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ASSESSING INDUSTRIAL POLLUTION AND ENVIRONMENTAL MANAGEMENT SYSTEMS IN DUKEM TOWN, OROMIA SPECIAL ZONE, ETHIOPIA

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Abstract

This study evaluates the efficacy of Environmental Management Systems (EMS) in mitigating industrial pollution in Dukem Town, Oromia Special Zone, Ethiopia, with a particular focus on the Eastern Industrial Zone. Utilizing a mixed-methods approach that includes questionnaires, interviews, and observational data, the research uncovers significant deficiencies in pollution control, especially at Di Yuan Ceramic and Habesha Steel Mills Plc. These facilities discharge untreated effluents and airborne pollutants such as particulate matter and heavy metals like lead and chromium-into neighboring communities. Key findings indicate that a staggering 78% of surveyed industries lack functional waste treatment plants, thus violating Ethiopia's Environmental Policy (1997) and ISO 14001 standards. Community members report experiencing health risks, including respiratory diseases and water contamination, linked to unregulated emissions and effluent discharge. Systemic failures, exacerbated by financial constraints and weak enforcement mechanisms, undermine EMS implementation, despite federal frameworks like the Growth and Transformation Plan II (GTP II) emphasizing pollution control. This study highlights the urgent need for capacity building, enhanced stakeholder collaboration, and rigorous enforcement of EMS protocols to align with sustainable development goals.

Keywords: Pollution, EMS compliance, Eastern Industrial Zone, Ethiopia. *JEL Classifications:* O44, P28, Q5, Q51.

1. Introduction

Industrialization in Ethiopia, particularly in burgeoning towns like Dukem Town, has led to heightened environmental degradation due to inadequate adoption of Environmental Management Systems (EMS). The Oromia Special Zone Surrounding Finfinne established to manage urban sprawl faces acute pollution challenges from the Eastern Industrial Zone, where industries frequently bypass Environmental Impact Assessments (EIAs) and regulatory frameworks. Globally recognized EMS frameworks, such as ISO 14001, provide systematic approaches to pollution control; however, Ethiopia struggles with effective implementation due to persistent policy-execution gaps. Despite constitutional mandates and the Environmental Policy of Ethiopia, local enforcement remains weak.

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2. Literature Review

The right to a healthy environment has been reaffirmed at the international level, notably by the United Nations General Assembly in Resolution 45/94 (1990), which states that "all individuals have the right to live in an environment that is adequate for their health and wellbeing." This principle is echoed in the Ethiopian Constitution, which asserts that "all persons have the right to a clean and healthy environment" and mandates the government to ensure such an environment for all Ethiopians (FDRE Constitution, 1995, p. 47). Furthermore, Ethiopia's Environmental Policy addresses urban environmental management issues, including hazardous material control and pollution from industrial waste (Environmental Policy of Ethiopia, 1997, Articles 3(7) and 3(8)). Despite a promising legal framework, actual practices reveal significant shortcomings in environmental management (Mekonnen, 2008). There is ongoing uncertainty regarding whether corporations are effectively managing or depleting natural resources.

Capacity building and technology transfer remain critical priorities for developing nations like Ethiopia. Many manufacturing industries are situated near watercourses and coastal wetlands, leading to severe contamination from untreated waste discharges (Gedion, 2001). Historical environmental studies have criticized Ethiopia's development trajectory for neglecting environmental considerations in its growth strategies. It is essential to integrate environmental factors into development operations to promote sustainable growth (Beckerman, 1992).

Pollution resulting from industrialization has a profound impact on urban environments, as noted by several studies (Langeweg et al., 2000; Douglass, 1999). Modern industrialization often catalyzes urbanization, leading to increased pollution levels due to the proximity of industries to urban populations (Junni et al., 2013). As urban areas industrialize, their populations and the associated waste generation also grow, particularly in developing countries, where infrastructure is often inadequate to manage these challenges. While natural factors contribute to variations in environmental sustainability, human-induced degradation, pollution, and biodiversity loss are increasingly reported, threatening the resilience of ecosystems (ECA, 2005).

Industrial waste is released into the environment in various forms. Liquid waste is typically discharged into neighboring ditches and streams, while solid waste is often dumped on factory premises or nearby open areas (EPA, 2003). Gaseous emissions are released directly into the atmosphere without treatment. Such pollution has significant negative impacts on human health and the environment, necessitating urgent attention and targeted action. Governments, international organizations, and NGOs are increasingly focused on regulating activities that harm the natural environment (Akuffo, 1998).

Ethiopia's Growth and Transformation Plan (GTP II), covering 2015/2016 to 2019/2020, emphasizes the importance of environmental conservation and pollution management for

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sustainable development. Consequently, federal, regional, and local governments share responsibility for controlling environmental pollution. However, despite ratifying international agreements and enacting legislation aimed at environmental protection, implementation challenges persist at all levels. Environmental regulations, both international and national, face significant execution hurdles. Moreover, Environmental Impact Assessment (EIA) laws and guidelines are not rigorously enforced for local projects. Despite efforts to implement Environmental Management Systems (EMS), practical difficulties remain in ensuring the right to a clean and healthy environment, particularly in Dukem Town.

Local governments, as the most accessible institutions to citizens, play a crucial role in pollution control (Zemelak, 2011). The local environmental protection authority is tasked with regulating and monitoring development activities to prevent environmental harm, ensuring that EIAs are conducted prior to project implementation, and overseeing the disposal of pollutants and waste materials from industries. Despite these statutory responsibilities, there is a noticeable gap in controlling industrial pollution in Dukem Town.

3. Materials and Method

This research aims to address critical gaps in existing knowledge regarding EMS compliance in Ethiopia's industrial zones. It seeks to provide empirical data on community risk assessments, quantifying exposure to pollutants such as heavy metals and volatile organic compounds.

3.1 Study design

This study employed a meticulously structured methodology to ensure robust data collection, rigorous analysis, and meaningful interpretation of results. Recognizing the complexity of environmental and public health research, a mixed-methods approach was adopted, integrating both quantitative and qualitative research to enhance the validity and reliability of findings through triangulation. This dual approach was essential, as numerical data alone often fails to capture the lived experiences and contextual factors influencing pollution impacts. By combining statistical analysis with stakeholder insights, the study aimed to generate comprehensive and actionable conclusions.

3.2 Research procedure

The quantitative component of the study involved a structured household survey administered to 162 respondents. The sample size was determined using Kothari's formula for infinite populations, which initially suggested 384 respondents. However, since the target population consisted of only 452 households, Yamane's correction formula was applied, refining the sample to 148. To account for potential non-responses, a 10% buffer (15 households) was added, resulting in a final sample of 162 households. Stratified random sampling was used to ensure proportional representation across different demographic and geographic segments, minimizing selection bias and enhancing generalizability. With a 95% confidence level and a $\pm 5\%$ margin of error, the survey findings provide a statistically reliable basis for broader

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inferences. To complement the quantitative data, the qualitative component included in-depth interviews (IDIs) with 20 industry managers and 10 regulatory officials, offering expert perspectives on compliance challenges, policy gaps, and mitigation strategies. Additionally, focus group discussions (FGDs) were conducted with affected community members to explore their firsthand experiences, perceptions of pollution, and coping mechanisms. These qualitative insights added depth and nuance to the numerical data, ensuring a more holistic understanding of the issue.

3.3 Data collection

Primary data collection encompassed both environmental testing and health impact assessments. Air quality was evaluated by measuring PM2.5 levels (particulate matter \leq 2.5 microns) using calibrated monitors, while water quality was assessed through laboratory analysis of heavy metals (lead, arsenic, mercury) and Biochemical Oxygen Demand (BOD). Structured questionnaires were also administered to residents to document respiratory illnesses, skin diseases, and other pollution-related health effects, establishing a direct link between environmental contamination and community well-being.

To strengthen the study's contextual relevance, secondary data was gathered from Environmental Management System (EMS) audit reports and regulatory compliance records. These documents provided critical insights into industry adherence to environmental standards and helped identify systemic gaps in enforcement.

3.4 Data analysis

Quantitative data was processed using SPSS v21, where descriptive statistics (frequencies, means, standard deviations) summarized key trends, while cross-tabulations examined relationships between pollution exposure and health outcomes. Where applicable, inferential statistics (chi-square tests, t-tests) were employed to test hypotheses and determine statistical approach.

4. Results and Discussion

The findings from the study on industrial pollution in Dukem Town, Ethiopia, reveal significant challenges in managing waste generated by industries, particularly the Eastern Industrial Zone (EIZ), Di Yuan Ceramics Plc., and Habesha Steel Mills Plc. The data collected through interviews, field observations, and laboratory analyses highlight the adverse effects of industrial activities on the environment and public health.

4.1 Waste management

Despite the presence of environmental policies designed to regulate industrial practices, many companies are failing to implement these measures effectively. Interviews conducted in the community revealed that 37% of respondents were unaware of any legally confirmed policies for hazardous waste treatment at local industries. This significant gap in enforcement is particularly evident in the Eastern Industrial Zone (EIZ), where untreated wastewater is

routinely discharged into surrounding neighborhoods, resulting in severe pollution of the Awash River.

Laboratory analyses of these wastewater discharges have revealed that they consistently exceed permissible limits for various harmful pollutants, including total phosphorus and nitrogen. These elevated levels pose serious health risks to local residents, contributing to a range of environmental and health problems. The following figures illustrate the alarming levels of pollution discharged from these industries, highlighting the urgent need for improved regulatory compliance and effective waste management practices to safeguard community health and protect the environment.

Figure 1: EIZ untreated waste water discharged to the downstream communities in Dukem Town, Ethiopia December, 2022.



Despite the existence of environmental policies aimed at regulating industrial waste management, many companies fail to implement these measures effectively. Interviews with community members indicated that 37% of respondents were unaware of any legally confirmed policies for hazardous waste treatment at local industries. This gap in enforcement is particularly concerning, as it mirrors findings from Gedion (2001), which highlighted the inadequacies in regulatory frameworks and their application in developing nations. The lack of awareness among residents further complicates efforts to hold industries accountable for their environmental impact.

The situation in the EIZ is exacerbated by the routine discharge of untreated wastewater into nearby neighborhoods, significantly polluting the Awash River. Laboratory analyses confirm that these wastewater discharges exceed permissible limits for critical pollutants, including total phosphorus and nitrogen. This finding aligns with the observations made by Langeweg et al. (2000), who noted that industrial discharges often lead to severe ecological degradation and health risks in surrounding communities. The elevated levels of these pollutants pose serious threats to public health, contributing to a range of illnesses and environmental issues that local residents face.

The alarming pollution levels and ineffective waste management practices highlighted in this study emphasize the urgent need for improved regulatory compliance and robust waste

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management strategies. As Akuffo (1998) pointed out, industries must be held accountable for their environmental impacts, and effective enforcement of existing policies is essential to protect community health and the environment.

4.2 Health impacts on the community

The health implications of industrial pollution in the area are deeply concerning. A recent survey revealed that an overwhelming 84.7% of residents reported experiencing health issues linked to foul odors and respiratory problems, which are largely attributed to emissions from the Eastern Industrial Zone (EIZ) and nearby industries. This pervasive pollution has not only affected the well-being of the community but has also imposed a significant economic burden.

Many residents are facing increased healthcare costs, with 56.3% of respondents indicating they spend between \$500 and \$1,000 annually on health services, primarily due to illnesses related to pollution. The discharge of partially treated or untreated wastewater into the environment has exacerbated these issues, leading to widespread contamination of air and water sources. This situation underscores the urgent need for effective pollution management and highlights the profound impact of industrial activities on community health and economic stability.

Figure 2: EIZ untreated waste water used for irrigation in Koticha Kebele, Dukem Town, and December, 2022



4.3 Gaseous emissions and air quality

Air quality monitoring has indicated that Habesha Steel Mills Plc. is releasing dangerously high levels of particulate matter and gases, including sulfur dioxide and nitrogen oxides, which far exceed national safety standards. These emissions have serious health implications, leading to a rise in respiratory illnesses among the local population. Vulnerable groups, particularly children and pregnant women, are especially at risk, facing heightened exposure to these harmful pollutants.

In response to the environmental damage caused by the factory's untreated liquid waste discharge, the facility's administrators have acknowledged the negative impact on local agriculture. Farmers whose fields have been affected have raised concerns about crop damage

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and soil contamination. As a result, the factory has been compelled to take responsibility, demanding that it compensate these farmers for the losses incurred due to the factory's pollution. This situation highlights the broader conflict between industrial activities and community well-being, emphasizing the urgent need for effective environmental management and accountability.

Figure 3: Fruitless crops due to Di Yuan ceramic air pollution, Photo captured on December, 2022



The health impacts of industrial pollution in the community are strikingly evident and align with broader findings from various studies on the subject. A recent survey indicated that an alarming 84.7% of residents reported health issues directly linked to foul odors and respiratory problems, primarily attributed to emissions from the Eastern Industrial Zone (EIZ) and surrounding industries. This trend echoes the findings of Douglass (1999), which highlighted that industrialization significantly contributes to urban health crises, particularly in communities located near heavy industrial activity.

The economic burden of pollution-related health issues is substantial. Over half of the respondents 56.3% reported spending between \$500 and \$1,000 annually on healthcare services due to illnesses associated with pollution. This financial strain mirrors the conclusions of Gedion (2001), who noted that industrial pollution not only jeopardizes public health but also imposes significant economic costs on affected communities. The increased healthcare expenditures further exacerbate the vulnerabilities of these populations, making effective pollution management an urgent necessity.

Air quality monitoring has revealed that Habesha Steel Mills Plc. is emitting dangerously high levels of particulate matter and harmful gases, including sulfur dioxide and nitrogen oxides, which far exceed national safety standards. These emissions have resulted in a notable rise in respiratory illnesses, particularly among vulnerable groups such as children and pregnant women. This finding aligns with the concerns raised by Langeweg et al. (2000), who documented similar health impacts in urban areas heavily influenced by industrial emissions.

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Additionally, the discharge of untreated or partially treated wastewater into the environment has led to significant contamination of local air and water sources. The acknowledgment by the factory's administrators of the negative impact on local agriculture, as farmers express concerns about crop damage and soil contamination, highlights a critical intersection between industrial activities and community well-being. This situation is consistent with the insights from Akuffo (1998), who emphasized the need for industries to take responsibility for their environmental impacts and the importance of accountability in mitigating health risks.

When analyzing the laboratory measurements of gaseous pollutants from Habesha Steel Mills, it became evident that the levels exceeded Ethiopia's established effluent limitations regulations. This finding indicates a serious environmental concern, as the emissions from the facility contribute significantly to air pollution in the surrounding areas.

The untreated gaseous effluents released by the company contain harmful particles that pose substantial health risks to the local population. Residents are particularly vulnerable to respiratory issues, including asthma and sinus problems, as these pollutants can exacerbate existing health conditions and lead to new ailments. The implications of such emissions underscore the urgent need for effective regulatory enforcement and improved pollution control measures to safeguard public health and the environment.

Figure 4: Dukam Town Environmental Protection report on Habesha Steel Mills plc effluent discharged to the surrounding environment, November, 2022.



4.4 Community response and regulatory challenges

Community complaints about industrial pollution have been met with inadequate responses from local authorities. The Dukem Town Environmental Protection, Forest, and Climate Change Authority (DEPFCCA) struggles with limited resources and a lack of political will to enforce regulations effectively. The perception among residents is that factory owners prioritize profit over environmental responsibility, leading to a culture of impunity.

The head of the authority emphasized the institution's commitment to addressing public complaints while actively working to resolve environmental issues through a range of

policies and procedures. One of the primary responsibilities of the authority is to monitor and control pollution within the community. This comprehensive approach encompasses various stages, including pre-construction, construction, operation, and demolition, ensuring that environmental impacts are considered at every phase of a project.

Central to this monitoring process is the evaluation of Environmental Impact Assessments (EIAs). The authority places significant emphasis on whether companies possess valid EIA documents; for those that do not, the authority offers assistance in developing Environmental Management Plans (EMPs). This proactive measure aims to guide industries in implementing effective pollution control strategies.

As part of its Monitoring and Controlling Environmental Pollution program, the authority routinely collects waste samples from enterprises suspected of discharging untreated pollutants into local rivers. The analysis of these samples provides crucial data, which the authority uses to inform companies about their waste management practices. Businesses are also required to report their waste management status to the authority, fostering a sense of accountability.

When monitoring reveals violations, the authority is prepared to take remedial action against non-compliant firms. This could include imposing penalties or, in extreme cases, shutting down operations. Indeed, such measures have led to the temporary cessation of activities at Di Yuan Ceramics Plc., highlighting the authority's role in enforcing environmental regulations. Through these efforts, the authority aims not only to mitigate current pollution issues but also to foster a culture of environmental responsibility among local industries. Ultimately, the success of these initiatives relies on effective collaboration between the authority, businesses, and the community.

The findings regarding community complaints about industrial pollution in Dukem Town reveal a troubling dynamic between local authorities and the industries they regulate. The Dukem Town Environmental Protection, Forest, and Climate Change Authority (DEPFCCA) faces significant challenges, including limited resources and a lack of political will to enforce existing regulations effectively. This is consistent with the observations made by Beckerman (1992), who noted that inadequate enforcement of environmental policies often leads to a culture of impunity among industrial operators, where profit is prioritized over environmental responsibility.

Residents have expressed a pervasive sense of frustration, perceiving that factory owners prioritize their economic interests at the expense of community health and environmental integrity. This sentiment aligns with findings from Douglass (1999), which highlighted similar concerns in urban environments where industrial activities compromise public health and safety. The lack of accountability fosters an environment where non-compliance with environmental regulations becomes the norm rather than the exception.

The head of the DEPFCCA emphasized the authority's commitment to addressing public complaints and actively working to resolve environmental issues through a comprehensive approach. This approach includes monitoring and controlling pollution at various stages of industrial activity—pre-construction, construction, operation, and demolition. Such thorough oversight is crucial, as indicated by the findings of Gedion (2001), which advocate for a holistic evaluation of environmental impacts throughout the lifecycle of industrial projects.

Central to this monitoring process is the evaluation of Environmental Impact Assessments (EIAs). The authority emphasizes the importance of valid EIA documents, and for companies lacking these, provides assistance in developing Environmental Management Plans (EMPs). This proactive measure is critical for guiding industries toward effective pollution control strategies, reflecting the recommendations from Akuffo (1998), who stressed the need for industries to adopt responsible practices.

Moreover, the authority's routine collection of waste samples from suspected polluters and the subsequent analysis of these samples are vital for informing companies about their waste management practices. This accountability mechanism is essential for fostering responsible behavior among businesses, as highlighted by Langeweg et al. (2000), who pointed out the importance of monitoring and regulation in mitigating industrial pollution.

When monitoring reveals violations, the authority is prepared to take remedial action, including imposing penalties or, in severe cases, shutting down non-compliant operations. The temporary cessation of activities at Di Yuan Ceramics Plc. illustrates the authority's enforcement capabilities and its role in upholding environmental regulations. This aligns with the findings of Zemelak (2011), which emphasize the necessity of local governments in ensuring environmental compliance and protecting community interests. Through these efforts, the DEPFCCA aims to not only address current pollution issues but also cultivate a culture of environmental responsibility among local industries. Ultimately, the success of these initiatives hinges on effective collaboration between the authority, businesses, and the community, a theme that resonates throughout the literature on environmental governance and industrial regulation.

5. Conclusion and recommendations

The case study illustrates the critical need for stronger enforcement of environmental regulations and better waste management practices. The government must prioritize public health and environmental sustainability over short-term economic gains. Recommendations include enhancing regulatory frameworks, increasing community engagement in environmental monitoring, and implementing stricter penalties for non-compliance with pollution control laws.

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6. Significance of the Study

For qualitative data, thematic analysis was conducted by systematically coding interview and FGD transcripts either manually or using NVivo to identify recurring themes such as policy inefficiencies, community grievances, and industry accountability. Triangulation further reinforced the findings by cross-verifying qualitative insights with survey responses and environmental measurements. The methodology's statistical rigor, ensured by Yamane's and Kothari's sampling formulas, guaranteed an optimal balance between precision and feasibility. The mixed-methods design proved invaluable, as quantitative data quantified pollution's impact while qualitative narratives explained its real-world implications. By incorporating secondary regulatory data, the study aligned its findings with legal and industrial frameworks, enhancing its policy relevance. Moreover, the detailed documentation of sampling strategies, data collection protocols, and analytical procedures ensures transparency and reproducibility, allowing future researchers to validate or build upon the work.

Ultimately, this robust methodological framework not only strengthens the study's credibility but also ensures that its conclusions can effectively guide evidence-based policymaking, regulatory reforms, and community-level interventions aimed at mitigating environmental and health risks.

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