SYSTEM FOR SIMULATION, CONTROL AND EVALUATION OF EMERGENCY SITUATIONS IN THE EVENT OF POLLUTION WITH DANGEROUS SUBSTANCES

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Abstract: Analysis of accidents on waterways, sea or river resulting pollution with harmful substances (hydrocarbons, chemicals) reveal that each accident is unique in its kind. Therefore, for each type of pollution a different strategy must be applied. In these circumstances, simulation, control and evaluation of these emergency scenarios, based on rigorously constructed scenarios, are necessary both to avoid or limit of possible mistakes and necessary for gaining experience used further for a correct approach to possible situations that can occur. Present paper is a result of the implementation of PISCES II (Potential Incident Simulation, Control and Evaluation System) in the research and education process of the "Mircea cel Batran" Naval Academy. Research undertaken by the authors highlights how this module helps to: reduce risks of pollution and response time; assign appropriate logistics and equipments to intervention; train human resource for effective management of emergency situations caused by pollution.
Keywords: pollution, dangerous substances, emergency scenarious, containment

1. Introduction

Even though the Black Sea is one of the most sensitive marine ecosystems and one of the most isolated in Europe, activities in this area are characterized by a high risk of pollution [1]. Water transport of dangerous goods transport on sea routes, that connects Europe, Asia and Africa and further inland waterways, is one of the main activity [2,3]. To this is added a significant exploitation of offshore resources, oil and gas, expanding of subsea pipelines, processing and refining of petroleum products in the seaside area and other economic activities with marine pollution potential [4]. In the event of pollution, following an event related to these activities, the consequences can be disastrous and can cause major economic, social and environmental costs [5].

Starting from these realities, accident analysis (pollution by oil / chemicals) registered on sea or river waterway, reveals that each accident is unique in its kind. Therefore, for each class of pollution a different strategy must apply. In these conditions are necessary support solutions that facilitate: simulation, control and evaluation based on emergency scenarios rigorously constructed [6,7]. These can be used both to avoid / limit mistakes and gain of experience necessary for the proper approach of situations with high risk of producing. Research undertaken by the authors highlights how simulation solution helps to: reduce risks of pollution and response time; logistics and equipping appropriate for intervention; human resource training facilities ready for effective

management of emergency situations caused by pollution. In these circumstances, the intervention organization and personnel training for a real situation are particularly difficult and costly. Simulation of the discharged pollutant is the easiest solution, largely canceling these drawbacks and providing an important tool for pollution response planning strategies.

In these circumstances paper presents an overview of research undertaken by the authors to identify solutions for simulating, testing and evaluation of emergency situations in case of water pollution by harmful substances. This initiative is part of Project PSCD 153/2015 Implementation of PISCES II Module (Potential Incident Simulation, Control and Evaluation System) in research and education of the "Mircea cel Batran" Naval Academy of Constanta.

2. Simulation of emergency situations and response to maritime or river pollution - requirements

In recent years, the technology used in various fields is more complex, methods of training and education have evolved through the implementation and application of methods and modeling and simulation solutions. From this perspective, emergency management in the maritime economic and interest zone of Romania, on the Danube, on inland waterways or in the Danube Delta is a major objective for a sustainable development.

These areas are characterized of high biodiversity and natural values, which are subject to high standards of environmental management. From

this perspective, for these situations, adequate protection from disasters caused by pollution, such as chemical spills from ships or other stationary sources at sea or on land, must be provided.

Review of literature real situations shows that there is room for improvement on the coordination and cooperation among government agencies that can intervene in emergency situations caused by pollution. The conducted analysis shows that emergency entities are the main structure for coordinating cases of marine pollution, and agencies that take over management of operations are different depending on the location and severity of the pollution. Sea areas and inland waterways affected are often difficult to monitor and responsible agencies must continuously improve their level of preparedness and response, given the increasing risks of water pollution. On the other hand, intervention units don't have sufficient means of intervention and aren't adequately equipped to manage incidents of water pollution.

From the research, authors have concluded that a module for training and research on pollution emergencies constitutes a useful tool for management and for the increase of response capacity. Such a module would allow the development of an advanced information management system for hazardous substances that can cause leakage and represents a threat to sustainable development. Short-term preoccupation will be assigned to reduce risks of pollution and response time by creating a prevention plan, by proper equipping, but also to train and to develop actional skills of human resource. In this way, inter-institutional coordination and monitoring of incidents of this kind will be more efficient thanks to the use of training facilities that module would provide.

This approach will be capitalized in future research and in the development of human resource, benefiting from the module support for generating complex scenarios of pollution, based on data sets adapted to the specificities of each analyzed area. In this way, complex intervention teams can form and train, with representatives from the institutions responsible for emergencies caused by pollution, which will result in creating positive synergies that will contribute to improved coordination. The expected results will be summarized and highlighted by prevent and respond to emergencies caused by pollution plans, applicable to both onshore and offshore areas, both for stationary sources of pollution and for those which are mobile.

Undertaken research should evaluate necessary response capabilities, elements relating to logistics of intervention and reaction times. One such module would provide the necessary technical support to improve inventory systems of pollutants, monitoring and exchange of information between agencies, as well as coordination and evaluation. Technical study conducted brings together the main requirements imposed to specialized simulation module for emergency preparedness and response:

Training and research facilities

By customizing emergencies at the appropriate marine / river oil pollution, such a module should ensure both training and research. The module must provide to participants an interactive environment by generating relevant information based on mathematical modeling of environment, of hydrometeorological conditions (wind, current, etc.) and the amount of hydrocarbons spilled.

As mentioned, the module must be a powerful research tool, aiming mainly dynamic simulation of marine pollution by oil and support (planning) response operations. It requires that the mathematical model to provide information on: the nature of hydrocarbons film spilled, hydrometeorological conditions, processes of evaporation, emulsification, dispersion, change in viscosity, distance from the coast, including suggestions about emergency equipment.

Flexible and efficient structure adapted to requirements

The main requirements that module must met are presented in table 1.

Table 1 Main requirements for the module

Requirement	Breakdown of requirement
Management of emergencies in real time	To integrate informations provided both in real time, as a result of an event in progress, and in the modeling developed for research and exercise.
Adaptation to national and international legislation	To include International conventions: Marpol 73/78, Oil Pollution Act of 1990, OPA 90.
Realism and precision	The simulation environment should facilitate precise trajectory modeling of pollutants and to determine the area in which it reaches the coastline.
Developing forecasts and scenarios	To facilitate the process of establishing forecasts regarding pollutant

	behavior under the influence of meteorological factors.
Flexibility	To establish a real working interface with AIS and GPS modules.

Generation and development of scenarios in case of pollution

In performing simulations, the module must ensure selection of systems and equipments in case of oil pollution, such as: vehicles, vessels, aircraft, personnel, skimmers, equipment for dispersants spreading, equipment for fire fighting and technique used in Search and Rescue operations. In this regard, system must offer the possibility of using a real database, specific to each simulated accident, with possibilities of generating new scenarios for research or training. In this way, the system can be used to organize the response in real situations or for training.

Also, the module should allow the possibility to modify data in real time, based on existing information / collected from the affected area, weather conditions, including air temperature, wind speed and direction, wave height and profile currents. The module should offer both use of maps developed before by the producer and use of electronic maps and references from other sources, such as topographic maps, aerial photos, images obtained by satellites, electronic maps developed according to standards. From the foregoing, conducted research revealed a number of programs / modules for simulation of pollution by harmful substances / hydrocarbons (table 2)

Table 2 Main softwares used in case of pollution by harmful substances

Name of the software	Facilities of simulation module
Environmental Sensitivity Index (ESI) Maps	ESI performs a punctual analysis of the effects associated with hydrocarbon pollution.
GNOME	GNOME is a modeling and simulation software which forecasts the evolution of hydrocarbon film on the water surface.
Trajectory Analysis Planner	TAP is a useful tool in substantiating contingent plans. It provides protecting solutions against potential hydrocarbon leaks.
Spill Tools	Spill Tools is a free set of programs that enables simulating the effects associated with oil spills.
Dispersant Mission Planner (DMP2)	DMP2 is a useful tool for sizing respond capability to an oil pollution, by using dispersants.
Selection Guide for Oil Spill Response Countermeasures	The online guide develops a set of measures applicable in case of oil spills. Enables rapid assessment of the impact and facilitate determination of minimum response measures.
ADIOS	ADIOS is a tool used to develop pollution response, adapted to the type of oil spilled and the specific environmental conditions in which the discharge occurred.
GOODS	GOODS is an online tool that complements GNOME package. Converts in GNOME format the information necessary in decision-making process (data about ocean currents, wind distribution, etc.).
CAFE	CAFÉ database complements pollution response facilities, assess the impact on the environment and biological species subject to the impact of hydrocarbons and chemicals.
Unit Converter for Spill Responders (NUCOS)	Simulation unit assess impact associated with a spill of oil / other vectors pollutants.
Electronic Incident Command System (ICS) Forms	ICS package is used in response to pollution capacity development or other emergencies.
PISCES	A powerful tool for planning and decision making, in support of prevention of pollution actions and intervention in the real case.

Conclusions
Among the solutions presented, PISCES is the only package that provides both research and training facilities. PISCES is used by a large number of training centers worldwide, as well as governmenthal authorities, proving to be a powerful tool for intervention in real cases and planning and decision making in support of action related to oil pollution. PISCES II module develops accident scenarios whereby national authorities, who have responsibility for the safety of shipping and the prevention of environmental pollution, can develop training programs for human resources responsible for such intervention, constituting at the same time the necessary support for decisions in case of pollution.

Bibliography

[1] Mihailovici, C.S., 2011. Analysis of Black Sea Pollution–Risks, Consequences and Measures. J Mar Technol Environ, 1, 65 (2011).

[2] Couper, A. (2015). The geography of sea transport (Vol. 5). Routledge.

[3] Medda, F., & Trujillo, L. (2010). Short-sea shipping: an analysis of its determinants. Maritime Policy & Management, 37(3), 285-303.

[4] Nicolae F., Perkovic M., Ristea, M., Cotorcea A., 2016. Method for Monitoring the Space-Time Development of Oil Spilled in Marine Environment Using Pisces II Simulation Software. Journal of Environmental Protection and Ecology 17, No 1, 136–145 (2016). ISSN 1311-5065.

[5] Nicolae F., Ristea, M., Cotorcea A., 2015. Estimating the Containment Costs in the Situation of Oil Spill in the Marine Environment. Case study: Romanian Black Sea Coast. Journal of Environmental Protection and Ecology 16, No 1, Marine pollution and ecology, 110–116 (2015). ISSN 1311-5065.

[6] Lebreton, L. M., Greer, S. D., & Borrero, J. C. (2012). Numerical modelling of floating debris in the world's oceans. Marine Pollution Bulletin, 64(3), 653-661.

[7] Perkovic, M., Ristea, M., & Lazuga, K. (2015). Simulation based emergency response training. "Mircea cel Batran" Naval Academy Scientific Bulletin, Volume XIX – 2016 – Issue 1.