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**Research Article**

# Risk management in the environmental management system of an oil refinery

**Sophia A. Tsareva[1], Yuri V. Tsarev[2*]**

[1] Department of Economics and Management, Yaroslavl State Technical University, Moskovsky Avenue, 88, Yaroslavl, 150023, Russian Federation
[2] Department of Information Systems and Technologies, Yaroslavl State Technical University, Moskovsky Avenue, 88, Yaroslavl, 150023, Russian Federation

[*]corresponding author: tsarevyv@ystu.ru

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**Abstract**

Slavneft-YANOS was one of the first in Russia to obtain the ISO 14001 compliance certificate for the Environmental Management System (EMS). This quality standard has the highest requirements for environmental management, environmental protection, and environmental safety. The paper presents the industry-specific features of the introduction of a risk-oriented approach to the EMS of oil refineries. It also uses fuzzy logic to describe analysis mechanisms and methods for assessing the risks of failure to meet the performance indicators of the EMS. The main advantage of fuzzy control in EMS is that it provides an effective means of mapping uncertainties and inaccuracies because the fuzzy logic on which control is based is identical to human thinking as opposed to traditional logical systems. Fuzzy control proves most useful as part of EMS performance analysis when processes become difficult to evaluate using common quantitative methods or when available information sources are interpreted inaccurately and uncertainly.

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## Introduction

The effective functioning of any organization is impossible without an active risk-oriented organization management system, regardless of its scale and production specifics. Today, the uncertainty in production is becoming more significant, risk situations are becoming more frequent, and, therefore, there is a growing need to integrate a risk management system into the existing management system of the organization.

There are many studies devoted to methodological issues of risk management: Fedoseeva and Kryukova (2008), Dorozhkina et al. (2014), Rodionova and Grigoriev (2015). For example, Russian economists Fedoseyeva and Kryukova (2008) noted that risk management is an integral element of company management, which consists of the preparation and implementation of measures to reduce the risk of making erroneous decisions and possible negative consequences. According to Filina (2008), risk management is based on long-term forecasting, strategic planning, and the development of a sound concept and program adapted to the uncertainty of the system to avoid or reduce adverse effects and generate high returns.

The analysis of international theoretical and practical studies of risk management proves that this study is urgent. For example, the statistics show that risk management in the organization's quality management system is the top priority at 78% of British, 74% of German, 76% of Italian, and 64% of French and Belgian medium-sized businesses (Zlobina et al., 2011).

The standardized approaches form the basis of numerous studies aimed at assessing the risks in the functioning of both Integrated Management Systems and Environmental Management Systems (EMS). In particular, Lahuta et al. (2021) described the concept of integrated risk management for service quality, safety, and health at work and environmental protection using the PAS 99 standard. The authors of the study propose to create a customized manual for integrated risk management in transport enterprises. The paper points out areas of integration to risks to quality, health, environmental, and labor systems.

Suarez-Paba and Cruz (2022) proposed a comprehensive risk management and rating system on a regional scale (Natech RateME). The system is based on probabilistic risk assessment methodology, which can support industrial enterprises to manage local and external risks of complex events and evaluate their performance in terms of minimum life cycle losses. The study of Hummel et al. (2021) considered environmental and social risks (E&S) integrated in the banking sector that is, E&S issues that are important in terms of adapting to a changing business environment. The authors develop a conceptual model that links contextual factors, a proactive strategic approach, E&S management tools, and E&S effectiveness. It is noted by Penman et al. (2020) that environmental decision-making requires an understanding of complex interacting systems across space and time scales. A number of statistical methods, estimation structures, and modelling approaches have been applied to make structured environmental decisions under uncertainty in some studies. This paper proposes the use of Bayesian Decision Networks (BDN) as a useful design to address uncertainties in environmental decision-making.

An interesting approach is implemented by Ma et al. (2013). It describes a major environmental risk management system based on ArcGIS Engine, NET and Oracle technologies. The system used a C / S structure. Three functional modules have been developed: the basic environmental information management module, the enterprise risk source reporting module; the audit and risk source management module. Fathi et al. (2020) pointed out that sustainable production management is impossible without taking environmental risks into account. In particular, it is noted that trade-offs between economic and environmental risks are possible by using Water Footprint (WF) as an environmental criterion and Gross Margin (GM) as an economic criterion.

A brief review of major accidents and an abstract analysis of risk assessment methods for the earthworks system is presented by Lin et al. (2021). A summary of potential risks during excavation is an important indicator for establishing an early warning system. The authors used fuzzy set theory and machine learning techniques to assess the risks of earthworks. They also showed how machine learning can be applied to risk assessment.

The research team of Chen et al. (2014) identified sources of environmental risk in the petrochemical industry using bow-tie analysis, evaluated sources of environmental risk using an integrated environmental risk assessment index, and classified sources of environmental risk considering both environmental consequences and management costs. In addition, this team is developing a standard environmental risk source management system based on the browser/server model and WebGIS technology. The system has four main functions: register and declare petrochemical enterprises, correct and confirm sources of environmental risks, assess and classify the sources of environmental risks, and manage the sources of environmental risks.

A group of researchers (Fu et al., 2020) noted that integrated energy systems can improve energy efficiency and contribute to sustainable energy development. To cope with the operational risk caused by system uncertainties, the authors introduced the CVaR method into the system optimization model for risk management. The CVaR model was adopted to solve the multi-criteria optimization problem using a two-stage stochastic programming method that simultaneously considers uncertainty in solar energy and energy demand. By comparing the optimization results obtained with the CVaR method and the traditional scenario-based stochastic programming method, the effectiveness of the CVaR method in managing the risks of integrated energy systems is confirmed.

Ifaei et al. (2019) proposed a holistic analytical approach to study the characteristics of integrated fossil fuel combustion energy conversion systems, taking into account the energy, economic, exergy, environmental, and risk (4ER) aspects. For this purpose, a life cycle is assessed to examine the environmental impact. Hazardous risks are also investigated using a hazard and operability approach. External hot and cold water systems are also studied using the new Water Exergy Nexus Analysis (WExN). Accordingly, two configurations have been developed that combine the Rankine Cycle (RC) and the Ejector Cooling Cycle (ERC) for two purposes: energy and cooling co-generation (CGS) and power generation (MGS). Water losses in both configurations are studied considering three refrigeration systems and two fossil fuel cycles using WExN analysis, and CGS and MGS performance is compared using multiple organic liquids. Thus, a retrospective analysis of bibliographic sources brings us to the conclusion that in order to ensure maximum efficiency and effectiveness, the management system of an industrial enterprise should be based on the latest achievements in risk assessment and management, as well as the best international experience.

The purpose of this study was to adapt the risk-oriented approach in the management of an Integrated Management System (IMS) of an oil refinery as risk assessment of IMS sustainability (Quality Management System and Environmental Management System).

## Materials and Methods

Slavneft-YANOS is the largest producer of oil refining products in Central Russia. Slavneft-YANOS's Integrated Management System has relied on the Quality Management System (QMS) and the EMS since its development and introduction. There are many reasons for it: namely, over the last ten years, Slavneft-YANOS has been actively protecting the environment by mitigating the adverse impact of production factors on the environment. According to ISO 9000:2015, performance is "the degree of implementation of planned activities and achievement of planned results" (ISO 9000:2015, 2015). One of the new features of the updated standard was the introduction of risk-based thinking, which provides a way to reduce the negative consequences of emerging uncertainties. However, it is almost impossible to maintain and control the quality of all processes simultaneously, given the large variety of uncertainties, so it is necessary to identify the criterial risks. Based on the fuzzy logic, it is possible to reliably assess the risks of failure of indicators reflecting the sustainability of the IMS. To use the fuzzy logic, it is necessary first to make an expert assessment of the probability of each type of threat and the damage from emerging threats. This data will be used as input values for the fuzzy output. We use the Mamdani algorithm as the main algorithm for fuzzy output. It divides the space of influencing factors into subareas with fuzzy boundaries, within which the response function takes a fuzzy value (Shtovba, 2001). This algorithm allows us to divide the selected processes into "productive" and "non-productive" ones with a sufficiently high degree of accuracy. The information on "productive" and "non-productive" processes can be used to determine a functional correspondence representing the dependence of IMS quality on process parameters. However, it is worth noting that the Takagi-Sugeno algorithm is also often used to obtain a clear output value with a large sample of input values. The main advantage of it is that the right-hand sides of the output rules are represented as linear functions. With this, there is no defuzzification needed, which, in comparison with Mamdani method, significantly reduces the time spent on additional calculations (Tsareva and Yuzhakova, 2018).

The next step is the formation of the membership functions of fuzzy sets. The experts' opinions are also used to form them. In most cases it is easier for experts to answer questions about the nature of fuzzy boundaries between adjacent terms. Information of this kind can be concentrated in the term boundary fuzziness functions $\mu_{i,i+1}(x)$, $i = 1, 2, \ldots, n-1$. Let some linguistic variable, given by a set of $n$ terms, be defined by the membership functions of these terms $\mu_i(x)$, $i = 1, 2, \ldots, n$, then $\mu_{i,i+1}(x)$ can be evaluated as follows: each expert indicates an interval $\Delta x_i$ on the scale of the universal set $X$ corresponding to the intersection of two neighboring terms $X_i$ and $X_{i+1}$ In this case, the experts may be asked to specify the interval of change in the threat probability corresponding to the transition from "very low" to "low". Functions $\varphi_{ij}(x)$ are formed on the intervals obtained as a result of the survey. The type of the functions is chosen from previous considerations (based on the researcher's view and preliminary data) (Asai et al., 1989). If there is no previous information on quality, we can present $\varphi_{ij}(x)$ as a rectangular function of unit area described by formula (1):

$$\varphi_{ij}(x) = \begin{cases} \dfrac{1}{\Delta x_{ij}}\ if\ x \in \Delta x_{ij} \\ 0\ if\ x \notin \Delta x_{ij} \end{cases}, \qquad (1)$$

where $i$ is the term intersection number ($i$ = 1, ..., $n$), $j$ is the expert number ($j$ = 1, ..., $m$).

According to the above, the function $\varphi_{ij}(x)$ reflects individual expert opinions, and a generalized opinion is formed using the formula (2):

$$\mu_{i,i+1}(x) = \frac{\sum_{j=1}^{m} \varphi_{ij}(x)}{\max \sum_{j=1}^{m} \varphi_{ij}(x)}, \qquad (2)$$

where the denominator is a normalization function in which max $\mu_{i,i+1}(x)$=1.

This processing of expert group evaluations allows us to get information about the nature of fuzzy boundaries between neighboring terms, concentrated in functions $\mu_{i,i+1}(x)$, which represent the generalized decision of experts. For example, the Mamdani algorithm, which is considered in this study and most commonly used, is based on using max and min operators. It allows us to obtain clear output values from fuzzy input data (Stoneburner et al., 2002).

For the oil industry enterprise we consider in this paper, the adequacy of the IMS performance assessment also depends on the effective management of environmental risks. For effective risk management, it is necessary to identify and systematize risks, i.e. to compile a register. The development of the risk register is based on the method of expert judgment. We also compile a map of the impact of risks on the impact objects. Experts assess the impact on a 5-point scale from "very weak" to "very significant" (Shlegel, 2011). Table 1 shows a two-factor matrix of probability and consequences, which allows to objectively differentiate risks and make a register of analyzed risks.

In table 1:

- $R_1$ is the risk of emission of pollutants into the environment;
- $R_2$ is the risk of inefficient maintenance and repair of equipment;
- $R_3$ is the risk of petroleum product leakage in the storage and production areas;

- $R_4$ is the risk of improper disposal of hazardous industrial waste;
- $R_5$ is the risk of improper transportation of flammable substances;

$W_i$ is the severity of impact ($W_1$ – very low (0.05), $W_2$ – low (0.1), $W_3$ – moderate (0.20), $W_4$ – high (0.40), $W_5$ – very high (0.80)).

Here is an explanation of the color coding of the matrix:

- red risks are included in the risk response plan;
- yellow risks are included in the general risk monitoring and control; they are mitigated through a reserve of financial resources and staff;
- green risks are monitored but are not managed.

Therefore, risk management ensures the reliability and efficiency of enterprise operations by identifying the risks that require management attention and prioritizing them in terms of enterprise objectives (Slavinskii, 2015).

Table 1. Matrix of probability and consequences.

| **Probability** | **Impact** | | | | |
|---|---|---|---|---|---|
| | $W_1$ | $W_2$ | $W_3$ | $W_4$ | $W_5$ |
| 0.9 | $R_1$ | $R_3$ | $R_1$ | $R_1$ | $R_3$ |
| 0.7 | $R_3$ | $R_2$ | $R_4$ | $R_3$ | $R_1$ |
| 0.5 | $R_4$ | $R_1$ | $R_2$ | $R_4$ | $R_4$ |
| 0.3 | $R_5$ | $R_5$ | $R_3$ | $R_2$ | $R_2$ |
| 0.1 | $R_2$ | $R_4$ | $R_5$ | $R_5$ | $R_5$ |

To study the IMS performance at Slavneft-YANOS, a methodical approach was used to determine the risks of failure to meet the indicators used to assess the performance. The task can be accomplished by implementing the algorithm given below.

Stage 1 – identification of indicators to assess the performance of the IMS. The process approach highlights the indicators of each business process. They can be used to determine the dynamics of IMS development and its state in any period of activity. The performance indicators of the integrated management system of Slavneft-YANOS are presented in Table 2. Most often, the indicators of IMS performance evaluation are identified by an expert (process owner) who refers to their own experience and intuition, which may lead to the decisions detrimental to the entire IMS due to a subjective view.

Stage 2 – setting variables in linguistic form. In order to understand which indicators to focus on first, a risk analysis is required for the indicators involved in the IMS performance assessment should be conducted. To ensure a fully sustainable level of enterprise IMS performance, there should be deliberate and effective decisions. This requires an analysis of cause-effect relationships, which a mathematical risk assessment can do. Risk analysis of IMS performance based on the method of fuzzy sets and fuzzy logic starts with the formalization of linguistic variables "threat probability" and "damage from possible threat".

Table 2. IMS performance measurement indicators based on data from Slavneft-YANOS.

| **Processes** | **IMS performance assessment indicators (QMS and EMS)** |
|---|---|
| | ***Management processes*** |
| Strategic management | Percentage of completion of quality objectives |
| Human Resources Management | Level of staff training in terms of quality |
| | Level of staff training in terms of ecology |
| Managing MS improvement | Readiness of the internal audit program |
| Procurement management | Level of compliance of purchased materials with established procurement requirements |
| | Level of provision with necessary material resources |
| Environmental management | Level of compliance of emissions with maximum permissible concentration (MPC) standards |
| | Compliance with environmental legislation |
| | ***Business processes*** |
| Production planning | Timely completion of production plan |
| Improvement of production | Implementation of the R&D plan |
| Product manufacturing | Customer satisfaction |
| | Total management in accordance with the documentation |
| | ***Supporting processes*** |
| Production support | Implementation of the equipment upgrade plan |
| | Level of provision of monitoring and measurement devices |

According to the theory of fuzzy sets, the segment [0,1] is chosen as the area of definition of the variables, and a set of terms is given for each of them. For the linguistic variable "threat probability" we form the following term set: "very low", "low", "medium", "high", "very high" and for the linguistic variable "damage from possible threat" we define the term set: "insignificant", "small", "medium", "substantial", "large", "unacceptable". We then use the method of consecutive intervals, which is convenient for expert evaluations. For this purpose, the entire interval [0,1] is divided into 20 sub-intervals.

After that, for two adjacent terms, each of the experts indicates those of the 20 subintervals that correspond to the intersection of these two terms, and then we calculate the length of the resulting interval (i.e. number of subintervals). This operation is performed for all adjacent terms. We have selected 5 terms, and four intersections of terms, then $\varphi_{ij}(x)_i$ ranges from 1 to 4. Since this study involved an expert group of 5 participants, $\varphi_{ij}(x)_j$ ranges from 1 to 5 (see Table 3).

Stage 3 – qualitative analysis of indicator risk. This analysis is aimed to determine the main risk factors of IMS, their probability and the possible damage from each of them. The expert needs to estimate the probability of a particular risk factor using the following modification of the qualitative risk analysis (see Table 4).

Stage 4 – obtaining the risk variable of the IMS operation. After describing all possible risk factors, it is necessary to calculate the risk indicator itself. For each threat, it is necessary to determine the values of the membership functions of the terms for "threat probability" $\mu_j(p)$ and "damage from possible threat" $\mu_j(u)$. Then we consider all combinations $(\mu_j(p), \mu_j(u))$ for which $\mu_j(u) \neq 0$.

The value of the membership function of "risk of ineffective system" $\mu_{ij}(R)$ is determined by the following rule: $\mu_{ij}(R) = \min\{\mu_j(p), \mu_j(u)\}$. If there are several values of the membership function of one term of "risk of ineffective system", the maximum value of them is the final one.

Table 3. Function values $\varphi_{ij}(x)_j$

| Expert | Intersection of terms | | | |
|---|---|---|---|---|
| | *very low and low* | *low and medium* | *medium and high* | *high and very high* |
| 1 | 0.50 | 0.5 | 0.5 | 0.5 |
| 2 | 0.25 | 0.33 | 0333 | 0.5 |
| 3 | 0.33 | 0.33 | 0.25 | 0.5 |
| 4 | 1.00 | 0.50 | 1.00 | 1.00 |
| 5 | 1.00 | 1.00 | 0.33 | 1.00 |

Table 4. Subjective assessments of input variables obtained in the course of expert assessment of the IMS at Slavneft-YANOS.

| IMS performance indicators | Threat | Probability | Damage |
|---|---|---|---|
| Quality and environmental management completion percentage | Complete or partial non-compliance with the stated objectives of the QMS and EMS | 0.14 | 0.1 |
| R&D plan execution rate | Lack of papers and research activity | 0.35 | 0.6 |
| Level of staff training in quality and environment | Lack of valid certificates for staff development in QMS and EMS | 0.6 | 0.6 |
| Equipment upgrade completion | Lack of data on regulated equipment upgrade deadlines | 0.5 | 0.45 |
| Level of compliance of emissions with MPC standards | Lack of control over standards | 0.05 | 0.85 |
| Compliance with environmental legislation | Use of irrelevant legal information | 0.17 | 0.45 |
| Level of compliance of purchased products with established procurement requirements | No or incomplete input controls | 0.5 | 0.7 |
| Readiness of the internal audit program | Non-compliance with statutory internal audit deadlines | 0.35 | 0.55 |
| Level of provision with necessary material resources | Failure to meet the production plan on time | 0.6 | 0.7 |
| Timely completion of production plan | Equipment malfunction | 0.75 | 0.35 |

As a result, the center of gravity method is used to obtain an explicit value of the output variable:

1. The figure denoted by the membership function of the linguistic variable "risk of ineffective system" is split into simple figures.

2. Now, the coordinate axis system should be selected. Since 2D figures have one axis of symmetry, they should be combined with one of the coordinate axes. The second coordinate axis is directed perpendicularly to the first one so that it crosses the center of gravity of one or more figures. The origin of coordinates may (or may not) coincide with the center of gravity of one of the figures. The second axis can be directed so that it passes through the lower (extreme)

point of the section. In the first case, the calculations are simpler.

3. The formulas should be drawn up to determine the coordinates of the section gravity center, which are (3) and (4):

$$X_c = \frac{s_1 x_1 + s_2 x_2 + \ldots + s_n x_n}{s_1 + s_2 + \ldots + s_n}, \quad (3)$$

$$Y_c = \frac{s_1 y_1 + s_2 y_2 + \ldots + s_n y_n}{s_1 + s_2 + \ldots + s_n}, \quad (4)$$

where $s_1, s_2, \ldots, s_n$ are areas of the profiles; $x_1, x_2, \ldots, x_n$ $y_1, y_2, \ldots, y_n$ are coordinates of their centers of gravity relative to the chosen coordinate axes.

The number of terms in the numerator and denominator of the formulas depends on the number of profiles the section is composed of. Substitute these values into the formula and find $X_c$ and $Y_c$. Remember that if the $X$ axis is aligned with the symmetry axis, then the coordinate $Y_c=0$. If the $Y$ axis is aligned with the symmetry axis, then $X_c=0$.

Calculations are made for all indicator threats. The full range of threats to the IMS based on the assessment indicators of risks and damage is presented as a diagram. Their analysis makes it possible to develop effective and informed decisions to control and minimize the identified risks and determine the balance between the possible damage and the cost of ensuring high performance of the IMS.

## Results and Discussion

In this study, the expert group was tasked with the identification of IMS performance indicators interrelated with the risk factors of the management system operation.

Using "lack of control over MPC standards" as an example, Figures 1, 2 and Table 5 show the results of calculations of the values of membership functions for "threat probability" $\mu_j(p)$ and "damage from possible threat" $\mu_j(u)$.

As a result, the risk value of the indicator "lack of control over MPC standards" was calculated using (5), which was 0.322:

$$R = \frac{\sum R_{\mu_\Sigma(R)}}{\sum \mu_\Sigma(R)}. \quad (5)$$

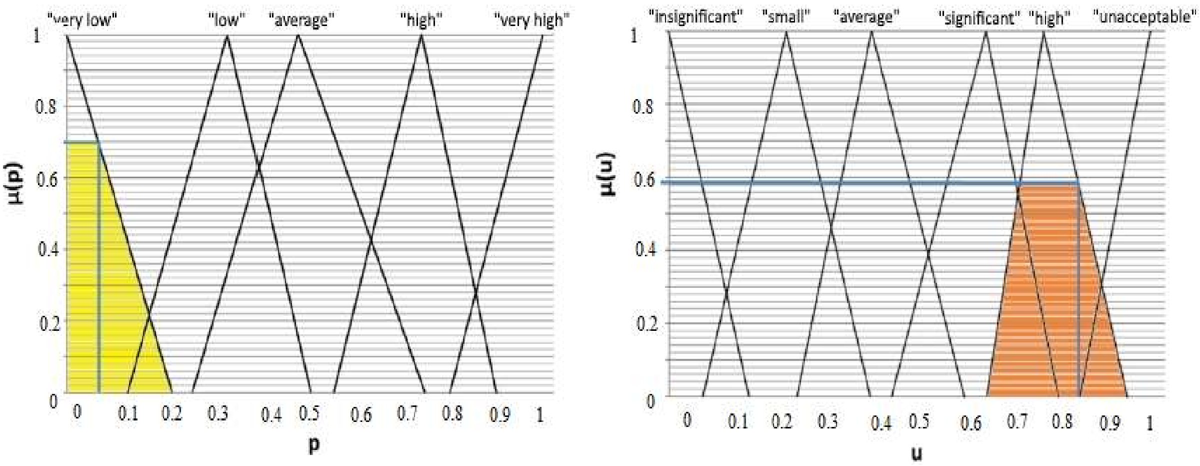


Figure 1. Determination of the values of the linguistic variable membership functions for "threat probability" $\boldsymbol{\mu_i(p)}$ and "damage from possible threat" $\boldsymbol{\mu_j(u)}$ for the threat "lack of control over MPC standards".

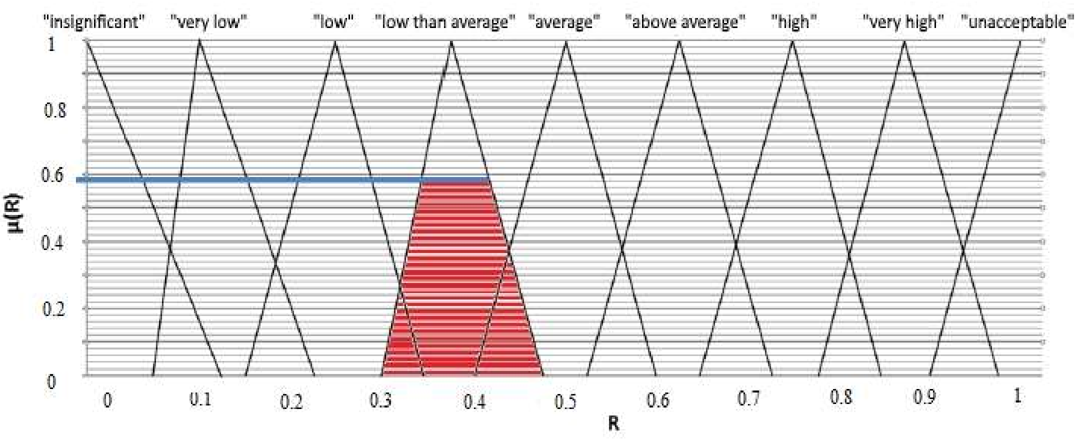


Figure 2. Risk that the system is deemed ineffective under the threat lack of control over MPC standards.

Table 5. Determining the value of the membership function for the terms of the linguistic variable “Risk of ineffective system” for the threat “Lack of control over MPC standards”.

| “Threat possibility” | $\mu_i(p)$ | “Damage from possible threat” | $\mu_j(u)$ | “Risk of ineffective system” | $\mu_{ij}(R)$ |
|---|---|---|---|---|---|
| Very low | 0.7 | High | 0.58 | Lower than average | 0.58 |

The full trend of changes in the risk and damage caused by threats to the IMS performance indicators at Slavneft-YANOS is shown in Figure 3. In this case, in terms of increased risk, it is worth paying attention to threats to the indicators "R&D plan execution rate" and “Level of compliance of emissions with MPC standards”. In terms of damage, it is worth paying attention to the indicators “Level of compliance of emissions with MPC standards” and “Level of compliance of purchased products with established procurement requirements”.

Here is a possible explanation of the results obtained:

1. The innovative technologies in the oil refining industry are highly important because the raw materials should be used rationally, there should be as small industry footprint in the environment as possible, while the budget should stay optimized. According to the research (Likhterova, 2004), Russian oil refineries lag significantly behind foreign companies in terms of innovation potential. Therefore, the importance of considering the risk “Level of R&D plan implementation” defines the level of functioning and development of this industry. It cannot be managed effectively without widespread use of innovative managerial solutions.

2. The oil refining industry suffers from the most pronounced environmental problems. Slavneft-YANOS, located within the city limits of Yaroslavl, has a complex negative impact on the health of the population and thus causes huge economic damage (sick leave payments, treatment costs) (State report, 2020).

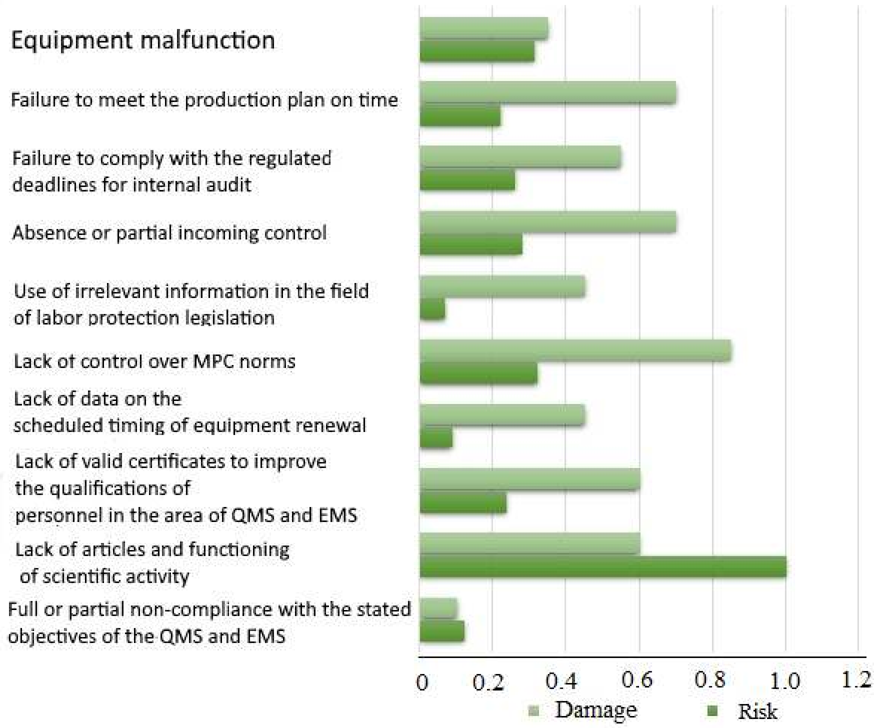


Figure 3. Trend of changes in the risk and damage caused by threats to the IMS performance indicators at Slavneft-YANOS.

We shall note that the oil refining industry has quite specific environmental management systems. Namely, enterprise-wide identification of environmental risks is not easy due to the complexity of refinery production systems and the diverse geographical location of refineries. There are several enterprise-level information systems that help manage compliance and mitigate risks, but most businesses still use their own unique solutions. That is why, the paper considers the extremely understudied issue of correlation of environmental norms and risks compliance and environmental management system efficiency within a particular enterprise of the oil refining industry. The developed method of IMS performance assessment based on fuzzy sets and fuzzy logic should help adjust to the current methodological techniques of environmental management system performance assessment. In particular, according to the internal reports on Environmental Management System of Slavneft-YaNOS, the EMS performance is rather good (Kresult=0.95-0.98). However, the company has a significant negative impact on atmospheric air in Yaroslavl (State Report, 2020). It means that the company has a number of problems related to operational control and assessment of compliance with regulatory environmental requirements. This is important in the context of corporate governance, as it indicates the potential risks that need to be addressed to ensure safety for the environment.

It should be noted that this case study of Slavneft-YaNOS can be generalized and scaled up, provided that the product line and manufacturing are typified. The limitation of this study is related to the sample size and the frequency of responses to the experts' questions when identifying the IMS performance indicators that are interrelated with the risk factors of the management system functioning.

3. The indicator "Level of compliance of purchased products with established procurement requirements", which is also very important, was caused by the key problem for the refining industry – ensuring the quality and continuous supply of raw materials for refining, which largely dictates the efficiency of use of production resources and reduction of the risk to fail the production plan. Due to this, special attention should be paid to the highlighted indicators, as the performance of the system as a whole will depend on the degree to which they are met. The risk-threat analysis under consideration should be conducted at the beginning of each year prior to the performance evaluation of the IMS in order to identify bottlenecks and plan actions to reduce them.

## Conclusion

The results of the analysis of existing approaches to risk assessment and management give every reason to consider it expedient and objectively necessary to develop such methodologies as the basic tools of risk management in the oil industry enterprises.

The objective of this study was to substantiate risk-oriented environmental management of Slavneft-YaNOS based on risk assessment and performance indicators of the Integrated Management System (IMS). The presented methodology can be used both for further scientific and methodical research and properly used by enterprises to form a high level of functioning and ensure high performance of the Environmental Management System.

The main contribution of this research is the adaptation of fuzzy sets theory in the assessment of sustainability risks of Integrated Management System, which allows to respond to them more quickly.

The IMS performance assessment based on the fuzzy sets method and fuzzy logic revealed the risk and damage trends from threats of IMS performance failure at Slavneft-YANOS. Namely, the enterprise should pay special attention to the increased risk caused by insufficient implementation level of the research and development plan and inadequate level of control over compliance with the standards of threshold limit value (MPC) of industrial emissions into the atmosphere.

The above approach makes it possible to implement comprehensive risk management through:

- Firstly, coverage of the entire production cycle of oil companies,
- Secondly, compensation for losses from accidental environmental pollution, as well as additional financing for environmental protection and emergency prevention measures implemented by enterprises.

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