The Beautiful City of Jakarta, Indonesia

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ABSTRACT: This research aims to analyze environmental conditions in Jakarta and identify practical solutions to air pollution, water pollution, and waste management. The research methods include air and water quality monitoring with modern sensors, analysis of emissions data, and interviews with stakeholders. Simulation models evaluate the impact of various interventions, such as public transportation improvements and pollution control technologies. The research results show that Jakarta faces significant challenges, with pollutant concentrations often exceeding safe limits. Simulation models estimate that reducing vehicle emissions and using renewable energy could reduce air pollution by up to 30% within five years. Pilot projects such as sensor-based air quality monitoring systems and household waste separation programs are progressing positively. However, budget constraints and resistance to change are still obstacles. The conclusions of this research emphasize the importance of integrating modern technology, strengthening environmental policies, and active community involvement. This research also offers a model that can be implemented by other cities in developing countries. Suggestions include policy adjustments, increased financial support, and community education programs to increase awareness and participation in environmental improvement.

KEYWORDS: air pollution, air pollution, waste management, monitoring technology

INTRODUCTION

This research is about the need to make Jakarta, Indonesia, a clean city, which is a very relevant issue considering the dynamics of urbanization and rapid growth that confront it. As Indonesia's capital and economic center, it faces serious challenges related to environmental problems such as air pollution and waste management (Edelman & Gunawan, 2020). With more than 10 million people living in large metropolitan areas, this problem affects citizens' quality of life and contributes to public health problems and global climate change. Rapid and unplanned urban expansion causes difficulties in efficiently managing urban infrastructure. At the same time, operational and financial constraints often hamper government efforts to impaste the need for improved pollution control systems (Wilonoyudho, 2017).

These issues underscore the importance of an integrated approach in addressing environmental challenges in developing cities. Implementing a more efficient waste management system, improving air quality through industrial and vehicle regulations, and improving drainage infrastructure are essential steps that must be taken (Nanditho & Yola, 2022). Technology-based approaches, such as sensor-based air quality monitoring systems and integrated waste management applications, can help these cities manage environmental problems more effectively. This approach also includes increasing community involvement in environmental management and promoting awareness about the environmental impacts of daily activities (Sosunova & Poras, 2022).

This research focuses on data-based and participatory strategies that have yet to be widely implemented in the city. While many previous studies have assessed pollution problems and waste management analyses separately, this study integrates environmental data with community surveys and technology-based urban planning models. By adopting this method, this research can provide more comprehensive and practical insight into ways to address ecological problems in Jakarta holistically and sustainably.

What differentiates this research from previous research is its multidimensional and high-tech approach. This research not only relies on statistical data and traditional planning models but also combines the latest technologies, such as intelligent sensor systems and big data platforms, to gain deeper insights into pollution patterns and waste management. This allows for more accurate analysis and strategies that are more responsive to changing environmental and social conditions in Jakarta.

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By utilizing this new approach, this research aims to provide practical and innovative recommendations that policymakers and stakeholders in Jakarta can implement. This includes data-based development strategies for monitoring air quality, improving waste management systems, and strengthening the role of communities in keeping cities clean. Thus, the results of this research can make a significant contribution to efforts to make Jakarta a cleaner and more sustainable city and provide a model that can be adapted by other cities in developing countries that face similar challenges.

LITERATURE REVIEW

Tourism

Tourism is an activity that includes traveling or visiting specific places for recreation, entertainment, or education. Tourism generally includes various activities outside of daily routines, including enjoying the beauty of nature, exploring historical sites, or experiencing local culture. Tourism can be domestic travel, where a person visits locations in their country, or international tourism, where travel is taken to another country. The primary purpose of tourism is to gain new and enjoyable experiences, as well as to relax the mind and body from daily routine stress (Seyfi et al., 2019). Apart from being a recreation, tourism also has a significant economic aspect because it can contribute to local and national economic growth. The tourism industry includes various sectors such as hospitality, transportation, and food services, all of which support and promote tourist destinations. Sustainable and responsible tourism development is also essential to minimize negative impacts on the environment and local communities. Therefore, tourism is often considered an activity that provides personal benefits and has a positive impact on society and the surrounding environment (Nautiyal et al., 2023).

Tourist City

A tourist city is a city that has a unique attraction and offers various interesting attractions for visitors, such as historical sites, iconic landmarks, cultural centers, and recreational activities. These cities often have developed infrastructure to support the tourism industry, including hotels, restaurants, and transportation facilities that make access easy for tourists. In addition, tourist cities usually offer a variety of activities that include culinary experiences, shopping, entertainment, and cultural exploration, which makes them attractive destinations for various types of tourists (García-Hernández, 2017). The development of a tourist city not only focuses on increasing its attractiveness for visitors but also positively impacts the local economy and preserving culture. Well-managed tourist cities can generate significant income through tourism, create jobs, and support local businesses. However, it is essential to implement sustainable tourism practices to reduce the environmental and social impacts that may arise from increasing tourist numbers. With the right approach, tourist cities can become models of successful integration between cultural preservation, economic development, and satisfying tourist experiences (Utama, 2017).

Cleanliness in a Tourist City

Cleanliness in a tourist city is a crucial aspect that influences the visitor experience and the city's overall image. A clean tourist city not only provides a pleasant and safe environment for tourists but also reflects a commitment to residents' quality of life. Efficient waste management, maintenance of public facilities, and cleanliness of tourist areas such as parks, beaches, and main roads are essential elements in maintaining cleanliness standards. In addition, adequate sanitation facilities and routine maintenance of public infrastructure also contribute to visitors' positive impression and comfort (Khair et al., 2022). Good hygiene in tourist cities impacts visitor satisfaction and the desires of the tourism industry itself. A clean environment helps attract tourists, improves a city's reputation, and supports promotional efforts for tourist destinations. To achieve and maintain high levels of cleanliness, cooperation between the city government, the private sector, and the community is required. Implementing environmental education programs, regular cleaning, and effective waste management policies are vital steps to ensure that tourist cities remain attractive and livable while keeping negative impacts on the environment minimal (Sandhubaya et al., 2021).

RESEARCH METHOD

This research explores solutions to making Jakarta a cleaner city with a focus on air pollution, air pollution, and waste management. The quantitative approach involves collecting data from air and air quality sensors installed at strategic locations and analyzing secondary data from government reports and previous studies. This monitoring aims to obtain real-time data regarding pollutants and environmental quality, which will be analyzed using statistical software to identify patterns and trends. On the other hand, waste management data will be obtained from managers and relevant government agencies to assess the existing system's efficiency.

The qualitative approach involves in-depth interviews with government officials, waste managers, and the community. This interview explores their perspectives regarding challenges and solutions in environmental management in Jakarta. In addition, case studies of other cities that have successfully dealt with environmental problems will be analyzed to derive lessons that can

be applied in Jakarta. Simulation models will be developed to test various intervention scenarios and their impact on environmental quality. Data-based strategy recommendations will be designed to address air pollution and waste management issues more effectively. Implementation of a pilot project and evaluation of its results will be undertaken to assess the effectiveness of the recommendations, with a final report presenting the findings and an action plan to be announced to stakeholders to gain support and ensure full implementation. This research aims to provide an innovative and practical approach that can be adapted by other cities in developing countries facing similar challenges.

RESULT AND DISCUSSION

Air Quality

The research results reveal that air quality in Jakarta consistently exceeds the safe limits the World Health Organization (WHO) set. Measurements carried out using air quality sensors show that the concentration of fine particles PM2.5 and PM10 often exceeds 150 µg/m³, a figure that far exceeds the maximum threshold recommended by WHO, namely 50 µg/m³ for PM10. High levels of PM2.5 and PM10 indicate severe air pollution, potentially hurting public health, especially in the long term. In addition, the data also shows that other pollutants, such as nitrogen dioxide (NO2) and carbon monoxide (CO), are at inducing levels, with high concentrations detected, especially in industrial areas and areas with heavy vehicle traffic. These conditions create significant health risks for society and highlight urgent problems that must be addressed.

This research identified that Jakarta's primary sources of air pollution are motorized vehicles, industry, and waste burning. Motor vehicles, especially those using fossil fuels, provide the majority of PM2.5, NO2, and CO emissions, compromising air quality in urban centers and major traffic areas. With their industrial processes, factories also contribute to air pollution by emitting harmful gases and particulates. In addition, burning waste, whether carried out officially or by individuals, also increases pollution by releasing dangerous contaminants into the air. Identifying these primary sources of pollution is essential for designing effective mitigation strategies and reducing air pollution levels in Jakarta, which will improve the city's residents' quality of life and health.

Air pollution

Air quality monitoring data in Jakarta's rivers and drainage channels shows significant and underestimated pollution levels. The measurement results show that Biochemical Oxygen Demand (BOD) concentration in many locations reached very high levels, up to 60 mg/L, far exceeding the safe limit set at 3 mg/L. High BOD levels indicate a high organic load in the air, which comes from domestic and industrial waste that is not managed correctly. An increase in BOD can reduce air quality and disrupt the balance of aquatic ecosystems by reducing oxygen levels needed by marine flora and fauna.

The measured Chemical Oxygen Demand (COD) level also shows a high figure, indicating the presence of organic pollution and industrial waste. High COD suggests that there are organic contaminants that are difficult to decompose naturally, which can come from various industrial sources and waste disposal. Pollution caused by COD weakens air quality, can damage the health of aquatic ecosystems, and affects the quality of air used by the community for various purposes, including daily needs and consumption.

Air analysis also revealed heavy metal contamination in several locations, with mercury and lead levels detected in dangerous concentrations. These heavy metals are hazardous pollutants that can seriously impact human health and ecosystems. Consuming air polluted with heavy metals can cause health problems such as poisoning and organ dysfunction. In contrast, in ecosystems, heavy metals can damage flora and fauna, reduce biodiversity, and affect the food chain. The location and handling of these pollution sources are critical to ensure that air quality in Jakarta can be maintained safely for public health and environmental sustainability.

Waste Management

This research reveals that the waste management system in Jakarta faces various significant challenges that affect its efficiency. One of the main problems is the volume of waste produced by residents and economic activities that far exceeds the capacity of the existing management system. Despite efforts to collect waste, recorded collection rates only account for around 60% of the total waste generated. This creates an accumulation of poorly managed waste, and the remaining waste that is not picked up or ignored often piles up in the surrounding environment, potentially causing severe health and aesthetic problems for the community.

This research shows that the lack of recycling facilities and the dismantling of waste at the source are essential factors in this problem. Much of the waste produced cannot be adequately separated between organic, inorganic, and hazardous materials, which hinders the recycling process and increases the burden on final disposal sites (TPA). As a result, a lot of waste that could be recycled or processed into new products ends up in landfills, which often operate beyond capacity. This causes the accumulation of waste in landfills, improving environmental conditions and increasing the risk of pollution of the surrounding land and air.

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This condition highlights the need for deep reform in Jakarta's waste management system. To overcome this problem, improvements are needed in waste management infrastructure, such as building more and more effective recycling facilities and implementing waste discount programs at the source. Municipal governments, the private sector, and communities must work together to develop and implement better policies for waste management, including public education about the importance of recycling waste. With a more integrated and sustainable approach, Jakarta can increase the efficiency of its waste management system and reduce negative impacts on the environment and public health.

Interview

In-depth interviews with stakeholders revealed that one of Jakarta's main obstacles to overcoming environmental problems is more effective coordination between the government, the private sector, and the community. Many participants emphasized that efforts to resolve ecological problems are often siled within the silos of each party, without good integration between government policies, private sector initiatives, and community participation. This weak coordination means that the policies implemented must be fully effective and are challenging to implement comprehensively. For example, although various initiatives from the government and the private sector address air pollution and waste management, the results are often not optimal due to a lack of support and harmonious cooperation from all relevant parties.

Interviews in this research also show that there needs to be more knowledge and awareness among the community regarding appropriate ways to manage waste and its impact on health and the environment. Many residents need to fully understand the importance of separating waste at the source, recycling it, and reducing the use of hazardous materials. This results in low community participation in environmental programs and hampers collective efforts to address pollution and waste problems. To overcome this problem, interview participants emphasized the need for more intensive public education and awareness campaigns to increase public understanding of waste management and its impacts. By increasing public knowledge and involvement and improving coordination between various parties, Jakarta can create more effective and sustainable solutions to the environmental challenges it faces.

The Simulation Model

The simulation model developed in this research provides in-depth insight into the potential impact of various intervention scenarios in addressing air pollution problems in Jakarta. Using integrated data from air quality sensors, emissions reports, and city growth projections, the model allows analysis of different scenarios to provide the effectiveness of pollution control measures. One of the main findings is that implementing scenarios involving improving the efficiency of public transport systems can significantly impact air quality. By introducing more efficient and environmentally friendly transport systems, such as electric buses or more integrated railway lines, emissions from private vehicles can be reduced, reducing overall air pollution.

The simulation model also raises the impact of introducing air pollution control technology and increasing the use of renewable energy. For example, implementing technologies such as emissions filters in vehicles and factories and transitioning to cleaner energy sources such as wind and solar energy show the potential for significant reductions in air pollution. Models show that by reducing emissions from motor vehicles and replacing fossil fuels with renewable energy, Jakarta could reduce air pollution levels by 30% within five years. These measures help reduce the concentration of harmful pollutants in the air and improve people's overall health and quality of life.

This model also emphasizes the importance of continuous implementation and support from various parties to achieve the desired results. Collaboration between government, the private sector, and society is needed to ensure that proposed interventions can be implemented effectively. Action plans based on these simulations should include detailed strategy implementation, adequate budget allocation, and evaluation mechanisms to integrate progress and make adjustments where necessary. With a planned approach and strong stakeholder support, Jakarta has an excellent opportunity to significantly reduce air pollution and create a cleaner and healthier environment for its citizens.

Strategy Recommendations

Based on the findings of this research, several strategic steps are recommended to improve environmental quality in Jakarta. First, one of the main recommendations is improving the public transportation system to reduce dependence on private vehicles. This includes the development of more efficient transportation infrastructure, such as fast bus lines, integrated rail systems, and clean energy-based public transportation. Providing alternative, more comfortable, and environmentally friendly transportation can reduce the number of private vehicles on the road, reducing air pollutant emissions. This implementation requires significant investments in infrastructure development and the procurement of a more environmentally friendly transport fleet, as well as careful planning to ensure effective integration into existing transport systems.

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This research advocates the implementation of real-time air and air quality monitoring technology as an essential step to manage and reduce environmental pollution. This technology enables the collection of accurate and up-to-date data on air pollutants and air quality, which can be used to identify pollution sources and assess the effectiveness of implemented policies. With better data, authorities can make more precise and quicker decisions when considering environmental issues and make necessary policy adjustments to ensure that ecological quality targets can be achieved. The application of this technology also involves the installation of sensors in strategic locations and the development of a data analysis system capable of providing real-time reports and warnings to the public and policymakers.

Other recommendations include strengthening recycling and waste management policies to address the problem of waste settling in landfills and reduce environmental impacts. This policy should include improving recycling facilities, implementing waste separation systems at source, and regulations supporting waste reduction and material reuse. On the other hand, community education programs are critical to increasing awareness about the importance of waste management and its impact on health and the environment. These educational programs should involve a variety of communication methods, including public campaigns, community training, and integration of environmental education materials in school curricula. With comprehensive strategic steps and active support from various parties, Jakarta can significantly progress in overcoming environmental challenges and creating a cleaner and more sustainable city.

Pilot Project Implementation

The pilot project implemented based on the recommendations of this research shows promising results in facing environmental challenges in Jakarta. In one of Jakarta's districts, implementing a sensor-based air quality monitoring system has had a significant positive impact. With this technology, air quality data is collected in real-time, enabling more accurate identification and monitoring of pollutant concentrations. Results from this monitoring system show a marked reduction in local pollution, thanks to the ability to respond and listen to emissions quickly. Apart from that, this project has also succeeded in increasing public awareness regarding air quality because transparent and publicly accessible data encourages citizens to pay more attention and participate in efforts to maintain the quality of the environment around them.

The pilot project also involves waste management initiatives focusing on dismantling and recycling at the household level. Implementation of this program has been proven to increase waste management efficiency significantly. With a transparent waste summary system and easily accessible recycling facilities, the volume of waste that must be disposed of in landfills can be reduced substantially. This program reduces the burden on landfills and increases the proportion of waste recycled into new materials, reducing the environmental impact of waste disposal. The success of this project emphasizes the importance of planned and integrated waste management at the community level and shows that significant improvements in environmental management can be achieved with the right approach.

Overall, the results of this pilot project provide strong evidence that the application of advanced monitoring technology and effective waste management systems can produce positive changes in the environmental management of large cities such as Jakarta. This project is also a model that can be replicated in other districts, with adjustments to suit local needs and specific conditions. The experience and data from this project can form the basis for planning and implementing broader, more sustainable environmental policies across the city. This initiative emphasizes the importance of cooperation between government, the private sector, and society in creating comprehensive solutions to environmental problems.

Evaluation and Adjustment

Evaluation of pilot projects implemented based on research recommendations reveals that although significant progress has been achieved, several challenges must be overcome to achieve optimal results. One of the main challenges is budget constraints, which affect the capacity to expand and maintain the various initiatives implemented. Limited budgets often hinder the implementation of more sophisticated technology, expanding facilities, and implementing comprehensive community education programs. In addition, funding limitations can hinder improvements and maintenance of existing systems, affecting the long-term effectiveness of these projects.

Another challenge is resistance to change from some communities, which can affect the successful implementation of designed sector policies and strategies. Some groups may feel unprepared to adapt to new changes, such as waste segregation or air quality monitoring technology, which may hinder active participation and compliance with such programs. To overcome this problem, adjustments in implementing policies and strategies are needed, including more intensive efforts in conducting outreach and public education. A more inclusive approach, involving open dialogue with various stakeholders and providing incentives for active participation, can reduce resistance and increase support from communities and relevant sectors.

Therefore, making the necessary adjustments and improvements is essential to ensure that all stakeholders are actively involved in these environmental projects. Continued government support, both in the form of adequate budget allocations and

supportive development policies, is critical to ensuring the success and desirability of this initiative. In addition, broader community involvement and increased awareness of the benefits of the changes made will help overcome resistance and increase the effectiveness of these programs. With a holistic approach and adapting to existing challenges, Jakarta can continue its efforts to improve environmental quality and achieve better results in the future.

CONCLUSION

This research provides a comprehensive picture of the environmental conditions in Jakarta and offers innovative data-based solutions to address various problems, such as air pollution and waste management. By integrating modern technology such as sensor-based air and air quality monitoring systems and strengthening existing environmental policies, this research shows that Jakarta can make significant progress towards status as a cleaner city. Implementing recommendations from this research, such as increasing the efficiency of the public transportation system, implementing pollution control technology, and strengthening recycling programs, is expected to reduce pollution levels and improve the quality of life in the city.

In addition to providing specific solutions for Jakarta, this research also offers a model that can be adapted by other cities in developing countries facing similar environmental challenges. With the strong foundation provided by this research, other cities can implement similar strategies for continuous improvement in their environmental management. This model focuses on technology and policy and emphasizes the importance of community involvement in achieving effective results. With an integrated and adaptive approach, this research provides valuable guidance for environmental improvement efforts in various urban contexts in developing countries.

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