Case study on emergency disposal of aniline pollution in Zhanghe River

Chen Sili, Feng Lishi, Pan Chaoyi, Chen Dinghao, Guo Qingwei, Chang Sha*, Wang Ji*
(South China Institute of Environmental Science, MEE, Guangzhou 510655, China)
* Corresponding author: changsha@scies.org, wangji@scies.org

Abstract: In view of the frequent occurrence of secondary environmental pollution caused by safety production accidents in China, a typical case of Zhanghe aniline pollution emergencies is selected and a comprehensive and systematic introduction to the emergency disposal technical scheme of this event is introduced, including the emergency target and general idea, situation prediction, response measures and summary of emergency disposal, which can be used for reference for the same type of emergency disposal technology for environmental emergencies in the future.

1. Introduction
Environmental emergencies occur frequently in China, and its high-incidence situation has not been fundamentally contained. According to incomplete statistics, a total of 2,363 environmental emergencies occurred nationwide during 2012-2016, more than 300 occur every year in recent years [1]. Environmental emergencies was caused by production safety accident, traffic transportation accident, enterprise emissions, nature disasters, and other factors [2]. During 2015~2017, the average environmental emergencies are more than 300 each year, more than 40% accident are caused by production safety accident, which is the main factor [1].

The team belongs to the Emergency Response Center – the only emergency-oriented secondary organization under the MEP, is specializing in emergency response to environmental emergencies and other related issues. the team had handled more than 10 cases of emergency environmental incidents caused by production safety accident from 2012 to 2017 which were appointed by MEP. This paper introduced the disposal process of aniline leakage pollution incident caused by the rupture of conveying hose in Shanxi Tianji Coal chemical industry group, which was handled by the team in 2013. This emergency environmental incident was a secondary production safety accident and was successfully handled with the technical implementation scheme made by the team. Now the implementation scheme of emergency disposal technology for emergency environmental incidents with aniline exceeding is introduced and summarized as follows.

2. Case Background
At 7:40 on December 31, 2012, the aniline leakage pollution incident caused by the rupture of conveying hose was found in Shanxi Tianji Coal Chemical Group Co., Ltd., which was located in Lucheng city. On the evening of January 4, 2013, the Handan city launched the contingency plan due to the occurrence of dead fish in the Zhuozhang River of Shanxi Province. The monitoring results showed
that the concentrations of the volatile phenol, aniline and ammonia nitrogen were all out of standards. The pollutants had already entered into the Yuecheng Reservoir and Dongwushi Reservoir of Hebei Province and had threatened the water supply safety of Handan city. On the afternoon of January 5, Shanxi Province reported that 38.68 tons of aniline had been leaked, of which about 8.76 tons had entered into the Zhuozhang River along the sewage pipeline. Some of the water had flow into Henan Province through the Red Flag Canal and had threatened to the water supply safety of Anyang city, Henan Province. On January 5, Handan municipal government decided to change the water supply from the Yuecheng Reservoir to the Yangjiaopu groundwater sources and caused water shutdown in some areas. On January 6, 2013, one day after the incident, appointed by the MEP, experts from the South China Institute of Environmental Sciences served as the team leader of the environmental expert group of the emergency, and lead the key members of the Environmental Emergency Center of the South China Institute of Environmental Sciences (SCIES) to the scene to undertake the main emergency response work for the environmental incident.

3. Emergency Target and Overall Thought

3.1 Emergency Target
Minimizing the degree and scope of pollution to the most extent to make sure no one drink excessive water. Ensuring Handan and other cities can return normal water supply and secure social stability. Minimizing the risk of the incident to human health, ecological environment and social disturbance.

3.2 Overall Thought of Emergency Response
To take all measures that can be taken to block up the polluted water mass into the nearby non-water sources, cutting off all the possible sources of pollution on the land, to accurate monitoring and forecasting the development of pollution incidents, Creating conditions for implementing drug addition in river channel, Reducing pollution load of river water phase, to reduce and eliminate pollution degree of water source area with reasonable dispatching; at the same time, to start up the emergency operation of waterworks and rural water quality assurance measures to ensure Handan, Anyang and other cities to reach the water supply standard, To coordinate various emergency measures and optimize the overall plan, to guide public opinion correctly and minimize the social impact of the accident.

3.3 Cause of Incident
At 8:00 on December 30, 2012, the operators in the storage and transportation workshop of Fangyuan Company of Shanxi Tianji Group started to transport aniline from V602A tank to V602B tank. According to the working procedure, the workers should open the automatic valve and the manual valve at the same time, however, due to negligence only the automatic valve was opened and no one checked whether the pipeline was unobstructed, the operators also didn’t check and deal with the long-term abnormality of liquid level of storage tank and the pressure of pump outlet. In fact, the valve at the root of V602B tank was closed all the time. Under normal operating pressure, the conveyor hose bursts and leaks quietly, but nobody knewed until 7:35 am on December 31, 2012, Ren Yongjie, the deputy manager of fangyuan company of tianji group, found that the liquid level of aniline storage tank in the central control detection record of total duty didn’t change, only then the leak was found. From 8 am on 30th to 8 am on 31st, during the leaked 24 hours, according to the investigation and calculation by the experts of the MEP, the total amount of aniline leakage in the raw material and finished product tank areas of Tianji Coal Chemical Industry Group was 319.87 tons; 134.29 tons flowed out of the factory, of which 8.76 tons flowed into the Zhuozhang River.

3.4 General Situation of Basin
The Zhanghe River is a tributary of the Wei River in the Haihe River Basin, which is originated from the southeast mountains of Shanxi Province. It has two sources: the Qingzhang River and the
Zhuozhang River and the two sources are called the Zhanghe River after they converge in the Hezhang Village on the southwestern border of Hebei Province. The Zhanghe River flows eastward to Guantao and merges into the Wei River. It has a total length of 466 kilometers (to Nantao) and a drainage area of 18,200 square kilometers[3].

From 1960 to 1969, the Red Flag Canal water conservancy project was built in Linxian county (today's Linzhou City) on the upper reaches of the river to divert the Zhuozhang River. There are the Yuefeng Reservoir with a reservoir capacity of 1.29 billion cubic metres and the Dongwushi Reservoir with a reservoir capacity of 100 million cubic metres in the Zhanghe River Basin of Hebei Province. At the time of the incident, the actual water storage capacity of the two reservoirs was 220 million cubic meters and 0.6 billion cubic meters, respectively[4].

According to the information provided by the hydrological department, when the incident occurred, the flow of the Zhuozhang River into the section of Hebei Province was about 8 cubic meters per second, of which the Red Flag Canal diverts 4 cubic meters per second and the flow of the Qingzhang River into the section of Hebei Province was about 6 cubic meters per second. After the confluence, the flow of the Zhanghe River reached 10 cubic meters per second, most of which enter into the Dongwushi Reservoir through the Yuefeng Canal. From January 6, 2013, it directly entered into the Zhanghe River downstream of the Yuefeng Reservoir through the Xiaoyuefeng Canal. But according to the environmental monitoring data, the water flow and polluted water masses were detected in the intake section of the Yuefeng Reservoir and the Dongwushi Reservoir.

![Flow Map of the Zhanghe River Basin](image)

4. Situation Prediction

At 21 o’clock on the 7th, the concentrations of volatile phenol and aniline in the section of Baishan Bridge exceeded the standard by 67 times and 49 times (0.338 mg/L and 5.04 mg/L, respectively); No volatile phenol and aniline were detected at the outlet of Yuecheng Reservoir and the concentrations of volatile phenol and aniline at the entrance of Dongwushi Reservoir exceeded the standard by 4 times (0.023 mg/L and 0.47 mg/L, respectively). On January 8th, the unpolluted water of the Qingzhang River had been diverted to the Dongwushi Reservoir via the Dayuelfeng Canal. The polluted water which had entered into the river channel between the interception dam of Haileshan hydropower station and the Yuecheng Reservoir length up to 33 kilometers were already frozen; The polluted water mass (about 5m³/s) entering the Zhanghe river was intercepted by the Dam of Haileshan Hydropower Station, then it was diverted to Nanshengang by the Xiaooyuefeng Canal and bypassed the Yuecheng Reservoir through the Xiangshui River to the lower reaches of the Zhanghe River.

5. Emergency Response Measures

5.1 Basic Ideas

In view of the residual and subsequent discharge of polluted water masses in the upper, middle and lower reaches of Hebei Province of the Zhanghe River Basin, by the construction of activated carbon dam and other engineering measures, the low temperature conditions was made full use to block, stagnate and freeze the polluted water masses in the nearby non-water source areas of the basin.
On the basis of the reduction of activated carbon adsorption, the effective degradation of aniline and phenol can be achieved by the natural degradation of falling aeration, microorganism and photodegradation, and the risk of pollutants entering the drinking water source and the lower reaches of the Zhanghe River can be eliminated.

5.2 Basic Principles
(1) Strictly sealing to prevent the polluted water mass undercurrent into the Yuecheng and Dongwushi Reservoirs; Impervious plugging was carried out for the iced polluted water masses from the Interception Dam of Haileshan Hydropower Station to the Yuecheng Reservoir and from Nanshengang of the Xiaoyuefeng Canal to the Dongwushi Reservoir.

(2) Full controlling of the polluted water masses came from the Xiaoyuefeng Canal to the lower reaches of the Zhanghe River through the Xiangshui River; Multi-level interception and decontamination works were carried out in the Zhanghe River channel downstream of the Yuecheng Reservoir Dam.

(3) Combination of near and far and step-by-step for pollution controlling: Closely monitoring of all the river channels which the polluted water masses passed, and necessary rehabilitation and cleaning engineering measures would be taken to deal with the polluted water masses as appropriate after the emergency incident.

5.3 Project Plan

5.3.1 Sewage interception of river channel into reservoir
The sewage interception dam was built at the river channel into the reservoir. And the activated carbon dam is used to absorb the pollutants entering the reservoir by undercurrent and seepage.

5.3.2 Artificial diversion storage
The polluted water masses in the Zhuozhang River acrossed the Yuecheng Reservoir through the Xiaoyuefeng Canal of the Zhanghe River and directly diverted into the dried-up channels and low-lying areas of the Zhanghe River in the lower reaches of dams (No crops, away from residential areas, not easily leaking underground), these areas were used as temporary storage areas and sewage treatment areas.

According to the water quantity data detected by the Local authorities, after the diversion of the Qingzhang River and Zhuozhang River, the water discharge of the Zhuozhang River through the Zhanghe River was 345,600 tons per day (4m3/s). The length of river channel between the Yuecheng Reservoir and the Wei River was about 110 kilometers, in the 10 kilometers channel segment between the entrance of the Xiangshui River into the Zhanghe River to the New Zhanghe Bridge, multi-level dam was built to hold up the polluted water. The width of the river was 200 meters and the average depth of multilevel intercepting dam maintained at 1 meters, which can store 2 million cubic polluted water. Therefore, the whole temporary treatment project can receive at least about 6 days of polluted water, which basically guaranteeing the storage of upstream polluted mass (zone) water.

5.3.3 Subsequent enhanced purification scheme of polluted water masses
Both the aniline and phenol are biodegradable organic compounds, the concentration of pollutants in the water was already low (aniline had dropped to 0.6-0.7mg/L), and combined with the self-possessed biological purification function of the Zhanghe River channel areas and the low-lying area, the combination treatment method of "artificial enhancement + natural restoration" was chose to treat the polluted water. Namely: (1) In the 110 kilometers river channel downstream of the Yuecheng Reservoir, the 10 kilometers river channel between the entrance of the Xiangshui River into the Zhanghe River to the New Zhanghe Bridge was chose to built multi-level activate carbon adsorption dam to artificially enhance the pollutant reduction effect by falling water aeration and activated carbon adsorption. At the same time, the natural attenuation effect of aniline and phenol was enhanced by
increasing the residence time of polluted water. (2) The natural remediation function of the downstream 100 kilometers river channel is used to further reduce the content of aniline and phenol in the polluted water, thereby basically eliminating the impact on the downstream reaches of the Wei River.

![Schematic diagram of project layout](image)

**Figure 2. Schematic diagram of project layout**

6. Summary

A scientific plan was drawn up at the first time after the leakage of aniline in the Zhanghe River happened. During the emergency disposal process, by the improvement of monitoring location, analyze the dynamic change trend quickly and accurately after various emergency disposal measures were adopted and guided the implementation of engineering pollution reduction measures. Successfully eliminate the risk of pollutants entering drinking water sources and polluting the lower reaches of Zhanghe River and ensure the safety of drinking water for the masses. The team had provided comprehensive technical support for this emergency response, which was highly appraised by leaders at the ministries, provinces and municipalities at all levels.

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