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Information technology of factory maps for chemical emergency preparedness and response in Pathumthani Province, Thailand

เทคโนโลยีสารสนเทศของแผนที่โรงงานอุตสาหกรรมสำหรับการเตรียมความพร้อมและตอบโต้เหตุฉุกเฉินด้านสารเคมีในจังหวัดปทุมธานี

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ABSTRACT: Pathumthani is one of the provinces in Thailand where chemical disaster could possibly occur. Although there are emergency response teams around, they have no sufficient information system to prepare and respond to chemical emergency. This study aims to: 1) survey and create a database of chemical use in all factories in Pathumthani Province 2) classify the factory types and 3) establish the coordinates of each factory on the Google Maps. Three thousand nine hundred and nine factories to be exact (3,909) factories in Pathumthani Province were included in the study. The characteristics of factories were retrieved from the public website of Department of Industrial works and Pathumthani Office of Industry. Data related to chemical information were collected from chemical safety data sheet on public website (www.chemtrack.org). The results showed that the factory type 58(1) has the most category in Pathumthani Province. Based on the analysis of locations of factories in the map of Pathumthani province, it was found that 543 factories showed chemical information with locations, and 2,068 factories had no chemical information but showed their location on the Google Maps, while 1,298 factories cannot be specified. The map of factories in Pathumthani Province should be more completely identified by cooperating with all establishments in the identification of coordinated location of factories. There are various documents that must be reported to the government offices in order to establish accurate factory locations and to improve the map of factories to serve as comprehensive and effective tool for chemical emergency response plan.

Keywords: Workplace; Safety; Emergency; Preparedness; Response

บทคัดย่อ: จังหวัดปทุมธานีเป็นจังหวัดหนึ่งที่อาจเกิดเหตุฉุกเฉินด้านสารเคมี แม้ว่าจังหวัดปทุมธานีจะมีทีมบุคลากรในการตอบโต้เหตุฉุกเฉินอยู่แล้ว แต่ก็ยังขาดระบบฐานข้อมูลที่เหมาะสมในการเตรียมความพร้อมและการตอบโต้เหตุฉุกเฉินด้านสารเคมี งานวิจัยนี้จึงมีวัตถุประสงค์เพื่อ 1) สำรวจและจัดทำฐานข้อมูลสารเคมีที่ใช้ในโรงงานอุตสาหกรรม 2) จำแนกประเภทของโรงงานอุตสาหกรรม และ 3) ระบุพิกัดของโรงงานอุตสาหกรรมทุกแห่งในจังหวัดปทุมธานีบน Google Maps โดยเก็บข้อมูลประเภทของโรงงานอุตสาหกรรมจำนวนทั้งสิ้น 3,909 แห่งจากเว็บไซต์ของกรมโรงงานอุตสาหกรรมและสำนักงานอุตสาหกรรมจังหวัดปทุมธานี และเก็บข้อมูลรายละเอียดของสารเคมีที่เกี่ยวข้องเพิ่มเติมจากฐานข้อมูลความปลอดภัยสารเคมีบนเว็บไซต์ www.chemtrack.org ซึ่งเป็นฐานข้อมูลที่บุคคลทั่วไปสามารถเข้าถึงได้ ผลการวิจัยพบว่าจังหวัดปทุมธานีมีโรงงานอุตสาหกรรมประเภท 58(1) มากที่สุด และพบว่ามีโรงงานอุตสาหกรรมเพียง 543 แห่งที่สามารถระบุข้อมูลสารเคมีและพิกัดที่ตั้งได้อย่างครบถ้วน ในขณะที่อีก 2,068 แห่งระบุได้เฉพาะข้อมูลพิกัดที่ตั้ง นอกจากนี้ ยังพบว่าโรงงานอุตสาหกรรมที่ไม่สามารถระบุได้ทั้งข้อมูลสารเคมีและพิกัดที่ตั้งได้มีมากถึง 1,298 แห่ง ดังนั้น โรงงานอุตสาหกรรมในจังหวัดปทุมธานีจึงมีความจำเป็นต้องแจ้งพิกัดที่ตั้งของตนเองลงในแบบรายงานสารเคมีและเอกสารต่าง ๆ ที่ต้องรายงานต่อหน่วยงานของรัฐ เพื่อให้การจัดทำและปรับปรุงฐานข้อมูลสารเคมีและพิกัดแผนที่เป็นไปได้อย่างสมบูรณ์ และทีมบุคลากรที่เกี่ยวข้องจะได้นำฐานข้อมูลดังกล่าวไปใช้เป็นเครื่องมือในการวางแผนและตอบโต้เหตุฉุกเฉินด้านสารเคมีได้อย่างครอบคลุมและมีประสิทธิภาพต่อไป

คำสำคัญ: สถานที่ทำงาน; ความปลอดภัย; เหตุฉุกเฉิน; การเตรียมความพร้อม; การตอบโต้

1. INTRODUCTION

Chemical accidents such as leakage, explosion and release from a factory is potentially hazardous to humans, animals, and the environment. The severity of the chemical accident depends on the amount of chemical leak, distribution area and the magnitude of the population at risk who suffered sufficient exposure to the released chemical(s) to induce illness or injury.[1] For example, in the evening on 4 August 2020, 2,750 tons of ammonium nitrate that had been stored at Beirut's port for six years without safety measures exploded and it resulted to the death of at least 200 people, inflicted injuries to 6,500 and left some 300,000 homeless.[2-3] The chemical emergency response team had to perform their functions and to help the victims in surrounding area.

Currently, there are regulations and tools being implemented in disaster management. For example, in the United States, factories that use or produce the toxic chemicals must be permitted and required careful handling according to the safety regulations of the Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), Federal Emergency Management Agency (FEMA), and Chemical Safety and Hazard Investigation Board (CSB).[4-6] In case of emergency situations, workers should know what type of evacuation is necessary and what their roles are in carrying out the emergency evacuation plan according to the Emergency Action Plans (OSHA 1910.38) and Exit Routes and Emergency Plan (Appendix Subpart E).[6-8] In the United Kingdom, after disaster occurrence, the emergency response team uses the geographical information systems to combine the census data with the results of dispersion modelling to find the injured, dead and missing people within defined geographical limits.[1]

Thailand has a policy for the safety of all sectors in Thailand 4.0 called “Safety Thailand” which aimed at allowing workers to live safely in both general well-being and in performing their work-related functions without occupational diseases, illnesses, and accidents. As a result, there must be assessments to prevent dangers in both factories and surrounding communities.[9]

Thailand’s Ministry of Industry, Department of Industrial work (2020) had classified the factories into 107 categories[10], but there are 33 categories that use hazardous chemicals in their operations.[11] In Pathumthani Province, there are more than 3,500 factories being classified into 27 categories that use hazardous chemicals[12, 13], and chemical disaster is one of the top five public health emergencies in the local area of Pathumthani Province.[14] In 2019, the statistics of occupational accident and illness report indicated that Pathumthani Province was the one of the top five provinces with the highest rate of occupational accident and illness. The major cause was the use of hazardous chemicals.[15] Not only the workers in the factory but also the populace in surrounding communities was affected by hazardous chemical use in the factories. Previous studies showed that roadside occupations in industrial estate and people who lived near fracking sites had health problems. Some manifested symptoms ranged from respiratory ailments to birth defects. The reasons were attributed to toxic chemical content in the air, which was above national safety standards[16], and biomarker of some hazardous chemical detected in urine among the population at risk.[17] However, because of the different characteristic of chemicals, processes, technology and equipment in each factory, the hazard chemical accidents occur depending on its characteristics.[6] Therefore, if the emergency response teams have no sufficient plan and information system to prepare and respond to chemical emergencies, it will cause damage to live, properties, factories and surrounding communities.

Geographic information system (GIS) is the most common system used to develop a real-time risk analysis tool. It is used to establish the emergency response and risk communication plan for the effective decision-making. Even so, it can only develop the modelling of the chemical distribution of each chemical for each factory such as in the study of Yoo and Choi (2017) that used GIS to analyse the risk of chlorine gas distributed to the community in South Korea.[18] Therefore, Google Map is considered a more useful software to develop the factory mapping for the chemical emergency preparedness and response plan than GIS. In this study, Google Maps shows the location of all factories in Pathumthani Province by using the factory database from the Department of Industrial Works and Pathumthani Office of Industry website. In addition, other details including the name of factory, telephone number, number of workers, location of the factory, factory category and so on[12, 13] are also indicated. This information and features help to create the factory maps of chemical use for emergency preparedness and response plan.

Therefore, this study aimed to survey and create the database of factories in Pathumthani Province including the chemicals being used in the production process. This study further aimed to classify the factory types and establish the locations of these factories on the Google Maps of Pathumthani province. This information technology will reduce the risks of illness, accident sand emergency situations for workers and people in the surrounding communities.

2. METHOD

This survey research reviewed and gathered information about factories in Pathumthani Province. A purposive sampling had arrived at the inclusion of 3,909 factories. The researcher had obtained permission to use the factory data from the Department of Industrial Works and Pathumthani Office of Industry website (public database). Information including name of factory, factory category, address, location, chemical information, telephone number, number of workers were collected by the researchers and six research assistants. The details were collated using the data collection form created in MS office Excel. For fire extinguisher, chemical absorbent and National Fire Protection Association (NFPA 704) symbol, the researchers checked the chemical safety data sheet on public website (www.chemtrack.org). However, all information from the data collected were accessed privately. Only Pathumthani emergency response team has access to this database. For data analysis, descriptive statistics was used to describe the data.

Since this study collected secondary data from all public website and Department of Industrial works, the approval of human research ethics and research consent form were not required.

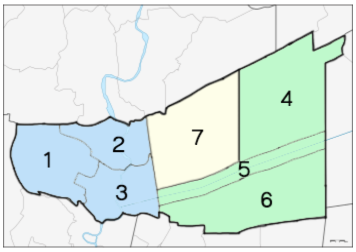
3. RESULTS

The top five industries which are located in Pathumthani Province include: 1) factory type 58(1) - making concrete products, mixing concrete products, gypsum or plaster products (n=208 out of 3,909, 5.32 %), 2) factory type 64(13) - turning, drilling, milling, grinding, or general welding (n=169, 4.32 %), 3) factory type 95(1) - repairing of motor-driven vehicles or components of such vehicles (n=161, 4.12 %), 4) factory type 53(1) - manufacturing tools, furniture, or decorations and spare parts of such products (n=129, 3.30 %) and 5) factory type 37 - factory of furniture or decorations in buildings from wood, glass, rubber or other nonmetal which is not furniture or interior decoration buildings from extruded plastic, and spare parts of such products (n=120, 3.07 %).

The chemicals used in the factories in Pathumthani Province were classified by the Department of Industrial Works of Thailand into 27 categories include: 1) Factory type 6(2), Preservation of aquatic animals by smoked method, add salt, pickled, dried and freeze (n=1), 2) Factory type 7(1), Extraction of oil from plants or animals or fat from animals (n=5), 3) Factory type 14, Factories engaged in the business of making ice or ice cutting (n=30), 4) Factory type 16, Distilled or mixed liquor factory (n=1), 5) Factory type 22(1), Carbonized fermentation, combing, rolling, spinning, twisting, bleaching or dyeing of fibers (n=3), 6) Factory type 22(3), Bleaching, dyeing or finishing of thread or textile (n=3), 7) Factory type 22(4), Textile printing (n=1), 8) Factory type 34(5), Wood preservation or wood drying (n=3), 9) Factory type 36(4), Making a picture frame or glass frame from wood (n=3), 10) Factory type 37, Factory of furniture building or interior decoration from wood, glass, rubber or other nonmetal which is not a furniture or interior decoration of the building from the plastic in the image and the parts of such products (n=109), 11) Factory type 38, one or several pulp or paper production (n=7), 12) Factory type 40(1), Plastering or gluing the paper or cardboard or compressing multiple layers of paper or combine a cardboard (n=7), 13) Factory type 42(2), Storage, separation, selection or packing of hazardous chemicals (n=16), 14) Factory type 43, Factory of fertilizer and one or more pesticides (n=49), 15) Factory type 44, Production of synthetic resin, elastomers, plastics or synthetic fibers which are not fiber (n= 7), 16) Factory type 45, Factory engaged in color-related business, shellac varnish, shellac or any of the products for the use of drugs or other fillings (n=41), 17) Factory type 48(1), Furniture or metal polish, wax or building decoration materials (n=38), 18) Factory type 50(4), Mixing petroleum products or mixing product from petroleum and other materials which are not mixing products from natural gas and other materials (n=45), 19) Factory type 53(7), Shoe making or parts of shoes (n=5), 20) Factory type 64 (10), Making finished metal products with enamelling japanning or lacquering (n=16), 21) Factory type 89, Gas production plant which is not natural gas transportation or gas station (n=1), 22) Factory type 91, Packing goods without any or many production (n=2), 23) Factory type 91(2), Filling of gas which is not a filling of gas as fuel that controlled by fuel law (n=9), 24) Factory type 92, Cold room factory (n= 108), 25) Factory Type 100 (1), Painting, spraying or coating (n=15), 26) Factory Type 100 (2), Spraying or coating with lacquer or other lacquer oil (n=2), and 27) Factory Type 100 (5), Anodizing plating (n=17).

However, there are only 543 factories (13.89 %) that are able to classify the hazardous chemicals based on factory type while 3,376 factories are household industries or small industries such as rice mills that do not have the list of chemicals being used.

Table 1 Data on the location of factories in Pathumthani Province

No.	District	Total of factory	Location		Location error		Location missing		Maps
			Total	Percent	Total	Percent	Total	Percent	
1	Lat Lum Kaew	477	285	59.75	79	16.56	113	23.69	
2	Sam Khok	357	213	59.66	48	13.45	96	26.89	
3	Mueang Pathumthani	487	361	74.13	109	22.38	17	3.49	
4	Nong Suea	92	36	39.13	29	31.52	27	29.35	
5	Thanyaburi	301	146	48.50	89	29.57	66	21.93	
6	Lam Luk Ka	992	736	74.19	256	25.81	0	0.00	
7	Klong Luang	1,203	834	69.33	258	21.44	111	9.23	
	Total	3,909	2,611	66.79	868	22.21	430	11.00	

Based on the analysis of map locations of factories in Pathumthani province, it is evident that 2,611 factories (67.53 %) can specify the locations on Google maps (Table 1). Therefore, only 543 factories (13.89 %) with chemical information, and 2,068 factories (52.90 %) without the chemical information on the Google Maps are shown, while 1,298 factories (33.21 %) cannot be specified. Fig. 1 shows an example of the distribution of factory type 37 in Pathumthani Province that have showed only 79.82% on Google Maps (87 out of 109 factories). However, 22.21 % of the factory location (868 out of 3,909 factories) were found to be erroneous, and the most location errors (31.52%) are found in Nong Suea District (Table 1). Therefore, Google Maps users should consider double checking the exact locations of these factories.

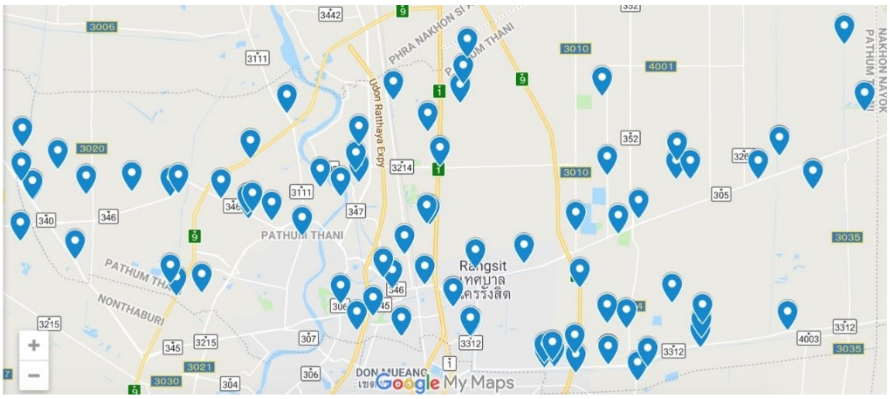


Fig. 1 The distribution of factory type 37 in Pathumthani Province, Thailand

In addition, the details of the factory information were limited based on Google Maps layout. Fig. 2 shows an example of the important information of factory on the Google Maps system including factory name, factory type that can be linked to the hazardous chemical information, address of the factory, hazardous chemical information code, number of employees (separated by gender), telephone number and location.

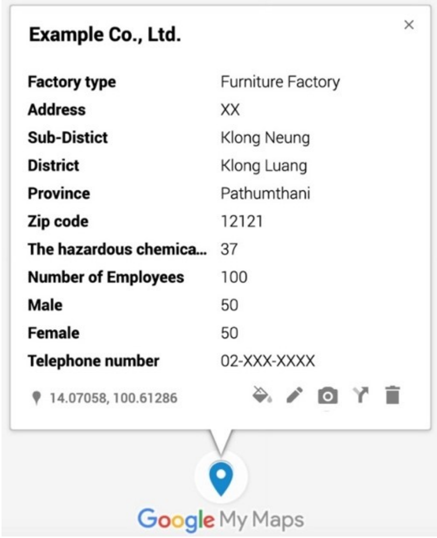


Fig. 2 An example of the important information that showed on the Google Maps system.

4. DISCUSSION

The list of hazardous chemicals used in each factory can be used to predict the chemical accident risk. The occurrence of chemical accident, especially in chemical industries, is an important information to determine the existence of actual risks in each factory.[6] However, the hazardous chemical accident risk reduction is difficult to implement because there are limitations for the hazardous chemicals data management. The summary by Wood and Fabbri (2019) is as follows[6]:

• There are many hazardous sources due to different industries, substances, processes and equipment. The data collection of those may be erroneous.

• There are many variables that can influence chemical accident risk. The actual risk levels may fluctuate significantly over time.

• The data of high severity chemical accidents can greatly underestimate actual risk because the high severity chemical accidents have a low frequency.

• It is difficult to make a complete image of the chemical accident risk because the sources of chemical accident risk distributed over geographic areas and there are many industries.

• The chemical accident in the factory is a private information. The government cannot get access.

• It is difficult to collect and quantify the loss data following an accident because this data belongs to many stakeholders.

Based on the facts that Pathumthani Province has the top five industries, it implies that no factory is not using hazardous chemicals in their processes. However, when we focused on 27 categories of factory type, the top five industries in Pathumthani province were factory type 37 (n=109), factory type 92 (n= 108), factory type 43 (n=49), factory type 50(4) (n=45) and factory type 45 (n=41), respectively. Therefore, there were many hazardous chemicals being used in whatever process is done in these factories. The fire extinguishers should be strategically provided for each chemical use. For example, in case of an emergency response, the appropriate extinguisher for the fire caused by ammonia solution is water spray[19], but water isn't suitable to extinguish the fire caused by nitrocellulose[20]. The chemical emergency response teams should be trained and educated not only about the suitable fire extinguishing agent, but also about the absorbent material in case of chemical spills and the personal protective equipment for the chemical emergency response because different chemicals mean differences in both physical and chemical properties. [19, 20]

From the results of this study, there are three groups of the factories that needed an update of their data pertaining to the hazardous chemicals use in each factory type and an update on their factory locations for the effective chemical emergency preparedness and response plan. These include;

- 3,366 household industries or small industries where no list of hazardous chemicals in their process were found,
- 430 factories where locations were not found and,
- The locations of 868 factories with erroneous mapping of the factory database.

If these aforementioned groups of factories do not update their data, this map cannot be effectively used for chemical emergency preparedness and responses. For example, In the U.S., they also have the Mapping Chemical Risks and chemical emergency response plan, but many factories did not report about their hazardous chemical uses to the U.S. Environmental Protection Agency's (EPA) Risk Management Program (RMP) because their hazardous chemicals fell below the volume reporting threshold.[21] This indicated that the chemical emergency response plan cannot be effective to prevent and respond to the chemical emergency case. Therefore, the three groups of factories above should report the list of all chemicals they use in their process and send it with their factory locations. Both the researchers of this study and other related chemical emergency response team can update the data in maps of factories in Pathumthani Province database for more effective chemical emergency preparedness and response. Mitra et al. (2003) suggested that not only the organization-based chemical emergency response team, but also the community-based should be enjoined in these chemical emergency response teams[22]. In brief, the residents who live around the factories should have substantial knowledge of factory locations and chemical use. They should also be able to identify the symptoms and perceive odors and fumes of the chemicals. For example, hydrogen sulfide can be detected by its rotten egg-like smell. The empowerment of communities will aid in the effectiveness of chemical emergency response plan, in gathering health symptom evidences and evacuation aspect.[21] This recommendation is supported by Cullinan (2002) who suggested that the chemical emergency response team should consist not only of medical staff, toxicologists and environmental health experts, public health specialists from the government but also local community representatives.[1] Since the details of the factory's information were limited by Google Maps layout, the researchers then selected only the important data to be shown. All map users should use it when mapping manually and use it with care.

The maps of factories in Pathumthani Province should be more thorough if cooperation with all establishments and the identification of coordinates location of industrial factories are conducted. Moreover, various documents should be submitted to the government offices in order to have accurate factory location and to improve the maps of factory. These lead to a more comprehensive and effective tool in chemical emergency response plan.

In addition, if there are established representatives from the committee of organizations such as Department of Industrial Works, Pathumthani Labor Protection and Welfare Office and Pathumthani Provincial Disaster Prevention and Mitigation, resident representatives from surrounding communities and other related organization, their role and involvement are useful in the development of factories database system and set a policy of chemical emergency response plan. The update and development of the database system will be continually improved and the chemical emergency response plan will be effective and sustainable. This study provides information that benefits Pathumthani Province not only as a pilot province in the preparation of programs or systems for emergency surveillance, especially the chemical emergency surveillance system in the factory, but also serves the Safety Thailand policy in Thailand 4.0 strategy.

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