



Study on the Analysis of Chemical and Hazardous Chemical Accidents in China During 2016-2021

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Abstract By collecting and organizing chemical and hazardous chemical production accidents from 2016 to 2021, systematic statistics on the time of occurrence, accident level, region of occurrence, type of accidents, industry distribution and other aspects were launched respectively, and the development trend of accidents, accident characteristics and causes of accidents were comprehensively analyzed. The results of the study show that: the number of accidents and deaths of chemical and hazardous chemicals in China fluctuates a little, but the overall trend is down; accidents occur more often in summer, the end of the year and 16h-18h; the number of accidents and deaths in Hebei and Shandong is higher; explosions and poisoning and asphyxiation accidents are the main types of accidents; most of the accidents occur in the production and operation links; and the number of accidents of fine chemical industry accounts for as high as 45.2%. Finally, countermeasures to further prevent and reduce chemical and hazardous chemical accidents are proposed from the perspective of enhancing intrinsic safety.

Keywords chemicals and hazardous chemicals; trends in accident development; accident characterization; causes of accidents

1. Introduction

China's chemical and hazardous chemicals industry is developing very rapidly, as the world's first chemical production country, now the chemical output value in the world's total output value accounted for more than 40%. However, chemical and hazardous chemical accidents occur from time to time, and the loss of accidents is very heavy, the systematic study of chemical and hazardous chemical accidents is of great significance to reduce and prevent chemical production accidents ^[1].

Many scholars have done statistics and analysis on chemical and hazardous chemical accidents, Wu Zongzhi et al ^[2] based on the statistical analysis of China's hazardous chemical accidents from 2006-2010, concluded that the main types of hazardous chemical accidents are poisoning, asphyxiation, explosion, the accidents mainly occur in the production process, the important reason for the accidents is the violation of the operation or the defective equipment and facilities, and the main types of hazardous substances are flammable gases, flammable liquids, corrosives and explosives; Cindy Liao et al ^[3] based on the statistical analysis of the hazardous chemical leakage accidents occurred in China during the period of 2010-2015, concluded that during the period of 2010-2015, the high incidence of hazardous chemical leakage accidents is April, the high incidence of the province is Shandong, Zhejiang, Sichuan, the accident is mainly intensive in the transportation and storage links; Hu Xinsheng et al ^[4] through the study of the occurrence of hazardous chemical accidents in China during the period of 2011-2015, the accident mainly occurs in the transportation and storage links. 2015 the occurrence of hazardous chemical accidents characteristics, concluded that during this period, the number of accidents and the number of deaths in general show a downward trend, accidents occur in summer and winter, the most common area for the eastern coastal region; Wang Wei et al ^[5] based on the study and analysis of China's 1981-2020



larger and above hazardous chemical accidents, concluded that accidents often occur from April to July, Shandong, Jiangxi, Liaoning for the high incidence of accidents provinces, mainly occurring in the fine chemical industry, production links, mostly explosive accidents, human factors dominated; Zhang Le, Tong Xing [6] based on the 2010-2019 29 heavy mega-accidents from the time characteristics, consequence characteristics, types of characteristics, geographic and economic characteristics and the main lessons characterization of the risk governance contradictions in the field of hazardous chemicals production, and put forward policy proposals to resolve these contradictions; Zhang Shengzhu et al [7] through the study and analysis of the statistical analysis of chemical and hazardous chemical accidents from 2016 to 2020, it was concluded that the number of accidents during this period showed a decreasing trend, with the most accidents occurring in the second quarter, and the majority of accidents involving explosions, poisoning, and asphyxiation.

The production process of chemical and hazardous chemicals is relatively complex, the reaction conditions are very harsh, and there are many types of hazardous chemicals used. The flammable and explosive, toxic and corrosive properties of hazardous chemicals bring great safety hazards to the production of enterprises, and if they are not properly controlled, they can cause significant personal injury and death and huge property losses [8]. Therefore, it is of great significance to study the characteristics and patterns of accidents for the statistics and analysis of chemical and hazardous chemical accidents that occurred in the past, in order to safeguard the lives and properties of the people.

2. Overall situation of chemical and hazardous chemical accidents in China

Chemical production is characterized by flammability, explosiveness, high temperature and high pressure, and the risk of accidents is much higher than that of other industries. According to statistics, in 2016-2021, a total of 1,051 chemical and hazardous chemical accidents occurred in China, resulting in 1,325 deaths, as shown in Figure 1.

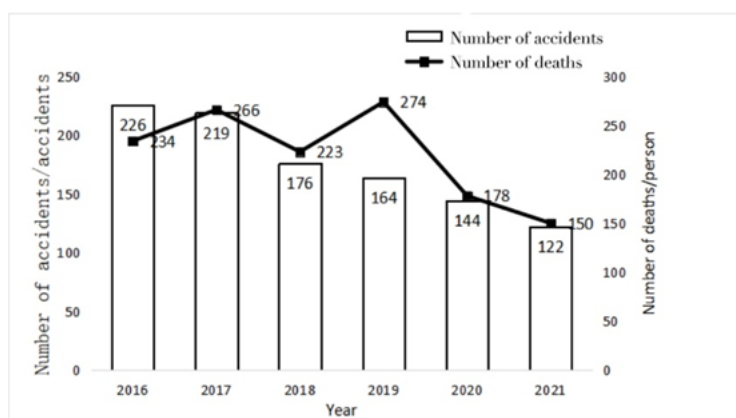


Fig.1 Overall statistics on chemical and hazardous chemical accidents in China, 2016-2021

Specifically, the total number of chemical and hazardous chemical accidents in the country showed a decreasing trend, and compared with the number of accidents in 2016, the number of chemical and hazardous chemical accidents in the country in 2021 decreased by 46.0%, and the number of accidents decreased by an average of 9.2% per year. The number of deaths showed fluctuation from 2016 to 2019, especially on March 21, 2019, when Jiangsu Tianjiaoyi Chemical Company had a particularly major explosion accident, the accident caused 62 deaths, and the number of deaths reached the maximum in this year, and the number of deaths after 2019 showed a downward trend again. The reason for this is that from 2016 to 2020, the country will implement the "13th Five-Year Plan", the state attaches great importance to the work of chemical and hazardous chemical production safety, and in 2021, the country will start to implement the "14th Five-Year Plan", which will pay more attention to the safety of the chemical and hazardous chemical fields. In 2021, the country will start to implement the "14th Five-Year Plan", paying more attention to safety in the field of chemicals and hazardous chemicals.



3. Analysis of chemical and hazardous chemical accidents, 2016-2021

3.1 Time pattern of accidents

(1).Accident month analysis

China's 2016-2021 chemical and hazardous chemicals larger and above accidents occurred 73, resulting in 428 deaths, according to the month of the accident on the number of larger and above accidents and the number of fatalities, as shown in Figure 2.

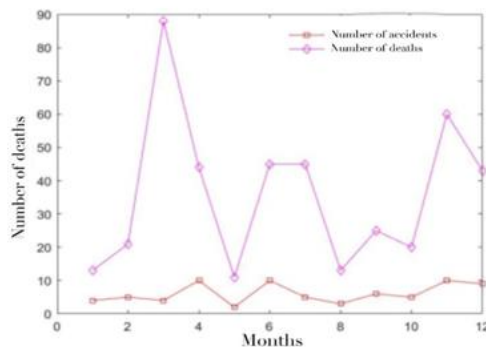


Fig.2 Monthly statistics of larger and above accidents

As can be seen from the chart, the number of accidents and deaths of larger and above accidents in each month show a highly fluctuating state, the highest number of occurrences is in April, June and November, the chemical and hazardous chemical accidents in April and June are more frequent, is due to the fact that at this time in the summer, the weather is hot, the temperature is high, and it is very easy to cause leakage of hazardous chemical and volatilization, which causes hazardous chemical burning and explosion accidents; in November, there are more chemical and hazardous chemical accidents mainly Because it is the end of the year, chemical enterprises production pressure, staff pressure, mood, etc., easy to cause misoperation induced accidents. The number of deaths is obviously higher than the average is March, June, July and November, June is mainly due to a higher number of accidents, March, July, November deaths, more with Jiangsu Tianjiayi "3 • 21" accident, Sichuan Yibin "7 • 12 "accident, Henan Sanmenxia City Yima" 7 • 19 "accident, Hebei Zhangjiakou" 11 • 28 "and other major and major chemical accidents.

(2).Analysis of the time period of the accident

Statistics on the time period of chemical and hazardous chemical accidents of large and above accidents from 2016 to 2021 are shown in Figure 3.

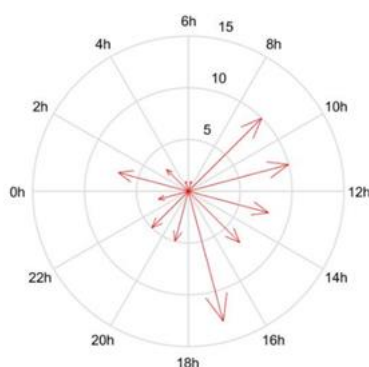


Fig.3 Statistics on the time period of larger and above accidents

As can be seen from the figure, during the day, accidents occur more often in these time periods, in order of 16h-18h, 8h-10h, 10h-12h, 12h-14h; of which 8h-10h, 10h-12h, 16-18h is the peak of the chemical and hazardous chemical accidents occurring in the 8h-10h, the enterprise employees have just started to go to work, has not yet entered the work state completely, and it is easy to Mental inattention, sloppiness and carelessness,



resulting in operational errors in the work; 10h-12h and 16-18h, this time period is in the employees before leaving work, after a few hours of work, energy, physical strength, endurance have been consumed, mental fatigue, and the possibility of misuse of the operation will be elevated. Taking 6h and 18h as the boundary, the time period of a day is divided into two parts, and the number of accidents in 6h-18h is much higher than that in 18h-0h, which is due to the fact that 6h-18h is in the daytime, which is the main time for chemical and hazardous chemicals production, and the temperature during the daytime is generally higher than that at night, and the high temperature can easily lead to the leakage and volatilization of the hazardous chemicals, etc. [9].

3.2 Accident level analysis

Accident grades are categorized into four grades: general, large, major and especially major accidents, and statistics on the number of chemical and hazardous chemical accidents and the number of fatalities according to accident grades from 2016 to 2021 are shown in Figure 4.

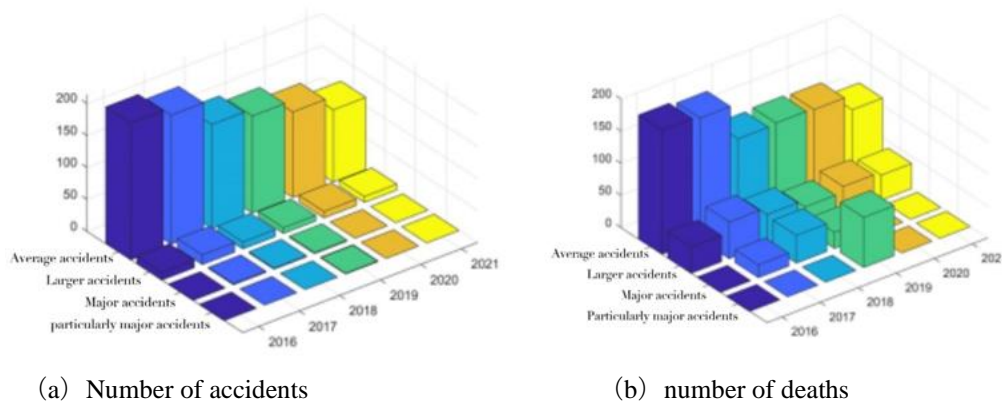


Fig.4 Accident level statistics

In 2016-2021, the general accidents of chemical and hazardous chemicals in China are significantly higher than the larger and above accidents, and the number of general accidents shows a decreasing trend; the number of larger accidents shows a fluctuating state, and the overall situation is relatively stable; from 2016 to 2020, a total of 7 major chemical and hazardous chemical accidents occurred in the country, of which 166 people were killed, compared with the "Twelfth Five-Year Plan" period, the number of accidents increased by 2, and the number of deaths increased by 99, showing a high incidence of serious accidents. 2021, there were no serious accidents, and the number of large chemical and hazardous chemical accidents dropped to single digits, and there have been no serious accidents for more than 30 consecutive months, which creates the longest interval in the period of statistical records.

The number of fatalities in general accidents is roughly proportional to the number of accidents, with the number of fatalities in general accidents showing a downward trend and the number of fatalities in larger accidents showing a fluctuating trend. In terms of the mortality rate of accidents, the mortality rate of overall accidents is 1.3, the mortality rate of general accidents is 0.9, the mortality rate of larger accidents is 4.0, and the mortality rate of major and especially major accidents is 23.7, with heavy and large chemical and hazardous chemicals accidents having a greater impact on the number of fatalities.

3.3. Regional analysis of accidents

Statistics on the distribution of larger and above accidents of chemical and hazardous chemicals in China by region from 2016 to 2021 are shown in Figure 5.



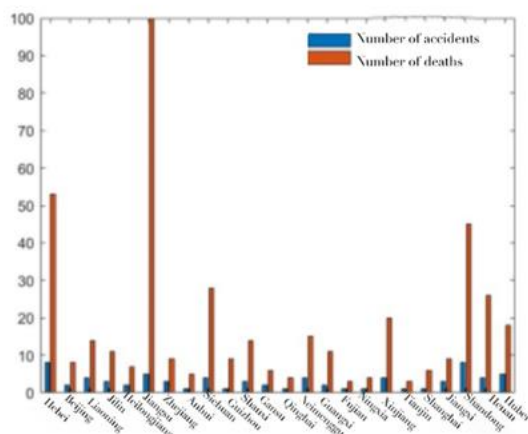
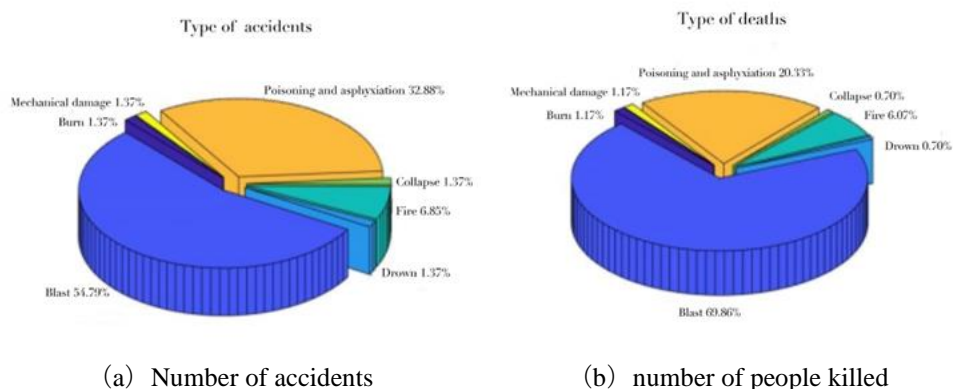


Fig.5 Regional statistics on larger and higher accidents

As can be seen from the figure, Hebei and Shandong have the highest number of accidents, 10, followed by Jiangsu, Hubei and Henan; Jiangsu, Hebei and Shandong have more fatalities. The reason is that, Shandong, Jiangsu and Hebei, these areas, strong economic strength, developed transportation, chemical industry development is very rapid, many industrial parks located in these provinces and nearby, and chemical production process is very complex, involving a wide range of hazardous chemical species, so that the chemical and hazardous chemicals accidents. It can be seen that the occurrence of chemical accidents is closely related to production and business activities, and government departments should strengthen the supervision and monitoring of key chemical provinces.

3.4. Analysis of accident types

Statistics on the types of accidents of large and above accidents of chemical and hazardous chemicals in China from 2016 to 2021 are shown in Figure 6.



(a) Number of accidents

(b) number of people killed

Fig.6 Statistics on the types of larger and above accidents

Among the types of accidents of large size and above in chemical industry and hazardous chemicals, explosion accidents and poisoning and suffocation accidents occur most frequently, accounting for 54.79% and 32.88% of the total number of accidents, and the number of deaths accounts for 69.86% and 20.33% of the total number of accidents, respectively. The high frequency of explosion and poisoning accidents indicates that chemical and hazardous chemical enterprises have deficiencies in safety instrumentation, monitoring and control, and safety management, and that monitoring and prevention of these two types of accidents should be strengthened.

3.5. Analysis of the accidental chain of events

The accidents are statistically analyzed according to the production, use, transportation, storage, operation and waste operation links, and the links of larger and above accidents of chemical and hazardous chemicals in China from 2016 to 2021 are shown in Figure 7.



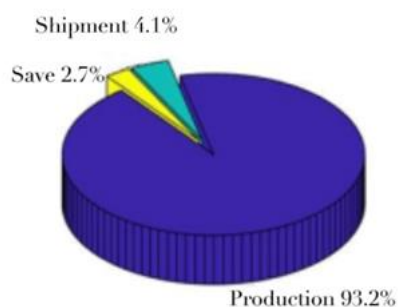


Fig.7 Statistics on the links of larger and above accidents

The highest percentage of the number of accidents of chemical and hazardous chemicals large and above in China in 2016-2021 was in the production link, accounting for 93.2%. The production link requires more complex process technology and strict operating conditions, which also involves a wide variety of hazardous chemicals, and all these factors can lead to chemical and hazardous chemical accidents occurring more often in the production link. In 2019, a particularly serious explosion occurred in the chemical storage tank of Jiangsu Tianjiaoyi Chemical Company, which was caused by the company's illegal storage of nitrification wastes^[10], so for the storage link, it is also need to pay great attention to the risk factors that exist in this link.

The key operation statistics for chemical and hazardous chemical accidents of large and above accidents in 2016-2021 are shown in Figure 8.

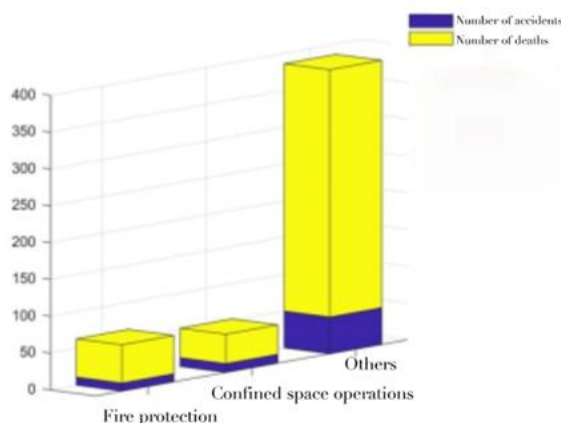


Fig.8 Statistics on the operation chain of larger and above accidents

During the period of 2016-2021, among the 73 accidents of larger grade and above of chemical and hazardous chemicals nationwide, 11 accidents were caused by fire-activated operations, accounting for 15.1% of the accidents of larger grade and above of chemical and hazardous chemicals, resulting in 52 deaths, accounting for 12.2% of the total deaths of accidents of larger grade and above of chemical and hazardous chemicals, with an average of 5 deaths for each accident, which is mainly due to the violation of regulations. The main reason is that illegal fire operation is easy to trigger fire and explosion accidents; 12 accidents were caused by restricted space operation, accounting for 16.4% of the accidents of larger grade and above of chemical and dangerous chemicals, resulting in 40 deaths, accounting for 9.3% of the total deaths of accidents of larger grade and above of chemical and dangerous chemicals, with an average of 3 deaths in each accident, which is mainly related to the failure to follow the procedures to detect and blindly rescue these factors. The main reason is related to the factors of not following the regulations to test and blindly applying rescue. The number of accidents caused by fire and restricted space operations accounted for nearly one-third of the total number of accidents, which needs to be highly emphasized.

3.6. Accident Occurrence Industry Analysis



The chemical industry is divided into four categories: fine chemical industry, basic chemical industry, coal chemical industry and petrochemical industry, and in 2016-2021, China's chemical industry and hazardous chemicals large and above accidents occurred in the industry statistics to get the highest percentage of accidents in the fine chemical industry, which accounted for 45.2%; followed by the basic chemical industry and coal chemical industry, accounting for 24.7% and 17.8% of the total number of accidents, respectively. The reason is that the fine chemical industry is a technology-intensive integrated industry, the production process is long, complex raw materials, unit reaction, and in the intermediate process of the control of the high requirements of the fine chemical application involves a number of fields and multi-disciplinary theoretical knowledge and professional skills, including separation technology, multi-step synthesis, compounding technology, commercialization and processing, which leads to the fine chemical industry is more likely to appear in chemical and hazardous chemical accidents. and hazardous chemical accidents.

4. Countermeasures

Combined with the results of the analysis of the characteristics and patterns of chemical and hazardous chemical accidents in China from 2016 to 2021, countermeasures to prevent and reduce accidents are proposed:

(1). In view of the seasonal characteristics of accidents, strengthen the chemical industry at the end and beginning of the year as well as the summer production safety supervision and management.

(2). According to the regions where accidents occur and the distribution of chemical enterprises and other characteristics, in the high incidence areas of the chemical industry, it is necessary to strengthen the supervision and control of process equipment and production operation, restricted space, flaming and other operations, to promote the governance of chemical safety in accordance with the law, and to soundly improve and implement the responsibility of the enterprise for safety production and the management system.

Optimizing chemical production processes, adopting harmless process technologies and non-toxic substances, improving the level of automated production in enterprises, and strengthening the construction of intrinsic safety levels in enterprises.

5. Conclusions

Through the above research and analysis, the following conclusions can be drawn:

(1) During the period 2016-2021, the total number of chemical and hazardous chemical accidents in China showed a slow downward trend, and the number of deaths in accidents each year, although rebounded in 2019, is still in a declining trend overall; the number of larger and above accidents and deaths are still high, which needs to be further strengthened to reduce the rate of accidents.

(2) Explosion and poisoning and suffocation accidents are the main types of accidents, and the number of accidents and deaths in these two categories account for more than 80% of the total number of accidents and total number of deaths, and should be managed with emphasis.

(3) The hot season and weather are prone to chemical and hazardous chemical accidents. Enterprises should rationalize their production schedules and strengthen on-site supervision, and the government and supervisory authorities should also carry out production inspections for the seasonal season and promptly supervise enterprises to effectively implement work safety.

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