reuse and recycle processes when possible in a new way, or treat and reuse it in the same way, or in another type of activity. Some examples of recycling are:

1. Distillation of used solvents,
2. In cleaning processes, the glassware can be initially washed with used solvents,
3. Purchase only compressed gas cylinders from manufacturers that accept the return of empty or partially used ones,
4. Avoid the contamination of fuel with solvents or heavy metals,
5. Share chemical agents among the various university units,
6. Control the use of metallic mercury.

If the above procedures are not suitable for specific situations to minimize waste, an alternative may be the final chemical treatment of the generated hazardous waste. The techniques routinely used in reducing chemical waste are: neutralization, precipitation, oxidation, reduction and distillation, practices to be conducted by trained laboratory technicians.

7.6 SALT FORMATION

These processes can remove hazardous components of chemical waste and the final product can be discarded as common trash. Precipitates derived from these reactions may require more effective waste treatment.



EVAPORATION

As the acid and base neutralization process completes the neutralized solution is evaporated in wide pan under sunlight for the formation of salt.

Salts are formed when a compound that is ionized in solution forms a strong ionic interaction with an oppositely charged counter ion, leading to crystallization of the salt form. Salt is an ionic compound that can be formed by the neutralization reaction of an acid and a base. Salts are formed if solutions of different salts are mixed, their ions recombine, and the new salt is formed. The collected acid and base solution after neutralization when evaporated under sunlight it leads to the formation of salt. Hence the salt formed is used in organic chemistry experiments by students for identification of salt from unknown sample.

7.7 Treatment For Volatile Chemicals

Volatile chemical includes acetone, ethanol, benzene, chloroform, methanol, etc. As volatile chemicals are ignitable and may catch fire hence they need to be treated before entry into the environment. The treatment procedure recommended for volatile chemicals are as follows:

1. Distillation
2. Evaporation

7.8 Treatment For Heavy Metal Containing Chemicals

Heavy metal containing chemicals include arsenic, lead, mercury, cadmium, barium, etc. they also may cause harm to the human health and environment. These chemicals are rarely used in our chemistry laboratory and

the equipment required for the identification of these chemicals are not available hence their treatment procedures were not performed.

8. Future Aspects

1. Toxic waste can harm people, animals, and plants, whether it ends up in the ground, in streams, or even in the air. Some toxins, such as mercury and lead, persist in the environment for many years and accumulate over time. Humans or wildlife often absorb these toxic substances when they eat fish or other prey.
2. It has been reported that India produces approximately 960 million tonnes solid waste every year in form of by-products produced by various sectors i.e. industry, municipal, mining, agriculture and other process in form of organic waste (roughly 350 million tonnes agricultural), inorganic waste (around 290 million).
3. Because proper management and disposal of laboratory waste requires information about its properties, it is very important that laboratory personnel accurately and completely identify and clearly label all chemical and waste containers in their laboratory, as well as maintain the integrity of source material labels.

Application of these above simple procedure ensures that the numerous state and Federal regulatory requirements for waste handling are mat and avoid unexpected difficulties such as generations of form of waste (chemical, biological, radioactive) that the institution is not prepared to deal with.

- Hazardous healthcare waste can result in Infection, Genotoxicity, cytotoxity, chemical toxicity, radio activity hazards, physical injuries and public sensitivity. To avoid these hazards chemical waste management is important.
- Small amount of infectious waste generated during various chemical processes occurring in laboratories can make non-infectious to infectious.
- Mercury is highly toxic heavy metal that possess a global threat to human health and environment.
- In order to stop all this the following can be recycled:

1. Excess unopened chemicals
2. Excess laboratory glassware
3. Consumables with no expiration
4. Solvents can be purified
5. Toxic metals like Hg , Ag , etc can be recycled

- Toxic waste can harm people, animals, and plants, whether it ends up in the ground, in streams, or even in the air. Some toxins, such as mercury and lead, persist in the environment for many years and accumulate over time. Humans or wildlife often absorb these toxic substances when they eat fish or other prey.
- It has been reported that India produces approximately 960 million tonnes solid waste every year in form of by-products produced by various sectors i.e. industry, municipal, mining, agriculture and other process in form of organic waste (roughly 350 million tonnes agricultural), inorganic waste (around 290 million).
- Because proper management and disposal of laboratory waste requires information about its properties, it is very important that laboratory personnel accurately and completely identify and clearly label all chemical and waste containers in their laboratory, as well as maintain the integrity of source material labels.

Hence, To avoid these hazards, and to save the environment and to safe guard the future resources and health of living being chemical waste management is an important step should be taken by every individual working in college or clincal laboratories.

9. CONCLUSION

Green chemistry was a concept introduced by EPA in the 1990s, a more sustainable chemistry in collaboration with the American Chemical Society (ACS) and the Green Chemistry Institute. This green chemistry concept is rela ted to the invention, development and application of me thodologies that reduce or eliminate the use of dangerous chemicals and sub-products, harmful to human health or the environment.

The concept of green chemistry is to avoid this hazard. Thus, in avoiding this hazard you can make use of the basic paradigm of Toxico logy that is the concept of risk, which includes the hazard or toxicity, which is likely to produce harm under specific conditions, namely:Risk= Hazard (or toxicity) x Exposure.

Since chemical safety is the opposite of chemical risk, any of the above presented alternatives such as the replacement of a less intrinsically toxic compound, or alteration of exposure conditions are welcome. If low risk products are used, no additional costs will be needed to secure conditions of exposure.

In conclusion, the implementation of constant train ing of university teachers and students with regard to safety in the use, storage and disposal of dangerous prod ucts, is

key for all above mentioned procedures of health and management quality to become a reality.

10. REFERENCE

1. How to dispose hazardous waste https://www.wikihow.com/Dispose-of-Hazardous-Waste browsed on dated, 12 Dec 2017.
2. Chemical waste risk reduction and environmental impact generated by laboratory activities in research and teaching institutions Elizabeth de Souza Nascimento1,*, Alfredo Tenuta Filho2.
3. How to dispose acid and base https://www.wikihow.com/Dispose-of-Acid-Safely browsed on dated, 15 Dec 2017.
4. Laboratory waste management and disposal delloyd.50megs.com/hazard/labwaste.html browsed on dated, 22 Dec 2017.
5. "Waste Disposal in Academic Institutions", Kaufman J. A. (Ed), Lewis Publishers, Chelsea MI, 1990.
6. "Hazardous-Waste Disposal", Chemical reaction, Incineration and Landfill, www.acechem.co.za /disposal[3].html browsed on dated, 22 Dec 2017.
7. "Immobilizing liquid Organic Laboratory Waste", Amos Turk et al, J. Chem. Ed., 1992; 69(11)
8. Vogel's Textbook of Practical Organic Chemistry Brian S. Furniss et al. Fifth edition, 1196-1286.
9. Elementary Practical Organic Chemistry Part 1: Small Scale Preparations Arthur I. Vogel 2nd edition, 170-176.
10. Solid Waste Management on a Campus in a Developing Country: A Study of the Indian Institute of Technology Roorkee Nikhat Parvez *, Avlokita Agrawal and Akhilesh Kumar.
11. https://www.rsc.org/globalassets/04-campaigning-outreach/realising-potential-of-scientists/regulations-health-safety/waste-management-in-chemical-laboratories-200312.pdf.