1. INTRODUCTION

Cities in both developed and developing countries are key points of biogenic emissions and climate change impacts including the urban heat island effect. Anthropogenic Heat (AH) emissions are an important driver of warming in urban areas. The implementation of mitigation measures within urban sectors such as improving energy efficiency and reducing industrial and commercial energy consumption is crucial in limiting and controlling urban heat island effects and improving air quality. Characterizing atmospheric emissions is a fast step for the generation of empirical evidence to identify policy measures that are most likely to simultaneously meet development needs and allow for societal wellbeing and economic growth while managing environmental impacts.

This study provides an initial estimate of AH emissions for Durban for 2011. A top-down emission model was developed to quantify the AH emissions using municipality energy consumption statistics.

2. METHODOLOGY

AH emissions were quantified from energy consumption data from the effective (Durban) and ineffective (Isipingo-Bahere) inventory. AH emissions were quantified for the commercial, residential, industrial, traffic, and human metabolic sectors. These sectors have been acknowledged to be the primary sources of AH emissions in buildings. Transport and population emissions (Quah et al., 2010).

Equation 1 is proposed to quantify the anthropogenic heat emissions from fuel combustion (\(Q_{\text{comb}}\)) and was adopted from Quah and Roth (2010).

The equation was applied to the quantification of AH emissions from buildings and traffic.

\[
Q_{\text{comb}} = \sum_{i} M_{i} \cdot H_{i} \cdot LHV_{i} \quad \text{(W/m²)}
\]

Where \(M_{i}\) is the fuel type, \(H_{i}\) is the mean hourly consumption of fuel type, \(LHV_{i}\) is the lower heating value of the fuel type, and \(A_{i}\) is the size of the source emission area (ha). The source emission area for traffic was the road surface area covered by roads.

The equation was also applied to the quantification of emissions from buildings with the latter area considered for urban land use such as industrial/commercial/educational. The heat load of combustion fuel is also known as the net calorific value and the information is acquired from the South African Department of Energy (SAD, 2010).

Equation 2 is proposed to quantify anthropogenic heat emissions from buildings due to electricity consumption (\(Q_{\text{elec}}\)) and is modified from Quah and Roth (2012).

\[
Q_{\text{elec}} = \sum_{i} P_{i} \cdot f_{i} \quad \text{(W/m²)}
\]

Where \(P_{i}\) is the mean electricity consumption of hour \(i\) in Watts and \(A_{i}\) is the size of the source emission area (ha). It is assumed that all energy consumption by buildings released into the environment in the form of heat (Quah et al., 2010).

AH emissions from human metabolism (\(Q_{\text{met}}\)) were quantified using the factorial adopted from Allen et al. (2011) and is indicated by Equation 3.

\[
Q_{\text{met}} = \sum_{i} P_{i} \cdot f_{i} \quad \text{(W/m²)}
\]

Where the human population is indicated by \(P_{i}\). The area of the domain is \(A_{i}\) and the metabolic heat site is indicated by \(f_{i}\), which is occupied from Quah et al. (2010). Human population data was collected from Statistics South Africa.

Spatial disaggregation of the AH emissions was achieved using the methodology of Lee et al. (2009). Equation 4 is modified by Equation 4.

\[
Q_{\text{met}} = \sum_{i} P_{i} \cdot f_{i} \quad \text{(W/m²)}
\]

Where \(A_{i}\) is the total human metabolism, \(f_{i}\) is the density of the area fraction of sectors including residential, industrial, and commercial land use. The South African national land cover database for 2009 and 2011 is used to identify each land use type. The total data was provided by Statistics South Africa.

3. Results and Discussion

The total hourly averaged AH emissions for Durban is 77 W/m² for 2011. The primary contributors to the total AH emissions are traffic and industry. The spatial distribution of the AH emissions from these sectors are indicated in Figure 1. As indicated in figure 2, total AH emissions are composed by 40% transport, 20% industry, 20% commercial and the remainder by human metabolism and education.

The objective of compiling the emission maps was to identify key emission hotspots. The spatial distribution of the total AH emissions are indicated in figure 3. The maximum emission intensity ranges between 230 and 23 W/m² with areas of the highest emission intensity located in the industrial sector category. These areas are located in specific industrial regions such as in the north of the city. Other areas with relatively greater AH emissions were found to be located in large industrial areas with high industrial intensity such as in the northeast of the city. Other areas with relatively greater AH emissions were found to be located in large industrial areas. These areas include Siphego, Duma, Ridge/Riders, and Prospect. Additionally, the areas of Durban North and Isipingo Rocks are major transport regions which use less commercial and light industrial centers.

Efforts to reduce anthropogenic heat emissions will contribute to urban heat island mitigation and the road transport and industrial sector should be prioritized.

4. Conclusion

This is one of the first studies to quantify AF emissions for a South African city. AH emissions are essential factors in city-scale atmospheric circulation and surface temperature and so such the type of analysis will allow policymakers to identify key areas to quantify these emissions. South African cities have a high and spatial scale that can support urban climate assessment. Future work will include the composition of the AH emissions estimate quantified in this study modelled emissions for Durban at a global scale.

References


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