Environmental Gaseous Sensing Using Sniffer Drone for Urban Development Control.

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Abstract. This study aims to present an environmental gaseous sensing analysis using drones in urban development control for the industrial area. The data collection method based on the possibility of gas dispersion in a heavy industrial area in Klang, Malaysia, to the neighbouring land uses. The sniffer has carried five types of gaseous sensors and mounted in DJI Matrice 100 quadcopter UAV. However, for this study, we analysed two significant gases related to an industrial area consisting of *Carbon dioxide* (CO^2) and *Hydrocarbon* (C_xH_y). The information has been collected in two modes of time which is in the early morning and afternoon. The data was mapped and analysed with a vector layer to identify either it breaches a concentration limits for gases collected. The finding stated that, the morning concentration reading is more dense compare to the afternoon. Results show that CO^2 and C_xH_y still under control and minimise the risk for the local population. However, the safety precaution should be undertaken since gas dispersion's future potential would go beyond and affect the surrounding activities. In conclusion, this study shows the UAVs potential as one of the best mechanisms to monitor the environmental effect. Simultaneously, there is a need to review existing urban development control since climate change and sustainability are linked through their interaction in industries, and its surrounding land uses.

Keywords: Environmental aseous, Sniffer drone, Industrial, land use and urban planning.

1 Introduction

The development control function seeks to manage and regulate property development to ensure that all development takes place at an appropriate time and place and in such a manner that it conforms to a pre determined set of policies or standards (Booth, 1983; Miller, 1990). The development control impose for industrial area are consist of development guidance for industrial development including the buffer zone implementation. The buffer zone's main aim is to preserve the quality of life by adopting the sustainable development concept. It also to ensure that appropriate consideration be given when selecting a site so as to avoid or minimize environmental conflicts arising from land use incompatibility (DOE, 2012). Public concern on about air pollutions appears to have increased over the past decades. As humans that are exposed to air pollution, water pollution and soil pollution among others, we also face an increased risk of falling victim to illness and disease. Industries may be significant contributors to air pollution experienced by local populations (Mohd Noor et al., 2018; Petrovic et al., 2016). There are many studies have inestigated the possible contribution to poor air quality accounted for 4.5 million premature death worldwide and 5% of those diagnosed with lung cancer will be due to extended exposure to pollution. A small percentage of chest infections, lung diseases, athsma and heart diseases can also be attributed to pollution (Buteau et al., 2020; Lyu et al., 2019; Roy & Braathen, n.d.).

The International Energy Agency (IEA) reported Malaysia's carbon emission was a total of 194 million tons for 2011, which has seen an increase of 290.7% from 1990 levels (IEA, 2013). Research using a long-range energy alternative planning system (LEAP) projected that without any mitigation measures, Malaysia's carbon dioxide (CO2) emission in 2020 will amount to 285.73 million tons; a 68.86% increase compared to year 2000 (Safaai et al., 2010). In relation to these facts, the cities are becoming hotter and societies might highly have exposed to health problems. Malaysia industrial activities, it also affects the GHG emission resulted from industrial. The highest percentage of gaseous emission from industry are CO2 as of 2014, CO2 emissions from the manufacturing and construction sectors were 12.97 percent of total fuel combustion in Malaysia. The highest in the last 43 years was 48.40 in 1971, while its lowest in 2014 was 12.97 (IEA Statistic, 2014). CO2 emissions from manufacturing and construction industries also include emissions from industrial automotive producers generating electricity and/or heat from the combustion of fuels in industry. Carbon dioxide is a colorless gas with a density about 60% higher than that of dry air. It occurs naturally in Earth's atmosphere as a trace gas. The current concentration is about 0.04% (410 ppm) by volume, having risen from pre-industrial levels of 280 ppm. The scale below shows that if the ppm value is above 1,000 ppm the environment is not safe for the people. While, a hydrocarbon is an organic chemical compound composed exclusively of hydrogen and carbon atoms. Hydrocarbons occur naturally and form the basis of crude oil, natural gas, coal, and other important energy sources. Hydrocarbons are highly combustible, producing carbon dioxide, water, and heat when burnt. Therefore, they are highly effective and sought after as a source of fuel. The highest percentage of hydrocarbon for industrial category is subjected to 2.2 percent basef on areas in United States. Methane leaking from hydrocarbon wells and pipelines is not just wasted energy and money, but a potent source of environmentally damaging greenhouse gas emissions. As regulations tighten and sensor technology improves both satellites and drones are helping detect such leaks.

Assessment of air quality has been traditionally conducted by ground based monitoring, and more recently by manned aircrafts and satellites. Small drones equipped with environmental sensing payloads are emerging as a valuable tool in different meteorology disciplines such as atmospheric chemistry, industrial emission monitoring and urban development control (Alvear et al., 2017; Burgués & Marco, 2020)(Hedworth et al., 2021). An environmental sensing payload gives drones a unique set of abilities such producing 3D air quality maps with high spatial resolution, monitoring toxic gases in dangerous or hard to reach locations or analysing the chemical composition of the lower atmosphere (Anweiler et al., 2017; Ruiz-Jimenez et al., 2019). The increase in the commercial drone manufacturing sector, which now offers a broad selection of small drones that are affordable for most research group .The availability of low cost lightweight gaseus sensing instruments, as well increasing social concern and tightening regulations on air pollution and global warming. The growing interest in drones for gases sensing applications is also evident from the recent market appearance of gas detectors specifically designed for drone applications and drones with integrated gas sensors. Aerial drones can be classified into two different categories according to their design: fixed wing mainly used for sampling over long distances and; rotary wing and used on localized studies (Chang et al., 2016; Corrigan et al., 2008; Noor et al., 2019, 2020).The use of multiple rotors at the periphery, equidistant around a central core, allows the allocation of sensors and sampling systems on the center of the craft , far away from potential turbulences and interference (Zhang et al., 2017) UAV/drones equipped with gas sensors to measure carbo dioxide, ozone, hydrocarbon and other pollutants have been used for air quality monitoring in land use acitivities in cities, greenhouses, mines and other dangerous or difficult to access location (Babaan et, al 2018; Bui et al, 2019 and weber et al 2017). This paper investigate the use of UAV sniffer drone for environmental analyse in urban development control for the industrial area. Being one of the among the first attempt to apply a drone technology to the heavy industrial area with dangerous chambers, our objective was not only to map the environmental gaseous but also to identify the potential of drone technology for development control in industrial area in Malaysia.

2 Study Area

The study area of Klang Industrial Area is located between 02º52N to 02º59N latitudes and 101º16E to 101º23E longitudes. Klang Industrial Area is surrounded by massive development in Klang City. The total area of Klang Industrial Area are 3748.03 hectares which consists based on type of industry activities. The type of industry activities are heavy industries which consists of 488.05 hectares, light industries comprises of 413.24 hectares, medium industries within the area of 2039.858 hectares and service industries allocate area of 20.2 hectares. The area comprises of 66.64 acres of heavy industry. This area involved in manufacture, electrical substation and industrial gas supplier. The company that include in the case study area are three main companies which contribute to manufacturing industries. These industries are focusing on palm oil processing, provision of industrial gas and manufacture and distribute industrial, specialty and medical gases respectively.

Figure 1: Location of study in Heavy Industrial Area of Klang, Malaysia.

3 Material and Methods

3.1 Drone data and Ancillary Information

The data has been collected from drone and ancillary data sources. The main data collected from the primary sources consist of gaseous data from sniffer drone that mounted to DJI Matrice Quadcopter (Table 1). The ancillary information collected from secondary sources include road network, drainage pattern, cadastral map of alienated land parcels, urban map and records industrial development in the site.

Table 1. Drone and sensor specification used in this study

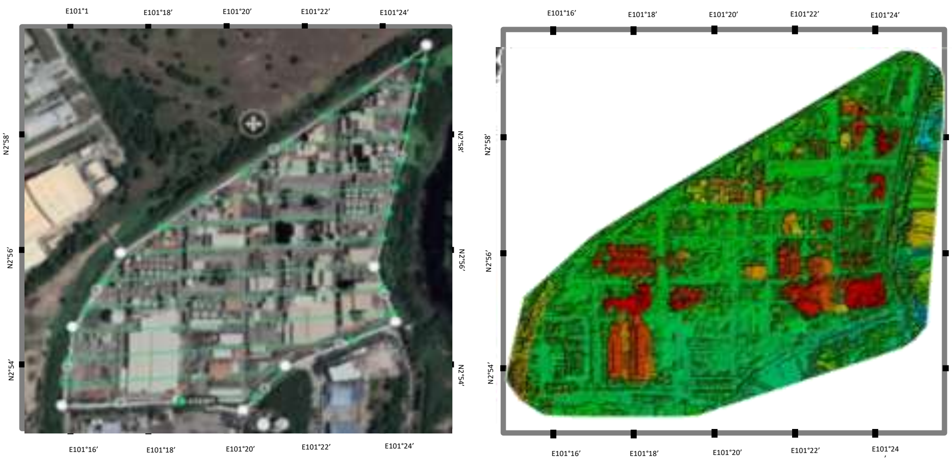
Element	**Description**
Drone Features	DJI Matrice 100. QuadCopter, 5km control range, HD video downlink, 1kg payload capacity, 20 min flight time with Sniffer4D installed.
Sensor	CO_2 module, 0 – 5,000ppm High-resolution O_3+NO_2 module; Wide-range CxHx (CH_4) module; High-res CO module; High-res SO_2 module;
Processing Software	Sniffer4D Mapper

3.2 Methods

The fieldwork was carried out on September 2020 under the permit of International Islamic university as an authority which managed research in Klang Industrial areas.

For the drone mission, a sniffer4D sensor as a mobile sensor on air pollutant mapping system carried 5 types of gaseous. It was mounted in Quadcopter drone of DJI matrice 100. Flight track at 100 meters were plan in Drone Deploy software and uploaded through its datalink (Fig.2a). The time was set up in early in the morning in order to get the accurate reading for gaseous that emited from industry activities.

The georeferenced images from the drone was further mosaic in Sniffer4D mapper Version 1.3.10.23 and Pix4D Mapper. The mosaic image were exported as a regular image with RGB values and Digital elevation Model (DEM) (Fig.2b). The produce RGB and DEM images were further rectified using Quantum Geographic Information system (Q-GIS3.16-Havannah software) were further rectified with the coordinate reference system was assigned to EPSG:3380 (Selangor)/UTMWGS.



(a) (b)

Figure 2 . a) The flight path assigned to the study area; b) Digital Elevation Model .

4 Result and Discussion

4.1 Industrial on Carbon Dioxide

The case study area is in normal range of outdoor CO_2 but the concentration value maybe in future will reach the hazardous level. The case study area which we take the reading of CO_2 represents many types of heavy to medium industrial activities. Based on Minnesota Department of Health, which they used the same hazardous scale as mentioned above have set the average concentration should not exceed 10,000 ppm over an 8-hour period, and the average concentration should not exceed 30,000 ppm over a 15-minute period.

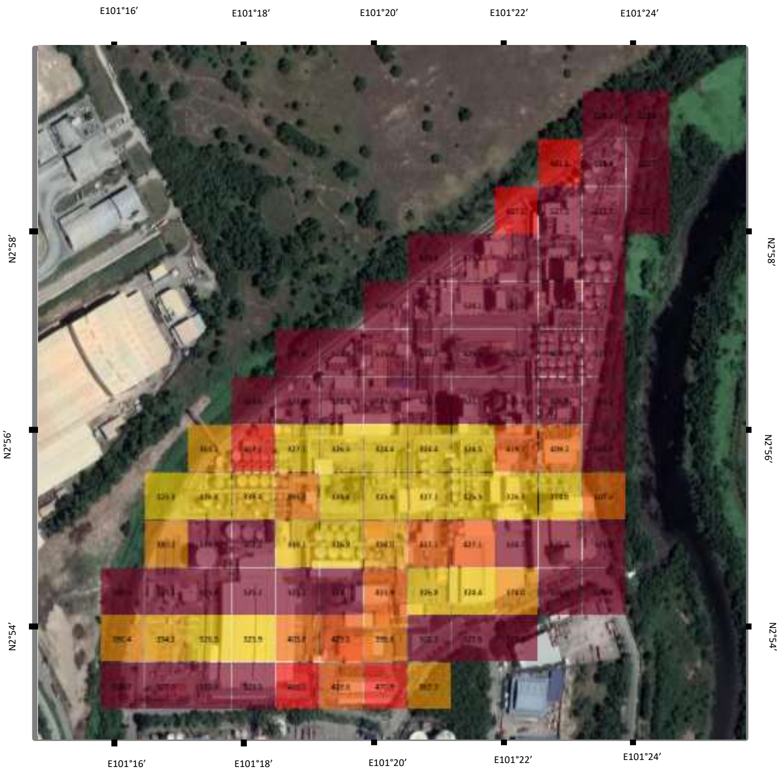


Figure 3: Reading path for Carbon dioxide (CO_2) by Sniffer4D drone at Pulau Indah at 100m Altitude
(Mission Time 2020/09/03 07:20:32 to 2020/09/03 07:36:11)

These standards have been developed for healthy working adults and might not be suitable for sensitive populations such as children and elderly. As stated above, the range of CO_2 of case study area for 100m is 267.018 ppm respectively, which is below 1,000 ppm. The scale shows that if the ppm value is above 1,000 ppm the environment is not safe for the people. This situation shows that the value of may be increases, thus the government must have a mitigation measure to avoid any disaster or pollution happened which result from high concentration of CO_2.

Table 2. Details of Co2 data captured by Sniffer Drone

Details of data capturing	Units
The total detected area (m2)	256431.844
Co2 Average Concentration	480.632 mg/m³
CO_2 Maximum Grid Concentration	527.348 mg/m³
CO_2 Minimum Grid Concentration	324.284 mg/m³
CO_2 Maximum Point Concentration	535.143 mg/m³ 2020/09/03 07:24:02

CO_2 Minimum Point Concentration	319.287 mg/m³ 2020/09/03 07:28:29

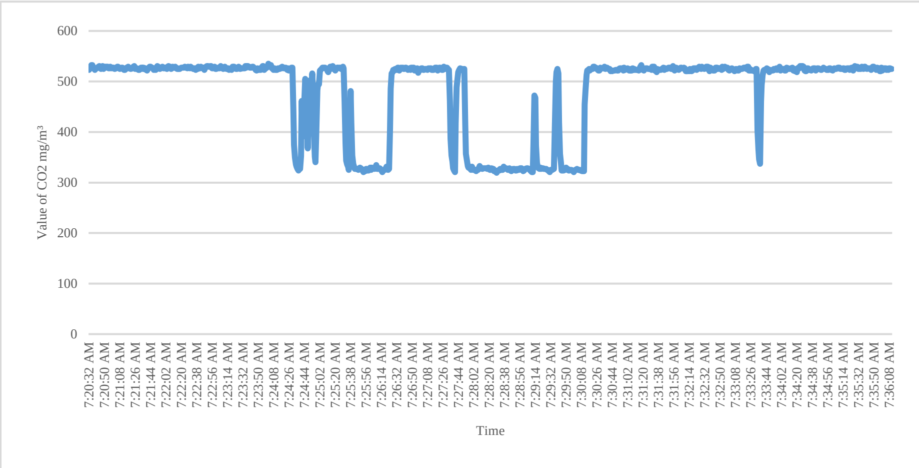


Figure 2 . The concentration values for carbon dioxide (CO_2) captured in study area

There are many gas limits for industrial activities and one of them are gas emission limit for hydrocarbon. At concentrations hundreds to thousands of times above the levels present in the atmosphere, these compounds are only very reactive. At levels below 500 ppm, no effects have been identified. The hydrocarbons that are aromatic are biochemically and biologically active. The vapours are much more irritating to environmental factor such as higher temperatures, weather inversions, low wind speed. Inhalation of vapours of aromatic compounds and haematological compounds may result in systemic injury. As per stated for the industrial gas category the limit subjected to 2.2 percent maximum for a certain area. In addition, it is stated that the percentage of 1% = 10000ppm. Therefore, the limit hazardous gas of hydrocarbon from industry has stated that below 500 ppm (U.S. Department of Health, Education, and Welfare). Hence, to relate with the industry site shows that the average of hydrocarbon is 0.078% which equivalent to 780 ppm. It shows the hazardous level for hydrocarbon. The reading is high and reach the hazardous level because hydrocarbon gas is mostly emitting from the industry stated in the area. Liquids, gases, and vapours can be hydrocarbons. Oil and gas extraction sites will release dissolved hydrocarbon gases such as methane, ethane, propane, and butane from production liquids and even evaporate. At atmospheric temperature and pressure, hydrocarbon gases found in crude oil are readily released into the air. The hydrocarbon usually are compacted and release from pressurized tank that usually found in the liquid manufacturing industries.

Figure 4: Reading path of Hydrocarbon by SnifferA4 drone at Pulau Indah at 100m Altitude
(Mission Time 2020/09/03 07:20:32 to 2020/09/03 07:36:11)

Table 3. Details of CxHy data captured by Sniffer Drone

Reading	Unit
The total detected area (m2)	204447.406
CxHy Average Concentration	0.070 %
CxHy Maximum Grid Concentration	0.071 %
CxHy Minimum Grid Concentration	0.066 %
CxHy Maximum Point Concentration	0.072 % 2020/09/03 19:30:04
CxHy Minimum Point Concentration	0.062 % 2020/09/03 19:31:17

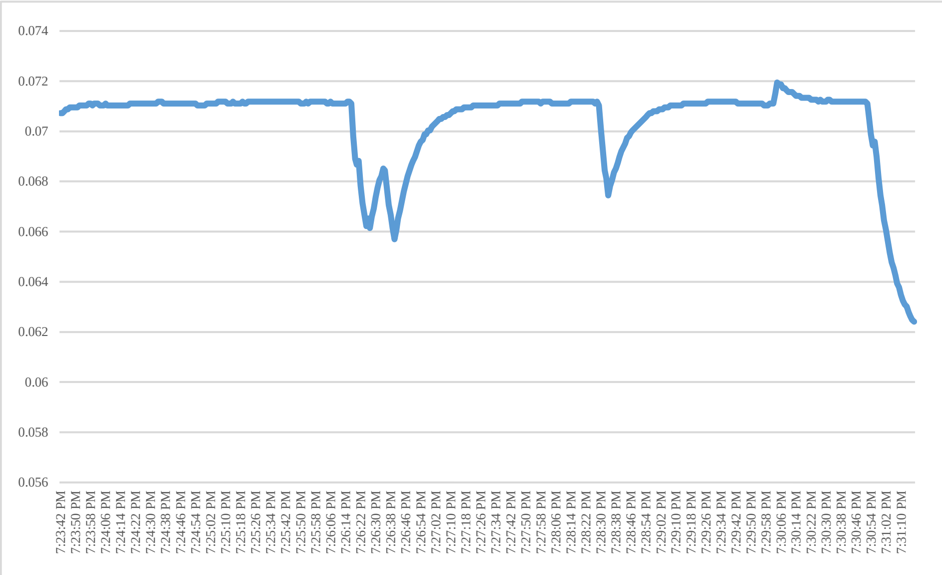


Figure 5: The concentration values for carbon dioxide (*CxHy*) captured in study area

The overall esult shows that the value of CO_2 is between average 291.928 ppm - 290.890 ppm and it is still below the hazardous level for CO_2. The value of the hydrocarbon are 650 ppm – 700 ppm which have the highest value between the three session. The value have reached the hazardous level for the hydrocarbon gaseous. In the case of high concentration, it shows the range of medium to high concentration level of carbon. Even though, the concentration level did not reach hazardous scale, but local authority and responsible parties must take precaution steps to control the carbon emission in industrial area. Hence, the Municipal Council must take consideration in carbon emission in future development and a significant step for local authorities in collaboration with regional and national authorities would be to define and fund appropriate institutions/s to collect and report this data in a standardized format, which offers comparative analysis of headline indicators at local, national and international level.

The recommendation in zoning of industrial area based on gaseous emission is important because based on findings medium and high concentration level are closely located to each other. For this reason, local and regional areas of industry will be an important analytical unit to ensure that the emission of gaseous takes place at the lowest concentration and to avoid dangerous climate change in good time. Local authorities also play an important and powerful role as green economy regulators, asset owners and potential customers. Therefore, local government should encourage green skills by encouraging sustainability and triple bottom line reporting, and sustainable practices in the building and design industries in zoning future industry development. The study in Klang Industrial area, Malaysia to carbon emission that contribute to GHG emission, has unfortunately attempted to match several other gaseous that contribute to GHG emission such as nitrogen and ozone due to financial and time constraints. So the analysis focused solely on carbon dioxide and carbon monoxide emission in Industrial area. It is recommended that other industrial area should be carried out for future research on the other gaseous emissions that lead to GHG emissions. Taking into account GHG emissions in Malaysia as the city is threatened by rapid urbanization, this continuous study has to be done in order to develop any future industrial area requirements in order to control the development.

5 Conclusion

Overall, this research have used UAV-based system to capture the environmental sensing gaseous for development control purposes. The UAV/drone system includes the DJI Matrice 100 carried a SnifferA4 sensor. Through this demonstration, the system proved to be safe, effective and economical tool assessing development control in heavy industrial area. Ultimately, the pollutant control measure can be derived by the system simultenously assessing development control for the industrial area. This research on using UAV/drone to capture environmental sensing gaseous is important in supporting the SDG number 11 which is "inclusive, safe and resilient communities". But this ambition is multifaceted and covers incongruous policy priorities and industries. One critical area of tension is evident between the goals of compact city (CC) growth (resource and land use, etc.) and urban green space (UGS) goals (important in, for example, living ability, biodiversity, and climate regulation) as GHG emission also related to climate change.

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References

Alvear, O., Zema, N. R., Natalizio, E., & Calafate, C. T. (2017). Using UAV-based systems to monitor air pollution in areas with poor accessibility. *Journal of Advanced Transportation, 2017*. https://doi.org/10.1155/2017/8204353

Anweiler, S., Piwowarski, D., & Ulbrich, R. (2017). Unmanned Aerial Vehicles for Environmental Monitoring with Special Reference to Heat Loss. *E3S Web of Conferences, 19*. https://doi.org/10.1051/e3sconf/20171902005

Booth, P. (1983). *Development Control and Design Quality: Part 1: Conditions: A Useful Way of Controlling Design?* (Vol. 54, Issue 3). https://www.jstor.org/stable/40112001

Burgués, J., & Marco, S. (2020). Environmental chemical sensing using small drones: A review.

In *Science of the Total Environment* (Vol. 748). Elsevier B.V. https://doi.org/10.1016/j.scitotenv.2020.141172

Buteau, S., Shekarrizfard, M., Hatzopolou, M., Gamache, P., Liu, L., & Smargiassi, A. (2020). Air pollution from industries and asthma onset in childhood: A population-based birth cohort study using dispersion modeling. *Environmental Research*, *185*. https://doi.org/10.1016/j.envres.2020.109180

Chang, C. C., Wang, J. L., Chang, C. Y., Liang, M. C., & Lin, M. R. (2016). Development of a multicopter-carried whole air sampling apparatus and its applications in environmental studies. *Chemosphere*, *144*, 484–492. https://doi.org/10.1016/j.chemosphere.2015.08.028

Corrigan, C. E., Roberts, G. C., Ramana, M. V, Kim, D., & Ramanathan, V. (2008). Capturing vertical profiles of aerosols and black carbon over the Indian Ocean using autonomous unmanned aerial vehicles. In *Atmos. Chem. Phys* (Vol. 8). www.atmos-chem-phys.net/8/737/2008/

Hedworth, H. A., Sayahi, T., Kelly, K. E., & Saad, T. (2021). The effectiveness of drones in measuring particulate matter. *Journal of Aerosol Science*, *152*. https://doi.org/10.1016/j.jaerosci.2020.105702

Lyu, R., Clarke, K. C., Zhang, J., Jia, X., Feng, J., & Li, J. (2019). The impact of urbanization and climate change on ecosystem services: A case study of the city belt along the Yellow River in Ningxia, China. *Computers, Environment and Urban Systems*, *77*. https://doi.org/10.1016/j.compenvurbsys.2019.101351

Miller, C. E. (1990). *Development Control as an Instrument of Environmental Management: A Review* (Vol. 61, Issue 3).

Mohd Noor, N., Abdullah, A., & Hashim, M. (2018). Remote sensing UAV/drones and its applications for urban areas: A review. *IOP Conference Series: Earth and Environmental Science*, *169*(1). https://doi.org/10.1088/1755-1315/169/1/012003

Noor, N. M., Afiq, A., Abdullah, A., Abdullah, A., Ibrahim, I., & Sabeek, S. (2019). 3D CITY MODELING USING MULTIROTOR DRONE FOR CITY HERITAGE CONSERVATION. In *MALAYSIA Journal of the Malaysia Institute of Planners* (Vol. 17).

Noor, N. M., Ibrahim, I., Abdullah, A., & Aiman Abdullah, A. A. (2020). Information fusion for cultural heritage three-dimensional modeling of Malay cities. *ISPRS International Journal of Geo-Information*, *9*(3). https://doi.org/10.3390/ijgi9030177

Petrovic, J., Lecic, D., & Pavlovic, D. (2016). Sustainable urban development and industrial pollution. *Industrija*, *44*(1), 167–185. https://doi.org/10.5937/industrija1-10466

Roy, R., & Braathen, N. A. (n.d.). *The Rising Cost of Ambient Air Pollution thus far in the 21st Century RESULTS FROM THE BRIICS AND THE OECD COUNTRIES*. https://doi.org/10.1787/d1b2b844-en

Ruiz-Jimenez, J., Zanca, N., Lan, H., Jussila, M., Hartonen, K., & Riekkola, M. L. (2019). Aerial drone as a carrier for miniaturized air sampling systems. *Journal of Chromatography A*, *1597*, 202–208. https://doi.org/10.1016/j.chroma.2019.04.009

Zhang, J., Ji, Y., Zhao, J., & Zhao, J. (2017). Optimal location of a particulate matter sampling head outside an unmanned aerial vehicle. *Particuology*, *32*, 153–159. https://doi.org/10.1016/j.partic.2016.09.012