



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 2, February 2025

Enhanced Oil Recovery in Visoka Oilfield: The Role of Nitrogen Injection in Heavy Oil Production

Ortenca Gropa^{1*}, Erison Karamani², Nevina Polo³

Assistant Lecturer, Department of Energy Resources, Polytechnic University of Tirana, Tirana, Albania¹

Assistant Lecturer, Department of Energy Resources, Polytechnic University of Tirana, Tirana, Albania²

Assistant Lecturer, Department of Energy Resources, Polytechnic University of Tirana, Tirana, Albania³

ABSTRACT: The Visoka oilfield, a mature reservoir in Albania, is characterized by heavy oil with high viscosity, making conventional recovery methods inefficient. As production declines due to the limitations of primary and secondary recovery, Enhanced Oil Recovery (EOR) techniques have become necessary to sustain and improve output. Among the various EOR methods, nitrogen injection has emerged as a promising solution for increasing oil recovery in Visoka. This paper explores the geological and reservoir characteristics of the Visoka oilfield, the challenges associated with heavy oil production, and the necessity of EOR techniques. It highlights nitrogen injection as a method that enhances oil displacement efficiency by reducing oil viscosity, improving sweep efficiency, and maintaining reservoir pressure. A case study of Well TOG 8 demonstrates the recent success of nitrogen injection in increasing oil production, showcasing its potential for broader application in the field. The study concludes that nitrogen injection is a viable EOR strategy for Visoka and similar heavy oil reservoirs, offering a sustainable approach to maximizing oil recovery and extending the economic life of the field.

KEYWORDS: Enhanced Oil Recovery (EOR), Nitrogen Injection, Heavy Oil, Visoka Oilfield, TOG 8.

I. INTRODUCTION

In 1963, the presence of oil-bearing Paleocene limestone was identified in the Patos-Marinza monocline during drilling operations at well G-622 (Kodhelaj, 2012). This discovery, later named the Visoka Field, played a crucial role in driving further exploration of carbonate reservoirs in Albania (Moci, 1995). The main productive horizon in the Visoka oilfield (Kodhelaj, 2012) is an Upper Cretaceous limestone of Eocene age, located at depths between 1000 and 1800 meters (Transoilgroup, 2023). The upper sections of these deposits are primarily composed of mudstone limestones in their upper sections, which transitions into grainstone formations, sliding layers, and clastic horizons, marking the transition to older geological formations (Transoilgroup, 2023).

The reservoir holds heavy crude oil with an API gravity between 5° and 16°, averaging around 10°. Historically, the field has been developed through more than 243 vertical wells, with approximately 98 of them currently in production, including both vertical and horizontal ones. Additionally, a significant portion of the remaining reserves (about 1/3 of them) is locked within inactive wells, which could potentially be reactivated for production (TerraOilSwiss, 2021). The inactivity of some wells may be due to poor connectivity with the hydrodynamic system through fracture networks, high initial water saturation, or complete losses during drilling-often linked to highly fractured or karstic zones. These conditions often require specialized extraction methods like dry shale pumping and resulting in reduced productivity (TerraOilSwiss, 2021).

Above the carbonate reservoir, a 30 - 35meter thick Marne transition layer acts as a protective seal, followed by a substantial sequence of Oligocene (Pg3) flysch deposits, which form an impermeable cap rock, effectively trapping hydrocarbons. The thickness of these flysch layers ranges from 600 to 700 meters. In the Paleocene and Cretaceous formations, the proportion of grainstone and clastic components increases, leading to an improvement in the reservoir's storage and flow characteristics (TerraOilSwiss, 2021).

Structurally, the southern section of the field extends southeastward, forming a pericline with a gentle dip of 10°-12°. This extension, combined with other geological factors, has played a role in creating a trapping mechanism that

accumulates oil and gas in this part of the structure. The upper tectonic unit presents itself as a monocline trending north-northwest, with a dip angle of approximately 10° - 12° in that direction (Kodhelaj, 2012).

The oil extracted from the Visoka field has a specific gravity ranging between 0.990 and 1.013 g/cm³ (TerraOilSwiss, 2021), classifying it as ultra-heavy crude with viscoplastic, non-Newtonian properties, making its extraction and processing more complex.

Heavy crude oil represents an essential hydrocarbon resource worldwide. Traditional oil production generally follows three main phases: primary, secondary, and tertiary recovery. In both light and heavy oil reservoirs, the initial phases primarily rely on natural drive mechanisms and water injection. However, these conventional techniques are mostly effective for lighter heavy oils and shallow, homogeneous reservoirs. Consequently, a significant portion of heavy and extra-heavy crude remains trapped in deeper, more heterogeneous formations. To efficiently extract these challenging reserves, advanced Enhanced Oil Recovery (EOR) techniques must be implemented. Over the years, various EOR strategies have been developed, mainly categorized into thermal and chemical methods (Sun, 2024).

Enhanced Oil Recovery (EOR) refers to any method applied beyond the initial production stage to extract additional crude oil. It encompasses techniques aimed at increasing the reservoir's drive mechanism to improve overall recovery rates. By definition, EOR includes all processes that enhance cumulative oil production to maximize hydrocarbon extraction (Al-Anazi, 2007).

II. LITERATURE SURVEY

The Visoka oilfield is situated in central Albania, approximately 5 km southeast of the town of Fier. Structurally, it lies within the North Ionian zone, specifically in the Pre-Adriatic depression, which was formed between the Late Eocene and Pliocene as part of the regional fold-thrust belt. The oilfield extends in a north-southwest direction, covering an area of about 40 km², (TerraOilSwiss, 2021) measuring 13 km in length and 4 km in width (Transoilgroup, 2023). The location of the work area is illustrated in Figure 1. (TerraOilSwiss, 2021).

The Visoka reservoir consists of porous and non-porous bioclastic limestones and mudstones, dating from the Cretaceous to the Neogene Eocene. It is relatively shallow, with depths ranging from 800 to 1600 meters, and is divided into distinct stratigraphic packages. The primary reservoir space is formed by fractures and localized dissolution pores, resulting in a heterogeneous distribution across the reservoir. Fracture intensity varies, with a more complex and well-developed fracture system in the mid-southern region, while the northern section exhibits relatively fewer fractures. High-yield wells are often located near low-yield or dry wells within these fractured zones, highlighting the reservoir's complexity. The average matrix porosity is around 2%, with fracture porosity also averaging 2%, and the effective permeability is measured at $200 \times 10^{-3} \mu\text{m}^2$ (Transoilgroup, 2023).

The stratigraphy of the reservoir is categorized into four packages from top to bottom (Figure 2):

- Package 1: 80 m thick, with 1.7% porosity, characterized by a high degree of fracture development.
- Package 2: 65 m thick, with 2.2% porosity.
- Package 3: 120 m thick, with 8.1% porosity, classified as a tight formation.
- Package 4: 140 m thick.

The reservoir has moderate thickness, with thinning edges, rapid thickness variations, and strong heterogeneity (Transoilgroup, 2023).

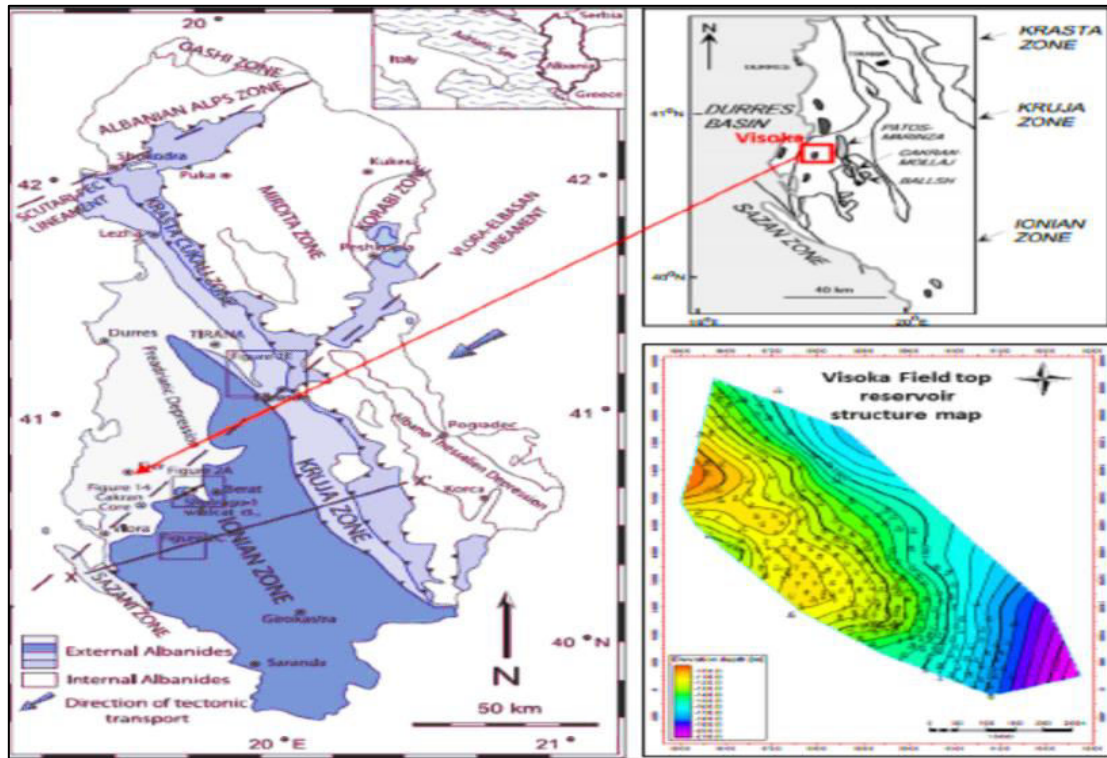


Figure 1. Map of Work Area Location (Transoilgroup, 2023), (TerraOilSwiss, 2021)

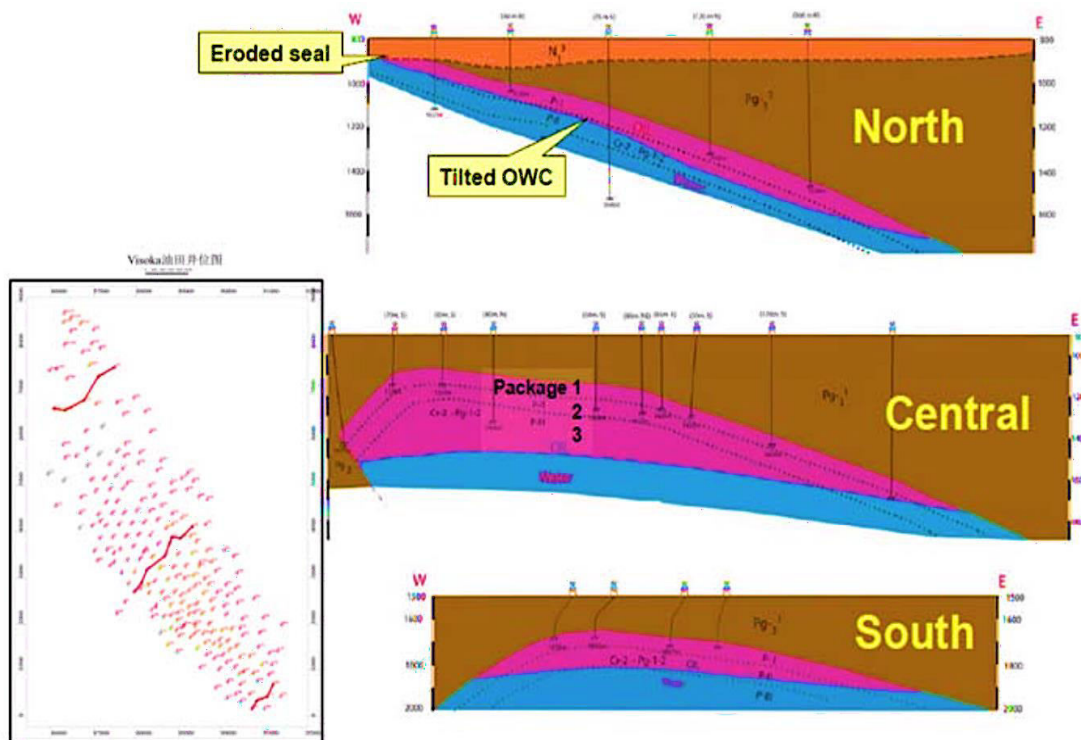


Figure 2. Geological Cross-Section of the Visoka Oilfield (Transoilgroup, 2023), (TerraOilSwiss, 2021)

Table 1 Key Reservoir Parameters of the Visoka Oilfield (Transoilgroup, 2023)

Oil-bearing area (km ²)	40	Production method	Open hole completion
Estimated reserves (MMbbl)	601	Drive mechanism	Bottom aquifer drive+depletion drive
Reservoir depth (m)	800-1600	Initial reservoir pressure (MPa)	14.4
Oil-water contact depth (m)	1150-1800	Saturation pressure (MPa)	8.9
Oil-bearing formations	Creataceous-eocene	Current reservoir pressure (MPa)	/
Reservoir thickness (m)	370-420	Matrix porosity (%)	2
Rock type	Bioclastic particless limestone+packstone	Fracture porosity (%)	2
Surface crude oil density (gr/cm ³)	1.0168	Effective permeability (x10 ⁻³ μm ²)	200

Table 2 PVT (Pressure-Volume-Temperature) parameters (Transoilgroup, 2023)

Pressure coefficient	1.03	Water type (shallow/deep)	NaHCO ₃ /MgCl ₂
Formation temperature (°C)	42-50	Gas-to-oil ratio (m ³ /t)	40
API gravity	7-16	Sulfur content (%)	5-6.1
Crude Oil density (g/cm ³)	1.0168	Asphaltenes content (%)	10
Viscosity at 50°C (mPa*s)	30320-98000	H ₂ S concentration (PPM)	10
Reservoir oil viscosity (mPa*s)	60-150	Pour point (°C)	15
		Salinity (mg/l)	11000-110000

1.2 The Need for innovative recovery methods

Heavy oils are dense, viscous type of crude with a high asphalt content, typically having an API gravity between 10° and 20° and a viscosity exceeding 100 cP. Bitumen and oil sands share similar properties but are even denser and more viscous, with API gravity below 10° and viscosities often exceeding 10000 cP. Due to their high viscosity and density, extracting, processing, and transporting these unconventional crude oils require significantly more energy, making their production more expensive (Shah, 2010).

Throughout the lifespan of an oilfield (Alagorni, 2015) oil recovery occurs in three main stages (AI-Anazi, 2007):

1. Primary Recovery – Oil flows naturally to the surface due to existing reservoir pressure.
2. Secondary Recovery – Water/gas is injected to maintain pressure and displace the oil.
3. Tertiary Recovery – Also known as Enhanced Oil Recovery (EOR), this stage uses advanced methods such as CO₂ or nitrogen injection, steam flooding, and chemical treatments to extract remaining oil (AI-Anazi, 2007), (Tileuberdi N. A.-D., 2024).

Initially, in the primary stage, oil flows naturally due to natural reservoir pressure to the surface. However, as pressure declines, water injection is introduced in the secondary stage to maintain pressure and push oil towards production wells. Together, primary and secondary recovery methods typically extract less than one-third of the original oil in place (OOIP). To enhance recovery, EOR techniques are implemented, potentially increasing total recovery to 40-60% of the reservoir's oil (Alagorni, 2015). EOR, often referred to as tertiary recovery or Improved Oil Recovery, enhances oil displacement by either reducing viscosity to improve flow or applying pressure to move oil through the reservoir. The process also improves sweep efficiency, ensuring a larger portion of the reservoir is contacted during extraction. The three main categories of EOR are (Shah, 2010):

- Miscible displacement (e.g., CO₂ or nitrogen injection)
- Chemical flooding (e.g., polymer, surfactant-polymer, or alkaline-surfactant-polymer formulations)
- Thermal recovery (e.g., steam injection) (Shah, 2010).

One widely used EOR method is gas injection, which involves injecting gas into the reservoir to enhance oil mobility. If the gas is injected at or above the minimum miscibility pressure (MMP), it mixes with the oil and is called miscible gas injection. If injection occurs below MMP, the gas remains separate from the oil, known as immiscible gas injection. The ability of gas to mix with oil depends on factors such as composition, fluid properties, pressure, and temperature. One of the most commonly used gases in this process is nitrogen (N₂). Nitrogen has been successfully applied in oilfield operations for pressure maintenance, gas cycling, and gas lift (Al-Anazi, 2007).

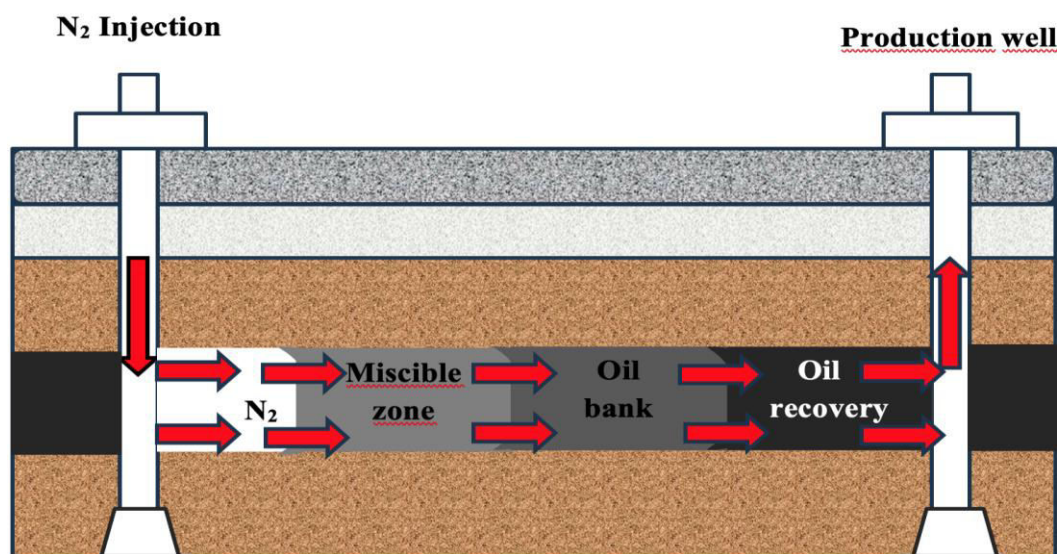


Figure 3. A schematic illustration of the Nitrogen Injection method

Compared to CO₂ injection, nitrogen injection operates on a similar principle but is less effective at dissolving in oil. However, nitrogen is more cost-effective, making it a viable alternative for large-scale, high-pressure injection projects. At high pressures, lighter hydrocarbons (C₂ to C₆) in the crude oil evaporate, forming a miscible mixture, but the technique is generally limited to reservoirs deeper than 1372 meters (Shah, 2010).

In Albania, a nitrogen injection project has been implemented in the Visoka oilfield by TerraOil Swiss company, showing positive results in enhancing oil recovery. This method has improved oil mobility by reducing viscosity and maintaining reservoir pressure.

1.3 Nitrogen injection as an Enhanced Oil Recovery (EOR) method

Recent advancements in thermal recovery methods include N₂-steam hybrid technology, CO₂-enhanced thermal production techniques, and hybrid thermochemical steam flooding. Research has shown that introducing non-condensable nitrogen can significantly minimize heat loss to surrounding rock formations, both above and below the reservoir (Sun, 2024).

Since the 1950s, nitrogen (N₂) has played a crucial role in the oil industry, particularly in well completions. One of its key applications is nitrogen miscible flooding, which operates similarly to CO₂ flooding but with lower miscibility (Anikin, 2024). Despite this limitation, nitrogen has several advantages as an injection gas. Being inert and non-corrosive, nitrogen requires extremely high pressures to become miscible, but once achieved, it effectively reduces oil viscosity and enhances displacement. Due to the cost and availability constraints of natural gas and CO₂, nitrogen has become a viable and economical alternative for miscible gas displacement in oil recovery (Alagorni, 2015).

A major benefit of nitrogen injection is its low cost, which allows for large-scale gas injection at high pressures. At these pressures, the lighter hydrocarbons in the crude oil (C₂ to C₆) evaporate, forming a miscible phase. Additionally, the injected fluid dissolves into the oil, either on first contact or through multiple contacts, reducing interfacial tension and improving oil displacement at the microscopic level. This process also helps maintain reservoir pressure, while the expansion of dissolved gases further enhances oil flow. A narrow transition zone (mixing zone) forms between the injected gas and the reservoir oil, leading to a piston-like displacement. As the process progresses, this mixing zone expands, influencing the overall efficiency of the flood (Shah, 2010).

Commonly used gases for displacement in EOR include high-pressure nitrogen (N₂), carbon dioxide (CO₂), methane (CH₄), methane enriched with light hydrocarbons, and liquid petroleum gas (such as propane, C₃H₈). However, a key drawback of this method is that its efficiency declines as oil density and viscosity increase. Because gas naturally rises due to its low density, it tends to accumulate at the top of the reservoir, making this approach more suitable for lighter oil types rather than heavy crude (Shah, 2010).

Studies have shown that the difference in oil recovery efficiency between N₂ and CO₂ flooding is more pronounced in large pores than in small ones. However, when comparing their performance at different pressures, the trend remains consistent across both small and large pores. While pore size has only a minor impact on recovery variation, displacement pressure plays a crucial role. CO₂ flooding generally results in higher recovery rates in larger pores compared to N₂ flooding (Tileuberdi N. A.-D., 2024).

The cost and supply limitations of natural gas and CO₂ have made nitrogen an increasingly preferred choice for enhanced oil recovery through miscible gas displacement. Compared to CO₂ or hydrocarbon-based gases, nitrogen is cheaper, non-corrosive (Al-Anazi, 2007), and widely available, making it particularly advantageous in deep, high-pressure reservoirs containing light to medium oil (C₁ to C₇ components). However, nitrogen requires a higher minimum miscibility pressure (MMP) than other injection gases, which makes it less suitable for offshore applications, except in cases where it is used for reservoir pressurization (Anikin, 2024).

III. METHODOLOGY

The table above presents data on well TOG-8 in Visoka oilfield, which has been treated using the nitrogen injection method. The oil production column compares the average daily production (tons/day) before and after injection, as well as the actual production over time, demonstrating how the injection process has helped sustain production levels.

This method has significantly improved oil mobility by introducing nitrogen gas and surfactant chemicals, which help reduce fluid viscosity. As a result, TOG-8 has been producing approximately 3 tons/day for 3.6 years, significantly reducing water content in the extracted fluid (Transoilgroup, 2023).

Table 3 Production Data for Well TOG 8, January 2015-July 2020

Well	Pumps	Production Data Overview	Average daily production (tons/day)
TOG 8	PCP	Production Start Date – January 2015	6.107
TOG 8	PCP	December 2015	4.981
TOG 8	PCP	January 2016	4.954
TOG 8	PCP	December 2016	2.439
TOG 8	PCP	January 2017	2.493
TOG 8	PCP	December 2017	1.597
TOG 8	PCP	January 2018	1.418
TOG 8	PCP	December 2018	0.63
TOG 8	PCP	January 2019	0.68
TOG 8	PCP	December 2019	2.29
TOG 8	PCP	January 2020	2.54
TOG 8	PCP	July 2020	1.42

Table 4 TOG 8 Production Report, December 2022

Well	Injection Method	Injection Duration		Oil Production (tons/day)		12/31/2022	
		Start Date	End Date	Before Injection	After Injection	Current Production	Exploitation Time (Months)
TOG 8	N ₂ Injection	03/16/2022	06/16/2022	0.80	3.00	3.00	6

IV. EXPERIMENTAL RESULTS

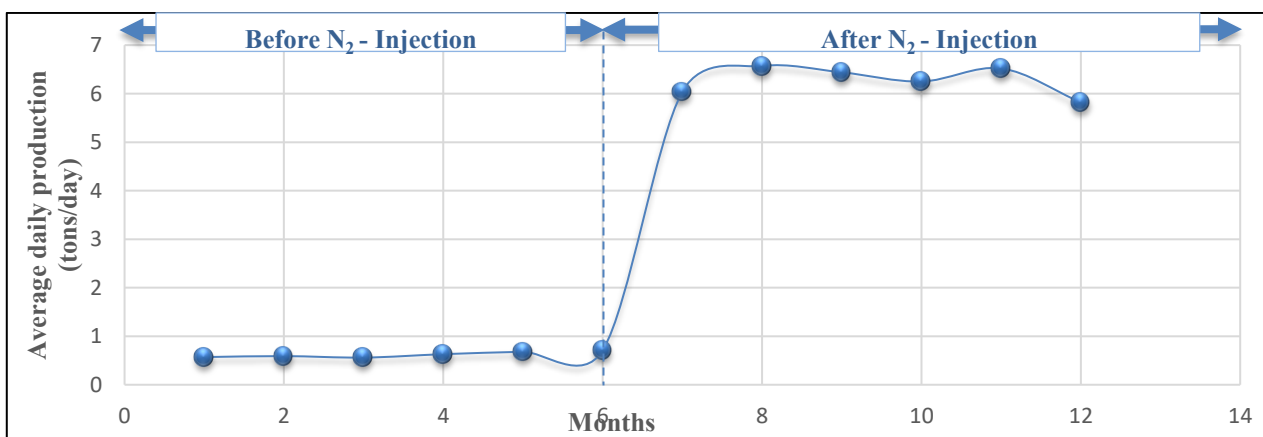


Figure 4. TOG 8 – Comparison of Production Rates in Well TOG 8, Before and After Nitrogen Injection

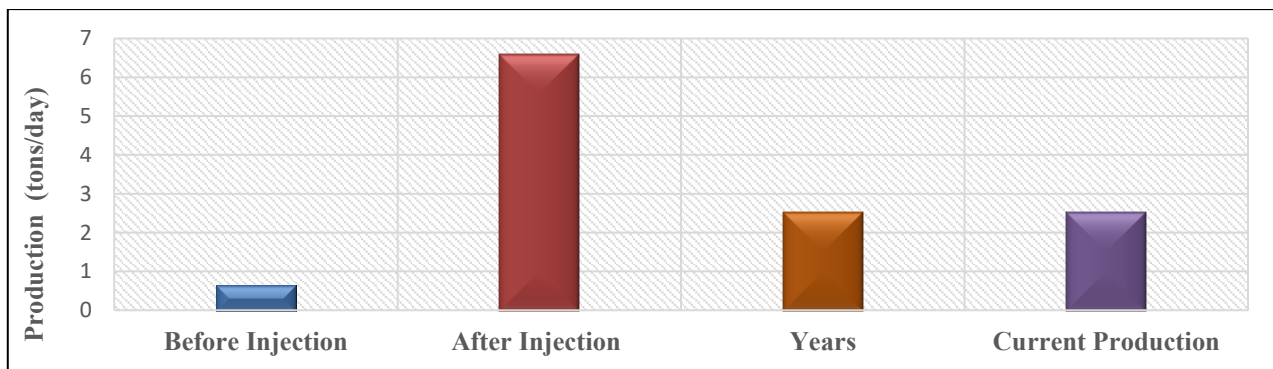


Figure 5. Enhancement of Well TOG 8 Productivity Using Nitrogen Injection

Based on the data from Table 4 for well TOG 8, the oil production curve over a period (six months before and six months after nitrogen injection), as shown above in Figure 4 and Figure 5, indicates an improvement in the oil recovery factor and, consequently, the effectiveness of the injection method used. It is clearly observed that production increased by 3 tons/day after nitrogen injection.

V. CONCLUSION

The presence of large reservoirs with substantial condensate reserves increases the necessity of implementing efficient recovery methods. One such approach is nitrogen injection, which is used for pressure maintenance in gas-condensate reservoirs or caps to enhance condensate recovery. Nitrogen is one of the most readily available and highly effective agents for enhancing oil and condensate recovery due to its favorable chemical and physical properties, as well as its widespread availability. The effectiveness of nitrogen in oil displacement is further improved by its ability to be injected

at high pressures in deep reservoirs and the presence of light hydrocarbons such as methane and its homologs in the reservoir oil, which support miscible displacement processes.

Additionally, its cost efficiency and local availability make it a more economical option compared to other gases used in enhanced oil recovery (EOR). Furthermore, nitrogen is an environmentally friendly alternative that supports sustainable reservoir management. Given its widespread availability and low risk of corrosion, nitrogen injection is expected to play an increasingly important role in future oil recovery projects, contributing to the sustainable management of hydrocarbon resources (Tileuberdi N. M., 2023).

Overall, some key benefits of nitrogen injection include:

- Cost-effectiveness – Can be generated in large quantities under various conditions (Anikin, 2024), particularly in high-pressure reservoirs (Tileuberdi N. M., 2023).
- Environmental safety – Chemically inert and does not react with water. Research indicates that nitrogen injection can lead to the recovery of 45% to 90% of the original oil in place (OOIP) (Anikin, 2024).
- Operational safety – No-corrosive and no-flammable, reducing equipment degradation (Anikin, 2024), which make it a reliable solution for reservoir rocks and well infrastructure (Tileuberdi N. M., 2023).

The method of nitrogen injection in Visoka oilfield characterized by heavy crude oil, has shown success in enhancing oil recovery, by reducing oil viscosity, improving sweep efficiency, and maintaining reservoir pressure. A case study of Well TOG 8, for instance, demonstrates that nitrogen injection increased production from 0.8 tons/day to 3 tons/day over a 3.6 years.

REFERENCES

1. TerraOilSwiss. (2021). Visoka Oilfield TOG-8, Nitrogen Injection Stimulation Program. Albania: Europe Tavaa Oil Royal Energy Ltd.
2. Transoilgroup. (2023). Shtojcë e Draft-Program zhvillimi dhe buxheti për vitin 2024, TerraOilSwiss. Albania: Europe Tavaa Oil Royal Energy Ltd.
3. Sun, H., Wang, H., Cao, X., Shu, Q., Fan, Zh., Wu, G., Yang, Y., Wu, Y. (2024). Innovations and applications of the thermal recovery techniques for heavy oil. *Energy Geoscience*, 1-12.
4. Kodhelaj, N., Bode, A., Zoga, P., Koja, N., Zeqo, E. & Zeqiraj, D. (2012). The Surface Distribution of Oil Spills, the Environmental Status of the Visoka Oilfield, Its Rehabilitation Ways: Case Study. UBT International Conference, 71. (pp. 487-493). Prishtina, Kosovo: UBT Knowledge Center.
5. Tileuberdi, N., Mashrapova, M., & Toktarbay, Zh. (2023). A Review on Nitrogen Flooding for Enhanced Oil Recovery. *Engineered Science Publisher LLC*, 1-12.
6. Shah, A., Fishwick, R., Wood, J., Leeke, G., Rigby, S., & Greaves, M. (2010). A review of novel techniques for heavy oil and bitumen extraction and upgrading. *Energy & Environmental Science*, 700-714.
7. Moci, A., & Marko, Dh. (1995). Oil production history in Albania oil fields and their perspective. Retrieved from [web.archive.org](https://web.archive.org/web/20110727141944/http://www.oildrop.org/Info/Centre/Lib/6thConf/19950003.pdf):
<https://web.archive.org/web/20110727141944/http://www.oildrop.org/Info/Centre/Lib/6thConf/19950003.pdf>
8. Tileuberdi, N., AL-Dujaili, A. N., Mashrapova, M., Togizov, K., Sanatbekov, M., & Auyelkhan, Y. (2024). Optimizing Oil Recovery by Low-Pressure Nitrogen Injection: An Experiment Case Study. *Engineered Science Publisher LLC*, 1-13.
9. Anikin, O. V., Derevyanko, V. K., Bolotov, A. V., Minkhanov, I. F., Varfolomeev, M. A., Konstantinovich, E. A., Kadyshcheva, V. A. (2024). Gas enhanced oil recovery methods for offshore oilfields: Features, implementations, operational status. *Petroleum Research xxx (xxxx) xxx*, 1-12.
10. Alagorni, A. H., Yaacob, Z. B., & Nour, A. H. (2015). An Overview of Oil Production Stages: Enhanced Oil Recovery Techniques and Nitrogen Injection. *International Journal of Environmental Science and Development*, 693-701.
11. AI-Anazi, B. D. (2007). Enhanced Oil Recovery Techniques and Nitrogen Injection. *CSEG RECORDER*, 28-33.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details