ISEIS-Environmental Informatics

Environmental risk management with the aid of city emergency response system in Nanning City

Y.S. Pei*, K.J. Zhang, X.G. Liu

The Key Laboratory of Water and Sediment Sciences, Ministry of Education, School of Environment, Beijing Normal University, Beijing 100875, P.R. China

Abstract

Environmental risk management (ERM) is updated on the city emergency response system (CERC) in Nanning City, China. The technical routine developed better support effective urban ERM in the Nanning CERC. Started from identification of risk sources, programs of sources monitoring, risk prediction and early warning, treatment and disposal, and management with update were discussed. Furthermore, environmental risks posed by the China-ASEAN (Association of Southeast Asian Nations) Expo, an international trade fair were evaluated. The inverse searching technique was used to identify the hazardous sources that can cause risks at the Expo. The paradigm of ERA facilitates investigating the connections between hazard sources and adverse effects for people involved in the Expo. Sensitivity amongst people involved during the Expo was determined according to human oriented characteristics. Temporal and spatial sensitivities of the Expo related to the environmental risks were defined. The developed methodology has successfully safeguarded the China-ASEAN Expo from 2004 to 2008. This work highlights major steps in the procedure for update on the CERC with ERM, which provides a demonstration case for integrating urban emergency response and environmental management with functional enhancement.

© 2010 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.

Keywords: Emergency; Sensitive object; Risk sources; Early warning; Implementation

1. Introduction

City emergency management is increasingly important to safety of urban residents and development of modern city. Countermeasures against the city crisis have been widely addressed [1]. Due to populations being vulnerable to hazards, emergency response is not solely dependent upon proximity to the source of the threat or the physical nature of the hazard-social factors also [2]. Attention to the temporal and spatial risks benefits handling the
emergency and further the subsequent process of recovery [3]. Analysis of major factors that affect the city public emergency management provides scientific basis for public security [4].

More and more cities in the world have constructed city emergency management systems. These systems are continuously updated with renewal components and enhanced functions for responding to varied potential risks, e.g. bioterrorism [5]. The New York City has operated a syndromic surveillance system based on emergency department chief-complaint data since November 2001 [6]. A multi-data source surveillance system was used to detect a bioterrorism attack during the G8 Summit in Scotland [7].

Environmental risk presents the likelihood of injury, disease, or death resulting from human exposure to a potential environmental hazard. Without sufficient control and mitigation of chemical reaction hazards, reactive incidents have led to severe consequences, such as release of flammable and toxic materials, and threats to human lives, properties, and the environment [8]. It is possible to establish a common basis for the different perspectives, by looking at environment risk as the full spectrum of the dimensions with possible consequences and associated uncertainties [9]. Environmental risk is a crucial issue within urban risk; however, there are few literatures have addressed environmental risk management coupled with integrated urban emergency system.

This work addressed environmental risk management (ERM) with emphasis of update on city emergency response system (CERC) in Nanning City, China. A technical routine was developed to meet requirement of urban ERM and further update on the Nanning CERC. Starred from identification of risk sources, programs of sources monitoring, risk prediction and early warning, treatment and disposal, and management with update were discussed. This work tried to highlight major steps in the procedure of update on the CERC with ERM, and to evaluate the potential environmental risk in the China-ASEAN Expo caused by environmental pollutions. As the high sensitivity of people involved in this Expo, temporal and spatial sensitivities with respect to the environmental risk were investigated by the methods of classification and gradation. This work provides an actual case for integrating urban emergency response and environmental management with functional richness.

2. Materials and Methods

2.1. Background

China's first CERC has constructed in Nanning City on Nov. 11, 2003. The system exemplified the breakthrough in city emergency response management (Fig. 1). The Nanning CERC enables the sharing of information and communication networks. As a result, the infrastructure greatly improves the efficiency of existing facilities for emergency services and, in the mean time, accelerates the responding process during emergencies. In addition, the CERC also enables a better protection and services to citizens of Nanning and helps the city make important progress in building a well-managed metropolitan city.

By analyzing the incoming information flow, computer aided dispatcher enables the operator to quickly coordinate and deploy emergency services according to predefined processes. Furthermore, the improved Geographic Information System (GIS) has been integrated into Nanning CERC, providing computer aided dispatcher with location information featuring interactive digital map and event tracking, which makes it much easier for fast and efficient decision-making in emergency. Nanning CERC is regarded as one of the most successful CERC projects in China, providing excellent emergency services to Nanning citizens and mega events such as the China-ASEAN Expo.

As one of the most successfully implemented CERC projects in the country, Nanning CERC has been providing highly convenient and efficient emergency services to its residents. By integrating 110 police, 119 fire, 120 medical, 122 traffic services and 12345 mayor hotline, Nanning CERC has greatly improved emergency services with unified dispatching management across different department and region. There is a requirement of update on the CERC with ERM to enhance functions of the CERC and to respond unexpected environmental pollution accidents.
2.2. Technical routine

The study aimed at both development of urban ERM and update on the CERC. A technical routine was proposed and carried out (Fig. 2). Risk sources in the center of the routine, which bring about natural or man-made pollution accidents, may result in potential environmental risks. Around the sources, accidents and risks, four aspects of researches and development serve the ERM and renovate the CERC, including sources identifying and monitoring, risks forecasting and early warning, accidents treatment and disposal, and ERM with update in the CERC.

Identifying and monitoring pollution sources were at first based on either analysis of existing sources or investigation of undocumented sources in the city. Different-type sources were identified to the chemical, biological and radial with consideration of the media, such as water and air, through which pollutants may disseminate. Main sources were monitored by automatic inspecting equipments as well regular sampling analysis. Secondly, forecasting and early warning mechanisms were developed to predict risks with respect to temporal and spatial dimensions. Response mechanisms was outlined according to different grades of the risks with color indication such as green, blue, yellow, orange and red, from the lowest to the highest. Thirdly, treatment and disposal programs were worked out for imaginable accidents, in particular attention on organized procedure instead of the concrete treatment technologies. In final, comprehensive management was highlighted in reference to update on the CERC with ERM. The effectiveness of ERM was eminently improved due to full utility of the CERC functions.
3. Results and discussion

3.1. Identification and monitoring of risk sources

Nanning is exposed to many hazards, which have the potential for disrupting the community, causing damage and creating casualties. As a major chemical manufacturing and distribution center, Nanning also faces the threat of hazardous material accidents involving the transportation, manufacture and storage of chemicals on the highways and in the city's industrial areas. Statistics and analysis of pollution sources were carried out based on the data recorded in the local environment authority before January 2007. Investigation of risk sources in the city focus on the undocumented, which was carried from March to December in 2007. Distribution of main risk sources is shown in Fig. 3.

Chemicals generally exhibit their effects rapidly. Some have delayed effects that may not become apparent for several minutes to hours after exposure. This can lead to increased exposure and injury to victims who are not aware that they are being seriously affected by their inadvertent failure to rapidly exit the hazard area or decontaminate themselves. Nanning has 80 chemical enterprises of scale that produce over 1100 chemical agents as products and intermediates. Hazardous chemical agents in 14 enterprises are monitored by automatic equipments and those in 27 enterprises are regularly sampled to analyze.

Toxins are poisonous chemicals released by biological organisms. They may have a delayed effect of several hours to days. Toxins are generally very deadly, although some might only result in severe illness with subsequent recovery several days later. Pathogens can have a very wide range of effects and mortality. Generally, they must be inhaled or ingested and then incubate in the victim for several days before the first symptoms are observed. Forty three hospitals and research organizations may release harmful microbe to environment, where 6 hospitals are monitored for accidents prevention and 5 research organizations are asked to claim application status month by month.

Exposure of radiation by the inhalation pathway occurs radioactive materials entering into the lungs. Alpha and beta emitting radionuclides are of most concern for ingested radioactive materials. They release large amounts of energy directly to tissue, causing DNA and other cell damage. Direct or external exposure from radioactive material can be slowed by dense material and can be stopped if the material is thick enough. Nanning has totally 54 idle
radial sources, among which 39 sources were disposed and 15 sources that can not be disposed in time are under close inspection.

3.2. Forecasting and early warning of risks

To handle risks, it is essential to determine mechanisms of forecasting and early warning with respect to temporal and spatial dimensions. By use of color indication, a response mechanism was outlined according to different grades of the risks. Risks were divided into five grades indicated by green, blue, yellow, orange and red alarms, from the lowest to the highest (Fig. 4). For different graded risks, the corresponding measures consist of variable early warning and preparation. Basically, for lower grade risks such as the “Green” and “Blue”, response measures aimed at early preparation while for higher risks such as the “Yellow”, “Orange” and “Red”, response measures focus on limiting and prevention.

For the lower risks, responses to “Green” alarm on one hand include to refine and prepare appropriate preplanned protective measures; to ensure proper training of the citizen to face the risk; and to regularize process and measures to reply challenge with careful assessment of vulnerabilities. On the other hand, responses to “Blue” alarm need to check communications with designated emergency response or command locations; to review and update emergency response procedures; and to provide the public with any information that would strengthen its ability to act appropriately.

![Fig. 4. Early warning and preparation by grading forecasting](image)

For the higher risks, responses to “Yellow” alarm firstly need to increase inspection of critical locations; to coordinate emergency plans as appropriate with nearby jurisdictions; to assess whether the precise characteristics of the threat require the further refinement of preplanned measures; and to implement contingency and emergency response plans. Moreover, responses to “Orange” alarm enter to coordinate necessary security efforts with government agencies; to take additional precautions at public events and possibly considering cancellation; to
prepare to execute contingency procedures such as moving to an alternate site; and to restrict threatened facility access to essential personnel only. In final, responses to “Red” alarm need to increase or redirect personnel to address critical emergency needs; to assign emergency response personnel and pre-positioning and mobilizing specially trained teams or resources; to monitor, redirect, or constrain transportation systems; and to close public and government facilities.

3.3. Update on the CERC with ERM

Update on the CERC with ERM aims at effective response and management of environmental pollution accidents and provides strengthened ERM for risks. Before imbedding ERM in the CERC, logic database was constructed to include pollution sources, environmental risks and response measures inside (Fig. 5). The database is maintained routinely by special technique staff, supported from the local environment protection authority and pollution sources monitoring departments. Program of decision making consists of sources monitoring, risk forecasting and response grading, which is renovated with close inspection on the changed situation and optimized with technical advances.

After careful organization of ERM, it is appended to the CERC for improve ERM functions. In view of command system of the CERC, all risk sources are labeled in the city map with precise position determination through inner techniques of geographic information system. Analysis is feasible by way of logic algorithms with consideration of the temporal and spatial dimensions. Pre-established models could serve judgment and simulation of the made decisions to fit analysis and results. Coordination of different units in ERM is running in the buildup network. Furthermore, unique commanding may be feasible to coordinate different facilities with unanimous action, based on the work platform supported by both software and hardware. Information before and after an action can be a feedback obtained from response processes and management outcome.

3.4. Environmental risk assessment

The potential environmental risks were evaluated with consideration of the temporal and spatial dimensions as well as integrating qualitative and quantitative information. The inverse searching techniques was used to identify the hazard sources that will cause risks at the Expo Center such that measures can be taken to reduce the risk to an acceptable level. The paradigm of the ERA facilitates investigating the connections between the Expo Center and hazard sources. The area that can be affected by hazardous sources is denoted as a shooting area. Fuzzy evaluation was then implemented to determine whether the sensitive area and the attendants may suffer from these hazardous sources. Information associated with hazardous sources was used to determine the probability of accidents.
Fig. 6 illustrates the risk distribution from high poisonous nitrobenzol leakage in the second sensitive area. Risk indices with values varying from 0 to 10 were defined. From this figure, we observe that the Center of the Expo holds the highest environmental risk with index of 9.0 due to higher people intensity under the same exposure. Risk changes along with time variation is significant than that with spatial variation. The map derived from the inverse searching technique facilitates informed decision making.

![Fig. 6. Environmental risk evaluation of nitrobenzol leakage in the second sensitive area.](image)

4. Conclusions

Environmental risk management (ERM) is updated on the city emergency response system (CERC) in Nanning City, China. The technical routine developed better support effective urban ERM in the Nanning CERC. Started from identification of risk sources, programs of sources monitoring, risk prediction and early warning, treatment and disposal, and management with update were discussed. Furthermore, environmental risks posed by the China-ASEAN (Association of Southeast Asian Nations) Expo, an international trade fair were evaluated. The inverse searching technique was used to identify the hazardous sources that can cause risks at the Expo. The paradigm of ERA facilitates investigating the connections between hazard sources and adverse effects for people involved in the Expo. Sensitivity amongst people involved during the Expo was determined according to human oriented characteristics. Temporal and spatial sensitivities of the Expo related to the environmental risks were defined. The developed methodology has successfully safeguarded the China-ASEAN Expo from 2004 to 2008. This work highlights major steps in the procedure for update on the CERC with ERM, which provides a demonstration case for integrating urban emergency response and environmental management with functional enhancement.

Acknowledgements

This research funds by the Chinese Ministry of Science and Technology under Research Grant SQ2008AA06XK1481270.

References
[1] Varney SM, Hirshon JM. Update on public health surveillance in emergency departments. *Emerg. Medi. Clinics North Am.* 2006; 24(4):1035-1043.

[2] Cutter SL, Mitchell JT, Scott MS. Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina. *Ann. Assoc. Am. Geog.* 2000; 90(4):713-737.

[3] Xiong GQ, Yan XJ. Research on the synthetic evaluation indicators system of city public department emergency management capability. *Proc. 2007 Inter. Conf. Manag. Sci. Engineer.* 2007; 1-3:2499-2504.

[4] Williams G, Batho S, Russell L. Responding to urban crisis - The emergency planning response to the bombing of Manchester city centre. *Cities* 2000; 17(4):293-304.

[5] Zhao LD, Sun L. Emergency service modes of supply chains with replenishment sources. *5th Inter. Conf. Serv. Sys. Ser. Manag.* 2008; 1-2:140-146.

[6] Steiner-Sichel J, Greenko J, Heffernan R, Layton M, Weiss D. Field investigations of emergency department syndromic surveillance signals--New York City. *MMWR Morb. Mortal Wkly Rep* 2004; 53(Suppl):184-189.

[7] Meyer N, McMenamin J, Robertson C, Donaghy M, Allardice G, Cooper D. A multi-data source surveillance system to detect a bioterrorism attack during the G8 Summit in Scotland. *Epidem. Infect.* 2008; 136(7):876-885.

[8] Wei CY, Rogers WJ, Mannan MS. Layer of protection analysis for reactive chemical risk assessment. *J. Hazard. Mate.* 2008; 159(1):19-24.

[9] Aven T, Kristensen V. Perspectives on risk: review and discussion of the basis for establishing a unified and holistic approach. *Reliah. Engineer. Sys. Safety* 2005; 90(1):1-14.