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Discussion and Practice on the Management of Hazardous Chemicals in University Laboratories

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Abstract: *The laboratory is an important battlefield for higher education, teaching, and scientific research. Laboratory safety is an important condition to ensure the smooth progress of higher education teaching, scientific research, and other work. As one of the essential materials for university laboratories, the standardized use of hazardous chemicals is an important key to ensuring the safety of university laboratories. This article combined the actual situation of hazardous chemical management in university laboratories, and proposed optimization strategies for the safety management of hazardous chemicals in university laboratories from the aspects of institutional construction, team building, safety education, and information management, to ensure the safe operation of university laboratories.*

Keywords: *Hazardous chemical, Laboratory, Safety management, University security*

1. Introduction

University laboratories are important places for conducting basic experimental teaching and cultivating scientific and technological innovation talents, as well as reflecting the conditions and comprehensive strength of local universities. In recent years, various universities have fully implemented the construction tasks of school education development. Led by the construction of new engineering disciplines, the universities continuously expanded the research fields involved in experimental disciplines such as biology, physics, and chemistry. And the types and quantities of hazardous chemicals involved in conducting experimental research were increasing. Due to the toxicity and explosiveness of hazardous chemicals, strengthening the safety management of laboratory hazardous chemicals, especially the full process supervision of hazardous chemicals, had become an important part of laboratory safety management in universities [1]. Eliminating potential safety hazards of hazardous chemicals to ensure the normal operation of teaching and research activities, ensuring the personal safety of teachers and students, and maintaining campus safety and stability.

According to the *Regulations on the Safety Management of Hazardous Chemicals*, hazardous chemicals refer to highly toxic chemicals or other chemicals that have toxic, corrosive, explosive, flammable, and combustible properties, and pose a threat to human health, facilities, and the environment. According to the physical and chemical characteristics, hazards, and ease of management of chemicals, hazardous chemicals are further divided into eight categories: explosives, toxic substances, corrosive substances, and radioactive materials. In addition, according to the different levels of national regulation, hazardous chemicals are divided into two categories: nationally regulated hazardous chemicals and general hazardous chemicals. Controlled drugs include highly toxic chemicals, precursor chemicals, explosive chemicals, civilian explosive chemicals, and psychiatric chemicals.

The hazardous chemicals involved in the process of chemical research in universities include explosives, flammable liquids, flammable solids, oxidizing substances, corrosive substances, toxic substances, and various gases. The procurement and use of these chemicals are characterized by a wide variety of types, strong professionalism, and high difficulty in fine management. Generally, the use amount of chemicals that precursor chemicals and corrosive chemicals were relatively large and have strong pollution. While the amount of the explosive chemicals was small, but the danger was high. As raw materials or intermediates, the use of hazardous chemicals in teaching and research was inevitable. However, the application and storage of hazardous chemicals, especially in large quantities, also bring potential risks and hazards to campuses. In recent years, there have been frequent reports of campus safety accidents caused by improper storage and use of hazardous chemicals. The safety accidents caused by these hazardous chemicals not only cause casualties and property damage, but also have a negative social impact.

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2. Problems in the management of hazardous chemicals in university laboratories

2.1. The problem of inadequate laboratory safety management system

In recent years, with the rapid development of higher education, the types, quantities, and areas of research laboratories in universities have grown rapidly. The growing scale of laboratories and the complex affairs of laboratories are intertwined. Due to differences in subject categories and research directions, each laboratory lacked unified management standards and systems. However, the existing system had not been updated in a timely manner based on the development of schools and technological progress, which had a significant lag. Many university laboratories often encountered defects or inadequate management models in the management of hazardous chemicals. The main reason for this phenomenon was that the division of responsibilities of laboratory management leaders in universities was not clear enough and the relevant management systems were not sound enough. In the normal operation of some local university laboratories, due to the joint participation of multiple departments in the construction and management of university laboratories, there was no detailed division of responsibilities, and the responsibilities between departments were not clear enough, resulting in cross management and relatively difficult coordination and implementation. There was no clear document specifying the responsibilities of users and managers, which itself has significant loopholes and drawbacks. This matter would have a certain negative impact on the management of hazardous chemicals in university laboratories. The unclear responsibility system has resulted in the lack of a strict system and process for the management of hazardous chemicals, which can easily lead to safety hazards, affect the normal operation of university laboratories, and fail to ensure the personal safety of teachers and students [2].

2.2. The issue of opaque information on hazardous chemicals

The opacity of hazardous chemical management information was a major hidden danger in the management of hazardous chemicals in university laboratories. Some laboratories have issues with incomplete lists of hazardous chemicals and untimely information updates, which may lead to an increase in laboratory safety risks and confusion in management. Due to the high turnover of personnel in the laboratory, some teachers and students may not realize the importance of timely updating the list of hazardous chemicals for safety management. And they also lacked initiative in updating the list of hazardous chemicals, and failed to report newly introduced chemicals in a timely manner.

However, an incomplete list of hazardous chemicals could lead to teachers and students lacking sufficient awareness of potential hazards when using, storing, or disposing of them. Missing information on hazardous chemicals can affect the accuracy of laboratory risk assessment and may lead to insufficient understanding of potential laboratory risks among teachers and students. More seriously, in the event of an accident, an incomplete list of hazardous chemicals may lead to delayed emergency response, which affecting the efficiency of accident handling and threatening the safety of teachers and students.

2.3. Insufficient investment in laboratory infrastructure

With the continuous development of universities and the increasing number of students, many universities with decades or even centuries of history were limited by land use resources, resulting in insufficient laboratory scale [3]. Due to the insufficient scale of the laboratory, as well as the sharing of student basic experiments, graduation thesis experiments, open experiments, and even the sharing of teachers' research and rest rooms. The huge personnel mobility and uncertainty had increased the difficulty of laboratory management and safety hazards. The old laboratory had safety hazards such as doors and windows not meeting fire safety requirements, lack of installation of combustible gas alarm devices, aging ventilation systems, aging circuits, and overloaded circuit operation, which were far from the current laboratory safety standards. Explosion proof switches and lamps were not installed in flammable and explosive laboratories, and ordinary glass windows were used for ventilation cabinets. Hazardous chemicals were directly stored in the experimental building, and there was no dedicated hazardous chemicals warehouse that met the standards. High pressure gas cylinders were not stored in the cylinder cabinet. Some basic safety protection equipment was in short supply, such as sprinkler devices, disposable gloves, medical boxes, explosion-proof glasses, gas masks, etc. If these infrastructure were not improved, it would bring significant security risks.

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2.4. The issue of weak safety awareness

At present, most domestic universities have not yet incorporated laboratory safety education into their curriculum system, resulting in teachers and students not systematically learning knowledge about hazardous chemical safety. The reasons for the weak safety awareness of teachers and students often include the following. Firstly, because teachers and students focused on academic research and teaching, they may prioritize safety issues at a lower level and neglect the cultivation of safety awareness. Secondly, teachers and students may have insufficient understanding of the characteristics, properties, and potential reactions and hazards of different hazardous chemicals, leading to neglect of their potential hazards. Thirdly, due to the relatively low occurrence of hazardous chemical accidents and the lack of personal experience and understanding of hazardous chemical accident cases, teachers and students were unable to learn from the experiences of others and improve their own vigilance. They misjudged the risk of accidents and neglected the existence of safety hazards [4].

In the *Opinions of the Ministry of Education on Strengthening the Safety Work of University Laboratories*, it was pointed out that " Persist and focus on safety education, publicity, and training. " Let safety culture and safety education "enter the mind and heart" and play their due role. In university laboratories, it was a serious problem that the lack of awareness and safety awareness among teachers and students regarding the potential hazards of hazardous chemicals. Due to the lack of targeted and systematic experimental education and training activities, students had weak safety awareness and cannot detect safety hazards. This situation may lead to careless chemical experiment operations, increased risk of accidents, and a lack of ability to respond in a timely manner after accidents occur. Therefore, enhancing the safety awareness of teachers and students had become crucial.

2.5. Shortage of full-time management personnel and shortage of funds

The tight financial situation in universities, coupled with insufficient awareness of the importance of laboratory safety, had led to many laboratories facing the dilemma of insufficient funding for teachers, technical personnel, and operation and maintenance, which seriously restricting the normal functioning of laboratory research and teaching [5]. Due to their own professionalism and specificity, hazardous chemicals cannot be generalized in management compared to other ordinary chemical reagents. And they required specialized safety management personnel. Based on the current staffing situation of university laboratories, many of the daily management of hazardous chemicals in university laboratories was carried out by laboratory personnel from various departments, and these personnel also undertaked teaching and experimental auxiliary work. There were fewer full-time laboratory management personnel and more part-time personnel. The safety management of university laboratories was difficult and carries heavy responsibilities. Most full-time management personnel in universities were seriously lacking, and their energy investment was limited. As a result, the level of attention paid to the management of hazardous chemicals was reduced, which was highly likely to lead them to overlook the safety risks of hazardous chemicals.

3. Measures and Countermeasures for Safety Management of Hazardous Chemicals

3.1. Establishing a sound management system for hazardous chemicals

In university laboratories, the management of hazardous chemicals not only required the attention of individual teachers and students, but also required the establishment of systematic management systems. Universities should refer to domestic and foreign standards and norms to establish laboratory safety regulations with their own characteristics [6]. By formulating detailed hazardous chemical management systems, laboratories could achieve standardization and standardization in procurement, storage, use, and disposal. This could reduce management risks and improve work efficiency. This also helped to establish a scientific, standardized, and safe management system, and provid strong support for the safe operation and sustainable development of the laboratory. At the same time, it was necessary to establish a sound three-level safety management system for schools, colleges, and laboratories. Under the unified management of the school, established a laboratory safety management responsibility system with "unified leadership, centralized management, hierarchical responsibility, and individual responsibility", implement a mechanism of "who is in charge, who is responsible" and "who uses, who is responsible", implement responsibility to individuals, and establish a safety responsibility system for all personnel involved in the laboratory. A dedicated safety management organization needed to be established and equipped with dedicated safety management personnel. Meanwhile, establishing a hazardous chemical

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management system could effectively promote laboratory safety management and risk control. The responsibility system was the foundation of all safety management work. Only by establishing a comprehensive safety responsibility system and strictly implementing it in actual safety management work could the quality of safety management work be fundamentally guaranteed, and a safer and better university laboratory environment be created.

3.2. Establishing a professional management team

Schools should establish sufficient laboratory management positions as needed and build a management team with strong technical and business capabilities. Schools should conduct regular training for laboratory management personnel and organize regular learning and visits for laboratory management personnel to broaden their horizons, learn new and scientific management models, improve management efficiency, and reduce safety hazards. A professional management team could provide professional guidance on hazardous chemical safety management for teachers and students, ensuring the correct storage and use of chemicals. If a safety accident occured and teachers and students were unable to handle it, management personnel could quickly take measures to effectively respond to the accident.

Schools could also invest sufficient funds to improve the salary and benefits of laboratory management personnel, recognize the importance of laboratory management work. School also need to encourage laboratory management personnel to obtain safety engineer qualifications to enhance laboratory safety management capabilities. Universities had a system for assessing teaching quality, but there were few systems for awarding and evaluating laboratory management personnel. In terms of professional title evaluation and salary benefits, laboratory management personnel should be considered to stimulate the work enthusiasm of experimental technicians.

3.3. Standardizing the management of hazardous chemicals

The procurement, storage, collection, use, and disposal of hazardous chemicals must be managed in a standardized manner. Firstly, it was necessary to clarify from the source. In the actual procurement process, it was necessary to strengthen the procurement approval of hazardous chemicals. Only after all approval procedures were passed could the purchase of hazardous chemicals be carried out. Procurement must be made through qualified and legitimate channels. Universities need to set up dedicated storage areas for hazardous chemicals, equipped with necessary safety equipment and facilities, such as ventilation systems, fire protection facilities, eye washing equipment, etc., and regularly maintain the equipment and facilities. The storage of hazardous chemicals should also be scientific and orderly. It was strictly prohibited to store solid and liquid chemicals together, and attention should also be paid to the storage of incompatible chemicals. Before using hazardous chemicals, users must consult the nature and safety protection measures of the chemicals used in advance, understand their characteristics and emergency response methods, and be able to effectively respond in the event of accidents. The process of chemical waste disposal also needed to be standardized and followed environmental requirements. Schools should clarify the disposal methods and processes of chemicals, and recording detailed information on discarded chemicals. After the laboratory hazardous waste was uniformly recycled by the school, it was handed over to a qualified hazardous waste disposal company for centralized disposal.

3.4. Strengthening publicity and education on hazardous chemical safety

After the establishment and improvement of the hazardous chemical management system, publicity and training should be provided to school teachers and students to ensure that all teachers and students understand and follow the system. The non-standard use of hazardous chemicals in laboratories was the biggest safety hazard. The weak safety awareness of laboratory personnel was the direct cause of unsafe behavior and non-standard operations. Universities could regularly conduct safety training on hazardous chemicals to enhance the safety awareness, operational skills, and protective skills of teachers and students. In addition, the methods of safety management publicity and education should be diversified, such as posting promotional posters in the experimental building, placing promotional display boards, inviting experts to conduct safety lectures, using online platforms to promote safety knowledge, and holding hazardous chemical safety knowledge competitions. Hazardous chemical safety education should be carried out within the school scope, and hazardous chemical management standards should be comprehensively popularized.

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3.5. Using information technology to manage

With the advancement of technology, information management was playing an increasingly important role in the management of hazardous chemicals in university laboratories. By utilizing information technology and combining with the actual development of chemical laboratories in universities, a hazardous chemical management platform was established to dynamically and informationally manage the entire process of procurement, use, and disposal of hazardous chemicals, which effectively improving the accuracy, real-time, and convenience of information. This played an important role in the standardization and safety of hazardous chemical management in university laboratories, and provided important data support for sorting out clearer management ideas and methods, bringing many advantages to the management of hazardous chemicals in laboratories.

3.6. Strengthening the construction of laboratory safety facilities

To some extent，the construction of laboratory safety facilities could protect the personal and property safety of teachers and students. Chemical storage should be located in a dedicated area, which should also be effectively isolated from the experimental operation area to reduce the risk of accidental leakage or fire spread. Ventilation and exhaust facilities need to be installed in this area to ensure timely discharge of harmful gases and reduce indoor pollution and fire hazards. Dangerous chemicals should be placed in dedicated chemical storage cabinets according to regulations. Therefore, appropriate safety cabinets should be equipped in the chemical storage area to store toxic, flammable, corrosive and other hazardous chemicals separately to prevent mutual reaction and leakage. Meanwhile, installing safety equipment such as fire alarm systems and gas leak detectors in the storage area could effectively prevent laboratory safety accidents. In addition, the laboratory should be equipped with emergency rescue materials, such as fire-fighting equipment, escape protection equipment, and emergency medicine boxes. Clear fire evacuation plans should be posted in the hallway, and emergency sprinkler devices should be installed to play an important supporting role in handling emergencies.

4. Conclusions

In the safety management work of universities, laboratory safety was undoubtedly a crucial task. It could not only ensure the life and health of teachers and students, but also layed a solid foundation for the sustainable development of the school. Among them, the management of hazardous chemicals was the most crucial part. There were various types of hazardous chemicals in university laboratories, and their use was relatively frequent. Therefore, by improving the chemical management system, establishing a professional management team, strengthening the safety education of hazardous chemicals for teachers and students, using information technology to strengthen the full process management of hazardous chemicals, and comprehensively strengthening the equipment and construction of safety facilities, the probability of safety risks occurring in university laboratories could be effectively reduced. A harmonious, safe, and perfect environment for the use of university laboratories could be established to ensure the orderly operation of teaching and scientific research activities and provide guarantees for the optimization and development of scientific research and higher education in our country.

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