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## Environmental Law Enforcement Based on Law Number 32 Of 2009 and the Challenges of the Industrial Revolution 4.0

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### ABSTRACT

Law functions to protect various human interests and is implemented in both peaceful conditions and when violations occur. The decline in environmental quality due to the exploitation of natural resources is often justified in the name of people's welfare. This condition raises demands for effective environmental law enforcement amid the challenges of the Industrial Revolution 4.0. This research aims to analyze the impact of pollution and weak law enforcement, as well as examine the role of technology in improving legal effectiveness and formulating adaptive regulatory strategies in the digital era. This research employs a qualitative-descriptive approach, utilizing a library research method and inductive-deductive analysis, informed by various literature sources. The effectiveness of environmental law depends on fundamental principles, the application of technology, and collaborative law enforcement. Digital technology and industrial automation can strengthen the monitoring and transparency of ecological law if developed with an inclusive and fair approach. Law No. 32/2009 remains relevant, but requires adaptive policies.

**Keywords:** Environmental Law, Industry 4.0, Revolution

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## A. INTRODUCTION

In a simple society, boundaries or rules are necessary to maintain balance and order, which is referred to as law. Law enforcement can embody the value of justice, and the application of legal functions is carried out through philosophical thinking that upholds the values of equality, truth, and freedom.<sup>1</sup> Environmental pollution and damage in Indonesia pose a serious threat to ecosystems and quality of life. Conflicts of interest between business actors, the community, and the government exacerbate the situation. Weak environmental law enforcement hampers the fulfillment of people's rights to a healthy environment. Therefore, strict and effective law enforcement is urgently needed to prevent repeated violations, serve as a deterrent, and support sustainable development.<sup>2</sup>

Law enforcement broadly encompasses the implementation, application, and enforcement of laws by legal subjects through judicial or arbitration mechanisms.<sup>3</sup> Law enforcement involves the use of formal and informal legal tools to ensure compliance with applicable laws and regulations. Based on Law No. 32/2009, the law enforcement system should reflect the principles proposed by Gustav Radbruch: legal certainty, expediency, and justice. Legal certainty safeguards the public from arbitrary actions, while expediency emphasizes that the law must yield tangible benefits and not provoke social unrest.

The Industrial Revolution 4.0 has a major impact on the environment and law enforcement. Technologies such as satellites, AI, and electronic systems enhance the efficiency of law, but also present challenges, including cybercrime and legal disruption. Adaptive regulations, up-to-date laws, community engagement, and enhanced law enforcement capabilities are necessary to address the complexities of the digital era. Law enforcement must uphold justice that is contextual and inseparable from the substance and culture of law. As a socio-empirical phenomenon, law affects social life and acts as a tool of state power.<sup>4</sup>

According to Taverne, moral and professional law enforcement officers can still produce effective law enforcement even when the applicable law is less than ideal. Law

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<sup>1</sup> Maudy Andreana Lestari, "Kedudukan Amdal Dalam Perlindungan Lingkungan Hidup Berkelanjutan: Tinjauan Dari Sudut Pandang Nichomachean Ethics," *Padjadjaran Law Review* 8, no. 2 (2020): 41-51.

<sup>2</sup> Sebastian Raul, Ronald J Mawuntu, and Christine J J G Goni, "Tinjauan Hukum Atas Larangan Pembukaan Lahan Dengan Sistem Pembakaran Hutan Dalam Rangka Melindungi Lingkungan Hidup Berdasarkan Undang-Undang Nomor 6 Tahun 2023 Tentang Cipta Kerja," *Lex Privatum*, no. 3 (2023).

<sup>3</sup> Nur Hadiyati and Cindo, "Kontekstualisasi Pencemaran Ekosistem Laut Dalam Mencapai Sdgs: Suatu Kajian Hukum Lingkungan Di Indonesia," *NUSANTARA: Jurnal Ilmu Pengetahuan Sosial* 8, no. 3 (2021): 300-313.

<sup>4</sup> Muhamad Edo Khoirul Majid, Naura Hafiza Ainayyah, and Naila Amrina, "Optimalisasi Sistem Layanan Pengadilan Berbasis Elektronik Guna Menjamin Keterbukaan Informasi Menuju Peradilan Yang Modern," *Jurnal Legislatif*, 2022, 97-115.

enforcement is a system that relies on harmony between elements, such as the integrity and competence of judges, prosecutors, police, and technical apparatus. Bagir Manan views law enforcement as the real application of law in society, which affects the sense of justice and legal satisfaction. Law enforcement is also the foundation for maintaining social peace and must protect the interests of citizens, especially in the era of Industrial Revolution 4.0.

Environmental law enforcement is regulated in Law No. 32 of 2009 and includes administrative, criminal, and civil aspects. In Indonesia, environmental law enforcement officers include police, prosecutors, judges, technical officials, and legal counsel. Jimmly Asshiddiqie emphasized that the quality of individuals and institutional bureaucracy determines the effectiveness of law enforcement. The state plays a significant role in regulating and supervising the activities of citizens for the common good, and this process is closely tied to constitutional law and state administrative law.<sup>5</sup>

In a welfare state, state and government duties are carried out based on constitutional law through authorized institutions, including those related to sustainable environmental development. Compliance with national law is a priority in legal policy, in line with national development goals based on the principles of Pancasila and the 1945 Constitution.<sup>6</sup> The development of natural resources and the environment is aimed at supporting economic growth and community welfare. The Ministry of Environment and local governments play a crucial role in environmental law enforcement, ensuring sustainability and the application of sustainable development principles. Ecological management is regulated by Laws No. 4/1982, No. 23/1997, and No. 32/2009; however, further scientific studies are still needed to ensure the effectiveness of these regulations. The literature on Indonesian environmental law is still limited and tends to be descriptive. Therefore, the development of environmental legislation is necessary as a response to community needs and as a means to address environmental problems.<sup>7</sup>

Administrative sanctions are administrative legal tools used to address violations of environmental regulations, based on complaints or supervisory results. The objectives include environmental protection, restoration of environmental quality, and providing a deterrent effect. Types of sanctions include written warnings,

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<sup>5</sup> Ujang Suratno, "Arah Pembaharuan Hukum Nasional Dalam Menghadapi Era Revolusi Industri 4.0," *Yustitia* 5, no. 1 (2019): 155–69.

<sup>6</sup> Erlina Maria Christin, *Formulasi Legislasi Perlindungan Data Pribadi Dalam Revolusi Industri 4.0*. 9, 2020.

<sup>7</sup> Ahmad Ainur Ridlo and Imroatin Arsali, "Dinamika Penegakkan Hukum Lingkungan Di Indonesia Dalam Menghadapi Problematika Lingkungan Hidup," *Journal Presumption of Law* 6, no. 2 (2024): 140–57.

government coercion, suspension, and license revocation. Its implementation must follow legal procedures, legality of authority, and the principle of sustainability.<sup>8</sup>

The determination of administrative sanctions is carried out by the minister, governor, or regional head and can be delegated to related officials. Administrative decisions must be made by public law and based on the principle of legality. Principles of administrative law, including those of jurisdiction, legality, and discretion, form the basis for the validity of decisions.<sup>9</sup> Strong leadership at all levels is essential in environmental law enforcement. Public services, including environmental protection, are a basic right of the people. In the context of the Industrial Revolution 4.0, adaptive and technology-based law enforcement is necessary, along with robust regulations to address the challenges of the digital era.<sup>10</sup>

## **B. RESEARCH METHODS**

This research method applies a qualitative descriptive approach. This research model employs library research, incorporating inductive-deductive analysis, which draws on several literature analyses. This research is known as library research, which involves analyzing text data. The data are then interpreted using the descriptive method of analysis, which involves systematic and consistent data collection. This data is analyzed, selected, and combined to conclude using deductive analysis, starting from general issues and then drawing specific conclusions.

## **C. RESULTS AND DISCUSSION**

### **1. Environmental Law**

Environmental law is a set of legal norms that regulate people's behavior towards the environment and its order. In Indonesia, environmental law is regulated in Law Number 32 of 2009 concerning Environmental Protection and Management, which emphasizes the basic rights of every citizen to a good and healthy environment. Environmental law focuses on the sustainable and responsible use of natural resources. The theoretical and conceptual framework of environmental law emphasizes the importance of preventing and overcoming environmental problems through regulation, supervision, and law enforcement.

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<sup>8</sup> M Irfan Islami Rambe and Nirwana Sukmawati, "Penerapan Prinsip Kehati-Hatian Dalam Perizinan Lingkungan Di Era Industri 4.0.," *Innovative: Journal of Social Science Research* 4, no. 4 (2024): 16049–57.

<sup>9</sup> Ananda Eka Putri et al., "Peran Hukum Lingkungan Dalam Menghadapi Ekstraktivisme Di Sektor Minyak, Gas, Dan Mineral Di Indonesia Ananda," *Alam: Jurnal Lingkungan Dan Kelautan Internasional* 1, no. 1 (2025): 1–21.

<sup>10</sup> M.Yazid Fathoni, "Peran Hukum Adat Sebagai Pondasi Hukum Pertanahan Nasional Dalam Menghadapi Revolusi Industri 4.0.," *Refleksi Hukum: Jurnal Ilmu Hukum* 5, no. 2 (2021): 219–36.

The scope of environmental law encompasses the sustainable management of natural resources, protection of environmental quality, environmental impact assessment (EIA), and management of environmental pollution and damage. Environmental law enforcement is carried out through administrative, criminal, and civil channels.<sup>11</sup>

The Industrial Revolution 4.0 has brought significant changes to the industrial sector and daily life, resulting in negative impacts, including increased greenhouse gas emissions, air pollution, and damage to ecosystems. However, on the other hand, this revolution also provides opportunities for environmental conservation efforts through real-time monitoring of air and water quality using IoT and AI. In the legal context, environmental law must be adaptive and responsive to technological changes, providing solutions to new problems, such as digital pollution or technology-based environmental crimes. This requires strengthening the capacity of law enforcement officials to utilize the latest technology for environmental monitoring and enforcement. Based on this, environmental law is a crucial instrument for maintaining the balance between environmental utilization and protection. Law enforcement must be carried out in an administrative, criminal, and civil manner.

## **2. Principles of Environmental Law (Prevention, Precaution, Polluter Pays)**

Environmental law is a legal instrument that regulates the relationship between humans and their environment, aiming to maintain ecosystem balance, prevent damage and pollution, and ensure the sustainability of natural resources for both present and future generations. The principles of environmental law serve as the primary guidelines for policy-making, implementing business activities, and enforcing laws against environmental violations.<sup>12</sup>

### **a. Prevention Principle**

The prevention principle is a fundamental principle in environmental law that emphasizes proactive action to prevent pollution and environmental damage before negative impacts occur. This principle is based on the understanding that preventing damage is far more effective and economical than repairing damage that has already occurred.

- 1) Basic Concept: This principle requires every party, especially businesses and governments, to conduct risk assessments and take necessary steps to avoid

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<sup>11</sup> Rahul Gonzales, "Memaksimalkan Potensi Generasi Muda Di Industri Pertambangan Untuk Meningkatkan Ekonomi Indonesia Menuju Indonesia Emas 2045: Generasi Muda Untuk Bangsa," *Jurnal Himasapta* 7, no. 1 (2022): 39, <https://doi.org/10.20527/Jhs.V7i1.5344>.

<sup>12</sup> Raynold Sebastian Hasiholan Gultom and Muthia Sakti, "Praktik Greenwashing: Perlindungan Hukum Dan Tanggung Jawab Korporasi Ditinjau Dari Hukum Indonesia," *Jurnal Interpretasi Hukum* 4, no. 3 (2023): 626–41, <https://doi.org/10.22225/juinhum.4.3.8331.626-641>.

negative impacts on the environment. An example is the obligation to conduct an Environmental Impact Assessment (EIA) before starting a project or activity that has the potential to cause environmental impacts.

- 2) Implementation: In practice, the principle of prevention is realized through regulations that require environmental feasibility studies, implementation of environmental standards, and strict supervision of potentially polluting activities. The government can also impose administrative or criminal sanctions in the event of violations that ignore prevention obligations.
- 3) Benefits: By prioritizing prevention, environmental damage can be minimized, thereby reducing the cost of environmental restoration and the resulting socio-economic impacts. Additionally, this principle supports sustainable development by maintaining the ecosystem's carrying capacity.

b. Precautionary Principle

- 1) The precautionary principle is a principle that emphasizes the need for careful and conservative action in environmental management, especially when there is scientific uncertainty about the impact of an activity on the environment.
- 2) Basic Concept: When there is a threat of serious or irreparable environmental damage, and there is not yet full scientific certainty about the risk, precautionary measures should be taken first. This principle places the burden of proof on the party conducting the activity to demonstrate that its activities are safe for the environment.
- 3) Implementation: The precautionary principle encourages proactive and preventive rather than reactive decision-making. Examples include banning or restricting the use of hazardous chemicals that have not been proven safe, or postponing projects that have the potential to cause major ecological
- 4) Benefits: This principle protects the environment and society from unforeseen and potentially permanently damaging risks. As such, the precautionary principle is an important instrument in environmental risk management in an era of technological uncertainty and climate change

c. Polluter Pays Principle

The polluter pays principle is a principle that stipulates that the party causing environmental pollution or damage is obliged to bear the costs of preventing, controlling, and restoring the environmental impacts caused.

- 1) Basic Concept: This principle emphasizes the economic responsibility of the polluter, ensuring that the general public or government does not bear the costs of environmental damage. Thus, this principle serves as a mechanism

for internalizing environmental costs into the economic activities of businesses.

- 2) Implementation: In practice, the polluter pays principle is applied through administrative sanctions, fines, environmental rehabilitation obligations, and economic mechanisms such as environmental taxes and emissions trading systems. For example, a company that pollutes a river must pay the cost of cleaning up and restoring water quality.
- 3) Benefits: This principle encourages more responsible behavior from businesses and individuals while creating incentives to adopt green technologies and best practices in their operations. It also assists the government in financing effective environmental management.

Law No. 32/2009 on Environmental Management is a fundamental principle in environmental management that emphasizes the need for environmental assessment and public consultation to minimize potential conflicts and negative impacts. This principle is particularly relevant in the context of climate change and biodiversity degradation, whose impacts are complex and difficult to predict. The Polluter Pays Principle is an economic and legal mechanism that corrects market failures by internalizing environmental costs into production costs. In Indonesia, this principle is implemented through regulations that require businesses to pay fines, conduct environmental rehabilitation, and fulfill waste management obligations. The government has also developed economic instruments such as carbon taxes and emissions trading systems to reduce pollution. These principles complement each other, providing legal certainty and justice for all parties involved. The effective implementation of these principles will promote sustainable development, maintain ecosystem balance, and protect individuals' rights to a healthy and sustainable environment.<sup>13</sup>

### **3. Technological Development in the Industrial 4.0 Era and Its Relevance to Environmental Protection**

The Industrial Revolution 4.0, which is characterized by advances in digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data, and digitalization, presents significant opportunities for environmental protection. IoT sensors can monitor air, water, and soil quality in real-time, enabling early detection of pollution and rapid preventive action. AI and other digital technologies optimize energy use, manage waste, and organize environmentally friendly transportation systems. Smart cities integrate various technologies to create a more

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<sup>13</sup> Muhamad Farhan et al., "Penerapan Hukum Dalam Menanggulangi Kejahatan Siber Penegakan Hukum Terhadap Tindak Pidana Siber," *Jurnal Ilmu Hukum, Sosial, Dan Humaniora* 01, no. 06 (2023): 8–20, <https://doi.org/10.572349/Kultura.V1i6.569>.

efficient and sustainable urban environment. Digitization of waste and resource management enables more efficient and transparent waste management, including automated and integrated measurement of water and air quality. The Industrial Revolution 4.0 encourages industries to transform into green industries that prioritize resource efficiency and the use of renewable energy. Digitalization and information technology accelerate environmental permitting and monitoring processes, improve transparency, data accuracy, and the effectiveness of environmental law enforcement.<sup>14</sup>

However, challenges faced in the development of Industry 4.0 include the negative impacts of technology and industry, such as increased greenhouse gas emissions and ecosystem damage due to rapid industrial activity. Data security and human resource skills are also challenges, with the need for skilled human resources and access to technology for the underprivileged. In addition, addressing the digital divide and promoting social inclusion requires collaboration among government, industry, and society, as well as the implementation of training and digital inclusion programs to reach all levels of society. Based on this, the Industry 4.0 era presents significant opportunities for environmental protection; however, challenges such as negative industrial impacts, data security concerns, and the digital divide must be addressed through collaboration and effective policies. This era opens up great opportunities while demanding awareness and collective action from all parties to preserve the environment for the sustainability of the ecosystem and the quality of life of the community.

#### **4. Implementation of Law No. 32 Year 2009**

Law No. 32/2009 serves as the primary legal framework for environmental protection and management in Indonesia. This law regulates the principles, policies, and mechanisms of sustainable environmental management to preserve environmental functions for the welfare of present and future communities. The main substance of Law No. 32/2009 includes:

a. Principles of Environmental Protection and Management

Includes the principles of prevention, precautionary, polluter pays, community participation, and the principles of justice and sustainability.

b. Environmental Management

Includes planning, utilization, control, maintenance, supervision, and environmental law enforcement. Business activities and/or activities that have the potential to cause environmental impacts are required to conduct an

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<sup>14</sup> Osi Karina Saragih, Murniyati Yanur, and Juli Natalia Silalahi, "Sosialisasi Dan Edukasi Peran Satuan Tugas Pencegahan Dan Penanganan Kekerasan Seksual (SATGAS PPKS) Terhadap Resiliensi Mahasiswa Korban Kekerasan Seksual Di Universitas Palangka Raya," *Jurnal Masyarakat Madani Indonesia* 2, no. 4 (2023): 510–21, <https://doi.org/https://doi.org/10.59025/js.v2i4.177>.



Environmental Impact Analysis (AMDAL) or Environmental Management Efforts and Environmental Monitoring Efforts (UKL-UPL).

c. Environmental Licensing

Regulations regarding environmental permits are the primary requirement for implementing business activities that have the potential to cause environmental impact.

Mengatur mekanisme penegakan hukum melalui instrumen administratif, perdata, dan pidana untuk menjamin kepatuhan terhadap ketentuan lingkungan hidup.

d. Environmental Law Enforcement

Regulates law enforcement mechanisms through administrative, civil, and criminal instruments to ensure compliance with environmental laws and regulations.

e. Environmental Dispute Resolution

Provides mechanisms for resolving environmental disputes both through out-of-court and court channels.

This law emphasizes that environmental protection and management are a shared responsibility between the government, business actors, and the community, with the main objective of preserving environmentally sound and sustainable environmental functions. Law No. 32/2009 enforces environmental law through three main instruments: administrative, civil, and criminal. Administrative instruments are preventive and efficient, allowing law enforcement to carry out more quickly and efficiently. These instruments include supervision and monitoring of environmental permits and business activities that can pollute or damage the environment. Sanctions given to violators of environmental provisions include written warnings, government coercion, license suspension, and license revocation. State administrative lawsuits allow the public or legal entities to file a lawsuit against administrative decisions deemed detrimental to the environment.<sup>15</sup>

Civil instruments resolve disputes and recover losses resulting from environmental pollution or damage. These instruments aim to restore the environment to its original condition or recover losses incurred. Civil lawsuits can be filed by individuals, community groups, or legal entities, and regulate the liability of businesses that cause environmental pollution or damage. This instrument provides justice for victims of pollution and encourages business actors to take legal responsibility for the environmental impacts they cause. Criminal instruments are used as a means to address serious violations that threaten

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<sup>15</sup> Fathoni, "Peran Hukum Adat Sebagai Pondasi Hukum Pertanahan Nasional Dalam Menghadapi Revolusi Industri 4.0."

environmental sustainability and public welfare. These legal efforts include investigation, prosecution, trial, and enforcement of court decisions, and can result in fines, confinement, or imprisonment. Environmental criminal law enforcement must be integrated and coordinated with relevant sectoral officials to ensure effective implementation. Criminal instruments are the last resort for enforcing environmental law, providing a strong deterrent effect for violators.

Law No. 32/2009 on Environmental Protection and Management involves various government agencies and law enforcement officials working together to ensure effective and integrated environmental protection and management. The Ministry of Environment and Forestry (MoEF) is the primary regulator responsible for supervising, enforcing administrative law, and coordinating environmental law enforcement across the nation. Provincial and District/City Environmental Offices conduct supervision and enforcement of environmental laws at the local level, including the issuance and supervision of environmental permits. The Police and the Attorney General's Office investigate, prosecute, and enforce criminal laws against environmental violations. The District Court and State Administrative Court handle criminal and civil environmental cases, while NGOs act as independent watchdogs and advocates for environmental protection. Inter-agency coordination is crucial for effective and integrated law enforcement, given the complexity of environmental cases that involve multiple sectors and regions.

The implementation of Law No. 32/2009 prioritizes a comprehensive approach through administrative, civil, and criminal law instruments. Administrative instruments serve as preventive measures, civil instruments provide mechanisms for recovery and compensation, and criminal instruments serve as prosecution efforts against serious violations. The success of this law depends on the active role and effective coordination between central and local government agencies, law enforcement officials, as well as the participation of the community and non-governmental organizations (NGOs).

## **5. Law Enforcement Strategy in Era 4.0**

In the Industry 4.0 era, law enforcement strategies are focused on strengthening technology in environmental monitoring, implementing e-government in supervision, and fostering collaboration between government, industry, and society. Rapid advances in digital technologies, such as the Internet of Things (IoT), artificial intelligence (AI), big data, and integrated information systems, offer opportunities to improve the effectiveness of environmental law enforcement. Technologies such as sensors, satellite imagery, drones, and automated monitoring systems enable real-time and accurate data collection, enabling early detection and action on potential pollution. Big data and AI are

leveraged to analyze pollution patterns, predict environmental risks, and identify perpetrators, thereby improving the efficiency and effectiveness of law enforcement. Satellite imagery and drone technology are utilized to monitor land cover changes, deforestation, and illegal activities that impact the environment, thereby providing strong evidence for law enforcement and surveillance of areas that are physically difficult to reach.<sup>16</sup>

E-government is a crucial strategy in environmental monitoring, integrating administrative, licensing, reporting, and monitoring processes electronically. The government utilizes online systems for applying for and monitoring environmental permits, such as the Amdalnet system, which manages Environmental Impact Assessment documents digitally. This system facilitates the monitoring of business actors' compliance with environmental regulations. Public reporting and participation are also crucial aspects of e-government, which enables the public to report environmental violations online, thereby increasing public involvement in oversight and enforcement. Digitally integrated environmental data facilitates coordination between government agencies and accelerates the decision-making process in environmental law enforcement.<sup>17</sup>

Collaboration between government, industry, and society is essential for effective environmental law enforcement in the 4.0 era. The government must provide an adaptive regulatory framework, enhance the capacity of law enforcement officers, implement environmentally friendly technologies, and be transparent in its environmental impact reporting. Additionally, it should encourage community participation through digital platforms. Multi-stakeholder partnerships can be realized through coordination forums, shared digital platforms, and environmental technology education programs. This collaborative approach addresses the complexity of environmental problems across sectors and regions. Therefore, the environmental law enforcement strategy in the Industry 4.0 era must integrate the strengthening of environmental monitoring technology, e-government in supervision, and close collaboration between government, industry, and society. Digital technologies, such as IoT, AI, big data, and integrated information systems, provide opportunities to enhance the effectiveness, transparency, and accountability of law enforcement.

## **6. Challenges of the Industrial Revolution 4.0**

The Industrial Revolution 4.0 has revolutionized the industrial world through automation, artificial intelligence (AI), the Internet of Things (IoT), and big

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<sup>16</sup> Bagus Bahrul Ulum and Muhammad Ilham Cahyo Kusumo, "Mengembangkan Strategi Yang Berkeadilan Untuk Meningkatkan Penegakan Hukum," *Indigenous Knowledge* 2, no. 1 (2023): 40–50.

<sup>17</sup> Ahmad Muchlis, "Penegakan Prinsip Kepentingan Terbaik Anak Pada Penerapan Diversi Dalam Sistem Peradilan Pidana Anak," *Jurnal Hukum Progresif* 12, no. 1 (2024): 66–77.

data. However, these advancements also present significant environmental challenges. Industrial automation enhances production efficiency by minimizing human involvement and accelerating processes through the use of robots and automated control systems. However, these improvements can lead to new forms of pollution, including air, water, and soil pollution. Advanced technologies, such as robots and sensors, require a substantial amount of energy, which can lead to increased greenhouse gas emissions from non-environmentally friendly sources. Therefore, automation must be balanced with environmentally friendly waste and energy management technologies to prevent further environmental damage. The rapid development of new technologies such as AI, IoT, and big data creates a dilemma between promoting economic growth and protecting the environment. While these technologies enable higher efficiency and the potential to reduce negative environmental impacts, they can increase the risk of pollution and environmental damage if not balanced with sustainable policies and practices. This requires a balance between technological innovation and environmental protection through adaptive regulation, strict supervision, and the application of the precautionary principle and polluter pays principle in environmental law. Addressing these challenges requires responsive regulation, enhanced supervisory capacity, and collaboration between government, industry, and society. This will enable the technology to be utilized optimally without compromising environmental sustainability.

## **D. CONCLUSION**

Environmental law in Indonesia is regulated in Law Number 32 of 2009 which is the main legal umbrella that affirms the rights of every citizen to a good and healthy environment and regulates environmental protection and management with key principles such as prevention, precaution, and polluter pays that serve as guidelines in policy making, business implementation, and law enforcement to maintain ecosystem balance and prevent environmental damage. In the implementation of environmental law, there are complementary instruments of administrative, civil, and criminal law to ensure compliance, facilitate dispute resolution, and prosecute environmental violations. The success of law enforcement is highly dependent on effective coordination between government agencies, law enforcement officials, as well as the active involvement of the community and NGOs as independent oversight bodies. The era of Industrial Revolution 4.0 presents significant opportunities for environmental protection through the utilization of digital technologies, including IoT, AI, big data, and integrated information systems, which enable real-time environmental monitoring, increased transparency, and effective law enforcement. However, these

technological advancements also present challenges, including potential increases in pollution, data security risks, and digital divides that require serious attention. Environmental law enforcement strategies in the Industry 4.0 era must prioritize strengthening monitoring technology, implementing e-government in supervision, and synergistic collaboration between government, industry, and society. Adaptive regulations, increased human resource capacity, and public participation are key to utilizing technology optimally without compromising environmental sustainability. Therefore, environmental law in Indonesia must continue to be developed and implemented comprehensively, in response to technological advances, and supported by multi-stakeholder synergy, to ensure the sustainability of environmental functions for the welfare of present and future generations.

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