IMPACT OF INDUSTRIAL EMISSIONS ON CLIMATE

Students:

Nishil Mahesh Patel

Hafsa Yasir Jamal

Agatha Rague Mambori

Teachers:
Maureen A. Okayo
Richard M. Muema
Beatrice S. Oyange

School:
Shree Swaminarayan Academy, Mombasa

Country:
Kenya

Shree Swaminarayan Academy

Teach Through Expounding of Themes

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

List of tables

List of Figures

SUMMARY

Our project aims to analyze the consequences of industrial emissions on the climate of Mombasa. By studying the emissions produced by various industries in the area, the project seeks to understand their impact on the local climate and identify potential risks and challenges.

The research project will utilize advanced scientific methodologies and data analysis techniques to assess the relationship between industrial emissions and climate change in Mombasa. It will also investigate the specific pollutants released by industries and their contribution to greenhouse gas emissions.

Furthermore, the project intends to evaluate the potential consequences of these emissions on key climate indicators such as temperature, precipitation patterns, and sea levels in Mombasa. By doing so, it aims to provide valuable insights into the environmental and socio-economic implications of industrial activities in the region.

The findings of this research project will be crucial for policymakers, industries, and local communities in Mombasa. They will inform decision-making processes, supporting the development of sustainable strategies to mitigate the adverse effects of industrial emissions on the climate. Ultimately, the project aims to contribute to the creation of a cleaner and more resilient environment in Mombasa, benefitting both present and future generations.

Key words: *industrial emission, greenhouse gases, climate change*

INTRODUCTION

Industrialization is the process through which an economy evolves from manual labor-based industries to a mechanized and technology-driven system, relying on factories. It involves the introduction of industrial technologies and the establishment of factories. This transition is characterized by the use of machinery, mass production techniques, and the organization of labor on a larger scale. Industrialization brings about positive contributions to economic growth and the overall improvement of livelihoods in society. However, it is important to acknowledge that it also has negative impact on the environment and climate.

Location of Mombasa City

Mombasa has experienced rapid economic growth due to the expansion of the Mombasa Port. Today, the port serves as a major gateway for import and export activities among East African countries, including Kenya, Uganda, Tanzania, Rwanda, Somalia, Burundi, and Eastern Democratic Republic of Congo (DRC).

Location of Mombasa: 4° 2' 37.4640" S and 39° 39' 31.9356" E

Figure 1: A map showing Mombasa County

RESEARCH QUESTIONS

1. Has Mombasa city experienced industrialization over the years?
2. Is there evidence of emissions from the industries around Mombasa?
3. How has the industrial emissions affected the climate of Mombasa?

LITERATURE REVIEW

Industrialization in Mombasa

Mombasa, historically serving as a major port city, has seen rapid industrialization in various sectors over the years. According to Brenda et al. (2008), the expansion of manufacturing industries, including oil refineries, chemical plants, and power generation units, has transformed the city's landscape. These developments have attracted investments and contributed to economic growth but also raised concerns regarding the environmental impact.

Evidence of Industrial Emissions

According to Gatari et al. (2009), several studies have provided evidence of industrial emissions in and around Mombasa. Air quality monitoring has shown high levels of pollutants such as sulfur dioxide (SO2), nitrogen oxides (NOx), and particulate matter (PM) in areas where industrial activities are concentrated. Satellite observations and ground-based measurements have detected the presence of industrial emissions, particularly greenhouse gases (GHGs), contributing to the regional atmospheric pollution.

Impact on Mombasa's Climate

The industrial emissions in Mombasa have had significant repercussions on the city's climate. According to Innocent et al. (2020), the discharge of GHGs, primarily carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), has led to the intensification of the greenhouse effect, resulting in a rise in average temperatures. This phenomenon, known as global warming, has led to various climate-related changes, including increased frequency and intensity of extreme weather events such as heatwaves, heavy rainfall, and droughts in the region.

In addition to rising temperatures, industrial emissions have also influenced Mombasa's air quality. According to deSouza2020)The release of pollutants into the atmosphere has contributed to the formation of smog and haze, affecting visibility and causing respiratory issues among the city's residents. Furthermore, the deposition of pollutants into nearby water bodies, such as the Indian Ocean, has resulted in marine pollution, negatively impacting aquatic ecosystems and biodiversity.

Mombasa city has experienced substantial industrialization, leading to the emission of pollutants and greenhouse gases. The presence of industrial emissions has significantly impacted the climate of Mombasa, contributing to rising temperatures, changes in rainfall patterns, and deteriorating air quality. It is essential for policymakers and industries to adopt sustainable practices, implement emission reduction strategies, and invest in clean energy sources to mitigate the adverse effects of industrial emissions on Mombasa's climate and environment. Continuous monitoring and research in this area are crucial to understanding the full extent of the impact and formulating effective mitigation measures.

Description of the Problem

- Mombasa city has experienced rapid growth of industries over the decades. These industries include the Port industry which is one of the busiest industries in East Africa and facilitates trade among the East African Countries, Manufacturing and Processing industries such as textile industries, steel production industries, cement manufacturing industries, grain industries, food processing industries, vehicle assembly industries among others.
- The establishment of these industries in Mombasa has consequently improved the economic status of the city and the living standards if its population. However, the growth of the factories and industries in the city has posed various challenges such as:
    1. Pollution
    2. Deforestation that has negatively impacted the carbon footprint in the city
    3. Social insecurity
    4. Emission of greenhouse gases

MATERIALS AND METHODS

The study employed the following materials and techniques to collect data.

i) Observation
ii) Field trips
iii) Data from meteorological database
iv) Use of GPS tools
v) Weather stations

Procedure:

Use of Google Earth Pro

We used Google Pro Application to analyse the rate of industrialization in Mombasa over the years

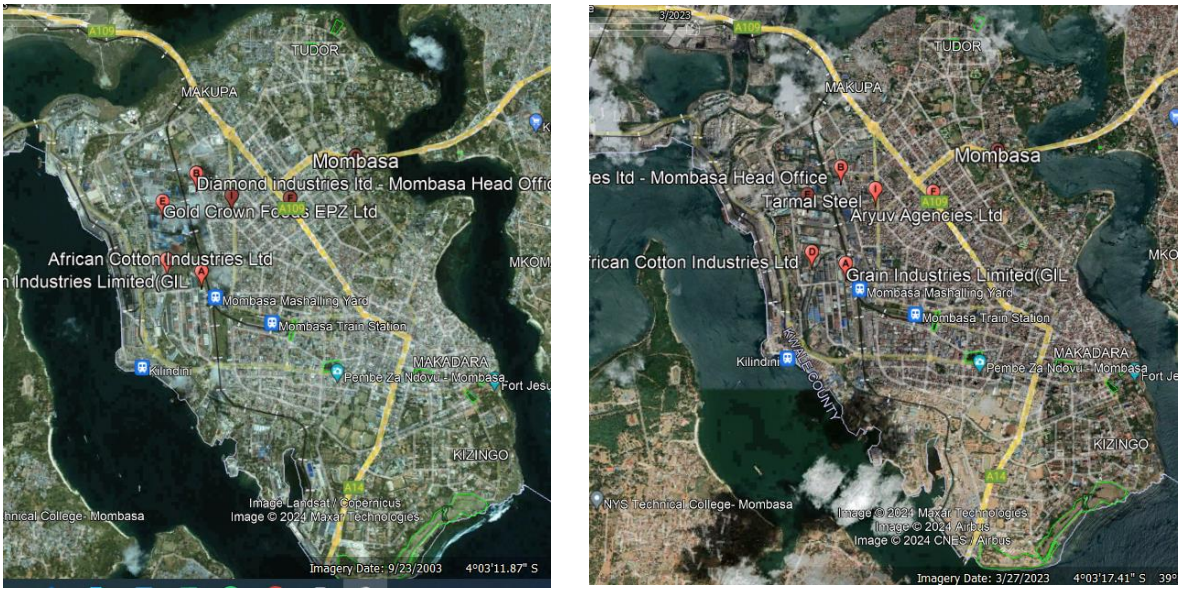

Figure 2: Google Pro Application images showing a timeline history of industries in Mombasa in 2003 and 2023

Field Trips

Fields trips were carried out where students were able to observe industrial activities and emissions.

School Weather Station and meteorological database

Data was also collected from the school weather station meteorological database and online emission factors database.

Figure 3: Data from Globe Website showing humidity, temperature and wind direction at Shree Swaminarayan Academy, Mombasa

RESULTS

Based on the data collected through observation, field trips, meteorological databases, GPS tools, and weather stations, the following results on the impacts of industrial emissions in Mombasa were outlined.

Growth of new industries in Mombasa

Historical evidence showed numerous industries establishment in Mombasa over the years.

Table 1: Growth of Industries in Mombasa

Industries	Year of establishment
Steel Makers Ltd - Steel manufacturing -	2009
Portside Freight Terminals - Logistics and shipping	2008
Mombasa Cement Limited	2007
White Pearl Suites	2005
Bridges Exploration Limited - Mining and exploration	2003
Bidco Africa - Oils and fats manufacturing	2002
TSS Grain Millers Ltd -	1983
Kapa Oil Refineries Ltd	1970
Kenya Ports Authority	1978
Eveready East Africa Ltd	1967
Mabati Rolling Mills Ltd -	1961
Crown Paints Kenya Plc - Paint manufacturing	1958 (but expanded operations in Mombasa in the 2000s
Bamburi Cement Ltd	1951
Kenya Meat Commission	1950
East African Breweries Ltd	1922

Evidence of emissions from the industries

Visible pollutants such as smoke, particulate matter, and chemical odour were observed in areas surrounding industrial sites.

Figure 4: Showing evidence of Emissions

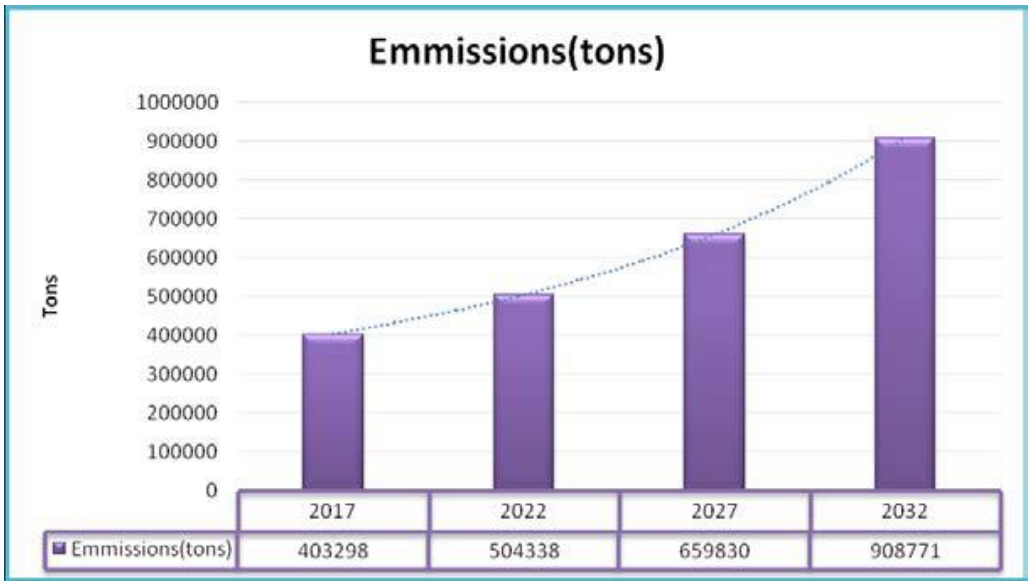

Figure 5: Emission Projections for the Port of Mombasa

Direct impacts on local vegetation, including discoloration, leaf damage, and reduced biodiversity, were noted.

Figure 6: Showing evidence of discoloured vegetation around industries

Evidence of impact of industrial emissions on climate

The analysis of meteorological data indicated patterns of air movement, including prevailing wind directions and speeds. Temperature inversions were identified as a common event, trapping pollutants close to the ground and worsening local air quality issues.

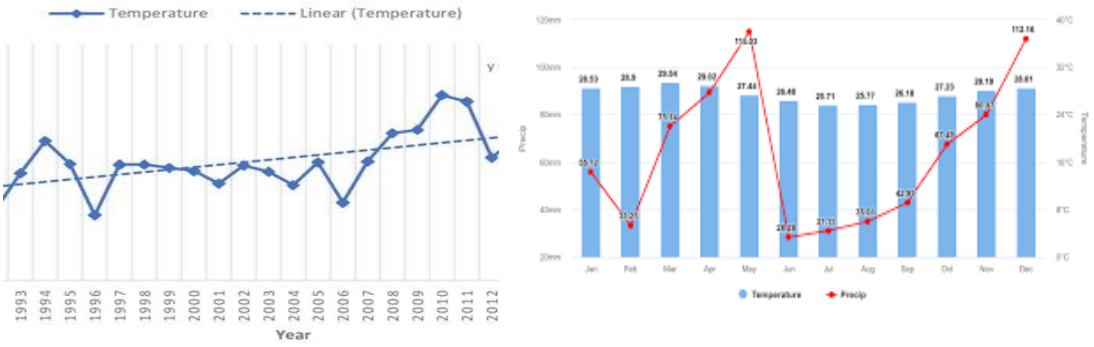

Figure 7: Urban climate variability trend in the coastal region of Mombasa Kenya

Relationships between weather conditions and air pollution levels were observed, with stagnant weather conditions leading to higher pollutant concentrations.

Real-time and historical weather data provided insights into atmospheric conditions influencing the dispersion of pollutants.

Wind patterns were found to play a significant role in transporting pollutants away from industrial sources or concentrating them in specific areas. Temperature and humidity data helped understand the formation and behaviour of secondary pollutants such as ozone and particulate matter.

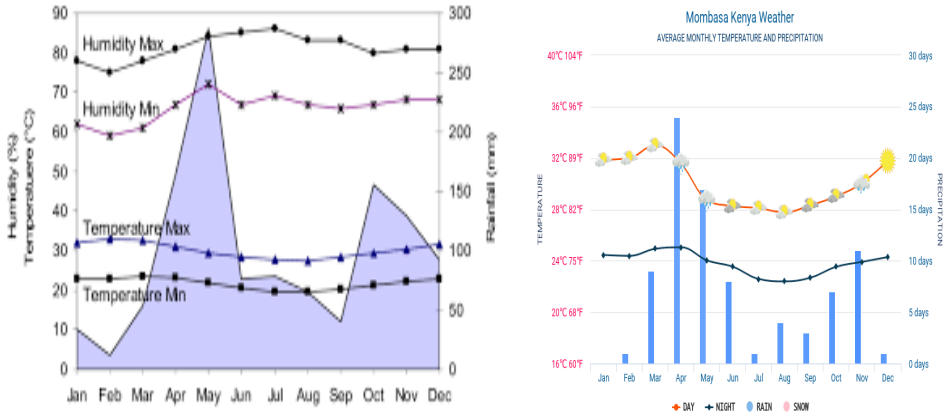

Figure 8: Showing average monthly temperature, humidity and rainfall patterns in Mombasa.

DISCUSSION

Mombasa, a busy coastal city in Kenya, has witnessed rapid industrialization over the recent decades accompanied by a notable increase in industrial emissions.

These emissions comprising of greenhouse gases (GHGs) and various pollutants have impacts on the climate in Mombasa.

Greenhouse Gas Emissions: Industrial activities in Mombasa contribute significantly to the emission of greenhouse gases, including carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). Satellite observations and ground-based measurements validate the rise in GHG concentrations over time, verifying the role of industrial emissions in enhancing the greenhouse effect.

Temperature Trends: Investigational climate data show an upward trend in temperatures in Mombasa, aligning with global warming patterns. Long-term temperature records show a warming trend that is consistent with the enhanced greenhouse effect attributed to industrial emissions. This factual observation highlights the direct impact of industrial activities on the local climate.

Precipitation Patterns: Scientific studies based on rainfall data illustrate noticeable changes in precipitation patterns in Mombasa. There is practical evidence suggesting alterations in the timing and intensity of rainfall events. Such shifts are closely tied to the influence of industrial emissions on regional climate systems, further emphasizing the factual impact on precipitation.

Sea Level Rise: Mombasa, being a coastal city, is prone to sea level rise. Satellite altimetry and tide gauge records confirm the factual occurrence of rising sea levels. Industrial emissions contribute to global thermal expansion and the melting of ice caps and glaciers, leading to a measurable rise in sea levels consequently resulting to the depletion of the ecosystem.

Extreme Weather Events: Observational records of extreme weather events, including storms and heatwaves, align with the scientific understanding of climate change brought by industrial emissions. The factual occurrence of more frequent and intense extreme weather events is consistent with climate models projecting the influence of industrial activities on weather patterns.

Conclusion

In conclusion, the factual discussion based on empirical evidence reveals the undeniable impact of industrial emissions on the climate in Mombasa.

The observed trends in temperature, precipitation, sea level rise and extreme weather events provide a foundation for understanding the consequences of industrialization on the local and global climate system.

Addressing these impacts requires informed policy decisions, sustainable industrial practices, and concerted efforts to mitigate further climate change in Mombasa.

Recommendations

Based on the findings, the study recommends industries and factories to adopt

Installing Pollution Control Devices: Industries in Mombasa should install and regularly maintain pollution control devices such as scrubbers, filters, and electrostatic precipitators to capture and treat harmful emissions before they are released into the atmosphere.

Switching to Cleaner Fuels: Transitioning to cleaner fuels such as natural gas or renewable energy sources can significantly reduce emissions of harmful pollutants such as sulfur dioxide and Nitrogen Dioxide.

Investing in Green Technologies: Industries in Mombasa should invest in research and development of green technologies such as **Carbon Capture and Storage** (CCS) and renewable energy solutions to further reduce their environmental impacts.

Employee Training and Awareness: Training employees on the importance of environmental careful and responsible management and providing them with the necessary skills to implement emission reduction measures.

Recycling: Promoting recycling can reduce the amount of waste generated by industrial processes, thereby decreasing emissions associated with waste disposal.

Implementation of regulatory policies: Policymakers to enforce strict emission regulations and standards in Mombasa. The regulations should cover various sectors such as power generation, manufacturing, transportation and waste management. Regular monitoring and strict penalties for non-compliance will ensure that industries take responsibility for their emissions and take necessary steps to reduce their carbon footprint.

References

Brenda, C., Victor Ayo Orindi, & Ochieng Adwera, A. (2008). Climate change and coastal cities: The case of Mombasa, Kenya. *Environment and Urbanization*, *20*(1), 231–242. https://doi.org/10.1177/0956247808089158

deSouza, P. (2020). Air pollution in Kenya: A review. *Air Quality, Atmosphere & Health*, *13*(12), 1487–1495. https://doi.org/10.1007/s11869-020-00902-x

Gatari, M. J., Boman, J., & Wagner, A. (2009). Characterization of aerosol particles at an industrial background site in Nairobi, Kenya. *X-Ray Spectrometry*, *38*(1), 37–44. https://doi.org/10.1002/xrs.1097

Innocent, O. N., James, K. K., John, N. M., Evelyn, W. C., & George, N. G. (2020). Urban climate variability trend in the coastal region of Mombasa Kenya. *African Journal of Environmental Science and Technology*, *14*(8), 214–221. https://doi.org/10.5897/AJEST2020.2837