E-Komtek Journal
Vol. 10, No. 1. (2026) pp. 196-209
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Sustainable Waste Management Assessment of Small–Medium Motorcycle Workshops

Muhammad Fajar Sodiq[1], Onery Andy Saputra[2], Dewandono Bayuseto[3], Ilyas Syafiq DR[4]

[1,2,3] Department of Automotive Engineering, Polytechnic Indonusa Surakarta, Indonesia, 57418
[4] Department of Medical Science Technology, University Kuala Lumpur, Malaysia, 43000

onery@poltekindonusa.ac.id

https://doi.org/10.37339/e-komtek.v10i1.3061

Published by Politeknik Piksi Ganesha Indonesia

Article Info
Submitted:
04-03-2026
Revised:
21-05-2026
Accepted:
03-06-2026
Online first :
30-06-2026

Abstract

The growth of small-to-medium-sized motorcycle repair shops in Soloraya has increased the amount of waste that has the potential to pollute the environment if not managed properly. This study analyzes the characteristics of repair shops, the types and amounts of waste, management practices, and the potential economic value from a sustainability perspective. The study was conducted at ten repair shops (n = 10) through observation, structured interviews, and surveys. In one month, the ten workshops produced 1,214 used oil bottles, 337 liters of used oil, and 20 used batteries, as well as non-hazardous waste in the form of metal components and brake pads. The dominance of used bottles and oil reflects the high level of routine maintenance. Management is still limited to temporary storage and delivery to third parties with substandard facilities. Waste has economic value: oil at $0,09/liter, batteries and metal at $0,68/kg, indicating both environmental risks and circular economic opportunities.

Keywords: *Workshop Waste, Hazardous Waste, Circular Economy*

Abstract

Pertumbuhan bengkel sepeda motor skala kecil–menengah di Soloraya meningkatkan timbulan limbah yang berpotensi mencemari lingkungan jika tidak dikelola tepat. Penelitian ini menganalisis karakteristik bengkel, jenis dan jumlah limbah, praktik pengelolaan, serta potensi nilai ekonomi dalam perspektif keberlanjutan. Studi dilakukan pada sepuluh bengkel (n = 10) melalui observasi, wawancara terstruktur, dan survei. Dalam satu bulan, sepuluh bengkel menghasilkan 1.214 pcs botol oli bekas, 337 liter oli bekas, dan 20 pcs aki bekas, serta limbah non-B3 berupa komponen logam dan kampas rem. Dominasi botol dan oli bekas mencerminkan tingginya perawatan rutin. Pengelolaan masih sebatas penyimpanan sementara dan penyerahan ke pihak ketiga dengan fasilitas belum standar. Limbah bernilai ekonomi: oli *$0,09*/liter, aki dan logam *$0,68*/kg, menunjukkan risiko lingkungan sekaligus peluang ekonomi sirkular.

Kata-kata kunci: Limbah Bengkel, Limbah B3, Ekonomi Sirkular.

1. Introduction

The growth of motorcycle use in Indonesia has made motorcycle repair shops an important part of the transportation system and local economy, especially in urban areas and buffer areas such as Soloraya. Small to medium-scale motorcycle repair shops are generally dominated by routine maintenance services and minor repairs that are carried out repeatedly. These activities directly produce workshop waste in the form of hazardous and toxic (B3) waste, such as used oil and used batteries [1], [2]. Previous studies showed that workshop waste can pollute the environment if not properly managed, especially in small businesses with limited facilities and environmental management systems [3]-[5].

Globally, waste management practices in small and medium enterprises are increasingly oriented toward circular economy principles emphasizing resource efficiency and waste valorization. [11]-[14]. Hazardous waste management practices in the automotive sector have also been studied in various international contexts [15], [16]. However, the implementation of this approach in small-scale motorcycle repair shops at the local level is still relatively limited.

Based on this research gap, this study analyzes waste management practices in small-to-medium motorcycle workshops in the Soloraya area by integrating workshop characteristics, waste generation, management practices, and the economic potential of waste within a sustainability framework. This study is expected to contribute to regional policy development, strengthen the role of workshops in the circular economy, and enrich studies related to waste management in the automotive small-business sector [17]-[20].

2. Method

2.1. Research Location

This research was carried out in the Soloraya area, which includes the city of Surakarta and several surrounding areas. The selection of the research location was based on the high intensity of the use of motorcycles as the main mode of transportation for the community and the development of small to medium-scale motorcycle workshops in the area. Therefore, Soloraya is considered representative for studying motorcycle workshop waste management.

The research objects consisted of ten actively operating small-to-medium motorcycle workshops in the Soloraya area. The selected workshops routinely carried out motorcycle maintenance and repair activities and generated workshop waste, especially used oil and metal

waste.

2.2. Research Time

This research was carried out during the period September-November 2025. The period was selected to allow repeated observations, interviews and waste generation recording under stable workshop operational conditions.

2.3. Justification of Sample Quantity

The sample of ten motorcycle workshops was selected because this study is exploratory and intended to provide an initial overview of workshop characteristics, waste generation, management practices, and economic potential in the Soloraya area. This approach is consistent with previous studies using limited samples in small-business waste management research[13], [14].

The purpose of this study was to obtain an initial overview of workshop characteristics, waste generation, management practices, and the economic potential of waste in small-to-medium motorcycle workshops in the Soloraya area

This approach is in line with previous studies that have used limited sample sizes to identify early patterns and key issues in small business waste management, particularly in sectors that have not been extensively studied empirically [13], [14]. As such, the ten workshops were seen as representative enough to illustrate the variation in motorcycle workshop waste management practices at the regional level and as a basis for further research with a wider scope.

2.4. Measurement and Data Collection Methods

Data collection was conducted through field observations, structured interviews, and survey recording. Field observations were used to identify workshop conditions, types of waste generated, and waste handling practices. Structured interviews with workshop owners or managers were conducted to obtain data on service frequency, waste generation volume, and waste management mechanisms. This approach ensured that the collected data reflected actual workshop conditions[3], [5].

Waste generation measurements focused on used oil, used batteries, and non-B3 waste in the form of metal and plastic components. Waste quantities were recorded based on service frequency and converted into monthly units using volume- and activity-based measurements in accordance with B3 waste identification methods in the small business sector [5]. Data on the

potential economic value of waste were calculated based on waste volume and the average local selling price in the Soloraya area, then analyzed descriptively and presented in the form of tables and diagrams to support the analysis of workshop waste management in the perspective of sustainability and circular economy [12], [13].

2.5. Data Analysis Techniques

The data analysis in this study was carried out using a mixed analysis approach, including quantitative descriptive analysis and qualitative thematic analysis. Quantitative descriptive analysis was used to process data on waste generation and the potential economic value of waste. The data were analyzed in the form of percentages, proportions, and compositions to show the dominance of waste types, comparisons between workshops, and the contribution of each type of waste to total generation. The results of this analysis are presented in tables and diagrams to facilitate interpretation and comparison.

Thematic qualitative analysis was used to analyze the data from interviews and observations related to workshop waste management practices. Qualitative data are categorized into main themes, such as waste storage patterns, waste distribution mechanisms, environmental awareness levels, and obstacles in the implementation of sustainable waste management. This approach is used to explain the cause-and-effect relationship that underlies quantitative findings and to enrich the discussion of research results.

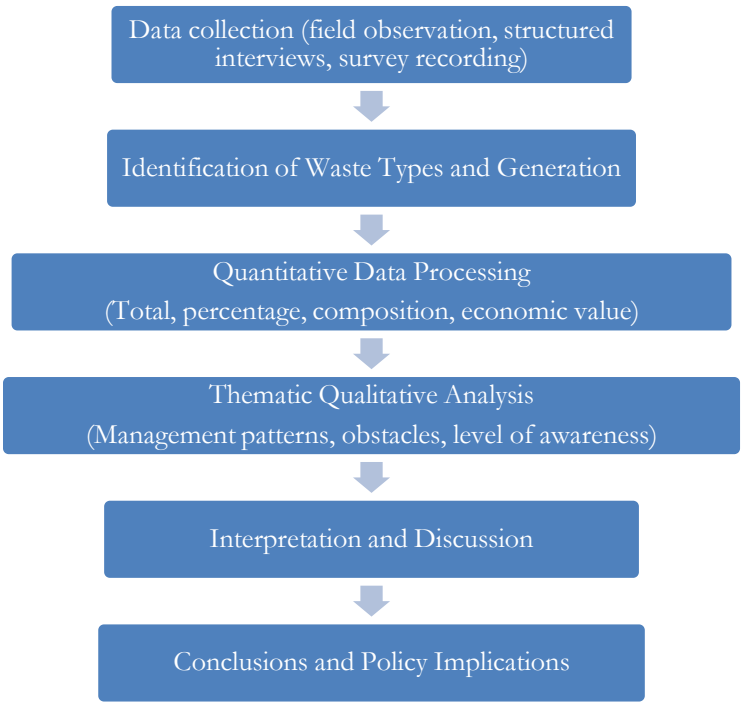

Figure 1. Research Data Analysis Flow

2.6. Data Validity

Data validity was maintained through triangulation by comparing data obtained from field observations, interviews, and survey records. Information regarding waste generation and waste management practices was verified through direct observation of workshop conditions and waste storage facilities.

In addition, data recording was carried out systematically and consistently during the study period to minimize observation bias. The application of triangulation aims to improve the reliability of the data and ensure that the results of the study represent the actual condition of motorcycle workshop waste management in the Soloraya area.

3. Results and Discussion

The results and discussion can be made as a unit containing research findings and explanations.

3.1. Characteristics of Motorcycle Workshops in the Soloraya Area

The characteristics of motorcycle repair shops in the Soloraya area show a dominance of small to medium-scale workshops, with main services focused on routine maintenance and light repairs. This reflects community needs that are still oriented toward daily vehicle maintenance rather than heavy repairs. These characteristics are in line with findings [4], which state that small-scale workshops in urban areas generally operate with limited facilities and non-standardized environmental management. This operational pattern also reflects the tendency of small technical institutions to apply simple administrative and management systems, as described in engineering management and information system studies published in *Jurnal E-Komtek* [21].

Table 1. Characteristics of Motorcycle Workshops in the Soloraya Area

No	Workshop Code	Total Workforce	Dominant Service Type	Average Daily Services	Workshop Scale
1	B1	2 person	Light service & oil change	8–12 unit	Small
2	B2	3 person	Light service	10–15 unit	Small
3	B3	4 person	Component service & replacement	15–20 unit	Intermediate
4	B4	2 person	Oil change & tune-up	8–10 unit	Small
5	B5	5 person	General services & electricity	18–25 unit	Intermediate
6	B6	3 person	Light service	10–14 unit	Small
7	B7	4 person	Brake service & replacement	15–18 unit	Intermediate
8	B8	2 person	Oil change	7–10 unit	Small
9	B9	3 person	General services	12–16 unit	Small
10	B10	4 person	Parts service & replacement	16–22 unit	Intermediate

Source: Field observation results (2025)

Based on Table 1, most workshops are small-scale businesses with 2–3 workers and fewer than 15 motorcycle services per day, while medium-scale workshops have more than 3 workers and higher service volumes, leading to greater waste generation. This variation affects waste management capacity and storage facilities.

Larger workshops produce more waste but are not necessarily supported by better management systems, indicating that business scale does not automatically improve environmental awareness and compliance, as also reported by [5].

3.2. Generation of Motorcycle Workshop Waste in the Soloraya Area

The results of the study show that used oil is the most dominant type of waste produced by motorcycle workshops in the Soloraya area. The dominance of waste oil can be explained by the characteristics of workshop services that are dominated by routine maintenance, especially engine oil changes, which have a much higher frequency than other types of repairs. This pattern reflects the general character of small to medium-scale motorcycle repair shops that are oriented towards fast and repetitive service.

To strengthen the quantitative findings regarding the generation of workshop waste, field documentation was carried out at each research location. This documentation shows the actual condition of storage of waste oil, oil bottles, used batteries, and metal components that are routinely serviced. Visually, most workshops still store waste simply without special containers that meet B3 waste management standards.

Figure 2. Documentation of Motorcycle Workshop Waste

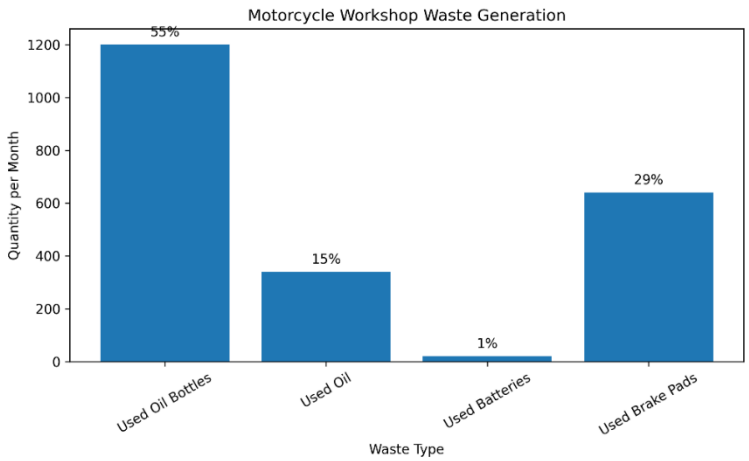

Figure 3. Motorcycle Workshop Waste Generation Diagram Based on Waste Type

Figure 3 shows that used oil bottles are the dominant waste compared to other types. This is directly related to the high frequency of oil changes in routine workshop services. Although waste oil is smaller in quantity, it is classified as B3 waste with a higher pollution risk. These differences indicate that waste management strategies should consider not only quantity but also hazard level.

These findings are consistent with research [5] which states that used oil is the main contributor to B3 waste in motor vehicle repair shops. Internationally, these results are also in line with studies [13] in Waste Management, which emphasizes that small businesses in the automotive sector generate hazardous waste mainly from routine activities with high frequencies, not from complex technical activities. This similarity shows that the dominance of used oil waste is a structural phenomenon that occurs not only in Indonesia, but also in various contexts of developing countries.

However, in Soloraya, high used oil generation is not matched by standardized storage and management systems. This differs from international contexts [14], where small businesses are more integrated into circular economy systems, indicating a gap in policy and institutional support at the local level.

To illustrate the variation in the type and amount of workshop waste, the data on waste generation is presented in the form of the following table.

Table 2. Generation of Motorcycle Workshop Waste in the Soloraya Area

Waste Type	Waste Sources	Workshop 1	Workshop 2	Workshop 3	Workshop 4	Workshop 5
Used oil	Engine oil change	33	33	33	33	33
Used batteries	Battery replacement	2	-	2	3	4
Scrap metal	Component replacement	48	48	72	96	72
Oil bottle	Engine oil change	144	96	120	120	50

Based on Table 2, the generation of workshop waste is dominated by used oil bottles by 55%, followed by used brake pads at 29%, used oil at 15%, and used batteries at 1%. The dominance of used oil bottles is related to the high frequency of engine oil changes as the main service of the workshop, resulting in a large amount of used packaging that still contains lubricant residue [3], [9]. Used brake pads come from the service activities of the braking system and contain abrasive materials and metal particles that have the potential to pollute the environment if not managed properly [13]. Used oil, although in a smaller percentage, is included in the category of B3 waste with significant potential for soil and water pollution due to the content of hydrocarbons and harmful additives [1]. Regulatively, B3 waste management has been regulated in Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Environmental Protection and Management [10].

Although smaller in percentage, used oil is classified as hazardous waste with high potential for soil and water pollution due to hydrocarbons and harmful additives [1], [2]. Therefore, its management must be carried out in accordance with the provisions of applicable environmental regulations, as stipulated in Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Environmental Protection and Management [10]. Used batteries have the lowest contribution quantitatively, but are still risky because they contain heavy metals such as lead and acidic electrolytes that are corrosive and harmful to the environment[3]. Overall, these findings highlight the need for waste sorting and management strategies based on waste characteristics, as well as the potential application of a circular economy approach through waste utilization and recycling [11], [12].

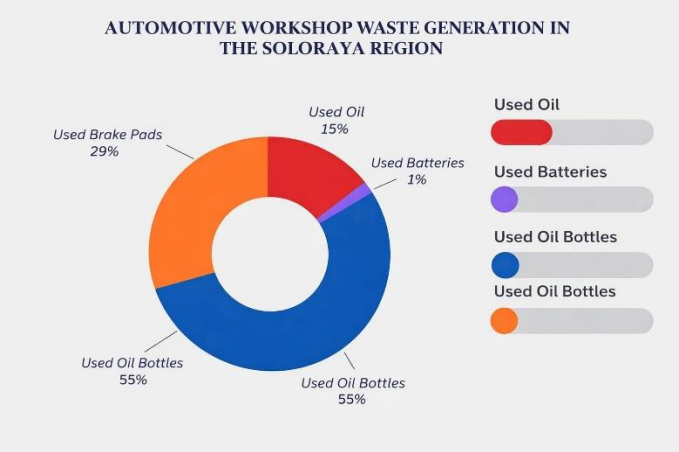

Figure 4. Motorcycle Workshop Waste Generation Diagram Based on Waste Type

3.3. Potential Economic Value of Motorcycle Workshop Waste in Soloraya

In addition to potentially polluting the environment, motorcycle workshop waste in the Soloraya area also has economic value that can be utilized, especially in waste oil, used batteries, and metal components. The results of the study show that some workshops have utilized the waste by selling it to collectors, although this practice is still carried out informally and has not been integrated into the workshop business management system.

These findings are in line with [1] which states that used oil has economic value because it can be reused as energy or industrial raw materials. Internationally, [12] in the Journal of Cleaner Production emphasized that the use of waste as a resource is a key element in the implementation of the circular economy in small and medium enterprises. Thus, the potential economic value of workshop waste in Soloraya can be seen as a strategic opportunity, not just a side activity.

However, it is different from practices in some countries that have integrated small businesses into the circular economy supply chain [14], the use of workshop waste in Soloraya is still passive. Workshops generally only act as waste suppliers without obtaining significant added value. This condition shows that the economic potential of waste has not been utilized optimally due to limited access to information, institutions, and policy support.

The potential economic value of workshop waste is presented in the following table to provide a comparative overview between waste types.

Table 3. Potential Economic Value of Motorcycle Workshop Waste in the Soloraya Area

Waste type	Utilization Method	Recipient Party	Economic Value
Used oil	Sales	Collector	$ 28,58
Used batteries	Sales	battery collector	$ 27,14
Scrap metal	Sales	Scrap metal collector	$ 67,58
Oil bottle	Sales	Plastic waste collector	$ 7,21
Total:			$ 130,52

Based on **Table 2,** the total potential economic value of motorcycle workshop waste in the Soloraya area reaches $130,52 per month. Scrap metal contributes the highest economic value, followed by used oil and used batteries, while used oil bottles make the smallest contribution. The high value of scrap metal and waste oil is related to the frequency of workshop service activities that routinely produce such waste [1], [2]. In addition, the existence of a relatively stable local recycling market also increases the economic value of the used materials [20]. These findings confirm that workshop waste is not only an environmental issue, but also has economic potential that can be utilized through sales and recycling processes. This is in line with the circular economy principle which emphasizes the recovery of material value in sustainable production and consumption systems [11], [17]

The economic value of waste is presented in a bar chart to compare the contribution of each waste type and identify high-value priorities without inferential statistical analysis. This quantitative descriptive approach supports recommendations for more effective waste management to reduce environmental risks while increasing economic benefits.

When compared to other cities, the economic value of workshop waste in Soloraya is lower than in metropolitan areas such as Surabaya and Jakarta due to fewer workshops and lower service intensity. Previous studies show that high vehicle-density areas generate larger quantities and higher economic value of workshop waste because of more frequent oil changes, brake pad use, and metal component replacement. [2], [20]. However, compared to semi-urban areas or districts with limited workshop activities, the economic value of waste in Soloraya is moderate and shows the potential for the development of a circular economy-based management system [11]. This difference is influenced by the scale of the workshop's business, the level of spare parts actors towards the use of economically valuable waste.

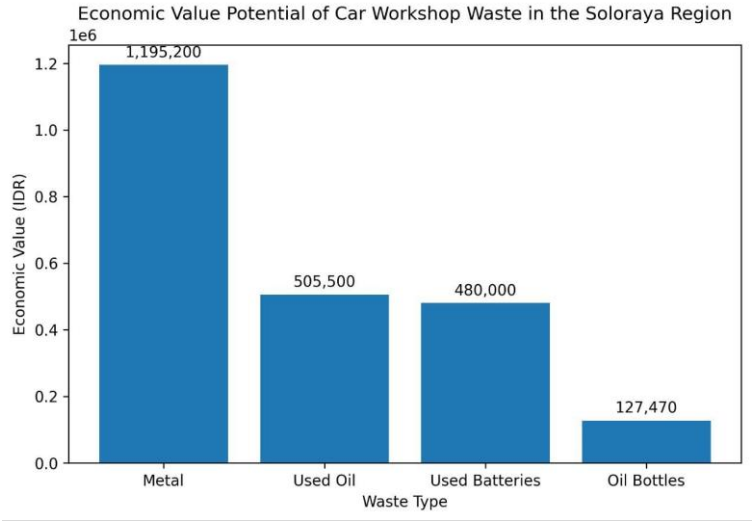

Figure 5. Diagram of the Potential Economic Value of Motorcycle Workshop Waste in Soloraya

3.4. Motorcycle Workshop Waste Management Practices

The practice of managing motorcycle workshop waste in the Soloraya area is generally still limited to temporary storage and handing over waste to third parties. This pattern shows that waste management has not been carried out in an integrated manner, but is reactive and dependent on external parties. This finding is in line with [2] who stated that motor vehicle workshops tend not to implement a comprehensive waste management system due to limited facilities and knowledge. These findings are also consistent with a study published in *Jurnal Ekomtek*, which reported that small-scale automotive workshops still face technical and managerial constraints in implementing standardized hazardous waste management systems [22].

The lack of consistent waste segregation and standard-compliant storage facilities shows that environmental risk control is still not a top priority. This is in contrast to workshops that have implemented environmental management standards, as reported in several previous studies, which show that the implementation of waste management systems is able to significantly reduce the potential for pollution [3]. This difference emphasizes the importance of interventions in the form of capacity building and supervision in workshop waste management.

3.5. The Position of Workshop Waste Management in the Circular Economy Framework

Waste management in Soloraya motorcycle workshops can be analyzed within a circular economy framework based on the 4R principles. However, most workshops are still limited to

collecting and handing over waste to third parties, indicating that the system is not yet fully integrated.

In the reduce aspect, waste reduction at the source has not been carried out systematically, such as through lubricant control or the use of environmentally friendly products. Reuse of components is still limited and not formally documented. Recycling is more visible, especially in metal waste and used oil that have economic value and are sold to local markets. However, energy or material recovery has not yet been implemented in small-scale workshops in the study area

These findings indicate that workshop waste management in Soloraya is still in transition toward a structured circular economy system. Systematic integration of the 4R principles can improve resource efficiency, reduce environmental pollution risks, and optimize economic value [12]. Thus, strengthening the capacity of business actors and supporting regional policies are key factors in driving the transformation towards a sustainable workshop waste management system.

3.6. Implications of Sustainable Motorcycle Workshop Waste Management

The findings imply that waste management in Soloraya motorcycle workshops has strong potential to be improved toward a more sustainable system. High used oil generation and the economic value of waste provide a basis for strategies that focus not only on pollution control but also on resource utilization.

If workshop waste management is carried out with a sustainable approach, then motorcycle workshops can transform from a source of pollution to part of the local circular economy system. This is in line with the findings [5] which emphasizes that the integration between waste management and economic aspects can improve the environmental compliance of small business actors. Thus, the sustainable management of motorcycle workshop waste in Soloraya not only has implications for environmental protection, but also for increasing economic added value and the sustainability of the workshop business itself.

4. Conclusion

This study shows that small-to-medium motorcycle workshops in the Soloraya area generate hazardous and non-hazardous waste, especially used oil, oil bottles, used batteries, and metal components. Waste generation is closely related to routine maintenance activities that

dominate workshop services. However, waste management practices are still limited to temporary storage and delivery to third parties without standardized systems.

The study also demonstrates that automotive workshop waste possesses economic value and significant potential to support circular economy implementation through recycling and resource recovery activities. Therefore, strengthening environmental awareness, improving waste management systems, and increasing policy support are important to encourage sustainable motorcycle workshop waste management in the Soloraya area.

References

[1] M. A. Ariasyah, A. A. Sani, and Azaruddin, "Proses Pengolahan Limbah B3 (Oli Bekas) Menjadi," *J. Austenit*, vol. 12, no. 2, pp. 48–50, 2020.

[2] V. Azteria and R. A. Gani, "Pengelolaan Limbah Minyak Pelumas Sebagai Upaya Pengendalian Pencemaran Lingkungan," *BIOLINK (Jurnal Biol. Lingkung. Ind. Kesehatan)*, vol. 6, no. 2, pp. 178–185, 2020, doi: 10.31289/biolink.v6i2.2725.

[3] E. Kristanti, A. Muharamin, and A. C. Ni'am, "Identifikasi Limbah Berbahaya Dan Beracun (B3) Di Bengkel Xyz Lamongan," *Environ. Eng. J. ITATS*, vol. 1, no. 1, pp. 1–6, 2021, doi: 10.31284/j.envitats.2021.v1i1.2174.

[4] T. N. Sari, M. Pradipto, and S. Hartini, "Sosialisasi perbaikan metode kerja dengan prinsip keselamatan dan kesehatan kerja pada bengkel kendaraan bermotor," *J. Apl. Tek. dan Pengabdi. Masy.*, vol. 5, no. 1, pp. 9–14, 2021, doi: https://doi.org/10.36339/je.v5i1.378.

[5] E. Wardhani and A. P. Triatmaja, "Identifikasi dan Kuantifikasi Limbah Bahan Berbahaya dan Beracun (LB3) pada Industri X di Kota Bandung," *Serambi Eng.*, vol. 6, no. 3, pp. 2128–2134, 2021, doi: https://doi.org/10.32672/jse.v6i3.3246.

[6] T. Herdito, Risna, and M. Lutfi, "1121-3579-3-Pb," *J. Sains Terap.*, vol. 7, no. 2, pp. 57–63, 2021.

[7] M. Hidayat, M. Raharjo, and A. Wibowo, "Tantangan pengelolaan limbah B3 pada usaha mikro dan kecil," 2022.

[8] A. R. Putra and S. Wahyuni, "Tingkat kepatuhan pengelolaan limbah B3 pada UMKM sektor otomotif," 2023.

[9] B. Susanto and P. Lestari, "Pengelolaan limbah bengkel kendaraan bermotor berbasis lingkungan," 2021.

[10] P. R. Indonesia, "Peraturan Pemerintah Republik Indonesia Nomor 22 Tahun 2021 tentang Penyelenggaraan Perlindungan dan Pengelolaan Lingkungan Hidup," 2021. [Online]. Available: https://peraturan.go.id/id/pp-no-22-tahun-2021?utm_source

[11] M. Geissdoerfer, P. Savaget, N. M. P. Bocken, and E. J. Hultink, "The circular economy – A new sustainability paradigm," 2017.

[12] A. Kumar, R. K. Singh, and S. Modgil, "Exploring the relationship between sustainable supply chain management practices and organizational performance: A circular economy perspective," *J. Clean. Prod.*, vol. 277, pp. 124–147, 2020, doi: https://doi.org/10.1016/j.jclepro.2020.124147.

[13] D. Mmereki, A. Baldwin, and B. Li, "A comparative analysis of solid waste management practices in small-scale enterprises: Implications for circular economy," *Waste Manag.*, vol.

119, pp. 98–108, 2021, doi: https://doi.org/10.1016/j.wasman.2020.11.047.
[14] N. van Buren, M. Demmers, R. van der Heijden, and F. Witlox, "Towards a circular economy: The role of Dutch logistics industries and governments," *Sustain.*, vol. 8, no. 7, pp. 1–17, 2016, doi: 10.3390/su8070647.
[15] A. Silva, M. Rosano, and L. Stocker, "Hazardous waste management practices in small automotive workshops," 2021.
[16] Y. Zhang, H. Li, and X. Chen, "Automotive waste management and circular economy practices," 2022.
[17] E. Commission, "Circular economy action plan: For a cleaner and more competitive Europe," 2022.
[18] O. for E. C. and Development, "Business models for the circular economy: Opportunities and challenges," 2021.
[19] U. N. E. Programme, "Waste management and circular economy approaches for SMEs," 2021.
[20] F. Rahman, I. Nugraha, and A. Setyawan, "Economic value of waste recovery in small-scale industries," 2023.
[21] J. E. Elektro-komputer-teknik *et al.*, "Perancangan Sistem Informasi Alumni Berbasis Website," vol. 4, no. 2, pp. 191–199, 2020.
[22] A. Z. Yusuf *et al.*, "Pemberdayaan Indsustri Bengkel Sepeda Motor Melalui daur Ulang Sampah Komponen Otomotif," vol. 3, pp. 323–329, 2025.