Air Dispersion Modeling Using AERMOD

Jamaican communities in close proximity to the highly industrialized Kingston Metropolitan region have suffered tremendously from the impacts of unsatisfactory air pollution monitoring and the lack of enforcement of regulatory standards. This is in part due to the lack of funding available to the state-owned regulatory agency, NEPA, and the technological barriers which would allow them to assess and to regulate for compliance.

The main sources of air pollutants in Jamaica have been bauxite/alumina plants, power plants, cement, lime, chemical processing, the petroleum refining industry and automobiles. The substances most commonly found in the air include particulates, carbon monoxide, aldehydes, acrolein, hydrogen bromide, hydrogen fluoride, hydrogen chloride, hydrogen cyanide, nitrous oxides, and oxides of sulphur, phenols, dioxins and furans.

Notwithstanding these issues, some large industrial manufacturing companies have been proactive in assessing their impact, through dispersion modeling, namely Caribbean Cement Company Limited and PetroJam Limited. These initiatives are undertaken in part, to assess their impact on the environment and also mitigate these impacts. This research will illustrate how the US EPA's recommended, short range (50 km) dispersion modeling software, AERMOD, can be used to evaluate air pollution episodes as well as predict strategies to reduce these impacts in sensitive areas within the Kingston Metropolitan Region.

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INTRODUCTION

AERMOD is an air dispersion modeling software that can be used to predict the concentration of air pollutants within a 50 km radius from the source. It is a Gaussian-based model that usually has the following assumptions: emission rate constant, terrain relatively flat, the plume is symmetric and the maximum concentration of the pollutant within the plume is at the centerline. Although AERMOD is Gaussian based, modeling can be done for both flat and elevated terrain and also accounts for urban effects, thus one of the many reasons why this model is the Environmental Protection Agency's recommended software for short range modeling. The pollutant of interest for this work was benzene. Benzene is inherently carcinogenic and while there is there is no worldwide standard for ambient benzene levels the National Resource Conservation Act (NRCA) limit for benzene is $1\mu g/m^3$ for an annual averaging period. This figure was used to guide simulations and evaluate results obtained through AERMOD.

METHODS

This research used AERMOD to predict the concentration of benzene within the industrial district in close proximity to Petrojam, resulting from operations at the petroleum refinery. Compliance with environmental standards and potential health effects to sensitive receptors within a 50 km radius were also examined. Variables of interest investigated were terrain, season and time of day to establish effects on the concentration in sensitive zones within the 50 km radius. Volatile Organic compounds such as benzene are released to the atmosphere during the refining process however fugitive emissions from valves, flanges and storage tanks are the main sources of benzene, and these sources were investigated. Sources that involve

combustion also release benzene to the atmosphere but are considered negligible and were not considered for this work.

AERMOD

Pre-processors in AERMOD were used to prepare data for simulation. Data that were required for simulation were meteorological data; terrain data and land cover data. AERMET was the pre-processor used to prepare meteorological data; files that included hourly surface data and upper air data for the period of January 1, 2017 to December 31, 2017. Land cover data was generated by using the Land use creator utility in the NLCD92 format where AERSURFACE calculated Albedo, Bowen ratio and surface roughness. Terrain data was generated using WebGis where the SRTM1 (Global~30m) - Version 3 was selected. This file was selected because the simulation was done outside the United States of America.

RESULTS AND FUTURE WORK

Eight simulations were conducted where terrain, time of day and season were manipulated to establish a relationship with maximum concentration of benzene for 1hr and 8 hr averaging period. It was found that the day time had lower concentration than night time where the maximum concentration predicted was 0.5 $\mu g/m^3$. Simulations done to predict maximum ambient benzene concentration for an annual averaging period predicted a maximum concentration of 0.1$\mu g/m^3$. A risk assessment was done to assess the possible health effects due to exposure to benzene. Furthermore, Petrojam plans to upgrade which means the addition of equipment such as valves and flanges. These equipment will be additional sources of benzene at the refinery. The JPS Power Plant was not accounted for in the simulation due to time constraint

therefore for future projects, the JPS Power should be accounted. Future work will also explore the various other sources of benzene within the industrial district in close proximity to Petrojam.

References

Air Quality Consultant Limited. (2005). *Air Dispersion Modeling Report for the Proposed 5000 MTPD Cement Manufacturing Facility to be Located at Bodles, St. Catherine, Jamaica*. Retrievedfrom http://nepa.gov.jm/eias/kingston/cement_jamaica/cemet_plant_quarry/appendices/AIR%20DISPERSION%20MODELING%20REPORT%20Nov%204.pdf

Brelsford, R. (2017). Jamaican refinery due $1-billion overhaul. Retrieved September 26, 2017, fromhttp://www.ogj.com/articles/2017/02/jamaican-refinery-due-1-billion-overhaul.html

Daly, A., & Zannetti, P.(2007).AMBIENT AIR POLLUTION. Retrieved from http://www.ewp.rpi.edu/hartford/~ernesto/F2013/AWPPCE/AdditionalReadings/Air/Daly-Zannetti2007-AirPollutionModelingOverview.pdf

Environmental Protecting Agency. (2017). Air Quality Dispersion Modeling –Preferred and

Recommended Models. Retrieved from https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#cal3qhc

Gibson, M., Kundu, S., Satish, M. (2013). Dispersion Model Evaluation of PM 2.5, NOX and SO2 from Major line and Point Source in Nova Scotia, Canada using AERMOD. Retrieved from http://www.sciencedirect.com/science/article/pii/S1309104215303858

Grigoras, G., Cuculeanu, V.,et al (2010). Air Pollution Dispersion Modeling in a Polluted industrial area of complex terrain from Romania (Doctoral dissertation). Retrieved from http://inpressco.com/category/ijcet. (Accession or Order Number)

Hadlocon, L., Zhao, L., Bohrer, G., Kenny, W., Garrity, S., Wang, J., Upadhyay, J. (2015). Modeling of particulate matter dispersion from a poultry facility using AERMOD. Journal of the Air & Waste Management Association,65(2), 206-217. doi:10.1080/10962247.2014.986306

Hegdec, V.S.,Lokeshwari,N., et al (2013). Modelling of Pollutants from a Point Source: A Case study from Coke Industry, Dharwad, India (Doctoral dissertation). Retrieved from http://inpressco.com/category/ijcet. (Accession or Order Number)

Petrojam, JPS Combine to Address Air Quality at Marcus Garvey Drive. (2013, August 26). Retrieved September 20, 2017, from http://jis.gov.jm/petrojam-jps-combine-to-address-air-quality-at-marcus-garvey-drive/

Troung.S, C.H. et al (2016). Accidental benzene release risk assessment in an urban area using an atmospheric dispersion model. (2016, August 30). Retrieved December 16,207,fromhttps://www.sciencedirect.com/science/article/pii/S1352231016306811

Zannetti, P., Daly, A. D., & Freedman, F. R. (2015). Dispersion modeling of particulate matter containing hexavalent chromium during high winds in southern Iraq. Journal of the Air & Waste Management Association,65(2), 171-185. doi:10.1080/10962247.2014.981317