Assessment of air quality and contribution of gas flaring to atmospheric pollution in the Niger Delta using remote sensing and Geographic Information Systems

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Abstract

Due to economic, accessibility and security constraints, the majority of developing countries within the low-latitudes lack the capacity to establish networks of ground-based air pollution monitoring stations. As a result, there is a lack of systematic and consistent measurements and monitoring of the concentrations of air pollutants in most of these countries. In addition, there is the lack of verifiable inventories of sources of atmospheric emissions. This research presents an investigation into the relevance of currently available satellite sensors to estimate concentrations of air pollutants (carbon monoxide, nitrogen dioxide and tropospheric ozone) and carbon dioxide over the Niger Delta, a developing region in southern part of Nigeria. It further presents a methodological framework designed to interpolate column concentrations from satellite sensors over the entire study area using ordinary kriging interpolation techniques in ArcGIS Geostatistical Analyst. The study also carries out an assessment of the reliability and resolution of the interpolated surfaces based on a subjective categorisation of the number of column measurements available from satellites sensors and the mean of the Euclidean distances between the column measurements. The results indicate varying degrees of reliability and resolution. Seasonal variations in concentrations are also observed.

In addition to the satellite sensor-based assessment of concentrations of air pollutants and CO_2, this research designed and constructed a GIS-based Niger Delta Emission Inventory (NDEI) infrastructure for criteria air pollutants (carbon monoxide, particulate matter, nitrogen oxides and sulphur dioxide), methane, non-methane volatile organic compounds and carbon dioxide. The NDEI has point-source, line-source and area-source components. Due to the lack of access to data, the infrastructure is populated with data generated based on a series of assumptions. This produced estimates with varying degree of uncertainties. However, the process successfully validates the functionality of the infrastructure to produce accurate emission estimates as and when accurate data are input. Although the estimates of emissions generated from the inventory are not accurate, the spatial distributions of the emissions are accurate to the extent of the available input spatial data.

The comparison of the spatial distributions of the concentrations of CO, CO_2 and NO_2 from satellite sensors with the spatial distributions of emissions of CO, CO_2 and NO_x respectively indicates that concentrations of these trace gases are higher downwind of the sources. The variations observed in the spatial distribution of concentrations indicate that seasonal variations in rainfall and relative humidity also have effects on concentrations of these gases over the Niger Delta.

The thesis concludes by recommending further research work to explore opportunities to infer ground level concentrations of pollutants from satellite sensor measurements. In

addition, the thesis recommends the implementation of a site survey to collect site-specific information in order to refine the input data into the NDEI to produce accurate estimates of emissions. The recommendations made from this study aim towards enhancing the development of relatively inexpensive means of measuring and assessing air quality for developing regions within the low latitudes.