### Information Technologies for Designing the Surveillance System to Monitor Caspian Sea Water Contamination

#### Mereke Bapanovna Zhumadilova

Caspian State University of Technologies and Engineering named after Sh. Esenov, Aktau city, 32 mcr., Mangystau region, 130003, Respublic of Kazakhstan

Abstract: The ecological system of the Caspian Sea, where both Kazakhstan and foreign companies are extracting hydrocarbon crude, is currently in a pre-crisis state, and there is a real risk of its further deterioration due to constant intervention, including the planned development of shallow waters in the north-eastern part of the Caspian Sea. Kazakh part of the Caspian Sea requires state regulation in the field of environmental monitoring. This needs the application of systematic approach to environmental issues, which involves community health and environmental surveillance system, recording of obtained data, forecasting, and ability to actively influence the situation. The application of databases, created to collect information, as well as monitoring the current situation allows one to identify pollution focuses with sufficient accuracy and develop the adequate control monitoring in order to provide prompt response.

[Zhumadilova M.B. The Information Technologies for Designing the Surveillance System to Monitor Caspian Sea Water Contamination. *Life Sci J* 2013;10(12s):849-854]. (ISSN:1097-8135). <u>http://www.lifesciencesite.com</u>. 137

**Keywords:** Environmental monitoring, the Caspian Sea, environmental quality objectives, forecasting, seal mortality, deterioration of ecosystem, biosystem, the Caspian Sea ecosystem.

#### 1. Introduction

"The environmental monitoring implies regulated environmental control, providing, first of all, continuous assessment of the environment conditions of human and biological objects (plants, animals, microorganisms, etc.), as well as assessment of the status and functional value of ecosystems; secondly, it provides the conditions for determining the corrective actions in cases where the environmental quality objectives are not met" [1].

Monitoring algorithm is consistent to assigned functions and includes the steps outlined in Table 1.

Table	<b>1.</b> I	Monitoring	algorithm	steps
-------	-------------	------------	-----------	-------

	<ol> <li>specification of the surveillance object</li> </ol>
	2. investigation of the surveillance object
Monitoring	<ol> <li>definition of the components of information model of the surveillance object</li> </ol>
	4. measurements planning
	<ol> <li>interrogation and evaluation of the surveillance object status; determination of the constructed information model validity</li> </ol>
	6. forecast of the status transformations of the surveillance object at time periods
	7. convenient interface for obtaining information and capability
	of bringing it to the user

The goal of public policy in the field of environmental safety under Ecological Security Concept of the Republic of Kazakhstan for 2004-2015 is "to ensure the security of natural systems, vital interests of society, and the rights of individuals against threats resulting from natural and anthropogenic impacts on the environment" [2].

The "Environmental Code of the Republic of Kazakhstan" #212-III of 09.01.2007 provides for the

establishment of the Unified State Information System for the environment and natural resources monitoring (Article 139). "Information support of the Unified State Information System for the environment and natural resources monitoring is based on the data of the state monitoring of environment and natural resources, which are transmitted to the consolidated database. These data are collected by specially authorized state bodies, as well as during production monitoring, carried out by natural resource users under industrial environmental monitoring" [3].

### 2. Techniques.

Systematic approach to solving the problem of environmental monitoring provides a symbiosis of legal issue, information base, and computer technologies. The latter involves information acquisition, systematization, and analysis [4]. Acquisition of information should be carried out according to the following parameters studied:

1. the current status of the surveillance object;

2. the reasons of existing and admissible changes of object's status including sources and factors of anthropogenic impact;

3. maximum allowable changes and possible variations of loads on the object;

4. analysis of admissible system reserves.

## 3. The main part.

The need to develop environmental monitoring of the Caspian Sea is caused due to the facts of environmental disasters. "The Caspian Sea is endorheic, it washes the shores of Russia (Dagestan, Kalmykia, and the Astrakhan region) and Azerbaijan, Iran, Kazakhstan, and Turkmenistan" [5]. The Caspian Sea is an area of active oil production and transportation. In this regard, there are situations of oil spill, and the penetration of oil residues in the waters of the Caspian Sea. Particular circumstances, generating anxiety, are related to frequent cases of Caspian seal mortality due to their pestilence. Over the whole second half of the last century only eight such cases were officially recorded, while just in the first decade of this century already five cases were noted.

Thus, the first case occurred in 2000, when about 30,000 Caspian seals were perished, at that over 10,000 carcasses were found just on the coast of Kazakhstan. A significant number of seal carcasses were moved from the northern Caspian Sea to the south. The deaths were caused by chronic toxicosis. The decomposition products of crude oil, fuel and bunker oil, as well as pesticides were found in animal carcasses that led to a sharp drop in seals immunity and their exposure to infectious diseases. In addition, in 2001 in the waters between the coast of Mangistau region and Turkmenistan 250 thousand tons of sprat were perished that is annual catch quota of all Caspian bordering countries and 40% of all sprat stocks in the Caspian Sea. It was found that perished sprat contained a high amount of heavy metals and petroleum products.

The second case happened in the spring of 2006, when over 337 seals and over 2,000 sturgeons perished during a mass plague.

The third case occurred in 2007; dead seals were found since the end of March on the coast between the Kalamkas and Karajanbas near "Kalamkas" check dam. Number of dead seals approached to 1,000. According to the version of the commission that investigated the causes of the animal deaths, a canine distemper virus was the most likely cause. The presence of the virus in the dead seal carcasses was confirmed by expertise conducted by two institutions - the Research Institute for Biological Safety Problems and the Institute of Microbiology and Virology, Ministry of Education and Science of the Republic of Kazakhstan. Probable causes were associated also with adverse weather conditions.

The fourth case happened on May 10, 2011in Bautino settlement of the Tupkaragan region. To clarify the circumstances, specially created commission surveyed coastal zone in the area of "Bautino Spit" and found 7 decomposed carcasses of

dead seals. According to experts, the seals were killed 3-4 months before their carcasses were found. As the analysis of previous years data have shown, a number of weakened and malnourished baby seals die at the end of the lactation period or at the youngsters' stage in spring, and less frequently in summer and fall. Just 5-7% of emaciated youngster animals survive to maturity. Based on long-term data analysis, total death of offspring during the lactation and molting periods (from January 30 to March 10), for different reasons, varies from 10-15% to 30%. Most of the seal offspring is perished due to mechanical damage between ice floes, from exhaustion, and because of the raptors attacks. Some seal carcasses clearly manifest traces of cuts from fishing nets. Therefore, it is quite possible that part of the seals suffered from the actions of poachers, throwing their nets into the sea.

The fifth case occurred on March 25, 2012. "During the inspection of the coastline between the Urdyuk Cape and "Bautino Spit" on March 25, 2012, 35 dead seals were found. All seals were at the youngster stage. The decomposition degree of dead carcasses shows that animals death was relatively recent, within 1.5-2 weeks", - reported the Kazakhstan News Information Agency. And after 7 months, on October 22, 2012, a massive plague of seals occurred in Dagestan part of the Caspian Sea not far from Makhachkala, as it was reported. More than 15 remains of large animals and their dead calfs were found on the coast of the Caspian Sea. A possible cause was associated with poachers.

Contamination of the environment has influenced the state of waterfowl. Mass bird deaths are observed on the sea coast to the east of the Ural River creek every year since 1981. Corpses of birds are permanently found to the east of the lower Ural River up to the Komsomolets Gulf, i.e. over a distance of 300-350 km. In May 1988, 250-300 thousand birds of 27 species were cast ashore due to wind from the west; taking into account birds that were cast to the open sea and nailed to the reed beds, this figure would rise to about one million. Predominantly these were river and sea ducks, baldcoots, sandpipers, and gulls. A similar trend is taking place at the present time.

In general, the Caspian Sea ecosystem is considered to be in a pre-crisis condition that may even worsen as a result of large-scale invasion into the environment due to the planned oil production development in shallow waters in the north-eastern part of the Caspian Sea. The Ecological Security Concept of the Republic of Kazakhstan for 2004-2015 has been developed due to the increasing incidence of environmental disasters.

"The goal of the state policy in the field of environmental protection is to ensure the safety of natural systems, vital interests of society and the rights of individuals against threats, arising from natural and anthropogenic impacts on the environment" [1]. Another priority goal is "prevention of Caspian Sea shelf against contamination, as well as averting water resources against depletion and pollution" [1]. "Environmentally sound development of the state is based on the following principles: commitment to assess the impact of economic and other activities on the environment, followed by sanitary-epidemiological environmental and expertise" [1].

Environmental problems of the Caspian Sea the problems, associated with intense are development of the Caspian Sea resources. Upcoming massive development of hydrocarbons in the Kazakh sector of the sea poses a potential threat to the ecological security of the country. Not only Kazakhstan, but also Russian companies are producing oil in the Caspian Sea. For them the organization of effective environmental monitoring of offshore oil production is becoming increasingly important issue due to the expansion of hydrocarbons production and transportation that can lead to negative consequences for coastal areas in emergency situations. According to the Maritime Doctrine of the Russian Federation for the period up to 2020, approved by Presidential Decree of the Russian Federation #PR-1387 of 27.07.2001, "the prevention of marine pollution is one of the main provisions relating to the maintenance of national interests in the World Ocean". One of the principles of national maritime policy is "the development of monitoring systems to control the state of the marine environment and coastal areas". In recent years, environmental monitoring of marine areas has received much more attention. In particular, Shirshov Institute of Oceanology of the Russian Academy of Sciences (IO RAS) conducted works under the project of Ministry of Education (RP-22.1/001) namely "Creating a multi-level system of regionally adapted environmental and geodynamic monitoring of the seas of the Russian Federation, including primarily shelf and continental slope", which resulted in a development of information support system for industrial and environmental safety of offshore oil and gas facilities. Joint Stock Company "LUKOIL", one of the leading oil companies, has launched special programs of industrial environmental monitoring for the development of the Caspian Sea oilfields.

Framework Convention for the Protection of the Marine Environment of the Caspian Sea and the regional strategy for priority action define the main directions for the use of the Caspian Sea resources and the general interaction between the Caspian bordering countries in regard to future measures for the protection of the Caspian ecosystem.

"The research should result in development of clear regulatory environmental requirements that provide an environmentally safe economic activity at sea, including zoning of the Caspian preserved area" [1].

"Information support of the Unified State Information System of the environment and natural resources monitoring is based on the data of the state environmental and natural resources monitoring, transmitted to the consolidated database. These data are collected by specially authorized state bodies, as well as during production monitoring, carried out by natural resource users under industrial environmental monitoring" [2].

To create a unified information service for environmental monitoring, tracking process of environmental information should be automated. To improve the automation process, the information should be structured. For this purpose, the process of environmental monitoring is split into following several stages.

When transmitting the environmental information on hierarchical levels from the local level to a more global level, the scale of the basemap, on which this information is applied, increases, changing respectively the resolution of the information portraits of ecological situation. At the regional level, closely spaced exposure sources represent a source array. As a result, a small town with a few dozens of emissions looks at the regional information portrait as one local source with parameters that are determined based on the monitoring of the sources. During data transmission from one hierarchical level to another. both information about the emission sources and other data, characterizing the environmental conditions, are generalized [3].

The following information is needed to develop the project on environmental monitoring:

1. environment pollutants sources;

2. pollutants transfers;

3. landscape-geochemical processes of pollutants redistribution;

4. data on the status of anthropogenic emission sources.

Systematic observations of the following objects and environmental parameters are conducted in the emission sources impact zone.

The principle of designing a monitoring system should be based on the development of a functional working model, or on the planning of the whole processor chain for gaining the information from problem statement to information output to the consumer for decision-making. Since all stages of information gaining are interrelated, insufficient attention to the development of any stage will inevitably lead to a sharp decline in the value of all information received [3].

Based on the analysis of national systems development, we state here the main requirements for the design of such systems. These requirements should include the following five basic steps:

- 1. definition of the monitoring systems tasks and requirements to information, necessary for their implementation;
- creation of organized structure of monitoring network and development of surveillance principles;
- 3. construction of the monitoring network;
- 4. development of data/information acquisition system and providing information to consumers;
- 5. creation of a system for verification of obtained information in terms of compliance with the requirements baseline, as well as revision, if necessary, the monitoring system.

"The software system should allow one to implement accumulation, processing and storing information on a single methodological basis, ensuring exchange of information between the different levels, as well as the data banks of the systems and subsystems of the Unified State Information System for monitoring the environment and natural resources" [2]. One should envisage that "the exchange of information within the Unified State Information System for monitoring the environment and natural resources is implemented on a nonrepayable basis in accordance with the lists, forms and timelines, approved by the authorized body in the field of environmental protection, in agreement with the specially authorized government bodies, exercising monitoring of relevant natural resources" [2].

For more convenient usability and better data retrieval, all information is structured. To the best advantage this requirement can be met employing database [6]. At that, the database must meet the following requirements:

1. The system should be fully integrated with other existing information systems;

2. All systems must use a single database of attribute-based and mapping information;

3. Composition and sensitivity label of information, stored in the newly developed database structures, must be defined by the administrator.

Depending on the environmental monitoring goals, database model allows one to store data on environmental monitoring based on various aspects:

1. according to the environmental values;

2. according to the environmental monitoring objects;

3. according to the data source and organization.

Reference information includes the following [7]:

- cartographic information;

- meteorological and hydrological information;

- object related information;

- integrated data on the environmental situation in the surveillance zone and the region;

- personnel and public health protection plans in case of accident at the facility;

- pollutant propagation models in case of accident at the facility;

- design data on accident at the facility and the information concerning consequences of the accident;

- regulatory documentation on environmental issues;

- reference information of terms and definitions.

A regular grid with a pitch of 0.1, 0.5, or 1.0 km is plotted on the city index map. Using a specially designed program of random sampling, samples are collected and analyzed at points coinciding with the grid nodes, superimposed on the index map. To obtain statistically reliable mean values of the measured concentrations, one conducts the combinations analysis of the grid nodes, combined into squares with the area equal, for example, to 2-4 km<sup>2</sup>, taking into account various wind directions. This method makes it possible to determine both the boundaries of industrial complexes, and the zones of their impact. This provides an opportunity to compare the obtained results with the data calculated by mathematical models. Employment of simulation techniques in these works is mandatory [8].

Important control methods of so-called trans-border transfer of the global flow of pollutants, transported over long distances from the release point, is the system of ground and aircraft-based stations, coupled with mathematical models simulating the pollutants spread. Trans-border transport network of stations is equipped with systems of gas and aerosols sampling, collecting dry and wet depositions, and analysis of pollutants in the samples collected [9]. The information comes in meteorological synthesizing centers, which provide collection, analysis and storage of information about trans-boarder transport of pollutants in the atmosphere; prediction of pollutants transport, based on meteorological data; identification of emissions and pollutant source areas; recording and calculation of pollutant depositions from the atmosphere to the underlying surface, and the other operations.

Common standardized methods of sampling and analysis, as well as data processing and transmission are used to ensure comparability of the observations, obtained in different geographical and temporal conditions [10]. Information derived from observing network, is divided into three categories depending on the degree of urgency: emergency, current, and operating information. Emergency information includes information about sudden changes in the level of air pollution and is immediately transmitted to the corresponding organizations (control or economic). Current information contains generalized observations for a month, while operating information - for a year. Information on the latter two categories is transferred to supervisory authorities upon its accumulation, i.e. on monthly and yearly basis. Operating information. containing data on average and the highest levels of air pollution over a long time period, is used in planning for the atmosphere protection measures, the establishment of emission standards, and the assessments of air pollution damage to the national economy [11].

Stationary site is a specially equipped pavilion, which houses the equipment required for the record of pollutant concentrations and meteorological parameters according to the specific program [13]. Place to locate stationary site is chosen taking into account the meteorological conditions of formed air pollution levels [12]. At that, pre-defined range of tasks includes the following: evaluation of the average monthly, seasonal, annual, and maximum one-time concentrations, as well as assessment of the probability of exceeding concentration limit values.

Opportunities for the implementation of a holistic, systematic approach addressing issues of environmental monitoring requires the use of geographic information systems (GIS), which serve the basis of the monitoring system [14].

**4. Conclusion:** the system is solving the following tasks:

- 1. Monitoring the pollution supply into the environment;
- 2. Centralized data transfer to the departmental monitoring system;
- 3. Collection, analysis, and systematization of information from other departments involved in monitoring the pollutants levels, environmental condition and health indicators in the surveillance areas and regions of enterprises location, taking into account accidents and other emergencies, occurred in the past;
- 4. Accounting and control of terrenes, contaminated due to regional companies operation, as well as consideration the measures

aimed at their decontamination and rehabilitation;

- 5. Creating an objective picture of the environmental impact of industrial enterprises on the environment and public health, including a comprehensive assessment of the risks associated with their operation;
- 6. Providing information analysis support of the governance and enterprises, including the cases of emergency environmental impacts;
- 7. Automated integration of expert activities on environmental monitoring in different countries.

The implementation of a systematic approach to the environmental monitoring issue provides for the community health and environmental surveillance, as well as the opportunity to actively influence the situation. Application of the controlling action of a system as well as subsystem for environmental impact assessment makes it possible to control pollution sources based on the mathematical model of the process flows of industrial facilities or regions, possessing the a model of the environmental impact. Simulation of the current situation allows one to identify pollution focuses with sufficient accuracy and develop adequate operational control action on the technological and economic levels, as well as automate coordinated activity of international experts on environmental monitoring.

# **Corresponding Author:**

Dr. Zhumadilova, Caspian State University of Technologies and Engineering named after Sh. Esenov, Aktau city, 32 mcr., Mangystau region, 130003, Respublic of Kazakhstan.

# References

- 1. Hachaturov, T.S., 2002. Economics of Nature. High School: 256.
- 2. Ecological Security Concept of the Republic of Kazakhstan for 2004-2015, 2003, 1241.
- 3. Environmental Code of the Republic of Kazakhstan, of 09.01.2007, №212-III.
- Hotuleva, M.V., O.M.Cherp and V.N.Vinichenko, 2000. How to organize a public environmental impact assessment. A Handbook for NGOs, 3<sup>rd</sup> edition, Moscow, Ecoline, pp: 272.
- Geographical Encyclopedia. Date of View 04.11.2013: www.kodges.ru/nauka/obrazovanie/29040geograficheskaja-jenciklopedija.html view
- 6. National Action Plan on Environment Protection for Sustainable Development of the Republic of Kazakhstan, Center NPDOOS/UR.

- 7. Pupurev, E.I., 1992. Environmental monitoring system Ankom-AM. Ecological problems of Moscow. Ground measurements network, Moscow, pp: 146.
- Golovanov N.V., A.A. Knyazev, A.M. Pugin and V.V. Shaidakov, 2001. The mobile station for operational environmental monitoring. Problems of prediction, prevention and emergency relief operation. II International Scientific and Practical Conference, Ufa: 77-80.
- 9. Spellerberg, 2005. Monitoring Ecological Change. Gardners Books, pp. 243.
- 10. Zuur, A.F., E.N. Ieno and G.M. Smith, 2007. Analyzing Ecological Data, Springer, pp: 685.
- 11. Kabirian A. and M. R. Hemmati, 2007. A strategic planning model for natural gas transmission networks. Energy Policy, 35: 5656-5670.

24/12/2013

- 12. Seiffert M., 2008. Environmental impact evaluation using a cooperative model for implementing EMS (ISO 14001) in small and medium-sized enterprises. Journal of Cleaner Production, 16: 1447-1461.
- Michaela, A., B. and P. Castka, 2008. Underlying mechanisms in the maintenance of ISO 14001 environmental management system. Journal of Cleaner Production, 16: 1949-1957.
- Zeilhofer P. and V. P. Topanotti, 2008. Geographic information systems and ordination techniques for evaluation of environmental impacts in informal settlements: A case study from Cuiaba, central Brazil. Applied Geography, 28: 1-15.