An Insight Into Selected Literature On Disasters, Hazards And Safety In Laboratories And Industries

Sunil Jayant Kulkarni

Abstract: The workers and people working in chemical and allied industries are exposed to the toxic releases and emissions. They face risk of many possible disasters. Health awareness, safety and hazard identification are very important aspects of modern day operating procedures in chemical, pharmaceutical, petroleum, biochemical and allied industries. Chemical engineering the core of industrial development. Various raw materials with variety of properties and applications are used for synthesis of products. High temperature and pressure conditions are required in many reactions and also for storage of various materials in liquefied forms. Extreme operational and storage conditions call for stringent safety norms and disaster management systems. Various chain reactions and exothermic reaction are cause of concern. Any problem in cooling system can cause huge disaster. The awareness about consequence of small errors should be emphasized on the workers. The chemical engineering education is complimented by laboratory studies and experimentation. These experiments also involves many chemicals and hence laboratory disaster identification and mitigation measures need to be studied. Research laboratories are more prone to such incidences as many new materials are synthesized and new processes, reactions are developed. This paper summarizes these guidelines and practices.

Index Terms: Prevention, injuries, accident, disaster, accident, calamities, safety, awareness, policy.

1 INTRODUCTION

Toxicological properties of various materials, chemicals, heavy metals and their effect on human being are discussed by many investigators [1-5]. Exposure to various compound like phenol can cause various long term and short term effects [6-10]. The extent of effect on living system depends on time of exposure and the concentration. Organic materials present in the wastewater can also cause health problems [11-15]. Toxicity due to heavy metals is also cause of concern. Heavy metals have tendency to accumulate in human bodies [16-20]. The workers and people working in chemical and allied industries are exposed to the toxic releases and emissions. They face risk of many possible disasters. Health awareness, safety and hazard identification are very important aspects of modern day operating procedures in chemical, pharmaceutical, petroleum, biochemical and allied industries. Chemical engineering the core of industrial development. Various raw materials with variety of properties and applications are used for synthesis of products. High temperature and pressure conditions are required in many reactions and also for storage of various materials in liquefied forms. Extreme operational and storage conditions call for stringent safety norms and disaster management systems. Various chain reactions and exothermic nature of reaction are cause of concern. Any problem in cooling system can cause huge disaster. The awareness about consequence of small errors should be emphasized on the workers. The chemical engineering education is complimented by laboratory studies and experimentation. These experiments also involves many chemicals and hence laboratory disaster identification and mitigation measures need to be studied. Research laboratories are more prone to such incidences as many new materials are synthesized and new processes, reactions are developed. Proper safety guidelines are required for such laboratories. Many agencies, government and nongovernment bodies, regulatory authorizes have prepared guidelines and standard procedures for handling disasters and accidents in laboratories and industries. This paper summarizes these guidelines and practices.

- *Dr. Sunil Jayant Kulkarni is working at Gharda Institute of Technology, Lavel, Maharashtra, India as an Associate Professor in Chemical Engineering. Email:suniljayantkulkarni@gmail.com.*

2 REVIEW ON DISASTERS, HAZARDS AND SAFETY IN LABORATORIES AND INDUSTRIES

It is always envisaged that the chemical engineer have detailed idea of possible the accidents and hazards in chemical industries. Most of the industries showcase personal protective equipment as major disaster management activity. As they say 'prevention is better than cure', proper knowledge and awareness of the process is key to avoid the accidents. Redddy and Yarrakula discussed the accidents taken place across 30 countries [21]. They identified 70 such accidents and analyzed them. The statistics show that on an average 30 deaths and 90 people injuries occur per accident [21]. These figures are really alarming. The number of deaths are maximum in African and Asian countries. In developed countries the deaths are very less and injuries are more. This indicates difference in medical facilities and also sophistications and awareness of post-accident handling of accidents and first aid. Industries handling hydrocarbon and toxic chemicals are more prone to accidents. Also Flammability and explosive nature of hydrocarbon is reason behind sixty percent of accidents. In laboratory practices, it is desired that all the investigators, guides, subject teachers are aware of the properties of the chemicals, they are handling. Physical, chemical and biological properties are indicators of possible hazards due to them. Use of proper clean up procedure after spillage is decided based on the nature and amount of chemical spillage [22]. If the properties and nature of chemical is not known then the spillage should be treated as highest risk to human safety and dealt with accordingly. Approximately up to 4 liters of spillage of the inflammable nontoxic chemicals is treated as minor spillage. Also spill with 20 ml of hazardous chemical is treated as minor spill [22]. For minor spillage cleanup is done by laboratory staff. If the release or spillage poses major health risk and requires immediate evacuation, high level of toxicity and unclear about data about chemicals, then this type of spillage is termed as major spillage. Studying the material and safety data sheet before handling the chemicals is required to avoid the accidents. According to Chen, effective process safety management is key to process safety [23]. In detail study of the chemicals and processes is needed for effective safety management. Collecting data, acquiring information and gaining knowledge are steps towards effective safety management. Knowledge can be of two types [23]. One is

explicit, acknowledge that can be shared and documented without discussion. Other is tacit knowledge, which comes from experience and should be discussed with other members. A good knowledge framework helps in preventing disasters and hazards. Identification, storage, classification and selection of knowledge should done based on available data and experience. Explosion is one of the common disaster type happening in chemical and allied industries. The explosion prevention activities can be carried out at three levels [24]. Manufacturers, operators and auditors form three levels of such activities. According to Abdou, laboratories and research organization have been slower to adopt such safety practices and programs [25]. In an activity program most of the dangers can be avoided by proper practices. It is envisaged to have science instruction program for safe operation of laboratories and research facilities. According to him, safety and health should be important aspects of science instruction programs. Security is preventive measure taken to avoid accident. Safety is protection against accident while security is prevention against deliberate harm. Difference between them can be described by using one examples. Labelling helps to recognize hazardous chemicals. This is safety aspect. Also labelling helps to identify the thefts also. This is security aspect of labelling. The factors such as Genetics, Specific chemical, Protection controls, Dose & Duration Concentration Life style & Environment affect the diseases and their severity. People should be trained to use fire extinguisher. The chemicals must be labelled clearly about their properties such as flammable, poison, explosive, toxic, bioactive and biohazards etc. Various measures are taken in Japan for determining health and safety of workers [26]. Promotion of safety program and appreciation of disaster and safety related activities can be helpful in spreading safety the chemicals. Bologna et al. discussed safety aspects of computer based systems for chemical process industries[27]. The safety issue has cultural, management and engineering aspects to think and study [27]. The safety problems must be address in the context of entire system. Various protective systems have mechanical, hydraulic, pneumatic, electrical, electronic, programmable electronic tools. Process measurement, regulation and surveillance applications are made easier with the use of proper instrumentation systems. Computers are used for Control and alarm systems Safety systems Interlocking systems Leak detection systems, Instrument monitoring systems Fire and gas detection systems [27].In India, there is need for sustained efforts for educating workers about risk and hazards at workplace and need for training about the same [28]. Substantial efforts are still required to improve prediction, mitigation and release of hazardous chemicals, gases in the atmosphere. The emission of toxic gases in the atmosphere during accidents is major concern for the people around the area. Atmospheric conditions decide their concentrations at various distances from the source. Efforts are done for educating the people for handling the situation when disaster occurs in chemical industries. National disaster guideline were published by the government of India in 2007 [28].In detail guidelines for infrastructure, medical facilities, handling, and storage are discussed in detail in these guidelines. In the context of worldwide threats due to misuse of chemicals and reagents, it is important that the research and educational institutes are aware of possible accidents due to intentional or unintentional activities of the people [29]. Daily commitment by each person can make the safety program successful. Faculty members should promote the safety programs and make student aware of possible hazards. The possible hazards is very important term because student may have to face many situations they may not have encountered with in real life. Mock accidents and disasters can help students to handle the future scenario if it actually occurs in much better and composed manner. According to McLeod, formal job safety analysis is the best safely tool [30]. All emergency exits and drains should be regularly checked. Eating and drinking in the laboratory area must be strictly avoided. The guidelines for loss prevention and control for high-hazard chemical and petrochemical plants should be paid more attention [31]. These guideline helps in evaluation of highly divergent protection levels. Pre-emergency planning, preventive maintenance and inspection and management of change were some key aspect discussed in the global asset protection guidelines [31]. Oluoch et al. discussed the Occupational Safety and Health Hazards' Exposure in water service industry [32]. They prepared and got filled the questionnaire for obtaining primary data. They conducted risk analyses for biological, chemical, ergonomics, physical, and psychological and safety risks. Their study indicated that biological and chemical risk was very high for the workers. Various government agencies and research organizations are involved in providing assistance and creating awareness about safety and hazards in research laboratories [33]. The importance of consulting and listening to the past researchers is being emphasized upon the researchers. Fuentes-Bargues discussed risk analysis for fuel storage terminal [34]. They used hazard and operability study (HAZOP) and fault tree analysis for the purpose. Size and complex nature of plants, variety of chemicals handled makes the HAZOP study important part of safety measures. The probability of risk and failure can be analyzed by the FTA. Loading and unloading of chemicals are probable risk incidents for the workers. Loading area is prone to spillage hazards. Training of staff can help in avoiding the danger due to human errors. When natural disaster (earthquake) occurs during laboratory working, the ongoing experiments should be completed and no new experiments should be started. Prior to evacuation, all the chemicals should be identified and labelled. Appropriate storage locations should be identified and materials should be stored accordingly. Also tightly sealed, waterproof containers should be used for storing reactive chemicals (35). Handling of nano-chemicals and emergency planning need to be discussed and implemented with lot of thought. Many new material and new equipment are being synthesized and fabricated with specific applications. Identification of possible hazards due to these new developments should be taken into consideration while preparing laboratory safety guidelines [36].Pharmaceutical industries and prone to biohazards and toxic release. Toxicological data and hazard identification are important aspects of safety measures [37].Hazardous materials are classified from A to E categories. Various government and non-government agencies, firms and laboratories are working hard to keep the people safe. They have published studies and guidelines for hazards, safety and disaster management in chemical laboratories [38, 39]. These efforts need more support from government, workers, research and people at large for implementation of more safe and clean practices. Proper disposal of electronic and hazardous waste can avoid many potential disasters. Most of the times the solid waste is buried in the land. This is a potential risk as the soil

cover can be get removed and waste may be exposed. The hazardous waste poses big threat to the people near the dumping site [40-42]. Incineration, sanitary landfill and aerobic and anaerobic methods can be used for solid wastes depending on their composition [43-45]. Proper disposal of electronic and hazardous waste can avoid many potential disasters. The management of electronic waste is very important from hazard prevention perspective. Compared to developing countries, India needs more awareness among the stakeholders regarding E waste. Policy frameworks are prepared from time to time [46-47]. Legal measures are also being taken in India and other developing countries. E-waste recycling is being explored and practiced [48-50].

3 CONCLUSION

Health awareness, safety an hazard identification are very important aspects of modern day operating procedures in chemical, pharmaceutical, petroleum, biochemical and allied industries. Chemical engineering the core of industrial development. Various raw materials with variety of properties and applications are used for synthesis of products. High temperature and pressure conditions are required in many reactions and also for storage of various materials in liquefied forms. Extreme operational and storage conditions call for stringent safety norms and disaster management systems. Various chain reactions and exothermic nature of reaction are cause of concern. Any problem in cooling system can cause huge disaster. The awareness about consequence of small errors should be emphasized on the workers. Proper disposal of electronic and hazardous waste can avoid many potential disasters. The management of electronic waste is very important from hazard prevention perspective. Compared to developing countries, India needs more awareness among the stakeholders regarding E waste.

REFERENCES

[1] M.d Metzler, E. Pfeiffer, “Chemistry of Natural and Anthropogenic Endocrine Active Compounds”, The Handbook of Environmental Chemistry Vol.3,Part L Endocrine Disruptors, Part Iwww. lu.lv/ecotox/publikacijas/ENDOCRCHEM.P DF,pp.64-80, 2001.

[2] C. Philippat, M. Mortamais, C. Chevrier, C. Petit, A.M. Calafat, X.Ye, M. J. Silva, C. Brambilla, I. Pin, M. Charles, S. Cordier, R. Slama, “Exposure to Phthalates and Phenols during Pregnancy and Offspring Size at Birth”, Environmental Health Perspective, National Institutes of Health U.S. Department of Health and Human Service”, pp.125,7Sept.2011, http:// dx.doi.org / 10.1289/ ehp. 1103634.

[3] S. J. Kulkarni, J. P. Kaware, “A Review on Health Effects of Phenol”, International Journal of Research (IJR), Volume 2, Issue 05, May 2015,968-973

[4] P. Amale, S. Kulkarni, K. Kulkarni, “Studies on Packed Bed Treatment for Organic Matter in Distillery Effluent Studies on Packed Bed Treatment for Organic Matter in Distillery Effluent”, International Journal of Engineering Science and Innovative Technology (IJESIT) , Vol.3, No. 5, pp.268-272,September 2014.

[5] S. J. Kulkarni , A. K. Goswami, “Applications and Advancements in Treatment of Waste Water by Membrane Technology-A Review”, International Journal of Engineering Sciences & Research Technology,Vol.3,No.9,pp.446-450,2014.

[6] C.D. Sandau, “Toxicology And Environmental Levels Of Halogenated Phenolic Compounds”,Organohalogen Compounds, Vol. 65, pp.51-54,2003.

[7] A. Mpofu, H. D. Sapirstein, T. Beta, “Genotype and Environmental Variation in Phenolic Content,Phenolic Acid Composition, and Antioxidant Activity of Hard Spring Wheat”, J. Agric. Food Chem.,Vol.54, pp. 1265-1270, 2006.

[8] F. Kayama, H. Horiguchi, A. Hamamatsu, “Potential Health Effects of Alkyl phenols in Japan”, The Journal of the Japan Medical Association, Vol. 127, No. 2, pp.216-220, 2002.

[9] M. A. Khan, “Effects of Phenol, Benzalkonium Chloride, Oxymetazoline, Tobacco and Formalin on Nasal Mucosa of Albino Rat”, J.Anat.Soc. India, Vol., 55, No.1, pp.60-66, 2006.

[10] S. Andini, R. Cioffi , F.Colangelo, F. Montagnaro, L. Santoro, “Adsorption Of Chlorophenol, Chloroaniline And Methylene Blue On Fuel Oil Fly Ash”, J Hazard Mater. Vol.157, No.2-3, pp.599-604, 2008.

[11] P. Amale, S. Kulkarni, K. Kulkarni, “Studies on Packed Bed Treatment for Organic Matter in Distillery Effluent Studies on Packed Bed Treatment for Organic Matter in Distillery Effluent”, International Journal of Engineering Science and Innovative Technology (IJESIT) , Vol.3, No. 5, pp.268-272,September 2014.

[12] S.J. Kulkarni, “Removal Of Organic Matter From Domestic Waste Water By Adsorption”, International Journal of Science, Engineering and Technology Research (IJSETR), Vol.2,No.10,pp.1836-18840, October 2013.

[13] Y.Satyawali,M. Balakrishnan, “Wastewater treatment in molasses-based alcohol distilleries for COD and color removal-A review”,J. Environ. Mgmt.,Vol., 86, No.3, pp. 481-497, 2008.

[14] S. J. Kulkarni, A. K. Goswami, “Adsorption Studies for Organic Matter Removal from Wastewater by Using Bagasse Flyash in Batch and Column Operations”,International Journal of Science and Research,Vol. 2,No.1,pp.180-183, 2013.

[15] V. Mudgal, N. Madaan, A. Mudgal, R.B. Singh, S. Mishra, “Effect of Toxic Metals on Human Health”, The Open Nutraceuticals Journal, Vol.3, pp.94-99,2010.

[16] J. Khayatzadeh J., E. Abbasi., “The Effects of Heavy Metals on Aquatic Animals”, The 1 st International Applied Geological Congress, Department of Geology,Islamic Azad University-Mashad Branch, pp.688-695,Iran, 26-28 April 2010.

[17] B. S. Bada and O. T. Oyegbami, “Heavy Metals Concentrations in Roadside Dust of Different Traffic Density”, Journal of Environment and Earth Science, Vol 2, No.8, pp.54-61, 2012.

[18] G.Pandey, S.Madhuri, “Heavy Metals Causing Toxicity in Animals and Fishes”, Research Journal of Animal, Veterinary and Fishery Sciences,Vol.2, No.2,pp.17-23,2014.

[19] S. J. Kulkarni, S. R. Dhokpande, J.P. Kaware, “A Review on Studies on Effect of Heavy Metals on Man and Environment”, International Journal for Research in Applied Science & Engineering Technology, Vol.2, No.10, pp.227-229, 2014.

[20] S. J. Kulkarni, J.P. Kaware, “Removal of Cadmium from Wastewater by Groundnut Shell Adsorbent-Batch and Column Studies”, International Journal of Chemical Engineering Research, Vol.6, No.1, pp.27-37, 2014.
[21] K. Reddy, K. Yarrakula, “Analysis Of Accidents In Chemical Process Industries In The Period 1998-2015”, International Journal Of Chemtech Research, Vol.9, No.4, pp. 177-191, 2016.
[22] Univ. Of Alabama In Huntsville, ‘Emergency Preparedness And Disaster Resistance In The Laboratory.Https://Www.Uah .Edu/... /07.07. 21 _Emer gency_ Prep aredness _ And_ Disaster_R
[23] Mingliang Chen, Process Safety Knowledge Management In The Chemical Process Industry, American Journal Of Chemical Engineering, Vol.4, No.5, pp.131-138, 2016.
[24] Dmt Gmbh & Co. Kg Plant & Product Safety Center For Fire & Explosion, ‘Fire And Explosion Protection In The Chemical Industry, Https://Plant-Product-Safety.Dmt-Group.Com/.../2018-05-Broschuere_Bsex, pp. 1-4, 2018.
[25] W. M. Abdou, “To Professionals: Chemical Safety and Chemical Security Overview”, Ajce, Vol.4, No.3, pp,110-132, 2014.
[26] Measures For Securing Safety And Health Of Workers, Https://Www.Mhlw.Go.Jp/ Engl Ish/Wp/Wp- Hw5/Dl /23010404e.Pdf, 121-130
[27] S. Bologna, G. Dahll, O. G. Picciolo, Enichem, R. Taylor, “Safety Applications Of Computer Based Systems For The Process Industry”, Ente Per Le Nuove Tecnologie, It9800369 L'energia E L'ambiente,Dipartimento Energia, Supported By The Essi Programme Of The European Commission, Rt/Erg/97/14, 1-62,1997.
[28] National Disaster Management Authority Government Of India, National Disaster Management Guidelines Chemical Disasters, pp.1-124. April 2007
[29] L. Moran, T. Masciangioli, Editors, “Chemical Laboratory Safety And Security A Guide To Prudent Chemical Management”, Committee On Promoting Safe And Secure Chemical Management In Developing Countries, The National Academies Press Washington, Dc Www.Nap.Edu, pp.1-281, 2010.
[30] Lab Manager, “Laboratory Hazards and Risks”, Labmanager.Com, Vol.12, No.5, pp. 1-76, June 2017.
[31] A Publication of Global Asset Protection Services Llc, High-Hazard Chemical And Petrochemical Plants, 100 Constitution Plaza, Hartford, Connecticut 06103, Https://Axaxl. C Om/-/Media/Gaps/H21 ____0.Pdf, pp.1-7, 2015.
[32] I. Oluoch, P. Njogu, J. O. H. Ndeda, “Effects of Occupational Safety and Health Hazards Exposure on Work Environment in the Water Service Industry within Kisumu County – Kenya”, IOSR Journal of Environmental Science, Toxicology and Food Technology ,Vol. 11, No. Ver. I , pp.46-51, 2017.
[33] Identifying and Evaluating Hazards in Research Laboratories, Guidelines developed by the Hazard Identification and Evaluation Task Force of the American Chemical Society’s Committee on Chemical Safety, Copyright 2015 American Chemical Society, pp.1-147, 2015.
[34] J. Luis Fuentes-Bargues, M. Carmen González-Cruz, C. González-Gaya, M Piedad Baixauli-Pérez, “Risk Analysis of a Fuel Storage Terminal Using HAZOP and FTA”, Int. J. Environ. Res. Public Health, Vol.14, pp.1-26, 2017. doi:10.3390/ijerph14070705,1-26
[35] Laboratory Emergency Response to Natural Disasters, Bostan University, www.bu.edu/ehs/files/2012/10/Lab-Safety-Advisory-102612.pd
[36] The Committee on Prudent Practices in the Laboratory: An Update; National Research Council, Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version, http://nap.edu/12654
[37] O. G. Bhusnure, R. B. Dongare, S. B. Gholve, P. S. Giram, “Chemical hazards and safety management in pharmaceutical industry”, Journal of Pharmacy Research, Vol. 12, No.3, pp.357-360, 2018.
[38] J.A.Haagsma, L. Tariq, D.J.Heederik, A.H.Havelaar, “Infectious disease risks associated with occupational exposure: A systematic review of the literature”, Occup Environ Med., Vol.69, pp.140-146, 2012.
[39] Code of practice for the safe use and storage of chemicals (including pesticides and herbicides) in agriculture, pp. 1-88, 2006.
[40] S. Sharma, “Management of Hazardous Waste-Opium Marc”, International Research Journal of Environment Sciences, Vol.3, No.8, pp.64-66, 2014.
[41] S. J. Kulkarni, “Review on solid waste management with emphasis on hazardous waste”, International Journal of Research and Review, Vol.3, No.12, pp.16-19, 2016.
[42] A.V. Mane, “A Critical Overview of Legal Profile on Solid Waste Management in India”, Int. J. Res. Chem. Environ., pp.1-16, 2015.
[43] V.L.Lau, “Case Study on the Management of Waste Materials in Malaysia”, Forum Geoökol, Vol.15, No.2, pp.7-15, 2004.
[44] A. A. Amador, “A Hazardous Waste Management Solution For Bogota”, A Project Report Presented to The Faculty of the Department of Anthropology San José State University, pp.1-264, 2010.
[45] P. Tamilchelvan, M. Dhinakaran, “Anaerobic Digestion Treatment of Tannery Waste Water”, International Journal of Engineering Research and Applications”, Vol.2, No.3, pp.932-936, 2012.
[46] A. Borthakur, P. Singh, “Electronic waste in India: Problems and policies”, International Journal of Environmental Sciences, Vol.3, No. 1, pp. 353-362, 2012.
[47] D. Sinha-Khetriwala,, P. Kraeuchib, M. Schwaninger, “A Comparison of Electronic Waste Recycling Inswitzerland and in India”, Environmental Impact Assessment Review, Vol. 25, pp. 492– 504, 2005.
[48] A. Nair, N. Hari, “Management of Informal E-waste Recycling with Special Reference to India”, International Journal of Innovative Science, Engineering and Technology, Vol. 2, No. 3, pp.45-52, March 2015.
[49] S. J. Kulkarni, “E-Waste Recovery, Reuse, Recycle, Management and Treatment An Insight”, International Journal of Scientific Research in Computer Science, Engineering and Information Technology, Vol. 2, No. 1, pp. 25-28,2017.
[50] A. Jayapradha, “Scenario of E-waste in India and Application of New Recycling Approaches for Ewaste Management”, Journal of Chemical and Pharmaceutical Research, Vol.7, No.3, pp.232238, 2015.