Comprehensive Air Quality Assessment Using Portable Devices: A Pilot Study for an In-Class Project

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Introduction

According to the World Health Organization (WHO), 92% of the world's population lives in a polluted environment. Air pollution had drawn increasing attention from the public due to its effect on human health. WHO estimated 6.5 million deaths associated with both indoor and outdoor air pollution in 2012. Studies have shown that breathing in air pollutants could trigger health problems or worsen respiratory and cardiac conditions. For example, a study conducted in 95 large U.S. communities, including about 40% of the total U.S. population, has shown a statistically significant association between changes in ground level ozone concentration and mortality.

There are two types of air pollutants, primary and secondary pollutants. Primary pollutants are produced from processes, such as nitrogen oxides (NOx) from high temperature combustion and particulate matter (PM) from the burning of fossil fuels. Secondary pollutants are not directly emitted, but they are formed in the air as a result from primary pollutants' interactions. An example of secondary pollutants is ground level ozone (O_3), it is created by the chemical reactions between nitrogen oxides and volatile organic compounds in the presence of sunlight.

This research project aimed to develop a course project to incorporate into the current undergraduate curriculum. The Aeroqual series 200 (S200) portable devices was investigated by conducting collocation calibration measurements. The data obtained were compared statistically with that obtained by the federal reference monitor and posted on the Environmental Protection Agency (EPA) database. The potassium iodide (KI) paper method of determining ground level ozone concentration was tested extensively as KI paper can be easily obtained. Standard operation procedures for the handling the S200 unit, navigating EPA database, and the KI paper method were compiled, which could be used by the instructor of the Environmental Chemistry course.

The results of this study could be used by instructors as part of the course project for the Environmental Chemistry course, allowing students in the class to gain hands-on experience with air quality monitoring. This also led to further studies on sensor durability which will determine the viability of using low-cost portable device to support field measurements.

Approach

Collocation measurements were conducted using S200 paired with nitrogen dioxide (NO_2), PM and O_3 sensors at the New Haven Criscuolo Park, an EPA air monitoring site that measures NOx, PM and O_3. For each measurement, the local weather conditions were recorded by a handheld weather station. Data of the same day and time interval will be downloaded from the EPA database and compared statistically to determine the reliability of the S200. Ozone data collected previously at the University of New Haven, West Haven campus was compared to the EPA data from the same day and time interval to study the performance of low-cost portable devices compared to the sophisticated EPA air monitors.

The KI paper method was tested extensively by exposing test strips for four, six and eight hours. The papers were collected and analyzed immediately after the exposed time. Relative humidity of the test site was recorded every hour during the test period. These results were compared to the Air Quality Index (AQI) updated throughout the day.

Standard operation procedures, including standard operation procedures for instrument handling and data collection, KI paper method, and navigation of the EPA database, were compiled. These materials could be used by instructor of the Environmental Chemistry course to allow students to gain hands-on experience with air quality monitoring.

Results and Discussion

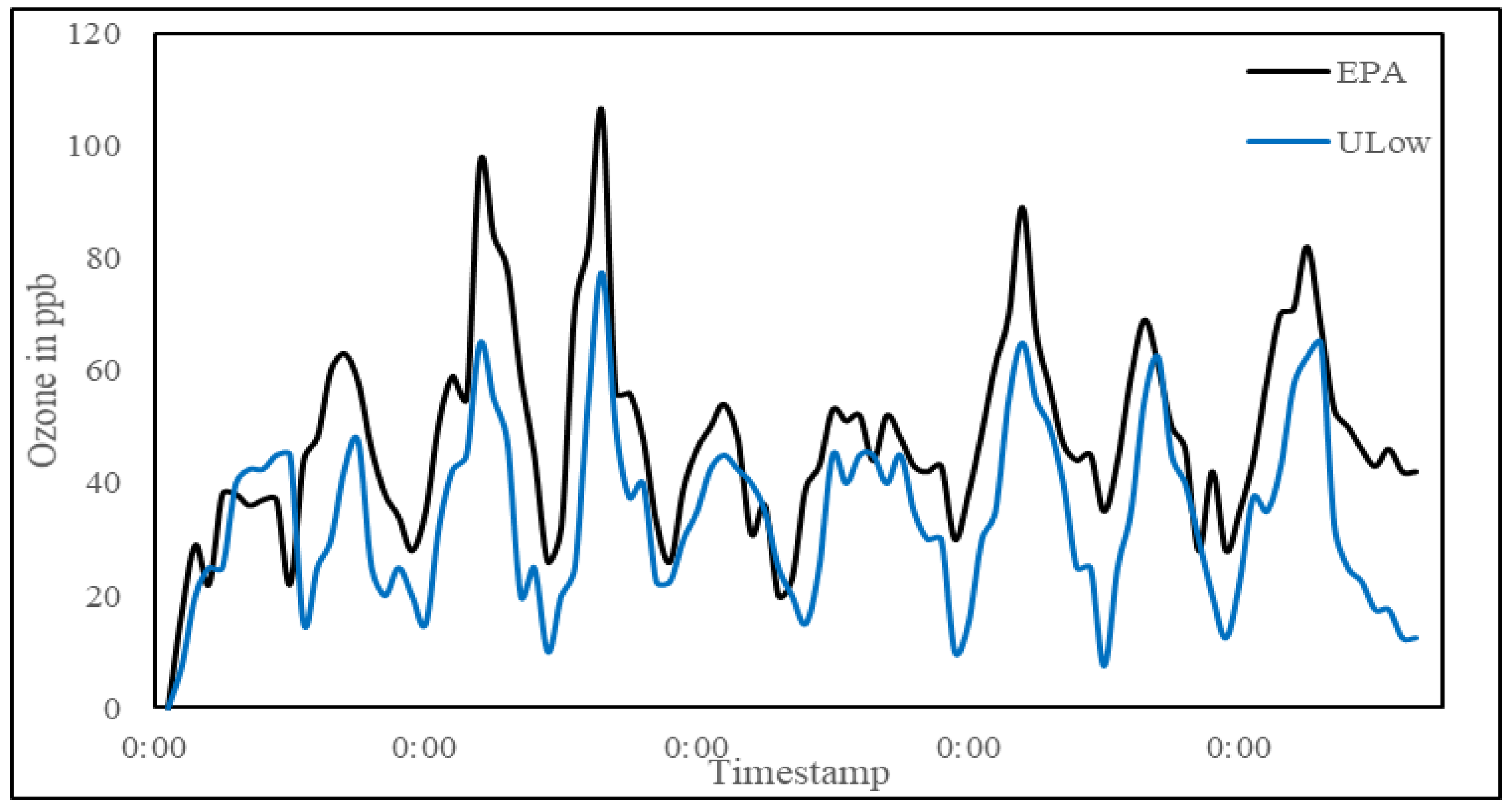

Figure 1: Ozone trend of EPA federal reference monitor (black) and Aeroqual ultra low (ULow) sensor (blue) of the same data and time interval. Measurement period: July 2017.

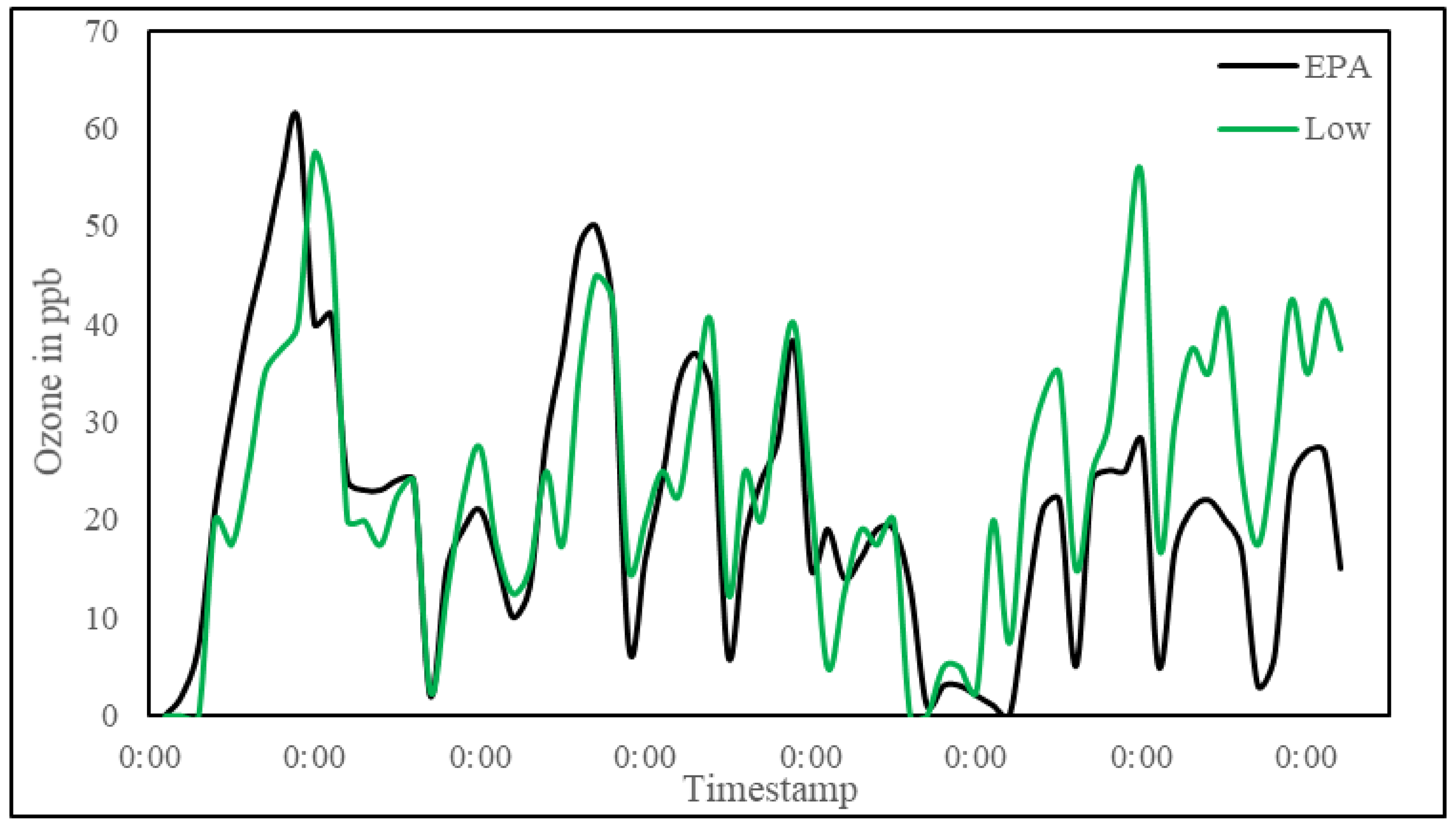

Figure 2: Ozone trend of EPA federal reference monitor (black) and Aeroqual low (Low) sensor (green) of the same day and time interval. Measurement period: September 2017–December 2017.

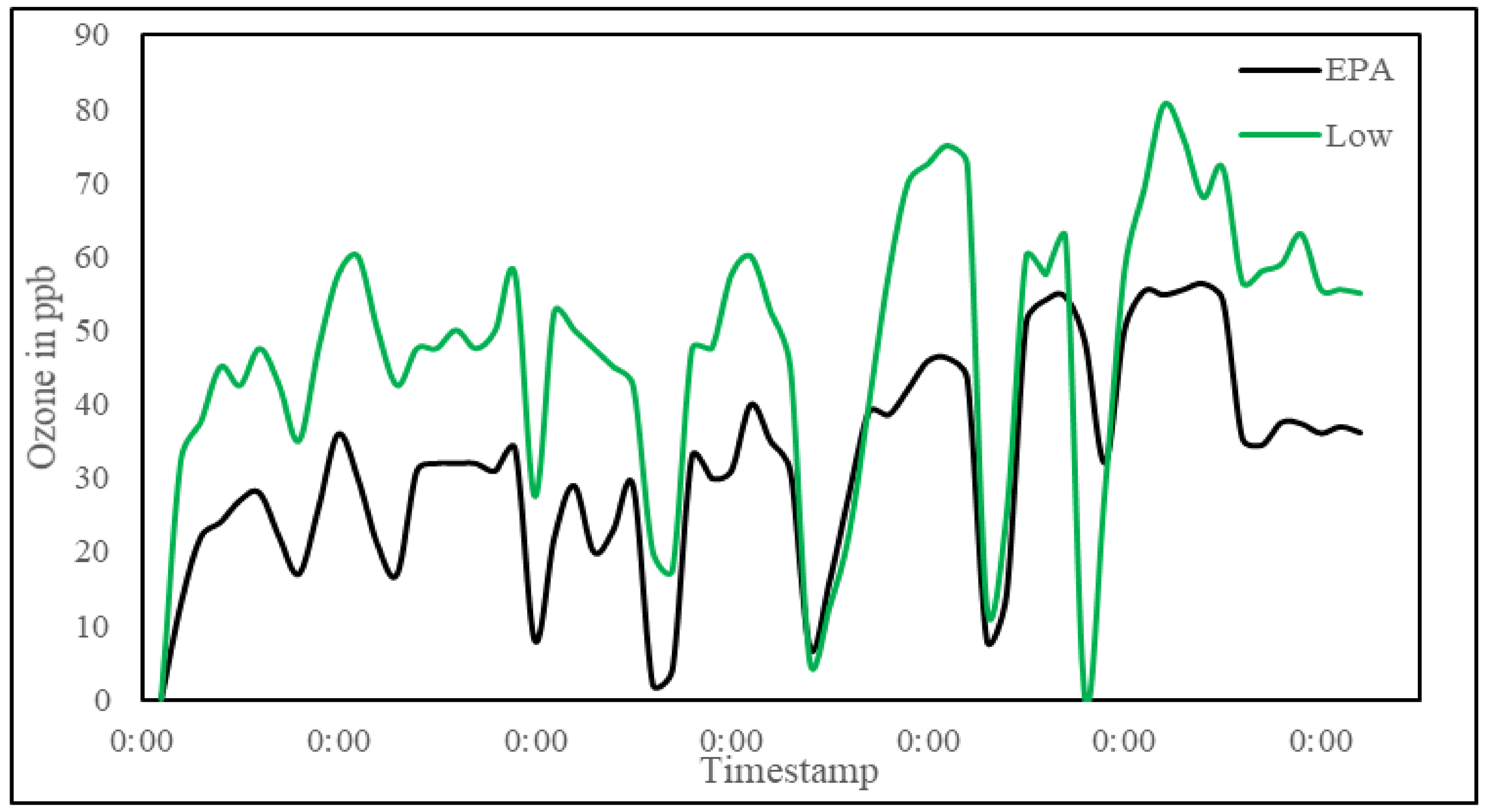

Figure 3: Ozone trend of EPA federal reference monitor (black) and Aeroqual low (Low) sensor (green) of the same day and time interval. Measurement period: January 2018-April 2018.

Table 1: Averaged ozone concentration obtained from the potassium iodide method and Air Quality Index (AQI) ozone data and its corresponding concentration range obtained from the Connecticut Department of Energy and Environmental Protection AirNow website.

Potassium Iodide Paper Method			CT DEEP Data	
Schoenbein number	Average RH	Ozone (ppb)	AQI (Ozone)	Ozone range (ppb)
8	70%	120	46	0-50
8	50%	150	84	101-150
10	50%	160	112	151-200
10	55%	150	43	0-50
10	40%	160	33	0-50
10	60%	150	108	151-200
10	70%	130	195	201-300
10	55%	150	38	0-50
10	60%	150	46	0-50
10	70%	130	147	201-300
10	60%	140	42	0-50
10	50%	150	45	0-50

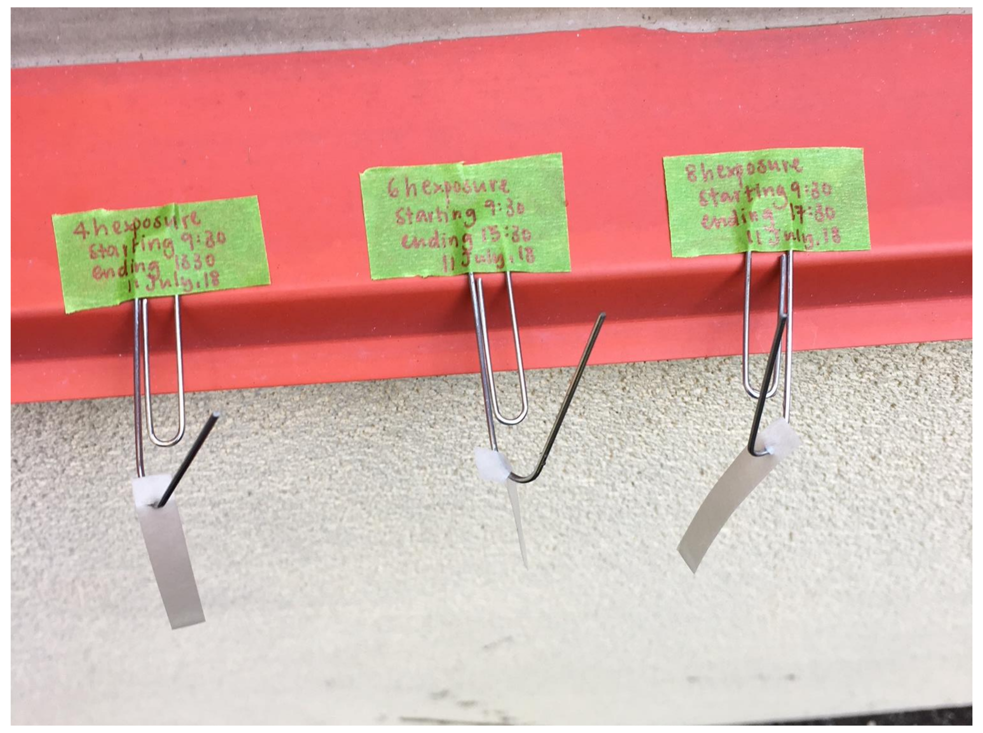

Figure 4: KI paper set up.

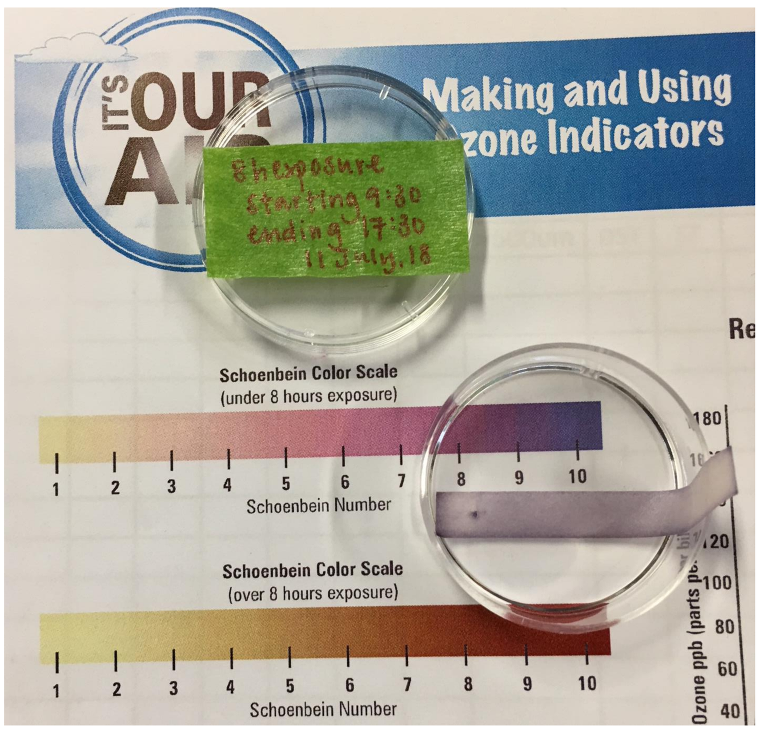

Figure 5: Colour change on test strip after exposed for eight hours.

Conclusions

The ozone trend curves from University of New Haven, West Haven campus data were compared to that of the EPA data, and they showed a similar trend, with off-sets in their absolute values. A higher offset was observed with the aging of sensors. The KI paper method was inconclusive due to the inconsistency observed on the test strips and the differences compared to the AQI reported values. The collocation measurement data will be analyzed to determine the viability of implementing this low-cost device in the community as a supplementary method of air quality monitoring.

References

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