INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (IJSREM)
VOLUME: 07 ISSUE: 06 | JUNE - 2023 SJIF RATING: 8.176 ISSN: 2582-3930

Dispersion analysis of Particulate Matter for Sustainable campus

[Ashmitha, T.[1], Gandhimathi, A.[2], Prasanth, S.[3]]

Author 1: PG Student, Dept. Of Civil Engineering, Kumaraguru College of Technology, Coimbatore-641049, India

Author 2: Associate Professor, Dept. Of Civil Engineering, Kumaraguru College of Technology, Coimbatore-641049, India

Author 3: Technical Assistant, Dept. Of Civil Engineering, Kumaraguru College of Technology, Coimbatore-641049, India

Abstract

Atmospheric pollution has increased in higher concentration in day-to-day life. Many sources of pollution cause heavy damage to human beings, monuments, and other living and non-living organisms. The pollutant dispersion varies as spatial, temporal, and spatiotemporal variation. The study was done in Kumaraguru College of Technology (11.079458ºN & 76.989494ºE), as it is known as a sustainable campus in Coimbatore city. The campus is covered with 4200 trees with an average of 10,000 students, working and non-working staff. Four locations (Main gate, Security office, Bus parking, Girl's hostel) were spotted, for analyzing PM_{10} on the campus using a respirable dust sampler. Collection of data and tabulating data from different locations on campus, a map to understand the dispersion of PM_{10} was created. Spatio-temporal interpolation using QGIS open software and the IDW (Inverse Distance Weighted) method was used. The study concluded that there is some variation in dispersion levels inside the sustainable campus. Comparison of results with TNPCB air quality standards. The contours for dispersion analysis done after interpolation mapping. This variation is noted by interpolation and contour mapping study using QGIS.

Key words: Sustainable campus, respirable dust sampler, QGIS, spatial interpolation.

I. INTRODUCTION

The sustainability campus covers green areas, or green space with great potential. SDGs 4 and 15 (Sustainable Developmental Goals) interaction says that applying the goals in the university had great ecological potential because of the development of the extensive presence of green space (Luciana Londero Brandli, 2020). The Smart Campus initiatives of air quality sensors implementation on campus provide a report on air quality in urban mobility and another source of the generation of air pollutants. It discussed the implications of the university context regarding ESD and SDG integration (Mazutti, 2020). The sustainability course conducted a qualitative evaluation from a pilot 14-week ethics that provided a framework for thinking about sustainable practices in personal and professional lives. The survey taken from students on campus about sustainable development and its feature of need in current life explained the present knowledge on sustainability (Kelly Biedenweg, 2013).

During the COVID-19 pandemic, research in SDG (Sustainable Developmental Goal) issues and observing knowledge. Mexico had the highest knowledge and Colombia the lowest was reported. The research plan from universities must consider the student report of interest in SDGs to promote specific projects that may have extensive participation of professors and students. Four countries were recognized with a research interest and compared the interest in creating sustainable cities and communities and responsible consumption and production (Aldo Alvarez-Risco, 2021). Physical learning resources are augmented with digital and social services were made as a goal for identifying the steps towards building such an environment and involved learning processes. Gateway to study these areas studied with the help of ambient learning space (ALS) induced by the multitude of PLOM objects in the concept (Atif, 2013).

CO, NO2, O3, and PM pollutants were monitored using Smart Personal Air Quality Monitoring System (SPAMS) for real-time air quality monitoring. The integration of the commercially available low-cost CO, NO2, O3, PM, temperature (T), and humidity (RH) sensors with the microcontroller and GPRS. Measurements that were performed in the field by walking on footpaths and traveling by bus at various duration of day and different days in a week. Two sample sets were taken on a bus and walking, with higher concentrations of CO and NO2 in the bus was due to peak traffic flow. During the noon, O3 concentration was found to be highest due to photochemical reactions (Nagendra, 2018).

Development of cities and changes in lifestyle have affected the environment in different ways, one among them being air pollution. Pollution in the air made people migrate from place to place, and studies show that it was also a reason for the migration. The degree of haze pollution in 35 major cities measured the PM. Monitoring has been done based on international students and local students in China, and results found that international students are more sensitive to urban air pollution (Xiaoxiao Liu, 2021). Reducing air pollution by implementing the newest technologies within markets is in current development. Car mobility decarbonization of passengers is to estimate the social cost saving to perform environmental and economic analysis. In a DWPT charging lane, coils were considered continuously distributed along a dedicated charging lane and generated positive externalities. Changes have made a reduction in air pollution and the release of pollutants (Paolo Lazzeroni, 2020).

Collection of air quality monitoring using a drone sensor developed to monitor CO, NO_2, SO_2, O_3, CO_2, CH_4, and particulate matter (PM_{10}). Carbon and other emissions reduction by promoting and implementing groundbreaking sustainable energy and efficient energy programs. Field data sampling was done by 3D space in location as designed in this study. Real-time data was collected and displayed on the TV screen. Emissions from different sources of vehicles and monitoring done by drone technology by sensor installation (Udawatta, 2016). Predicting O_3, NO_x, CO, and $PM_{2.5}$ concentrations using long short-term memory (LSTM) approach is more efficient than other deep learning methods. Hourly concentration prediction during 2008-2010 data found that LSTM model efficiency deal with complexities and ambient air quality forecasting. Meteorological factors play a vital role in CO and NO_x concentration generated. $PM_{2.5}$ and O_3 concentrations during prediction were influenced by factors such as meteorological, traffic, and emission characteristics (Krishan, 2019).

Real-time Environmental Applications and Display System (READY) for producing air parcel trajectory and dispersion models were the results. The displaying meteorological data to run HYSPLIT atmospheric transport and dispersion model results. READY has a section on dispersion model evaluation verification and support training with animations that are available for multi-time period simulations. Dispersion products viewed using Adobe pdf, Google Earth kmz, or other formats developed by the READY model (Glenn Rolph, 2017). Explaining the spatial variation of air pollutant concentrations within a LUR (Land use regression) modeling framework to estimate SRS (Satellite Remote Sensing) and comparing both models, AQM estimates performed relatively better than SRS estimates model for $PM_{2.5}$. Higher resolutions generated for ground-based measurements for $PM_{2.5}$ and NO_2 incorporate SRS and AQM datasets and related information to the local geographic and local sources (Xiaofan Yang, 2017).
Computational Fluid Dynamics (CFDs) was used as an alternative method to predict the behavior of hydrogen gas after an accidental release. Different ventilation conditions for the fuel concentration profile in the compartment were produced in the enclosed area. Release and dispersion of hydrogen in the compartment with no ventilation, with one opening, with two openings, and with the combination of forced and natural ventilation were considered as different scenarios which resulted in the most effective technique as a combined method as in a compartment area (Mohammad Dadashzadeh, 2016).
Air quality and its impacts on human health were assessed by Air Quality Index (AQI). Studies assessed three different years for spring, summer, fall, and winter during the 2017-2019 & 2020 period and compared air pollution for PM_{10}, $PM_{2.5}$, SO_2, CO, NO_2, and O_3. Winter > Spring > Fall > Summer is the order that indicated the air quality in summer was much better than in winter in terms of seasons. Among cities, Anqing had the best air quality and Suzhou had the worst condition. Restriction on industrial production and mobile transportation during February and March 2020 was the main reason for the reduction in air pollutant levels in ambient air. The study showed that air quality near central China improved significantly (Kaijie Xu, 2020). This study aims to monitor PM_{10} concentration in a sustainable campus using a respirable dust sampler: dispersion modeling of PM_{10} concentrations using QGIS; Air Quality Index in sustainable campus study.

II. MATERIALS AND METHODS

A. *Sustainable campus*

Conservation of natural ecosystems, reduction of natural resource consumption and recycling or reusing waste in a meaningful manner and promoting carbon-neutral energy uses is the main motive of the sustainable university campus. A Sustainable campus intends to reduce our ecological footprint, raise awareness about environmental problems, or research sustainable solutions in educational institutions that are working to transform themselves as agents of change were living and learning institutions for sustainability. 17 Global goals adopted in 2015 as a universal call to action to end poverty, protect the planet and ensure that by 2030 all people enjoy peace and prosperity and to ensure that development must balance social, economic, and environmental sustainability by adopting Sustainable Development Goals (SDGs).

B. *Study location:*

Kumaraguru College Of Technology (KCT) is in the hotspot of the north-eastern part of Coimbatore, TamilNadu, India (11.079458ºN & 76.989494ºE), which experiences a hot semi-arid climate. It's the fast-growing area in Coimbatore that has now emerged as the “IT Corridor of Coimbatore”. KCT glory of this green canopy is great with infrastructure for academic excellence and general facilities. Co-existing architecture (Microcosm) that covers the following:

1. Energy and emission: The target of this energy and emission is to reduce the per-capital carbon footprint of the campus by 40% in 2030 and to explore opportunities to reduce emissions and improve energy efficiency on the campus.
2. Water security: Rainwater harvesting, and percolation pond are structured here to improve the water security on campus.
3. Waste management: Resource recovery park created to achieve zero waste campus by 2024 by recycling and reusing wastes generated in campus.
4. Biodiversity enrichment: Ahimsa Vanam to create a space for introspection and inspiration that shall support rich biodiversity with 150 species of flora to reduce the 60% usage of paper as a commitment to curb environmental damage.

The Kumaraguru campus is home to 4000+ trees, 65+ species of birds, 40+ species of butterflies, and 4000+ trees inside the campus, with an average release of 10,92,000 pounds of oxygen inhaled by 42,000 humans.

C. Selection of location:

KCT has a sprawling campus of 150 acres with 8000+ students and working and non-working staff in the campus. KCT main gate (11.081183° & 76.990216°) is a bus stop at Thudiyalur – Saravanampatti road used by KCTian and other visitors. A linear direction from the main gate towards the hostel road inside the campus is mostly used by all modes of transportation. Locations are selected based on two reasons:(i) as a road-based area to determine dispersion from a single source line; (ii) plug point station for equipment usage.

TABLE I. SAMPLING LOCATION

S.No.	Location	Latitude (°N)	Longitude (°E)
1	Main gate	11.081183	76.990216
2	Security office	11.08054	76.990144
3	Check post	11.07907	76.990423
4	Hostel gate	11.07718	76.990767

Fig. 1. Sampling points

D. Sampling of PM10:

Suspended particulate matter in the air affects the earth's system in incoming solar radiation and outgoing terrestrial longwave radiation. Suspended particulate matter sampling, 10 microns down to 0.1 microns, was sampled using a Respirable dust sampler. It works under centrifugal force using the cyclone that separates PM into two fractions one is respirable dust, and another one is coarse cum non-respirable dust from the air stream. Sampling was done during September month (15.9.2022 – 18.9.2022) at four different locations in the KCT campus with measurement of temperature (°C), Relative humidity (%), and windspeed (km/hr.). Spatiotemporal data were sampled (collection of samples by varying both location and time) in the KCT campus. Glass microfiber filter (GF/1) of a size range: of 20.3 cm x 25.4 cm (8 x 10 inch) PM_{10} was sampled.

Fig. 2. Respirable dust sampler

E. Dispersion modelling:

Dispersion modeling for any point source done by Arc-GIS, AERMOD, GIS (Geographic Information System), Land use regression model (LUR), Computational fluid dynamics (CFD) model, and HYSPLIT transport & dispersion model. Dispersion modeling using QGIS (Quantum Geographic Information System) with latitude and longitude values for all sampling points processed in IDW interpolation and counter-mapping. Method of dispersion modeling for interpolation model as follows: Layer > Add raster layer > Processing > Toolbox > IDW interpolation > layer properties > Style > Single band pseudo color. Counter maps are created as follows: Processing > Counter > Add observed data to interpolated counter > Save IDW interpolation. Before feeding the data into QGIS, the data is saved in a .csv file format.

III. RESULTS

F. Concentration of PM_{10}:

The observed data of PM_{10} by using a respirable dust sampler is tabulated in a table and calculated using the expression below. The weight of the filter paper was taken using a weighing machine, and the volume was calculated using an empirical equation. The concentration of PM_{10} measured at four different locations resulted as 1st the sampling location (main gate) having a higher concentration than the 4th location on monitoring. Particulate matter of fewer than 10 microns collected in a filter cup differences in all study locations sampled. Results show there is a gradual decrease in $PM_{<10}$ collected. Comparing data with air pollution standard given by CPCB (Central Pollution Control Board), the ambient PM10 (162.2 µg/m^3) is higher at the initial sampling location (11.081183° & 76.990216°) than CPCB standards (100 µg/m^3). But the other three locations; the security office, Check post, and Hostel gate (34.72 µg/m^3, 67.78 µg/m^3, 4.45µg/m^3), are lesser than the standards given.

Expression used:

$$PM_{10} \text{ conc.} = \text{Wt. of the filter paper / Volume}$$

whereas,

$$\text{Volume} = \text{Volume of air flow rate} * \text{time}$$
$$\text{Volume of airflow} - 1 \text{ m}^3/\text{min}$$
$$\text{Time} - 120 \text{ min}$$

TABLE II. SAMPLING RESULTS OF PM

S.No.	Location	PM_{10} (µg/m^3)	$PM_{<10}$ (µg/m^3)
1	Main gate	162.22	18
2	Security office	34.72	80
3	Check post	67.78	10
4	Hostel gate	4.45	0

G. Dispersion modelling:

Dispersion modeling for PM_{10} concentration is done by QGIS IDW interpolation mapping and counter-mapping. Interpolation and counters for PM_{10} concentration could be an easier method for visualization in dispersion modeling.

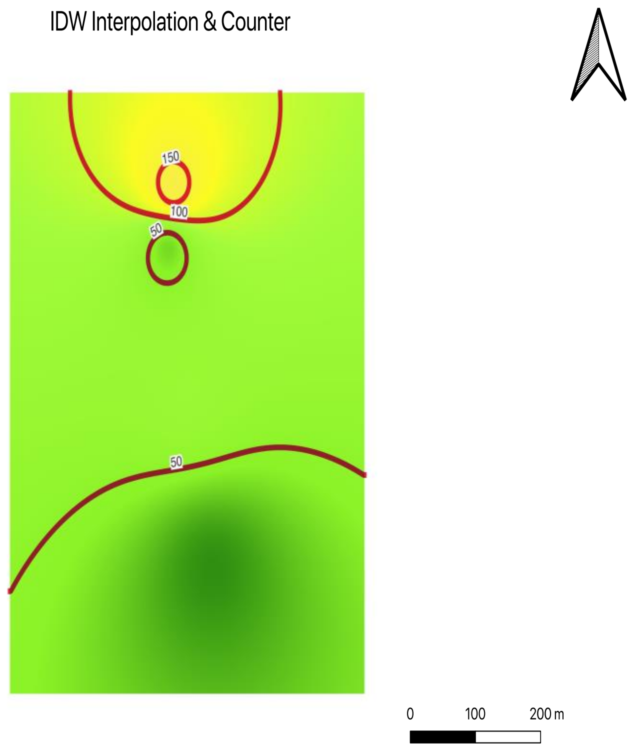

Fig. 3. Interpolation mapping

IV. CONCLUSION

Concentration variation at 1st and last sampling location of monitoring shows an influence in sustainable campus in the dispersion of pollutants. The notable one in the interpolation results is that the PM_{10} dispersion reduced in the sustainable campus in a linear path. The reason for this reduction may be due to:

- Green cover.
- Reduction in the circulation of vehicles.
- Sustainable rules applied in the campus.

The above-given statement on the results observed and the study done in the sustainable campus fields. Results in this study concluded that the dispersion of Particulate matter is under control inside the sustainable campus. A quick check of PM_{10} in the sustainable campus done in this study for a particular part showed a positive move towards sustainable ideas taken care of by the KCT campus. More studies could carry out on gaseous pollutants because the green cover in the sustainable campus with have more reaction over the gaseous pollutant. Future studies could be carried out based on other equipment for temporal data.

REFERENCES

[1] Alvarez-Risco, A., Del-Aguila-Arcentales, S., Rosen, M. A., García-Ibarra, V., Maycotte-Felkel, S., & Martinez-Toro, G. M. (2021). Expectations and Interests of University Students in COVID-19 Times

about Sustainable Development Goals: Evidence from Colombia, Ecuador, Mexico, and Peru. *Sustainability*, *13*(6), 3306.

[2] Atif, Y., Mathew, S. S., & Lakas, A. (2015). Building a smart campus to support ubiquitous learning. *Journal of Ambient Intelligence and Humanized Computing*, *6*(2), 223–238.

[3] Rolph, G. D., Stein, A. F., & Stunder, B. J. B. (2017). Real-time Environmental Applications and Display sYstem: READY. *Environmental Modelling and Software*, *95*, 210–228.

[4] Wivou, J., Udawatta, L., Al-Shehhi, A., Alzaabi, E., Albeloshi, A., & Alfalasi, S. S. (2016b). Air quality monitoring for sustainable systems via drone-based technology. *International Conference on Information and Automation*.

[5] Xu, K., Cui, K., Young, L., Wang, Y. X., Hsieh, Y. J., Wan, S., & Zhang, J. (2020b). Air Quality Index, Indicatory Air Pollutants and Impact of COVID-19 Event on the Air Quality near Central China. *Aerosol and Air Quality Research*, *20*(6), 1204–1221.

[6] Biedenweg, K., Monroe, M. C., & Oxarart, A. (2013). The importance of teaching ethics of sustainability. *International Journal of Sustainability in Higher Education*, *14*(1), 6–14.

[7] Krishan, M., Das, J., Singh, A., Goyal, M. K., & Sekar, C. (2019b). Air quality modelling using long short-term memory (LSTM) over NCT-Delhi, India. *Air Quality, Atmosphere & Health*, *12*(8), 899–908.

[8] Brandli, L. L., Salvia, A. L., Da Rocha, V. M., Mazutti, J., & Reginatto, G. (2020). The Role of Green Areas in University Campuses: Contribution to SDG 4 and SDG 15. *World Sustainability Series*, 47–68.

[9] Mazutti, J., Brandli, L. L., Salvia, A. L., Gomes, B. P., Damke, L. I., Da Rocha, V. M., & Rabello, R. D. S. (2020). Smart and learning campus as living lab to foster education for sustainable development: an experience with air quality monitoring. *International Journal of Sustainability in Higher Education*, *21*(7), 1311–1330.

[10] Dadashzadeh, M., Ahmad, A., & Khan, F. (2016). Dispersion modelling and analysis of hydrogen fuel gas released in an enclosed area: A CFD-based approach. *Fuel*, *184*, 192–201.

[11] Sm, S. N., Yasa, P. R., Mv, N., Khadirnaikar, S., & Rani, P. (2019). Mobile monitoring of air pollution using low-cost sensors to visualize spatio-temporal variation of pollutants at urban hotspots. *Sustainable Cities and Society*, *44*, 520–535.

[12] Lazzeroni, P., Cirimele, V., & Canova, A. (2021). Economic and environmental sustainability of Dynamic Wireless Power Transfer for electric vehicles supporting reduction of local air pollutant emissions. *Renewable & Sustainable Energy Reviews*, *138*, 110537.

[13] Yang, X., Zheng, Y., Geng, G., Liu, H., Man, H., Zhaofeng, L., He, K., & De Hoogh, K. (2017). Development of PM2.5 and NO2 models in a LUR framework incorporating satellite remote sensing and air quality model data in Pearl River Delta region, China. *Environmental Pollution*, *226*, 143–153.

[14] Liu, X., Dong, X., Li, S., Ding, Y., & Zhang, M. (2021). Air pollution and high human capital population migration: An empirical study based on 35 major cities in China. *Sustainable Production and Consumption*, *27*, 643–652.