Research on Port Ship Pollution Prevention and Control System Based on the Background of Marine Environmental Protection

Jie Hui *
Jiangsu Maritime Institute, Nanjing 211100, China

*Corresponding author e-mail: 20090946@jmi.edu.cn

Abstract. In the context of marine environmental protection and ecological protection, the article discusses the operating conditions of ship’s main pollution prevention equipment such as marine sewage discharge, oil-water separators and other equipment and the disadvantages of difficult monitoring of ship exhaust emissions. This paper designs an ocean-going ship based on Beidou Integrated pollution prevention and monitoring system for environmental protection vessels and ports. The system can continuously send information on the operating conditions of marine sewage discharge, oil-water separators and other equipment and ship exhaust emissions to shore-based ship management companies and maritime regulatory agencies through Beidou satellites in real time, providing technical support and information support for remote monitoring. At the same time, it effectively prevents the occurrence of marine pollution by ships and creates a new model of marine environmental protection.

Key words: Marine environmental protection, port parking, ship pollution prevention and control, sewage, oil-water separator, exhaust emissions.

1. Introduction
Since entering the "Twelfth Five-Year Plan", as Chinese inland waterway shipping has developed into a national strategy, inland waterway shipping has developed rapidly, the number of ships has grown rapidly, and the trend of large ships has become increasingly obvious. At the same time, due to the limitation of the level of economic development in the inland areas of our country, the management level of inland rivers and the conditions of ships are uneven, which makes the pollution situation of inland rivers facing increasingly serious. Chinese inland river vessel pollutant discharge regulations are relatively lagging behind, and the standards are relatively low. The management agency lacks effective means to effectively monitor the illegal discharge of ships. As a result, the illegal discharge of pollutants by ships continues to be banned, and the water quality of inland rivers is facing serious threats [1]. Therefore, the establishment of a compliant, reasonable and efficient ship pollutant receiving, transhipment and disposal model can effectively improve the environmental quality of Chinese waters and reduce the environmental impact caused by water transportation. Based on this research background, the thesis builds an integrated monitoring system for ocean-going ships' environmental protection ship-shore based on the Beidou system's short message communication function. It collects data from various
sensors, modulates and encrypts the data, and the crew can view the collection in real time. To understand the operating status of anti-pollution equipment. Through the ship-to-shore communication system, the collected ship anti-pollution data information is fed back to the ship management company and the maritime supervision department. The analysis of the data can determine whether there is illegal discharge, and realize the daily operation supervision of ships, especially ocean-going ships, and make up for shipping supervision.

2. System Framework
The data collection unit of the shipboard terminal collects the operating condition parameters of anti-pollution equipment such as domestic sewage discharge and oil-water separators through various sensors, and transmits them to the ship's control centre for data statistics and storage. The system modulates and encrypts the generated data information. Then the system transmits the information to the ground control centre through the ship-to-shore communication system, and the ship management company and maritime supervision department can understand the status of the ship's anti-pollution equipment in a timely manner, thus forming an integrated ship-to-shore monitoring system, which can greatly improve the monitoring of ship anti-pollution. Level and the enforcement of maritime regulatory authorities [2]. The composition of the ship anti-pollution monitoring system is shown in Figure 1, including a ship-borne terminal system, a ship-to-shore communication system, and a shore-based data monitoring system.

![Figure 1. The composition of the ship's pollution prevention monitoring system](image)

3. System function analysis
According to the requirements of ship pollution damage assessment, the system consists of 9 major parts, namely, pollution accident information collection subsystem, leakage diffusion simulation subsystem, petrochemical products database, meteorological and hydrological data database, environmentally sensitive areas and vulnerable resources database, Preliminary evaluation subsystem, monitoring data...
processing subsystem, emergency rescue facility database, and further evaluation subsystem [3]. The relationship between the various subsystems is shown in Figure 2. The various components of the system are integrated through GIS software. The main functions of each component are as follows:

![Figure 2. System function analysis](image)

3.1. Pollution accident information collection subsystem
The function of this subsystem is to quickly collect basic information about leakage and pollution accidents, such as the time and location of the accident, the name and quantity of the leakage, etc. The collection of information can include the alarm of the accident ship, the positioning of the ship by the VTS system, and the pre-declaration of the ship Information and many other ways [4]. This subsystem can comprehensively analyse the information collected through a variety of ways, and provide relevant information in graphic form through GIS.

3.2. Petrochemicals database
The database includes information on the main hazard characteristics of common petrochemicals, emergency rescue measures, etc. Because there are many types of petrochemicals, it is impossible to collect all petrochemicals. It can statistically analyse information on leakage accidents and dangerous goods transportation declarations over the years.

3.3. Environmentally sensitive areas and vulnerable resources database
The database is established on the basis of the investigation of environmentally sensitive areas and vulnerable resources along the coast in the region. The GIS-based database mainly includes: towns, villages, enterprises, water facilities, water intakes, aquaculture areas, historical sites, Nature reserves, precious and endangered animals and plants and their habitats.

3.4. Leakage diffusion simulation subsystem
This subsystem mainly includes the diffusion model of pollutants in water and air. It can predict the possible impact of the accident based on the relevant information that has been obtained. The diffusion model of pollutants in the air should include both neutral gas and heavy gas diffusion. This model, the diffusion model of pollutants in the water should also consider the impact of tides. This subsystem can input the calculated results into the GIS system for graphic display.

3.5. Preliminary evaluation subsystem
This subsystem firstly evaluates the scale and type of the leakage accident based on the preliminary information of the accident that has been obtained through the query of the petrochemical characteristics database, and then theoretically analyses the development trend of the accident and the possible impact range through diffusion simulation. Finally, using the spatial analysis function of GIS, by querying the
environmentally sensitive area and vulnerable resource database, a list of sensitive areas and vulnerable resources in the affected area is given to evaluate the accident.

3.6. Monitoring data processing subsystem
This subsystem is mainly responsible for monitoring the environmental monitoring data in order to observe the development of the accident. In the preliminary assessment, although the relevant model is used to analyse the affected area theoretically, the actual situation may be very complicated. Therefore, it is necessary to use environmental monitoring the monitoring data provided by the department monitors the spread of leakage in water and air, and at the same time, it can also evaluate the effects of various measures that have been taken.

4. System software and hardware design

4.1. Hardware design
The hardware design includes two parts: shipborne terminal hardware system and shore-based hardware system, as shown in Figure 3. The onboard terminal hardware system includes onboard data processor, onboard data storage and flame detector, oil concentration sensor, liquid level sensor, flow sensor, time counter and other data acquisition modules [5]. Among them, we took into account the large amount of information and high real-time requirements of the data set to be processed by the system, and selected STC89C52RC single-chip microcomputer as the processor, which has the advantages of high performance, low power consumption and real-time signal processing.

4.2. Software design

4.2.1. Protocol and message design. To realize the functions of the system, it is necessary to design related interface protocols. They are the "information collection and detection sub-system interface interaction protocol" where the sensor signal enters the shipborne extended equipment, the monitoring information enters the base station from the shipborne extended equipment to the "base station interface interaction protocol", and the monitoring information is generated by the shipborne extended equipment. Use the 5G channel to enter the "Information Monitoring and Management Sub-system Interface Interaction Protocol" of the maritime supervision platform [6]. The ship's sewage discharge information transmission/alarming on-board subsystem is connected to the multi-sensor-based on-line monitoring subsystem for marine sewage discharge through RS232 or RS422. The on-line sewage discharge monitoring subsystem composes pollution source discharge information into a self-defined sentence that complies with the 61162 standards, according to "Information collection and detection subsystem interface interaction protocol" is actively output through the serial port. At the same time, because there
is no special ship sewage discharge information in the message format, the 6th message was chosen to realize the transmission of monitoring information from the ship to the base station. In order to control the flow, it is only used to transmit the information on whether the sewage discharge of the ship exceeds the standard. "1" means the discharge exceeds the standard, and "0" means the discharge does not exceed the standard.

4.2.2. Monitoring platform software development. The software platform of the ship sewage discharge online monitoring system is developed by using Microsoft Visual C++ 6.0 combined with ArcGIS software. The software can dynamically display the ship sewage discharge monitoring signal, the ship sewage information combined with the geographic information system, display the working status signal and alarm signal of each device, and realize a friendly human-computer interaction interface. The designed main interface of the system includes 6 sub-menus including current time display, ship selection confirmation, parameter setting, ship-shore information processing, alarm setting, and operation control [7]. Click the parameter setting submenu to set the working parameters of marine oil-water separators, exhaust emission monitoring and other equipment; click the ship-shore information processing submenu to display and query the information sent by the ship management company and maritime regulatory authorities; click The alarm setting button can independently set the upper and lower limit alarms of some sensors according to different working conditions; click on the operation control to select the working mode of marine oil-water separators and other equipment, and manually start and stop some marine auxiliary equipment control.

5. System Test
The author uses STM32F103ZET6 single-chip microcomputer programming to realize the monitoring terminal oil-water separator operating status information collection, and uses VS2010 to compile a set of inland water vessel oil-water separator remote monitoring system. The database software used is SQL2008 to realize the remote monitoring of the monitoring terminal. The interface of the system is simple in design and easy to operate. It adopts a graphical display mode for easy viewing by maritime supervisors. The software interface is shown in Figure 4. Judging from the test results, the overall system operation effect is good.

![Image](image-url)  
**Figure 4.** Supervision information system interface
6. Conclusion
The Beidou-based environmental protection ship-shore integrated monitoring system for ocean-going ships can monitor the operating status of pollution prevention equipment on ships in real time, providing technical and information support for remote monitoring. This system satisfies the daily operation and supervision of ocean-going ships and makes up for the shortcomings in shipping supervision. At the same time, it has become an innovative case of the Beidou system relying on ships to realize the application of marine environmental protection.

References
[1] Willburger, K., Schwenk, K., & Brauchle, J. Amaro—an on-board ship detection and real-time information system. Sensors, 20(5) (2020) 1324-1336.
[2] Xue, C., & Tang, L. Organisational support and safety management: A study of shipboard safety supervision. The Economic and Labour Relations Review, 30(4) (2019) 549-565.
[3] Tian, Z., Liu, F., Li, Z., Malekian, R., & Xie, Y. The development of key technologies in applications of vessels connected to the internet. Symmetry, 9(10) (2017) 211-223.
[4] Ancione, G., Lisi, R., & Milazzo, M. F. Human health risk associated with emissions of volatile organic compounds due to the ship-loading of hydrocarbons in refineries. Atmospheric Pollution Research, 12(2) (2021) 432-442.
[5] Chen, J., Wan, Z., Zhang, H., Liu, X., Zhu, Y., & Zheng, A. Governance of Shipping Emission of SOx in China's Coastal Waters: The SECA Policy, Challenges, and Directions. Coastal Management, 46(3) (2018) 191-209.
[6] Scarpa, G. M., Zaggia, L., Manfè, G., Lorenzetti, G., Parnell, K., Soomere, T.,... & Molinaroli, E. The effects of ship wakes in the Venice Lagoon and implications for the sustainability of shipping in coastal waters. Scientific reports, 9(1) (2019) 1-14.
[7] Huang, Q., Cui, Y., Liu, X., & Liang, X. Analysis of Administrative Management and Operation Cost in China's Maritime Shipping Market. Journal of Coastal Research, 94(1) (2019) 398-405.