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CRUDE OIL MANAGEMENT INTO DIESEL FUEL IN WONOCOLO VILLAGE: LOCAL WISDOM, ENVIRONMENTAL RISKS, AND LEGAL FRAMEWORK GAPS

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ABSTRACT

The management of crude oil into diesel in Wonocolo Village, Bojonegoro, is a traditional practice inherited from the Dutch colonial era, combining local wisdom with the community's historical values. The background of this study arises from the need to understand how traditional oil processing practices impact the environment and how legal gaps affect the sustainability of these activities. This study aims to analyze diesel management in Wonocolo Village from the perspectives of local wisdom, environmental risks, and compliance with regulations, particularly Permen ESDM 2025. The method used is a qualitative approach, with data collected through in-depth interviews with seven respondents, field observations of processing facilities, and document studies related to regulations and alternative fuels such as biofuel and green diesel. The results indicate that traditional practices remain effective in producing diesel with high community involvement, but pose significant environmental risks due to liquid and solid waste being discharged directly into soil and waterways. In addition, limited regulatory knowledge creates a legal grey area. This study emphasizes the need to integrate local wisdom, technological modernization, environmental education, and adaptive regulations to establish sustainable, safe, and legally compliant diesel management practices.

Keywords: diesel management; local wisdom; environmental impact; regulation; Wonocolo Village.

INTRODUCTION

Since the era of modern industry, fossil fuels such as petroleum and diesel have served as the backbone of the global economy due to their vital roles in transportation, energy production, and various industrial sectors (Sangeetha et al., 2022). However, the heavy dependence on fossil fuels has created a range of strategic challenges, from limited reserves and price volatility in international markets to significant environmental impacts (Sui et al., 2023). Air pollution, soil and water contamination, and greenhouse gas emissions are among the negative consequences of the massive exploitation and consumption of fossil fuels (Eremeeva et al., 2023). The advancement of science and technology has driven the search for more environmentally friendly and renewable energy alternatives, including the development of biofuels, green diesel, bioethanol, and various other forms of green fuels that have the potential to reduce dependence on fossil resources while minimizing ecological impacts (Iskandar et al., 2021). This phenomenon reflects a global shift toward the concept of sustainable energy and green technology, emphasizing the importance of balancing human needs, environmental preservation, and economic sustainability (Garcia-Garcia et al., 2024).

Beyond technological and environmental aspects, social, cultural, and economic factors also play a crucial role in energy resource management (Adeola et al., 2022). Human activities related to fuel processing, whether on an industrial or community scale, are often influenced by local wisdom, social norms, and traditional practices that have evolved over generations (Aljaafari et al., 2022). Such local wisdom often encompasses efficient natural resource management, environmental quality maintenance, and collaborative mechanisms among community members (Nilawati, 2023). Studies indicate that integrating local knowledge with modern technology can produce more effective, safe, and sustainable management models (Pal & Sen, 2024). However, the gap between traditional knowledge and modern technical standards remains a challenge, making technological innovation and adaptive regulation essential factors to ensure that energy resource management can proceed sustainably without disregarding existing cultural and social values (Pal & Sen, 2024).

Legal and regulatory dynamics also significantly influence energy and fuel management. Clear and consistent regulations are required to govern production, distribution, and fuel usage, including waste processing mechanisms, product quality standards, and occupational safety (George et al., 2024). Regulatory ambiguity or legal gaps often lead to natural resource management practices operating within a legal grey area, which can pose legal risks, social conflicts, and environmental degradation (Wati et al., 2021). Overly rigid regulations that fail to consider local conditions may hinder innovation and reduce community participation (Hesti et al., 2021). Therefore, the design of adaptive and contextual policies that accommodate social and cultural values, as well as sustainability principles, is essential to support holistic fuel and energy resource management (Omozue, 2021).

At the global level, energy issues are closely linked to the Sustainable Development Goals (SDGs), including targets to reduce carbon emissions, improve energy efficiency, and ensure affordable and clean energy access for all (Olujobi et al., 2022). Scientific research in this field increasingly emphasizes the importance of innovation in fuel processing, the use of green technologies, and the utilization of renewable resources (Tahamata & Hattu, 2024). The concepts of circular economy and waste-to-energy have emerged as attractive models because they enable waste to be reprocessed into fuel or energy, thus reducing environmental impact while increasing economic value (Yanti, 2022). These developments also encourage collaboration among various stakeholders including governments, industries, academics, and communities to create more efficient and sustainable energy systems (Bayramoğlu & Nuran, 2024).

Several previous studies have explored oil processing into alternative fuels using different approaches. Fahmi et al. (2022), in their study *"Biofuels as Substitutes for Fossil Fuels (Biofuel: Biodiesel, Bioethanol, BioAvtur, Green Diesel, Green Gasoline, Green Avtur)"*, emphasized that Indonesia still relies heavily on crude oil imports, making the development of green gasoline from palm oil refineries a strategic solution for national energy security. Lutfi (2021), in *"Utilization of Used Oil Waste into High-Speed Diesel (HSD) Fuel"*, discussed that HSD derived directly from crude oil differs from that produced through used oil waste processing, which requires technology capable of maintaining fuel quality. Furthermore, Iskandar et al. (2021) examined the recycling of HDPE plastic waste into diesel through a pyrolysis process, demonstrating the potential of petroleum as an alternative fuel source that can be combined with plastic waste. Yudhistira & Wibowo (2022) discussed green diesel as a renewable liquid fuel derived from used cooking oil and hydrocarbon blends, emphasizing the importance of environmentally friendly processing. While all these studies

focus on fuel innovation, few have highlighted local wisdom practices and the management of traditional crude oil processing in rural areas such as Wonocolo Village, which possesses historical significance and environmental relevance.

Wonocolo Village in Bojonegoro has oil wells and diesel processing facilities that have remained operational since the Dutch colonial era; however, these activities face several complex issues. First, the crude oil processing practices in the village pose environmental risks, including soil and water contamination from oil spills or industrial waste, which can affect the local ecosystem. Second, although this activity carries historical value and represents the local community's wisdom, there is no clear legal framework or regulation explicitly governing diesel production and distribution at the village level. This legal uncertainty creates ambiguity for local operators and residents, including whether such activities qualify as MSMEs under the 2025 Ministry of Energy and Mineral Resources Regulation (Permen ESDM 2025). Third, the socioeconomic impacts of this practice have not been fully optimized due to the limited integration between local wisdom, modern technology, and environmental risk management.

This research aims to comprehensively analyze the management of crude oil processing into diesel in Wonocolo Village through the perspectives of local wisdom, environmental impact, and legal framework gaps. Specifically, it seeks to identify traditional oil processing practices, assess the associated environmental risks, and evaluate the relevance and adequacy of existing regulations, including Permen ESDM 2025, in supporting such activities. The study also aims to provide recommendations that integrate the preservation of local wisdom, environmental protection, and legal certainty so that diesel management in Wonocolo Village can proceed sustainably and with environmental awareness.

The urgency of this research arises from the need to balance industrial heritage preservation, local wisdom conservation, and environmental protection in Wonocolo Village. Given the traditional nature of its operations, the risks of pollution and environmental degradation are high, while the absence of a clear legal framework creates social and economic uncertainty for the local community. This study is crucial to provide a scientific foundation for formulating both local and national policies that support safe, efficient, and sustainable oil processing practices. The urgency also relates to Indonesia's need to balance energy security with natural resource preservation, aligning with global trends toward renewable fuels and environmentally friendly industrial practices.

The novelty of this research lies in its integration of three dimensions that are rarely studied simultaneously: local wisdom, environmental impact, and legal framework gaps in managing crude oil into diesel at the village level. Most previous studies have focused on biofuel or green diesel development, or the conversion of industrial waste into alternative fuels, without considering the historical, social, and cultural contexts of local communities. This research offers a unique perspective by combining the traditional oil processing practices of Wonocolo Village, which have been operating since the Dutch era, with environmental risk analysis and regulatory evaluation, thereby providing a foundation for contextual, sustainable, and culturally respectful policy recommendations.

RESEARCH METHODS

This study employs a qualitative research method with a descriptive approach to gain an in-depth understanding of the practices involved in managing crude oil into diesel in Wonocolo Village, Bojonegoro, as well as its implications for local wisdom, environmental impact, and legal framework gaps. Data were collected through direct field observations of oil wells and processing facilities, in-depth interviews with residents, business operators, and village officials, as well as document studies related to the 2025 Ministry of Energy and Mineral Resources Regulation (Permen ESDM 2025), literature on renewable fuels, and previous studies on biofuels, green diesel, and *waste-to-fuel* processing. Data analysis was conducted using content analysis and thematic analysis methods to identify patterns of local wisdom practices, potential environmental risks, and existing legal gaps. The results of this study are expected to provide a holistic overview of traditional diesel management practices in Wonocolo Village while serving as a foundation for sustainable and context-based policy recommendations.

RESULTS AND DISCUSSION

Results

This study aims to explore the management of crude oil processing into diesel in Wonocolo Village, Bojonegoro, emphasizing the integration of local wisdom, environmental impact, and legal framework gaps. The research employs a qualitative approach, collecting data through in-depth interviews with seven respondents, field observations of oil wells and processing facilities, and document analysis related to the 2025 Ministry of Energy and Mineral Resources Regulation (Permen ESDM 2025) as well as literature on alternative fuels such as biofuels and green diesel. The focus of the study includes traditional oil processing practices dating back to the Dutch colonial era, potential risks of environmental pollution, and the understanding of legal compliance among community members and business operators. Through this approach, the study is expected to provide a comprehensive overview of traditional diesel processing practices while serving as a foundation for sustainable policy recommendations that respect local cultural values.

Table 1. Characteristics of Respondents

No	Characteristics	Number of Respondents	Percentage (%)
1	Age 20–30 years	2	28.6
2	Age 31–40 years	3	42.9
3	Age 41–50 years	1	14.3
4	Age >50 years	1	14.3
5	Gender: Male	5	71.4
6	Gender: Female	2	28.6
7	Oil processing business operator	4	57.1
8	Supporting worker/resident	3	42.9

Based on Table 1, the majority of respondents are aged 31–40 years (42.9%), indicating that the productive age group serves as the main workforce in diesel oil processing activities in Wonocolo Village. Male respondents dominate (71.4%), reflecting the physically demanding nature of traditional oil processing, which remains largely male-oriented. Most respondents are oil processing business operators (57.1%), while the remaining 42.9% are supporting workers or local residents, illustrating the collective community involvement in oil processing activities. With this respondent distribution, the collected data are considered representative for analyzing local wisdom, environmental risks, and legal framework gaps within the village context.

Table 2. Observation Results on Crude Oil Management into Diesel in Wonocolo Village

No	Observation Aspect	Field Findings	Impact / Notes
1	Processing Infrastructure	Facilities still use machinery from the Dutch colonial era, with partial simple modernization	Low efficiency, high risk of leakage
2	Production Process	Crude oil is processed into diesel through filtering, heating, and distillation	Traditional processes generate liquid and solid waste
3	Waste Management	Oil waste is discharged into the soil and open drainage channels	Significant risk of soil and water pollution
4	Local Wisdom	Processing practices are inherited through generations, using natural filtration methods	Preserves tradition but does not yet meet modern environmental standards
5	Legal Compliance	No official permits or specific regulations from Permen ESDM 2025	Legal gap; potential sanctions if inspected
6	Health and Safety	Minimal use of personal protective equipment, high risk of accidents	Requires education and proper occupational safety procedures (SOPs)
7	Community Involvement	Most residents serve as supporting workers and informal supervisors	High community engagement; potential for participation in environmental preservation efforts

Observations in Wonocolo Village reveal that the management of crude oil into diesel is still heavily influenced by traditional practices inherited from the Dutch colonial era, with infrastructure largely relying on old machinery and only minimal modernization. As a result, production efficiency remains low, and the risk of leakage is quite high. The production process involves manual filtering,

heating, and distillation, generating both liquid and solid waste that is directly discharged into the soil or open drainage channels, posing a significant risk of soil and water contamination to the surrounding environment. Although the community applies local wisdom in their filtering methods to preserve tradition, these practices do not yet comply with modern environmental standards or the 2025 Ministry of Energy and Mineral Resources Regulation (Permen ESDM), creating a legal gap that could lead to sanctions if reviewed. From a health and safety perspective, the use of personal protective equipment is minimal, increasing the risk of occupational accidents. However, community involvement remains high, as the majority of residents participate as support workers or supervisors, indicating a strong potential for environmental education and community engagement in promoting ecological preservation and production safety. This observation underscores that although diesel oil management in Wonocolo holds historical and cultural significance, technical interventions, regulatory reinforcement, and environmental education are still required to establish safer, more efficient, and sustainable practices.

Table 3. Interview Results from Respondents in Wonocolo Village

No	Main Question	Summary of Respondents' Answers	Notes / Impact
1	Knowledge about diesel oil processing	All respondents understand the stages of processing crude oil into diesel	Indicates a strong transfer of local wisdom
2	Perceived environmental impacts	5 out of 7 respondents mentioned odor and waste contaminating soil/water	Respondents are aware of pollution risks
3	Compliance with regulations	Only 2 respondents were aware of the 2025 Ministry of Energy and Mineral Resources Regulation (Permen ESDM)	Legal gap is clearly evident
4	Challenges in processing	Limited modern equipment and lack of safety training	Reduces efficiency and workplace safety
5	Suggestions for improvement	All respondents agreed on the need for environmental education and official regulations	Shows community potential for sustainable improvement

The interview results with seven respondents indicate that knowledge regarding the processing of crude oil into diesel remains strong, primarily because this practice has been passed down through generations and has become part of the local wisdom in Wonocolo Village. Most respondents (5 out of 7) were aware of environmental impacts such as odor, soil contamination, and waste discharge into open channels, reflecting ecological awareness despite the persistence of traditional management practices. In terms of regulation, only two respondents were familiar with the 2025 Ministry of Energy and Mineral Resources Regulation (Permen ESDM), indicating a legal gap that may lead to potential sanctions and operational uncertainty. The main challenges identified include limited modern equipment and the lack of occupational safety training, which affect production efficiency and safety. All respondents suggested the need for environmental education and the implementation of official regulations to ensure that diesel oil processing practices remain sustainable, safe, and legally compliant, while also engaging the community in preserving local wisdom and environmental sustainability.

Discussion

Local Wisdom and Diesel Oil Processing Practices

Wonocolo Village in Bojonegoro has an oil industry heritage that has remained active since the Dutch colonial era, where the practice of processing crude oil into diesel is carried out using methods that combine simple technology and local wisdom. Observations and interviews indicate that the local community has developed technical skills in filtering and distilling crude oil using traditional facilities, which mainly consist of old machines, distillation tubes, and simple heating tools. This activity functions not only as a livelihood but also as a symbol of cultural heritage passed down through generations, fostering social identity and community values in the village. Respondents explained that the filtering methods using cloth and natural containers are part of local wisdom that allows the produced diesel to maintain relatively stable quality, even though it does not yet meet modern industrial standards. The knowledge transfer from generation to generation remains strong, forming the foundation for the sustainability of oil processing practices despite technical and infrastructural limitations.

Collective community involvement is one of the key aspects of this local wisdom practice. Most residents act as support workers or process supervisors, ensuring that each production stage is closely monitored by the community. This community-based monitoring helps maintain oil quality and minimizes the potential for work-related accidents. Such a system reflects the principles of community-based management, in which natural resource management is conducted through active participation of local residents. While this approach provides social and economic benefits, there are significant limitations in terms of efficiency, production capacity, and safety standards. The use of old machinery and manual tools results in lower productivity compared to modern processing, while the lack of personal protective equipment increases the risk of occupational accidents. Interviews also revealed that some business operators are aware of the need for modernization; however, limited capital and restricted access to technology hinder the adoption of innovative technologies.

The local wisdom practices in Wonocolo also possess a strong sociocultural dimension. Diesel oil processing activities are not merely a form of work but an integral part of tradition that shapes community identity, strengthens social cohesion, and preserves historical heritage. For instance, natural filtering and traditional heating methods continue to be used despite the availability of modern technological alternatives, as the values of heritage and respect for previous generations are prioritized. This condition indicates that integrating local wisdom with modern technology must be done carefully to avoid undermining cultural values while improving efficiency and safety. Therefore, this study emphasizes the importance of an integrated management approach that respects local wisdom while introducing best practices in oil processing, including safety training, product quality monitoring, and environmental education.

Wonocolo Village's crude oil-to-diesel processing practices, inherited through generations, blend traditional methods with local wisdom. Observations show that the community uses old machines, distillation tubes, and simple heating devices to refine crude oil into diesel. This activity serves not only as a source of livelihood but also as a symbol of cultural heritage that reinforces community identity. The filtering process using cloth and natural containers enables the production of diesel with relatively stable quality, even though it does not yet meet modern industrial standards. The process of knowledge transfer across generations ensures the continuity of these practices while strengthening the community's technical skills in oil management. Similar studies highlight the importance of integrating community-based management in traditional natural resource practices—for instance, Adeola et al. (2022) emphasize how oil exploration in Africa combines social and technical aspects to maintain sustainability, and Fahmi et al. (2022) discuss the use of crude oil–based biofuel to support energy resilience.

Collective community participation serves as the main foundation of this practice, with residents acting as support workers and process supervisors. Each production stage is closely monitored by the community to ensure product quality and minimize the risk of workplace accidents. Although this approach provides social and economic benefits, there are notable limitations in efficiency, production capacity, and occupational safety. The use of old machinery and manual tools results in lower productivity than modern processing methods, while the use of personal protective equipment remains minimal. This finding aligns with Lutfi (2021) and Iskandar et al. (2021), who noted that traditional or waste-based oil processing requires technological upgrades and safety training to improve efficiency and safety. Therefore, integrating local wisdom with modern technology must be carried out carefully so that heritage values are preserved, while best practices in oil processing and environmental education are introduced to the community.

Environmental Impacts and Legal Framework Gaps

In addition to the aspect of local wisdom, the management of crude oil into diesel in Wonocolo Village has significant environmental impacts. Based on field observations, liquid and solid waste from the distillation process is often discharged directly onto the ground and into open drainage channels, posing risks of groundwater and river contamination around the facilities. Oil waste and solid residues contain hydrocarbon compounds that are difficult to decompose, creating a high risk of soil contamination and local ecosystem degradation. Respondents acknowledged the presence of strong odors, changes in soil color, and potential health problems such as skin irritation and respiratory disorders. This condition indicates that although traditional practices are culturally effective, they remain inadequate in meeting modern environmental standards and thus require intervention through improved environmental management including waste treatment before disposal and the use of additional filtering technologies to minimize pollution.

Beyond physical impacts, gaps in the legal framework represent a serious issue affecting the sustainability of oil processing practices. Only a small portion of respondents were aware of the 2025 ESDM Ministerial Regulation (Permen ESDM 2025), reflecting limited understanding of legal compliance. Currently, the processing activities operate without official licenses, creating legal uncertainty and risks of administrative sanctions. This condition reveals that while traditional oil processing provides economic and social value, it has not yet been formally recognized, placing diesel management within a legal grey area. The absence of clear regulations also complicates the consistent application of environmental standards, as there are no formal guidelines for waste management, product quality monitoring, or occupational safety training.

Environmental impacts and legal gaps are closely interconnected. The lack of formal regulation prevents traditional processing practices from evolving toward more environmentally friendly methods, while the waste produced continues to pose risks to the community and local ecosystems. This underscores the need for a policy integration strategy in which both local and national regulations are adapted to local wisdom and community capacities. For example, implementing community-based business licenses, environmental education programs, and occupational safety training can enhance legal awareness and reduce ecological impacts. This study highlights the importance of a holistic approach that integrates social, cultural, technical, and legal dimensions, ensuring that diesel oil processing practices are not only economically sustainable but also environmentally safe and legally legitimate.

Traditional diesel oil management in Wonocolo has led to notable environmental consequences. Field observations reveal that liquid and solid waste from the distillation process is often discharged directly into the ground and open channels, resulting in soil and water contamination risks. The waste contains hydrocarbon compounds that are resistant to degradation, posing threats to local ecosystems and public health, including skin irritation and respiratory problems. These findings align with those of Aljaafari et al. (2022) and Eremeeva et al. (2023), who emphasized that diesel production—even from alternative sources continues to cause environmental harm when waste management is inadequate. This condition demonstrates that although traditional practices remain culturally significant, they fail to meet modern environmental standards, necessitating interventions in environmental management, such as pre-disposal waste treatment, additional filtration technology, and quality monitoring to mitigate ecological risks.

In addition to physical impacts, legal gaps remain a serious barrier to the sustainability of oil processing activities. Most respondents were unaware of the 2025 ESDM Ministerial Regulation, meaning the processing activities continue without official licensing, creating a legal grey area with potential administrative sanctions. The absence of clear regulation also hinders consistent enforcement of environmental and occupational safety standards. These findings are consistent with studies by Olujobi et al. (2022) and Nilawati (2023), which highlight the negative effects of illegal oil processing on the economy and environment due to weak legal oversight. Environmental impacts and regulatory gaps are interrelated the lack of regulation enables traditional practices to persist without adopting environmentally friendly modifications, while waste production exacerbates risks to communities and ecosystems. A policy integration strategy that aligns regulations with community capacities and local wisdom is therefore essential, such as through community-based business licensing, environmental education, and safety training programs. This holistic approach ensures that diesel oil processing practices are not only economically sustainable but also ecologically safe and legally compliant, while preserving the community's cultural heritage values.

CONCLUSIONS

The management of crude oil into diesel in Wonocolo Village, Bojonegoro, represents a unique practice that integrates local wisdom with the industrial legacy of the Dutch colonial era, serving both as a source of livelihood and a symbol of the community's cultural heritage. This traditional practice remains effective in producing diesel fuel, with a high level of community involvement both as business operators and supporting workers reflecting a strong principle of community-based management. However, this study also identified several significant challenges, including technological limitations, low production efficiency, limited use of personal protective equipment, and environmental pollution risks stemming from the disposal of liquid and solid waste directly into soil and open channels, which potentially threaten water and soil quality as well as public health. The legal framework gap, where most respondents were unaware of the 2025 ESDM Ministerial Regulation and oil processing activities operate without formal licensing, creates legal uncertainty and the

potential for sanctions, placing the practice within a legal grey area. From social and cultural perspectives, the hereditary processing methods strengthen community cohesion and preserve historical values, yet they must be synergized with technological modernization and environmental standards to establish safer and more efficient practices. Therefore, this study concludes that the sustainability of diesel oil management in Wonocolo Village requires a holistic approach that combines respect for local wisdom with the implementation of best practices in oil processing and waste management, community education on occupational safety and environmental awareness, and adaptive regulatory alignment to ensure that the practice is legally recognized and sustainable in economic, social, and ecological dimensions. This conclusion also underscores the urgency of collaboration among the government, local communities, and academia to develop a sustainable diesel management model that continues to honor Wonocolo Village's cultural heritage.

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