Methods for Prospecting and Monitoring Hydrocarbon Gases on Oil and Gas Platforms and Basins: A Brief Review

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This work provides an overview of oil and gas prospecting methods and techniques, focusing on their advantages and limitations. It also highlights their application in monitoring hydrocarbon leaks on platforms and basins. A mapping of techniques, classified into geological, geophysical, and geochemical categories, illustrates their relevance, offshore or onshore suitability, and practical applicability. The discussion underscores the need for integrated approaches to improve exploration efficiency and safety while aligning with sustainable development goals (SDGs).

Keywords: Prospecting. Oil and Gas. Geochemistry. Geophysics.

Global oil consumption continues to outpace exploration, intensifying the need for effective prospecting techniques to maintain market balance.

According to the ANP statistical yearbook [1], oil production grew by 1.6% from 2022 to 2023, reaching 93.8 million barrels per day, while consumption rose by 6%, totaling 97.3 million barrels per day. Efficient oil and gas prospecting is crucial for identifying hydrocarbon-rich regions, reducing costs in unpromising areas, and improving exploration success rates. Over time, geological, geophysical, and geochemical techniques have evolved to enhance reliability and minimize environmental impact [2]. However, when applied individually, these methods often need to provide precise predictions. A combination of techniques is necessary for comprehensive assessments [3].

Monitoring hydrocarbon leaks on platforms and storage sites is equally critical, as light hydrocarbons identified during prospecting can also indicate potential leak sources [4]. Moreover, this study aligns with UN Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production) [5].

Thus, this work aims to map the most relevant and commonly used oil and gas prospecting techniques, evaluate their advantages and limitations, and highlight opportunities for technological advancements in the sector.

Materials and Methods

The study's methodology involves a systematic mapping of existing techniques for oil and gas prospecting, using the Web of Science database to identify key methods published between 2013 and 2024. A flowchart (Figure 1) outlines the research steps:

- Review and identify relevant techniques.
- Evaluate techniques based on criteria such as efficiency, theoretical framework, validated data, and application.
- Map methods by relevance, identifying offshore or onshore suitability and references.

The findings highlight the most relevant methods, their advantages, limitations, and specific applications.

Results and Discussion

Oil and gas prospecting methods fall into geological, geophysical, and geochemical

Received on 27 June 2024; revised 28 August 2024.
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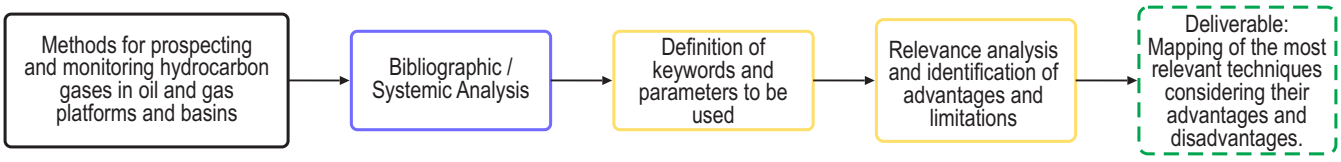
J Bioeng. Tech. Health 2024;7(3):306-308

Figure 1. Work flowchart.



categories. While geological and geophysical methods provide a qualitative overview, geochemical methods offer quantitative analyses, enhancing precision [6,7]. Table 1 presents an overview of essential techniques within each category.

Geological Methods

Typically the first step in prospecting, these methods use geological maps and sound data to identify potential hydrocarbon formations. While effective for initial assessments, they lack the precision needed for detailed exploration [4,8].

Geophysical Methods

Techniques like seismic surveys provide high-quality subsurface images, making them invaluable for complementing geological analyses. Advanced methods, such as 3D seismic imaging, offer enhanced accuracy but come with high costs and operational challenges [6].

Geochemical Methods

These techniques detect hydrocarbons released to the surface, providing direct evidence of oil and gas presence. They are particularly useful for

Table 1. Mapping of oil and gas prospecting techniques.

Methods	Techniques	Usage	Advantages	Limitations	Reference
Geological	Aerial Photogrammetry	On-shore/Off-shore	Detailed information about sedimentary basins	Indicates only the possibility of oil and gas activity, without guaranteeing acceptable levels of confidence.	4.6
	Photogeology	On-shore/Off-shore	Identification of structures favorable to oil accumulation		
Geophysical	Seismic	On-shore/Off-shore	Low cost compared to others and high-quality results on subsurface soil	Uses many sensors and devices to generate elastic waves (requires high manpower). Requires extensive data processing.	6.12
	Seismic 3D	On-shore/Off-shore			
	Seismic 4D	On-shore/Off-shore			
	Magnetometry	On-shore/Off-shore	Provides another perspective of analysis regarding magnetic anomalies	External influences in data reading and analysis (e.g., dissociated salt in the sea, fields generated by other sources)	9
	Electromagnetism	On-shore/Off-shore			
Geochemical	Pre Gas Analysis	On-shore	Practical and does not require sample treatment	Collection must be done between 1-10m from the surface for better results	3.9
	Adosrbed Gas Analysis	On-shore	Better results and more studies available	Requires sample treatment	10.9
	Dissolved Gas Analysis	On-shore/Off-shore	Used for prior leakage detection	Requires the presence of a water table and is less practical	3
	Microbiological Analysis	On-shore	Can be used in any type of region where other methods are ineffective	May be influenced by other volatile hydrocarbon generations	11.8

validating findings from geological and geophysical methods. However, their effectiveness depends on complementary data and environmental conditions [9].

Prospecting methods also monitor hydrocarbon leaks, as similar detection principles apply. This dual utility emphasizes the importance of continued innovation and integration of techniques to improve reliability and reduce risks.

Conclusion

The analysis reveals various prospecting techniques, each with distinct advantages and limitations. While newer methodologies are gaining prominence due to their precision and innovation, gaps still need to be found in their effectiveness across varying environments.

Combining multiple techniques is essential to achieving reliable exploration outcomes. This integrated approach ensures efficient resource allocation and aligns with the SDGs by promoting sustainable and responsible resource management.

Future research should focus on developing cost-effective, adaptable technologies that address current limitations and enhance the industry's capability to prospect and monitor hydrocarbons efficiently.

Acknowledgments

The authors thank Professor and Doctor Lílian Lefol for her guidance and the Centro Universitário SENAI CIMATEC for academic support. This research is supported by FINEP and the ANP PRH 27.1 program at SENAI CIMATEC.

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