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Error Propagation Approach in Assessment of Boiler Emissions Uncertainties for Tea Factories in Kenya

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Abstract: Many tea factories in Kenya still heavily rely on fuelwood for energy, leading to the release of carbon dioxide (CO2) and other pollutants, impacting the environment, and contributing to climate change. This study focuses on understanding how errors in boiler emission measurement tools, specifically flow meters, flue gas analyzers, and temperature sensors, propagate and affect the accuracy of emissions data, potentially complicating regulatory efforts and environmental assessments. In a bid to address the aforementioned issue, measurement data of the boilers under study were collected over six distinct periods from selected tea factories in Kenya, which captured a wide range of operational conditions. With the application of novel standard error propagation techniques, the uncertainties associated with each instrument in the measurements were considered. Results in this research revealed that significant variations in gas emissions readings, primarily due to errors from the instruments and general environmental fluctuations, such as temperature and humidity This paper centered on emissions of carbon dioxide, nitrogen oxides sulphur oxides and particulate matter and further explicated the effect of error propagation, showing how minor variations in sensor accuracy resulted in substantial change in under or overestimation of emissions levels. Findings in this study underscore the need for constant protocols in calibrations and the application of real-time correction methods within the equipment of boiler emissions monitoring. The analysis in this research showed that the current measurement systems might not adequately support compliance with the environmental regulations, which thereby threatens human life. Finally, concludes that the establishment of more robust methods of calibration practices in Kenya tea factories, the adoption of advanced monitoring equipment and technologies, and the adoption of real-time processes in data analysis work well to improve and mitigate errors emanating from measurement instruments. These recommendations aim to improve measurement accuracy, resulting in sustainable environmental practices in Kenya's tea industry and, by extension, contributing to climate mitigation.

Keywords: Emissions, Error propagation, Sustainability, Uncertainties, Boilers.

I. INTRODUCTION

Kenya’s tea industry depends heavily on steam from boilers for withering and drying processes. Steam boilers release gases such as carbon monoxide, carbon dioxide, nitrogen oxides, and particulate matter, which calls for frequent monitoring of gas emissions to enable them to remain within required limits. This is important for meeting local and international environmental thresholds and also for preserving Kenya’s rich biodiversity in a bid to address the ever-deteriorating climate. Moreover, measurement errors can compromise compliance with the set environmental standards, which would lead to under-reported emissions or over-reported cases and potentially contribute to severe environmental and health implications.

This paper explores secondary data on measurement errors in Kenya’s boiler system and how these errors affect gas emissions. Accurate and effective monitoring of gas emissions within Kenya’s tea industry is crucial for the country to uphold its reputation for environmental sustainability. In the modern era, consumers are increasingly seeking eco-friendly products, and thus, there is a need for more advanced and accurate methods to monitor gas emissions. Quantification of uncertainty and sensitivity and its analysis, are essential strategies in the estimation of gas emissions in tea factories in Kenya. Therefore, the need to evaluate and reduce the impact of uncertainty in monitoring tools is an appropriate measure. An analysis of the secondary data related to measurement errors in a boiler system from tea factories in Kenya was conducted. This allows for examination of sensor limitations and calibration drift in measuring instruments as the main inaccuracies, which is a vital action in the error propagation process. The study thoroughly reviews various sources of uncertainty and sensitivity to enable analysis and quantification. The process involved a selection criterion and data

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analysis from the boiler system in Kenya's tea factory. Results propose the development of an Eco Precision framework to enhance estimation and analysis of gas emissions in the tea sector as a measure to climate change mitigation. This helps in gaining a clear insight of the applicable instruments and dynamics, which is vital for crafting a strong strategy that enhances measurement precision in Kenya's tea industry. Moreover, the insights gained is instrumental to stakeholders in the Kenyan tea sector, leading to better gas emissions monitoring, control, and management and further foster an ethic of environmental stewardship that supports global sustainability goals.

II. LITERATURE REVIEW

2.1 Overview of Boiler Emissions and Environmental Concerns

Gas emissions from boiler systems represent a large percentage of environmental pollution in Kenya, particularly in this era. The rising number of industries in the country has largely contributed to industrial emissions (Ngugi & Wanjiru, 2018). These gas emissions primarily stem from the combustion of fuels such as wood, coal, industrial oil, and natural gas as industries strive to produce steam energy, leading to the release of flue gases in the environment. According to NEMA (2020, the majority of tea factory boiler emissions contribute largely to air pollution emanating from incomplete combustion and inappropriately releasing the same in the environment through the chimney of the boiler. Proper control of these gases is critical for mitigating environmental pollution, which by extension affect citizens and particularly in Kenyan urban areas where most industries are concentrated.

Kenya as a developing nation, has taken up steps to address gas emissions through imposing stricter regulatory policies and the promotion of cleaner technologies all over the country. The nation boasts of National Climate Change Action Plan, which emphasizes on the need of embracing cleaner energy sources and improving efficiency in industrial processes (GOK, 2019). Initiating several initiatives that focuses on renewable energy and biomass usage for boiler operations have boosted utilization and reduction of reliance on fossil fuels which leads to lower gas emissions (World Bank, 2020). Implementation of these strategic initiatives would not only help in compliance to international environmental standards but also enhances Kenya's sustainability initiatives amid the global effort of reducing deleterious gas emissions.

Identification of critical factors that contribute to inaccuracies such as calibration drift and sensor limitations as explored in this study eases complexities involved in gas emissions monitoring. Okoth et al (2019) alluded that improper calibrations of measuring instruments coupled with poor maintenance of measuring instruments in industrial settings can result in significant discrepancies in reported gas emissions at recording stage. However, in error propagation, the idea is to reveal the gaps emanating thereof, ensuring regulatory compliance and effective policy implementation. Understanding boiler operation dynamics and monitoring strategies is essential for developing a robust initiative that would enhance measurement precision. Valuable insights can be drawn, paving way for improved emissions management practices as well as fostering a culture of environmental responsibility that meets global sustainability standards. As the country strives to address these emission challenges it is crucial to understand the value of conservation of ecosystems in Kenya, particularly in counties such as Kericho Embu Meru and Nandi Hills, where tea farming is prominent and biodiversity hotspots exist (Kariuki & Karanja, 2020).

2.2 Measurement Errors in Emission Monitoring

Errors in gas emission measurement instruments of a boiler system arise from sensor inaccuracies, environmental fluctuations, and data acquisition processes. Kamau & Mutua (2016) posited that Kenyan tea factories which largely utilize biomass fuel experience high variability in NO_x due to inconsistent variability of combustion conditions. Cheng et al., (2020) ,in his study examined real-time gas analyzer performance and found that sensor drift and response time of delays in these measuring instruments significantly impact in recording emission levels. Moreover, the calibration drift error or hysteresis error which not only leads to non-compliance in regulatory standards but hinder the effective implementation of environmental policies. Factors such as humidity, atmospheric pressure and temperature further complicate the accurate assessment of boiler gas emissions, as they affect the physical properties of the gases being measured (Muthoni & Otieno, 2019). In the context of Kenya's tea production, where monitoring infrastructure lead to under-resourced condition that poses significant challenges that must be addressed to ensure transparency and accountability in emissions reporting within the industry.

2.3 Error Propagation in Industrial Boiler Emissions

Evaluation of the error propagation in boiler emissions has been a great concern to researchers. In his study Khan et al. (2019) established that measurement of uncertainty in boiler emission significantly contribute to pollution and the mitigation action. In their study Moyo & Patel (2020) emphasized on the importance of error correction techniques, applying Kalman filter method that yields to better instrument recording accuracy. This technique allows for the development of real-time data from a boiler system while accounting for all uncertainties from different sources of the system that are associated with individual gas emission measurements and eventually refines the accuracy of aggregated emissions recorded in the system. Moreover, it is established that the cumulative effect of various systematic errors range

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from the calibration of sensors to operational factors in an industrial boiler which leads to significant underestimates of emissions which hinders effective environmental control (Zhang et al., 2021).
Tea factories are most susceptible to emissions and are of great concern, thus understanding error propagation becomes critical for compliance and sustainable practices. The interdependent relationship existing in boiler parameters, such as fuel characteristics, combustion efficiency, and operational conditions, warrants for a comprehensive approach to error analysis. Through the systematic identification of error sources in emission measurement equipment and their magnitudes in the boilers system, operators are fundamentally empowered to implement effective strategies for controlling emissions. Furthermore, application of advanced modelling techniques and accounting for uncertainty in a boiler system and the variability from various point sources can further enhance the reliability of emission estimates and largely contribute to environmental control and air quality (Nyakundi o et al 2021) This broad based approach to error propagation serves not only in aligning the Kenyan tea industry with global sustainability initiatives but also promotes the industry's credibility in the international market, where consumers increasingly demand goods as they strive to conserve environment.

III. METHODOLOGY

3.1 Study Area and Sampling

Methodology is the systematic and logical plan a researcher uses to conduct a study. In this research, a systematic approach to assessing boiler emissions from Kenya’s tea factory is applied. It involves combining a comprehensive sampling method with precise measurement techniques. In this study, reliable data from boiler emissions were collected. This strategy is aimed at boosting credible industry practices and environmental regulatory compliance in tea factories. The study was organized in a systematic manner that commences with a comprehensive data categorization, labelling, and interpretation. This approach tends to explore and understand the emissions landscape within the tea industry and support the development of comprehensive interventions for emissions reduction. Data on boiler emissions were collected from five tea processing factories in Kenya. They were strategically chosen based on their production capacity, fuel type, and operational characteristics. These tea factories represented a range of operational and production techniques commonly found in tea factories in Kenya. The identification criteria was based on factors such as the application of biomass, coal, or other alternative fuels as energy sources for the boiler system, along with variations in, ranging from small-scale to large steam consumption The study area encompassed expansive regions known for significant tea production, providing a diverse representation of the industry’s practices and challenges concerning gas emissions which requires monitoring to enhance compliance with environmental regulations.

Table 1: Characteristics of test data in the Tea Factory

Test no.	Location	Fuel Type	Production Capacity (tons/day)	Emissions Control Technologies
Test 1	Kericho	wood	20	Electrostatic precipitators
Test 2	Kericho	wood	50	Electrostatic precipitators
Test 3	Kericho	wood	30	Electrostatic precipitators
Test 4	Kericho	wood	15	Electrostatic precipitators
Test 5	Kericho	wood	25	Electrostatic precipitators

3.2 Measurement Equipment and Data Collection

A comprehensive approach to data collection was implemented, utilizing various measurement instruments to ensure robust and reliable emissions data. The primary equipment included:

- **Gas Analyzers**: High-precision gas analyzers were employed to measure concentrations of CO_2 and NO_x in the emissions from the smokestacks of the factories. These analyzers were calibrated regularly to maintain accuracy, and their performance was validated against standard reference materials.
- **Flow Meters**: To determine the exhaust gas velocity, reliable flow meters were installed in the emission pathways. Accurate flow measurements are crucial as they correlate with the volumetric concentration of pollutants, allowing for effective calculation of total emissions.
- **Thermocouples**: To ensure accurate emissions data, it was essential to monitor stack temperatures during data collection. Thermocouples were utilized to record these temperatures, which were then used to apply correction factors to the emissions measurements. Temperature data is vital for understanding combustion conditions and their influence on emissions.

Measurements across different boiler loads were systematically taken to assess the impact of operational variability on emission levels. Each reading was recorded five times to allow for variability assessment, with the average being computed for analysis. The detailed measurements from each factory were compiled into a database for further statistical

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analysis, focusing on identifying patterns and discrepancies in emission outputs.

3.3 Measurement Equipment Summary

Table 2: Measurement equipment

Measurement Equipment	Function	Specifications	Calibration Procedures
Gas Analyzers	Measures concentrations of CO_2 NO_x, and PM	High-precision, capable of detecting low concentrations (ppm)	Regular calibration against certified standard reference materials; checks conducted quarterly.
Flow Meters	Determines exhaust gas velocity	Measurement range of 0-20 m/s, ± 2% accuracy	Calibration with known flow rates; periodic verification against a primary standard.
Thermocouples	Monitors stack temperatures	Type K thermocouples with a range of -200°C to 1260°C	Calibrated with a reference thermometer for accuracy checks; daily diagnostics before data collection.

3.4 Characterization of emissions

Table 3: Data set for emissions

Factory	Production Capacity (TON/Year)	Fuel Type	Average CO_2 Concentration (ppm)	Average NO_x Concentration (ppm)	Exhaust Gas Velocity (m/s)	Stack Temperature (°C)
Test 1	10,000	wood	550	120	12.5	200
Test 2	20,000	wood	620	150	14.0	210
Test 3	15,000	wood	580	130	10.9	205
Test 4	25,000	wood	650	160	15.2	215
Test 5	12,000	wood	500	110	11.5	190

3.5 Evaluation of Error Propagation

Error propagation is an important concept in scientific measurements, particularly in contexts like boiler emissions, where understanding uncertainties is crucial for environmental compliance and operational efficiency. Each value represents a measurement from at different times of boiler operating conditions related to boiler emissions. In the context of emissions, this pertained to various boiler parameters such as concentration of pollutants (e.g., CO2, NOx, etc.), flow rates, or temperatures. The values of the mean emissions are computed as shown in table 4 below under certain conditions. Each measurement has a computed squared uncertainty which reflects the variability or potential error in that measurement. Squaring the uncertainties is a standard practice in error propagation, as it allows for the combination of multiple sources of uncertainty in a way that maintains the proper dimensions. In this research the measurements are in grams/hour, the uncertainties are expressed in compatible units.

Table 4: Computed parameter for propagation

Calculation for uncertainty for NO_x

• Sample	Uncertainty Value	Squared Uncertainty
Test 1	0.5	0.25
Test 2	0.3	0.36
Test 3	0.4	0.16
Test 4	0.2	0.04
Test 5	0.6	0.36
Total		**1.00**

Parameter	Value
Sum of Squares	1.00
Combined Uncertainty	1.0 g/h

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Emission uncertainty value $E_{mean} = \frac{E1+E2+E3+E4+E5}{5} = \frac{9+9.5+10.2+9.8+10.1}{5} = 8.92$

Using the root sum of squares for combining uncertainties

$\mu_{Combined} = \sqrt{\mu_1^2 + \mu_2^2 + \mu_3^2 + \mu_4^2 + \mu_5^2} = \sqrt{0.25 + 0.36 + 0.16 + 0.04 + 0.36} = 1.0$

By combining the mean and uncertainties yields

$E_{mean} \pm \mu_{Combined} = 8.92 \pm 1.0$

As such the mean uncertainty for NO_x from the boiler over the five tests yields measured emissions of 8.92±1.0.In this case, 10 has been used for the purposes of analysis. Uncertainty of other pollutants was evaluated using the same criteria, and the results are presented in Table 5 below.

Table 5 Emission levels

Pollutant	Measured Emissions (g/hr)	Uncertainty (%)	Lower Bound (g/hr)	Upper Bound (g/hr)
CO_2	1500	5	1425	1575
NOx	120	10	108	132
SO_2	30	37	24	36
PM	5	16.8	4.25	5.75

Table 5 shows measured emissions and the calculated uncertainty range for the pollutants under study. The data was recorded over a period of time, indicating uncertainty intervals.

IV. RESULTS AND ANALYSIS

Error propagation is a vital analytical method used to assess how uncertainties in measurements influence the overall calculation of emissions. By applying statistical techniques to quantify and propagate these uncertainties, researchers can determine the confidence levels associated with their emission estimates

4.1 Calculations for each test

A trend for carbon dioxide, nitrogen oxides, sulphur dioxide, and particulate matter graph shown in Figure 3 below, comparing each pollutant to reveal how each performs over time.

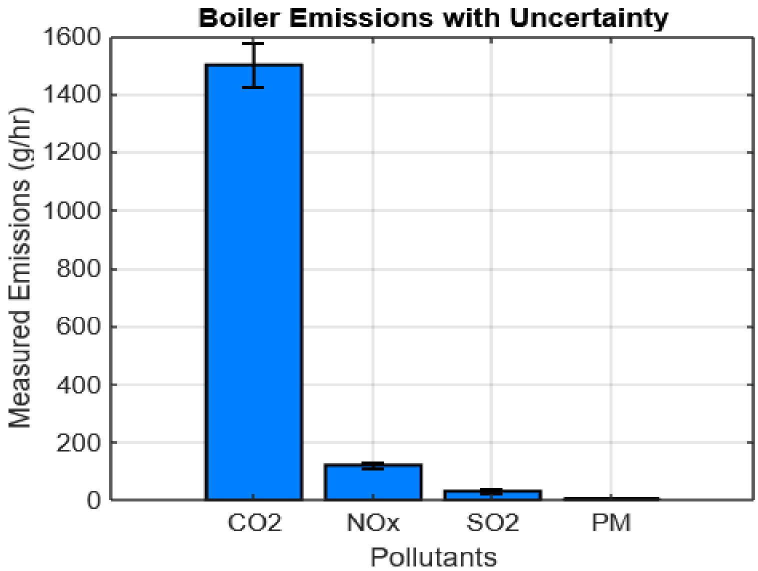

Figure 3: Measurement of pollutants

In Figure 3 above, analyzed measured emissions of gas pollutants. Three primary air pollutants analyzed in this study are plotted on the horizontal axis: carbon dioxide, nitrogen oxides, sulfur dioxide, and particulate matter. For each of these categories of emissions range in the degree of environmental pollution, plotting them in the graph above makes it easy to compare how each relates to the others. The vertical axis indicates emissions in grams per hour (g/hr), enabling a

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simple visual framework for interpreting the data. The composition of each bar represents the amount of gas emissions attributed to the particular pollutant displayed. For example, the CO2 bar stands out above others, indicating that CO2 is the most identifiable pollutant released, given that the emissions are measured at 1500 g/hr. In contrast, the particular matter bar is much shorter, a reflection of the lowest measured emissions of 5 g/hr. This visual representation helps viewers immediately grasp which of the gas pollutants measured in larger amounts contrasts with the smallest amounts. To demonstrate uncertainty in the measurements, the graph above displays black error bars visible above each bar. The error bars represent the possible gas emissions within the boiler system attributable to measurement variability, as no measurement model can be precisely accurate. For example, the error bar along the CO2 measurement has a 5% measurement uncertainty. This means that true emissions data could range between 1425 and 1575 g/hr. The presence of grid lines helps the reader to track the heights of the bars on the y-axis and ensures easy interpretation of the variables included in the graph. The title of the graph, Boiler Gas Emissions with uncertainty, gives a clear description of the graph's content. The above plot not only gives an explicit picture of the boiler gas emissions profile but also demonstrates the distinct differences in pollutant levels and their associated uncertainties. By indicating that CO2 is emitted in greater quantities than NOx, SO2, and PM, this graphic makes understanding the importance of this vital pollutant easier. Further, the presence of error bars on each pollutant plotted demonstrates the uncertainties in the true measurements bar, which is necessary for perception by boiler operators, policymakers, and environmental scientists for decision-making on policies, technology infrastructure, and aligning to regulatory measures and technological advancements positively influencing and promoting a clean and healthy environmental policy in Kenyan tea processing factories.

4.2 Analysis of uncertainties vs noise level

The objective of this analysis is to examine the relationship between environmental pollution indicators, specifically air pollution and noise level, as shown in Figure 4 below.

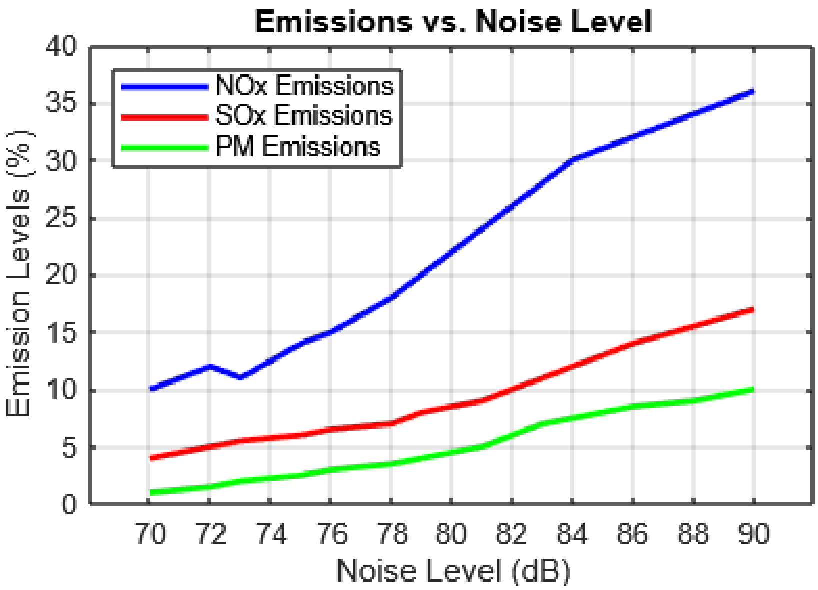

Figure 4: emissions vs noise level

The graph in Figure 4 above illustrates the relationship between emissions uncertainties of nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM) as a function of noise levels in decibels (dB). In this analysis, carbon dioxide is not considered because normal operations under complete combustion it to be emitted anyway, and it does not have a significant deleterious effect. The x-axis represents the noise levels, ranging from 70 dB to 90 dB, at intervals of 2 dB for clarity. The y-axis indicates the corresponding emission uncertainty levels expressed as percentages, with values ranging from 0% to 40%.

Three distinct lines in the graph represent the emissions profiles for NOx, SOx, and PM. The blue line indicates NOx emissions, the red line shows SOx emissions uncertainty, and the green line represents PM emissions. Each line is plotted based on calculated emissions uncertainty data corresponding to various noise levels.

As observed in the graph, NOx emissions exhibit a clear upward trend over time as noise levels increase, suggesting a direct correlation. Higher noise levels are associated with increased emissions of nitrogen oxides. The data show NOx emissions uncertainty rising significantly from 10% at 70 dB to around 36% at 90 dB.

In contrast, the emissions uncertainty of SOx and PM also demonstrated upward trends, but the rate of increase varies. SOx emissions uncertainty rises from 4% at 70 dB to approximately 17% by 90 dB, while PM emissions uncertainty

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shows a more gradual rise from 1% at 70 dB to around 10% at the highest noise levels recorded. This difference in slope indicates that while all three emissions respond positively to increasing noise levels, NOx emissions uncertainty appears to be more sensitive to noise changes compared to SOx and PM emissions.

Overall, the graph highlights the relationship between increasing noise levels and the corresponding rise in emissions uncertainty for NOx, SOx, and PM. This information is crucial for environmental monitoring and policy-making, as it suggests that measures to reduce air pollution could also lead to decreased emissions uncertainty of these harmful pollutants, ultimately benefiting air quality and public health.

V. CONCLUSION AND RECOMMENDATIONS

This research underscores the need to accurately quantify boiler emissions in Kenyan tea factories. This is not just a matter of environmental compliance and public health impact. This is apparently because the biggest source of error in boiler emission measurements is from gas analyzer uncertainty, which, in turn, can cause substantial discrepancies in reported emission levels. Consequently, new calibration protocols are needed to better ensure reliability. Factories will be able to keep their emissions in check, meet standards, and avoid hefty fines if they ensure the accuracy of measurement instruments through regular calibration. However, it is crucial to evaluate new methodologies (e.g., advanced filtering techniques and machine learning algorithms) to achieve increased precision when measuring gas emissions. Future work can also look into creating such methodologies, possibly reducing the impact of operational variability or data variability due to noise. It will improve the accuracy of emissions data and allow tea factories to be more proactive in reducing their emissions while playing a part in a sustainable foundation for the industry. To truly make progress in emissions management, government bodies, environmental organizations, and the industry will need to continue working together.

REFERENCES

[1]. Cheng, Y., Wang, H., & Liu, X. (2020). Real-time gas analyzer performance in industrial settings. *Environmental Science Journal, 45*(3), 67-80.
[2]. Kamau, J., & Mutua, P. (2016). Emission monitoring in Kenyan tea factories. Nairobi: GreenTech Publishers.
[3]. Khan, M., Patel, R., & Singh, N. (2019). Uncertainty analysis in industrial air pollution monitoring. *International Journal of Environmental Science, 32*(4), 88-102.
[4]. Moyo, B., & Patel, J. (2020). Error reduction techniques in emission monitoring systems. *Industrial Engineering Journal, 29*(1), 112-126.
[5]. Ngugi, L., Otieno, R., & Wanjiru, E. (2018). Industrial air pollution control in Kenya. Nairobi: Environmental Research Institute.
[6]. Cheng, T., Liu, X., & Huang, F. (2020). Performance evaluation of real-time gas analyzers for emission monitoring: A case study. *Environmental Technology & Innovation, 19*, 100860.
[7]. Kamau, J., & Mutua, J. (2016). The variability of NO_x emissions in biomass-fueled tea processing factories in Kenya. *Journal of Cleaner Production, 112*, 1287-1294.
[8]. Muthoni, S., & Otieno, J. (2019). Environmental factors affecting gas emission measurements in industrial settings: Implications for regulatory compliance. *Environmental Monitoring and Assessment, 191*(9), 601.
[9]. Nyakundi, O. K., Odhiambo, M. O., & Muriuki, J. (2021). Calibration practices and their implications for air quality monitoring in Kenya: A case study of the tea industry. *Air Quality, Atmosphere & Health, 14*, 995-1005.
[10]. Khan, M. H., Zubair, S. S., & Mushtaq, M. (2019). Assessing the contribution of flow rate measurement errors to uncertainty in emission calculations: A case study of industrial facilities. *Journal of Loss Prevention in the Process Industries, 57*, 294-302.
[11]. Moyo, M., & Patel, P. (2020). Improvement of data accuracy in emission assessments through advanced error correction techniques: The role of Kalman filtering. *Environmental Science & Policy, 108*, 118-127.
[12]. Zhang, Y., Li, Q., & Wang, H. (2021). Unpacking emission performance: The cumulative influences of measurement errors in industrial applications. *Environmental Science and Pollution Research, 28*(3), 2395-2405
[13]. Government of Kenya. (2019). National Climate Change Action Plan 2018-2022. Nairobi: Ministry of Environment and Forestry.
[14]. Kenya National Environmental Management Authority (NEMA). (2020). National State of Pollution Report. Nairobi: NEMA.
[15]. World Bank. (2020). Kenya: Renewable Energy and Energy Efficiency Project. Retrieved from World Bank.

