Study of CO_2 Behavior in Simulated Urban Canyons

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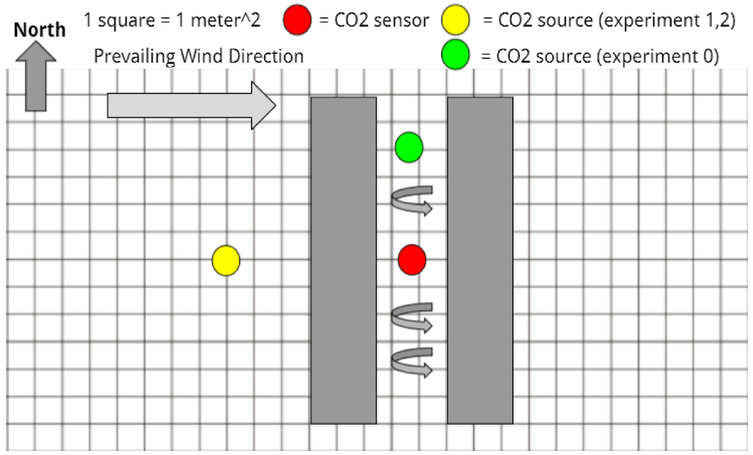
Abstract

Urban canyons, city blocks with tall buildings, may trap particles and molecules carried by the wind from oil recovery sites and surrounding areas[2]. This can cause health, environmental and safety concerns for residents within the area. This experiment studies the concentration and behavior of CO_2 in a scaled down simulated urban canyon using CONEX shipping containers. Concentration from source to canyon is specifically studied in this experiment. Through testing the amount of gas that is needed to accurately study CO_2 settlement in urban canyons, additional experiments can be performed. This relevant information can be scaled up to make predictions of CO_2 behavior in urban canyons. By studying the characteristics, solutions can be found to help alleviate these settled gasses and better the health of residents that frequent these localities.

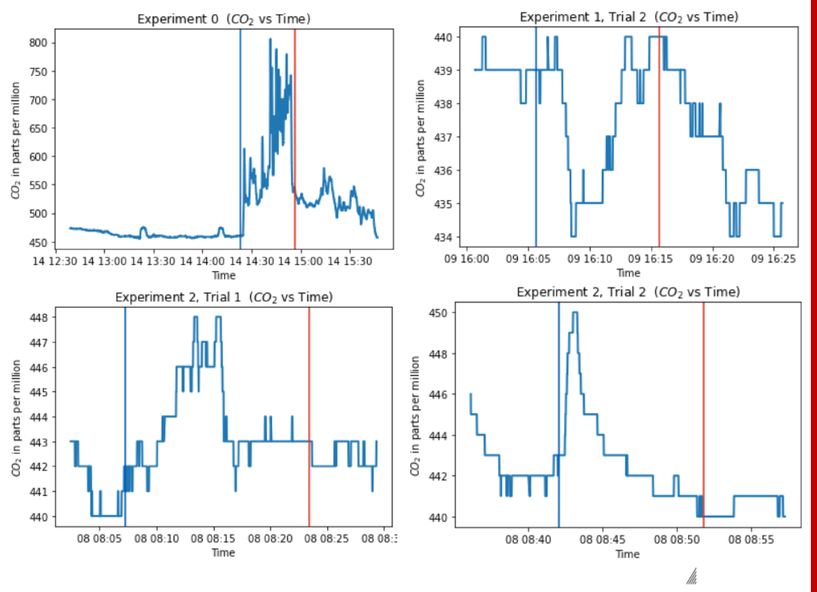
Experimental Design

•A simulated urban canyon was constructed by using two CONEX 12.2x2.4x2.4m containers. Each was placed 2.4m apart, and doors were used to close ends of the canyon depending on experimental design.
•A mobile CO_2 sensor was connected to a laptop to record CO_2, in parts per million. This sensor was an Arduino Nano with Sensair AB K30 CO2 sensor, sampling with 1ppm sensitivity in the range from 0-1%. The sensor measured at 1Hz and was logged using a laptop monitoring the 9600 baud connection from the Arduino. The K30 is an optical sensor with a 10cm path length that passively samples the atmosphere through a hydrophobic membrane.
•A CO_2 source, varying on experiment, can be placed within the canyon walls or outside the canyon.
- Experiment 0 - Citronella combustion within canyon
- Experiment 1 - Citronella combustion outside canyon
- Experiment 2 - Sodium Bicarbonate reaction outside canyon

•Weather station was placed at the site to record wind direction and weather conditions. Additionally, there is a nearby Mesonet station where the experiment was performed.



Data



Equations

Experiment 0 & 1 Reaction

$C_{10}H_{18}O + 14O_2 \rightarrow 10CO_2 + 9H_20$

1.103 moles burned

10 * 1.103 - 11.03 moles
= < 485.32g of CO_2
*assuming ideal combustion, over 10 mins

Experiment 2 Reaction

$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

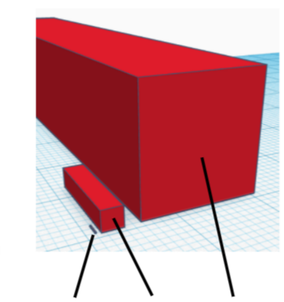
37.8 moles of reactant
31.8 moles of reagent (limiting)

31.8 moles
= 1399.518g of CO_2
*over 10 mins

Reaction Scaling

Wind Tunnel Canyon Volume (C) (1.5*0.057*0.06)
= 0.00513m^3 (**0.102g** of CO_2)
CONEX Canyon Volume (12.2*2.4*2.4)
= 70.272 m^3 (**1399.518g** of CO_2)
Approx. Urban Canyon Volume (C) (80.4*14.6*14.6)
= 17139.6m^3 (**341342.44g** of CO_2)

Experiment Scaling Visualization



Future Directions

There are many future studies that can be performed using the data from this experiment. Now knowing the amount of CO_2 to provide readable results, further experimentation can be done by studying wind patterns and concentration of CO_2 and different positions around the canyon[5]. While prevailing wind data was collected from this experiment, more atmospheric observations and relations to CO_2 can be made in the future. Relating atmospheric data and crossing it with CO_2 data would be a next step. Additionally, a ventilation system can be tested to see how effectively CO_2 concentrations can be alleviated from the canyon. By performing future experiments and ideas, more information can be found concerning CO_2 behavior in urban canyons to better the public.

Discussion

Based upon the results, a minimum level of CO_2 concentration must be established in order to have readable results. In order to perform an urban canyon experiment while using CO_2 from outside the canyon, the amount of CO_2 (in grams) will need to be approximately 19.92 times the volume of the canyon. Experiment 2 provided enough CO_2 to have readable results. Any less will not give recordable or reliable results. For urban canyon experiments done with a CO_2 source within the canyon, it was found that the amount of CO_2 (in grams) to create a sufficient experiment is 6.91 times the volume of the canyon. While more experimentation could be done to see if less will work, 6.91 times gives good results. These combined results can be the foundation for further experimentation and experimental designs when working with urban canyons.

Pictures

Acknowledgements & Sources

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