ISSN 2321-743X
International Journal of Research in
Engineering and Bioscience
Volume 2 Issue 6 (Pages 54- 63)
IJREB
Journal home page: www.ijreb.org

MEASUREMENTS OF CARBON DIOXIDE (CO_2) IN INDOOR AND OUTDOOR AIR OF DIFFERENT MICROENVIRONMENTS AT A SEMI ARID REGION OF INDIA

Amit Masih and Ajay Taneja

[1]Environmental Research Lab, Department of Chemistry, St. Andrew's College, Gorakhpur, India

[2]Department of Chemistry, Dr. B. R. Ambedkar University, Agra, India

ABSTRACT

The inexorable rise of atmospheric carbon dioxide (CO_2) concentrations is perhaps the most familiar scientific graph of the 20th century. It sits as indisputable evidence that human activity is modifying the earth's atmosphere at a global scale and is at the centre of the debate on global climate change. The cause of this rise is well understood; CO_2 is being emitted through the large-scale burning of oil, coal and gas, which power modern industrial economies, with an additional contribution coming from the clearing of tropical forests and woodlands. However, these changes are meshed within an immense natural global carbon (C) cycle that is still poorly understood and that will almost certainly provide new surprises. Thus, the present study deals with the measurements' of CO_2 in indoor and outdoor air of different microenvironments at Agra which is considered to be a semi arid region of India as two third of its boundary are surrounded by the Thar desert of Rajasthan.. The air sampling was performed for the span of one year. CO_2 was measured by a portable YES-206 Falcon IAQ monitor. The highest CO_2 concentrations were found to be at roadside (583 ppm and 559 ppm) followed by rural site (546 ppm and 509 ppm) and urban site (497 ppm and 481 ppm) for outdoor and indoor respectively.

KEYWORDS: CO2, Microenvironments and global carbon

INTRODUCTION

Urbanization processes have increased pollution levels in urban areas which require long-term researchers to understand the ecosystem dynamics with particular attention to those urban systems of high historical and archaeological valence (Gratani & Varone, 2006). The urban ecosystems are composed of a mélange of different patches types ranging from totally non-biological and completely anthropogenic supported to natural ecosystems. The urban carbon cycle has its own driving forces, significantly different from those of natural ecosystems (Kakouei, et al., 2012). Carbon dioxide (CO_2) is actually regarded as a primary air pollutant because of its involvement in the global "greenhouse effect", correlated to the background levels of CO_2 (Nowak & Crane, 2012). It is also considered as a cause, or, at least, as a "tracer" of indoor air pollutants responsible of discomfort episodes in the "sick building syndrome" investigations, where high CO_2 levels indicate an adequate ventilation rate (Matese et al., 2009; Tiwari et al., 2011).

Humans and automobile activity produced more then 80% input of CO_2 into the urban environment and motor vehicles are significant sources of air pollution emissions (Hiller et al., 2011). The main factors influencing vehicle emissions are the vehicle type, technology and fuel used, and the operating mode of the vehicle that is the speed, acceleration and engine temperature (Soegaard et al., 2003). CO_2, when released into the atmosphere, pose a direct and serious hazard to living organisms in general, and to humans, in particular (Kardowski et al., 2010). Therefore, even if the main climatic effects of CO_2 are not local, it is important to measure CO_2 at great urban sites and in general in each ecosystem in which human activities are most concentrated. Moreover, CO_2 is site and time dependent and it is related to weather conditions (Ramamurthy et al., 2011). In the last few years, much attention has been focused on the increase of air pollutants (Brack, 2002). A large number of work shows that CO_2 concentrations values around and over 1000 ppmv in indoor sites are often measured, depending on both internal sources and external air pollution, coupled with low air change levels (Liu et al., 2012). Studies in this field also showed that CO_2 values of twice the background value (about 370ppmv) are not unusal at urban centres of the main cities, where a dome effect has been highlighted (Hoornweg et al., 2011; Soegaard et al., 2003). In general, pollutants are released at ground level and their upward movement is restricted because of tall buildings and congested thoroughfares. Therefore, high building up of pollutants frequently occurs causing adverse effects on the environment quality of urban areas (Henry et al., 2009; Nesmani et al 2010). The effects of humans and urbanization on environmental processes can be better understood using the urban ecosystems a study tool in comparison with the control sites (Gratani and Varone, 2005; Torres et al. 2011).

To our knowledge there has been a shortage of CO_2 studies in India. The aim of this study was to determine the concentration and circulation of CO_2 at three different microenvironments and also to analyse the main factors affecting CO_2 concentration inside the Agra city.

MATERIAL AND METHODS

Site description

Agra, the city of Taj Mahal (27°10'N 78°02'E) is located in the north central part of India about 200 kms South of Delhi in the Indian state of Uttar Pradesh. Agra is considered as a semi-arid zone as two third of its boundary are surrounded by the Thar desert of Rajasthan. Three highways are crossing the city. The climate during summer is hot and dry with temperature ranging from 32°C to 48°C. In winter the temperature ranges from 5.5°C to 30.5°C. The down ward wind is south-south-east *i.e*. SSE 29% and North- East *i.e.* NE 6% in summers and it is west-north-west *i.e*. WNW 9.4% and north-north-west *i.e*. NNW 11.8% in winters. The atmospheric pollution load is high because of the down ward wind; pollutants may be transported to the different areas mainly from an oil refinery situated in Mathura (50 Kms from the centre of Agra City). Agra has 1,271,000 of population. 3, 86,635 vehicles are registered and 32,030 generator sets are used. It has been indicated earlier that in Agra, 60% pollution is due to vehicles (Masih et al., 2006). St. John's College, which is situated in the heart of Agra city, is considered as a roadside area. It lies by the side of a road that carries a maximum traffic density of about 10^5 vehicles per day, which results in production of smoke, and total suspended particulate matter by engine idling and gear changes. Towards the north is located Dayalbagh which is exclusively rural (agricultural) area. The Taj trapezium (area surrounding the Taj Mahal 10,400 ~ km^2) located to the south of the site is considered to be an urban (residential) area and is totally a green belt. Figure 1 shows map of Agra showing different sites.

Monitoring of CO_2

CO_2 was measured by a portable YES-206 Falcon (Indoor Air Quality) IAQ monitor (Young Environment Systems, Inc. 140-8771 Douglas St. Richmond, B.C. V6X1V2 Canada). The operational characteristics of the analysis are presented in Table 1. Zero and span were checked at regular intervals using zero air and CO_2 standards. Table 1 shows the specifications of YES-206 analyser.

RESULTS AND DISCUSSION

Table 2 depicts the annual average meteorological parameters ie. air temperature, humidity, wind direction and wind speed throughout the year. The statistical data of indoor and outdoor CO_2 concentrations of all the microenvironments for a span of one year has been illustrated in Table 3. At urban site the maximum concentration was found to be 497 ppm with a minima of 351 ppm at indoors whereas a maxima of 481 ppm and a minima of 366 ppm at outdoors. At rural site, maxima and minima were 546 ppm and 368 ppm for indoor air along with 509 ppm and 317 for outdoors respectively. At roadside the maxima was 583 ppm with a minima of 359 ppm for indoor whereas 559 ppm maxima with 324 ppm minima for outdoors. Table 4 shows indoor/outdoor ratios for urban, rural and roadside microenvironments for the whole year having a range from 0.7 – 1.2 (urban), 0.9 – 1.4 (rural) and 1.0 – 1.4 (roadside). Figure 2 illustrates the relationship between indoor and outdoor CO_2 concentrations at rural, urban and roadside houses. It explains full day indoor variation for all the pollutants at rural, urban and roadside house. Though the outdoor concentration are low but still have positive impact at urban and roadside houses where as in normal site indoor resource are very demonstrating and are at very high levels. CO_2 concentration is seen to be constant throughout the day but gives two small peaks. Figure 3 shows the annual wind direction for summer, monsoon and winter seasons. Figure 4 depicts the CO_2 concentration rose diagram at different microenvironments during winter, summer and monsoon which illustrates that during winter season, generally the wind direction was north-northwest, whereas the wind direction was towards northwest-west. During monsoon season, the dominant wind flow was in the southwest direction with some flow towards east direction. During all the seasons the CO_2 concentration was found between ranges of 315 – 585 ppm.

REFERENCES

Brack, C.L., 2002. Pollution mitigation and carbon sequestration by an urban forest. Environmental Pollution 116, S195–S200.

Gratani, L., Varone, L., 2006. Carbon sequestration by Quercus ilex L. And Quercus pubescens willd. and their contribution to decreasing air temperature in Rome. Urban Ecosystems 9, 27–37.

Gratani, L., Varone, L., 2005. Daily and seasonal variation of CO2 in the city of Rome in relationship with the traffic volume. Atmospheric Environment 39, 2619–2624.

Henry, M., Tittonell, P., Manlay, R.J., Bernoux, M., Albrecht, A., Vanlauwe, B., 2009. Biodiversity, carbon stocks and sequestration potential in aboveground biomass in smallholder farming systems of western Kenya. Agriculture Ecosystems & Environment 129, 238–252.

Hiller, R.V., McFadden, J.P., Kljun, N., 2011. Interpreting CO2 fluxes over a suburban lawn: the influence of traffic emissions. Boundary–Layer Meteorology 138, 215–230.

Hoornweg, D., Sugar, L., Gomez, C.L.T., 2011. Cities and greenhouse gas emissions: moving forward. Environment and Urbanization 23, 207– 227.

Kakouei, A., Vatani, A., Bin Idris, A.K., 2012. An estimation of traffic related CO2 emissions from motor vehicles in the capital city of, Iran. Iranian Journal of Environmental Health Science & Engineering 9, 9–13.

Kordowski, K., Kuttler, W., 2010. Carbon dioxide fluxes over an urban park area. Atmospheric Environment 44, 2722–2730.

Liu, C., Li, X., 2012. Carbon storage and sequestration by urban forests in Shenyang, China. Urban Forestry & Urban Greening 11, 121–128.

Masih, A., Taneja, A.,(2006). Polycyclic Aromatic Hydrocarbons concentrations and related carcinogenic potencies in soil at a semi-arid region of India. *Chemosphere*, **65**, 449-456

Matese, A., Gioli, B., Vaccari, F.P., Zaldei, A., Miglietta, F., 2009. Carbon dioxide emissions of the city center of Firenze, Italy: measurement, evaluation, and source partitioning. Journal of Applied Meteorology and Climatology 48, 1940–1947.

Nesamani, K.S., 2010. Estimation of automobile emissions and control strategies in India. Science of the Total Environment 408, 1800–1811.

Nowak, D.J., Crane, D.E., 2002. Carbon storage and sequestration by urban trees in the USA. Environmental Pollution 116, 381–389.

Ramamurthy, P., Pardyjak, E.R., 2011. Toward understanding the behaviour of carbon dioxide and surface energy fluxes in the urbanized semi–arid Salt Lake Valley, UTAH, USA. Atmospheric Environment 45, 73–84.

Soegaard, H., Moller–Jensen, L., 2003. Towards a spatial CO_2 budget of a metropolitan region based on textural image classification and flux measurements. Remote Sensing of Environment 87, 283–294.

Tiwari, R., Cervero, R., Schipper, L., 2011. Driving CO_2 reduction by integrating transport and urban design strategies. Cities 28, 394–405.

Torres, M., Pinho, P., 2011. Encouraging low carbon policies through a Local Emissions Trading Scheme (LETS). Cities 28, 576–582.

Table 1. Specifications of YES – 206 analyser

Sensor Type	Range	Sensitivity	Accuracy	Response Time	Warm up time	Operating conditions	Calibration interval
NDIR	0-9,999	+/-1ppm	+/-50ppm or +/-5% of reading	<60 seconds for 90% of step change	<60 seconds at 22ºC	0-50ºC	12 months

Table 2. Annual Average Meteorological Parameters

Months	Air Temp (^oC)	Humidity (%)	Wind Direction	Wind Speed (m/s)
January	14.6	74.2	NW (232.6)	2.65
February	18.4	62.8	N (207.2)	3.04
March	25.2	54.9	N (177.9)	1.42
April	32	31	E (193.0)	2.0
May	34	35	NW (207.0)	2.0
July	32	68	SW (182.0)	2.0
August	29	87	E (157.0)	2.0
September	30	67	E (204.0)	1.0
October	28.7	78.2	E (147.3)	1.14
November	22.3	55.1	NW (215.2)	1.39
December	16.8	72.5	NW (240.2)	2.34

Table 3: Average Monthly Concentrations of CO_2 (ppm)

Months	Urban		Roadside		Rural	
	I	O	I	O	I	O
Oct.'04	372 ± 22	366 ± 12	390 ± 14	374 ± 18	378 ± 16	348 ± 28
Nov.'04	388 ± 14	398 ± 18	479 ± 28	397 ± 13	392 ± 22	362 ± 32
Dec.'04	392 ± 16	386 ± 24	544 ± 50	384 ± 25	408 ± 24	358 ±18
Jan.' 05	398 ± 21	372 ± 16	523 ± 16	419 ± 36	412 ± 27	364 ± 29
Feb.' 05	384 ± 18	368 ± 14	462 ± 41	378 ± 23	368 ± 14	372 ± 24
March' 05	351 ± 28	481 ± 33	474 ± 64	324 ± 24	427 ± 51	383 ± 36
April' 05	487 ± 41	451 ± 29	503 ± 66	371 ± 35	461 ± 53	317 ± 35
May' 05	476 ± 38	382 ± 31	467 ± 61	342 ± 29	453 ± 49	503 ± 43
June'05	429 ± 32	366 ± 26	517 ± 71	412 ± 40	477 ± 37	407 ± 39
July' 05	456 ± 33	347 ± 22	359 ± 53	331 ± 28	481 ± 52	419 ± 41
Aug.' 05	351 ± 27	437 ± 26	421 ± 57	368 ± 38	543 ± 61	509 ± 55
Sept.' 05	487 ± 37	475 ± 43	582 ± 71	413 ± 62	452 ± 39	393 ± 21
Oct.' 05	458 ± 39	472 ± 32	548 ± 67	472 ± 67	467 ± 41	448 ± 38

Table 4. Indoor/Outdoor Ratios

Months	Urban	Roadside	Rural
Oct.'04	1.0	1.0	1.0
Nov.'04	0.9	1.2	1.0
Dec.'04	1.0	1.4	1.1
Jan.' 05	1.0	1.2	1.1
Feb.' 05	1.0	1.2	0.9
March' 05	0.7	1.4	1.1
April' 05	1.0	1.3	1.4
May' 05	1.2	1.3	0.9
June'05	1.1	1.2	1.1
July' 05	1.2	1.0	1.1
Aug.' 05	0.8	1.1	1.0
Sept.' 05	1.0	1.4	1.1
Oct.' 05	1.0	1.2	1.0

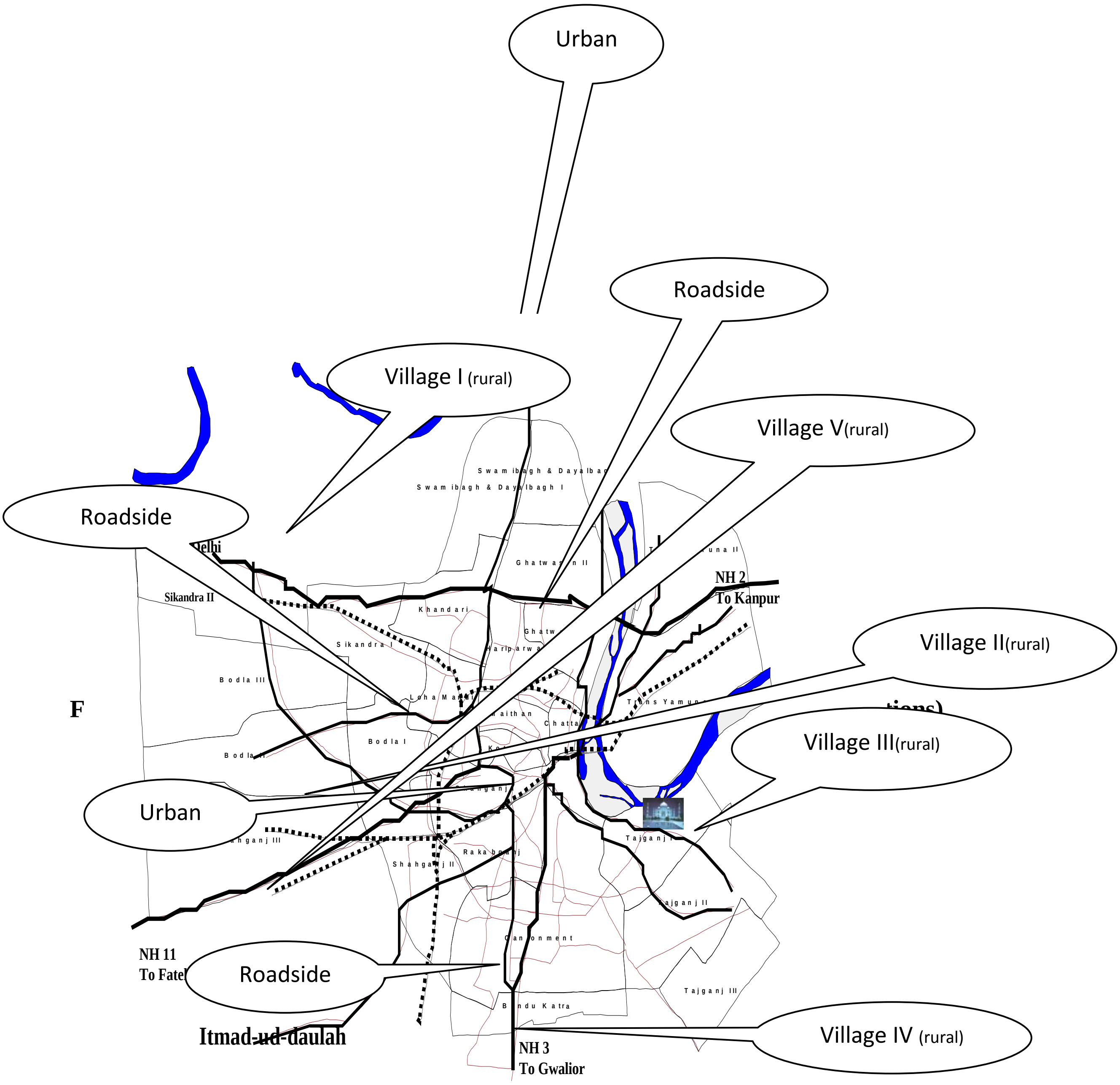

Figure1: Three different microenvironments (rural, urban and roadside locations)

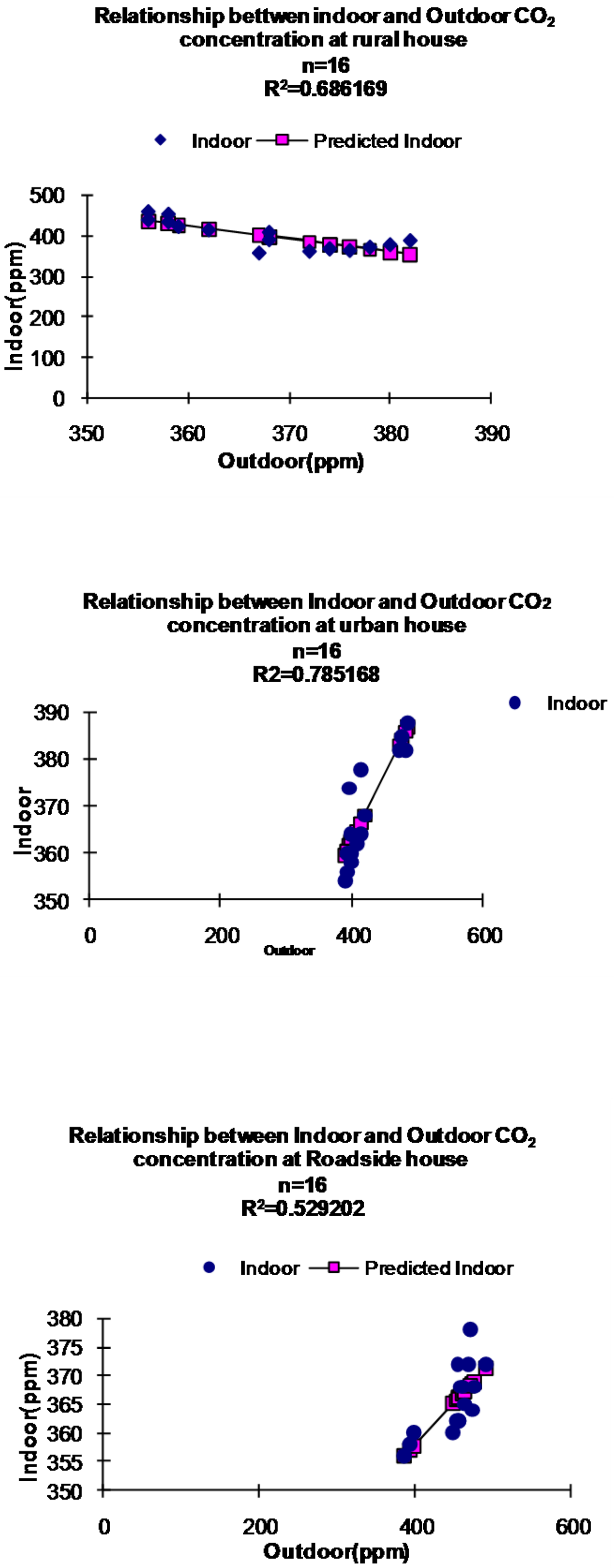

Figure 2: CO_2 indoor/outdoor relationship at rural, urban and roadside houses

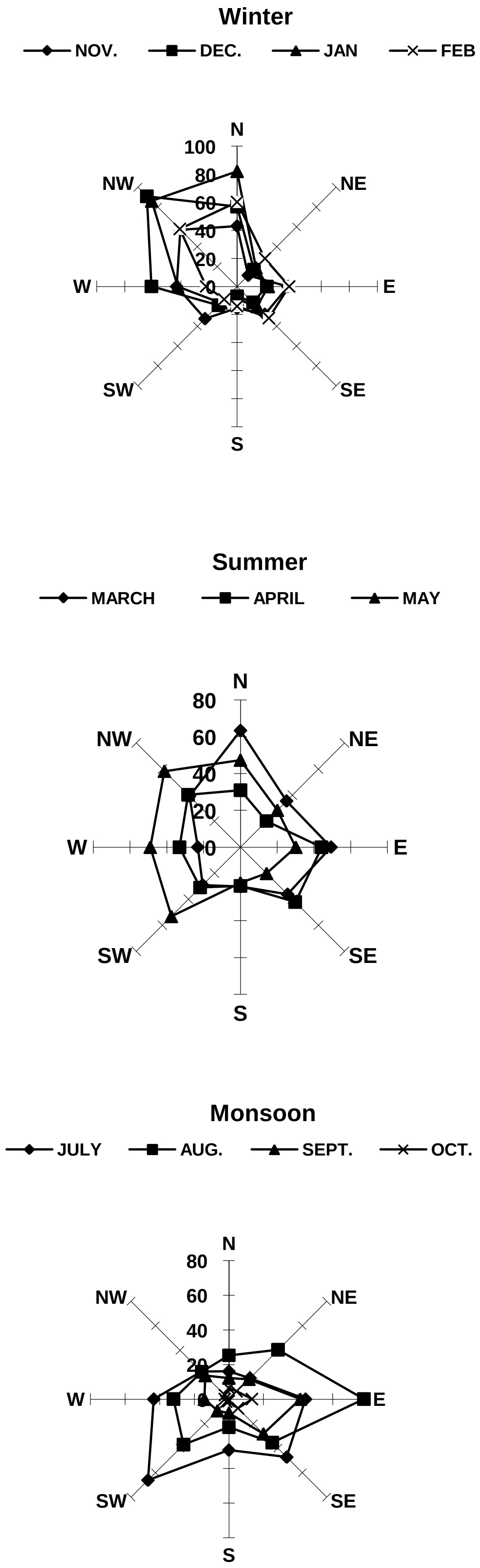

Figure 3: Annual Wind Direction (winter, summer and monsoon)

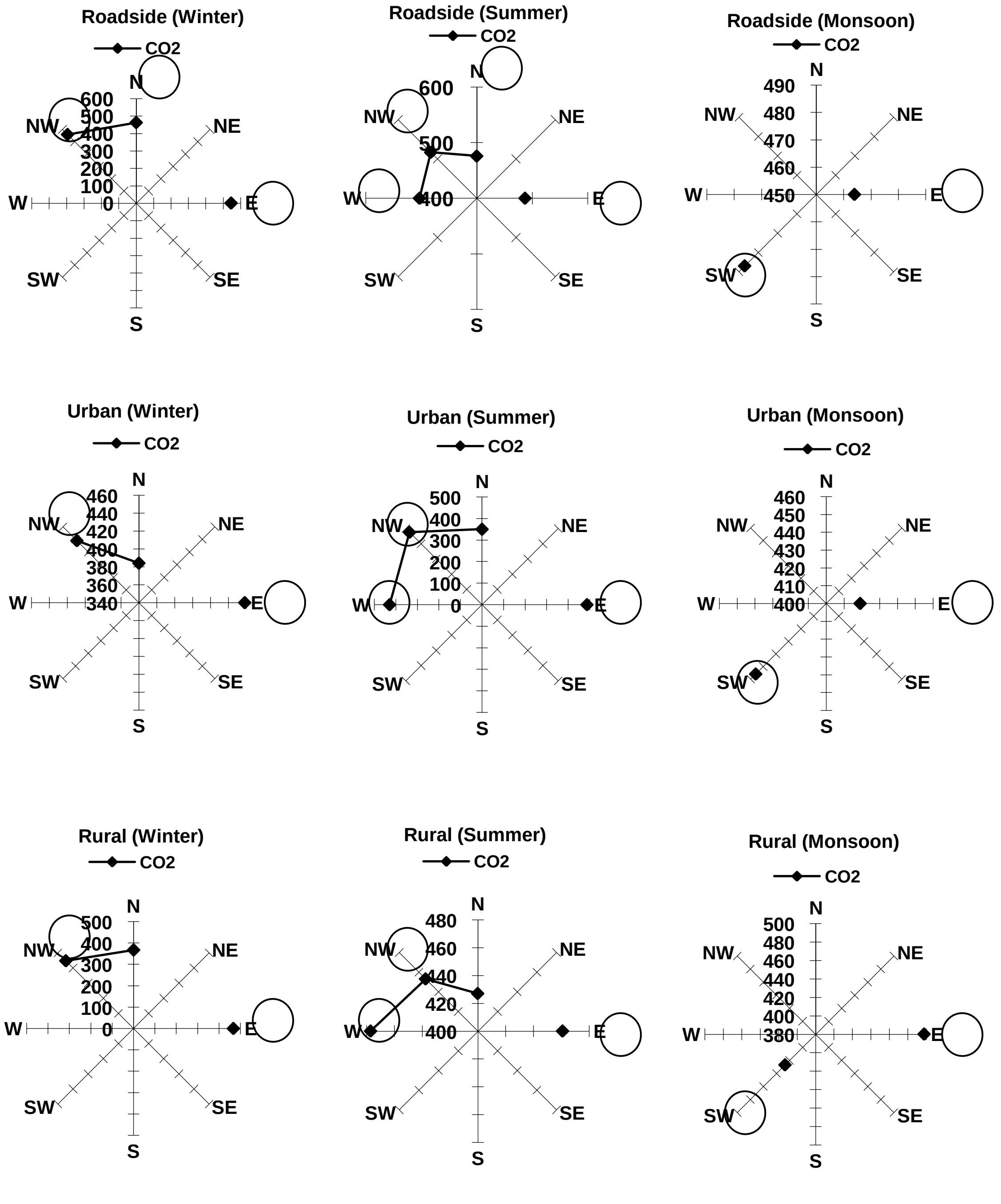

Figure 4: CO_2 Concentration rose diagram at different microenvironments during winter, summer and monsoon