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Smart Digital Systems for Industrial Environmental Risk Monitoring and Sustainable Management

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Abstract. This research article provides an overview of digital platforms developed for monitoring and managing environmental risks in industry. These platforms use advanced technologies to collect, analyze and interpret data, providing information about potential hazards. By leveraging real-time information from a variety of sources such as sensors and drones, these platforms enable proactive risk management strategies. Moreover, they promote communication and collaboration between stakeholders, promoting an integrated approach to environmental risk management. With their ability to optimize processes and resources, these digital platforms represent a transformational tool that can improve efficiency and sustainability in industrial operations.

1 Introduction

The fundamental methodological approaches proposed for assessing enterprise risks include systemic, complex, differentiated, dynamic, process-oriented, and integral methods. These methodologies aim to comprehensively comprehend risks within the enterprise framework, considering the interconnectedness of components, various factors like financial, operational, environmental, and social aspects, and the evolving nature of risks over time. They emphasize analyzing risks based on specific characteristics and attributes, understanding risks within organizational processes, and integrating multiple perspectives and techniques to offer a comprehensive view of risks [1]. These approaches are indispensable for conducting thorough risk assessments, enabling organizations to identify, analyze, and manage risks effectively to safeguard operations and achieve objectives.

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Likewise, the widespread impact of digital transformation on society extends across diverse industries, with a particular emphasis on the chemical and solar energy sectors in this article. It explores the influence of digital technologies on environmental safety within the industry, examining their effects, relevant technologies, and how companies utilize them to optimize production processes while addressing environmental concerns. Expert surveys provide insights into the specific impacts and applications of digital technologies in enhancing environmental safety.

An equally important goal of environmental monitoring is to provide the environmental management system with modern and reliable information that allows: to assess indicators of the condition and functional integrity of ecosystems; identify the reasons for changes in these indicators and assess the consequences of such changes, as well as determine corrective measures in cases where target indicators of environmental conditions are not achieved; create the preconditions for determining measures to correct emerging negative situations before damage is caused [2]. Hence the main tasks of environmental monitoring: - monitoring the main sources of anthropogenic impact; - monitoring of anthropogenic impact factors; - monitoring the state of the natural environment and the processes occurring in it under the influence of anthropogenic factors; - assessment of the physical state of the natural environment; - forecast of changes in the state of the natural environment under the influence of anthropogenic factors and assessment of the predicted state of the environment [3]. Accordingly, the main practical areas of monitoring are: - monitoring the state of the environment and the factors affecting it; - assessment of the actual state of the environment and the level of its pollution; - forecast of the state of the environment as a result of possible pollution and assessment of this state. The main objects of environmental monitoring: natural environments (atmospheric air, surface waters of land, sea waters, soil and land cover, landscapes, geological environment); sources of anthropogenic impact leading to the entry of toxic, hazardous and environmentally harmful substances into the environment (wastewater, industrial emissions, etc.), to changes in the existing or natural state of natural environments, and changes in the landscape of territories; natural resources (water, land, forest and other biological); environmental impact factors (noise, thermal pollution, physical fields); state of biota, its habitats and ecosystems.

2 Research methodology

The main methodological approaches for assessing enterprise risks encompass systemic, complex, differentiated, dynamic, process, and integral approaches. These methodologies aim to comprehensively understand risks within the enterprise context, considering interconnections between components, various factors such as financial, operational, environmental, and social aspects, and the dynamic nature of risks over time. They emphasize analyzing risks based on specific characteristics and attributes, understanding risks within organizational processes, and integrating multiple perspectives and techniques to provide a holistic view of risks [4]. These approaches are crucial for conducting thorough risk assessments, enabling organizations to identify, analyze, and manage risks effectively to safeguard operations and achieve objectives.

Similarly, the global impact of digital transformation on society spans various industries, with a particular focus on the chemical and solar energy sectors in this article. It explores how digital technologies influence environmental safety within industry, examining their effects, relevant technologies, and utilization by companies to optimize production processes while addressing environmental concerns. Experts were surveyed to gather insights on the specific impacts and applications of digital technologies in enhancing environmental safety.

3 Results and Discussions

The concept of Industry 4.0, which many manufacturers envision as their future, is intricately linked to the idea of a "smart" enterprise - one that is agile, stable, and efficient, utilizing automated systems and networked data transmission to the fullest extent [5]. What about the environmental aspect? The current market tools greatly facilitate the work of professionals directly involved in environmental safety and sustainable development issues. While these systems may not offer ready-made solutions, they significantly streamline the handling of large volumes of statistical data, enabling in-depth and comprehensive analysis. Manual processing of such data would often be too time-consuming, risking the relevance of the results.

At Henkel's cleaning and detergent production plant in Engels, two intelligent systems, Wonderware and Enablon, are directly in operation [6]. Wonderware serves as a global platform connecting all Henkel cleaning and detergent businesses. It enables the analysis of technological and auxiliary processes based on parameters of sustainable development, such as energy and water consumption, facilitating subsequent adjustments. Real-time monitoring of data from meters installed in factories allows for the determination of hourly resource consumption in specific areas or technological installations. This data aids in analyzing overconsumption causes, identifying energy consumption trends, and making accurate forecasts.

Combined with data from SAP and climate stations, Tableau utilizes this information to prepare visual reports [7]. These reports enable the observation of energy consumption dependencies on production line efficiency, monitoring of weather impact on energy consumption, and comparison with similar industries worldwide. The integration of these systems enhances statistical data processing, leading to the development of process efficiency solutions.

Within the oil and gas sector, various environmental risks are identified:

1. Greenhouse Gas Emissions: Oil and gas activities contribute to climate change by releasing significant amounts of CO2 and CH4 through combustion and flaring associated gas.

2. Accidental Spills and Releases: Oil and chemical spills occur during field development and hydrocarbon transportation due to equipment failures, human errors, or extreme environmental conditions, posing severe environmental consequences, particularly near coastlines or areas with slow water exchange [8].

3. nmVOC Emissions: Evaporation of crude oil during storage or transfer generates non-methane volatile organic carbons, which, when reacting with NOx in sunlight, form ozone, posing health risks and harming vegetation and structures.

4. NOx Emissions: Produced during the combustion of associated gas and gas in turbines, NOx emissions can cause local environmental damage, leading to acid rain and affecting coastal ecosystems [9].

5. Wastewater Emissions: Older oil fields produce more associated water and rock residues containing petroleum products and chemicals [10]. Current purification systems for water and rock masses are imperfect, posing environmental risks.

These classifications underscore the significant impact of oil and gas operations on ecosystems and highlight the risks associated with emergency spills and emissions resulting from pipeline and tanker damage during transportation. Addressing these environmental risks is critical for ensuring the sustainable performance of oil and gas industry entities.

4 Conclusions

Concluding, digital platforms have emerged as pivotal tools for monitoring and managing environmental risks in various industries. These platforms offer a comprehensive suite of functions, facilitating extensive coverage across sectors such as manufacturing, energy, and transportation.

In the realm of environmental risk management, state-of-the-art digital platforms play a crucial role. They enable stakeholders to access real-time data, analyze trends, and implement proactive measures to mitigate risks effectively. However, there remains room for improvement, particularly in terms of ensuring balanced information dissemination and expanding the range of services and features offered.

Access to these advanced digital platforms is often limited to government bodies or large organizations due to the substantial investment required. Nevertheless, the integration of big data and Internet of Things (IoT) technologies enhances the platforms' capabilities, enabling more efficient risk monitoring and management.

Looking ahead, the convergence of digital platforms with emerging technologies holds immense promise. Hybrid eco-monitoring systems, for instance, present an opportunity to revolutionize environmental supervision by detecting and addressing illegal activities such as unauthorized construction and deforestation.

Furthermore, leveraging these digital platforms for monitoring hazardous facilities, engineering structures, and communal services could yield significant benefits. By fostering collaboration among regulatory agencies and operational entities, these platforms expedite the resolution of environmental issues and enhance the overall efficiency of facilities management.

Overall, digital platforms represent a critical component of modern environmental risk management strategies. Their continued development and integration with cutting-edge technologies hold the potential to significantly enhance environmental sustainability efforts across industries.

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